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ENHANCING EFFICIENCY IN INTERNATIONAL COOPERATION BETWEEN MEMBERS OF THE EUROPEAN SPACE AGENCY

Master Thesis

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I hereby confirm that I have written the Master's thesis independently.
All works and major points of views from other authors, data from other sources of literature and elsewhere used for writing this paper have been referenced.

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ABSTRACT

The aim of this thesis is to demonstrate the significance of international cooperation for peaceful collaboration between nations in science as well as politics. International cooperation is essential for exchanging knowledge, technology and gaining a competitive advantage on the global market. I will argue that international scientific cooperation can help foster cross-cultural understanding and improve cross-country relations both among individuals and on a political level. The paper will focus on the European Space Agency (ESA) as a successful example of international cooperation. It will highlight ESA's cooperation agreements and its benefits for the nations involved and its citizens. The thesis assesses both weaknesses and strengths in the ESA bound cooperation amongst its member states, as well as its cooperation with the European Commission. Finally, it visualizes the current situation and points out potential considerations for future directions and development in the form of a structural model, and analyses the implication for other international organisations.

Keywords

International Cooperation, ESA, European Commission's Space Policy, Policy Alignment, Competitiveness, Communication

LIST OF ABBREVIATIONS AND ACRONYMS

CEO	Chief Executive Officer
CERN	European Organization for Nuclear Research
CFSP	Common Foreign and Security Policy
CNES	Centre National d'Études Spatiales
CNSA	China National Space Administration
CSG	Centre Spatial Guyanais / Guiana Space Center
DLR	Deutsches Zentrum für Luft-und Raumfahrt / German Aerospace Center
ECS	European Cooperating State
ELDO	European Launch Development Organisation
ESA	European Space Agency
ESO	Estonian Space Office
ESOC	European Space Operations Centre
ESRO	European Space Research Organisation
ESTEC	European Space Research and Technology Centre
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EC	European Commission
ECS	European Cooperating State
EGNOS	European Geostationary Navigation Overlay Service
GDP	Gross Domestic Product
GMES	Global Monitoring for Environment and Security
ISRO	Indian Space Research Organisation
ITT	Invitation To Tender
JAXA	Japan Aerospace Exploration Agency
NASA	National Aeronautics and Space Administration
PECS	Plan for European Cooperating State
PPP	Public-Private Partnership
ROSCOSMOS	Roscosmos State Corporation for Space Activities
SME	Small and Medium-Sized Enterprise

TFEU	Treaty on the Functioning of the European Union
TTIP	Transatlantic Trade and Investment Partnership
UN	United Nations
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space
UNOOSA	United Nations Office for Outer Space Affairs
US	United States

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INTRODUCTION

Whether it concerns trading goods, solving political matters or generating knowledge, international cooperation has become more and more important in an increasingly advanced and connected society. Most global problems cannot be solved by nations individually but need cooperation and support from other nations in various areas. Be it finding solutions to war, countering terrorism, tackling climate change, or designing a mission to Mars, many complex issues can only be solved through joint collaboration. However, it often proves difficult to find effective ways of cooperation, especially if multiple nations are involved. Hurdles such as cultural differences, language barriers, knowledge gaps or policy incompatibilities might block successful cooperation. Overcoming these hurdles and building more successful collaboration among nations is one of the core issues of research regarding international cooperation in international relations; particularly as successful economic and scientific ties have shown to improve political terms. International cooperation has been identified as one of the key research areas of the European Union (EU) regarding its Horizon 2020 research goals. For this reason, many reports of the European Commission are focusing on key areas and problems in international cooperation. Furthermore, several of these reports establish a connection to the European Space Agency (ESA) as one of the main organisations in international cooperation in research and innovation in space technology in Europe. The following research will focus on the importance of international cooperation for increased efficiency and competitiveness of the agency in an increasingly competitive global environment. ESA, along with its collaboration in the International Space Station, is considered to be one of the most successful organisations in peacefully coordinating transboundary research projects world-wide. Understanding the mechanisms behind the cooperation structure within the agency might help to enable further peaceful international cooperation within more nations in the future. Chapter 1 pinpoints the main research questions and elements needed to solve it.

In Chapter 2, main concepts of cooperation on different levels will be outlined. The chapter begins with the core elements of cooperation and moves to the specifics of international cooperation, in particular international scientific cooperation. A brief history of the development of ESA as an organisation provides aid to clarify and understand the

cooperation mechanisms and relationships between the different institutions and members. The following chapter will highlight not only the cooperation between members of ESA but also the cooperation agreements between ESA and the EU, which will become increasingly important in the future years. In 2007, the European Commission defined a Space Policy for the EU in the Treaty of Lisbon and has since then increased its collaboration with ESA. Although there are several studies and reports presenting the developing cooperation between the European Commission and ESA, they are mainly focussing on the current *status quo* and possible shortcomings, and do not offer any suggestions for improvement. As the analysis of the European Commission's communication reports as well as ESA documents show, there is still a lack of coordination and a lack of knowledge on how to cooperate more successfully. The same applies to ESA's policy coordination with its member states. Since this area is very topic-specific, only little research has been conducted on how to overcome these hurdles in cooperation. The aim of my master thesis is to fill this gap and to provide answers on how to better align policies and make coordination more successful and efficient. Those areas, in which ESA lacks coordination are identified and addressed in more detail. Whereas ESA and EC reports always only offer one-sided point of views, this analysis will include all possible aspects and will not only state the problem areas but also attempt to find a viable solution. This will help ESA to become more competitive globally. Considering recent developments in space politics this is essential for remaining a leading organisation in space research and technology, particularly as states such as China and India are rapidly increasing their own space capabilities.

In Chapter 3 and 4, a case study of ESA and its members will be used to assess its relations to its member states and to the European Commission and identify strengths and weaknesses. Case studies are frequently used in social sciences and differ from other forms of research as they are first and foremost qualitative in nature rather than quantitative. They are usually confined to one case or to a few at the maximum. This has led to debates whether case studies allow for generalizability (Hammersley, Gomm 2009, 4-6). Results obtained by case studies, without doubt, have to be viewed in a distinct manner from quantitative forms of research or statistics. Their case-specific nature does not allow for an immediate transfer to other cases or to generalization. However, one major advantage of case studies is their in-depth analysis that allows for unique approaches and solutions for one specific case. These solutions can (but not necessarily need to always) be transferable and provide support in similar circumstances. A case study was chosen as a method of analysis of international cooperation structures for a number of reasons: it will shed light on many aspects of theory of

international cooperation and test arguments for applicability in a real-life example. It can be argued that case studies, in a case like this, can provide more in-depth analysis and more thorough testing of a theory than the alternative – a comparative study – would provide. Comparative studies or probable theories derived from them can be tested best for their likelihood and applicability in a specific situation (Eckstein 2009, 129). In comparison, a case study provides an in-depth understanding of the analysed organisation and can identify unique challenges and weaknesses that can be used in helping the organisation to develop. In some circumstances, insight from one case will also provide useful strategies applicable to other cases. One line of argumentation on case studies follows the consideration that they "do not aspire to statistical generalizability; they aim for analytical generalization through theory" (Bartlett and Vavrus 2017, 117). Although qualitative research might not seem to have the same general applicability, it provides a unique testing ground for theories and assumptions and offers unique insights that can be applied to aspects of future cases. The focus will be put on creating an explanatory case study, which is to be distinguished from descriptive or exploratory case studies (ibid. 31). The method applied in the following case study includes an evaluation of the different hierarchical structures on a horizontal level. It aims at explaining how cooperation within ESA functions and how a higher level of efficiency might be reached.

Case studies have a tendency to lead to fairly large amounts of data. In order to systematically structure this data and to analyse the institutional structure of ESA, an institutional model will be created and evaluated by using the information collected through the thorough literature research as well as supplemented information through open questionnaires and interviews. It will help to envision the structure and relationships within the space agency and allow for better insight. Since not all information can be obtained by literature research, the use of semi-structured interviews based on a questionnaire was chosen as the most suitable method to obtain missing data. While semi-structured interviews allow a certain level of guidance through the interview, the interviewee is still able to elaborate on aspects that are of importance to him or her. As a result, the maximum amount of relevant information can be detected. Additionally, including participants from various areas of cooperation allows for higher saturation and a sufficient base for research. As in any area of communication, interpreting the utterances correctly represents one of the main challenges (Alsaawi 2014, 151-155). The collected data will be used for the design of a structural model.

Modelling of the institutional structure will help gain insight in the relationships between the different actors and will form a basis for the facilitation of future decision-

making. As pointed out by Joshua M. Epstein (2008), there are several reasons for constructing a model: it offers guidance in explaining events or possible outcomes of an event, reveals core dynamics and uncertainties, facilitates data collection and the development of new research questions, questions the status quo and sparks debate, and, in addition, shows trade-offs and offers alternatives. Models educate and train practitioners as well as the public and offer alternatives in conditions under which the current set-up fails to function effectively (Epstein 2008). While models are always idealisations and can never depict reality in all its details, they can offer a way to better understand certain dynamics. Particularly in a world filled with vast amounts of information, it is a viable option to use models as a framework for analysing and understanding data (Page 2013, 10) Models are simplifications that help us understand the world. Although by definition no model is perfect, they offer support by revealing the conditions necessary for the model to work or even by identifying its flaws. Models are frequently used to depict natural systems, but are beginning to be more frequently applied to social systems. What makes application in social science more delicate is the fact that, in contrast to natural systems, many actors tend to not always act rationally. In addition, there are no direct causal relations in complex systems. For one outcome there are usually several interrelated causes. This makes it challenging to deduct any causes or to link strategies with certain outcomes. Nevertheless, models allow depicting complex realities in a simpler and easier graspable way and foster the creation of potential future scenarios. For this, the assumption that human actors are striving to reach the best possible outcome lying within their capabilities is a necessity to warrant a model's survival (Page 2013, 9-17). To sum up, the different arguments show that although models offer only potential outcomes and no certainty, they are valuable tools for making decisions. The more models there are available as tools, the less strenuous deciding on future paths will be.

All the results obtained from the case study and the creation of the model are summarized and analysed critically in a final chapter. The conclusion highlights deductions derivable from the conclusions made and provides an outlook for potential areas of future research.

1. RESEARCH QUESTIONS AND HYPOTHESIS

The European Space Agency is a unique international organisation, which combines research efforts of more than 22 states and has enabled peaceful scientific cooperation for more than 60 years. It was involved in some of the largest peaceful cooperation projects the world has ever seen and still provides a platform for exchange and innovation. This makes it a valuable institution for Europe and the world. Nonetheless, studies of ESA have been rare in comparison to other international organisations. What makes this research topic even more a novelty is the fact that whereas both the European Space Agency and the European Commission have stated complications in their cooperation, as well as in the cooperation between member states, there has been no further research conducted in this area and no possible suggestions for improvement made. As both the EU and ESA are planning on increasing their cooperation agreements and policy alignment, a new structure for cooperation is necessary. Successful international cooperation within ESA will lead to an improvement in competitiveness, possible further integration of its members and a higher quality in research.

An improved cooperation structure will increase efficiency within ESA and will have positive effects on cooperation in the global international community. In order to achieve cooperation, reasons for a lack of cooperation as well as means to improve it have to be discovered. When it comes to international cooperation within ESA members, cooperation deficiencies might exist due to overlapping or non-aligned policies as well as impairment in communication, among member states, and in particular, between the EU and ESA. In order to test this assumption, the cooperation structure of ESA will be analysed.

The outcomes of the research conducted will benefit citizens of the member states as well as the states and their economies as a whole. In observing successful cooperation strategies, ideas and guidelines might be discovered that can be applied to other areas in which cooperation between nations is still facing difficulties. Trying to improve cooperation within ESA is therefore essential for both the agency and its outside implications. The thesis will deal with examining current weaknesses and suggest possible new methods of tackling them. By understanding ESA's structure and cooperative mechanisms, not only can the efficiency within the agency be assessed, but also lessons can be learned for other areas of

cooperation in Europe or the world. Literature on international relations theory highlights the significance of international cooperation for various sectors of relations in an international arena, in particular for science and space research in Europe.

In order to understand the functioning and the significance of the organisation, one research question arises. Eventually, the aim of this question is not only to reveal new information, but also to allow assistance of the agency itself in its goal of remaining a forerunner in a growing competitive international space environment. The overarching question, therefore, is: *How can ESA become more efficient in an increasingly competitive international environment?*

To answer this research question six different angles were identified and used. Each of the different angles contains a core element in understanding the cooperation structure of an international organisation. Addressing and analysing those elements allow for the design of the most efficient cooperation structure and a solution to the research question.

1. *ESA's current membership structure and reasons behind it:* First of all, ESA's structure in addition to the relation to its members and the European Union have to be identified. Reasons for the development of this structure found in its historical development and in its convention are necessary in order to understand its current position in Europe. This angle will be highlighted in detail in order to be able to cover more in-depth enquiries in the next steps.
2. *ESA's current position in international space research:* With other dominant space agencies and a growing demand for space research and exploration worldwide it is necessary to embed ESA in its current international environment to understand the need for its growing cooperation and memberships.
3. *Main challenges and opportunities regarding cooperation:* Understanding still existing or growing challenges will help address one of the core issues needed to be solved before efficiency and competitiveness of ESA can be increased. This question might reveal similarities to other international organisations. Challenges will be revealed through literature research, interviews as well as questionnaires sent to national space agencies and ESA project participants. Differences in national space interests, EU and ESA's interests will be identified. To recognize the main benefits of collaboration for ESA and its members it is important to understand the interests of governments, businesses and civil society in space sciences and their involvement in

ESA. This question is at the core of addressing why international cooperation in space is needed.

4. *Potential options for funding:* One essential element for creating a more efficient and competitive European Space Agency is increasing its budget. There are different options for doing so, from government funding, EU funds, private-public partnerships to civil engagement.
5. *Opportunities for improvement of cooperation and policy coordination mechanisms between the European Commission and ESA:* In particular with its Horizon 2020 programme, the EU and ESA policies and programmes overlap in many aspects. A clear and coordinated approach can help to increase the overall performance of Europe in the global space sector. Aspects 5 and 6 are crucial in explaining how the competitiveness of ESA can be increased.
6. *The ability of international cooperation to increase integration of European Union member states:* This last angle aims at identifying similarities and parallels between the cooperation of European countries in ESA as well as in the European Union. Can the way states are interacting in ESA have a positive influence on their perception of belonging together in a European context? This question looks at potential implication for joint research, projects and politics.

Different tools were used to discover an answer to the overarching research question. Relevant data was assembled via in-depth literature research in chapter 2, which reveals the importance of cooperation for international relations, particular in the context of space research and exploration. Based on conclusions of literature research in chapter 2, issue areas will be observed more closely in form of a case study of ESA in chapter 3 and 4. The case study will reveal possible options for improvement in the cooperation and policy coordination between the different agents. The focus will be put on the relationship between ESA and its members, as well as the EU. To understand cooperation structures within ESA it is relevant to understand historical relations as well as ESA's current structure.

On the basis of the literature research, chapter 4 aims at addressing all the sub-questions with support of interview and questionnaire data. The literature research is supplemented by several interviews or open questionnaires with representatives of national space agencies, project coordinators with ESA or ESA representatives themselves. To identify ESA's need for efficiency, its current position in the global competition for space was analysed. Finally, a structural model was designed to highlight structural relations within ESA

and help identify challenges within the cooperation mechanism. Identifying fruitful cooperation procedures within ESA will facilitate long-term cooperation with other international actors and provide guidelines on future conduct in space cooperation, particularly as this area is currently still only marginally regulated.

Furthermore, international scientific cooperation and international politics find themselves deeply intertwined. It can be argued that cooperation on a scientific level also has benefits for political interaction and political integration of the member states. However, I believe that in the case of the European Space Agency, increased policy coordination and joint implementation will face difficulties as several members of ESA are not members of the EU and some EU members are not members of ESA. Increased funding from the EU will challenge this divergence. However, the creation of a single framework for cooperation in space with implementation in all member states – both of the EU and ESA – and an inclusion of EU members to ESA are needed to facilitate cooperation and increase its competitiveness in a long-term perspective. Formulation of a clear long-term goal as well as increased financial support to improve the quality of education and scientific research in all EU member states will assist this process. The development of a structural model will help to gain insight into cooperation processes, reveal relationships between the different agents and help decision-makers in deciding on future pathways.

2. COOPERATION IN INTERNATIONAL RELATIONS

2.1. Cooperation

Cooperation is an essential part in society's capability to function and survive in an ever growing and complex world. To understand cooperation in all its forms, different levels of interaction have to be distinguished: the level of the individual, the level of different organisations within one state or jurisdiction and the level of transboundary, international interaction.

Cooperation starts at the level of the individual, where working together allows a person to succeed in more actions than by working alone. Imagine a heavy table that would be impossible to be lifted by one person but can be moved if two people cooperate and support each other. In order to know in which direction the table will be moved, communication between the two actors is of utmost importance, or else both might be pushing in opposite directions even though their goals (moving the table) might be the same. For cooperation to be successful, it takes not only clear communication but also the agreement on the direction to be taken. The latter will to some extent depend on the power of the two individuals, their willingness to cooperate as well as the degree of importance of the decision to be made in their eyes. If both individuals want to move the table, but both, for instance, want to move it to their own room, both of them will be stuck and no outcome will be found. This example shows that actors tend to cooperate only if there is a gain involved by doing so (even if this might only be the promise of a friend to help moving objects at a later point in time). However, if they manage to cooperate, hurdles impossible to surpass as an individual can be easily overcome. This idea can be further applied to research groups or think tanks whose members can support each other and help gain a broader and more in-depth understanding of the research topic by cooperating and sharing information. In the majority of cases, this leads to more significant research outcomes. In addition, potential flaws, errors and alternatives can be better analysed. Cooperation therefore can lead to superior outcomes, but it requires a joint action that both parties agree to.

What is striking is that the Cambridge Advanced Learner's Dictionary (2017) defines cooperation at an individual's level merely as "the act of working together or doing what they

ask for". The focus of this definition is placed on agreeing to work together. Certain motifs are not specified or needed – basically, benevolence of one actor and/or the willpower of another actor might be enough to reach cooperation. However, in a business context the definition is changed to seeing cooperation as "the process of working with another company, organization, or country in order to achieve something" (Cambridge Business English Dictionary 2017). What this definition implies in comparison is that the parties working together only do so in assuming that both will be benefitting from the situation. As a result, cooperation will always require a certain degree of relative or absolute gain in order for the parties to enter into any type of cooperation agreement. Although this might sound logical, it is an element frequently diminished in debates between divergent organisations with different aims but a need for cooperation. In order for cooperation to be established, a certain degree of overlap of goals and ideals that allow both parties to benefit from the situation is needed. To a certain extent, cooperation always includes a degree of selfishness in any rational actor. Interests of the actors and their goals are closely linked to their willingness to cooperate. Tom R. Tyler sees cooperation as "a decision about how actively to involve oneself in a group, organization, or community, through taking actions that will help the group to be effective and successful"; at the same time, he recognizes that this often results in "a conflict between an individual's immediate personal or selfish interests and the actions that maximize the interests of the group" (2013, 21). Cooperation can only take place if the different actors are willing to focus on long-term goals and advantages. Those long-term goals have to be of equal or greater value as the individual's short-time benefits of not-cooperating. Moreover, the actors have to be aware of the existence of such long-term benefits. In addition, cooperation requires certain rules and regulations under which actors can collaborate to ensure the equal reception of benefits in the future. Otherwise, the prospects of future gains will be eagerly swapped for individual, short-term gain, often in the form of economic advantages. A working mechanism ensuring cooperation and sanctioning uncooperative behaviour is therefore a requisite in reaching long-term goals.

What is often neglected when talking about cooperation agreements between states or large organisations is that this is not only a decision head of states or CEOs have to agree to, but an agreement that has to be accepted on all levels. One example is the planned economic cooperation agreement TTIP, which was seen as beneficial by politicians, but had to be withdrawn due to huge resistance from civil society. Another example can be seen in the EU member states' citizens' resistance in accepting negotiation talks between the EU and Turkey for membership of the latter. Similar instances can be found in business corporations that

want to achieve a change in their structure or their partnerships. In order for cooperation to be successful, there not only needs to be external cooperation but also internal cooperation. Internal cooperation ensures coherence within an organisation. A simple agreement matrix, as presented in *Figure 1*, can help determine the expected level of agreement and cooperation within one organisation. The x-axis of the matrix generally shows the individual members' agreement on cause and effect, whereas the y-axis represents their agreement on goals and aims (Christensen et al. 2006).

