

# A Humble Extension into Space and Time

A scenario-based study into the future of the space sector

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# Summary

The space sector is in a rapid transition. New business models and techniques are being created that challenge the older institutional parties within a field that speaks to the imagination. These developments raise the question of what the future might entail for humans in outer space. This study seeks to answer that question through a scenario-planning method which reasons from uncertainties, rather than certainties. The theoretical fields of International Relations and Public Administration provide the footing, as what we do in outer space is an extension of what happens on earth. The schools of realism and liberalism constitute a broad spectrum of how states, international organizations and business might interact with one another and shape the future. The history of the space sector, trends, drivers and uncertainties are analyzed as part of the scenario-planning method which have produced two main uncertainties; *“Will there be more international cooperation of competition between states in their outer space activity?”* and *“Will the commercialization of the space sector stagnate/stop or grow?”*. The two uncertainties are juxtaposed and impart four scenarios that provide unique visions for the future of the space sector.

De ruimtevaartsector transformeert onder gevolg van *New Space*. Het is een fenomeen die staat voor een beweging van verregeande commercialisatie en inzet om ruimtevaart goedkoper, sneller en efficiënter te maken. Ruimtetoerisme, ruimtemijnbouw en kolonisatie van andere hemellichamen zijn voorbeelden van ambities die worden nagestreefd door vernieuwende bedrijven. Deze ontwikkelingen roepen de vraag op hoe de toekomst van de sector zal veranderen, en wat mogelijk zal zijn voor mensen in de ruimte. Via een scenario-planning methodiek zal deze studie hier antwoord op geven door scenario's te creëren. Een theoretisch kader bestaande uit theorieën van International Relations en Bestuurskunde zal de basis vormen omdat wat wij in de ruimte zullen doen, grotendeels een reflectie en extensie is van wat wij op aarde doen. The geschiedenis van de ruimtevaartsector, de trends, drivers en onzekerheden worden geanalyseerd als onderdeel van de scenario-planning methodiek en hebben twee onzekerheden geproduceerd; *“Zal er meer internationale samenwerking of competitie zijn tussen staten in hun buitenaardse activiteiten?”* en *“Zal de commercialisatie van de ruimtevaartsector doorgaan of stoppen?”* Hieruit zijn vier unieke scenario's te vormen die elk een uniek beeld geven van hoe de toekomst van de ruimtevaart eruit kan zien.

# Preface

The 21<sup>st</sup> century will mark the advent of new ambitious commercial exploits into outer space and presumably encourage several new initiatives that can transform life on earth. The same century will also see the coming of age of several superpowers and smaller emerging states that continue to develop and expand their space programs. New questions arise in light of these developments that cannot be answered by current legal and administrative frameworks related to space governance and security. The Outer Space Treaty from 1967 is perhaps the most important document that exists in this regard, declaring that outer space, its celestial bodies and the moon cannot be subject to national appropriation; it belongs to the regime of *res communis omnium*. Yet the treaty needs to be updated to include considerations from the private sector and new developments that make the exploitation of outer space even more attractive for nation-states. New constellations of small satellites, (private) sub-orbital flights and the harvest of natural resources on other celestial bodies are just some examples of a new emerging space industry. The resulting rise in interest of space ventures will likely expand the scale and frequency of space missions in the future. Low-cost technology has furthermore made it possible for a wider range of private and public parties to enter the space domain which will increase the complexity of interactions in legal and organizational areas. Responsibility and liability in space consequently become more tenuous topics and are mostly regulated through bilateral agreements in the current state of affairs. A more substantive solution might be favored then, that addresses the legal questions and establishes future frameworks of international cooperation or competition in space. The next chapter of the space age will not only be moved by techno-nationalism after all, but by a new commercial spirit that will drive the expansion of human activity up there.

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# Introduction

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The United Nations' Committee on the Peaceful Uses of Outer Space (COPUOS) has served in the creation of five treaties that guide the behavior of nation-states in conducting their space activity. Although the treaties address important topics, the overall consensus is that they are either lacking in detail or the number of ratifications and signatories is underwhelming<sup>1</sup> (Stuart, 2009). The lack of substance or support for the treaties indicate two elements that explain why international cooperation can be hard to achieve. One is that the COPUOS operates on the basis of consensus, making hard language and definitive boundaries hard to overcome as each delegation has to agree on every matter before it can be included in the final document. Second, and more importantly, cooperation has to serve the self-interest of nation-states and is thus not a surety in the international domain. States will only agree to cooperate if they perceive that such an agreement will benefit their own needs and arguably enter into competition if this proves more favorable. Cooperation and competition in space have been part of a political game since the Cold War, yet a radical new dynamic will increase the complexity of the space arena as the entrance and expansion of smaller space businesses marks a decisively new zeitgeist. The resurgence of national space programs will help to invigorate the idea of outer space, but the most fundamental change in people's appreciation of space will happen through the continuous private effort to make it accessible. A reconsideration of the international framework regarding outer space is deserved as bold new space missions are announced from both public and private sector and technological advancements facilitate ease of access to space that is greater than ever before.

## | Central question

The international framework is outdated and insufficient as it cannot provide definite guidance for countries and companies in their spaceflight endeavors, whilst the international community has to address important questions that will determine its course regarding these endeavors for the coming decades. The objective of this study is to explore the probable futures of state and non-state

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<sup>1</sup> The Moon Treaty of 1979 for example was presumed to succeed the Outer Space Treaty by placing jurisdiction of all celestial bodies under international law. Presently, it's considered a failed treaty as 11 countries have signed the document and no space-faring power has ratified it (Harding, 2013).

actors in the field of outer space activity through a process of scenario-planning that allows for the further identification of strengths and weaknesses. The research question that flows from the objective can be formulated as follows:

*What strengths and weaknesses can be identified in the future scenarios of international cooperation and competition in space?*

The goal of this study is twofold; to provide insight in how the future of the space sector might unfold by identifying the differing possibilities and what the value is of the theories that will ground the scenario-building process. This study will cover international forms of cooperation and competition between state and non-state actors in outer space activity. Cooperation is to be understood as purposeful behavior that is aligned with other actors in order to anticipate their interests. Competition can be understood in two ways. Private organizations compete to offer the best balance in price and quality in their services and products. Competition between nation-states can vary from techno-nationalism – a form of national pride and prestige expressed through the nation’s technological prowess – to a state of war. Competition between nation-states will be regarded as a driver that can accelerate growth in general. War as a result of space politics in the coming decades is an unlikely scenario yet the fear of war, or more specifically, the fear of losing is an important rationale for nation-states that seek to secure their own survival and can drive space technology. The field of Public Administration will also be included as the theories of complexity and network governance can contribute to a better understanding of the complexity involved with a transforming space sector and how cooperation between the public and private sector might happen. Finally, the scenario-planning method TAIDA will be an essential part of this study’s methodology as the approach from uncertainties, rather than certainties, will lead to unique results that can provide a new vision on the future of the space sector. The central question of this study will be divided by the following sub-questions and these will serve as the chapters of this thesis:

1. What is the theory of international cooperation, competition and complexity and network governance?
2. What is the scenario-planning method TAIDA?
3. What are the trends and uncertainties related to the space sector?
4. What are the scenarios for the future of human activity in outer space?

## | Why space?

The significance of this study can be specified in two ways. First, the societal relevancy is illustrated in anticipating the future of public and private space ventures. As the exploitation of space is rapidly changing, serious concerns have been raised by the international community over legal, security and governmental space topics whereas existing treaties and international agreements cannot provide definite solutions. The recent laws on space mining in the US in 2015 and Luxembourg in 2017 are an example of this by demonstrating the loopholes within the Outer Space Treaty. The largest supported international document with 107 countries as parties prohibits the appropriation of celestial bodies but does not specify the status nor control of resources that are the result of economic (mining) activity. To paraphrase Sergio Marchisio (2016) during the 10<sup>th</sup> United Nations Workshop on Space Law: “... *this Treaty is as wildly insufficient today as it was then ... It rather romantically establishes basic principles related to the peaceful uses of outer space. The semantics allow for plenty of wiggle room. Modern space legislation is desperately needed*”. A study into the future of the space sector can provide probable scenarios that can serve as possible dots on the horizon. States, international organizations and businesses can then anticipate on these possible futures and build strategies that address current concerns of the sector. It is also valuable to learn what the future might hold when a clear institutional framework is absent and how this affects the space sector and the world as a whole. The scenario-planning method TAIDA can also provide unique scenarios that have not been produced by other studies and can therefore provide valuable insights by which all parties in the international arena can benefit.

Second, the scientific relevance is echoed by the same ambition to map out probable futures concerning activity in outer space and can then contribute towards the emerging fields of space law and public space policy. Combining theories from International Relations and public policy analysis can furthermore elaborate on the concept of international cooperation by taking systemic and network characteristics into consideration and help explain cases of cooperation that benefit from a synthesis between the two studies. The value of both bodies of literature can also be put to the test by examining the usefulness of the theories in the scenarios built by the scenario-planning method thereby contributing to the scientific relevance of this study. A ‘future-test’, as opposed to an empirical test, can be done to test the relevancy of the theories. It is not an empirical test because the scenarios in the future can never be determined with absolute certainty. But the methodology does provide the opportunity to ascertain whether the proposed theories can say something



meaningful in those specific future scenarios. The theories on international cooperation, competition, complexity and network governance provide a systemic understanding of the present, yet these same theories might prove unfit in understanding different scenarios set in the future.

## | Reading guide

The premise and objective of the study has been discussed in this introductory chapter, along with the significance of this research that is explained through its societal and scientific relevance. The second chapter will present a review of the related literature. The schools of realism and liberalism from International Relations theory provide the basis of analyzing nation-states entering into cooperation or competition with one another. Public policy analysis offers network governance theory that supplements the systemic understanding of International Relations with a fluid concept of cooperation where non-state actors take a more prominent role on the complex world stage. The review will finish with a particular scenario-planning method that enables anticipation of probable futures and develop long-term strategies. The third chapter will discuss the methodology and address the ways the validity and reliability of this research can be safe-guarded and improved. The analysis of future international cooperation in space will occur through a combination of literature review, data-analysis, interviews and scenario-planning. The fourth chapter discusses the results of this study by analyzing the different scenarios wherein the interaction between state and non-state actors can manifest in different ways. The last chapter will provide a summary and conclusion to this research and close with some final remarks on possible courses of action.

# Theoretical Framework

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This chapter will expand on the theoretical foundation of this study. The selected theories will be explained and arguments are provided for why these theories were chosen. The underlying rationale for the selection of the theories has been that whatever human activity will happen in outer space, is an extension of the affairs that transpire on earth. The field of International Relations has therefor been selected as the main source for theory. The field has been divided into multiple schools of thought and for the purpose of this study it is necessary to explain the two main schools; realism and liberalism. The purpose of including the schools of realism and liberalism is to ground this theoretical framework in the fundamentals of international relations and offer differing tools of analysis. For example, the realist will explain war as a symptom of the anarchic international arena but the liberalist would disagree and point towards imperialism or undemocratic regimes as the root cause. Realism is mostly concerned with power, security and has a focus on states viewed as unitary actors. Liberalism gives attention to interdependence, institutions and cooperation. Together<sup>2</sup>, both schools offer theoretical templates for the analysis of international cooperation and other theoretical constructs. It should be noted that both schools should not necessarily be viewed as arch-enemies, but rather as opposite sides that complement one another.

The field of public policy has also been identified as a useful source of theory, in part because the field of International Relations emphasizes the role of the state and the international level. The theory on complexity and network governance complements this static view and offers a more nuanced understanding of the difficulties that arise within the complex interactions in the space sector.

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<sup>2</sup> One explanation as to why realism and liberalism seem to provide convincing arguments for their cases is because they study different sub-fields within International Relations. Realists tend to take security issues under consideration while liberalists look at non-security, mostly economic, cases where common interests are more likely to be found (Keller, 1992).

# 1 Realism

Realism views states as actors with the goal of maximizing their interests in a hostile environment characterized by anarchy and three core elements can be identified among the various strands of the school (Dunne & Schmidt, 2013). The first element prescribes a central role to the nation-state that is the representation of the will of the people and this view can be defined as statism. The international arena on the other hand has no central authority to enforce rules, hence anarchy rules outside the domestic borders. Anarchy forces states to put their own security as a first priority. The second element is survival and is concerned with power. In order to survive the anarchic state of the international arena, states rely on their power and the accumulation of power is the best way to guarantee the continued existence of a state. The final element dictates that states cannot rely on other states or international organizations for their survival and are therefore reliant on their selves with self-help as the only option left. When threatened by a more powerful state or group of states, the defender will enlarge its own military prowess. If this proves insufficient then alliances will be sought with other states thereby counterbalancing the conflicting side. A balance of power will be reached and has been a mechanism that secured the survival of smaller or weaker states throughout history. Realism offers a worldview where conflict is not only commonplace, it is sensible because states should after all place their own interests above anything else.

## **Absolute and relative gains and international competition**

Absolute and relative gains are theoretical concepts within the school of realism which explains how states interreact in a competitive environment. The realist Joseph Grieco explains that states want to increase their power and cooperation is feasible if that will lead to an expansion of their power. States are at the same time conscious of how much power other states might acquire through the same cooperation, and will be prone to abandon a cooperative arrangement when other states gain relatively more power than they do. The relative gains of cooperation are therefore more important to states because they play a zero-sum game where one's gain is another one's loss. Liberalists focus on the economic dimension and contend that states should seek to cooperate because the absolute gains from trade and peaceful relations will result in an expansion of wealth for all.

## Hegemon

The idea of a hegemon is an important concept within the field of International Relations which is simply the most powerful state in the international arena. Both liberalism and realism provide an explanation for the motivations of a hegemon. Liberalism argues that the absence of a central authority in the international domain leads to failures in the public domain, i.e. global pollution, but a powerful enough state or hegemon might solve this by enforcing a specific regime policing polluting states. Even if the hegemon falls, the established regime will continue to exist because its members have found that cooperation has resulted in a situation where everyone is better off. The realist explanation contends the idea of nation-states forming regimes to collaborate, and reason instead that regimes are formed to solve coordination problems. Yet any cooperative agreement is still plagued by fear of cheating and the relative gains of other states (Little, 2013). The benign hegemon in the liberalist explanation offering to sustain the cost of a regime is furthermore perceived as a false assessment by realists. The regime is sustained because it favors the powerful<sup>3</sup>, i.e. the hegemon will create a regime if it views the detrimental effect of global pollution as a significant threat to its own interests. Realists argue in this regard that liberal thinking has neglected the importance of power within regimes.

## 2 Liberalism

Liberalism rejects the realist notion of power politics and stresses the interdependence of states, international organizations and international institutions. Institutions play a particularly important role in the liberal theory as they are critical for achieving international cooperation producing an international liberal order. David Baldwin (1993) has identified four varieties of liberalism that influence international relations offering various explanations for international cooperation or order. Commercial liberalism explains that free markets and trades will lead to a wealthier world which in turn will lead to a more peaceful world. The republican variety of liberalism states that democratic states are more inclined to stay at peace with other democratic states and this hypothesis is known as the democratic peace theory. The sociological variety of liberalism embraces the notion of an international civil society and argues that the interdependence between nations

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<sup>3</sup> Another example offered by Snidal and Sampson (2014) shows how the USA in the '80 sustained its own world economy regime which was not in favor of Third World Countries. The only way the calls from the 'South' for a regime-change could be realized was when the balance of power would shift from North to South.

increases due to increases in transnational activities. States become more intertwined and it is more costly to avoid or negate international cooperation. The final variety of liberalism is institutionalism and is presented as the most serious contender to realism, although some scholars point out that there is not a great difference between the two (Jervis, 1999). The idea of international institutions promoting peace and order was born out of early integration theory that suggested that states should invest resources and even yield sovereignty to integrated international communities that could promote peace and prosperity. Institutionalism reason that institutions improve international cooperation by assisting nation-states in a process that involves their interests. Current works of institutionalists are aimed at global governance which is a response to problems too big to solve for any one nation alone.

### **A definition of international cooperation**

The idea of international competition is explained through the concept of relative gains. The idea of international cooperation is put forth by Robert Keohane and defined it as “*when actors adjust their behavior to the actual or anticipated preferences of others, through a process of policy coordination.*” (Keller, 1992: 467). Two implicit elements are observed by Keller (1992). The first implicit element states that the definition assumes that actors move towards their goal but they don't have to share the same goal. The second implicit element states that actors coordinate their policies not necessarily to help others but to improve their own rewards in anticipation of the benefits of cooperating. These subtle remarks show a characteristically realist perspective and is true when the world is viewed as a zero-sum game. The case can also be made for liberalists when it is assumed that the expansion of wealth can happen through absolute gains and international cooperation flourishes because of the selfish motivations of states to better themselves. Keller (1992) concludes that the two aforementioned elements are crucial for defining cooperation and summarizes it as nation-states with goal-directed behavior mutually adjusting policy in order to improve everyone's situation.

### **Institutionalism**

Institutions have become a central tenet in liberalism's explanation of international cooperation. Lamy (2013) expands on three different kinds of institutions that international society has created. The first kind are constitutional institutions that are the most foundational and is presupposed for

the two other kinds; they are essentially about the existence of international society<sup>4</sup> itself. Nation-states recognize the norm of state sovereignty wherein each state is the master of its own domestic power structure and it entails the norms of self-determination and non-intervention. The second kind are fundamental institutions that make it possible for states to coordinate and cooperate in the anarchic international domain. The foremost examples of fundamental institutions are international law and diplomacy. The last kind are issue-specific institutions, otherwise called regimes, which comprise the fundamental institution's exercises within a specific topic. Regimes are the most concrete of the three varieties, detailing norms and decision-making procedures explaining which states are considered part of the institution and what course of action is allowed to be undertaken by its adherents. One example of a regime is the Non-Proliferation Treaty that aims to prevent the spread of nuclear weapons through legal and conventional measures.

The strength and attractiveness of international institutions can be found in the solution it provides to the dilemma of self-interest which result in coordination and collaboration problems (Stein, 2008). Coordination problems arise when states need to cooperate but varying interests and views on solutions hinder collective action. An institutional arrangement can coerce adherents to choose a specific equilibrium. Collaboration problems are repeatedly illustrated in the field of International Relations through the Prisoner's Dilemma. The game theory presents states as placing their own interests above those of others which leads to an outcome where everyone is overall worse off, whereas cooperation would have resulted in an overall better outcome for all<sup>5</sup>. An institutional arrangement would facilitate the means for states to reach a common beneficial outcome. Lastly, the case for institutions can also be made by illustrating how they can lower transaction costs. The cost of organizing a cooperation between states every time a comparable type of problem arises would be less if an institution would exist on a given policy area that could tackle the issue more efficiently. Institutions are thus important because they offer solutions to collaboration and coordination problems by involving the interests of states through complexes of prescriptive and normative tools that changes the behavior and expectations of its members.

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<sup>4</sup> Such an institutional arrangement has not been formally set down in, for example, an international constitutional law, but the international legal field has been discussing the concept since the 90's (Diggelmann & Altwicker, 2008).

<sup>5</sup> The Tragedy of the Commons is a classic example of the dilemma of self-interest by William Forster Lloyd. The common lands in a rural area would soon die out if all herders selfishly allowed their sheep unlimited grazing. An agreement between herders would prevent this and allow each the continued enjoyment of the commons.

### 3 Network Governance

Problems arising from the interconnectedness of people, organizations, ideas, norms and structures have spawned a host of literature within the public policy analysis theory about governance in networks that is able to address the complexity (Sørensen & Torfing, 2007). International cooperation is subject to the same complexities that plague governments in creating and exacting policies in complicated matters within political, economic and environmental topics. No single entity is equipped to provide a solution and the different ideas and norms of relevant stakeholders makes cooperation that much harder. The theory of network governance reason like liberalism that states are not the unitary actors and share the stage with international institutions, non-governmental agencies and businesses. The importance of the theory for this research is reflected in its approach to complexity that necessitates the involvement of state and non-state actor alike. The emphasis hereby made is on the private sector and its increasing importance in the next chapter of the space era. Public-private partnerships are already an important determinant for the success of space missions and contribute to economic growth and can be developed further as businesses can enter the market fields of, among others, satellite servicing, robotic mining, space communications and microgravity research (NASA, 2014). Network governance provides an insight into the complexities of public-private partnerships as part of the larger network of interconnectedness and interdependencies.