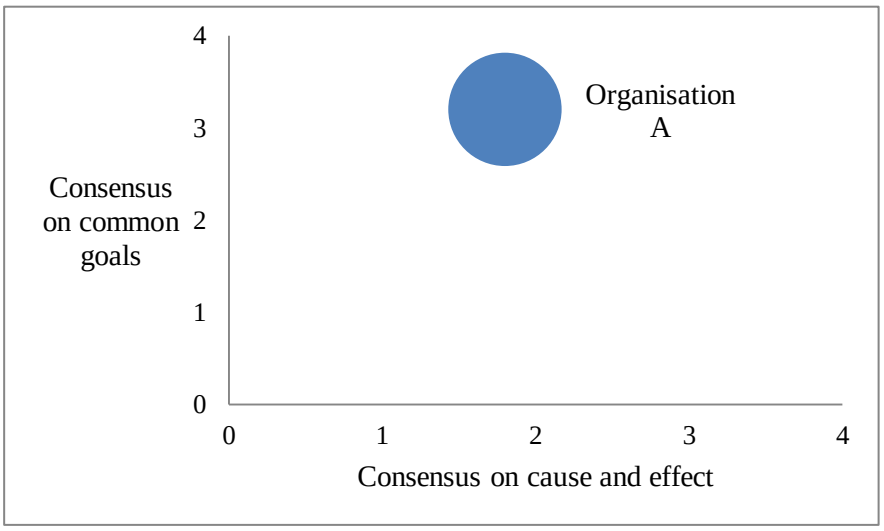

Figure 1. Simple Representation of an Agreement Matrix
Source: (Designed by the author)

The higher the consensus on common goals and aims as well as the causes and effects among the members of the organisation, the higher their willingness to cooperate and to adapt to changes in structure or system. An understanding of causes and effects and expected outcomes will make all members of an organisation more likely to support a decision and engage actively in achieving the best possible outcomes. An agreement matrix can be a helpful tool in observing internal acceptance of decisions and willingness to cooperate. The matrix can also be applied to cooperation between different democratic countries. Democracy can encourage cooperation but only if most citizens of the participating countries display a common understanding of and consent about causes and effects of the cooperation as well as a high level of harmony on their expectations and expected aims. Representation of agreement in a matrix can be a useful tool for international organisations, such as ESA, too. While there mostly is a high level of consensus on cause and effects in a team of specialists, consensus on goals might be lower depending on national interests. Splitting programmes into

mandatory and optional parts can be seen as a response to create higher agreement on goals and by doing so increases the approval within the organisation in all areas.

Cooperation is an essential factor in the success and efficiency of any organization, be it one of national, international, private or public nature. This can be explained by the fact that in "organizations, the benefits of membership depend, in the long term, upon maintaining the efficiency and effectiveness of the group. This requires cooperation from group members" (Tyler 2013, 21). Only by cooperating successfully and efficiently, does cooperation offer advantages over working individually. Especially, in an international organisation, such as ESA, awareness of all the different tasks and actors can be challenging. Whereas Tyler considers cooperation relevant for any member of an organisation on the level of individuals, a similar logic can be applied on the level of member states. Member states will benefit from interacting with each other under one larger organisational structure if they are willing to adhere to certain rules and regulations and investing in joint long-term goals rather than their own short-time interests or advantages.

Another important aspect to cooperation is "culture". The term *culture* can be applied to many different structural levels. For the purpose of this study Edgar H. Schein's differentiation between *macrocultures* and *organisational cultures* will be used. Culture can be defined as "a pattern of shared basic assumptions learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems." (Schein 2010, 18). Culture therefore is created where shared experiences and a history of previous practises exist. Culture forms the basis of our social structure. It provides society with a certain framework of rules, values and even language that helps members of society understand and master their lives. On a macro-level this refers to culture in specific nations, ethnic groups or even occupations. *Organisational cultures* function on the same basis as the members of an organisation share a certain set of values, beliefs, rules as well as a specific jargon. Organisational culture plays a relevant role ranging from private, public, non-profit to government organisations (Schein 2010, 2-3). It is this definition of culture that needs to be taken into account when dealing with cooperation between different organisations and different countries. Different concepts in social structure, worldviews, norms or different approaches to solving a problem pose additional challenges when attempting to achieve cooperation on an international as well as an "intercultural" level, be it across different organisations or countries. Clarity in communication and an awareness of potential different ways of addressing problems or situations are essential to manage joint

projects successfully. Sharing a similar (business or organisational) culture can immensely benefit a project as it helps members to collaborate effectively by offering certain shared rules and guidelines for behaviour and action. However, adding insights from different practises and experiences allows for more creative and innovative solutions. This is a particularly relevant aspect for ESA as the large scale of the projects connects various project members not only from different countries but also different business as well as science areas. The ensuing divergence in size, field of expertise, background and organisational structure of the project members render clear communication and guidelines invaluable for swift cooperation. By ensuring that participants of a cooperation project are aware of and agree to certain rules of procedure but by allowing them to jointly discover the best possible way to address a problem, solutions to hitherto insurmountable issues can be created.

2.2. International Cooperation

The necessity for international cooperation applies both at the level of nation states as well as at the level of large international business organisations. In certain cases cooperation within one nation or region might not be enough to solve a problem or create a new technology but collaboration with several countries might be needed. There are several circumstances, under which international cooperation will prove to be a requisite: First of all, certain issues might transcend across national boundaries and have to be addressed on all ends to be solved, from global warming, supply-chain inefficiencies to pollution of the lower-earth orbit. Only by working together across different nations or sectors can certain limitations be overcome and solutions to complex problems be found. Secondly, lack of resources, space or personnel might make it necessary to work together across larger regions or sectors. Combining material as well as financial resources allows for larger scale projects or research increasing the potential for new discoveries and innovation as risks and costs can be shared and therefore reduced for every individual participant. Thirdly, cooperation across different nations connects different approaches and various ways of thinking which allows overcoming hurdles previously thought of as impossible to overcome. Fourthly, some scholars argue that international cooperation creates interdependencies and connects people from different nations. As a result, this can lead to a decreased likelihood of wars and conflicts. This concept is mainly based on a liberalist perspective that interdependence “operates like the reins on the dark horse of inner passions; it provides a material incentive to stay at peace, even when there

are internal predispositions towards aggression" (Copeland 1996, 14). It is to be questioned if this concept can be applied in all cases, particularly when the core industry or economy of a country is at stake. However, in areas where cooperation for both countries proves to be economically beneficial, incentives to cooperate more closely on a political level are created.

Overall, it can be seen without doubt that cooperation, in particular international cooperation, is not only beneficial but also necessary in order to find novel techniques or solutions to complex problems. Scholars have disagreed on how this cooperation should be structured in an international arena in order to achieve the best outcome and highest level of stability. Realist scholars have argued that cooperation can be achieved only through the existence of a hegemon with sufficient power to control the other nations. The US is seen as the prime example functioning as a hegemon in (at least being essential for the initiation of) international trade and finances, as well as in space exploration in recent years. This theory has been criticized as it focusses mainly on the hegemon and neglects the role of smaller countries in the establishing and adhering to an international order (Jackson, Sørensen 2013, 183-184). While this might have been an adequate theory for explaining phenomena in the second half of the 20th century, it is to be doubted whether this is still the case today. Particularly, one of the main concerns in modern international organisations is the underrepresentation of developing nations or smaller member states. With economic development in many areas of the world, more and more strong and independent states arise. This is visible in the space sector as well with nations such as China and India investing increasing amounts of money into space research and missions. Finding a balance between the goals of the different nations and a fair way of joint action is one of the core challenges arising in almost all areas of cooperation, including cooperation in space. Cooperation can therefore be seen as a necessary tool to balance interests and powers and reduce tensions by collaborating and by jointly overcoming hurdles.

There are two main ways that enable international cooperation: agreements between single countries, as well as international institutions with a specific set or rules and overarching principles to which members of the institution have to adhere to. One of the classical branches of International Relations – institutionalism – focuses on the role and significance of those international institutions in order to make cooperation and the development of joint policies possible. The neo-liberalist scholar Robert Keohane argues that in political cooperation between states, negotiation to reach a mutually beneficial and acceptable outcome is required. He terms this "functional cooperation". He distinguishes this cooperation from "harmony", which assumes working together due to mutual interests

(Keohane 1984, 8-13). In areas, where ideas or individual goals only partly overlap or even divert, international cooperation offers a way of jointly moving forward even though that might imply having to adjust some goals and aims. This can explain the fact that, whereas countries collaborate in ESA, not all participate in all offered projects and many still keep national agencies to focus on projects that might not be of mutual interest to all other nations.

Assuming a membership of an international institution, all members have to equally adhere to the laws and regulations, which are constructed and amended by the member states. However, power of an individual member is never a negligible factor. Whether it is economic or military, power often gives larger members an advantage and allows them to bend the rules slightly more to their liking or have a larger say in the decision-making as such. This can even be seen the largest international organisation, the United Nations, which, despite having 193 member states, only hosts five all-time permanent members in its Security Council. These are the most powerful countries (or at least were so exclusively at the time of its establishment): the United States, Russia, China, France and the United Kingdom (UN 2017). This way of cooperation proves to be more efficient as decisions can be taken easier if there are fewer actors involved. However, it creates an imbalance between different members and will cause friction and internal challenges within the institution in the long run. Many international organisations therefore attempt to apply 'fair' representation of their members in decision-making processes. Factors determining a 'fair' representation often include financial contribution or population size or the member state, the latter being the case in some of the European Union's institutions, for instance. As membership to ESA is established on a voluntary basis, fair representation of its members is a key in ensuring a lasting existence of the agency.

International cooperation has several facets depending on whether the focus is put on non-governmental or governmental organisations or a combination of the both. For the purpose of this paper, business companies as non-governmental actors need to be mentioned. For business organisations, distinctions into multinational, transnational and international companies are useful to understand how they interact in the different countries. First of all, multinational corporations (MNCs) are operating in several countries but have one country from which they are managed. Second, transnational companies operate in several countries and do not have one defined home country. Third, international business companies (IBCs) are formed in one country serving as a tax haven but generally operate in many different ones and are also managed from another country (Business Dictionary 2017). Cooperation

agreements with different types of business organisations might therefore need different strategies depending on the organisation and its structure.

In governmental organisations, a distinction has to be made between supranational and intergovernmental organisations. In a supranational institution, decisions can be made above the authority of the member in contrast to an intergovernmental institution, in which the power to make decisions remain within every member state. Whereas supranational institutions are the expected outcome in neo-functionalism, intergovernmental institutions are the logical path in realism, as nations want to safeguard their power and interests (Hix 2005, 15). The latter case makes cooperation between members a larger challenge as all members need to agree to any decisions or changes to be made. Although ESA is an intergovernmental institution in which main decisions are made by unanimous votes, cooperation is still successful. For large-scale and expensive projects, approval of all members is an absolute necessity but lead to greater support of the project and trust and equality between members.

Furthermore, several scholars see international cooperation in non-government areas as vital as they increase integration. Ernst Haas argues that international cooperation in technical areas, such as communication, science or transportation, can lead to spill-over effects and as a result can create more cooperation and integration on the political level. This will ultimately result in a joint-goal for increasing human welfare rather than individualistic power-driven politics (1964, 12; 111-113). Examples for this can be seen in transnational research projects, business projects and transportation networks. By engaging citizens from different nationalities in a peaceful way, existing tensions and stereotypes between nations can be curtailed and citizens' support of aggression towards other nations reduced to a minimum. ESA can be used as a prime example with thousands of employees from various nations working together and sharing their knowledge and expertise.

The standard analysis of actor relationships in the field of international relations, which was first applied by Kenneth Waltz's *Man, The State and War* in 1959, distinguishes similar dimensions: the focus is put either on the (international) system as a whole, the state as an actor in this system or the individuals working for the different institutions or governments (Burchill, Linklater 2005, 19). In order for international cooperation to be as successful and efficient as possible, all three levels are of importance. The system level explains how the changes in the behaviour of one actor affect the other actors in the system. The state level highlights the internal conditions of a state that lead to certain decisions and cooperation agreements. The analysis of the individual reveals certain characteristics or ways of acting that facilitate cooperation in individual cases. As the analysis in the last point is very

actor-specific and relies on a present situation that is likely to change often and fast, this point shall not be taken into consideration for the following study. To understand the cooperation structure within ESA, it is therefore equally relevant to consider its position in the international system.

Overall, when studying cooperation, several aspects appear as relevant regardless of which of the three levels are evaluated: a willingness and incentive to cooperate, rules and guidelines that ensure beneficial outcomes for all the members agreeing to cooperate as well as the highest possible input from every member in respect to available capacities, knowledge, material and funds.

One of the most outstanding theories when analysing international cooperation in an international context is Morgenstern's and Von Neumann's Game Theory. It is a form of conflict study "between thoughtful and potentially deceitful opponents" and has frequently been used to explain cooperation or failing cooperation. Assuming rationality in players, they argue that if there are more than two players in a game, this results in the formation of coalitions (Poundstone 1993, 6). According to game theory, a lack of cooperation can be caused by asymmetries in gains, or by higher gains from defecting rather than cooperating resulting in a deadlock. When gains are higher with mutual cooperation than defecting, mistrust and striving for relative gains might still lead to defection (Poundstone 1993, 218-221). However, what is intriguing is Axelrod's argument stating that while the players' most logical outcome would be to defect in a single situation, they start to cooperate if they know they will be facing similar situations in the future. He terms this "tit for tat", meaning that what you do to your cooperation partner will be returned to you in the future. So, even if you assume a rational actor whose self-interest is his top priority, considering a "shadow of the future" even allows for cooperation in a realist setting (Axelrod 1984, 30-35). In addition, considering competition in an international system, creating alliances and cooperating can increase efficiency and competitiveness (Axelrod 1997, 7). This theory serves as a sound basis for explaining cooperation between states assuming that cooperation is necessary and repetition occurs. However, it is not enough to say that states cooperate because of a shadow of a future cooperation. From this point of view, one simple deception could be enough to lead decades of cooperation to a collapse and to deceptions from other cooperation partners. Especially, when cooperation is complex and stretches over long period of times, it is necessary to agree on certain guidelines and rules cooperation partners have to adhere to. Successful cooperation is best done by bi-or multilateral agreements or even by membership to organisations.

From a neo-functionalist perspective, Ernst B. Haas argued that organisations are the sub-systems of the international system, which influence it by feedback loops and increasing integration. He highlights the importance of organisations for integration and values this even above the achievement of their explicit objectives (Haas 1964, 86-90; 126) International organisations provide many benefits for their members; however, using an organisation for maximum integration regardless of potential risks even if this implies inefficiencies or less ideal outcomes has to be questioned. As can be seen in the current EU crisis, inability to produce outcome that allows for higher gains of nations in cooperation leads to unwillingness to cooperate and strong tendencies towards nationalism. Nevertheless, Haas' arguments provide an important basis for the analysis of international cooperation. He argues that if governing tasks are performed by technicians and experts, the likelihood of abuse of dominance and cooperation for political or personal motifs is reduced as the people in charge are interested in their tasks rather than in power (Haas 1964, 11). This consideration can be found in the origins of the foundation of ESA which was aiming at creating an institution based on scientific expertise rather than pure political decision-making.

In light of the different theories, it might sometimes appear demanding to explain reasons and motivations for successful cooperation. From a realist perspective it often seems challenging to create cooperation in places in which no dominant power is driving it. On the other hand, institutionalism theorizes that joining institutions or organisations leads to regularity and predictable outcomes in international cooperation and is therefore a likely outcome. However, none of the theories are capable of explaining all life situations. Overall, one of the most plausible reasons to explain cooperation remains the rational self-interest of a state, assuming it wishes for its best possible status of existence. If the actors can only reach this status through cooperation, this will be the most logical and likely step to be taken. To ensure the long-term viability of cooperation, agreements or memberships to organisations is necessary to offer stability and trust. Working together in one organisation can also lead to a stronger feeling of unity and membership and increase willingness to cooperate and decrease feelings of insecurity. I argue that cooperation within ESA is one example that proves this to be the case. Despite different theories and arguments, what can be seen is that particularly if absolute gains are preferred over relative gains, cooperating in international organisations lead to mutual benefits. However, strong enforcement procedures are necessary to guarantee fair conduct. They guarantee the members security, transparency and trust. Fruitful cooperation in one organisation might even increase trust and cooperation of countries in other areas (Burchill 2005, 65-66). In addition, cooperation increases interdependency and as a

consequence, could in certain circumstances result in more peaceful conduct of states with each other.

2.3. International Scientific Cooperation

In similar ways to businesses, which work together to increase their revenue and efficiency and have access to all resources needed, states can agree to cooperate in research and development to be more cost-efficient and to reach a higher quality of outcome. It, however, requires a high level of commitment to make it worthwhile:

> No matter what the motivation, international scientific cooperation is only as good as the science put into it, and it can be successful only if both sides are keenly interested in making it work. (MacLeod, Minners 1971, 1085)

What previous experiences in international scientific cooperation, such as medical programs between the US and Japan, have shown is that, in order to make scientific cooperation across nations an effective means of research, all sides have to be equally committed to making process. Investments in high-quality education and training as well as the availability of necessary means to perform scientific research form the basis on which international scientific cooperation has to be built.

The benefits of potential cooperation across nations in science become evident when considering combining the increased number of specialists educated in various locations as well as high-quality equipment and increased funds. Most ground-breaking research projects in the past decades have come from international research cooperation either between individuals or groups. For instance, the Nobel-prize winning design and synthesis of molecular machines was only possible through cooperation between the French Jean-Pierre Sauvage, the American Sir J. Fraser Stoddard and the Dutch Bernard L. Feringa (Nobel Prizes 2016). Most universities recognize the benefits of international collaboration and promote the exchange of personnel and an international research environment.

In Europe, research cooperation across borders took its first major step with the implementation of CERN, the European Organisation for Nuclear Research, in 1954. Since 1986, international cooperation is a key activity of the European Union's research policy as stated in the Treaty of the Functioning of the European Union (COM 2012 497, 3). For the European Union, international cooperation has become one of the key concepts in recent

years. International cooperation within its members serves to strengthen its capabilities in research and innovation and its economic competitiveness. Cooperating in science through sharing knowledge and agreeing to common practises in research helps to achieve higher results. Research cooperation is frequently used by the EU for its various external policies, such as their neighbourhood policy or the CFSP (Common Foreign and Security Policy) (COM 2012 497, 4).

As developing nations are getting a stronger foothold in research, trade and technology it is even more essential for Europe to strengthen its ties and to be seen as a major player in innovation and research, particularly when it comes to international competition for talent. In the area of space research, more and more nations such as China and India are beginning to emerge as space powers. Decisions made in Europe will determine the future relationship with these countries and their status as partners or competitors in space research. In addition, regarding challenges such as the need for an increase in sustainability to tackle global warming, to ensure food security and to develop sustainable resources, the EU "needs to strengthen its dialogues with international partners to build critical mass for tackling these challenges" (COM 2012 497, 2). However, a coherent strategy for international research cooperation and increased international collaboration with non-EU countries are seen as lacking (COM 2012 497, 3). With programmes, such as in the field of earth observation, ESA provides the means to help solve these global problems and provide incentives for further international cooperation.

To facilitate international cooperation the EU has set up several principles including "responsible research and innovation, research integrity; peer review of proposals; promotion of the role of women in science and the gender dimension in research, research and innovation; research careers […]; fair and equitable treatment of IPR; and open access to publicly funded research publications" (COM 2012 497, 9). The Global Research Council, with recommendations of the Carnegie Group, has increased efforts to set up common principles in international cooperation (COM 2012 497, 9). It is the goal of the EU to strengthen its role in international organisations and to increase observance, implementation and monitoring of activities (COM 2012 497, 11). Stronger collaboration with ESA to achieve joint policy coordination is therefore part of its core strategy as space activities serve the EU in gaining recognition as a major player at an international level.

For these reasons, international scientific cooperation is one of the core focus points of the European Union's Horizon 2020 programme. Horizon 2020 is the EU's biggest innovation and research programme, aiming at producing economics growth and ensuring

global competitiveness of European businesses and developing the European research areas (European Commission: What is Horizon 2020?). International cooperation in research and science "does not only improve the quality of research itself but also the quality of its utilisation and effects" (Royal Netherlands Academy of Arts and Sciences 2014, 6). The fact that international cooperation leads to an increased quality of research and thus following higher competitiveness in product development and applications explains the need of the European Union to focus more strongly on international cooperation. For upcoming years, the European Commission emphasizes the importance of the availability of research infrastructure. The EC's focus lies on structuring the scientific community, increasing attractiveness of scientific careers, and providing networking facilities and high quality research environment. By attracting highly educated individuals from different European countries, this aims at furthering economic development and innovation (Horizon 2020 Working Programme 2016-2017, 4). Research facilities provided by ESA play a core role in these plans as they employ top-level researchers and young graduates from various nations and enable them to reach their full potential. However, it must be noted that with increased collaboration in science and technology comes increased responsibility to ensure "the scientific responsibility, integrity, independence and objectivity as well as responsible research conduct" (Royal Netherlands Academy of Arts and Sciences 2014, 5). Responsible cooperation for the purpose of science and not exploitation is therefore a necessity. In order to create scientific research partnership, transparency is essential. Only if all partners are equally involved in the planning, able to make decisions and gain access to the data and results can cooperation in science be satisfactory to all sides.

2.4. International Cooperation in Space

Since projects in space sciences are extensive in scope and complexity, most national space agencies would not be able to sustain projects solely with their own capabilities. Cooperation becomes more and more important. Many large-scale projects that require cooperation stretch for years, or even decades, in some cases, for instance, when considering future missions to other planets. Cooperation, and not merely competition, is the key to ensuring a safe mission. However, since there is no global supranational institution to handle space matters, the responsibility to draft successful cooperation terms and agreements rests with the various space agencies. Well-drafted agreements can lead to lasting peaceful

cooperation, particularly in times when political relations might be strained between the countries.

The United Nations Office for Outer Space Affairs (UNOOSA) is, at current, the only supranational body regulating conduct in space. Its tasks are mainly limited to registration of objects transported into outer space. It hosts conferences on the peaceful use of outer space between all space-faring nations. The first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE) was organised in 1968, which marks 2018 as its 50th anniversary. In light of this anniversary, cooperation in space is highlighted through the creation of several high-level fora, which focus on space economy, society, accessibility and diplomacy to create socio-economic sustainable development through the application of space science projects (High level fora … 2017). UNOOSA looks at how society and the economy can prosper through research and projects in space, and how cooperation and partnerships can be built for space in a peaceful manner. In its Committee on the Peaceful Uses of Outer Space, five main treaties were developed over the past 50 years. Its basis, and the main treaty regarding conduct in space, the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* entered into force in 1967. It prohibits nuclear weapons and weapons of mass destruction in the orbit as well as any states' claims of celestial bodies. The treaty states that:

> The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of al1 countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind (General Assembly resolution 2222 (XXI), Article I)

Outer space is considered a common good of all of mankind. This is the core principle, on which all of the science and exploration missions are to be based. Any missions should be as transparent as possible and stations in outer space should be open to visits from any nation (Article XI and XII) In the following years, several additional agreements were adopted: the "Rescue Agreement", or: *Agreement on the Rescue of Astronauts and the Return of Objects Launched into Outer Space* (1968), the "Liability Convention", or: *Convention on International Liability for Damage Caused by Space Objects* (1972), the "Registration Convention", or: *Convention on Registration of Objects Launched into Outer Space* (1976) and the "Moon Agreement", or: *Agreement Governing the Activities of States on the Moon*

and Other Celestial Bodies (1984)[1]. While they outlay important guidelines in international cooperation in space, they do, however, lack to provide binding laws or regulations. Other scholars agree that the treaty as well as all other agreements and conventions regarding conduct in space do not offer "detailed rules or an authoritative process for deciding what types of space activities are inconsistent with these principles, when the individual or cumulative usage of space might damage the common interests, and how the benefits from space activities should be shared" (Gallagher 2010, 259). It is therefore in the responsibility of the individual nations and organisations to ensure peaceful cooperation and develop strategies that allow all nations to jointly use space. Voluntary measures generally seem to be preferred over binding agreements by actors such as the US (ibid. 257). However, this lack of global cooperation and governance is creating more and more challenges as orbits are getting more crowded, more and more nations plan on performing space activities and space debris is increasing rapidly as most objects used in space are not being returned to Earth. The latter seems to be a reminder of the Tragedy of the Commons, in which every actor uses the common ground to their utmost benefit until usage is no longer possible (Hardin 1968, 1247). So far, no lasting solution has been found to tackle this issue in any area of global governance. Results can be seen in still ongoing pollution or overfishing of the oceans which are destroying the "common grounds" of mankind. A solution needs to be found in order to avoid acting in the same way in our space environment.

Interest in space has been growing in the past few years. Space research has become an important means for civil as well as military purposes. While NASA, ROSCOSMOS , JAXA and ESA were the main players in space only several decades ago, there is growing interest in space from nations such as China, India, Iran, Argentina, Brazil, Israel, South Korea and many more. In 2010, there were 53 countries operating satellites in space (Space Foundation 2014). With growing economic performance and development, more and more countries are developing interest in space activities. This will open various opportunities for the existing space agencies, but will also result in a higher need for competition to remain a dominant actor in the field of space research and exploration. Innovative solutions on how to become more effective as well as rules on how to cooperate and behave in space are therefore necessary to master upcoming challenges.

In addition, political leaders often consider international cooperation an important soft tool for diplomacy, also called "science diplomacy" (COM 2012 497, 4) to enhance relations

[1] All conventions can be found on the homepage of the UNOOSA: http://css.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html

with key countries of cooperation and thus leading to better political relations as well as better scientific collaboration and higher efficiency in research and innovation. Successful cooperation in space might therefore not only have effects on technology and innovation within a country but also on its relations with other nations and on the space environment itself.

2.5. European Cooperation in Space

In order to remain a leading power in space research, European nations need successful cooperation. This cooperation can either take place through the European Space Agency or in coordination with the European Union. The latter has a particular interest in collaborating with ESA in order to strengthen its position as a leading research area for space research and innovation in space. Supporting space research and development of innovative technology in Europe will boost the economy, create jobs and increase the competitiveness of the space industry. Space applications acquired through research and development can be and are already used to tackle societal and global problems, such as using satellites for navigation systems or for environmental observation and examination. Also, in humanitarian aid and in foreign policy, space application can be used, be it for security or for humanitarian reasons. Within its member countries the European Union might be able to attain a higher level of integration through scientific cooperation. Coordination between the policies of the EU and ESA is therefore of great importance for both organisations.

Not only on a government level but also on an organisational level has international cooperation become crucial, especially in technology and research. It is not only about finding sources for raw materials but also about developing innovative techniques involving different perspectives and highly-skilled labour that renders international exchange and support indispensable. This in particular, is the case for the European Space Agency and its ability to acquire materials and personnel from a wide array of European countries. The high quality of equipment as well as the expertise of staff allow for the highest possible quality in space research.

3. ESA – THE EUROPEAN SPACE AGENCY

3.1. Structure and Membership

ESA is an international organisation founded in 1975[2]. At current, it consists of 22 member states, which are Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. It is the only space agency in the world that encompasses more than one nation, which makes it a unique intergovernmental organisation. The agency's main aim is to

> provide for, and to 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 applications systems (ESA Convention … 2010, Article II).

The focus of the cooperation projects lies in creating a long-term space policy for Europe, through coordination with national programmes and recommendations to member states as well as through industrial policy cohesion with its members. Particularly, regarding an ever-growing competitive environment in space and large-scale competition through space agencies, such as NASA, ROSCOSMOS and CNSA, bundling together Europe's technological and financial powers to become more efficient and capable in space research seems more important than ever.

ESA's facilities are distributed across several European countries, while its headquarters are placed in Paris, France. In addition, ESA holds a rocket launching site in Kourou, French Guyana. Due to its international character, there are three main official languages spoken at ESA: English, French and German. Nowadays, the main working language is English in most of its establishments, and French and English in its headquarters.

ESA finds itself in a unique position as it offers its services to both member states with a national space agency and without. In addition, it receives funding from the European Union, to which not all of ESA's members are members. The development of a coherent and

[2] The convention of the European Space Agency was originally signed by Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom in May 1975. Ireland joined in December 1975.

effective structure for cooperation therefore seems to be of a core element in the successful functioning of the organisation.

3.2. Foundation and Early Cooperation within the Agency

To fully understand the functioning of the European Space Agency as it is today, it is necessary to look at its founding and the development of cooperation between its members on which it is based today. The creation of an independent space agency originated in 1962 with the establishment of the European Launcher Development Organisation (ELDO) by Australia, Belgium, France, Germany, Italy, the Netherlands and the United Kingdom. The establishment of the European Space Research Organisation (ESRO), whose convention was signed by Belgium, Denmark, France, Italy, the Netherlands, Spain, Sweden, Switzerland, The United Kingdom and the Federal Republic of Germany, marked the beginning of joint research in space in Europe. European countries wanted a strong and independent organisation with a focus on peaceful research in space that would be able to coexist in the midst of the Cold War of the two superpowers, the United States and the Soviet Union. For this reason, one of the options at that time – working with support of NATO – was dismissed as this would have given the agency a military character and would have hampered potential cooperation with both the US and the Soviet Union (ESA Convention … 2010, 9; Bonnet, Manno 1994, 3). ESRO was originally purely designed as a research organisation and constructed in a way in which it would be able to operate as well as possible without direct interference of governments. This principle is still relevant for ESA's mandatory science programmes today. The agency was formed by a council of representatives of the member states and a scientific committee, which was to evaluate all research proposals.

When establishing cooperation between independent nations within one agency, several issues need to be addressed, which mainly consist of: the budget, the appointment of staff, the geographical distribution, the return on investment, and cooperation principles. To ensure fair distribution of costs, membership fees were, and still are, based on the GDP of the countries. In addition, no member state should contribute more than 25% of the total costs to limit disparities in membership fees. Distributing administrative, technical and scientific offices across the largest contributing members was deemed a necessity to ensure a balance in power and advantages. For these reasons, after several meetings, the headquarters were established in Paris. The technical centre (ESTEC) was originally located at the Technical

University Delft in the Netherlands, but was later moved to Noordwijk in the Netherlands. The European Space Operation Centre (ESOC) was voted to be established in Darmstadt, Germany. ESLAB, the small research laboratory was established in Frascati, Italy. The appointment of senior staff followed similar political considerations (Bonnet, Manno 1994, 5-9). Although this strains coherent coordination within the agency on the one hand, it helps to ensure willingness to cooperate between its members on the other hand.

In 1975 the European Space Agency (ESA) was established, combining ESRO and ELDO. Its main aim was to create and coordinate the interests of the national agencies and to create a joint European space policy (ibid. 20). The ESA Convention specifies the set-up of the ESA Council, its purpose, activities and programmes, the exchange of persons across borders for scientific aims, its organs, its transport system, industrial policy and possible funding options and financial contributions as well as dispute settlement methods. Concerning international cooperation the convention specifies:

> The Agency may, upon decisions of the Council taken by unanimous votes of all Member States, cooperate with other international organisations and institutions and with Governments, organisations and institutions of non-member States, and conclude agreements with them to this effect (ESA Convention … 2010, 39-40).

With a two-thirds majority of votes from the council, non-member states or organisations can participate in one or more of ESA's programmes or can obtain associate membership if they contribute "at least to the studies of future projects" (ibid. 40). Financial planning consists of ten-year-plans as well as annual and multi-year cost plans (ibid. 72). In addition, different interests of large and small member states have to be taken into account. Large members, who have their own national space agencies, were striving for projects beyond their means while small member states needed ESA as a substitute for a missing national agency. This created various demands and tasks for the space agency (ibid. 7-8). To ensure successful cooperation, the scientific program of the agency was established as a mandatory program to which all members had to contribute. Furthermore, the agency created optional programs, to which the members could choose to take part in depending on their national priorities and interests. To guarantee a fair return of investments, ESA created a *juste retour* (or fair return) principle for each of its programs, which would ensure equal involvements of a state's industry and personnel in coordination with the amounts of its payments (ibid. 24-34; 51-56). Most of the aspects agreed on at its foundation are still valid for ESA today.

3.3. Internal Cooperation

3.3.1. ESA and its Member States

With 22 members and eleven cooperation agreements in place, plus various institutions involved in the different member countries, coordinating diverging national, EC and ESA space policies is challenging. This is why it is particularly important to point out differences in regulations and develop a possible strategy for tackling existing deficiencies.

One of ESA's main aims is to develop a European strategy for space research by creating coherent policy guidelines that connect the national agencies to the long-term goals and projects of ESA. This is to be reached by internationalisation of national programmes, in which each member "shall make available for participation by other Member States, within the framework of the Agency, any new civil space project which it intends to undertake, either alone or in collaboration with another Member State" (ESA Convention … 2010, 89). This regulation ensures that space projects are executed under the umbrella of ESA and in cooperation with its members. It leads to trust and cooperation rather than competition between the member states and allows for a coherent representation of European countries in space.

Another important policy of ESA is its *juste retour* principle. In all its projects, the aim is to reach fair distribution of involvement depending on the members' contributions. This is measured through the industrial return coefficient:

> A Member State's overall return coefficient shall be the ratio between its percentage share of the total value of all contracts awarded among all Member States and its total percentage contributions (ibid. 97)

As the main amount of ESA's budget is spent on industry contracts, the return coefficient guarantees the employment of national industry in the same percentage as financial contributions were made. With 22,7 % of the contributions to the budget in 2017 coming from each France and Germany, they are the key contributors to ESA. As a result, their national space policies (through CNES in France and the DLR in Germany) have sizable leverage points in the creation of a European Space Policy (De Selding 2017). Generally speaking, however, funding from member states does not always stem from the Ministries of Science but, for instance, in the UK from the Science and Engineering Research Council linked to the Ministry of Trade and Industry. Its financial support for space science depends on the availability of funds shared with almost all sciences. The availability of funding and its

different origins puts constrains on several member states, particularly if they are restricted in size, population and GDP. This makes it harder for smaller member states to express and realize their goals and plans.

ESA will face several alterations in reaction to future changes due to an increasing number of members and a changing relationship between member states, and between the EU and ESA. Changes are necessary in order to increase competitiveness and efficiency (Agenda 2015 … 2011, 45). ESA aspires to have 29 members in the near future. This increases financial contributions but will lead to problems with guaranteed return as stated in the ESA convention. ESA foresees two possible solutions for this problem "namely reducing the contribution to the mandatory programme for acceding States, and keeping the contribution to the mandatory programme but allocating a fraction of this contribution to develop industrial capabilities in optional programmes. The goal of these solutions is to guarantee a return in the Mandatory Science Programme in a sustainable manner" (Agenda 2015 … 2011, 46-47). The first option does not appear to be viable considering a rise in spending in other space agencies around the world. As new members are meant to add the benefits of increased available funds and larger scale projects the solution of reducing mandatory fees seems counter-intuitive. As one option, ESA will need to be flexible in regard to its partnership to reach a necessary amount of funding. Successful examples of this are "public private partnerships (e.g. in the telecom sector), the relationship with the European Union and the relationship with spun-off operational entities" (Agenda 2015 … 2011, 47). An increase in innovation within the European Space Industry is necessary to tackle global competition, which can likely be achieved if more funding is available for investments into research and start-up companies.

Since 2001, ESA also offers affiliated states the option of establishing a bilateral European Cooperating State Agreement. This partnership allows for indirect participation in all ESA activities and procurements and is re-evaluated every five years. Up to now – Mai 2017 – ESA has concluded ECS Agreements with Hungary, the Czech Republic, Romania, Poland, Estonia, Slovenia, Lithuania, Latvia, Slovakia and Bulgaria. In addition, it has a special cooperation agreement with Canada (European Cooperating States … 2015).

3.3.2. ESA and the European Union

Europe is facing a unique situation when it comes to cooperation in space. While many European countries have their own national space agencies and agendas, most of them are connected with each other through a membership to the European Space Agency. In

addition, the agency receives funding for certain projects directly from the EU. Policy coordination with the European Commission has become more and more important in the last few years as it provides mutual benefits for both the EU and ESA.

Since many European countries are benefitting from the cooperation in the European Space Agency directly but also indirectly through their membership in the EU, coordinating policies with ESA has become more and more vital to the European Commission. The European Space Agency offers technologies to its member states' industry and citizens, thus boosting the economy and benefitting individual citizens. In November 2000, the European Union Councils alongside the European Space Agency developed the first joint European Strategy for Space. A cooperative structure was designed to connect ESA's executive with the European Commission. In 2004, a framework agreement was completed leading to the creation of the Space Council. (ESA: European Milestones 2012). This allowed the EC to design and implement laws regarding the use of space applications. In 2007, the European Commission and ESA submitted a first draft of a European Space Programme. Also, the "EC-ESA Joint Secretariat, in collaboration with Member States and EUMETSAT […] developed 'Elements for a European Strategy for International Relations in Space'" (COM 2008 561, 12). The focus was set on an aligned representation of Europe and a coordinated policy in dialogue with strategic partners, in particular, the US and Russia. An image of coherent European Space Policy was considered equally necessary in talks with relevant UN bodies about the peaceful usage of outer space (COM 2008 561, 19). The implementation of the Lisbon Treaty in 2009 not only created a legal basis for a European Research Area but also expressed goals for a common space policy:

> 1. To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, support research and technological development and coordinate the efforts needed for the exploration and exploitation of space.
> 2. To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space programme, excluding any harmonisation of the laws and regulations of the Member States.
> 3. The Union shall establish any appropriate relations with the European Space Agency. (TFEU, Article 189)

This article forms the basis of cooperation between the European Commission and the European Space Agency and explicitly mentions the possible creation of a European Space

Programme and the establishment of suitable relations for cooperation with ESA. Since the drafting of the agreement, the EC has continued to develop their own space policy and has increased its financial support and collaboration with ESA. Major projects, in which the EU is involved, include the European Geostationary Navigation Overlay Service, EGNOS, as well as the Galileo satellite navigation programmes and the Global Monitoring for Environment and Security (GMES) system (COM 2011 152, 4). Galileo, as one of the European Union's flagship projects, is the first satellite navigation systems created for civilian use. EGNOS, the first European satellite measure, along with Galileo are the main two space facilities, belonging to and managed exclusively by the EU (COM 2011 152, 5). The European Union contributes approximately 20% of the annual budget of ESA to invest in infrastructure and research in exchange for space data and applications that can be used for European citizens in various areas, such as "transport, energy, climate change, border management, security, migration, humanitarian crisis, telecommunication just to name a few" (Bienkowska 2016).

The EU benefits from cooperation with ESA in various ways. In a communication report, the EC defines the importance of research in space in the following way:

> Space is at the service of the European citizens. Many of the systems and services that are today essential for our well-being and security depend directly or indirectly on space. Without being aware of it, European citizens rely on space technologies when they use their mobile phones, do financial transactions, take an airplane, watch the weather forecast or look for the nearest restaurant in their cars. Space has become part of our daily live. Space is a driver for growth and innovation […]. (COM 2013 108, 1)

This extract about the account "On why space matters" shows the increased awareness of the importance of space and space research for Europe and the EU. Space research allows for scientific progress, particularly in fields such as telecommunications, navigation and Earth observation which are considered indispensable for the interdependence and security of the European Union. Furthermore, global issues, such as climate change, sustainable use of resources, societal changes and health can be addressed with the help of space technology. Moreover, space applications can be used for the EU's external policy in the fields of development assistance and humanitarian aid missions. Through ESA, the EU intends to strengthen its strategic partnerships with the US, Russia and China in the future as joint projects offer mutual benefits. Furthermore, the EU is planning a research partnership with

several African countries using knowledge and technology created through space research for cartography, food safety, deforestation, soil and water use etc. (COM 2011 152, 10-11).

Space research provides jobs, leads to economic growth and increases Europe's competitiveness. The commission recognizes that in order to increase global competitiveness, it is essential for ESA and the EU to work together more closely (COM 2013 108, 1). Results of this approach can be seen, as the EU contributed 1,7 billion € to ESA's budget in 2017. These funds will not be used for the mandatory science programme, but for programmes with optional membership status only, in which the EU has particular interest (Selding 2017). This way, differentiation between member states that are EU members and those that are non-members is more easily possible. Benefits of cooperation with ESA are seen in a growth of European industry. For a successful Space Industrial Policy improvements in five areas are considered particularly relevant: a coherent regulatory framework, the creation of a competitive base in Europe, higher cost-efficiency, the development of a market for space services and technology as well as technological independence and autonomic access to space. Furthermore, independence in key strategic areas such as launch service is seen as core element of the policy. For effective cooperation cohesion in the policies of the EU, ESA and its member states is crucial. Member states positions' in fora of international organisations should correlate closely to the EU Space Policy's position (COM 2013 108, 4-5). Creating an agreeable stance in an international system, that encompasses the interests of the EU as well as all member states and non-EU member alike requires willingness to cooperate and to make small concessions from each actor, including the EU.