#### **Complexity**

Complexity has two causes; a lack of information and knowledge and the differing views on what the problem exactly is and what solutions are available to combat this. Setting the two causes out against each other in a matrix produces four kinds of problem typologies which are presented in the following table:

Table 1 Typologies of problems

Consensus on problem perception	Consensus on required knowledge	
	Large	Little
Large	Technical problems	Untamed technical problems
Little	Political problems	Wicked problems

Source: Hoppe (2010: 16)

Technical problems can be compared to complicated problems where a strategy can be developed that everyone agrees on. Untamed technical problems require actors to first increase their technical understanding of the problem. Certain diseases are an example where everyone agrees a solution has to be provided for, yet the only thing missing is a cure. Political problems are caused by differing normative standards. The medical field is littered with cases where knowledge is sufficient to pursue a certain cure or new form of surgery but ethical codes of conduct and even values underpinning a society makes it a subject of intense debate. The fourth problem typology, wicked problems, are the most challenging and interesting cases where network governance can make a significant impact. A complex situation arises when actors do not possess enough knowledge on the topic and cannot reach an agreement over what the problem is and what more knowledge is required in order to move forward.

The process of interaction within a network can be analyzed through the core concepts of actors, resources and dependencies (Hughes, 2012). Actors are the individuals, groups or organizations that represent one autonomous entity within a network. They possess the capacity to affect and at the same time be affected by other actors. Resources are an encompassing conception of all the tools, tangible, intangible, formal and informal, an actor possesses to affect another or the process of decision-making. Dependencies arise from the distribution of these resources among actors within a given network.

### **Models of network governance**

Network governance is more or less the natural response for actors to seek cooperation with others in order to solve problems that transcends the actors' individual capacity to provide for a solution. It is an extension of the principal-agent theory where government agencies fund and oversee private



actors that have been hired to provide public services (Hughes, 2012). Governance in networks does not necessarily involve contractual-based relations but does emphasize the goal-oriented organization between state and non-state actors that is needed to reach a collective action. As Provan and Kenis (2007: p. 231) define, “...a focus on governance involves the use of institutions and structures of authority and collaboration to allocate resources and to coordinate and control joint action across the network as a whole.”. The authors continue in describing networks as consisting of at least three legally distinguishable organizations with a common goal and compare them through two dimensions. The first dimension is concerned with how the governance within a network happens. A shared and decentralized type of governance occurs when all actors take on a governing role where all network-members interact with each other. A centralized type of governance occurs when the opposite happens; a single actor or small group of actors assume the governing activity which will act as mediator between all other members. The second dimension builds upon the notion of a centralized governance and distinguishes between internally or externally governed networks. Three types of networks can then be distinguished; participant-governed networks, lead-organization governed networks and networks governed by an administrative organization (NAO).

The most common type of network consists of actors actively governing themselves. Participant-governed networks depend on the contribution of all its members in order to deliver its activities. An important latent effect of this shared governance is the establishment of a sense of community, by creating shared goal-directed behavior between all network-members that contribute in an equal fashion. Power relations regarding collective choice are symmetrical even among asymmetrical members, differing in capacity, size and performance. The likelihood of this, and any other model being adopted depends on a set of four contingencies displayed in the following table.

Table 2 Contingencies for effectiveness of network forms

Governance Forms	Trust	Number of participants	Goal consensus	Need for network-level competencies
Shared Governance	High	Few	High	Low
Lead Organization	Low	Moderate	Low	Moderate
NAO	Moderate	Moderate - many	High	High

Source: Provan & Kenis (2007: 237)

There is need for a high level of trust in a shared governance form because members rely on each other for the advancement of the process. A few number of participants works well because trust is established more easily then and the network can work more effectively. The need for network-level competencies stems from what the nature of members' tasks are and what external pressures are working on the network. A high level of network-level competency is needed if there is a strong interdependence between members. Shared governance is less likely to be adopted then, if there is a need for interdependent tasks, like quality control, because the requirements might exceed individual members' capacities. The equal distribution of power within a shared governance-network necessitates a high goal-consensus between its members. A heightened risk of reaching stalemates could otherwise undermine the whole network.

Lead-organization-governed networks can be contrasted with shared governance networks in how power is distributed (Antivachis & Angelis, 2015). The lead organization will be one dominant organization or a small number of organizations within the network that control a majority of the resources necessary for making the network work. All major decisions and activities will involve the lead organization and it is mandated either by an emerging process between members, or an external entity. A high level of trust and goal-consensus are not necessary and often

not found within a network where a powerful member can carry the process, and it follows then that more members can effectively participate in the network than in comparison with a shared governance form. There is furthermore a relative moderate need for network-level competencies which are centered at the lead-organization that is capable at performing these tasks.

The final form includes a separate organization that fulfills a strict administrative function in order to govern the whole network. The network administrative organization frees members from most operational concerns and are able to interact with each other as in a shared governance form. The level of trust is moderate as members can monitor the separate organization which can facilitate the largest number of members of any form because it has been created with the required network-level competencies. The administrative organization is the focal point of the network and the proposition is that, given time, the other two forms of network governance will tend to evolve into a NAO-governance form (Antivachis & Angelis, 2015). That is because the changing of contingencies will move a lead-organization network more likely towards a NAO-governance form, rather than a shared governance network given the multitude of complex interdependencies. The same conclusion is reached with a shared governance network through a political rational where its members are less likely to accept one of them gaining considerable influence, opting instead for the creation of a separate administrative organization.

# Methodology

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The following chapter will build upon the theoretical foundation and explain the research design which details the strategy, operationalization, methods and limitations of this study. The research strategy presents an overview of the intended steps to be taken that aims to answer the central question. The operationalization will refine theoretical concepts into measurable units and show how concepts are connected through a conceptual model that helps explain international competition and cooperation. The research methods expand on the tools of this research and particular attention will be given to the process of scenario-planning. This chapter will finish with a discussion of the study's limitations and notes on the validity and reliability.

## 1 Strategy

The process of answering the central question involves a scientific methodology that can be divided in a number of steps. The theoretical framework is the first step to be taken which provides a review of the relevant literature. Emphasis has been laid on the two main schools of International Relations theory, realism and liberalism, and their respective views on institutionalism, regime-theory and global governance theory. Both schools provide competing explanations that capture the main essence of relations between nation-states. Network governance theory supplements International Relations theory in approaching cooperation as a network of actors, its organization depending on four contingencies. The cumulative explanation of these theories offer a framework that encompasses both international cooperation and competition as the full spectrum of relations between actors. Elaborating on the liberalist understanding of cooperation through network governance allows for a comprehensive inclusion of non-state actors and a more detailed explanation of the cooperative agreement. Two conceptual models will be formulated, build upon the theoretical framework and will respectively explain cooperation and competition through the interconnectedness of the theoretical concepts. The operationalization of the conceptual models will follow wherein indicators and their respective units of measurement will be developed. The formulation of scenarios can then begin with a theoretical basis that has been fitted as a tool of analysis. Envisioning what probable futures exist in regards to international cooperation and competition in space requires a process of scenario-planning that emphasizes scenarios set at least

multiple decades ahead. The TAIDA method of scenario-planning fulfills this requirement and provides the methodological architecture of this study. Literature review will lay the groundwork for scenario-planning by discovering what trends and (un)certainties exist. Interviews with different experts will help recognize what the most important elements are in considering the future of space exploitation. Four different scenarios will then be constructed that encapsulate current developments and represent contrasting futures. An analysis of the scenarios follows wherein the risks and opportunities are disseminated. The study will conclude with remarks and recommendations and, hopefully, help anticipate for a new space era.

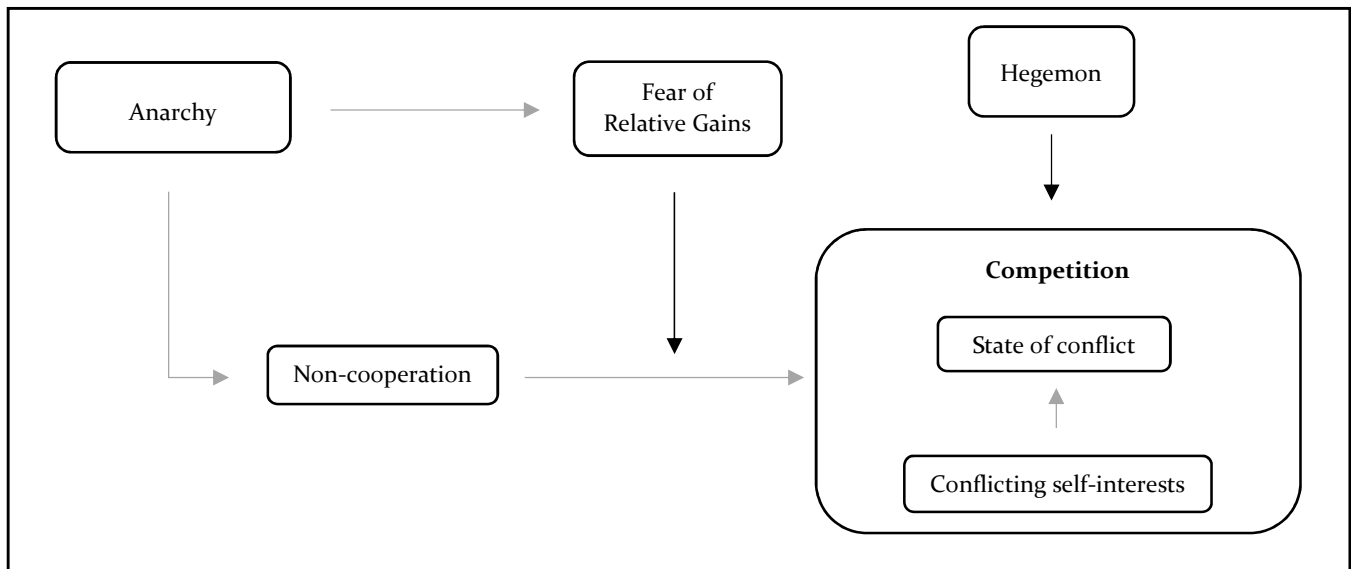
## 2 Synthesis, the Conceptual Models

Starting from Keohane's definition of (international) cooperation and the additional elements from Keller (1992), actors are understood as cooperating when they align their policy in order to adjust their behavior in anticipation for the overall improvement of everyone's situation. International relations theory of realism and liberalism explore actors' motivation for cooperating by respectively highlighting the coordination or collaboration problem. Institutional arrangements are important in this regard, providing the solution through collective action and explains current international cooperation structures. Yet a study of the future of international cooperation in space must take the private sector into consideration as is exemplified in the numerous public-private partnerships and the emphasis that is laid on the future role of the private sector in the exploitation of Low Earth Orbit (NASA, 2014). Network governance theory complements the static understanding of international cooperation as understood in International Relations' theory by focusing on the interdependencies between state and non-state actor alike. Complexity is herein the implicit force in governance theory driving actors to seek cooperative agreements. Combining the two modes of thinking provides a comprehensive understanding as to why, or why not, international cooperation in space will happen. Two conceptual models will be developed that flow from the realist and liberalist tradition. Complemented by network governance theory, both models will highlight different sides of international cooperation. The partition additionally lays the groundwork for the process of scenario-planning as both conceptions will be used to demonstrate the two extremities of international cooperation.

## 2.1 The Realist Model of International Cooperation

The first model will view the international arena as a place of conflict where anarchy drives states to be the sole guardian of their own continued existence. Cooperation (merely) happens out of coordination problems, with each state carefully evaluating the relative gains of each member within the cooperative agreement. The main characteristic of this view, in regards to this study, is the sole prominence of nation-states wherein all non-state actors are reduced and disregarded as participants with no real influence. The theory shows additionally why nation-states would be hesitant to cooperate and incentivized to compete as the rules of a zero-sum game force the players to consider relative power.

Model 1 Realist Conceptual Model of International Competition



The first independent variable *Anarchy* reflects the lack of a central authority and is the central premise that forces nation-states to consider their own interests. *Non-cooperation* is the first dependent variable that illustrates states pursuing their own strategy which do not necessarily have to compete with each other; it simply reflects states pursuing their own strategy without taking other states' interests into consideration. The variable *Fear of Relative Gains*<sup>6</sup> is the catalyst for enacting states to compete what leads to the dependent variable *Competition*, where states have

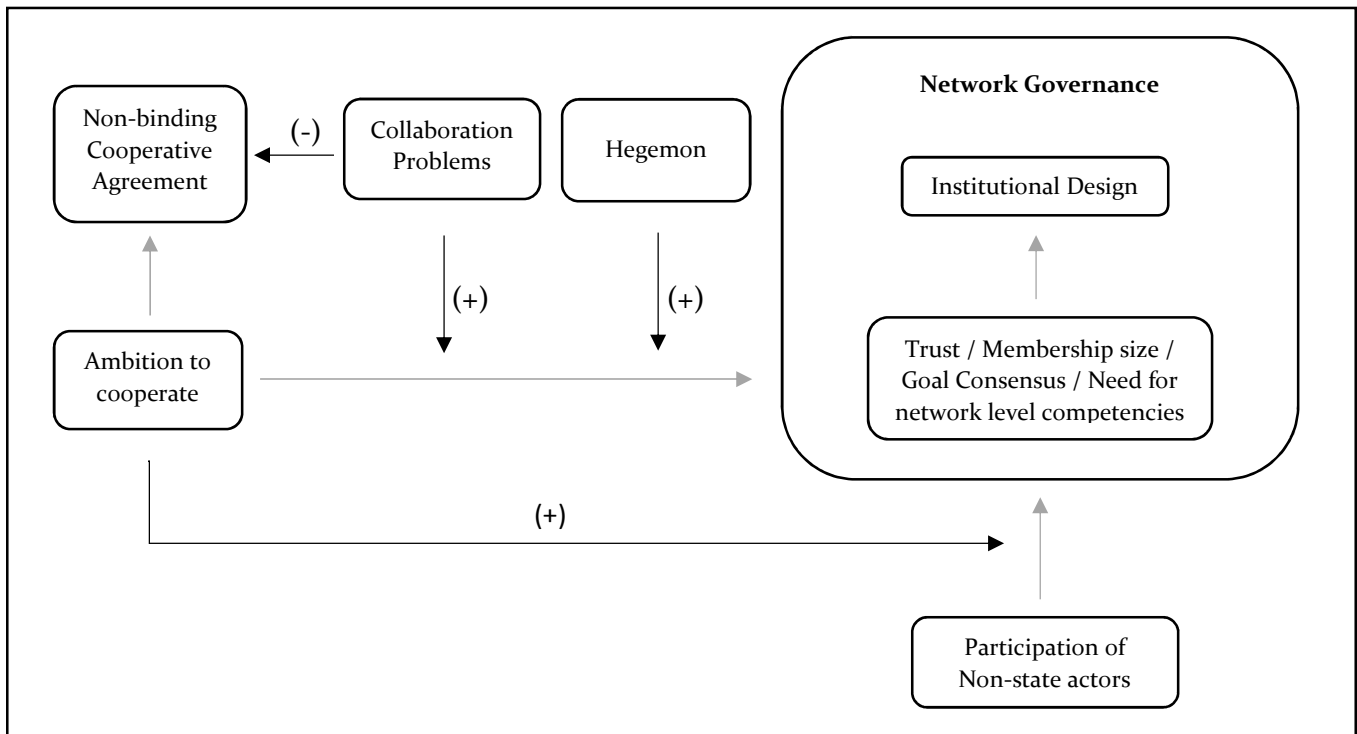
<sup>6</sup> The independent variable *Fear of Relative Gains* is to be understood as the fear of one nation-state for the (relative) gains of another nation-state.

*Conflicting self-interests* which can result in a *State of conflict*. In the realist perspective, states are constantly aware of the distribution of power and any increase of another states' power would mean a decrease of their own relative power (Lamy, 2013). Each state will act if it perceives their own security to be compromised and therefor compete to regain power. The independent variable *Hegemon* will stabilize world order through sheer power and minimize competition among states as explained through the hegemonic stability theory (Little, 2013). The realist hegemon is characterized by its excision of dominance through military, political and economic strength. In summary, a realist conception of international cooperation underlines the notions of power and relative gains and they are the implicit force that moves nation-states to consider competition over cooperation. Non-state actors have been purposefully left out because realism views the state as the sole actor within the international arena. The idea of statism explains that states are representative of the will of their people and that, in the end, the state alone is responsible for their own survival and interests. International organizations like the UN or NGO's are reduced to arena's where states interact with each other or as a vessel that is motivated by a state or a specific group of states.

## 2.2 The Liberalist Model of International Cooperation

The second model will lay the emphasis on cooperation as understood from liberalist notions of absolute gains and comparative advantage (Little, 2013). Network governance theory will be integrated to show the interdependence between state and non-state actors which provides a more fluid model of international cooperation.

Model 2 Liberalist Conceptual Model of International Cooperation



The model starts with the independent variable *Ambition to cooperate*, which entails the ambition of nation-states to cooperate. The main difference with the realist model is that states consider absolute gains, rather than relative gains. The potential of international cooperation can yield an enlargement of wealth for every state as comparative advantage allows states to specialize in their own products or services. States can then complement each other on the world stage through international trade or cooperation. The ambition to cooperate also stems out of complexity; states seek solutions for complex problems that transcend their own capacity and can result in two types of cooperative agreements. The first type is a *Non-binding Cooperative Agreement*, that is to say, an agreement that is a minimum conception of cooperation where states agree over a very specific



issue, detailing only the necessary conditions so states do not infringe upon each other. Such agreements are susceptible to collaboration problems as new developments can result in stalemates due to conflicting views. The moderating variable *Collaboration Problems* consequently motivates states to enter an institutional agreement which is conceived as the variable *Network Governance*. The *Institutional Design* will act as dependent variable of the four contingency factors mentioned by Provan and Kenis (2008) and shape the network structure into one of three different archetypes. The creation of such an arrangement is strengthened by the variable *Hegemon* which seeks to produce global goods or combat public failings in a classis liberal understanding, or wishes to reduce enforcements costs and creates an international institution that favors his interests in a liberal understanding. Network governance also takes non-state actors into consideration and stems partly from the complexity of problems that states cannot solve alone. The variable *Participation of Non-state actors* is therefore dependent on nation-states as they set the legal framework under which non-state actors must operate.

### 3 Operationalization

Operationalization of theoretical variables enables the measurement of the empirical world with conceptual models. Specifically, a set of indicators and accompanying items have to be defined in order to do so. The variables from the realist and liberalist conceptual models will be refined with indicators that signify how a theoretical variable can be measured and its items detail what the exact elements of measurement are.

Table 3 Operationalization of the Conceptual Model of International Competition

Variable	Dimensions	Indicators	Items
Anarchy		<ul style="list-style-type: none"> <li>Absence of a central authority</li> </ul>	<ul style="list-style-type: none"> <li>No state is recognized as a central authority by the international community</li> <li>Absence of shared belief between states in a singular set of universal informal rules</li> </ul>
Non-cooperation	Refusal to cooperate		<ul style="list-style-type: none"> <li>(Informal) offers to join in a cooperative agreement are refused</li> </ul>
	Failure to cooperate	<ul style="list-style-type: none"> <li>Coordination problems</li> </ul>	<ul style="list-style-type: none"> <li>Problem perceptions are in conflict</li> <li>Suggested solutions are in conflict</li> <li>Perception that cooperation fails</li> </ul>
Fear of relative gains	Awareness of distribution of power		<ul style="list-style-type: none"> <li>Proliferation of national intelligence agencies and communities</li> <li>Relative funding in national intelligence agencies, offset to total national budget</li> </ul>
	Power enlargement when threatened	<ul style="list-style-type: none"> <li>Development of own power</li> <li>States seeking alliances as to counter a more powerful state</li> </ul>	<ul style="list-style-type: none"> <li>Development of economic/political/military strength</li> <li>Economic, political or military cooperative agreements between states</li> </ul>
Hegemon			<ul style="list-style-type: none"> <li>State perceived as most powerful on the international economic/political/military stage</li> </ul>
Conflicting self-interests	Disagreement		<ul style="list-style-type: none"> <li>Perception of conflicting views</li> </ul>
	Interference	<ul style="list-style-type: none"> <li>Diplomacy</li> <li>Sanctions</li> <li>Espionage</li> </ul>	<ul style="list-style-type: none"> <li>Diplomatic visits/letters/emails/encrypted messages</li> <li>Reduction of diplomatic ties and limiting or tariffing trade</li> <li>Obtaining information without permission</li> </ul>
State of conflict	War		<ul style="list-style-type: none"> <li>Formal declaration of war</li> </ul>
	Acts of aggression	<ul style="list-style-type: none"> <li>Arm's race (technologies)</li> <li>(Digital) sabotage</li> <li>Proxy warfare</li> </ul>	<ul style="list-style-type: none"> <li>Investing direct or indirectly in military technologies/amassing physical weapons</li> <li>Deliberate weakening of an actor through disruption of processes/destruction of materials</li> <li>Supplying factions that fight the opposing actor directly or indirectly</li> </ul>

### 3.1 Variables of conceptual model of international competition

*Anarchy* is the systemic characteristic of the international arena that forces states to consider their own interests first (Harding, 2012). In the realist perspective, there is no single state powerful enough to claim the position of international central authority, leaving the international arena open for a competition between (powerful) states. The absence of a central authority on the international stage is explained through two items. First, the international community simply does not recognize a particular state as a central authority. The second item posits a set of rules as a proxy for a central authority, and the lack of a shared belief or enforcement thereof.