For ESA, closer collaboration with the EU is highly beneficial due to the fact that ESA as an international organisation was not able to change key space policy laws of certain member states leading to policy divergence. In addition, the need for implementation of certain laws and regulations regarding space and space technology led to the creation of several agreements concluding with the Lisbon Treaty drafted in 2007 (Von der Dunk 2011, 386). However, there are still several issues present that complicate cooperation between ESA and the EU.

Most member states have their own policies regarding space research. Their level of involvement, financial support and technical capabilities vary greatly. Coordinating member states' policies is one of the main aims of the Commission (COM 2011 152, 12). In addition, policy coordination is necessary between the EC and ESA for being able to use space applications in other areas and from allowing citizens and member states to benefit from research results. In 2008, the Commission pointed at several essential points in international

collaboration as “international cooperation in space areas in need of coherence with the EU’s external policy priorities, for instance when referring to applications of space systems for sustainable development, such as in Africa. International cooperation therefore offers a chance to practically implement the European space programmes (COM 2008 561, 12). In discussions with ESA interns the EU Commission expressed their hope for the transformation of ESA into “an organisation with an intergovernmental and an EU dimension in which military and civil programmes can coexist” (COM 2011 152, 12). Better coordination of the individual protagonists, be it ESA, EU or individual member states is expected to lead to more efficiency in the management of public resources (COM 2011 152, 12).

In its communication report, the European Commission points out five structural problems interfering in the relations between the EU and the European Space Agency. The first issue is differing financial rules within ESA and within the EU. Whenever ESA receives funds from the EU it is required to follow EU rules and EU financial regulations. However, the largest programs of ESA are mainly funded by member states contributions to which a different set of financial rules is applied. According to the Commission, this leads to high structural complexity that impedes management particularly when funds come from various sources (COM 2012 671, 3). It can be argued that management capabilities should always remain with ESA as it is equipped with experienced and highly qualified expert staff in this sector. Secondly, the Commission notes that there is an asymmetry of members between the EU and ESA as only 17 EU members are part of ESA. In addition, Switzerland and Norway, who are not part of the EU, are member states of ESA as well as Canada which has a bilateral agreement with ESA. This affects the EU not only in decision-making powers but also in security matters as space “capacities have often the potential to be used for civil and defence purposes” (COM 2012 671,3). Another problematic area in international relations between ESA and the EU is seen in a lack of policy coordination or structural connection of ESA decisions to the EU. This leads to lengthy negotiations whenever new programmes are to be decided upon. Finally, the Commission claims that the absence of a link to the European Parliament deprives EU citizens of a direct link to ESA (COM 2012 671,3). However, decision-making processes via ministerial councils grant the institution democratic legitimacy. Transparency and open communication channels improve the link between ESA and its members’ citizens.

Due to this lack in symmetry and efficiency the EU Commission proposes two possible solutions to be reached between 2020 and 2025: The first option comprises of “bringing ESA as an intergovernmental organisation under the authority of the European

Union (following, to a certain extent, the model of the European Defence Agency), or transforming ESA into an EU agency (following the model of existing regulatory agencies). The Commission, working closely with ESA, will carry out a detailed cost benefit and risk analysis of the different options, with a view to maximising synergies between the different actors" (COM 2012 671, 4). These measures would give accountability and legitimacy to ESA institutions and enhance efficiency and coordination with EU policies. In combination with flexible membership, countries such as Switzerland and Norway could still participate in ESA programmes. However, the latter option is highly unlikely to be implemented as the focus and aims of the different EU countries vary greatly in terms of space policy and transforming ESA into a supranational institution under the auspices of the EU would mean losing all their independency. To ensure a lasting partnership, the ability to develop national space programmes – in coordination with a European programme – needs to remain.

3.4.ESA and International Cooperation

Collaboration in space – be it within ESA and its member state or between ESA and several space agencies such as NASA and ROSCOSMOS – is one of the most fruitful examples of peaceful collaboration between nations. Reasons for this are seen in the fact that the focus on international cooperation in space is put on an open exchange of information, data and results acquired during missions allowing all participants to profit equally. Furthermore, the selection of scientific research projects is based upon the principle of research for scientific excellence excluding any non-scientific motivations that might conflict with this principle (Bonnet, Manno 1994, 1-2). This explains why space flight can be seen as "a factor for peace and a symbol of global cooperation" (Agenda 2015 … 2011, 36). It started with the Apollo-Soyuz Mission in 1975 and can be witnessed in the form of the ISS, the International Space Station, which is a partnership of five space agencies – NASA, ESA, ROSCOSMOS, JAXA and CNSA. In order for this coordination to work, harmonised utilization plans, a minimum degree of transparency and compatible hardware and operation procedures formed a requisite (Agenda 2015 … 2011, 36).

> The cooperation of a few astronauts of different nationalities in space triggers the close cooperation and build-up of trust among thousands of people on the ground, bringing nations closer together (Agenda 2015 … 2011, 37).

This project has created cooperation and solidarity. At the same time it shows difficulties and a need for increased collaboration that can be amended for future international collaboration. An example for this is the use of common interfaces or a greater amount of mutual dependence and trust. As ESA is a working example of voluntary cooperation of 22 countries it can also use its experience and expertise in extending collaboration to more countries, such as China, which is the third nation to build independent human launch capabilities and expressed desires for lunar exploration in the near future. Collaboration with ESA could enhance relationships between Russia, China and the US and could facilitate international cooperation in this sector. ESA's director general suggests the Mars500 project as a possible starting point for cooperation. In addition, the unique setting of the ISS could allow collaboration of scientists from all around the world. ESA started to enable it by trying to include scientists from EU member countries that are not part of ESA member countries (Agenda 2015 …2011, 37).

However, with recent developments in global politics and the changing leadership in the US, new challenges arise for ESA. With a new administration in the United States, a trend towards more nationalist and isolationist policies can be observed. These policies do not only concern military operation and national security issues but also affect cooperation in science and research, particularly in the space sector. In a majority of its large projects ESA depends on cooperation with NASA. Many of their joint projects are long-time cooperation projects that are particularly vulnerable to sudden political shifts and changes in funding. Differences in funding and governmental support oftentimes strain cooperation efforts. For instance, while ESA has a multi-annual budget, which is guaranteed but requires all members' approval for change, NASA's budget is only assured for one-year terms but can be amended more easily. A change in presidency in the US therefore always poses a particular sensible moment in cooperation, as this often goes hand in hand with budget cuts or shifts of emphasis and financial support for projects (Bonnet, Manno 1994, 117-118).

ESA and several of its member states have played a vital part in the creation of an international Global Space Exploration Strategy and in drafting a framework for international cooperation of space faring nations through the International Space Exploration Coordination Group, ISECG (COM 2008 561, 9). The more nations to plan on conducting missions in space, the more important it will be to agree on common principles on conduct and cooperation. ESA as the only multi-national space agency can be regarded as a role model in this respect as it has managed cooperation between countries for more than 60 years.

4. COOPERATION WITHIN ESA – CHALLENGES AND OPPORTUNITIES

The previous chapter has shown that efficient cooperation is necessary within ESA to increase its competitiveness but also to depict it as a role model for peaceful cooperation in an international environment. Several angles need to be addressed to identify ways of increasing efficiency in a large international organisation. The chapter is based on the approach of different angles to the research question in *chapter 1*. Each sub-chapter will address one of the angles beginning with the competitive situation of ESA, its members' benefits and challenges of cooperating, financing strategies, and different interests of cooperation partners. Cooperation with the Estonian Space Office will be used as an example to highlight cooperation structures. For this, an interview with Madis Võõras, the head of the Estonian Space Office, was conducted. From all the data collected and the knowledge gained in the research, a structural model will be designed to visualize a logical and simplified form of ESA's cooperation network.

The chapter is based upon literature research, particularly, for the comparison between the different space agencies in the international arena. For identifying benefits and challenges in cooperation within ESA, open questions were sent to all participating national space agencies of ESA. Data has been evaluated from responses received from representatives of DLR, INTA, NLO and ESO. In addition, questions have been answered by representatives of business partners and academia in the Netherlands and the Czech Republic.[3] All responses as well as transcripts, can be viewed in the annex. The open-answer questionnaires and follow-up interviews were based on the six angles identified relevant for the research question and provide a unique source of information, not available from literature. Main questions addressed were advantages and disadvantages of cooperation with ESA, main challenges and potential for future financing and cooperation strategies according to academia, business partners and representatives of national space agencies. This allowed an inclusion of all cooperation partners into improving and assessing the cooperation structure.

[3] To facilitate quotations the different respondents were named P1-P6. P1 corresponds to the ESO, P2 to NLO, P3 to INTA, P4 to DLR, P5 to Stellar Space Industries, P6 to the respondent of the Czech Academy of Sciences.

4.1. ESA's Competitive Situation

In order for ESA to stay competitive in a growing international competition for space exploration, a short analyzation of the largest space agencies across the globe has to be taken into consideration. *Figure 2* shows the annual budget of 2015 for space of the main spacefaring nations (the latest date to which comparable data for all countries was available) in Million US $. What can be seen is that the US by far surpasses all other nations in its spending.

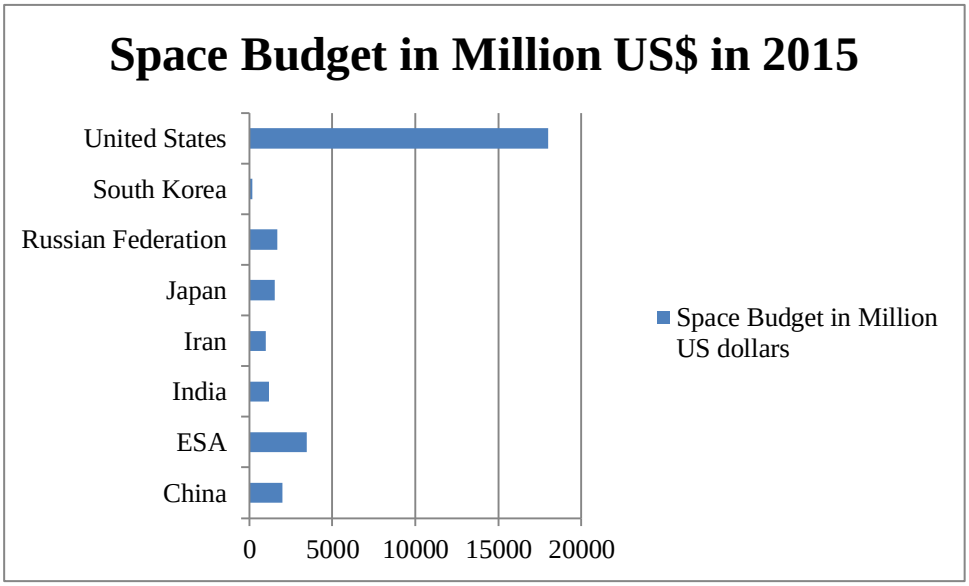

Figure 2. Space Budget per Country (in Million US $)
Source: (Compiled by the author on the basis of data provided in appendix 6)

For decades, the US's National Aeronautics and Space Administration (NASA), with a current budget of around 19 billion US$ (for the fiscal year of 2017), and the Russian Federal Space Agency (ROSCOSMOS), with a current budget of about 1,7 billion US$ per year, after major budget cuts in previous years, were the two dominant agencies in space. They were joined by ESA, whose current budget has grown to about 6,1 billion US$ in 2017. No other space agency comes even close to the level of spending of NASA, or even ESA. However, more and more countries invest a higher percentage of their GDP into space exploration, research and even launching capabilities. The China National Space Agency (CNSA) belongs to the leading space agencies in the world with high aspirations for space flight, particular manned exploration missions. Their annual spending is estimated by experts to amount to

about 2 billion US$, followed by the Japan Aerospace Exploration Agency (JAXA), with a budget of approximately 1,5 billion US$. In addition, the Indian Space Research Organisation (ISRO) is gaining increasing importance in the space sector and is spending roughly one billion US $ per annum on space technology. At current, those six space agencies are the only agencies with their own launching capabilities. *Figure 3* gives an overview of annual spending per country on space in relation to GDP.[4]

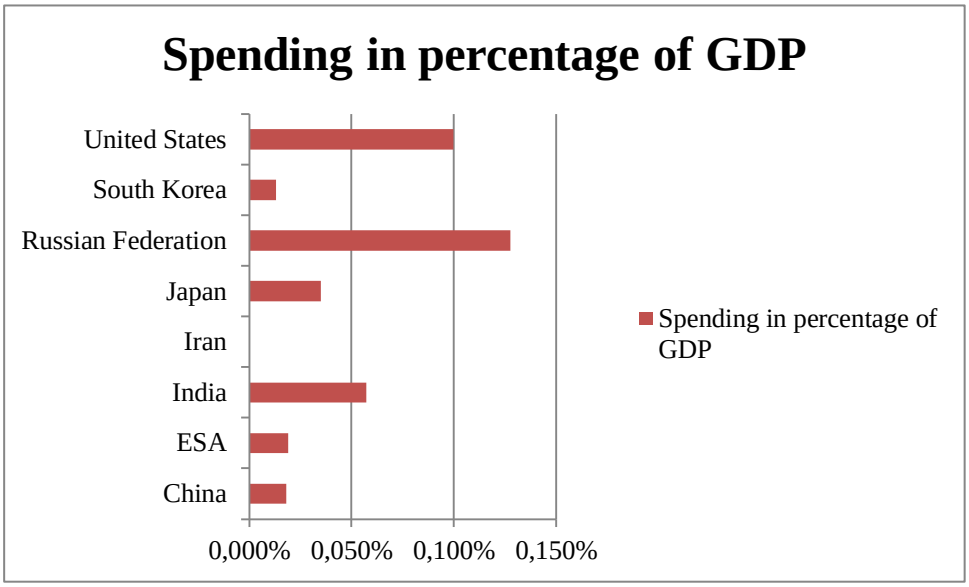

Figure 3. Spending in percentage of GDP per country[5]

Source: (Compiled by the author on the basis of data provided in appendix 6)

Spending on space projects and technology in ESA is (after budget cuts of ROSCOSMOS in the past few years) the second-highest in the world in million US$. When looking at spending in relation to the countries' GDP, however, Russia's expenditure for space exploration amounts to 5 times the percentage of its GDP. Apart from Russia and the US, Japan and India spend a larger proportion of their GDP on space research and exploration as compared to ESA. This can be easily explained by the high GDP of the ESA member states. If contributions to ESA and NASA are highlighted on a per capita spending, differences become even more apparent. While citizens of ESA member countries spend on average 6,7€ (about 7,1 US$) per year on membership fees, US citizens spend about 56 US$

[4] Budget numbers and GDP of the fiscal year 2015 were used as this was the latest available complete data set.
[5] The GDP of Iran is currently not available for 2015. The ESA percentage of GDP is based on contributions exclude EUMETSAT contributions. Numbers are calculated based on full members and therefore exclude Canada.

per year[6], about 8-fold the amount per person. This results in several strategic advantages on the side of NASA when cooperating with ESA. For instance, space industry in the US, is more competitive, and is able to sell products on the common market whereas this is not the case for the European Space Industry. Particularly, as space industry in developing countries, such as China and India, is increasing, the industries in Europe need to improve their efficiency to be competitive on a global market (Agenda 2015… 2011, 31). By investing in new technologies and supporting new applications ESA can contribute to a more competitive European Space Industry. For this, closer collaboration with the different industries as well as with EU institutions is vital (ibid. 32). *Figure 3* reveals that ESA member states would have enormous potential in terms of financial support of ESA activities if similar levels of spending in percentage of GDP as in the US, Russia or even India were to be reached. By raising contributions with regard to GDP proportions, more financial means would be available to higher expert staff and invest into research on new technology and independent projects. To achieve a dominant position in space research, being technologically advanced and independent is a crucial factor. Developing components in Europe instead of the US, from which currently 60% are imported, is one of the aims for future policies. Also, knowledge and skills in earth observation and space navigation could be expanded better with a higher amount of funding before developing nations catch up and become more dominant (COM 2014 108, 8). Greater financial capabilities would ensure a lasting and more balanced partnership between NASA and ESA, and would guarantee ESA a notable degree of independence and strengthened abilities for future cooperation with different space agencies.

It has to be taken into account that there are more and more space agencies investing significant amounts of money into developing technology for independent and increased access to space, particular in relation to economic development in nations, such as India, Brazil, Argentina and many others. Most of the agencies are interconnected through various bilateral agreements, including many agreements and cooperation in the past with ESA. Several countries, such as Argentina in 2011, also suggested the creation of a South American Space Agency, similar to ESA, which would allow for a completely new level of cooperation (Hulse 2011).

While ESA at present has a strong stance in the international environment, growing and upcoming space agencies will require it to find a new path of cooperation and to increase its funding, either via increased membership contributions or an extended member network.

[6] Calculations are based on World Bank data of 2015 and a US population of 321.418.820. See appendix 7 for more details.

4.2. Benefits of Cooperation within the ESA Framework

Cooperation within a larger organisation offers many benefits to states. It allows for greater financial means to tackle the costs of high-scale projects that could not be borne by a single country, or would not be needed by every country individually, such as the provision of launchers for space crafts and satellites. Cooperation leads to higher cost-effectiveness and efficiency as unnecessary double investments can be avoided. In order to identify the opportunities and advantages of cooperating within an intergovernmental agency, questionnaires with open questions were sent out to all national space agencies cooperating as ESA members and their responses and perspectives on reasons of cooperation were evaluated.

The interview and questionnaire responses mentioned several benefits. Central in the evaluation was the creation of a European independency, for instance by furthering the development of a European carrier rocket or the ability to perform larger and better coordinated projects that would not be possible by a nation on its own. ESA is regarded as a forum allowing different European nations to discuss space matters. Particularly for smaller countries cooperation in ESA offers various benefits as it allows them to be represented in space in the first place and to contribute "niche capabilities" or "special competences". In general, specialization is one of the perks of cooperating within ESA, which strengthens the economic performance of an individual country as well as of ESA as a whole.[7]

In addition, the free movement of people and the easy access to the job market within the area of the European Union allows attracting experts from different countries, facilitating specialization on one hand and ensuring attractive and high quality job within one's country on the other hand. ESA's "return of investment" principle has been highlighted positively several times as it guarantees a return to a nation's businesses and industry for the funds invested in ESA via membership fees. It serves as a viable incentive for small or new members, such as Estonia, to consider and trust in the benefits of ESA membership, particularly in the form of business opportunities for citizens.

Another major advantage of cooperation within ESA is its openness. "ESA is very open. ESA talks with you" (16:15-16:18), was one of the statements heard several times during the interview with the Estonian Space Office. A respondent from academia added that "they [ESA staff members] were very professional in their communication and always very helpful" (P6). For cooperation to be successful it is essential to have a clear communication

[7] The questionnaire responses and interview transcripts can be viewed in appendixes 2-5.

and a support structure. Participants need to have the opportunity to address problems and resolve their issues. Functioning feed-back channels enable effectiveness in projects and planning and increase willingness to cooperate. Feedback on communication with ESA has been showing how important accessibility of an organisation is in terms of communication.

Overall, in order to remain and extend a strong stance in growing international activities in space, bundling cooperation efforts to the highest possible outcome is necessary for European countries to remain leading in space research. As the example of ESA shows, this can be reached by guaranteeing safe investments, allowing specializations, as well as support and dialogue to help its members in achieving their best.

4.3. Challenges of Cooperation within ESA

As cooperation has several positive impacts on the efficiency of space-related projects, there can be elements that pose challenges to successful cooperation. Several challenges have been identified by participants of the questionnaire as well as during follow-up interviews. As challenge was seen that "activities outside the framework are abandoned" (P3) and that "entities belonging to the most influencing countries in Europe are privileged against the others" (P3). This statement is interesting as the way ESA is set-up it guarantees employment and return of investment depending on the financial contributions made per country. Countries with high contributions are therefore better represented in the organisation than countries with limited financial contribution. On one hand, for many decision-making processes the "one country, one vote" (P4) principle applies, which gives every member the same voting rights, making the organisation more equal in opportunities to its members regardless of size and income in comparison to many other institutions in the world. Therefore, one could argue that small countries actually benefit from this system. On the other hand, it might be argued that the actual decision-making processes, taking place before ministerial councils are held, might well be influenced by members of larger countries as they tend to provide a larger portion of the ESA staff. This argument, however, seems dismissible as those employees are directly employed by ESA and not the national agencies and therefore see the well-being of "their" organisation and community as priority over national projects alone.

Whereas more members enrich the cooperation, they also lead to higher complexity of the organisation. Finding a way to serve "national interests with respect for all other interests

in Europe" (P2) remains one of the main challenges in cooperation. Especially with a "one-country one-vote" scheme, it becomes more and more difficult to reach uniform decisions the more members there are that fully join ESA. However, in this form of decision-making lies, I believe, the strength of ESA as an international, inter-European organisation. Decisions might take longer to make, but if agreed upon by every member, they carry legitimacy and offer the organisation a high degree of strength and stability. The decisions form the basis of the organisation, its direction and its structure. Agreeing on those directions together and jointly finding solutions to complex problems allows for level cooperation that offers the same degree of respect and trust to all of its members and thereby creating a unique partnership that is rarely seen in other areas of international relations.

Furthermore, what appears from responses is that, particular in the case of smaller countries, the guaranteed return of investments tends to be difficult for every single project as not all countries have sufficient industries to be able to receive enough industry work packages from ESA to fulfil the promised quota. One option would be to extend the return of investment principle to more projects to allow for more flexibility in industrial return. Some critics argue to abandon the principle altogether. However, I believe that the return of investment is one of the core principles of ESA, allowing countries to invest large sums at low or no risk and ensuring the growth of their national economy and industry and providing high-quality jobs. Difficulties with achieving full return of investment might even out if countries are given support to develop niche capabilities and specializations that are needed for different space projects. Not only will they create local jobs but also increase efficiency within ESA as a high skilled work-force can bundle their energy one specific elements of a project, such as ICT, in which the respective country is already a specialist in. As projects require industry input higher than the general investment made, returns can exceed the investment of one country. This promise of higher return than investment will drive competition between industries and ensure efficient economies. Due to this, arguments that the return of investment is largely competition impairing in the EU market can be dismissed.

Another challenge mentioned was the different cooperation options with the EU and ESA. Especially for new members cooperation can be "very complex" (P1). What has been causing confusion between members are the different funding options offered in support of the EU's Horizon 2020 project. As both the EU and ESA aim at achieving a joint policy for space, their programs match officially. Although they do overlap in many aspects, they still differ in some. One of the main questions in the joint program of ESA and the EU is the degree of influence the EU needs to have over space policy in Europe. A discrepancy can be

seen between the competency of the EU in terms of space, agreed upon in the Treaty of Lisbon, and the competences for space of the national states. At current, the EU offers financial means to projects beneficial for the EU, such as Galileo. These projects are then managed and executed by ESA. A further analysis of cooperation of EU and ESA can be followed in chapter 4.7. Overall, main challenges occur around distribution of tasks and projects and fair representation of member states, particularly with growing extension of membership.

Particularly for businesses, the theoretical and detailed project proposals can be strenuous as the highest degree of specificity is needed to avoid ambiguity. Interview respondents from Estonia, the Netherlands as well as the Czech Republic stated that "working with ESA is complicated" and that it is "not obvious that some SME can do that" (P1); "I had almost no issues, except the bureaucracy […] And so many documents" (P6). Considering the size of ESA, it is only natural that bureaucracy represents an important aspect of coordination and cooperation to gain oversight over all potential partners and proposals. However, to facilitate cooperation, creating a system that allows for exchange of data more easily and with faster feedback options would allow for more effective collaboration and a higher quality of research and project proposals handed in.

When working with different partners, for instance on international projects, one participant stated that "the major challenge is the communication; personally, I have a lack of information" (P6). Similar problems were repeated by the Dutch business respondent who points out that "the communication can be better. That you that between partners that you exactly know which one can be used for a certain task or project (P5, 30:01-30:21). Cooperation, particularly with new partners therefore poses one of the major challenges for ESA member states' industry partners. Particular smaller companies and start-ups would require more assistance in the beginning to create a cooperation process that is faster and runs more smoothly. One way of support would be via the creation of a more interactive platform connect to the ESA emits tender system that allows for project coordination, addressing of issues and questions and support from ESA experts on the topic. The communication platform could also be used to display the full project to understand all components of the research projects and easily be able to find the specific tasks and functions of cooperation partners.

4.4. Financing Strategies

The largest contribution to ESA's budget stems from mandatory membership fees. Membership fees within the European Space Agency are based upon each country's respective GDP as well as some optional contributions and therefore vary greatly per country. All mandatory membership fees have to be accepted by a vote from every single member state of the organisation. Although membership is based on a country's GDP, contributions vary highly for every member as can be seen in *figure 4*.

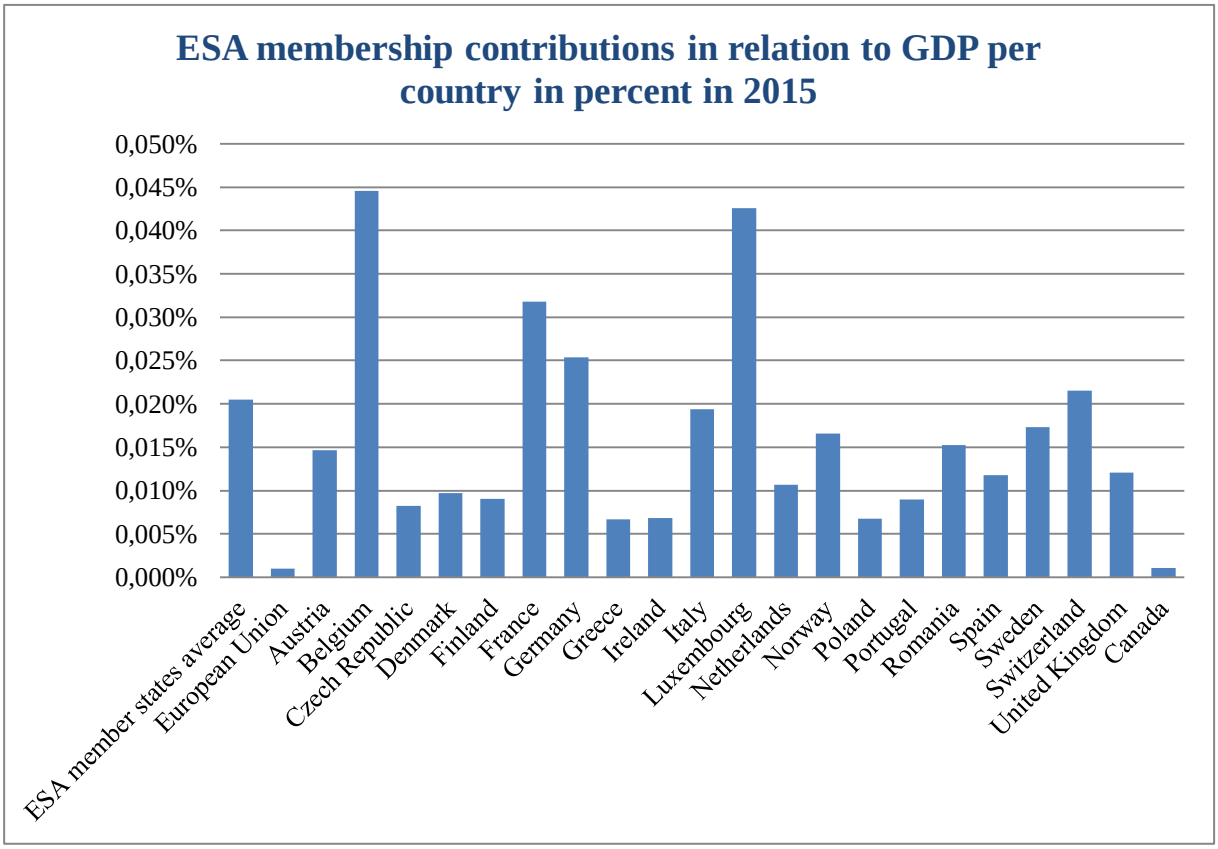

Figure 4. ESA Membership Contributions in Relation to GDP per Country in 2015 (in %)[8]
Source: (Compiled by the author on basis of data in appendix 7)

Membership fees to ESA only amount to a small part of a country's GDP. While this is approximately 0,2 ‰ of the GDP of a member state to ESA, countries, such as Luxembourg, Belgium, France and Germany have contributions highly above average ranging from 0,25 ‰ up to 0,45 ‰ of their respective annual GDP. France and Germany, with two of the largest economies in Europe, therefore, jointly provide almost half of ESA's total budget.

[8] Excludes EUMETSAT contributions.

This gives them a high degree of financial power within the organisation. In order to keep the organisation and its member balanced, membership fees are prohibited from exceeding 25% of total contributions to ESA per country. Advantages of a higher budgetary input can nonetheless be felt in the fact that strategic centres are located within countries with high contributions as well as the fact that staff numbers correspond to membership contributions.

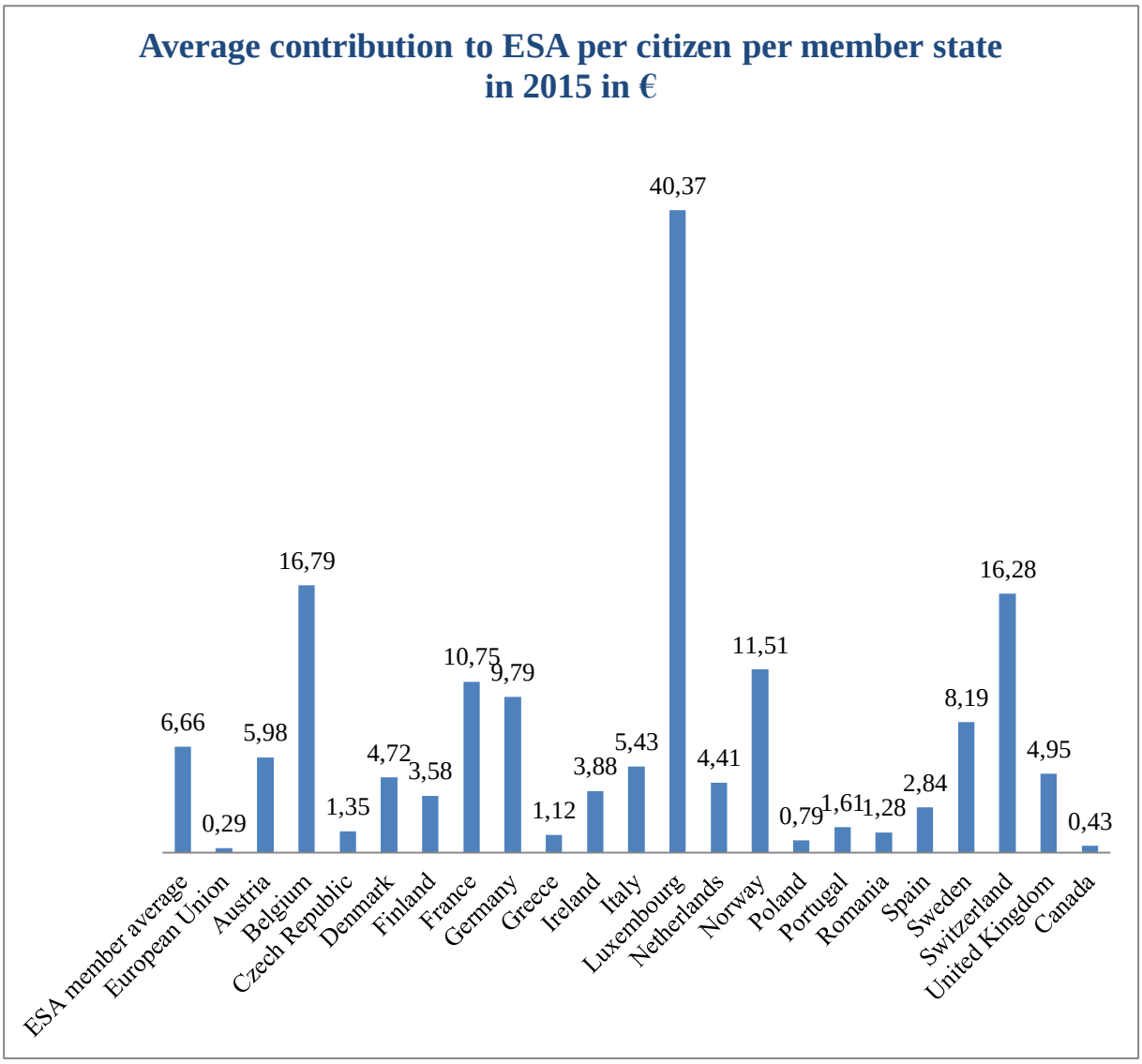

Figure 5. Average Contributions to ESA per Citizen per Member State in 2015 (in €)[9]

Source: (Compiled by the author on basis of data provided in appendix 8)

[9] Estonia joined ESA as a full member on the 4th of February, 2015. With yearly membership contributions of approximately 2,5 mio € this amounts to a per capita spending of about 1,91€ per year. For Hungary, which joined on the 24th of February 2015. and currently contributes 6,2 mio € to the annual ESA budget, this amounts to only 0,62€ per citizen. The data excludes expenditures for the EUMETSAT project.

Contributions shift slightly when looked at in contribution per citizen per member state in *Figure 5*. While the average contribution (calculated based on countries' GDP and ESA budget of 2015) for ESA members is around 6,7€, citizens of Luxembourg contribute on average six times more money to ESA. Citizens from other countries with high GDPs, such as Belgium, France, Germany, Norway, Sweden and Switzerland contribute above-average. Due to large sums in available national budgets, these countries, in general, tend to have a higher interest and are more involved in the space sector. However, despite high GDPs, contributions from countries, such as Austria, the Czech Republic, Denmark, Finland and the Netherlands are comparably low. Higher awareness among citizens of projects related with space and ESA's promise for a 100% return of investments for governments could be used as arguments in those countries to promote an increase of funds for ESA.

As in any organisation, higher funds offer a higher global level of impact and are the primary way to increase technological development, expertise and as a consequence, efficiency. Several options for increasing funds for projects have been discussed in the recent years and in surveys conducted by ESA. These include government investments, private-public partnerships and citizens' funding (crowdfunding) initiatives (ESA Citizens' debate on Space for Europe 2016). For this thesis, national representatives as well as business representatives have been asked in interviews and questionnaires on their opinion on best possible funding options (see appendix). If asked what was considered the most best form of funding, most respondents focussed on support from national governments.

Raising the budget via national government contributions can only be done with support from citizens. One way of receiving higher amounts of funding from governments is by raising citizens' awareness of the importance of space research and as a result, their willingness to contribute taxes to ESA's programs. There are at the moment, several initiatives to involve citizens in ESA's research. Activities range from open days at the different research facilities, multi-lingual newsletters to the involvement of artists or the creation of workshops. By involving citizens' in ESA's projects a higher level of awareness and interest can be created. In general, awareness of ESA's research and capabilities amongst the general population is still in need of improvement. Particularly in countries that do not host an ESA establishment, recognizing the importance of ESA might sometimes be difficult. The first citizens' debate conducted by ESA in September 2016 shows that even among those 1588 representatives participating in the debate – who by participating in the first place showed an above-average interest in space – 30% did not know much about ESA. 11% did not know ESA at all. (ESA Citizen Debate on Space for Europe 2016) This highlights the fact

that additional options need to be explored to involve citizens in space and raise their awareness about the topic. For this reason, involvement of citizens in informational events, including countries or cities that do not have an ESA research facility, need to be given more attention. Options could include smaller-scale live-events with Astronauts, work-shops with ESA research personnel, and opportunities for involvement, for instance in the form of competitions (and prizes such as "behind the scene" trips to ESA). Such events could bring space closer to the people in areas, in which citizens might normally not be in contact with space related science. Another effective way of increasing awareness of ESA is by promoting the organisation on TV via news channels, ads or even screening time in films produced by production companies in member states. In addition, school projects with ESA personnel or building toy brick rockets and satellites raises interest in STEM-related field sciences and offers young generations of researchers incentives obtain a degree in one of these areas. Highlighting the advantages ESA offers to citizens of its member states and being accessible to the public will raise willingness to fund the agency and dedicate a higher percentage of taxes to its research facilities.

Higher funds can on the one hand be reached by support from citizens and on the other hand by the promise of high returns. Interview correspondent, Madis Võõras, head of the Estonian Space Office, added that to raise higher funds "there is only one way – to prove to the government and to the parliament that this is beneficial to business" (10:20-10:23). In the questions addressed to national space agencies and business partners, funding from national government was seen as the most suitable solution with funding from the EU named second. The latter was seen critically by some national agencies as funding by the EU tends to correspond to stricter guidelines in the choice of projects, and a tendency to less independence from national agencies in the decision-making. In addition, stronger cooperation with the EU will require a review of the return-of-investment policy as it is seen as competition-distorting in some cases. In how far this is truly the case and in what ways this could be amended is something, future research needs to show if cooperation between the EU and ESA is to become closer.

What has recently been discussed more frequently is the establishment of public-private partnerships. There are more and more successful private companies developing equipment for space and cooperating with national space agencies. It is argued that with their massive turnover and employees, they would have the capabilities needed for co-funding projects. However, PPPs have to be seen with caution. They increase the risk of lobbying, corruption, transfer power from national governments to businesses and might not benefit all

countries equally (Hall 2015, 27;29). As privatization aims at reaching the highest maximum profit, core projects of ESA, such as scientific research in space, are likely to suffer as they yield less than technology applications or satellite operations. In addition, this form of partnership for long-term projects can likely have competition-distorting effects leading to reduced efficiency and a welfare loss for citizens. With PPPs caution has to be exercised to not put small or medium-sized enterprises at a disadvantage. In the case of ESA, PPPs would be particularly relevant for the promotion of space access providers, with special regard to the development of commercial spaceflights in future applications. While funding in the form of PPPs might be suitable in this area, clear guidelines and regulations have to be created a priori to avoid conflict.

Another increasingly common form of funding is funding for public projects through citizens, called crowdfunding. While crowdsourcing – getting ideas through the involvement of citizens – can function well for developing innovative ideas or solutions and for engaging civil society, crowdfunding can be rather problematic in a large setting, such as ESA. Crowdfunding is frequently being used for small community-based projects, such as parks and gardens with joint ownership. Citizens have an active choice in the form of project they want to support and help finance it. For grand-scale ESA projects however, this, at least from a current point of view, seems not yet feasible. First of all, receiving adequate funds for large-scale billion dollar operations is fairly unlikely. Secondly, since spending capacity varies greatly across the different member states of ESA, this way of funding would put less advantaged regions at a greater disadvantage. Ownership rights and lack of regulation when it comes to crowdfunding would make future operations testing from a legal perspective. In addition, three quarters of the participants of the ESA citizens' debate stated that crowdfunding is currently not a priority for them (ESA Citizens' Debate on Space for Europe, Question 5.5.4).

To sum up, citizen support and involvement for funding is essential and their input and feedback valuable for raising funds from national governments. By creating awareness of the benefits of space exploration and by guaranteeing return of investments, budgets of national governments for ESA can be increased. If being guaranteed to maintain intergovernmental decision-making in the cooperation within ESA, closer cooperation with the EU would be another viable option. PPPs, if applied with high caution, can serve for infrastructure development, especially in the launching sector. Crowdfunding, on the other hand, is for now is not a feasible option, but can remain an option for future applications.

4.5. The Estonian Space Office as an Example of National Cooperation with ESA

As one of the latest full members of ESA, Estonia presents an example of national and international cooperation structures within and beyond ESA. Cooperation between Estonia and ESA started in 2007 with a first Cooperation Agreement. On February 4th 2015, Estonia fully joined ESA as its 21st member state after signing the ESA Convention. Estonia's membership to the EU as well as its projects with ESA led to the creation of a national policy for space. The national space policy is managed by the Space Affairs Council at the Ministry of Economic Affairs and Communications. Estonian businesses can receive funding either via ESA or via the EU's Horizon 2020 Space programme (Estonian Space Office 2017). While Estonia, similar to other smaller European states, does not have a national space agency, it manages business and technology competences related to space through the Estonian Space Office, as part of Enterprise Estonia (EE). An interview with Madis Võõras, head of the Estonian Space Office was analysed to understand cooperation structures of Estonia in ESA, as well as its current advantages and challenges.