*Non-cooperation* is a state of affairs between states that lacks policy coordination and is the result of either refusing to cooperate, or failing to cooperate. Refusal to cooperate occurs when a party makes their intention to cooperate known, yet is rejected by the other party. The most notable example is how China's offers to cooperate in the International Space Station project were rejected by the United States (Stuart, 2009). Failure to cooperate is indicated by coordination problems that arise when interests and views vary too greatly between states that try to cooperate (Stein, 2008). This problem is constituted by differing views in problem definition and proposed solutions, contributing to a general sense that cooperation is failing.

*Fear of relative gains* is a consequence of the anarchic international system where each states enters into competition, making states wary of how powerful other states become in relation to their own power status. States are concerned with relative power as they collect information on other states and act upon this information when they deem another too powerful. The awareness of relative power is a necessary condition for fear of relative gains and can be itemized by the number of (national) intelligence agencies and communities or percentage of national funding that is directed towards these organizations. States act upon their fear when they perceive another state endangering their self-interests and react in two general ways. The first way sees states developing their own power through either economic, military or political strength. The second way shows how states can combine their power through an alliance in order to confront a larger threat, demonstrating how the enemy of my enemy is my friend.

The *Hegemon* is a nation-state that is able to influence the international system through its capacity to dominate the military, economic or political stage (Little, 2013). A hegemon is able to coerce or force other states into the alignment of their interests and provides a relative sense of order in the

international domain. It is not a central authority, however, as its authority is restricted and will always be challenged up until a new hegemon arises. The power of a hegemon is derived from the belief of other states in the hegemon's superiority. In other words, the relative power of a hegemon is derived from the perceptions of other states and these form the items of the variable.

*Conflicting self-interests* arise when the individual strategies of states come into conflict. The type of conflict can manifest itself on an abstract level where no action is undertaken by either side. There is simply an understanding between conflicting parties that their visions are opposed. Conflict can also manifest itself through interference with a clear action being undertaken by one or both sides and are itemized by diplomacy, sanctions or espionage. The general definition of diplomacy is described as management of international relations (Dunne, 2013). The narrow understanding of diplomacy will be upheld for the purpose of categorizing self-interest where direct communication between representatives of states is understood as attempts to influence and resolve the conflict of interests. This happens through all forms of oral and written communication. Sanctions are essentially punishments that include a broad spectrum of impositions on another state that primarily function as retribution for any offence that another state has committed (Little, 2013). Several types of sanctions can be distinguished with the most common types being diplomatic and economic sanctions. Diplomatic sanctions can exclude the entry of government officials into a country, reduce the number of embassy staff or cancel any official visit. Economic sanctions target a state's international trade through tariffs and embargo's or freeze the assets of certain high-ranking individuals or even the assets of the targeted government itself. Finally, espionage aims to gather secret information without any permission from the victim. An act that is usually directed towards (potential) enemies, yet the modern age has transformed the intelligence world where enemy and ally alike are increasingly subjugated to espionage. This is to say, espionage is almost ubiquitous and since the revelations of Snowden, a new status quo.

A *State of conflict* between two or more states takes place when the conflict of interests is irreconcilable without a forceful intervention. A declaration of war is the formal materialization of a state of conflict where one country enters into a state of war with another country. Formal declarations of war have been marginal in number, however, due to the United Nations Charter prohibiting states from using force except under specific conditions (Dunne & Schmidt, 2013). Acts

of aggression are the second dimension that captures the broader spectrum of informal acts of aggression. The main difference between the dimensions 'acts of aggression' and 'interference' is that acts of aggression are characteristically more aggressive and can more easily trigger an escalation of the situation, aggravating the relationship. The first indicator is an arm's race where physical weapons are stockpiled and military technologies are developed. The second indicator is sabotage and often a clandestine operation where another state is weakened through destruction and disruption. As modern countries are increasingly reliant on their digital infrastructure, (digital) sabotage becomes more dangerous which can potentially eliminate<sup>7</sup> an enemy state's entire capacity to retaliate or even function. The third indicator is proxy warfare where a third party is supported by a state to harm the enemy state. The damage can be targeted directly to the enemy state in which the third party is involved in a state of war. Damage can also be inflicted indirectly where the third party is in a state of war with another third party that is supported by the enemy state.

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<sup>7</sup> Stuxnet is a computer worm that has caused considerable damage to the nuclear program of Iran, delaying its nuclear development with several months. The controls for the centrifuges were overridden causing them to spin beyond their physical capacity, eventually damaging the installation. Many believe Stuxnet was the product of a joint operation between the United States and Israel although both have denied any involvement (Nakashima & Warrick, 2012). The worm targeted 'programmable logic controllers' and indicate that the agency responsible had access to considerable resources in order to produce such a specific damaging type of program. Digital warfare is a malicious new form of aggression where codes can infiltrate and affect physical objects, causing real-world harm.

Table 4 Operationalization of the Conceptual Model of International Cooperation

Variable	Dimensions	Indicators	Items
Ambition to cooperate		<ul style="list-style-type: none"> <li>• Belief in relative advantage through cooperation</li> </ul>	<ul style="list-style-type: none"> <li>• Specialization of states</li> </ul>
		<ul style="list-style-type: none"> <li>• Positive estimation of successful cooperation</li> </ul>	<ul style="list-style-type: none"> <li>• Analysis of risks/contingency plans/factors of success</li> </ul>
Non-binding cooperative agreement		<ul style="list-style-type: none"> <li>• Specific issue-related</li> </ul>	<ul style="list-style-type: none"> <li>• Well-defined issues</li> </ul>
		<ul style="list-style-type: none"> <li>• Minimum number of actors involved</li> </ul>	<ul style="list-style-type: none"> <li>• Only directly impacted states are involved</li> </ul>
Collaboration problems		<ul style="list-style-type: none"> <li>• Individual rationality</li> </ul>	<ul style="list-style-type: none"> <li>• Perception that each state will choose what is most beneficial to his own needs</li> </ul>
		<ul style="list-style-type: none"> <li>• Undesirability of individual choice outcome</li> </ul>	<ul style="list-style-type: none"> <li>• The outcome of individual choice is less beneficial than collective choice</li> </ul>
Hegemon			<ul style="list-style-type: none"> <li>• State perceived as most powerful on the international economic/political/military stage</li> </ul>
Participation of non-state actors		<ul style="list-style-type: none"> <li>• Inclusion of non-state actors on policy-level</li> </ul>	<ul style="list-style-type: none"> <li>• Voting rights for non-state actors</li> <li>• Non-state actors granted observer status</li> </ul>
		<ul style="list-style-type: none"> <li>• Non-state actors granted 'executive' status</li> </ul>	<ul style="list-style-type: none"> <li>• Legal framework for non-state actors to exploit activities in outer space</li> </ul>

Trust	Distribution of trust	<ul style="list-style-type: none"> <li>Degree of (mutual) dependency between actors</li> </ul>	<ul style="list-style-type: none"> <li>Resource allocation</li> <li>Decision-making structure</li> </ul>
	Need for centralization of trust		<ul style="list-style-type: none"> <li>Does everyone need to trust one another for the network to work?</li> <li>Is it sufficient to have one or a small set of actors to be trusted?</li> </ul>
Membership size			<ul style="list-style-type: none"> <li>Number of network participants</li> </ul>
Goal consensus	Goal similarity	<ul style="list-style-type: none"> <li>Compatibility of goals</li> </ul>	<ul style="list-style-type: none"> <li>Alignment of vision manifesto's</li> <li>Alignment of strategies</li> </ul>
	Actor similarity	<ul style="list-style-type: none"> <li>Organizational fit between actors</li> </ul>	<ul style="list-style-type: none"> <li>Work culture</li> <li>Employee base characteristics</li> </ul>
Need for network level competencies	Nature of task	<ul style="list-style-type: none"> <li>Need for specialized task-specific competencies</li> <li>Need for coordination on network-level</li> </ul>	<ul style="list-style-type: none"> <li>Implementation of highly specialized tasks as quality monitoring/grant writing/conflict resolution</li> <li>Decentralization of resources/high interdependency</li> </ul>
	External demands		<ul style="list-style-type: none"> <li>Fixed deadlines</li> <li>Budgetary constraints</li> <li>Changing regulations</li> </ul>
Institutional design	Membership rules	<ul style="list-style-type: none"> <li>Membership qualifications</li> <li>Universal</li> </ul>	<ul style="list-style-type: none"> <li>National income/political position/geographical position</li> <li>Every nation-state is able to join regardless of any requirements</li> </ul>
	Scope of issues covered		<ul style="list-style-type: none"> <li>Number of policy area's covered</li> <li>Depth and detail of issues covered</li> </ul>
	Centralization of tasks		<ul style="list-style-type: none"> <li>Who disseminates information?</li> <li>Who reduces bargaining and transaction costs?</li> <li>Who enhances enforcement?</li> </ul>
	Rules for controlling	<ul style="list-style-type: none"> <li>Voting arrangements</li> </ul>	<ul style="list-style-type: none"> <li>Voting weight of members</li> <li>Members having veto power</li> </ul>
	Flexibility of arrangements	<ul style="list-style-type: none"> <li>Adaptive flexibility</li> <li>Transformative flexibility</li> </ul>	<ul style="list-style-type: none"> <li>Escape clauses</li> <li>Possibility of renegotiation/sunset provisions</li> </ul>

## 3.2 Variables of conceptual model of international cooperation

The *Ambition to cooperate* originates from the liberalist understanding of absolute gains where cooperation leads to an overall improvement of those involved. The ambition is indicated by the belief of a state in the relative advantage of cooperation and the judgement that a cooperation will be successful (Dunne, 2013). Belief in the relative advantage of cooperation assumes that states consider the international community to complement one another in a form of mutual dependency where one country will specialize in one area in order to make up for its deficit in another area through international trade or agreements. The specialization of states in certain industries is an item of this indicator and the foremost example is the space industry. National space agencies are often reliant on other agencies for specific parts or technologies for a successful mission launch and this shows the comparative advantage of cooperating in a highly technical endeavor. The judgement that a cooperation will be successful is itemized by the research that states will conduct in order to conclude whether the benefits of cooperation outweigh the costs. Examples include feasibility studies, think-tank consultations and international deliberations assessing the potential cooperation.

A *Non-binding cooperative agreement* is an agreement between two or more states with a narrow focus in two dimensions, the scope of the issue and the number of actors involved. The agreement will concern itself with a specific topic that requires international cooperation between states that are affected by a certain situation and are therefore well-defined topics. Examples include specific natural or humanitarian disasters that attract bilateral assistance from other states, as well as developmental aid aimed to contribute to stability and security in a certain region. The number of states involved is also kept at a minimum in this way in order to facilitate a form of cooperation that can enact and follow through without the hurdles of a more lengthy decision making process caused by a larger congregation (Provan & Kenis, 2007).

*Collaboration problems* are exemplified by the Prisoner Dilemma which shows how cooperation can overcome the rational individual strategies actors pursue in favor for an overall preferable outcome (Dunne, 2013). The individual rationality is itemized by the belief of one state that other states will choose what is most befitting of their own interests. The realist conception of self-interest comes to mind when states will place their own interests above others. This individual choice strategy tends to lead to an overall less desirable outcome. Pollution, for example, is a collective problem that is caused by the individual interests of states. It would require collective coordination in order to address this problem which would benefit all in the long run.



The *Participation of non-state actors* is an important departure from the realist conception of the international arena where such actors are deemed insignificant. Non-state actors can be included on the policy level and executive level. Inclusion on policy level would grant actors the ability to participate in or observe decision-making procedures whilst a purely executive status would only enable them to carry out certain activities deemed legal or open by the framework set by the international cooperative agreement.

*Trust* is explained as making oneself vulnerable on the positive anticipation of another's intentions (Provan & Kenis, 2007). The network governance theory is concerned with the distribution of trust and the need for the centralization of trust. The distribution of trust is indicated by the degree of mutual dependency between the members of a network, which is measured by the distribution of resources between members and the decision-making structure of the network. The need for the centralization of trust is related to how the network functions through its members. If a network is dependent on a single or small group of members than a need for centralized trust is warranted as these members need the trust, and contribution, of the other members. Yet if the network is superficial, or every member needs to trust the other, then there is less need for centralized trust.

The *Membership size* is the number of members of a given network. A larger membership size leads to more complexity in the network, necessitating more coordination or a centralized command.

The *Goal consensus* of a network relates to the argument that a similarity in goals and domain facilitates a better performance of the organization (Provan & Kenis, 2007). Two dimensions are distinguished herein that pertain to the similarity of goals and similarity of actors. Goal similarity concerns itself with the alignment of the goals individual members have and is itemized by their visions and strategies. Actor similarity is concerned with the types of organizations involved and questions whether there is a fit. The organizational fit is itemized by the work culture of the organizations involved and the characteristics of their employee base. An important notion is that only the employees that have to interact with each other within the network should be considered in this assessment.

The *Need for network level competencies* depends on the nature of the task and the external demands on the network as a whole (Provan & Kenis, 2008). The nature of tasks that a network has to carry out specifies the need for specialized competencies, like quality control or conflict resolution, and the need for coordination on a network-level which is often the case when resources are decentralized and a high interdependency between members exists. The external demands are

the forces that influence the network from outside and are itemized by imposed deadlines, budget limitations and changing regulations.

The *Institutional design* determines how the voices of its individual members is aggregated into one collective choice (Provan & Kenis, 2007). The theory of Koremenos, Lipson and Snidal (2001) on the rational design of institutions forms the basis for operationalizing the concept of institutional design. The authors presume that international institutions are used to further the goals of states and their design is a sign of this exercise of power. The institutionalist position posits international institutions as the rational solution for problems that actors negotiate on. Five dimensions are discerned that explain the varying forms of international institutions. Membership rules form the first dimension and prescribe who is eligible to become a member. The institution can opt for certain qualifications, restricting states membership unless they meet a certain national income, political criteria or are located within a specific geographical location. The institution could also choose to allow all states to be members in a universal fashion. The only condition is that a prospective member has to be recognized as a state by the international community. The second dimension concerns itself with the scope of covered issues and is itemized by the number of policy areas covered. An institution can cover economic, environmental, political, scientific or militaristic topics or focus on a specific issue. The issues covered are often not by choice, yet it determines a large part of the institutional design. The third dimension is the centralization of tasks. This can be itemized by asking who is responsible for the dissemination of information, the reduction of bargaining and transaction costs and the enhancement of enforcement of rules and collective decisions. The fewer members involved, the more centralized the institution is in its design. The fourth dimension covers the rules for controlling and is indicated by the voting arrangements of an institution. The voting weight of members and the ability for members to veto are the corresponding items which determine how the decision-making procedure within an institution occurs. It also signifies the power structure within an institution where the powerful members carry a greater voting weight or possess veto power. The final dimension concerns itself with the flexibility of the arrangements. Institutional arrangements prescribe the behavior of its members and a flexibility of arrangements would allow members more freedom within this context. The flexibility is indicated by either an adaptive or transformative nature. Adaptive flexibility is found within the presence of escape clauses which enables members to not adhere to an arrangement if a certain condition is met. Transformative flexibility allows members to renegotiate arrangements in their entirety or when arrangements have to be determined again if sunset provisions are included.

## 4 Methods and scenario-planning

The last part of this chapter will expand on the methods of this study and, in particular, clarify the scenario-planning method TAIDA. A reflection on the validity and reliability on the methods and the study in general will conclude the methodology chapter. TAIDA has been selected because this study will envision the future which leads to a method based on scenario-planning. Of the differing methods of scenario-planning, TAIDA is the method that has been tried and tested the most. Developed in the 1950's and has been used for decades by some of the biggest businesses. Furthermore, different studies have been done which have envisioned the future of the space sector. Yet TAIDA has never been applied in this specific case.

### 4.1 The TAIDA-method

The essence of the TAIDA-method of scenario-planning, is to anticipate the future, multiple decennia's ahead. Scenario-planning in general envisions multiple scenarios, or alternative futures, and has been proposed to complement Mintzberg's (2000) notion of strategic planning. The planning of implementing strategy involves organizations assessing their own capacity and their environment, in order to organize their own resources and efforts that will enable their continued growth and survival in the future. The faults of classic strategic planning derive from the experience that no strategy can be produced that successfully deals with the complexity and uncertainties that originate from a dynamic environment (Conway, 2004). Scenario-planning addresses these issues and offers a distinct way of thinking as it differs from forecasts in the sense that all possible uncertainties will be accounted for, leaving little room for any certainties or 'givens' on which calculated prognoses can be made. It also differs from visions as it does not seek to formulate a desired outcome. Lindgren and Bandhold (2009) present a specific iteration of scenario-planning called TAIDA; which stands for Tracking, Analyzing, Imaging, Deciding and Acting. The first two stages of the scenario-planning process are particularly relevant for this study as the purpose is to explore and analyze, rather than act on any future scenarios. The method sets itself furthermore apart by focusing on scenarios set at least twenty years into the future. The case of international cooperation in space therefore lends itself to the TAIDA-method of scenario-planning as the transformative changes brought by current developments will not manifest itself in the coming years, but in the coming decades.

The

mental exercise of developing future scenarios can be guided by a set of principles, aimed to break from the more traditional modes of thinking (Lindgren & Bandhold, 2009). Seven principles are presented, and of these, three underscore a new mode of thinking that structure the process of identifying trends, un(certainties) and scenarios. The first direction is to think in futures and can be done in two ways; start from the present and work towards a hypothetical future based on causal relations between trends and events, or start by formulating a hypothetical future and reason what possible developments have made it happen. The second direction is to think in uncertainties. Very few certainties can be identified when formulating a scenario twenty years ahead and uncertainty must then be managed into a controlled state. The result is reducing uncertainty by identifying dichotomous uncertainties (either-or) and the relevant scenarios that have to be addressed. The final direction is to think in systems that emphasize the double loop learning, which entails that solving current problems requires stepping outside, or up, to view the situation from outwards in and generate lessons from this. The scenario-planning process can then be followed with a new sense of direction through the following steps (Lindgren & Bandhold, 2009).

### **I. Preliminary stage.**

Preparations have to be met before the actual process of scenario-planning can happen. The first step is to identify the system that will form the object of analysis by setting boundaries. The following step is to create guiding questions of the scenario-planning exercise which helps bring focus to the study. Setting the time horizon follows and is a critical factor as twenty or fifty years can make a large difference in the type of scenarios construed. The next step is to reconstruct the past and define the present situation and its relation is significant because the future is dependent on how the present has developed from the past. The final step builds upon the reconstruction of the past and present and requires the identification of a historic narrative where the underlying drivers show why certain developments have happened and can cause similar developments in the future.

### **II. Tracking**

Starting with an outward-in look the goal of tracking is to identify uncertainties, drivers and trends in the environment that are relevant to the focal question of a study. Trends are understood as a deep change that has already been happening for some time and is following a certain course.

Drivers are the underlying forces that move a trend. The global increase of CO<sub>2</sub> emission is for example a driver of global warming. Uncertainties can empirically be understood as descriptive statements over the future of which their true/untrue conditional cannot be confirmed in the present time. For example, the statement ‘the sea-level will have risen in twenty years’ is for most a given as global warming is expected to continue. Yet in scenario-planning, anything is possible and the statement might prove false if a radical new solution is found that can create icebergs and glaciers on continental levels that stem the rising tides.