With a population of 1,31 million people (Population … 2017) and current ESA contributions of 2,5 million € per year, this amounts to an annual spending of approximately 1,9€ per person per year. This ranks Estonia rather on the lower end of spending per person in comparison to the ESA member state average of about 6,7€ per person (see *figure 5*). Moreover, when taking into account Estonia's GDP of about 20 billion €, the membership to ESA accounts for an about 0,01 % leaving it below the average spent by other ESA member countries. However, due to the ascension to other international organisations in the future, it is fairly unlikely that the budget will experience any major increases in the upcoming years. For new and small members, such as Estonia, ascension to ESA is filled with challenges and opportunities alike. ESA offers funding and business opportunities, which under its return of investment principles, are guaranteed to go to Estonian companies, allowing them the "possibility for high-tech development" (P1, 00:15-00:18). In combination with Estonia's support for start-ups and business development, membership to ESA allows the country to develop its competences. New business opportunities with ESA enable further focus on areas of specialization, such as the ICT sector. A specialisation on areas of expertise is highly beneficial to develop an internationally successful economy as well as benefitting the joint organisation by adding high-value expertise and products. Cooperation therefore offers

benefit to Estonia through support of business and technology development and investment and all ESA members as a whole through increased specialization and efficiency of programmes and projects. ESA membership provides an incentive for the creation of space-related industry and business. Through cooperation with ESA and experience gained in ESA projects, many of the new businesses will be able to develop competencies outside of space technology for down-stream applications and a broader usage beneficial for the general public. Considering cooperation with ESA as fuel to the economy can be seen by the high degree of return of investments. Since its ascension to membership in 2015, Estonians businesses have received a 107% return of Estonia's membership fees to ESA. International cooperation can be seen as having a largely positive impact on the local economy, particularly under the rules and regulations which the ESA convention provides.

In the cooperation with ESA, member states and its businesses are faced with several challenges, particular with the high degree of technicality in project proposals. The Estonian Space Office agrees that "to cooperate with ESA is quite complicated" as "ESA is extremely regulated" (02:50-02:57). Experience in responding to invitations to tender (ITTs) is a prerequisite in being selected for project cooperation with ESA. The high degree of bureaucracy might therefore sometimes limit the implementation of viable project ideas due to a mere lack of formalities. This, unfortunately, is the case in every larger organisation. This issue can only be tackled by increased support in the preparation of proposals, from ESA, but particularly, from national organisations, such as the Estonian Space Office, in the case of Estonia. Investing financial means in preparing businesses for large international projects is necessary to help smaller and less experienced companies succeed.

While cooperation within ESA is definitely a learning process for members and national industry, what has been mentioned as one of the main benefits is that "ESA is very open. ESA talks with you. As contrary, for example, European Union in Horizon 2020. There, no one talks to you because there is so large inflow of projects that it's impossible to talk to them but in the case of ESA they talk to you and they give some feedback what went wrong if you didn't succeed" (16:15-16:45). This statement shows the importance of communication in international cooperation, especially for new members. As one of the benefits of international cooperation in scientific areas is that members learn from each other, feedback and availability to communicate is a prerequisite to advance and learn from mistakes together. In this respect, ESA can be highlighted as an examplatory organisation for cooperation as it focuses on supporting its members with guidelines and feedback if possible. Due to its specific nature and focus on one project area, experts from different countries and areas can

easily be connected through the organisation and its online platforms, such as the Belgian platform YouSpace, which is providing experienced space industry mentors (YouSpace 2017).

4.6. Interests of and Relations between the Various Actors

There are several reasons for engaging in joint space exploration, as explored in the previous chapters. Pooling of resources and experts guarantees higher results. National governments benefit from a positive impact on their nation's economies; internationally, cooperation can lead to more peaceful coexistence. "Space is also an enabler for responding to societal challenges and it effectively contributes to smart growth, the competitiveness of the European economy, and produces highly qualified jobs" (Bieńkowska, Woerner 2016). Cooperation in space is essential to tackle global problems, such as climate change, migration and security issues that cannot be solved by individual nations alone. United cooperation of European countries in space therefore strengthens the image of Europe and of the EU in the world. For the EU, successful cooperation within ESA could strengthen European Integration and reduce tensions between member states, by getting acquainted and cooperating in different contexts. For businesses, funding and investment options arise, and society in general benefits from new technology, new scientific discoveries and stability. Many actors are interested in cooperating for those unique reasons and benefits. As a result, cooperation becomes more complex as it involves interests of several different members and various layers and levels.

Figure 6 shows the complexity of ESA's cooperation with different participants and organisations and compares it to different wheels within a functioning machine. Whereas ESA cooperates with its individual members it also has to cooperate with the European Commission on a joint policy as well as with other space agencies, such as NASA, to develop new space applications and work together in space. If one compares this process to machine wheels in which every actor is part of this wheel, it needs all wheels to turn in the same way to move the whole. The more smoothly the wheels turn, the more effective is the machine. The more smoothly the members coordinate their actions, the more effective is the organisation as a whole.

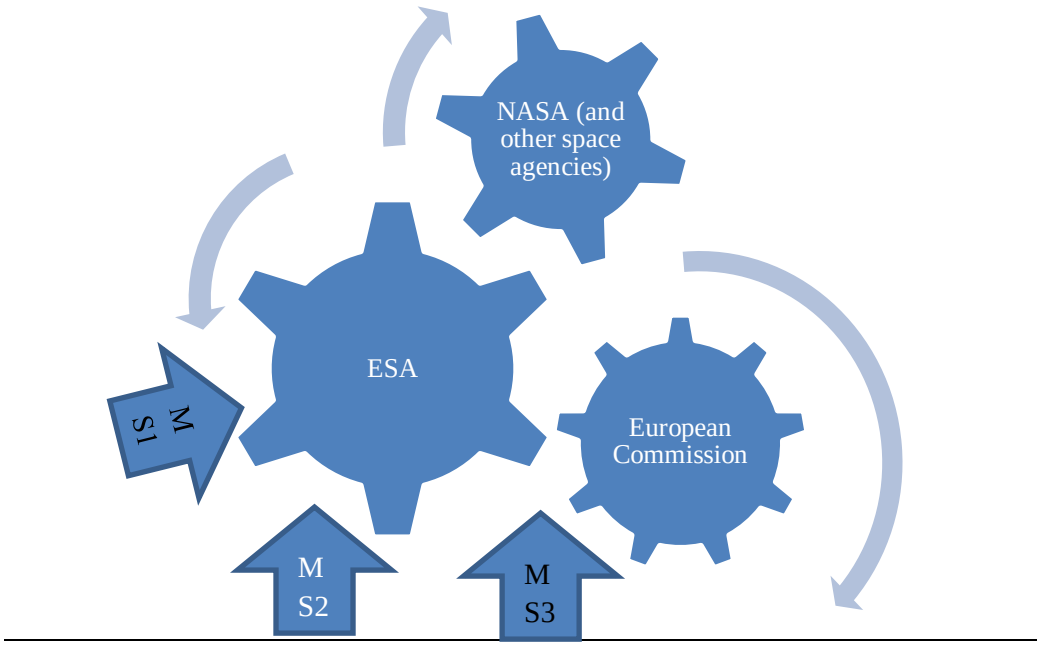

Figure 6. Cooperation as Spinning Wheels
Source: (Designed by the author)

The structure of the European Space Agency offers several challenges and opportunities in creating a functioning set of smoothly coordinated "wheels". As not all of the 22 member states are members of the European Union, the application of funding from the EU poses a challenge. Bulgaria, Cyprus, Lithuania, Latvia, Malta, Slovenia and Slovakia have special agreements with the European Space Agency, most of them under the European Cooperating State agreement. Under this agreement, cooperating states have no seat in the ESA council, but participate indirectly in its projects. They pay a reduced membership fee and benefit from the projects undertaken but cannot take part in the decision-making process. The EU as such currently only supports specific projects which are relevant for the entire EU-region.

Table 1 shows all member countries to ESA, to the EU or both. Some countries are no full members, but European Cooperating State (ECS) members, have Plans for European Cooperating States (PECS) or have special agreements with ESA. A PECS is a closer membership than associative membership and prepares countries and their industries and research for becoming a full member to ESA within five years. In addition, ESA has a special cooperation agreement with Canada, that lies in between being a cooperating state and a full member as it has a seat on the council but reduced membership fees.

Table 1. ESA Member States and Respective EU Membership

Country	ESA Member	EU Member
Austria	✓	✓
Belgium	✓	✓
Czech Republic	✓	✓
Denmark	✓	✓
Estonia	✓	✓
Finland	✓	✓
France	✓	✓
Germany	✓	✓
Greece	✓	✓
Hungary	✓	✓
Ireland	✓	✓
Italy	✓	✓
Luxembourg	✓	✓
The Netherlands	✓	✓
Norway	✓	
Poland	✓	✓
Portugal	✓	✓
Romania	✓	✓
Spain	✓	✓
Sweden	✓	✓
Switzerland	✓	
The United Kingdom	✓	No longer EU member state
Canada	In the council, cooperation agreement	
Israel	Cooperation agreement since 2011	
Bulgaria	ECS agreement since 2015	✓
Croatia	*ongoing negotiations	✓
Cyprus	ECS since 2016	✓
Lithuania	ECS since 2014	✓
Latvia	ECS since 2013 + PECS	✓
Malta	Cooperation agreement since 2012	✓
Slovenia	Associate member	✓
Slovak Republic	ESC since 2015 + PECS	✓

Source: (The European Space Agency … 2017, 4)

To reach a higher level of policy coordination and a common forum for all European states, expanding full membership to all countries in Europe will be a useful target in the long run. A question that arises in terms of membership is which countries will eventually be eligible to become full members. As ESA is an independent organisation it is not confined merely to the membership candidates of the EU or not even to any geographical limitations as the special cooperation agreement with Canada shows.

However, the more member states ESA acquires the more complex cooperation becomes. Most of the larger countries working together under the umbrella of the European Space Agency have their own national space agencies and space policies. National agencies serve as a structural board to manage part of ESA's tasks on a national or regional level. In addition, national boards allow for developing country specific targets and plans, and offer educational programs and research cooperation options with the industry in that country. Many smaller countries do not have their own national agency and rely on representation of their interests through ESA. In the majority of the smaller countries, cooperation with ESA comprises of the largest percentage of their space projects.

ESA serves as a forum to connect all the different countries and their respective agencies. Nonetheless, the member states' need to remain independent and upkeep a national agenda in addition to ESA projects puts limitations on policy coordination with the EU.

4.7. Cooperation Agreements between ESA, the EU and their Respective Members

Different aims and goals unite the national member states with ESA and the EU. With the Treaty of Lisbon the EU received a competence in space in 2004. Together with ESA it defined a European Policy for Space. ESA and the EU work together under the ESA/EC Framework Agreement. The level of involvement of the EU is debated when it comes to space exploration. As with every sort of cooperation (even similar to cooperation between individuals discussed at the beginning of this thesis) a balance of interests has to be sought. This can be achieved by focussing on the common goals and targets.

Strengthening the economics of both EU and ESA members and providing sustainable access to space is one of the shared core elements. Both ESA and the EU offer funding for space-related projects and industry to drive innovation and strengthen European businesses. While ESA and the EU share similar interests, their strategies tend to diverge. The most

critical distinction is that ESA is employing a return on investment principle for every member state guaranteeing almost 100% of return to for each nation's industry in respect to the amount of their membership fee. This guarantees a secure investment and offers a justification for using tax money for membership fees. However, this is strongly criticized by the EU which considers this principle as interfering with the free market structure and distorting competition. In projects funded by the EU, the EU adheres to government procurement regulations of the WTO which require "the principle of non-discrimination and do not allow any form of geo return" (COM 2013, 36). This is therefore a highly debated topic when projects of ESA involve cooperation with the EU. It can be argued, though, that particularly for new members or smaller members of ESA, this principle is of core value. It helps develop infrastructure and industry in every nation alongside as furthering education and research in this area and guarantees business opportunities in the region. Therefore, it creates highly-paid job opportunities, in particular also in countries that are struggling with economic disadvantages or brain drain. However, regulations need to be in place to ensure that SMEs and new enterprises have equal standing as long-time business partners in receiving contracts with ESA. It is the joint objective of both ESA and the EU to create a "globally competitive space sector" in order to ensure "European autonomy in accessing and using space in a safe and secure environment" (The European Space Agency … 2017, 73) Ensuring the autonomy of national space agencies but at the same time increasing cooperation between the different actors will allow for better policy coordination and willingness to cooperate. Common targets have to be prioritized to ensure that national interests do not impede the efficiency of the agency. However, with open invitations to tender and a more transparent selection of the most competitive industry or business partner fairness and effectiveness of cooperation can be ensured.

4.8. A Cooperation Model

In order to remain an important actor in space, ESA needs to remain a forerunner in space technology, research and application. A dominant position will make ESA a valuable partner and ensure long-term cooperation with other agencies. Furthermore, it enables ESA to plan and achieve more personalized missions. The latter is necessary for receiving citizens' support, which has been identified as core element for elevated funding. This creates a continuous circle:

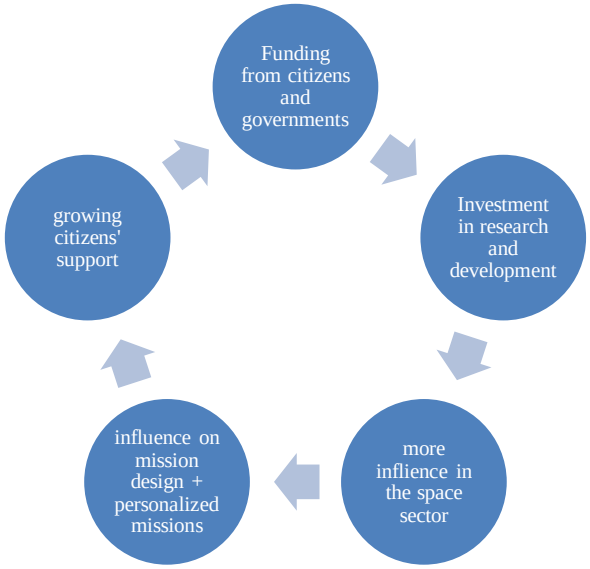

Figure 7. ESA Funding Scheme

Source: (Designed by the author)

If ESA receives a large amount of funding, it has a higher capacity for investing in research and technology development. This provides new job opportunities and attracts university graduates from all its member states. As a result, more and more universities cooperate with ESA, adding valuable research capital in the forms of laboratories, and knowledge exchange with professors and bright students. More knowledge exchange and research leads to more innovation and development of new technology. Not only will unique technology make ESA a valuable partner for various space missions, it also helps grow ESA's independence from other agencies. The ability to contribute various novel aspects to joint missions will allow ESA to have a larger influence on mission design and aims. This in turn creates an opportunity to connect space mission to citizens' ideas and aspirations, and includes them in the process. If citizens feel more included in space missions, their willingness to contribute to space research rises, leading to higher available funds and in turn to more research and faster innovation.

With recent expansions of membership and new forms of cooperation with businesses, cooperation in ESA has become very complex. A model of ESA's cooperation network was created to highlight particularly strong and weak spots of the network. The anatomy of a network needs to be identified as structure always affects function." (Strogatz 2001, 268). Knowing the structure of the network allows for visualization of the directions and nods through or to which information travels. Awareness of these streams can help improve weak

links. The model shows cooperation within ESA and identifies its strong and weak aspects. The model is (per definition) a simplification of the real world cooperation between ESA and its members as well as outside partners. To represent most relevant areas of cooperation, a (presumably larger) country with a national space agency (1) as well a country without a national space agency (2) have been chosen to represent cooperation structures. Their national cooperation partners with ESA comprise of firms A1 and B1 of member state 1 as well as firms A2, B2 and a university U of member state 2. Each of the partners in business and academia cooperate with ESA and with each other. In addition, national space agencies offer additional funding and projects represented by links between national partners in industry and academia with the national agency. Cooperation agreements and projects connect outside space agencies with ESA, national space agencies and businesses as well as academia. These links lead to a fairly dense network of cooperation among the various actors.

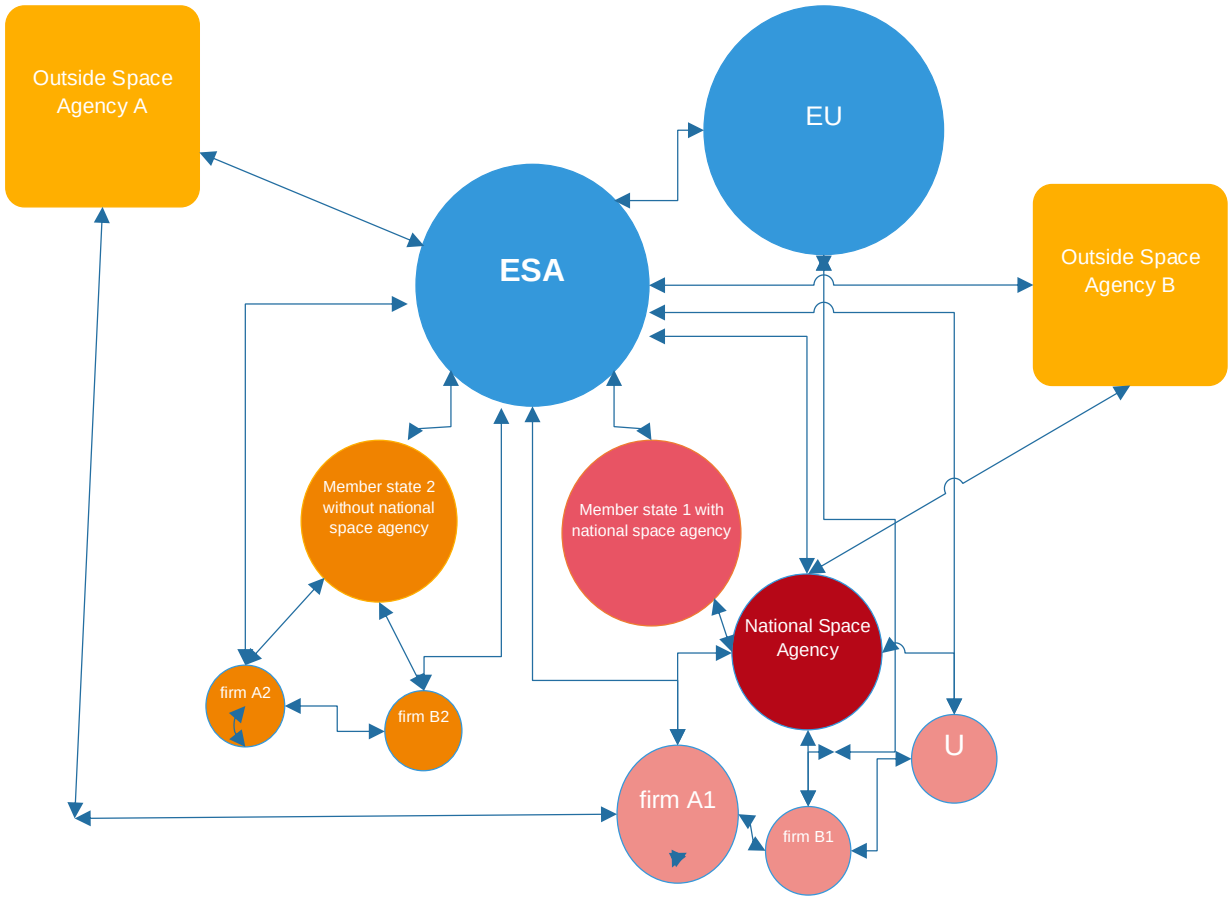

Figure 8. Structural Model of Cooperation in ESA

Source: (Compiled by the author)

The model in *figure 8* shows the cooperation structures between the different actors. ESA cooperates with the different countries via decision-making processes in ministerial councils and through relevant national departments. The link between ESA and the depicted national space agency represents the fact that countries that have their own national space programme and agency tend to have additional cooperation projects and agreements with ESA. One example is the agreement between ESA and CNES on access to the launch site in the CSG launch site. Firms and research groups of the respective countries mostly cooperate with ESA through replying to invitations to tenders and therefore executing ESA's projects and receiving funding from ESA. In some cases, these companies also apply for and receive funding from national space agencies or the EU. A high degree of bureaucracy frequently challenges these connections, particularly in funding from the EU. To manage extensive tenders, companies sometimes tend to cooperate and work on projects jointly. This tends to be executed by companies that already have experience in working together; thus, cooperation of companies from the same country might be more likely. Furthermore, universities and companies occasionally engage in projects with space agencies outside of Europe. While ESA has cooperation agreements with other space agencies outside of Europe, national space agencies, in addition, tend to have cooperation agreements with space agencies outside of ESA. The model, in coordination with the conducted interviews, reveals the following strong and weak elements in the cooperation structure within ESA, as depicted in *table 2*.