### **III. Analyzing**

Identifying underlying interconnections and exposing casual relations between the trends is the preparation for formulating scenarios. Understanding how trends can causally be explained to each other gives a certain direction in which the future can move. Scenarios can then be created that are partly grounded by the conception of the future, and are based around two driving uncertainties<sup>8</sup> that cannot be causally linked. Setting the two uncertainties against each other on an x and y-axis produces a four-by-four matrix with four scenarios. The probable future is then represented by four extremities based around the two driving uncertainties.

### **IV. Imaging**

The final step in envisioning the future is to make scenarios feel vivid through storytelling. Video’s and narrations are helpful tools in producing evocative images that can distill a clear image of a particular scenario. The purpose is to layer the story that incorporates the remaining uncertainties to account for a more comprehensive probable future.

### **V. Deciding**

The stage of deciding involves identifying the threats and opportunities within a given framework of reference. Strategies and areas of development are created based on the vision and goals of a particular faction

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<sup>8</sup> The selection of uncertainties must provide four very different scenarios that can capture the uncertainty of the future (Lindgren & Bandhold, 2009). It is a deeply qualitative endeavor and the arguments that are provided have to make the case why these uncertainties deserve priority.

## VI. Acting

Acting has a two-fold meaning within scenario-planning; one is implementing formulated strategies and the other is following up on the scenario-planning phase which is then a continuous effort integrating scenario-planning in the organizational routine.

Scenario-planning enables researchers to conduct inquiries into the future through a systemic process that otherwise would not have been possible through inductive or deductive research methods. International cooperation in space can then be regarded as an object of study as the purpose is to explore how cooperation or competition in the future might manifest itself given the developments and trends of today.

### 4.2 Interviews and document-analysis

The method of scenario-planning prescribes an unorthodox way of thinking – thinking from uncertainties – and will be aided by interviews and document-analysis. Document-analysis will help in the Tracking phase – identifying trends, drivers and uncertainties – and forms the main method in the preliminary phase of the TAIDA-process. The specific form of document-analysis to be used is content analysis and will be qualitative in nature (Van Thiel, 2007). Reports, (scientific) articles and public databases will be the main sources of data. The interviews will then help determine which uncertainties are the most important in constructing the differing scenario's, as well as give more information on the regulatory and political dimensions of outer space activities. The interview guide can be found in the appendix and will prescribe outlines of the topics as the interviews will be semi-structured (Van Thiel, 2007). A report of every interview will be included. The main objective is to garner information from experts in the field of outer space and to gain insight in how the field is evolving, and possibly in what direction. Following a brief descriptions of the methods, a rough sketch can be given of what research steps will be taken:

1. A document-analysis will be conducted in order to identify the boundaries and time-horizon that will precisely determine the object of study.
2. Following the same analysis, a historic narrative will be constructed in order to identify the drivers and trends that have shaped the present.
3. Interviews with experts supplemented with additional document-analysis will identify the (most important) uncertainties and give more information on the object of study.

4. Four scenario's will be construed through the two most important uncertainties and further expanded upon.

### 4.3 Reliability & Validity

The reliability of a study is based upon the accuracy in which variables are measured and if results are consistent when repeating a study following the same parameters (Van Thiel, 2007). A high reliability translates into a high quality of measurement and is important in determining the trustworthiness of the results. The validity of a study can be broken up in the internal and external validity (Van Thiel, 2007). The internal validity concerns itself with causality and if the reasoning within the study is sound. One important aspect of internal validity is whether the operationalization of theoretical concepts is correct, that they capture and measure what is meant to measure and not include anything else. The external validity asks the question whether the results of a study can be generalized (Van Thiel, 2007).

Triangulation is applied in order to strengthen the reliability and internal validity of this study. Utilizing several sources to cross-reference, examine and process information should minimize biases and overcome the limitations of using a single theory or method. Several experts will be involved from different fields in order to capture a broad spectrum of standpoints. The additional use of both International Relations' theories of competition and cooperation offer a dichotomous view on the exploitation of outer space which should provide a more comprehensive understanding. The nature of this study does prevent any conclusions pertaining to the external validity as this endeavor is highly subjective and therefore not a proper case to generalize. That being said, the importance of this topic makes this a valuable concern that deserves serious thought. To think about the future aids in the prevention of any hazardous paths to be taken and maybe even enjoy potential benefits that much better.

# Analysis

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The future of space is dependent on several (key) factors which entail how states and non-state actors will relate to one another, and in turn shape the next chapter of the space era. The aim of this study is to capture those factors, or uncertainties, through a scenario-planning method. What follows is a step by step process of identifying those uncertainties and build four scenarios that give a rough estimation of how the future of space can develop itself. The first step is to set the stage by determine the object of the study and reconstruct past developments that will highlight a historic narrative. The second step involves identifying the drivers, trends and uncertainties. Identifying the most important uncertainties lays the ground work for the last step in which the fours scenarios are explained and analyzed.



## Step I                      Setting the stage

The space age is a relatively new era in history<sup>9</sup>. In this regard, to study the future of space is to study the activities of humans in outer space. Yet what exactly constitutes human activity in outer space, and how far into the future can scenarios be build? The first step of the analysis will set the perimeters by determining the object of the study, setting the time horizon for scenario's, reconstruct the past and identify the trends and drivers though the conceptualization of a historic narrative.

### Object of the study

Outer space is identified as the space between celestial bodies and starts at 100 km of the sea-level of the earth, otherwise known as the Kármán line (O'Leary, 2009). To give a sense of what that means, planes usually fly at around 10 km altitude and the highest altitude a (special) balloon has reached was at around 56 km above sea-level (JAXA, 2003). Any human activity that is effectuated above the 100 km altitude barrier constitutes human activity in outer space. The Kármán line is a relevant barrier in regards to this study as the UN international treaties also adopt this point of demarcation.

The OECD perimeters (2016) are used in identifying human activity in outer space. In it, three spheres of human activity that involve outer space are typified. The first sphere is the *upstream space sector* and includes research and development and manufacturing and production for governmental, scientific and commercial endeavors. Tangible products like payloads and rocketry components fall within this category and are specific to the space sector. The second sphere comprises activity that is being enabled by the first sphere and is called the *downstream space sector*. Activities within the second sphere are mostly data services including television, communication and positioning systems. The last sphere comprises the *space-related or derived activities in other sectors* and are those services and products that are inspired by space technology. Examples include the technology inspired by the space sector in the medical, aviation or automotive industry. This study will mainly regard the first sphere. That is, any activity that has a physical effect

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<sup>9</sup> No definite border exists that separates outer space from the confines of earth. Treaties usually call upon the Kármán line to mark the start (O' Leary, 2009). This line is set at an altitude of 100 km above sea level.

in outer space and forms the primary object of study. Putting a man on the moon or placing a satellite in orbit are very clear examples, but launching an Intercontinental Ballistic Missile (ICBM) that (briefly) passes the altitude line of 100 km is also an example. The second sphere is broader and relates to human activity that is dependent on the physical exploitations of outer space. Satellites are the foremost example of this. Satellites enable long-distance communication, navigation and imaging which are absolutely crucial to the functioning of modern society. Yet it can also be argued that cyber warfare treads on the boundaries of space as satellites can be targets for cyber-attacks. The secondary sphere will not be weighed in the analysis but it is an important factor to consider when thinking about the scope of what activity in outer space actually means for everyday life. The third sphere is likewise not weighed but taken into consideration.

## Time horizon

Thinking about the future of space from a personal perspective has resulted in imaginative visions connected with a better image of humanity as a space-faring civilization. But these possibilities are as much a vision as it is science fiction. Setting the right time horizon is therefore important that enables us to differentiate between a scenario which can be anticipated upon and a scenario what can seemingly be a work of fiction.

A useful rationale in determining the proper time horizon is to simply see what space activities state and non-state actors have lined up for the future. A quick glance of some initiatives gives a sense of what major developments are (likely) to happen in the future and are listed in the table<sup>10</sup> below. These objectives are an indication for setting the right time horizon as the future of human activity in outer space will be largely dependent on what strategies the national space agencies and private organizations have in mind.

The first impression of the table gives a sense that most of these activities will happen within twenty years and gives reason to set this as the time horizon upon which scenarios can be formulated. Looking much farther ahead than twenty years raises the problem of not being able to differentiate between a scenario and science fiction. It is hard to predict what space agencies and organizations will want to achieve in 2080 as they themselves do not know. Of course, human

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<sup>10</sup> The list of activities is not exhaustive but includes most major, or prestige, projects that the larger space agencies and organizations have in mind. These activities are also the foremost examples of the differing themes under which each organization pursues their goals.

colonization of Pluto’s moon Europe or a human exploratory mission to the closest star system Alpha Centauri is imaginable, but it is not an ambition being actively pursued. The manner in which these goals might be pursued is also dependent on a myriad of other contingencies that is impossible to account for if a time horizon is chosen that is too far in the distant. In what ways, for example, could technology for space travel develop itself, or how would future politics influence the way nation-states interact with one another?

Table 5            Glance of planned activities

Activity and organization	Date
An ‘accessible’ mean for space tourism <u>Blue Origin</u> (Wattles, 2017)	2019
Construction of the Deep Space Gateway (Lunar Space Station) NASA and Roscosmos (Zak, 2017)	2020’s
First active debris removal mission for a clean space <u>ESA</u> (ESA, 2017)	2024
Asteroid mining <u>Planetary resources</u> (Wall, 2015)	2025
Launch mega-constellation of small satellites <u>SpaceX</u> (Caleb, 2017)	2025
Manned missions to Mars <u>NASA</u> (NASA, 2014).	2030’s
Establishing a permanent human colony on Mars <u>Mars One</u> (Mars One, 2016)	2032

## The International Relations & Governance of Space

The launch of the USSR Sputnik is usually an event heralded as the start of the space age, yet its start can even be traced further back. June 20, 1944 marks the date that an artificial object was placed above the Kármán line for the first time. It was a V2 rocket. The end of the Second World War is heavily intertwined with the beginning of the space age and, arguably, with much of its first decades. This is just a tip of the historic narrative that is important, as the aim of this study is to

build upon the trends and drivers identified in the narrative on which scenarios can be constructed. A retelling of the space age can be done in several ways. For the purpose of this study, the theories of International Relations and Public Administration offer a relevant lens through which the actions of governments and organizations can be described and analyzed, in order to anticipate the future. The first years of the space age were essentially an extension of the Cold War and is an object of study relegated to the field of International Relations as space was another stage for the superpowers to compete with one another. The two superpowers were not alone in the world, however, as other countries would observe the power struggle and opt for a different approach in formulating a space strategy. The creation of the European Space Agency (ESA) is a particular interesting case, for example, in which the organization was founded whilst its members were fully aware that they could not compete in the same way as the USA or the USSR. Public policy theory, and in particular network governance theory, compliments International Relations Theory in explaining how the ESA would seek and facilitate cooperation amongst its members.

The following narrative will recollect some of the defining events and activities in the history of human activity in outer space through the theories of International Relations and public policy. The retelling will chronicle the events in a mostly chronological order and deviate at points to elaborate certain positions which helps to identify the trends and drivers in the next step of the analysis.

### The Space Race

1,600 German science personnel were moved to the USA during Operation Paperclip which occurred between 1945 and 1959 (Jacobsen, 2014). The covert mission brought technicians, scientists and engineers to the USA for the main purpose of advancing its rocket technology as they were all affiliated with the V2 (*vergeltungswaffe*) missile program of Nazi Germany, many of them were also former members and even leaders of the Nazi Party. Wernher Von Braun and his team were among these personnel and they would all contribute, either direct or indirectly, to the space program of the USA as Von Braun and his team were eventually assimilated into the National Aeronautics and Space Administration (NASA). The USSR were arguably more aggressive with recruiting German personnel with the most noteworthy example being Operation Osoaviakhim (Taylor, 2013). More than 2,000 German science personnel were forcefully 'recruited' in 1946 from the Soviet occupied zones in Germany after the Second World War.

Nazi Germany pioneered the use of guided rockets and both fledgling superpowers took notice (Jacobsen, 2014). That is not to say that rockets were a new idea, but the V2 rocket program was a successful demonstration of rocket technology being able to strike from afar and would ultimately result in the Intercontinental Ballistic Missile (ICBM). The ICBM is particularly interesting in this regard because this missile stands symbolic for a revelation that helps understand how rocket technology changed the perception and experience of how countries would relate to one another, and to outer space. Before the ICBM's and V2 rockets, an attack on some town was 'tangible'. A land army could be spotted from afar and even airplanes would need to take-off from a within a certain distance (later developments would obviously render this limited range obsolete). With the advent of ICBM's, any place in the world could be attacked within just a few hours giving very little room to prepare or even evacuate. The terrifying part of the Cold War was that tens of thousands of nuclear warheads could be carried on ICBM's to any part of the world increasing the ability of each superpower to devastate the other and, ironically, forcing both superpowers into a stalemate. Yet advanced rocket technology also opened a new stage upon which the superpowers could test the strength of their ideologies. Outer space was now within the domain of human activity. The International Relations theory realism shines bright during the Cold War. There was no central authority on the international stage and the US and USSR were the only contenders for supremacy. Yet mutually assured destruction forced both sides to consider other forms of competition other than complete warfare. A fight to establish communism or democracy began to occur all around the world fueled by the two powers. In the same sense, a fight between communism and democracy began to take place in outer space.

The first use of rockets after the Second World War other than warfare was to launch them into high altitudes and study the conditions of the upper layers of the earth (Van Braun, 1963). It would not take long before the study of high-altitude conditions would eventually become an extension of the Cold War by sparking the Space Race. The Race would commence when the Soviet Union announced in 1955 that it would launch an artificial satellite<sup>11</sup> (McDougall, 2010). Two years later, Sputnik 1 was launched in 1957 making it the first object to be put in orbit, and marking a major victory for the Soviet Union. The following years saw them launching the first animal into space, making the first impact on another celestial body (moon) and, eventually, Yuri Gagarin

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<sup>11</sup> A distinction can be made between artificial and natural satellites (Fraser, 2013). An artificial satellite is any object that is intentionally put into orbit, whilst a natural satellite has had no human hand in its placement. The moon is an example of a natural satellite.

would be centerpiece in the first human spaceflight in April 1961 (Logsdon, 1970). The US was lagging behind and second place was the last place. President John F. Kennedy would reconsider his position on a big US space program because he sensed that Gagarin's flight put the USSR firmly in the lead. With the failed military invasion of Cuba, the Bay of Pigs Invasion, Kennedy wanted something to save the public image of his administration (Logsdon, 1970). Vice-president Lyndon B. Johnson was tasked with the question what programs NASA could develop that would enable the US to take the lead. Johnson was advised by Wernher Von Braun and the vice-president would present the option of a crewed moon landing, over the establishment of an Earth orbital space station, as a mission that would have the highest chance of success. The president chose to go the moon and was able to organize the largest amount of resources ever to be available for a specific project not related to war in US history, or any other country's history for that matter. Soviet leader Khrushchev would not disclose any information on whether they would attempt the same feat. Years later, it was revealed that they did develop and pursued a Moon program but it suffered significant setbacks, forcing the Soviets to abandon the program. Neil Armstrong and Buzz Aldrin would fulfill Kennedy's ambition on July 20, 1969 and place the US, retrospectively, as the winner of the Space Race in the most pinnacle achievement within this time period. Afterwards, NASA had ambitious plans lined up but support from Congress would wind down after the lunar landing. The last of the Apollo missions were eventually cut, and president Nixon pursued a period of détente. In a brief example of international cooperation between the two superpowers during the Cold War, the Space Race formally ended with the Apollo-Soyuz mission in 1975.

### The European Space Agency

While the Space Race was a power struggle between the two great powers, European space programs developed in a characteristically different way (Harding, 2012). Britain and France were the most important actors in this region after the Second World War and initially decided to develop their own nuclear and rocket technology<sup>12</sup>. The most important motivation for both countries to develop their rocket technology, which would mature into space technology, was from a national security perspective. The launch of Sputnik was as much a catalyst for developing the space program of the US, as the space programs of Britain and France. Britain managed to develop

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<sup>12</sup> This was, in part, a conscious effort by both governments to dissuade their own top technicians and scientists from moving to the US where an attractive environment developed for ambitious rocket and nuclear experts (Harding, 2012).

its own ballistic missile and wanted to launch its own satellite but could not realize a wholly independent British launch capability. The country was therefore dependent on the US and its missiles functioned as a complementary asset to the arsenal of its ally. France was more successful in this regard. It began developing its nuclear and rocket technology immediately after the Second World War and this culminated in a nuclear deterrence capacity comparable, in arrangement not magnitude, to that of the superpowers (Harding, 2012). France was also able to develop its own launch capability, successfully putting its first satellite in orbit in 1965.

The space programs of France and Britain diverged from the superpowers when a greater cooperation began to take place in the form of the European Economic Community (Bormann & Sheehan, 2009). Two organizations were set up in 1964 that would institutionalize this cooperation; the European Launcher Development Organization which was tasked with developing a pan-European launch capability, and the European Space Research Organization. Both organizations would eventually form the European Space Agency (ESA) in 1975 with ten founding members from Western Europe and it was a clearly different space agency as compared to NASA and Roscosmos. The ESA made a conscious decision to omit any military dimensions by dedicating itself to develop launchers exclusively for commercial purposes. The original charter of the ESA reflects this decision as it states that: “... *the Agency shall be to provide for and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space application systems.*” (Harding, 2012: p. 68). The individual member states agreed that more could be achieved when they would combine their efforts and in order to overcome collaboration problems, this cooperation would need to happen through an institution. With the formation of European space organizations, liberalism had gained another footing in the international arena of outer space exploitation. International cooperation was a purposeful choice of its members and it was fostered through the process of institutionalizing the cooperation in the form of the ESA. Network governance theory is able to supplement this understanding by bringing a nuance in the cooperative character of the ESA. As France was the most developed member in terms of rocket technology, it played a pivotal role in the creation of the ESA. The importance of France has caused the ESA to locate its headquarters in Paris and its launch site in French Guiana (Harding, 2012). The legacy of the importance of France is still relevant today as they are able to attract important activities within the cooperation of the ESA (Glazener, 2018).

The emergence of the European space organizations was also the direct result of European

scientists believing that its space ambitions were to be free from militaristic interests (Sheehan, 2009). NATO had clear interest in organizing the space programs in Europe and that would have led to a dual nature; a civilian program that was directed at attaining scientific goals, and a military program. The founders of the European Space Research Organization argued that a space program for Europe would need to be free of military influence so all European states would be able to partake. Neutral states – non-NATO members – as Sweden, Ireland, Finland and Switzerland were active members and helped shaped the ESA in a commercial and civilian orientated organization (Sheehan, 2009). The ESA is an important driver for European integration, and eventually the European Union would seek to carry this to its logical end. The EU took a formal interest in the exploitation of outer space with the Single European Act signed in 1987 (Sheehan, 2007). This topic would be on the agenda of the EU as it facilitated further European integration through the development of space technology via sponsoring and research and development, shaping the European market for the space industry and identifying the EU as an important stakeholder in terms of security. The relationship between the EU and the ESA would intensify over the years and eventually introduce a military dimension within the activities of the ESA. The ESA Agenda 2007, published in 2003, stated that: “The *ESA must change, rather than wait for its environment to force change upon it or, worse, disregard it on the grounds that it is not the instrument that is needed.*” (ESA, 2003: p. 10). The organization took notice of how the EU sought greater responsibility in providing security to its member states and how outer space was to be an integral part of that responsibility (Sheehan, 2009). The ESA came to the conclusion that it had to become part of the broader integration project lest it would be forced too later on, or even worse, become irrelevant and replaced.

### The United Nations’ Space Treaties

The launch of Sputnik I in 1957 stirred the world. The General Assembly of the United Nations established the Committee on the Peaceful Uses of Outer Space (COPUOS) a year later which was tasked with identifying a role for the UN in the peaceful uses of outer space (UNOOSA, 2018). The COPUOS was established as a permanent body in 1959 and has sought to facilitate international cooperation on matters related to outer space. The overall goal of the UN and its committees on matters concerning this topic has remained the same throughout the years and can be summarized in a single preamble of Resolution 1472 (XIV) that established the COPUOS as a permanent



committee in which the General Assembly states that: “*Believing that the exploration and use of outer space should be only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development, ...*” (UN General Assembly, 1959: p. 5).

The COPUOS produced five treaties, some more successful than others. The Outer Space Treaty (OST) of 1967 is the most successful treaty with 107 countries as parties and another 23 signatories (UNOOSA, 2018). The treaty provides the foundations for international space law. Its importance is evident from the principles it sets forth in which most of the international community adheres to, including the major space powers. Outer space is identified as a province of all mankind and no country may appropriate property rights in it. No military installations may be placed on any celestial body and no weapons of mass destruction may be placed in outer space. Countries are identified as the responsible, and liable, party for any of its governmental and non-governmental activities in outer space. The following four treaties all build and expand upon the OST (UNOOSA, 2018). The Rescue Agreement of 1968 goes more in-depth on how countries can assist one another in rescuing foreign objects and astronauts. The Liability Convention of 1972 provides more information on when countries are exactly liable for damage caused by objects launched in space that are their responsibility. The Registration Convention of 1976 introduced a mechanism in which countries were asked to notify the UN Secretary-General of any developments concerning their launched objects. This mechanism would simplify the process of identifying ownership of launched objects and any liability in the case of damage caused by the object. The Moon Treaty of 1984 aimed to, overall, clarify the OST and payed special attention to the exploitation of natural resources on the moon and other celestial bodies. It is considered a failed treaty as none of the major space powers have signed it (Harding, 2012). One important reason for the lack of signatories is that the treaty imposes a restriction of ownership of natural resources. No celestial object, including natural resources, may be appropriated by any country, entity or person. The failure of the Moon Treaty is an important indication of how the separate countries deviate from the UN (Liechty, 2015). Nonetheless, the five treaties work towards treating outer space as a common heritage and argue that its exploitation should happen in a peaceful manner. This liberalist understanding of how countries should organize their activities is, arguably, an important dimension in how space powers will continue to develop themselves. The OST has always been respected and the UN provides a platform that guides the international community into a peaceful discourse.

## The International Space Station and International Cooperation

The International Space Station (ISS) is the foremost example of international cooperation that involved the national space agencies of the United States, Russia, Europe, Japan and Canada in an agreement that has been formally established in the Space Station Intergovernmental Treaty of 1998. Still, the origins of the space station and the noticeable absence of China show a decisive political rationale underlining the cooperation (Sheehan, 2007). The first drafts for the ISS from a US perspective was to strengthen the relationships with its allies during the Cold War. The ‘station’ was meant to be a new ambitious project, led by the US, which would bring allies and friendly countries closer. Yet the idea did not attract a great public enthusiasm like the Apollo missions (Sheehan, 2007). Concerns were raised over whether NASA could keep a leading role within the proposed international cooperation project and one major ally, the ESA, would eventually threaten to back out if continuing alterations were made on part of the US. The project lost support, yet as the Cold War ended a new opportunity arose for the US and the newly formed Russian Federation to showcase a better relationship towards the world. The Russian Federation was included in the framework that would create the International Space Station. Aside a symbolic gesture, both countries found another merit in the cooperation as this new inclusion did result in enthusiasm back home for its respective, and reclining, space programs. The scope of the project highlights the importance of international cooperation in space and is a strong advocate for liberalism. The coming decade will see the expected end of the ISS, and new cooperative agreements are explored<sup>13</sup>.

A range of functional agreements exist that also highlight international cooperation in matters related to outer space (Sheehan, 2007). The International Telecommunications Union is one of the oldest intergovernmental organizations which was founded in 1865 and became a specialized UN agency in 1947. The agency is responsible for the coordination of satellite slots, use of radio spectrum over the world and facilitates the development of telecommunication infrastructure. Another example is the World Meteorological Organization which coordinates the exchange of meteorological data. These examples of technical cooperation highlight that the exploitation of outer space is not only driven by politics, but also by the necessity for an infrastructure on which the world today is so reliant.

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<sup>13</sup> A notable example of this is the relationship that is cultivated between the ESA and the Chinese Academy of Sciences (CAS) as both organizations have announced to develop a robotic space mission in a cooperative endeavor (Wall, 2015).

## (Emerging) Space Powers

The US and USSR dominated the world in terms of their outer space activity during the Cold War and are considered the first developed space powers (Harding, 2012). The European countries would roughly attain the same status with the formation of the ESA in 1975 wherein France had a leading position. In the East, Japan was one of the first Asian nations that had quickly developed its space program in the middle of the '50s and was able to launch its own object in 1970. China quickly followed by launching its satellite the same year making it the fifth country to successfully put an object in orbit. India was the next country to put its satellite in orbit in 1975. More countries followed over the years and, in 2010, twenty countries would possess the capability for launching objects into orbit (Harding, 2012). By 2018, over seventy governments have (partial) ownership of an object in orbit (Celestrak, 2018). This sharp increase within the last decade can be attributed to the overall lower cost for entering space; developing space technology is becoming cheaper, satellites become smaller and options for collaboration in space projects have increased. Yet the number of countries having ownership of something in space does not give a clear understanding of which of these countries will most likely develop themselves into major space players in the coming years. What countries can be expected to take a more leading role within the space domain? One indicator is to look at the developing world and identify the countries that are expected to be more dominant in space in the coming years. Harding (2012) provides a useful approach in this regard where he divides emerging space powers in three categories according to their capacity to develop and execute space missions. The first category are the more advanced space actors in the developing world that possess the ability to develop their own space technology and are (mostly) self-reliant in their launching options. The second category are those space powers that are reliant on more developed space powers to develop their space technology and to enable them to launch objects. The last category consists of nations that are marginally present in space and buy space technology that is needed from more developed space powers. Only the first category shall be examined for the purpose of this study and its accompanying time horizon. China, India and Brazil fall into this first category and share a number of characteristics (Harding, 2012). All three countries are among the fastest growing economies and have a history in developing their rocket and nuclear technology. The latter observation is significant as the pursuit of a space program is many ways similar to the pursuit of an ICBM with nuclear strike capability; an affirmation to the wider international community that your country possesses a significant capability and belongs to the

upper echelons.

China has in this regard been a very early participant enjoying help from the USSR. The USSR began to view China as a potential competitor for leading the communist world, however, and the relationship soared in the '60s. China has been more than able to develop its own space program and eventually became the third country that put a man, Yang Liwei, in outer space and became the third country, again, in 2007 that was able to destroy a satellite with an anti-satellite missile (Broad & Sanger, 2007). The destruction of its own satellite was a success and showed the world that China could now take out any satellite. Yet the consequences were also significant in other ways as the blast created the largest amount of space debris ever to be recorded. Over 2,000 pieces that are large enough to track and an estimated 150,000 smaller pieces now litter the orbital zone around earth that problematizes access to space in the literal sense.

India has developed its space program largely on the basis of its own merit (Harding, 2012). The country has achieved many of the same feats as China aside from human space flight and has pushed for a self-reliance in exploiting its activities in outer space. Perhaps the most telling achievement was its Mangalyaan satellite launched in 2013 that would enter Mars orbit in 2014 (Amos, 2014). The success of the mission is significant not only in its accomplishment, but also in its cost. The whole operation was budgeted on around 74 million dollars (4.5 billion rupees) which is strikingly cheap when compared to other space missions.

Brazil is the largest country in Latin America and coincidentally possesses the largest economy. It has increased its efforts to develop its space capability as part of the overall development of the country (Harding, 2012). More precisely, Brazil views a developed space program as the mean to establishing Brazil as a leading country. As a developing space power, it has relied on extensive cooperation with the United States. Yet after difficulty in the transfer of technology, Brazil has sought to better relations with other nations such as Russia, China and India (Selding, 2015). This is because the US had laid in place the International Traffic in Arms Regulations<sup>14</sup> (ITAR) that could prohibit the use of American technology. As such, the Brazilian government is seeking cooperation with other countries that minimize their use of American parts; a striking measure that hinders international cooperation with the US.

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<sup>14</sup> The regulation is a law that controls the export of, in essence, US technology. The goal is to prevent a transfer of sensitive knowledge to a foreign entity that may contribute to being detrimental to US interests (US Department of State, 2018).

## New Space

The space industry is dominated by large institutions that have, for a long time, set the pace at which space technology has developed itself. At first, governments were primarily invested in explorations missions (Segran, 2016). Then came the larger companies with big budgets who had a more commercial ethos but shared much of the same characteristics of the national space agencies. The *Old Space* is contrasted with *New Space*, an emerging part of the commercial sector that encompasses relatively younger businesses with a goal to develop space technology in an overall faster and cheaper way. They have a distinct commercial drive which is contrasted with the political character of the large space institutions. New Space captures an array of different organizations and is also identified as a broad movement that revitalizes the space industry. One of the most prominent examples of New Space can be found in the emerging market of launch capability (Cuadra & Park, 2013). SpaceX, Blue Origin, Virgin Galactic and Stratolaunch are some examples of NewSpace businesses that are revolutionizing launch capabilities; drastically reducing the costs of entering outer space that paves the way for a host of other opportunities. Aside these multi-billion dollar businesses are the smaller companies that are investing in various fields that either direct or indirectly relate to the exploitation of outer space, with most activity centered on earth-observation and small satellites.

The effects of New Space cannot be underestimated as these businesses are expected to transform the space industry. SpaceX, for example, has managed to accomplish some noteworthy achievements that has given the organization (extravagant) publicity in return. One such feat was being able to launch, orbit and recover a spacecraft that resulted in winning a NASA Commercial Resupply Services contract in 2008. The same contract could have gone to United Launch Alliance, a joint venture of Boeing and Lockheed Martin and an older institutional player in the industry, and this event shook up the industry that has long enjoyed a landscape with very few competitors and was not incentivized to innovate. Another feat was successfully landing its booster rockets, making them reusable<sup>15</sup> again. The ESA and ULA have been moved, in return, evaluating current and future launch capabilities (Wörner, 2018).

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<sup>15</sup> Neil deGrasse Tyson compared the feat with a Boeing 747; it's an incredible piece of machinery that is not thrown away after a single use, it is arguably the most important factor in making something expensive affordable. (Langlois, 2017).

## Summarizing Step I

The first step in the scenario-planning's method has set the stage of the study. The object of the study has been defined by identifying two spheres of human activity in outer space. The first sphere is the focal point of this study and is concerned with human activity that has a direct physical impact in outer space which is set to start at 100 km altitude, otherwise known as the Kármán line. The second sphere relates to human activity that is dependent on the physical exploitation of outer space. Satellite driven data is foreseen to power a substantive industry that could, for example, utilize earth observation to generate new business models that map areas best fit for specific agriculture, indicate more precisely the patterns of pollution or give information for governments to combat illegal deforestation. Although these examples do not fall within the scope of physical human activity in outer space, they indicate to drivers and trends.

The strategies of the largest national space agencies and commercial space enterprises reach envision goals that reach into the coming twenty years. As such, the time horizon for this study has been set at twenty years into the future for envisioning the scenarios of how human exploitation of space will be happen. Finally, an extensive historic narrative has been constructed of the space age that serves to identify the drivers and trends in the next step of the analysis. The theories of International Relations, in particular realism and liberalism, have guided the narrative as a lens through which the events have been chronicled.

## Step II                      Tracking

The second step in the scenario-planning method requires the identification of trends, drivers, certainties and uncertainties that helps create the differing scenarios. Several interviews have been conducted in order to help identify the most important uncertainties on which the scenarios will be created. The interviewees hold positions from varying backgrounds and a list can be found in the appendix. The study seeks to envision the future of international cooperation and competition and has therefore sought to include individuals from the public and private sector, as well as the institutional and emerging businesses.

### Trends

A trend is a so-called deep change that is persistent over a longer period of time (Lindgren & Bandhold, 2009). Regarding the space industry, two categories of trends are discerned that can impact the industry. The first category are mega-trends and are deep changes that are over-arching, impacting several parts, if not, the whole world. Three mega-trends are identified in an OECD report that affect the space industry and are outlined below, namely geo-political, social-economic and environmental. After a consideration of these mega-trends, a further appreciation is needed of the specific space-related trends and make up the second category of trends. These impact the three spheres of human activity in outer space and are identified in additional OECD publications and other works that take inventory of how the space industry is changing.

#### Mega-trend 1: Change of global power structure

The power distribution of nation-states has been shifting for a number of years and is likely to follow the same path (OECD, 2016: p. 15). Nations in Europe and Northern America have played a central role as being the most developed and wealthiest countries in the world, but new rising powers are developing themselves both in economic and political dimensions. The position of the United States in particular is likely to be challenged by China as its economy is expected to overtake that of the US somewhere between 2025 and 2030 (Scott & Sam, 2017). The shift from one hegemonic power to another will ripple through the whole of international relations as a result.

China, Russia and India will enhance their power, both hard and soft<sup>16</sup>, and new alliances will be established that will change the power distribution into a much more pluralistic world.

Activities in outer space are very much rooted in geo-political relations as nation's governments have historically been the initiator of space related activities and continue to be a driving force (OECD, 2014: p. 53). This force can mainly be explained in two ways; capital and double-use technology. National governments allocate billions of dollars into their space programs. The commercial sector can earn a profit by winning contracts and tenders but the money still originates from the public sector. The importance of the national governments is underlined again by the fact that space technology has mainly two uses; civil/science or military applications. Satellites collect information to determine weather patterns and movement of foreign armies. Global navigational systems can help vehicle drivers get from one point to another, this goes for automobiles and tanks. Even the underlying technology can be used for either a scientific purpose or a weapons application. How the space industry evolves is therefore largely dependent on how nations will interact with one another.

#### Mega-trend 2: Urbanization and a wealthier world

A larger transition from the rural to the urban will continue the migration movement within the developing world (OECD, 2016: p. 16). As countries such as China and India develop themselves, their cities will grow larger not only by birth<sup>17</sup>, but especially by the migration of the rural populace to the urban areas. Larger investments in infrastructure are then required to sustain the demands of a larger urban populace who rely more on modern products and services. The reliance on consumption of more costly goods is also propelled by the increase of the global welfare. The overall welfare, in economic terms, is increasing and overall poverty is decreasing, yet income inequality is also expected to continue the same pattern of increasing within and between countries. The result is a larger part of the global population that is neither poor or rich by their countries' standards. A growing middle class whose number will hover around 3.2 billion in 2020 and hit 4.9 billion ten years later (Pezzini, 2012).

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<sup>16</sup> Soft power is regarded as the ability to attain one's goals through attraction and persuasion (Nye, 2012). Hard power, in contrast, is gaining one's goals through coercion and payments.

<sup>17</sup> The growth of the world population is slowing down with developing countries experiencing the brunt of this development (OECD, 2016). Although there is still a high growth rate, the overall rate of population growth is losing steam. A relative peak was reached in 1968 where the world population grew with around 2,09 percent. The absolute peak was reached in 1988 where around 92 million people were born that year.



The growth of a global middle class is expected to fuel an increase in consumption of different electronics that rely on satellite-communication. The rationale is posited further as a more wealthy population requires more of everything. As they have more disposable income, they can drive their economies and world trade. More production leads to more movement of goods and people that all drive the demand for resources. This is the cycle that spurs economic growth overall where nations eventually develop themselves into modern countries. The development of a more modern world coincides with current waves of digitization where one resource is most important; information. A wealthier world reinforces the information age where more people want to stay connected, and to put it starkly, be measured. The influx of information coupled with a hunger for connectivity powers an infrastructure that not only relies on satellite communication, information and navigational capacity, but also spurs new developments within these space applications.

### Mega-trend 3: Climate change and environmental degradation

The world is warming. Emissions of greenhouse gasses trap heat and the average temperature will increase (OECD, 2016: p. 18). The global climate is changing as a result and the magnitude of change is dependent on how much the temperature will rise, and how the different climates will react to this. Rising sea levels, desertification and more unpredictable weather patterns are some of the consequences. Reducing the emission of greenhouse gasses is still a contentious topic as much of the global economy is reliant on oil, gas and coal. Further pollution is also expected to continue in large parts of the developing world with further degradation of soil, deforestation and loss of biodiversity.

Climate change challenges societies in a myriad of ways. Information gained from satellite imagery and sensory can greatly assist in staving off these challenges. Meteorology relies on space capabilities and observes the atmosphere and ocean surface (OECD, 2016: p. 18). A satellite can measure its position relative to the earth and give a precise indication of sea levels. It can also measure the atmosphere's chemical composition and track emissions of greenhouse gasses. Finally, satellites can observe wind speed, sea surface temperatures and storms that indicate and give off an early warning system. Combatting the negative effects of climate change can be greatly helped by the technology provided by satellite observation. Earth observation is furthermore an area of the space industry that is expected to grow substantially as data becomes the new religion as numbers on migration patterns, soil analysis and congestion provide the raw materials for further analysis.

## Space specific trends

A number of trends can be identified within the space sector that exist next to the mega-trends. These trends resonate more specifically with outer space activities and concern a range of developments in satellite technology, spaceflight/transportation, environment, investments in the space industry and security (Murthi & Gopalakrishnan, 2017). The OECD studies *Space 2030: Exploring the Future of Space Applications*, *The Space Economy at a Glance 2014* and *Space and Innovation* have been particularly insightful as these studies have mapped several trends related to the space industry. The following table presents an overview of the space-related trends and are elaborated upon in the section thereafter.

Table 6 Overview of trends related to activities in outer space

Trends	
Transportation	<ul style="list-style-type: none"> <li>• Private sector (mainly US) is becoming more important</li> <li>• Russia and China have developed themselves as, still, the only parties that offer human spaceflight</li> </ul>
Satellite technology and usage	<ul style="list-style-type: none"> <li>• Increasing reliance on satellites</li> <li>• Increasing number of governments operating satellites</li> <li>• Increasing number of satellites launched</li> <li>• Smaller satellites</li> </ul>
Investments in the space industry	<ul style="list-style-type: none"> <li>• Yearly investments in the <i>upstream</i> and <i>downstream</i> segment of the space industry is increasing</li> <li>• Public funding is stagnating overall</li> <li>• Public policy incentives (mainly US) spur <i>New Space</i></li> </ul>
Security	<ul style="list-style-type: none"> <li>• The UN and EU continue to explore measures to prevent the weaponization of space</li> <li>• Concise agreements reducing the weaponizations of space continue to fail to materialize</li> </ul>
Environment	<ul style="list-style-type: none"> <li>• Individual nation-states are developing their own legal foundation for the exploitation of resources in outer space</li> <li>• The amount of space debris continues to increase</li> </ul>

### 1. Trends in transportation

The most important trend in space transportation is the increasing importance of the private sector (Murthi & Gopalakrishnan, 2017). This development has, as of yet, only been noticeable in the US where several private initiatives exist that are in the early phases with SpaceX being the only one with a track record in delivering payloads. These initiatives are the likely source for innovation for the transportation payloads and human spaceflight. SpaceX and Blue Moon have been able to safely land rockets back on earth after being used for an initial launch. Reusability of these components marks a major innovative move that has caught the attention of the whole industry, sparking a reevaluation of existing launch systems within the more institutional organizations that provide launch services. The innovation originating from the US private sector is expected to put the US back on track in terms of space prowess since human spaceflight has not been offered by US entities since NASA ended its Space Shuttle Program. NASA has contracted SpaceX to develop human spaceflight capability in the form of the Dragon capsule but Russia and China remain the only two players that, as of yet, offer the ability to launch humans. Plans of China for a permanent moon station and a Chinese space station for that matter coincide with a remarkable increase of Chinese launch capacity in the past two decades as seen with the Long March rocket series (Banos, 2016). Further growth of space transportation can also be seen in ambitious plans for space tourism and exploration that has initiated the construction of additional space ports over the world.

### 2. Trends in satellite technology and usage

Satellite enable televisions, mobile phone services and communications and navigation through global position systems. The modern society is utterly dependent on satellite technology and the reliance on this will continue to increase as more countries become developed. This development is seen in the number of states that control or operate satellites of which the number has increased twofold in the last decade (OECD, 2016). There are approximately fifty states that operate satellites with twice as many states utilizing services provided by satellite technology. The private sector has also played in the growing reliance on satellites providing new applications for using information gained through satellites. Imaging and detection are two important area's that will provide new business opportunities as the information hunger of government and society continues to grow. There is also a growing number of satellites being launched. The amount of satellites launched doubled per year doubled in five years from 2010 with around 260 satellites launched in 2015 (OECD, 2015). This growth is largely made possible by the emergence of smaller satellites; the Nano- and

microsatellites. These satellites weigh up to ten kilograms which are drastically smaller and lighter compared to telecommunications satellites that weigh around 250 kilograms are the sizes of large refrigerators. Plans for constellations of smaller or nano-satellites can provide global access to the internet and provide more real time imaging services over every part of the world.