Table 2. ESA's Cooperation Structure

Strong elements	*Weak elements*
Existing links between business partners	Lack in communication between project partners
Links between the different national agencies (not shown in model)	Some countries at structural disadvantage – no ESA institution close by
ESA as accessible communication forum and central element	Coordination problems with the EU in terms of policy coordination
Great potential for expertise from cooperation with different countries, businesses and universities	Better support and integration into the network needed for start-ups and small businesses

Source: (Compiled by the author)

To address the weak spots identified within the existing structural models in *table 2*, an amended model has been designed with additional connections between various institutions and partners, which can be seen in *Figure 9.*

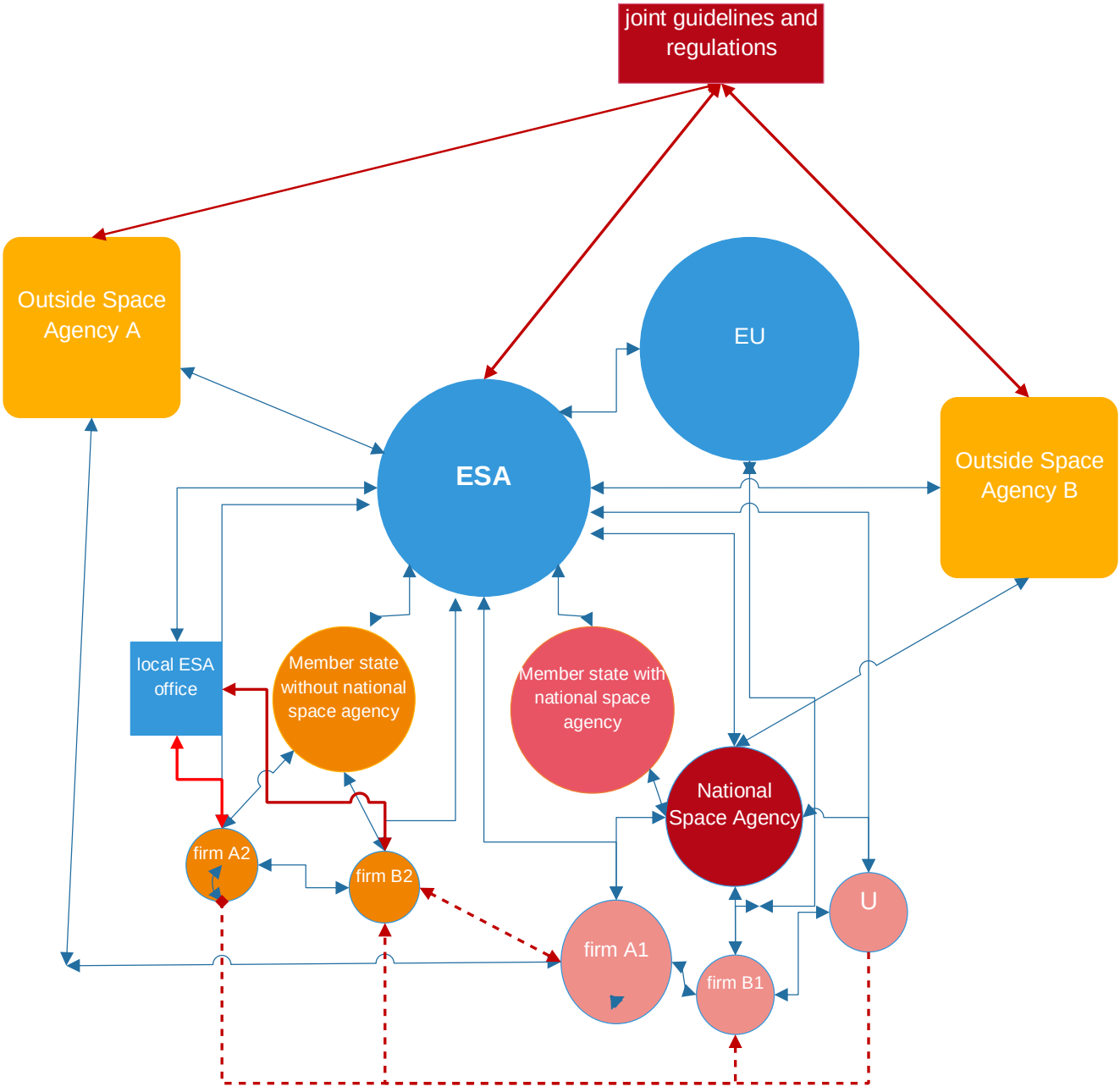

Figure 9. Proposed Amendments to the Structural Model of Cooperation in ESA

Source: (Compiled by the author)

What can be seen in *Figure 8 Structural Model of Cooperation in ESA* is that some communication links are missing. Each firm tends to be responsible only for a small part of the project and not be aware of the entire project to which their part will fit in or might have communication problems in addressing its partners. To make cooperation successful and efficient, closer links are needed between business partners, particularly partners coming from different countries. This is shown in the dotted red lines in the amended model in *Figure 9 Proposed Amendments to the Structural Model of Cooperation in ESA*. The dotted lines represent connections that change in intensity over time as cooperation partners vary depending on what project a frim pursues. Better communication between possible project partners will allow to choose the most suitable project partners and to get fast support with questions. An easily accessible communication platform for all members of business and industry is one option to increase communication. This platform can be organised by ESA and should include experts that help clarify projects and task distribution and share an image of the project as a whole to enhance understanding of the single tasks. An example of a project structure and visualization can be seen in *figure 10*.

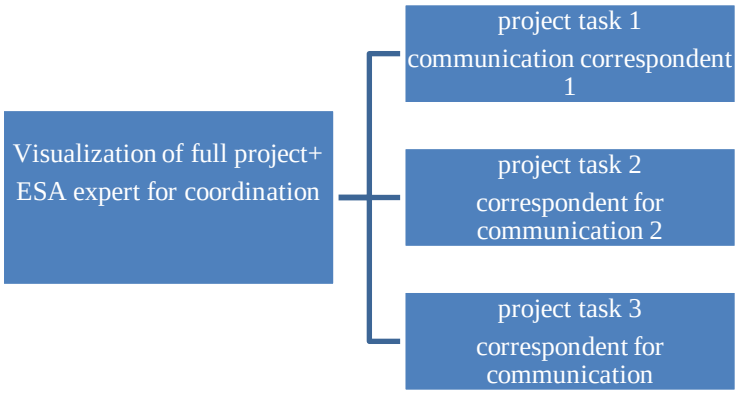

Figure 10. Ideal Project Visualization

Source: (Compiled by the author)

By presenting a visualization of the entire project to all participating research and industry partners and by specifying addressees for questions and coordination, projects can be performed with much more precision. This offers clear task division, fast response to questions and effective coordination of the project. Expertise and tips can be shared easily between different project groups and problems can be identified more easily. In addition, such a platform can help new businesses and small enterprises to connect to more experienced ones and help them with questions or formalities. Better linking potential research and industry

partners will guarantee a more efficient cooperation in projects, saving both time and resources and increasing innovation through the active exchange of ideas. Moreover, to strengthen the connection between member states that do not have a national space agency and ESA, local ESA offices can of benefit. They can help local partners and ensure the highest quality, offer support in national languages and promote space in research facilities and schools. Local ESA offices could serve as a link to businesses, as support system for start-ups and projects, and could offer expert training and even support facilitator functions.

Furthermore, increasing communication and cooperation between partners from different countries can increase innovation through the exchange of different experiences and expertise. Promoting joint ventures of international project groups for applications to tenders might help increase the quality of the products.

Increasing ESA's internal cooperation will also have positive effects on its external relations. Policy coordination and improvement of cooperation links and communication help increase efficiency and therefore competitiveness and trust in an international system. This improves cooperation with other space agencies, as it strengthens ESA's stance towards the outside and improves the quality of cooperation with other agencies. Setting an example in cooperation itself, also allows ESA and the EU to be trusted and seen as a role model in the development if a functioning global framework for dealing with space-related matters.

While ESA already obtains high reputation for its accessibility and opportunities for communication and exchange, the interviews and structural model helped to identify some areas that are still in need of developing stronger connections. These areas are: coordination and cooperation between project partners, clarity and support of new network members and coordination of policies with the EU. The development of a communication platform and local ESA offices will help address the first two issues while increased communication and coordination, particularly in terms of project funding, will lead to more efficient cooperation in European space policy in the latter case.

CONCLUSION

ESA is a remarkable und unique organisation as it manages the interests of 23 different member states and provides a unique opportunity for peaceful collaboration in space science and technology. As cooperation between all the different actors involved creates a complex structure, a network model in combination with several interviews and open questionnaires addressed at representatives of business, academia and national space agencies have been used to identify strong and weak elements of cooperation within ESA. The analysis showed strong accessibility of ESA to cooperation partners and satisfying conditions of cooperation for member states under the geo return principle. Individual project partners appeared to have difficulties in cooperation projects due to communication problems and delayed information processes. Connecting single project members and creating clearer mission plans through a communication platform including experienced ESA staff to be addressed in case of questions will allow for an improved and more efficient cooperation structure for projects. Local ESA offices in countries without national space agencies could be used to involve these member states as well as their citizens more in space projects. They could serve as facilitators, ambassadors of space to society and supporter of start-ups and small businesses. Investing in promotion of space to citizens to increase government funding has been identified as one of the core elements to increase the ESA budget in the future and as a result increase ESA's capabilities in space research and exploration. Increasing its financial means will permit larger investments into new technologies and start-ups with innovative concepts and ideas. ESA will be able to serve as a starting platform for European engineers and entrepreneurs and therefore strengthening Europe's economy and integration. Aligning funding opportunities between ESA and the EU, for example by integrating Horizon 2020 funding into ESA funding options, will increase business opportunities and spark the development of innovative companies in the space sector. Strong internal cooperation and increased available funds will ensure ESA's independent access to space and strong support from its member states and their citizens. In addition, it will make ESA more competitive in an international environment and more desirable as a strong cooperation partner.

ESA serves as a unique example of a highly successful international organisation, whose full members enjoy equal voting rights, and whose focus is to create equal benefits to its members and their citizens. By designing an open communication structure and by more and more involving citizens, support by its members can be assured. Higher levels of support and agreement with decision, will also lead to higher levels of funding. This in turn, can be used for promoting innovation and research in European partner institutions and start-ups. A return of investment will have positive effects on the European economy as a whole and with contributions of the EU lead to higher agreement of citizens to decisions and policy plans and therefore higher levels of integration. In addition, transparency and various international projects, benefitting national and European economies as well as citizens, can be seen as ways to increase trust and stability between the member states again increasing stability and cooperation in Europe. The case of ESA shows that successful long-term collaboration between different states can be possible and can lead to peaceful and mutually beneficial cooperation if members are open to communication, their national interests receive respect, and all cooperation partners – including citizens – are involved in the process. Although this is a case study of one international organisation, elements could be compared to or applied to other organisations under certain conditions and its applicability could be tested in future research. Communication, transparency and trust, as well as a the willingness to learn from each other and to invest all possible means into a cooperation projects appear to be the key elements to create the highest possible efficiency in cooperation within an international organisation such as the European Space Agency.

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APPENDIX

Appendix 1. Transcript: Interview with Madis Võõras on April 4, 2017

The following interview is based on a pre-viewed questionnaire added in appendix 2.

Madis Võõras is the head of the Estonian Space Office, established at Enterprise Estonia as a competence centre for business and technology. He was sent a list of questions, which were discussed during the following interview. Abbreviations have been used for the people speaking.

M: Madis Võõras

I: Interviewer (Margot Möslinger)

M: Ok, first question. *(reading out loud)* What do you see as an opportunity and advantages of cooperation with ESA? Ah, you know, the main advantage ah without saying that this is ah a possibility for high-tech development and ah and ah to raise awareness for companies and people entered in the European landscape for space, the main advantage is ah is ah the fact that the company has ah a reference as a ESA partner. And this is the main important thing that we would like to have because the ESA business is in our case too large (01:02) because the ESA business is limited to the country contribution which are two and a half million euros, not more and ah it's clear that it will not rise tremendously. So, the amount the project what we can do for ESA the amount of companies that can cooperate with ESA is quite limited and the main our aim is that the companies ah after the ESA project are capable to do the business with some larger space companies with the private industry so on. There is unlimited market. So, ESA market is limited but the ESA reference is extremely important.(02:01).

I think yeah the opportunity of course the opportunity is ah for certain competences for what we have in Estonia and one of the competences for example what we have is the competence in Earth Observation and ICT and of course we'd like to utilize this competence as much we can (2:33)

Ok. Then let's go to the second question. Where do you see challenges? (02:48) You know, the challenge is mainly related to the ah to the fact that to cooperate with ESA is quite complicated. That ah the business with ESA is extremely ah regulated in the details: there are requirements, there are invitations to tender, you have to respond you have to write very good level projects. You have to know all the ESA quality requirements, project requirements. It's not so simple. You need to have this competence and this is not obvious that some SME is capable to do all that. So, how to solve this problem? You need to have some facilitator between the industry and ESA. This is mandatory. And this, in our case, this facilitator is not Enterprise Estonia but, because Enterprise Estonia is simply doesn't have enough resources for that (03:59) or I mean human resources but we have some money. We have money and we procure necessary competences in from Estonian market (4:14). And ah we hope that with the next this kind of project we can start very soon in the beginning of April. Not all the procurement procedures and all necessary bureaucracy is done. So, we are very close to the three year project, which will provide the Estonian Industry a facilitation to ESA during the three years. And this is mandatory. Without that we are not able to get our money back.

I: So the facilitator, would that be a person that helps the industry ahm get the quality? (04:53)

M: Yes, yes that's not a person. It is the company or even the ah consortium of companies, consultancy companies (05:03).

I: But that would be an Estonian company basically?

M: Yes, an Estonian company, an Estonian techno-park. To Estonian techno-park, so the people who have the necessary competences and of course motivation from outside.

I: Especially, ahm if it's new companies that don't have that much space experience yet, like, is there a way to get more experience, for example by working together with other industry from other countries? Or do they have to get that within that country first to get the project in the first place?

M: You know, there are different cases (05:40). First of all, the consultancy company or the struc.. the facilitator has some 10 years experience. But as potential appliers or the companies who want to be a partner or just to respond to ESA ITT, the invitation to tender, ah there are quite different companies. There are SMEs, there are large companies, there are newcomers, some start-ups even who have very good ideas. They are really very different. So, this doesn't matter. What is the background of the company of course yeah it's important of course but the motivation and competence (06:34). If the competence is there can be a very good competence in the start-up. But a facilitator is mandatory because ESA is complicated (06:48).

I: Yeah, yeah that's true. And I also saw, I had a look at your structure and at all the different projects and I saw that like a lot of the ESA projects have different ministries, for example the EUMETSAT or the GALILEO, or for example, your Space Office. Is, so different ministries are responsible for this. Is this …?

M: Oh no, no,no,no there is only one ministry responsible for all the business relations related to space and this is the Ministry of Economic Affairs and Communications. And we have, of course, the Ministry of Science and Education in Estonia as well but this ministry is only dealing with space science issues. So, all the industry-related issues are the business of the Ministry of Economic Affairs and Communications (07:38). The reason why there is no Estonian Ministry for Space or yeah Space Ministry we can't say that because the space is quite a small fraction of the activities but the Ministry, space Ministry is the Ministry of Economic Affairs (08:03). So, let's continue.

The third question. What percentage? Since I can't say the percentage because ah I can say you the number which is our ESA contribution which is two and a half million per year (08:25). And there is no very big ah hope that it will increase in substantial manner but of course we do our best to have some more money because it is obvious that this is a kind of a minimum level and ah we could bring ah more money back from ESA. We have this ability here (08:54).

I: But am do you have projects independent from ESA as well? Or the space projects are mainly in cooperation with ESA?

M: The main projects are in cooperation with ESA. Ah, of course we have had and there will be some projects in cooperation with the EU that means the Horizon 2020 project (09:20). And as I said we hope that there will be a project outside or without ESA between Estonian companies and primes. Because this business is now running with the help of ESA but in the foreseeable future it is for sure that they are able to do the business without ESA as well (09:43). But of course, in any this kind of complex business the public sector, order as am the entry to the market is very relevant (10:02).

To increase the ESA budget, yes, I said there is only one way, there is only one way to prove to the government and to the parliament that this is beneficial to business (10:23).

I: Ok. So, basically in your point of view, what would be the best way to prove this? By high return of investment or by … (10:32)

M: Absolutely. Absolutely. High return of investment and in the ESA case you know there is, they calculate every the return co-efficient. And Estonia joined ESA officially as a full member on first of September 2015 and they calculated, and the new calculation, return calculation per year started on the first January of 2015 so we're in this period one year and four months and for this time we got a return coefficient, 109. That's pretty good (11:19). Jap. So, and of course, this is an argument to ask some more money from government but it's it's not so easy because in general the government has to make a reasonable decision and for example now we have or the government has on the table, Estonian accession to CERN. And the membership fee in CERN is ah is more than Estonian contribution to ESA but anyhow it's a money going out from the government budget and in the case of CERN there is no guaranty the money comes back. In the ESA there is a guarantee that the money comes back. There is the industrial return principle in the ESA convention but in the case of CERN this is not the case and ah yeah it's always ah not easy to convince that your project is the best because the government like to find some kind of equilibrium between the different memberships and ah (12:33).But luckily we are well-placed and we try to do our best to prove to the government, to the parliament that it's worth to contribute these funds to ESA. And this is real money. This is funds from Estonian government budget. This is not any EU structural funds funding, this is expensive money (13:02).

I: Also, the Estonian Space Office receives the funds from the government then? (13:08)

M: Yeah, Estonian Space Office receives a small funding from government to run our activities here and this is around ah 200k per year. Ah not more but the funding, the ESA contribution goes directly from the Ministry of Economic Affairs to the ESA (13:34). So, this money goes not via Enterprise Estonia or Estonian Space Office (13:43). So, what we have more?

I: […] So basically, for like the in terms of the ministry. What is their focus in terms of space policy? Is it more Earth Observation, or Human Spaceflight or Telecommunications? (14:04)

M: Ah , there is no Human Spaceflight, of course. Unfortunately, because ah there is a large need for an Estonia astronaut of course in the public. Ah but Earth observation is of course one of the priorities and then everything which is related to ICT because we have some strengths and unique competences here related to different ICT solutions for example not even not directly related to the space because ah this kind of issues like cyber security is for ESA and large organisations very important (14:58). And there are other areas outside of space technologies where we can contribute as well. But of course, the Earth Observation is one of our priorities, without any doubt (15:08).

I: And then also, when you communicate, or when you execute projects, that usually goes directly via your office, and then you communicate with the industry and the businesses, or how does this work?

M: You know, that's different. Of course, Estonia is so small. In principle, we know everyone. And we are very lucky if we find someone who we don't know (15:37) that enable us to do something but yes, we promote the opportunities that ESA has and of course, we are not directly guiding them to the right ITT but we do our best and ah you know in the case of ESA, there is very important you ah find right person in ESA to whom to talk because ESA is very open. ESA talks with you (16:18). Ah contrary, for example, European Union in Horizon 2020 (16:26). There no one talks to you because

there is so large inflow of projects that it's impossible to talk to them (16:39) but in the case of ESA they talk with you and they give some feedback what went wrong if you didn't succeed and then so on (16:48). So ah we tried to ah contact here our entrepreneurs with the right people in ESA and that's how I would ask (16:56).

I: So you would basically say there is communication between your engineers and the engineers that directly work in ESA and also between your office and the headquarters maybe? (17:07)

M: Yes, yes, in principle. We use all the channels but in reasonable way (17:11).