### 3. Trends in the investments in the space industry

The space sector is a growing industry as is evidence by the increase of yearly investments (OECD, 2016). The space economy has grown 100 billion dollar in a decade to around 320 billion dollars in 2015. The increase is also noteworthy as the financial crises of 2008 is suspected to have had an inhibiting impact on states' and business' ability to invest. A discrepancy can be identified, however, in how much the public sector invests in space-related activities as opposed to the private sector. While the decade preceding 2015 saw an increase of investments with around 100 billion dollars, government spending has stayed the same with yearly public investments of around 75 billion dollars. The public sector has not prioritized the space industry less per se, as could be concluded from the stagnant public spending. The surge of commercial activity can in this light be accredited to public policy changes that invites commercialization. New Space, new actors within the space industry, are evidence of a growing private sector which is on course to take on all fields of the space industry.

### 4. Trends in security

The reliance of governments and society on applications derived from satellite services makes outer space intrinsically part of a nation's security. The growing reliance on satellite technology makes security of outer space furthermore a contentious topic as governments will want to safeguard their space assets more and more. Apart from commercial and scientific uses, satellites provide governments with strategic benefits that use imaging for tracking foreign armies and arsenals, communications for a sophisticated military apparatus and even positioning for the guidance of weapons. International organizations such as the UN seek to prevent the weaponization of space. The UN Group of Governmental Experts, for example, constructed various measures for transparency and confidence building aimed at safeguarding outer space. Another UN initiative came from the COPUOS and aimed at developing a situational awareness of space (COPUOS, 2016). Several areas were explored that touched upon a collective and collaborative spirit of the international community such as space debris and sustainable applications. The European Union

has shown a similar ambition and has tried to construct an International Code of Conduct for Outer Space Activities. The Code aims to set examples that would address several topics in how states would behave towards in another when dealing with matters of outer space. After several rounds a final agreement was not reached and it is now up for further deliberations. Finally, a treaty that was put forth in the UN that aimed to ban the weaponization of space failed to materialize as states were unable to reach a consensus (Murthi & Gopalakrishnan, 2017).

#### 5. Trends in the environment

The final set of trends are environmental and two important developments can be discerned (Murthi & Gopalakrishnan, 2017). The first development relates to the exploitation of resources in outer space wherein the UN space treaties have historically played an important role. The OST forbids the appropriation of any celestial bodies. The Moon Treaty, furthermore, aimed to define resources of celestial bodies as common property for all mankind. But the Moon Treaty is understood as a failed treaty and states have begun to construct their own understanding of resources in outer space. The US has determined in 2015 that resources gained in outer space are property of the entity that has mined it. Luxembourg has followed suite and more countries are expected to follow this same route as no international resistance has erupted.

The second development relates to a growing body of debris in earth orbit (Murthi & Gopalakrishnan, 2017). There are around 18,000 objects in earth orbit that are trackable with another 180 million smaller pieces of debris that are invisible to current observation techniques. An eventual Kessler effect, in which the space debris would make access to outer space impossible without collision, is feared and has activated parts of the international community to take action. The UN Working Group for that matter has contributed to a situational awareness and the hope is that the active removal of debris in outer space will materialize in the coming years.

## (Un)certainities

The last part of the tracking stage will seek to identify the certainties and uncertainties of the future of human activity in outer space. A number of uncertainties have been identified through the study of literature in which particular attention has been paid to the OECD studies that have largely mapped the trends that have just been described. These studies also attempt to advise global policy makers on matters related to the space industry in how to move forward. In doing so, one certainty and a number of uncertainties can be identified as that are listed below.

### Certainty

#### **Civilian or scientific missions will always have a military consideration.**

From a historical perspective, a dichotomous division can be made in the nature of space missions. The goal can either be to serve civilian/scientific purposes on the one hand, or military purposes on the other hand. The matter is made more complex as civilian and scientific space missions can also serve to strengthen a nation's prestige; contributing to a geo-political game the same way a military space mission will do. Even now, new technologies are evaluated on any dual-use purposes before it is implemented or exchanged (Buijsrogge, 2018). The certainty is made clearer when we also understand that any (space) assets are also potential targets for any aggressor that requires protection. This is especially relevant for space assets as national security is tied with the ability to communicate and coordinate through satellite communications.

The distinction between civilian/scientific space missions and military space missions might seem like a highly conceptual construct which is not relevant because in reality the lines blur between the two. But it is important to distinguish between the scientific/civilian and the military because it relates back to the discussion between liberalism and realism. In liberalism we can find a narrative within the international domain that speaks of space as the *province of mankind*. The OST, for example, hints at exactly this. In conceptualizing space as something that belongs to all, the United Nations tries to combat a very realist notion; that space, in the end, is also a stage of anarchy. A place where nations will exert power and survival is the most important goal for states. This is not to say that space will be the next stage where wars will be fought, but it is part of the same anarchic environment that forces states to consider their own interests first.

## Uncertainties

Four themes have been identified that group seven uncertainties that are important. These themes and accompanying uncertainties<sup>18</sup> have been selected through the analysis of documents and framed through the theoretical concepts of International Relations and Public Administration as described in the theoretical framework of this study. An explanation of the themes and uncertainties is provided after the table. The purpose is to present these to several experts through interviews and, following their analysis, select two specific uncertainties that will ground the scenario-building phase.

Table 7 Overview of uncertainties

Theme	Uncertainty
International relations	<ol style="list-style-type: none"> <li>1. How will states interact with one another in space?</li> <li>2. What will the role of international organizations be in inter-state space relations?</li> </ol>
Relation between public and private sector	<ol style="list-style-type: none"> <li>3. Will the private sector or the public sector drive the space industry?</li> <li>4. What will the role be of the public sector in relation to the space industry?</li> </ol>
Space sector funding	<ol style="list-style-type: none"> <li>5. Will there be more or less public funding for space related activity?</li> <li>6. Will the market for the space industry grow?</li> </ol>
Militarization of outer space	<ol style="list-style-type: none"> <li>7. Will states view space as another stage for warfare?</li> </ol>

<sup>18</sup> An important note is that the uncertainties listed below consist of smaller uncertainties that have been grouped together. The result is a number of uncertainties that are defined at the same level of analysis.

## International relations

How human activity in outer space happens is largely dependent on how states and international organizations relate to one another in the international domain. States have used outer space as a domain through which they have pursued national interests; be it military or diplomatic. International organizations such as the UN and EU attempt to bring different states closer in order to facilitate international cooperation. Yet international competition has proven to be a conventional way of how states interact and can also be beneficial in some perspectives. Innovation, for example, is usually one of the main arguments for competition in the market place and it is equally true for the space market. When the US instituted ITAR, European countries began to develop the technology they could no longer source from the US (Bijersbergen, 2018). Not only were new technologies being developed, European countries began to develop home-grown industries which brought all the added benefits of creating employment and spill-over effects into other industries.

The first theme has been identified based on the theoretical framework of International Relations in relation to the works of Sheehan (2017) which underlines the importance of the global political arena for the outer space arena. The first uncertainty is primarily concerned with how states interact much like the International Relations school of Realism opts to consider the state as the most important entity. The second uncertainty incorporates the International Relations school of Liberalism which considers the role of international organizations and institutions within the global arena.

1. *How will states interact with one another in space?*

Human activity in outer space requires considerable resources and only states have historically been able to organize the means for such endeavors. The five UN space treaties further place all final responsibility to the state for any space missions that its private sector might undertake. States are identified as major powers that will shape the industry for the coming decades and how they will behave is of importance to the future.

2. *What will the role of international organizations be in inter-state space relations?*

International organizations also play an important role in this regard, steering how states interact with one another or facilitating international cooperation. The UN is the foremost example but there are several other examples that foster a civil space arena; the



International Space Environment Service and the Group on Earth Observations are two examples that respectively seek international cooperation on weather meteorology and earth observation. International organizations can have a mediating effect through sheer diplomacy or formulating and pursuing common goals.

## Relation between public and private sector

States have historically been the driver of the space industry through their space programs. The private sector would carry out government contracts or win tenders, but never had an decisive role on determining what should be on the agenda. That is changing. New Space has in that regard challenged the older institutional private actors through the use of more innovative technologies and reducing costs overall. Another important development is the market opening up for private money to be invested in space technologies because there are new possibilities. Smaller satellites will be the prime example of these new possibilities for the coming years, but ideas as space mining and space tourism are not from reality either. All these developments will impact the role of the public sector in how to position themselves within this new environment. Governments will likely still play a pivotal role in the years to come. Space technology, innovation and space programs are some explicit topics contained in the agendas of the most powerful countries. Subsidies, contracts and tenders are then powerful incentives for the private sector to make investments in the space industry worthwhile. Even if the space industry matures, an important role is still relegated to the public sector that could take on a supervisory role; enforcing space aviation regulation for example.

The second theme has been selected based on the recent developments regarding the commercialization of outer space as outlined in the OECD studies (2014: p. 35, 2017: p. 27) which have researched how the space sector is developing. The first uncertainty then asks whether the private or public sector will take on a more leading role in driving the space economy. The second uncertainty within this theme notes the importance of the state and subsequently asks what their role will be in the future.

### 3. *Will the private sector or the public sector drive the space economy?*

The public sector will play an important role within the industry, providing incentives for private organizations and regulations to guide companies. The main question is whether there will be a vibrant space market that is not dependent on public organizations or

incentives. Small satellites and earth observation could trigger a new market in which private parties sell launch services, satellites and data to consumers or other private parties. A space market that thrives on the private sector could introduce the benefits associated with privatization in general (OECD, 2016: p. 34). More innovation, cost reduction and produce better results overall. The reusability of rockets introduced by SpaceX is just such an example that is comparable to a small revolution within the launch services industry.

4. *What will the role be of the public sector in relation to the space industry?*

NASA (2015) has proposed to delegate much of the activity in Low Earth Orbit to the private sector, opting to focus on deep space and exploration. Perhaps the first step towards a larger trend that follows the commercialization of outer space. The role of the public sector then becomes more focused on scientific and regulatory considerations. The question is also open whether states will pursue the same commercialization, or choose to stay in control of their own space industries. How then, will governments organize their cooperation with private initiatives and what consequences does this have for national security, oversight and international competitiveness? It is important to note that this uncertainty is independent of uncertainty 3 because the public sector is such an important actor now, and in the future. States could, for example, also choose to inhibit commercialization of the space industry as part of their larger national agenda.

## Space sector funding

A simple but important theme is how much money will go towards space initiatives and the space industry in general. Human activity in space, which can either take on the form of a national space program or a private initiative, is still driven by funding. Allocating funding enables capital and labor, which can of course vary by price per country. As indicated by the trend in investments in the space industry, the global space industry in 2015 amounted to around 320 billion US dollars. Of that, 75 billion US dollars came from the private sector and the public sector's yearly contribution has stayed much the same over the ten years preceding 2015. More money, from either the public or private sector, would mobilize more labor and capital for the benefit of the space industry. Less money, would inhibit progress and in the worst-case scenario even set back the industry because space technology is mostly a long-term investment. Cutting funding for programs that have not

achieved a certain threshold would risk losing a part of the progress made.

The third theme regards the simple observation from the 2016 OECD study that space projects, like everything else, requires funding. Space projects are a more particular case because they require considerable amounts of funding to realize and the larger institutional parties have historically aimed to mitigate risks as much as possible. This is all changing as new investors now find new business models within the space industry. The first uncertainty within this theme takes note of the fact that global public funding for outer space activity has not been raised for the period 2005 – 2015 and considers what development might take place. The second uncertainty within this theme looks at new initiatives like small satellites and space mining and asks whether this will develop into a mature space market.

5. *Will there be more or less public funding for space related activity?*

The amount of public funding dedicated to the space industry has stayed the same for a number of years. Space policy is in this sense much like other public policy areas, the amount of funding is dependent on what the political agenda dictates. The problems arising from complex issues such as climate change and an aging population can press on national budgets. When US president Kennedy, for example, proposed to go to the moon, he managed to organize vast amounts of resources and that ambition was eventually realized in 1969. Yet budget cuts forced NASA to cancel the remaining Apollo missions 18, 19 and 20 as political support had dwindled by 1972.

6. *Will the market for the space industry grow?*

The space industry has grown over the last couple of years and it is likely to grow as space becomes more accessible and new business models are being developed to cater to a data-driven society (OECD, 2016). New avenues like space tourism are also likely to open brand new initiatives yet for the sake of this study; this is not a certainty but can have considerable impact on the future.

## Militarization of outer space

The militarization of outer space is, in principal, the development and placement of military constructs within the realm of outer space (OECD, 2004). Defining what military constructs are is a more complex matter made difficult by the dual-use nature of space technology. Weaponry such

as missiles are clear examples of military constructs, but earth observation can also serve military goals and can then be categorized as a military technology. Nonetheless, the United Nations (1967) has made it a clear mission to pursue a narrative where space is the *Province of all mankind*, a line of reasoning that resonates with the International Relations theory of Liberalism where international cooperation can serve the whole international community. The Space Race formulated another narrative where the US and Soviet Union saw outer space as a domain that could provide a strategic advantage over the other; a line of reasoning resembling the International Relations theory of Realism. Whether militarization will continue can be understood as whether the liberalist narrative or realist narrative will dominate. The relevancy of this theme is underlined by attempts of the UN to avoid a militarization, a fear that has valid grounds judging not only from the past but also of the present. The 2007 anti-satellite missile test carried out by China is an example as the country said it wanted to simply test its ballistic technology and the global community did not need to fear any kind of arms race (Kahn, 2009). The reaction was quite the contrary as countries mentioned that this was not beneficial to the idea of an outer space as a civil area which should only serve peaceful purposes.

The last theme considers the peculiar dual-nature of outer space activity. Not only can much of space technology be utilized for military goals, outer space in itself is a strategic dimension within the political considerations of states.

7. *Will states view space as another stage for warfare?*

The militarization of outer space is an ambivalent statement as the dual-use of space technology underlines the complexity of any application of space assets. Satellite imagery can provide military intel, but a satellite can also serve as a kinetic kill vehicle when launched towards another space asset. Aside the kill vehicle example, there are no weapons in outer space as we know of (White, 2017). International treaties do leave room for any state to deploy weapons aside weapons of mass destruction as these have been explicitly forbidden by the OST. Moreover, a narrative can also be identified where space is viewed as the next theater of war, just as there have been fights on land, on sea and in the air. It remains to be seen whether states in the future will adopt a similar understanding.

## Consultation results

The themes and uncertainties that have been identified are presented to a number of experts. These range from professors, to government officials, external consultants, civil groups and businesses. A list of the interviewees is provided in the first appendix. Each interviewee has been presented the four themes and accompanying uncertainties and has been asked to reflect and rank the two most important uncertainties. The results from the consultation will be presented and analyzed in two steps. The first step is to present a valuation of the uncertainties. The second step will reconceptualize the uncertainties wherein differing uncertainties will be integrated and expanded upon to reflect the findings from the consultations. This section will conclude with the selection of the two most important uncertainties upon which the scenario's will be built.

### I. Valuation of uncertainties

#### ➤ 1. *How will states interact with one another in space?*

Most interviewees placed great emphasis on the importance of state as the way they interact with one another is perceived to be of significant impact. One argument is that the five United Nations space treaties place the end responsibility at governments (Masson-Zwaan, 2018). The treaties are in essence the foundation for an international legal framework. According to these treaties, private activities have to be authorized and supervised by governments. But the treaties don't cover everything either and questions arising to the ownership of, for example, metals acquired through economic activity is being regulated through national legislation. The second argument underlines the importance of states is that outer space has a distinct military dimension (Van der Kolk, 2018). Outer space provides a strategic advantage through communication, imaging and positioning; denying another state access to these will seriously impair their operations. The problem of the dual-use nature of space technology is also relevant in this sense as states will keep a close watch on any technology transfer between countries as is evident through the US ITAR agreement. It is also expected that governments and companies will closely work together because of the dual-use nature and they could participate in several ways (Beijersbergen, 2018). The third argument is that governments have an important role to play in setting the scientific agenda (Van der Kolk, 2018). The market will strive towards goals that are commercially attractive, meaning that topics as exploration and deep space remain realms where states will have to set the way forward for the

foreseeable future.

Almost all interviewees judged it highly uncertain how states will interact with one another in the future, in particular with regards to whether there will be more cooperation or competition. Space programs like a colony on Mars or a Moon Base would require vast amounts of resources and labor that can only be achieved through international cooperation (Van Eijck, 2018). Achieving these incredible space projects is seemingly dependent on multiple countries working together. Yet current relations between the US and China also give reason to think that states might be highly reluctant to cooperate (Beijersbergen, 2018). Both countries view outer space as a strategic advantage and is therefore an extension of the politics on earth.

➤ 2. *What will the role of international organizations be in inter-state space relations?*

The role of international organizations in inter-space relations has mostly been judged to facilitate information sharing between countries and to provide a platform for discussion to take place. The International Telecommunications Union, for example, organizes discussions and negotiations among countries on assigning and allocating orbital slots for satellites and the use of frequency waves (De Dalmau, 2018). There was also consensus on what international organizations cannot seem to accomplish and that is taking a more leading role in setting common goals on the space agenda. The United Nations for example has tried to set up a more expansive legal international framework but has failed to do so. Businesses have asked their governments with regards to space mining to develop a regulatory environment in light of a lacking international one (Masson-Zwaan, 2018). In general, the United Nations seems to be the appointed entity to organize a more comprehensive cooperative approach to outer space activity. Yet the relative permissiveness of its treaties undermines the goal of the United Nations to dedicate outer space exclusively to peaceful purposes and this questions the importance of international organizations in general.

➤ 3. *Will the private sector or the public sector drive the space industry?*

One finding that came forth from the interviews is the expectation that the advent of smaller satellites will spawn a bigger interest in the services that can be facilitated, along with new ingenious launch capabilities (Rotteveel, 2018). This will likely lead to an increase of private investors who are interested in high risk and high reward business cases. The telecommunications sector is also expected to thrive because there is an ever-growing consumption of data and staying

connected (Van der Kolk, 2018). Yet the consensus existed that the public sector will continue to play an important role in the coming years in stimulating the space industry. Contracts and tenders are some of the existing tools that governments use to stimulate the space industry and space policies are important topics within national agendas. The European Union (2016), for example, has outlined a space strategy that seeks to develop Europe as a global competitive space actor that can access outer space autonomously and utilize its full benefits. The Galileo program is one such case where Europe has developed its own global position system. The public sector is therefore likely to be highly involved with the space industry in the foreseeable future.

➤ 4. *What will the role be of the public sector in relation to the space industry?*

The space industry will likely be highly dependent on the public sector because of its intertwinement with geo-political considerations which views (access) to outer space as a strategic decision. Yet how governments position themselves in relation to the space industry was a question that lead to varied answers. One the one hand, governments could adopt a regulatory position acting as supervisors much like the airline industry (Laan, 2018). At the other hand, governments could also directly invest in space ventures much like the model European countries have adopted for Airbus<sup>19</sup> in the past (Beijersbergen, 2018). An important comment was made with regard to the role of governments in the future (Rotteveel, 2018). There is a transition going on and the governments can take on a number of roles. First, there is the role of consumers; a large segment of communications and remote sensing will be of particular interest to the public sector. They could use regional data-sets to combat climate change and generate new models for public policy in general. Second, there is always an explorative and military role for governments. Deep space missions are still not attractive for commercialization on itself. The private sector could step in and build utilities that support a deep space mission but the responsibility for such a large mission is still relegated to governments. Lastly, governments will likely aim to stimulate innovation and science within their own economies to better position themselves on the global and outer space arena.

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<sup>19</sup> Airbus Group SE was the product of a merging of several air and space companies in Europe (Cuadra & Park, 2013). At one point, Airbus was owned for more than 50% by Spain, France and Germany. It has since reduced its overall public ownership.

➤ 5. *Will there be more or less public funding for space related activity?*

Some interviewers questioned whether there will be more public funding as other concerns exist that might pressure governments to allocate funds elsewhere (Van Eijck, 2018). The trend of overall public funding for the space industry which has stayed the same from the period 2005 – 2015 seems to suggest that outer space has not been gaining more attention and it can be reasoned that it has even declined. A world that is designed to grow would require governments to at least increase their yearly contribution in order to keep up. Others were adamant that outer space would never see less public funding because it's a highly politicized policy area (Beijersbergen, 2018). Nevertheless, both sides agreed that the amount of public funding was dependent on what the political agenda dictated. China has in this regard invested heavily into its own space industry in the last decade and other countries have noted this (Beijersbergen, 2018). As such, the uncertainty surrounding public funding is regarded to be subservient to the first uncertainty where the question is raised how states will interact with one another.

➤ 6. *Will the market for the space industry grow?*

There was a general consensus that the coming wave of small satellites will generate new business in the upstream space sector, e.g. new and more flexible launch capabilities, and in the downstream sector in which for example data generated from constellations of small satellites can provide information that is of interest for businesses and governments (Beijersbergen, 2018). Space tourism is also likely to be successful with several companies preparing for the next logical step-up from aviation services (Lan, 2018). Furthermore, space mining and colonization missions can also become very interesting catalysts that could propel the space industry into the 'stratosphere' (Sweers, 2018). The idea of space mining can become a lucrative option when there are plans to build expansive projects in outer space. Resources collected from asteroids can cost overall less compared to the alternative which is to launch all materials from earth. But with the absence of such projects, space mining seems to be an exotic venture for the coming years and governments will likely be the first to create such a demand. Colonization missions on the other hand are also interesting because the whole industry is then incentivized to organize and divide such massive projects into several nodes within the larger supply-chain. There was relative skepticism, however, regarding these 'exotic' ventures (Rotteveel, 2018). There seems to be no business case for space mining as of yet as there is simply not a demand for resources collected in outer space. There are



also plans for a moon base as an example of the first colonization of an extra-terrestrial body but such plans have yet to be confirmed. Still, the future of human activity in outer space can be greatly impacted by how large the market for the space industry might grow.

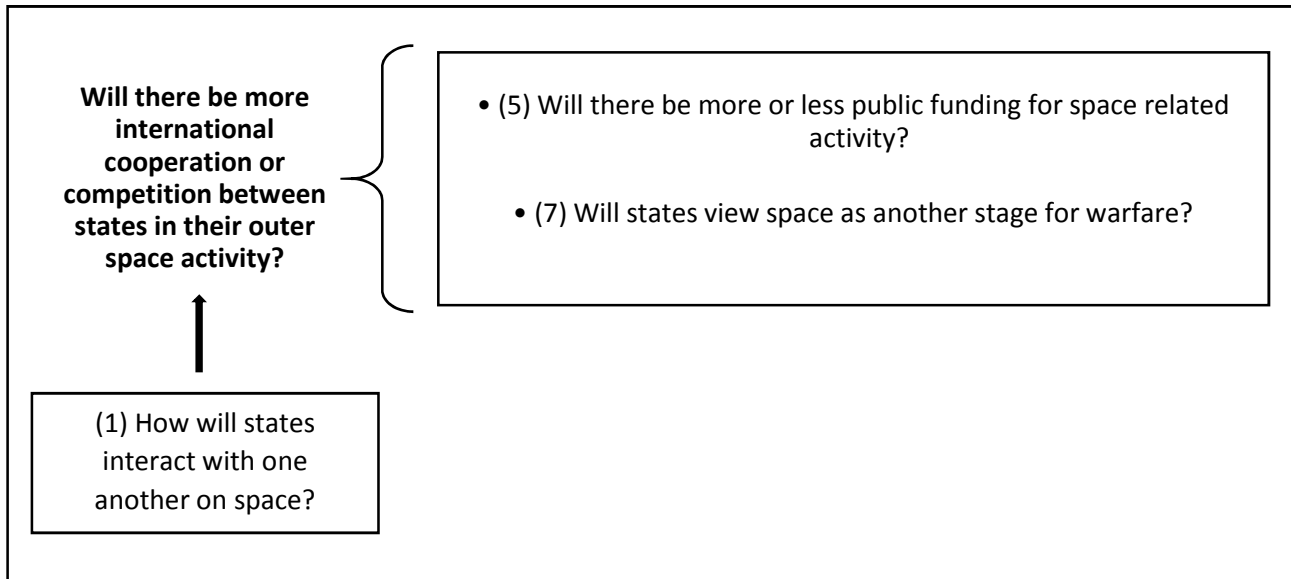
➤ 7. *Will states view space as another stage for warfare?*

The militarization of outer space is an important topic that all interviewees saw as having important consequences for the future. The dual-use nature of space technology is an important factor in this discussion which makes any outer space related activity militaristic in one way or another (Buijsrogge, 2018). There are more-over no known weapons in outer space, and the foreseeable future will likely not see the deployment of any space-based weapons (Rotteveel, 2018). It is also much easier to take out the ground stations, rather than firing an anti-satellite missile. States will therefore unlikely view outer space as another stage for warfare where physical damage is inflicted through space-based assets. More interesting is whether there will be an actual war which has consequences for how states will utilize outer space (Beijersbergen, 2018). A Cold War or Space Race can motivate governments to invest heavily in the space industry with the Apollo missions as the shining example. The militarization of war is then, like public funding for the space industry, dependent on the first uncertainty about how states will interact with one another.

## **II. Reconceptualization of uncertainties**

The second step will seek to formulate a new set of uncertainties that are based on the reconceptualization of the first set of seven uncertainties. The consultation revealed that the way states interact with one another is important for the future of human activity in outer space. States have an important role because the international framework places end responsibility at the state-level, outer space is inseparable from geo-political considerations and explorative and scientific space mission depend on the support from government. The importance of states was regarded to overrule uncertainties five and seven; whether there will be more or less public funding for space related activity and whether states will view space as another stage for warfare. As such, the first uncertainty on how states will interact with one another will be reconceptualized so it includes the considerations from the fifth and seventh uncertainty. This has been described in the figure 5.1.

Figure 5.1 First reconceptualization of uncertainties

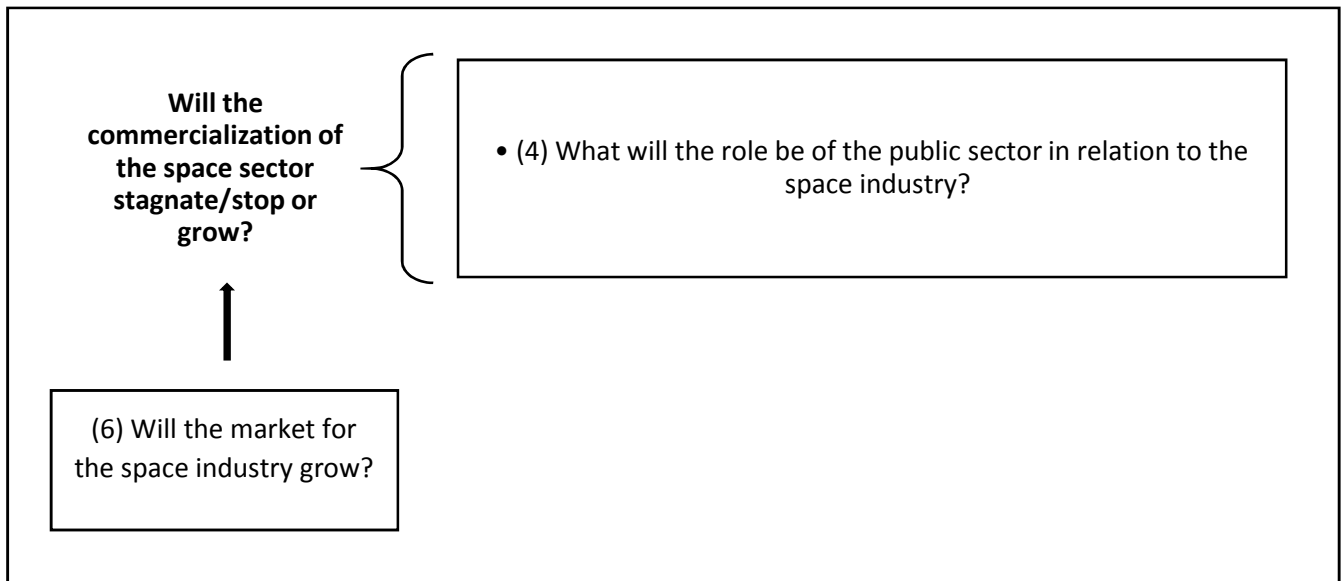


The political agenda of states largely dictates whether there will be more or less public funding and the relationship between countries will motivate states to view space as a civil arena or a stage for warfare. How states interact with one another is the overruling uncertainty which has been redefined through the spectrum of international cooperation and competition. This has led to the new uncertainty ‘*Will there be more international cooperation or competition between states in their outer space activity?*’. This uncertainty is in alignment with the overall theoretical framework. It views how states interact with one another to be either cooperative or competitive and incorporates the results from the consultations which have highlighted the importance of how states behave for the amount of funding and the militarization of outer space.

The second uncertainty to be reconceptualized focuses on the market for the space industry and regards new initiatives like space mining, tourism, colonization and small satellites to be highly important for the future. It is uncertain whether these ideas will lead to viable business cases. But if they do, the further commercialization of outer space is then expected to invigorate the space sector with not only a business rationale of innovation and profit-orientated effectivity and efficiency, but also with considerable more additional resources from private investors. The sixth uncertainty has therefor been redefined to ‘*Will the commercialization of the space sector stagnate/stop or grow?*’ so it includes the consideration that a mature market for the space industry also introduces a profit-orientated rationale which is starkly contrasted by, still, an environment where large institutional parties are risk-averse and bureaucratic. Figure 5.2 outlines the

redefinition. The fourth uncertainty has been integrated within this uncertainty because the role of the public sector is in various ways subservient to how large and mature the market is for the space sector. The aviation industry serves as an important indicator for how states could also grow into a supervisory and regulatory role.

Figure 5.2 Second reconceptualization of uncertainties



The two uncertainties outlined in figure 5.1 and 5.2 serve as the most important uncertainties based on results from the consultations. These will provide the outlines for the matrix wherein four distinct scenarios can be formulated.

## Scenarios

The final step will build upon the two most important uncertainties and envision four possible scenarios. The four scenarios are construed through a graph in which each axis represents an uncertainty. The ends of each axis, in turn, shows the dichotomous values of said uncertainty. Cross-combining the dichotomous values of both uncertainties yields four unique scenarios.

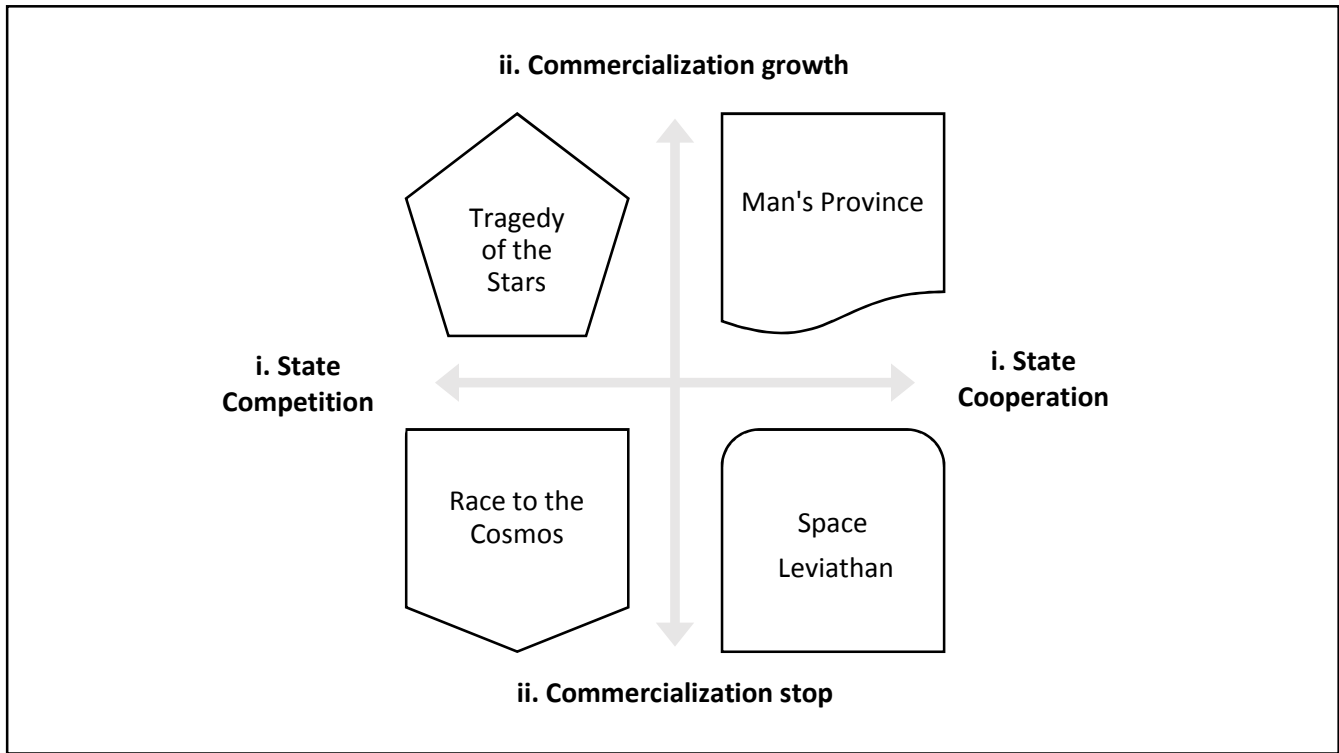
To recap, the consultation revealed that the space sector is largely dependent on the political agenda of states. Hence the International Relations schools of liberalism and realism provide a dichotomous set for the first important uncertainty. The consultation also revealed that the next important uncertainty is whether the commercialization of space will continue. The term 'commercialization' has been selected to emphasize not only the privatization of the space sector, but also the introduction of new goods and services on the (space) market. The uncertainties identified in literature have been reconceptualized in the two most important uncertainties which are presented in the figure below.

Figure 3      The two most important uncertainties

- i. *Will there be more international cooperation or competition between states in their outer space activity?*
- ii. *Will the commercialization of the space sector stagnate/stop or grow?*

These two uncertainties have been juxtaposed in a four by four matrix as displayed in figure 5.4. The four scenarios are an extreme imagining based on the combination of the values displayed at the end of each axis. Each of the scenarios will be expanded upon through a narrative set twenty year ahead and describes key elements of the possible future. The theoretical framework of this study will provide the structure through which each narrative can be told, detailing how states behave towards each other and how they position themselves towards the space industry.

Figure 4 The four scenarios



I. A future with strong cooperation between states facilitated by international organizations and institutions. A growing space industry that increases international cooperation and is growing into a mature market.

There is large consensus between states on how to utilize outer space for the benefit of the international community. The two superpowers, China and the United States, have found common ground in how to move forward and have paved the way for the rest of the world to join in. This originates from an ambition of states to seek cooperation because they believe in the relative advantage of joining forces. The United Nations has finally realized an international framework for space law and has spearheaded many new initiatives that connect states. Ambitious projects like the moon village could not have been realized without the enormous amounts of funding, nor without the involvement of a now increasingly growing private space sector.

The moon village started as a temporal base, an experiment between the space-faring nations of the world which demonstrated the benefits of a large international space mission. Yet the base could not have achieved its population, which nears one hundred colonists now, without new breakthrough technologies originating from innovative space companies. The cost of entering space has decreased dramatically and has enabled states to launch people and materials into outer space for less every consecutive year. The dozens of space mining companies have played a crucial role in this regard as not every material had to be launched from earth but could be obtained from asteroids and the moon itself. The space mining industry has now even begun experimenting with collecting and recycling space debris, being incentivized by the United Nations and the European Union. Contracts and tenders have been issued and has bolstered a growing market cleaning up earth orbit. The European Union, with the help of the European Space Agency, has been a front-runner in the idea of a clean space and has cultivated a number of European space companies which now lead the market.

The success of the moon village has intensified the international effort to colonize Mars. A special mission is being set up to realize a second planetary civilization. The project is not without its problems however. The resources and coordination required have garnered an unprecedented amount of interconnectedness between states, international organizations and businesses. The complexity has motivated the creation of a new international institution that originated from the United Nations. By decree of the UN General Assembly, a special council has been formed with representatives from every state that is willing to contribute which will organize the biggest space mission in human history. The largest space companies are being consulted on every part of this mission and have influenced the process and outcomes greatly. They negotiate with one another and strike deals but do adhere to firm policy guide lines set by the council and international legal framework. The international regime set by the special council and United Nations has coincidentally been the result of a growing private space industry that was unregulated at first. Growing activity in outer space from the private sector lead to incidental cooperative agreements between states in an attempt to provide legal footing for the activities. It soon dawned on states, however, that a more thorough institutional arrangement would be more efficient and effective, compelling states to transition into a role of regulator and financier of the space industry.

The space industry itself is characterized by a vigorous plethora of companies, some older and many newcomers, all united with the same ambition to grow their ideas in a competitive market. The

older institutional organizations were forced to adapt to a new set of rules. They used to be risk-averse because there was always a high cost associated with the space industry. That has changed significantly. Lower costs to enter space enabled companies to experiment with different business cases and the industry as a whole seems more likely to take on risk as it is evident that there is good money to be made. Countries in South America, Africa and Asia have all experienced significant economic growth, growing their societal needs based on an information infrastructure. Not only are the contracts and tenders from the public sector an attractive prospect, a growing number of investors are also interested in the space industry.

Outer space is regarded as a new territory to be claimed for the good of mankind. The power of the market will push the expansion of human activity in outer space into new heights, guided by a framework which represents the common goals of an international community.

### **Strength**

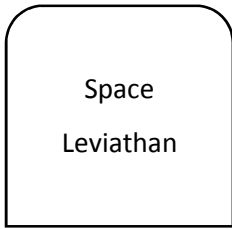
Consensus between states enables a strong international legal framework that negates market failure

Growing market for the space industry accelerates innovation and cost reduction leading to overall quicker progress

A growing private space industry creates more wealth overall and coerces states to coordinate with each other, reducing the risks of militarization and warfare

### **Weakness**

A large international cooperation between states leads to, unavoidably, redundancy and bureaucratization



**II.** International cooperation between states is strong which is being enforced by international organizations. The relationship between states is also important because any activity in outer space is almost wholly reliant on the public sector.

The two superpowers have united the international community and has set ambitious goals related to the usage of outer space. The (national) space agencies are working closely together and the United Nations assumes the role of facilitator for further international cooperation. The space industry is still dominated by the large institutional organizations that have existed for more than half a century. New Space, although a known phenomenon, never impacted the industry as a whole, often times never finding success or were quickly integrated with the larger organizations.

Development and innovation in the space sector has been constant, never accelerating nor depreciating. Public investments into the space sector has increased marginally due to newer countries developing an appetite for needs that are based on an information infrastructure that is reliant on satellites. Private investors have also invested in the satellite industry, capitalizing on the ever-growing hunger for data. Innovation in the space sector has therefor largely been reserved for communication technology and imagery which bolsters the current situation where satellite utilization is the focal point for governments as they seek to solve the common problems of global warming and pollution. A more erratic climate has resulted in more natural disasters. Desertification, rising sea waters and pollution have triggered governments to constantly track information on land, atmosphere and water.

Space missions are a prerogative of governments as no company has enough resources to initiate such a daunting undertaking. There is a moon base but it functions only as a space laboratory, an experiment between the largest space-faring nations after the International Space Station was decommissioned. The space laboratory provides useful insights but the project is often critiqued for the enormous costs. New alternatives have been explored and the moon base faces an end date as the low-gravity environment can also be simulated on earth. A few missions have explored Mars and the idea of a colony has long lingered at the United Nations. Yet the costs have always been too high and any viable colonization mission is still decades away.



Every contract and tender of the space agencies or international organizations are rewarded to space companies that have a too-big to fail rationale. Every project is costly and risks are avoided which results in long development and implementation times. Still, the majority of the work done in outer space is largely the product of the space agencies which work closely together and set up joint space missions. Beside the moon base, the constellations of small satellites have also introduced a need for tighter coordination and agreements on orbital slots. This has resulted in the formation of an international space agency which was founded by the biggest space faring nations. Each country has representatives in this agency that come together to set up joint missions and share insights and new technologies. The United Nations has happily aligned itself with these efforts, offering to involve smaller member states in these cooperative endeavors. The international space agency will involve all countries that want to contribute to the peaceful uses of outer space. However, insights provided in the organization structure of this agency reveal that the biggest space faring nations have greater power because they contribute more. Each of the founding members carries a veto right resulting in an agenda being favorable to the original founding countries. Smaller members have no choice but to adhere to these greater voices. As such, space companies also work closely with the agency as they represent the will of the international community on space-related matters. Even the United Nations is in constant consultation with the agency as they have an important say in how the international framework for space law is built. The international space agency is set to become the most powerful institution that will determine the course of human activity in outer space.

**Strength**

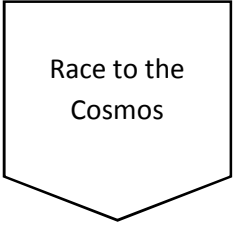
**Weakness**

Great cooperation between states has resulted in the usage of outer space for common problems of climate change and pollution

The integration of space agencies has led to an institutional arrangement where smaller members don't have a large voice

A space sector that is largely dependent on cooperating governments and large institutional organizations lacks innovation

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Race to the  
Cosmos

**III.** A new space race is in full swing between the biggest space faring nations. Ambitious space missions are set up by nations and their respective space agencies with the large institutional space companies profiting in the wake of this competition.

A rivalry has ignited between China and the United States with both countries regarding (access to) outer space solely as a strategic advantage. The rest of the world is forced to follow this race as the inevitable militarization of outer space also puts their national security needs first.

The international political arena has become a more chaotic environment as the hegemonic position of the United States has been challenged by China. The relationship between both countries has weakened over the course of the last years as trade wars, cyber wars and general conflicting interests have put both superpowers at odds. As a result, considerable investments have been made to increase their respective economic, political and military powers. Outer space is an important dimension in this struggle as information and communication through satellites is indispensable for national security. Techno-nationalism also reinforces investments made as each country considers its space achievements as a source of prestige. China was the first to establish a moon base and the US lagged behind. In response, the US announced plans for the colonization of Mars. The distinction between military and civilian space missions has also blurred over the years and the United Nations along with other international organizations have begun to formally question the goals of each space mission. The dual-use of space technology is the main concern and many of the space missions have been presented before the UN Security Council. However, the decision-making structure of the Security Council paralyzes any effort to normalize relations between countries through the United Nations and other international organizations have not been successful either.

The race has alarmed the other space-faring nations. Russia, Japan, India, Brazil, Canada and the European countries through the European Space Agency all have placed outer space highly on their own agenda. Old alliances are tested and new relationships are explored as the dynamic between China and the US determines the framework in which other countries try to position themselves. Earth's orbit is becoming busier with several constellations of satellites and space stations. Intense negotiations have been part of the dialogue between countries as they settle on how to assign orbital

slots. A delicate framework for the distribution for so-called governmental space rights had been established and is upheld for now. These space rights mainly outline the boundaries of how states can co-exist in outer space. The question that is pressing however, is whether countries will uphold these rights in the event of a large-scale conflict.

The governments of the world have made vast amounts of funding available for research of space technology and space capabilities. An unprecedented global development in the space industry is taking place where lucrative contracts and tenders are being rewarded. The older institutional organizations have gained much of these developments and have grown into a close relationship with their respective governments. Governments and their own native space industry are heavily intertwined and states dictate what technologies are developed. Many of which are focused on ballistics and intelligence. The militarization of outer space is increasing and there is concern that states have already developed offence capabilities in outer space. Satellites, space stations and moon bases are considered important national assets with the inevitable conclusion that these assets must be protected. A conflict or war on earth would now reach well into outer space as well.

### **Strength**

A great development in the space industry takes place due to governments pursuing outer space for its strategic advantage

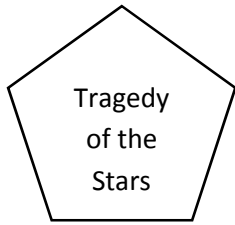
Advances in space technology have a spill-over effect in other sectors, although the focus is mainly on ballistic and intelligence technology

### **Weakness**

The dual-use dimension of space technology is more pronounced as states will actively steer towards strategic purposes in outer space

International organizations are mostly powerless as (powerful) states see no incentive to cooperate

The lack of international cooperation contributes to a polarizing international arena where states almost only consider their own survival



IV. States are in fierce competition with one another and the growing commercialization of the space sector has moved the international narrative to new heights as countries have an increasingly economical-political interest in outer space.

The world is divided between several countries that have conflicting relationships with one another. China and the US stand at the center and their actions ripple throughout the international community. Governments have a relative control over their native space industries as they still hold end responsibility for private activities explored in their national communities. The space industry itself is in spaceflight, utilizing abundant funds from public and private investors to explore ambitious initiatives and build upon their successes.

Testing their prowess in politics, trade and in outer space, China and the US have developed a competitive and almost hostile rhetoric in their relationship. A space race has been well underway for several years now and although the Chinese have managed to be the first to build a moon base, the US has gained a considerable lead in other areas. Launch capability, satellite technology and space mining are all areas that the US excels more in because they have nurtured an environment where private initiatives have flourished. The crowning achievement, however, was the first Mars base that is currently being expanded. The colonization of Mars has drawn numerous discussions and the United Nations has tried to facilitate talks on this topic. A (temporary) solution has been found which takes a form similar to the Antarctic Treaty. Any mission to Mars or activity undertaken can only serve peaceful purposes and all countries are allowed to explore and pursue their own Mars missions. The most important article of the Mars treaty, that no territorial sovereignty claims are recognized, is still being negotiated within the General Assembly. The US has, in the meantime, intensified their efforts to expand economic activity on Mars. Observers see a striking resemblance with the case of space mining. Although no celestial body may be claimed by any sovereign nation as ordained by the OST, materials extracted through economic activity can be claimed by the entity that has performed the economic activity. In the relative vagueness of the OST, countries have constructed their own legal framework in order to facilitate the private space mining initiatives. The US Congress has similarly passed a bill that creates a legal footing for any company to begin extracting materials on Mars for economic purposes.

States have also begun to express their interest in Jupiter’s fourth-largest moon Europa. The presence of water makes the celestial body a highly interesting target for potential economic activity and even settlement. No expense is spared and companies are more than willing to be employed by governments that pursue the next possible extra-terrestrial base. The space industry in this regard has almost no restrictions in what it can or may do save for one important regulation. Any joint mission or technology transfer between countries is carefully analyzed and, in most cases, kept within national borders. As a result, only the most capable space-faring nations are able to undertake ambitious space missions.

The relative unregulated space industry does come at a cost. Considerations pertaining to sustainability are second to economic and political success. The moon has become a testing ground for countries that aim for bases on other celestial bodies and the Earth’s orbit is littered with space debris. The European Space Agency has long tried to pursue its project of a clean space but the European Union nor the members of the ESA had any real interest in diverting their resources to this project and have instead invested in space mining, satellite and ballistic technology and extra-terrestrial habitation. It is likely that a Kessler-effect is only years away and experts have warned that if the international community does not act now, the very access to outer space will be in serious danger.

**Strength**

**Weakness**

The space industry is being driven by competing governments and a growing commercialization which leads to unapparelled developments within the sector

The lack of a comprehensive international framework for space law leads to loopholes that are being exploited through namely economic activity

Human expansion in the solar system is quickly becoming a reality driven by a growing space economy

Access to outer space and other sustainability concerns are a classic case of the commons, individual rationality leads to a depreciation of the common goods

## Value of selected theories in the future

The last step in the analysis of this study assesses the value of the International Relations schools of realism and liberalism and the Public Administration theories of complexity and network governance for the specific scenarios that were built to envision the future of human activity in outer space. To recap, what the future of how international cooperation and competition in outer space might unfold is a question that affects the collective international community. Realism and liberalism were therefore selected because they provide a systemic understanding of international cooperation and competition and can explain the same phenomena on earth, as in outer space. The theory of complexity provides an understanding of the interconnectedness of different actors and sets up the theory of network governance that aims to explain how actor might organize themselves in a cooperation. Network governance complements the theories of realism and liberalism by including different considerations such as trust and goal consensus and contextualizes the state-centric and systemic view of International Relations.

### **Realism and liberalism**

Both theories and their effluences provided the foundation for this study and the two conceptual models were based on the concepts of international cooperation and competition as understood by liberalism and realism. These theories also provided the lens through which a historic narrative was constructed that helped identify the uncertainties. Furthermore, the consultations underscored the importance of states and led to a reconceptualization of uncertainties which identified how states interact with one another as an important factor. The conceptual models for international cooperation and competition as a whole were then the ideal building blocks for the scenarios. Every scenario made use of the concepts provided by realism and liberalism. The scenario's that favored international cooperation were implicitly based on the case that states have an ambition to cooperate. The motivation for such an ambition might vary but the result is a future where states would seek to effectively reach a state of cooperation and seek the greatest result of that. Both scenarios also involved the notions of international organizations that had a facilitating effect. Particular importance was ascribed to the United Nations that already functions as a stage for international discourse. Given that states have an ambition to cooperate greatly increases the ambitions and effectiveness of international organizations as well. Another important concept in the scenarios was the (international) institutional arrangement which provided advantages over bilateral and issue-specific cooperative arrangements as an institutional arrangement was more

effective and efficient over time.

The scenarios that favored international competition were in their regard based on the implicit understanding that states operate in an anarchic environment and therefore considered their self-interests and own survival as paramount. The fear of relative gains was also an implicit understanding that drove states to compete with one another. For example, one scenario saw the two superpowers increasing their outer space activity because one cannot let the other be more powerful as this would inexplicably endanger their own position. It is reasoned that this space race triggered the rest of the international community to follow the same path for fear that their own survival would inevitably be compromised if they would not match their own power with others. There is one flaw in the theory of realism, however, that fails to capture the full spectrum of international relations in the future. Realism is a pure state-centric theory that largely ignores the roles of international organizations and other non-state actors. It is true that international organizations were powerless if states did not have an ambition to cooperate as envisioned in the scenarios but the importance of the private sector is then also ignored. The scenarios placed great value on the private space industry – with the emphasis on New Space – and realism on its own fails to capture that.

### **Complexity and network governance**

The theories of complexity and network governance were included to compliment the theories of International Relations and were therefore less pronounced in the scenarios but nevertheless also important. For example, one important and implicit driver for states to seek institutional agreements was the notion of complexity and its particular iteration in the form of wicked problems, as a joint space mission or any cooperation involves a large number of actors as they possess resources that can greatly contribute to the success of any ambitious (space) endeavor. This also involves the ideas of network governance where a high number of actors involved and the resources they control affect the institutional design of a cooperation. One scenario that favored international cooperation saw a large concentration of resources in the possession of a small number of actors and the institutional arrangements favored this small group as a result. The other scenario that favored international cooperation saw the required resources and responsibilities much more evenly spread out and the institutional design of that cooperative case was more egalitarian.

# Conclusion

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What we will do in outer space is an extension of the worldly affairs that dictate how we behave. As such, “we” refers to humankind as a whole and this thesis has sought to answer what our future in outer space might look like. Certain steps were made in preparation for this answer. The first was to understand humankind as a collection of entities that enter into certain relationships with one another. The theories of International Relations were selected to ground this study because they provide a framework to understand those entities as states, international organizations and institutions. The theories of Public Administration were chosen to supplement this understanding in order to consider the complexity of the interconnectedness of these entities and how these might organize themselves in a cooperative endeavor. Two conceptual models were then created that encompass the full spectrum of how these entities behave; competition or cooperation. The scenario-planning method TAIDA offered a method to envision the future based on a historic narrative, identification of trends and drivers and finally a number of uncertainties. The method also tested the value of the theories of International Relations, Public Administration and both conceptual models as their relevancy was assessed in the scenarios.

Two uncertainties were identified as most important after a consultation with experts; whether states will cooperate or compete and whether the commercialization of space industry will stop or grow. The dichotomous values of each of these uncertainties has been the foundation that provides an answer to this study’s central question; what strengths and weaknesses can be identified in the future scenarios of international cooperation and competition in space?

Four unique scenarios were constructed, each providing a distinct possible future.

- I. The premise of the first scenario was a growing commercialization of the space sector and an international community that pursued cooperation. This scenario saw a quick development of the space industry which enforced international cooperation because states would provide a comprehensive framework wherein businesses could operate.
- II. The premise of the second scenario was a commercialization stop of the space sector and an international community that pursued cooperation. The public sector was



wholly responsible for any activity in outer space and lead to the creation of an international space agency. An inevitable redundancy and bureaucratization was the consequence but a unified international community could effectively take on common problems.

- III. The premise of the third scenario was a commercialization stop of the space industry and an international community that pursued competition. A new space race dominated the international narrative and governments would allocate resources to stay ahead. Much like the first space race, this rivalry between the US and China foreshadows a repeat of history.
- IV. The premise of the final scenario IV was a growing commercialization of the space industry and an international community that pursued competition. A maturing and expanding space market was placed within the narrative of a space race. This growing market meant that governments now had increasingly economic interests in outer space, aside military and political.

Outer space is often associated with an ideal of a bright future of humanity in which we can almost leave behind all the squabbling, wars and diseases. A single quote by the late Carl Sagan (1994: p. 167) about a photograph taken from Voyager 1 at a distance of 40 AU from earth captures this yearning:

*“It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another and to preserve and cherish the pale blue dot, the only home we’ve ever known.”*

A captivating string of lines which has partly been the ambition for this study. This study, however, highlighted the inescapable intertwinement of worldly affairs with what we do up there. The schools of realism and liberalism were an exact match for describing how the future might look like because outer space is an extension of how we, the international community, behave with one another. The value of both schools in describing the future is thus confirmed, partly because these schools are so broad in nature that they could be applied to any future scenario that is dependent on interactions within the international arena. Realism with its state-centric view, the ideas of

relative gains and the hegemon are all valid concepts applicable to a myriad of scenarios. Even if an asteroid would endanger earth, realism would still be valid in explaining that states would seek cooperation in order to face a greater enemy. The same goes for liberalism and how international institutions and organizations facilitate cooperation. The value of both schools would only be undermined when a future is imaginable that would see no international community of states or where one single government rules as the highest authority; which is not imaginable in the near future. The theory on complexity and network governance follows the same logic. Both theories provide a valid explanation of what could happen because they describe the way people and groups of people interact with one another. And likewise, the only way the value of both theories could be undermined is when there would be no more groups of people with differing interests. This reasoning serves as a confirmation of the value of these theories put to use in future scenarios; one of the goals of this study.

The scenarios themselves all depict an extreme situation. All the interviewees hoped for a future with great cooperation between states, implicitly stating that no one would obviously favor a world with tense relationships between states that could well be on the brink of war. All the interviewees were also in favor of more commercialization in the space sector with greater competition leading to innovation. Yet the future could hardly be this ideal situation. It is much more likely that states will maintain a close grip on their commercial space sectors because this is vital for their strategic agenda and states will stay in (fierce) competition with one another as is currently the case. A game of relative gains with a nation's interests, and essentially its survival, on the line. This leads to reason that the game is to gain the upper hand, at the cost of any commons that the world might share. As the world is conflicted, what we do in outer space cannot be free of the agenda's and interests of those at odds. The yearning for an ideal understanding of a united humanity will therefore remain a wish, at least in the near future.

## Reflection

An appreciation will conclude this chapter and form the final part of this study in which a reflection will be given on the value of the selected theories and the methodology. The appreciation will also include the deliberations on what choices were finally made in this study.

### **Theoretical framework**

The theoretical framework has drawn from the fields of International Relations and Public Administration. The International Relations schools of realism and liberalism were selected because they represent the spectrum of how states can interact with one another. Different schools were deliberately omitted from the study as the scope of this study would not be fit, for example, to study how international politics is affected by gender or the material conditions as respectively represented by feminism and Marxism. Realism and liberalism were also selected because they form the foundation upon which the field of International Relations is built. Both theories provide an understanding of how cooperation and competition on an international (systemic) level can take place. One important comment which refers to the recommendation made is that realism and liberalism are systemic levels of analysis and it can be worthwhile to investigate the unit and individual or sub-unit of analysis. The unit level of analysis refers to the state level and concerns itself with how a state might relate to the international order and how its political organization, e.g. democracy or communism, might influence its behavior. The individual or sub-unit level of analysis refers to levels subordinate to the state level and concerns itself with relations between different parts of governments and politics. The individual unit of analysis is specifically designed to move away from a state-centric view in International Relations.

The theories from Public Administration served as a contextual framework that complemented the theories from International Relations. The theories of complexity and network governance helped ground certain aspects of (international) cooperation in how powerful countries can organize cooperation and implicitly pull the decision-making process towards themselves. This was especially important in formulating the scenarios where one case imagined a more plural organization because of the complexity involved, and the second case imagined a much more vertical organization due to a number of powerful countries possessing much of the resources that were required in that given situation. Given the consultation results, however, it would have also

been worthwhile to include more economic theories on world trade or transfer of technology for example.

## **Methodology**

The operationalization of international cooperation and competition proved to be of significant value in the process of creating the scenarios. The models were intended to be used as a comprehensive guide in which important parts would be used to explain how the future of human activity in outer space may be understood. The consultation revealed however that the importance of the state was paramount. The reconceptualization of the uncertainties was the result, which led to one two important uncertainties simply asked how states would interact with each other. Cooperation and competition were then the two dichotomous values that represented a full spectrum of the relations between states.

The scenario-planning method TAIDA was a method that has given this study a unique process and result. The OECD studies also constructed possible general futures but they involved an exploration of developments and trends and followed these to a logical end. This study has also identified trends and a historic narrative but the defining step – starting from uncertainties – has produced a different result which stands in stark contrast with the OECD studies and can therefore add a distinct appreciation on how to envision the future of the space sector. An important step in this process was the selection of the two most important uncertainties and eleven experts were consulted in this regard. Two comments can be made. The first comment relates to the number of experts and this study would have benefitted from simply involving more experts. The second comment relates to the background of the experts. Although the study has aimed to include experts from diverse backdrops – including science, government, associations, businesses large and small and space agencies – they all originated from within the Netherlands. The scope of this study concerns the whole world however and experts from different countries could have provided a more diverse insight.

An important comment that must be mentioned is that there was a specific bias involved in this study. The theories of International Relations and Public Administration and the conceptual models were found to be greatly relevant in the scenarios. The relevancy, however, was also partly the outcome of a process that was biased towards those same theories and models. The scenarios were based on uncertainties that were framed through the concepts of the aforementioned theories and models and the scenarios were also constructed on trends and a historic narrative that were

identified through a lens of those same theories and models. This bias is, however, inescapable as the reality of any methodology that tries to envision the future is the fact that it has to be established on certain theories and is therefore inclined to follow those theories and be judged by those theories. There is no independent measure or criterion because the future is simply said not known. Lastly, the appreciation of the scenarios, identifying the strengths and weaknesses, was grounded on certain normative assumptions. That is to say, on one specific normative view which is the perspective of the common good. A different appreciation could be done that reasons for example from the perspective of only the most powerful (space-faring) nations. The common good perspective was chosen because it refers to what is beneficial for the most of a single community. For a study on what the future of human activity in outer space might look like implicitly refers to the future of all.

# Literature

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# List of respondents

This appendix show the respondents that have been consulted. The list show the name, function, organization and the date of the interview.

Name	Function	Date
Tanja Masson-Zwaan	<u>Asst. Professor and Deputy Director</u> International Institute of Air and Space Law	15/1/2018
Eelco van Eijck	<u>Program manager Space Policy</u> Ministry of Economic Affairs and Climate	17/1/2018
Juan de Dalmau	<u>Head of ESTE &amp; ECSAT Communication Office</u> European Space Agency	26/1/2018
Reineke van der Kolk	<u>Manager Public Affairs</u> Airbus Defence and Space Netherlands B.V.	31/1/2018
Gerard Blaauw	<u>Chairman</u> Netherlands Space Society	7/2/2018
Erik Laan	<u>Founder and Space Industry Consultant</u> Eye on Orbit	14/2/2018
Jeroen Rotteveel	<u>CEO</u> Innovative Solutions in Space	16/2/2018
Jerre Sweers	<u>Managing Director</u> Stellar Space Industries	22/2/2018
Jeroen Glazener	<u>Coordinator Brussels Program</u> Netherlands Space Office	8/3/2018
Kees Buijsrogge	<u>Director</u> TNO Space	20/3/2018
Marco Beijersbergen	<u>Founder</u> Cosine Measurement Systems	20/3/2018