[…] You know, there is no space agency in Estonia. There is an Observatory in Tartu and we started to we started to call it as Estonian Space Centre because this is Estonian Space Competence Centre. They have four branches there; they have cosmology, astronomy, remote sensing and space technology. And they really have the space competences here. And we are here in principle, I can't say that we are bureaucrats but we are not the space engineers, we are intermediaries ah and we try to deal with relations between the right parties. That's our business (18:13). That's because the space office here is very small. We have altogether 3 people and no one from us is working full-time for space, we have other activities as well to run. But Tartu Observatory, they have around 100 people working there. And observatory is funded by Ministry of Education and Science and of course they are much more far from the industry. But luckily they have now acquired a different equipment for testing space craft ah fabrication, heating, electromagnetic waves so they have started to build up a space technology competence which is very reasonable (19:11).

I: And would you say you also have cooperation with the different universities in terms of that because I know that …? (19:18)

M: Yeah, absolutely. Because the competence related to the, to the real science of course is in universities (19:32). And we have really good cooperation. We built large universities, which means Tartu University and Tallinn University of Technology and ah multiple universities apply for different ESA invitations to tenders so ah we try to help them in the best way and of course we are very keen that applicant for ESA is not a university itself but a spin-off company from the universities (20:15). That's our aim. To generate entrepreneurship in the university as well (20:21). Not to pay additional salary for professors.

I: Makes sense. So basically, the main aim for you is also to have businesses that work with space technology rather than doing science in space if I understood that correctly?

M: Yes, absolutely. And there is one important aspect. What I'd like to tell you is that in the built large universities, there are now going on the student satellite projects. This is a very good tool to promote space technology and space business because those guys who are working with in the team of student satellite projects they will later establish their own company and run the real business. So, this is a very good training for engineers and luckily we have now coming in both large universities the student satellite project new big launch maybe next year, maybe 2019. That's it. (21:32)

I: Very interesting. But then you don't in Estonia right now there is not a real like space-engineering study that you can do? It's basically engineering and then you acquire competences? (21:44)

M: well, there was, there was a special class in Tartu University called Space and Defense Technologies. It was a kind of a course, half year or something like this. So that's the , I think the they continue still with this at the University of Tartu but the more specific deep-going space going studies that's not the case. (22:18)

I: And then, also, for Estonia right now, space technology is mainly used for business and Earth observation and not so much for defense capabilities or something? So you're not working with NATO to also develop capabilities?

M: Absolutely, that's right. That's right. But you have to understand one thing. In space, everything is dual use. Everything is dual use. So everything is usable for science or industry for economy or defense or military. Everything.

I: Ok. Because I know that ESA officially is not using any of this equipment for defense or security purposes because there is countries involved that are neutral but would that be for example a reason for a contribute working on this with an individual company or a national agency to be able to you know develop those kind of competences as well? (23:20)

M: You know, I asked form the previous ESA DG, Mr , how he is with this statement in ESA convention that ESA deals only with space for peaceful purposes and Mr said me that defense is very [much]for peaceful purposes. (23:46)[...] And it is written in the ESA convention that ESA deals with this kind of projects and there is no openly defense related projects and programmes in ESA but as I said everything is as dual use (24:11).

I: And then in terms of cooperation with other member countries of ESA? Do you have national agreements with other countries as well to work with space equipment or with countries outside of ESA or does this all work over ESA sort of?

M: Not yet, but in principle we have very good relations with our neighbors – with Finland, with Sweden, with Norway and ah we in principle I can say that at ESA we have very good contacts with all the member states but not bilateral contacts. (24:50)

I: So then the contacts within ESA, if you want to contact different national agencies or different nations am you contact ministries or contact more the engineers of like how would this work? ()

M: I in my case I contact my colleagues in ESA council, the other delegates to ESA and that's it's a very effective way (25:10).

I: Okok. And then if you want to talk to ESA as such you contact the headquarters or the administration? (25:19)

M: Yeah, absolutely. […] Because I am the head of the Estonian delegation to ESA and that's my task to do that. (25:30)

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Appendix 2. Questionnaire for National Space Agencies

Questionnaire: **Cooperation for space research in Europe**

Background information: The following questionnaire is part of a master thesis research project at Tallinn University of Technology conducted by Margot Möslinger. The aim of this questionnaire is to identify different structures of cooperation between national space agencies, businesses and the European Space Agency. The information obtained will be used for the purpose of the master thesis only. Filling out the questionnaire will take approximately 10min.

Name of space institution:

Number of employees:

Working language(s) within the institution:

1. How does typical project cooperation with ESA look like? What is the process and which part of the administration are you generally in contact with? Do local industry partners contact you or ESA directly?

Please enter text here

2. What do you see as opportunities and advantages in cooperation with ESA?

3. Where do you see challenges in the cooperation with ESA?

4. Approximately what *percentage* of your available total budget goes to membership and project related costs for ESA?

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5. What do you believe is the best way to increase ESA's budget?
   Please mark with an x (multiple options are possible)
   - o Increased support from national governments
   - o Increased business and private investments
   - o Optional sponsoring of projects by citizens such as via gofundme.com
   - o Increased funds from the European Union
   - o Other:

6. Do you have projects independent from projects in ESA? If yes, for which reason? Do they involve other space agencies?

7. Which project area of ESA is most important to you?
   a. *Please rank the following by adding to each a number from 1 to 5 (1 being the most important; 5 being the least important)*
      Earth Observation:
      Human Spaceflight:
      Telecommunications:
      Space Science:
      Space Technology and Applications:

   b. Can you briefly explain why?

Thank you for your participation!

Appendix 3. Interview Stellar Space Industries

The semi-structured interview with a representative of Stellar Space Industries, based in the Netherlands, was based on a slightly adapted questionnaire for businesses and start-ups in the space sector.

Questionnaire: **Cooperation for space research in Europe**

1. How does typical project cooperation with ESA look like? What is the process and which part of the administration are you generally in contact with?

   So, to be clear, ESA, works through tenders mostly. So as a company you cannot just go to ESA and say 'yeah we wanna work with you' that's not how it's done. You must see that ESA is like a are ambassadors for the space industry (03:40-4:00). So they are there to write proposals and think about large space missions and possible yeah they are only thinking on mission scale. So there should be something that does that looks at black holes in a in far space for instance. And then they will write a mission proposal and from that mission proposal if that gets accepted within ESA they will write tenders (4:31). An these tenders are basically ESA has a large wall where there is lots of work on that wall and they are looking for people that can do that (04:41). So industry can look at the wall and they say 'This is something we can do. We will need partners but we can do this. (04:55) That's like people like Airbus are also looking at those things basically (05:01).

   I: So basically you have to see what country you are from in order to apply for that tender?

   S: Exactly. Yeah yeah. (05:12)
   I: Do they normally write that in the tender already which countries this is applicable for or if there is a specific country that they would prefer?
   S: Yap. So you can take a look at there on the website. It's called *emits*. […] (05:41) Put ESA next to that. And you see that's a tender website and you will see all the projects that are in there. It's really it's not a nice structure they are not good at that but ah it works I would say(05:50). ..
   But ah if you want to cooperate with ESA as industry as an industry you really need to work on that.(06:00) And I can tell you that ESA always makes those tenders tailor-made for one company (06:09). You know what I mean?[…] I hear that from people that have been in the industry for a very long time. And then you hear it as well from people inside the company and also outside the company. It also makes sense because in the space industry especially in Europe they are afraid of making mistakes. (07:02) So they would like to everybody that is chosen for a job they want to have maximum insurance that they would finish the project.
   I: Especially if it's you know a really high investment as well so that's also understandable.
   S: Yeah but ESA is getting so much money, less money than NASA, but ah yeah. Yeah they have the money, for sure, but the politics within ESA I am not really satisfied that's one of the reasons I decided not to work for there (07:51) […] *compares Elon Musk to ESA – ESA outsourcing, relies on suppliers – becomes slow, his selling point: a smaller company can develop instruments cheaper as it produces everything itself (10:40)*
   ESA is doing it now with their SP you know with their start-up project projects. So they have like ASBIS it's called, a business incubator. That's what it is. They let small companies do their thing you know (11:00-11:25) They could stand in front of the ESA logo so that they are start-ups and they use a certain project could be used in ah in ah yeah in a product that is with a downstream application

(11:45). What do I mean with downstream application? Downstream application is something you and I as a person living on earth is using. (12:00) But sure. For me that would be maybe the same thing like later down the line we would get involved in downstream application, but my love is in space (12:07). So what does that mean? It means we want to build stuff that goes into space not ah not ah from earth (12:20)[…]

(12:58) So, Estonia Space or something. There is this company I know there is this Space 2.0 list that we are also on it. And I saw some Estonian company as well. And I fully agree yeah. If you are Estonian or you live in the Baltic area you get a lot of support from ESA (13:21) You know why? Because they are the places that are the most forgotten. Because nobody… you know what I mean? (13:29) They are they have no office there they do not have a facility there like ESA for me is like 15min cycling already (13:41).[…]

However, we do not have the mentality.(14:17) […] If you look to the states, the satellite industry in the States is a billion dollar operation. Like there are so many start-ups in the States and they are doing amazing things. People are investing millions of dollars in their companies(13:36) If you would do the same thing in Holland or somewhere else maybe in Europe it would be not the same. It would not have the same effect (14:45)

(14:51) For the normal person like space is maybe a waste of money because they do not see the return value in the short period. (14:59)[…]

Promotion of space (16:30) It's a little bit old-fashioned. They don't know how to do it.

2. What do you see as opportunities and advantages in cooperation with ESA?

So, from our point of view opportunities are mainly on the larger space missions and that we build upon a larger network (17:10-17:23). With this network we gain a lot of knowledge but also a lot of work basically, a lot of experience as well (17:31).

I: So basically this network is with other companies that also work in space-related areas? (17:40)

S: Exactly, exactly. Because they really want to they really want other companies from other states of Europe. They want them to work together (17:49).

I: And how do you normally work together? You just call them if you have a problem or you also do projects together? (18:00)

S: Well if you look to the tenders title I don't know if you see that but you could also see people that are interested in undertaking this project and you can call them basically. You say 'I see that you are interested. Are you also interested? Maybe we can ah do it together?' (18:14) Or you just call up an old friend from another company and say 'Oh this is on you wanna try this out?' And then you start it up. That's it (18:22).

(18:28) No but, and ESA is also like our government for the space industry so we need to go to them for funding (18:34).

I: Do you sometimes see differences in funding, for example from ESA or the EU or is this complicated for you or is it the same? (18:48)

S: So ESA is the best way currently of doing fundings because they know the projects (18:55). If I go to another if I go to my own government then I would lose you know (18:59). Why? Because they are too many people ah and they are going on funding calls and we are too novel for them (19:07). And ESA understands our projects (19:10) So, ESA is the best way of and ESA pays also 100%. If I go to my government they would like pay 60% in total and I would need to give the other 40 (19:24). And I say to my government 'yeah I'm doing a novel research ah you need to give me the other 40% too' 'Yeah, we cannot do that' (19:34). So that's also a major a major thing (19:40)

I: Ok. And then, for example, with the EU, for example the Horizon 2020 grants that you can get- is that something that's incorporated in like the ESA funding or do you have to apply for this separately? (19:51)

S: Yes. No, no, no. The Horizon 2020 budget, that's the prizes of all the prizes (19:56). That's uhm for a company my size at this very moment it would cost too much time and a lot of money (20:11). So but maybe later on but Horizon 2020 calls are really, really hard and you need a lot of people (20:22). You need a lot of

companies to join in like four or five or six maybe, you know? (20:28) And remember, if you are that large, then you rather go with a with a ESA tenders because you can do that with two or three people ah companies (20:42) Which makes lots much smaller.
I: But then you'd have to apply for the EU grant separately from the ESA grant? (20:51)
S: Yeah.
I: You could apply for both as well and get both the funding or you just have to choose one? (20:59)
S: Oh yeah. You could do both, but you if you win both you got a shit load of money and a lot of work (21:05)[…]

3. Where do you see challenges in the cooperation with ESA?
(21:53) The challenges? Ah for me basically now it's ah it's writing the tender calls because that's a lot of work (22:03) And ah it's also a risk (22:10) but ah from our end it's ah it's the only way of working with them unless you have a product they would like to buy (22:24) They could always buy something from you but we are not at that stage yet.

I: And then basically you have the opportunity to either have your own company and enter the project calls or to directly work for ESA within like ESTEC for example and develop technology there as well, right? (22:49)

S: Ahm yes.

I: And, for example if ESA itself develops something they also have cooperation with outside companies in their development center? Or that's just done by their internal engineers? (23:08)

S: Ahm yeah that's a good that's a thought. Well, mostly they yeah they would like to push it on somebody else basically. Well, I don't actually know if somebody within ESA thinks on who gets the.. because ESA is not a business ah it's an institute (23:33). So if you ah yeah, probably they will get the IP or something I need to check this I am not sure about that one (23:43)[…]

4. Do you work together with other companies or research institutions? Which ones?
(24:08) So we work now together so for instance Airbus Defense is based in the Netherlands is our client, that's also a big player in the Netherlands. And then you've got an institute that's called SRON, that's in Utrecht (24:32). Esron ah, TU Delft, then we've got CERN (24:40) And CERN we do your analysis with CERN because they are using a software which ESA is not using and we are using. So ah yeah and we are gonna show ESA that this is the correct programme to simulate ah upper atmospheric behaviors and ah yeah we got full support from CERN and that's really great because ah it's a really large institute and that provides basically free consultancy (25:17).

I: About that, if for example you as a company or as a start-up company need help in like a project proposal for example is there a way you can get support from ESA or is there a way that you can get like an outline that helps you with the proposal and shows you how it has to be written or something like that?(25:22-25:45)

S: Ahm no. Well they give you layouts which states what needs to be in there in the layout but from then on it's on you (25:54). And that's the point you need friends in the industry (26:01)
I: And there is no one you can contact to help you? (26:03)
S: Oh yeah. For our proposal we contacted like three old friends who were checking them all. (26:08) […]
Nr of tenders – mostly not a lot, talk to ESA and ask, one is probably a large institute (26:30-27:15)
If you are convincing and cheap then you will win mostly (27:22-27:26) […]

5. Which aspects, in your point of view, require improvement when working together with different research / business partners in space?

See above

(30:05) Well I think the communication can be better (30:10). That you that between partners that you excactly know which one can be used for a certain task or project (30:21). Because I noticed in the beginning a lot of times the that the people didn't really knew what we were capable of. Now that's fine but the communication is something which always can always improve(30:40).

I: But then it's not so much a language issue but really a communication issue?
S: Yeah, really understanding each other (30:49).
(30:56) But sometimes it really needs to be communicated at the base level. It always sounds you know a little bit childish or so but I think it's needed to understand each other properly (31:05).
(31:09) And we are in the space industry and people are only thinking high of themselves that's also something that is part of the industry (31:17). But over time that will change (31:21).

6. What do you believe is the best way to increase ESA's budget?

Please mark with an x (multiple options are possible)

   a. **Increased support from national governments**
   b. Increased business and private investments (PPPs)
   c. Optional sponsoring of projects by citizens such as via gofundme.com
   d. Increased funds from the European Union
   e. Other:

Explanation: Yeah because as an institute you rely on national governments (32:06-32:10).

PPPs: (32:34) Yes that's smart but that's sounding like a company. And that's not what ESA is (32:38) I mean it's like the university. ESA is like any other institute. They cannot make money because they already get tax money (32:55). […]

Increased funds from the European Union, isn't that almost the same as increased support from governments? (35:36)

I think the first two and then maybe the fourth one could be possible (37:08-37:11)

7. Do you have projects independent from projects in ESA? If yes, for which reason? Do they involve other space agencies?

Yes, we do. And we as you stated the reason is to be in dependent(37:22-34). So with our project we can go national, we can work international and national (37:42).

I: So you also work together with the Dutch Space Agency?

S: It is called NSO (37:51) Yes. Well we know each other. I need to go meet them have a meeting with them again sometime from now but we are too busy with something else (38:05).

I: But in theory you also have projects together with NSO?

S: Aah in theory yeah but am let's just say we are a little bit too young to work with them. They are really old (38:15-38:22). That is something I would also like to have. More younger people in the industry.

Do they involve other space agencies? Not at this moment (38:40-38:45) But ah in the long run probably yeah (38:47).

8. Which project area of ESA is most important to you?
   c. *Please rank the following by adding to each a number from 1 to 5 (1 being the most important; 5 being the least important)*

      Earth Observation: 1
      Human Spaceflight:
      Telecommunications:
      Space Science: 2
      Space Technology and Applications: 3

   d. Can you briefly explain why?
      Because we build of course, instruments for earth observation, but also for space science and space technology and other applications and the Dutch are renowned to build instruments. We are the best in the world (39:37). Or, one of the best (39:39).

Appendix 4. Interview Notes of the Representative of DLR

Notes from the interview with Dr. Gerd Kraft, Programmdirektor Raumfahrtsmanagement, Internationale Vertretung, from 19.04.2017 (15:13-15:45) – as response to the sent questionnaire (led in German – notes partly translated)

Nr of employees: DLR 8000 – Raumfahrtsmanagement/ Space Management 250

Subventioniert vom deutschen Wirtschaftsministerium, z.T. Verkehrs-und Forschungsministerium

Sprache: Deutsch; International: Englisch

Budget: 1,5 Mrd. € für deutsche Raumfahrt, mehr als Hälfte für ESA Programme

Typical cooperation: ESA Verträge mit Industrie und Forschung – Programme und Projektausschreibung, 20% der Mitgliedsbeiträge and Administrationskosten, 2000 Mitarbeiter

Advantages of cooperation: größere Programme, die ansonsten nicht möglich wären – z.B. Entwicklung einer europäischen Trägerrakete- 4 Mrd. €; europäische Unabhängigkeit;

Normal one country one vote – kleinere Länder also in Theorie gleich viel Mitspracherecht als große Länder; aber Pflichtprogramme – Bruttosozialschlüssel nach Wirtschaftskraft; alle 22 Mitgliedsstaaten müssen Budgetbeitrag zustimmen – Entscheidungen entsprechen etwa völkerrechtlichen Erklärungen

Optionale Programme e.g. Ariane Trägerentwicklung, ISS – für Deutschland sehr wichtig; Programmerklärung anhand one country one vote

Estland hat einen Bruchteil der Beiträge aber 1:1 Stimme

Challenge:

Geo-return – funktioniert nicht immer, da nicht alle Staaten über notwendige Infrastruktur verfügen, speziell kleinere Länder bekommen oft keine Industriepakete

Mehr und mehr Mitgliedsländer z.B. Estland, Ungarn und Polen (manchmal Sonderwünsche) – schwierig, alle Interessen unter einen Hut zu bekommen

EU stellt Mittel zur Verfügung aber ESA hat Exekutive bei Projekten, da sie über die Managementfähigkeiten verfügt z.B. Satellitensystem für Europa von ESA entwickelt

Horizon 2020 und ESA Raumprojekt sollte eigentlich abgestimmt sein aber ist es nicht – verwirrend für viele Länder; mit dem Vertrag von Lissabon hat die EU eine eigene Kompetenz für Raumfahrt erhalten; allerdings versucht diese ihre Position immer weiter auszudehnen („Machthunger der EU"); der Vertrag garantiert jedoch auch „jedem Land seine nationale Raumfahrtkompetenz" – diese wird als gefährdet gesehen, wenn die EU mehr und mehr versucht, darüber Kontrolle zu erlangen

Budget: für deutsche Raumfahrt – ESA Beiträge ; 858 Millionen €

Beiträge unter 25% - in ESA unterrepräentiert; mehr Italiener – warum? Weil Deutsche tendenziell längeres Studium haben, dann weniger mobil sind und Familie gründen wollen, wenn beide Partner arbeiten ist ein Job bei der ESA schwieriger und weniger finanziell attraktiv

Mars Mission – D nicht interessiert; ISS – einer der größten Förderer, bis 2024

Astronauten: im Verhältnis zu Beiträgen wenig Deutsche Astronauten; mehr Italiener und Franzosen – als ESA-Astronaut

DLR Beiträge an EU, ESA, EUMETSAT sowie nationale Projekte

Budgeterhöhung der ESA durch nationale Staaten besser als durch EU – entscheidungsfähiger und im Ende zahlen es ja die Staaten ohnehin selbst

Oder durch Public-Private-Partnerships, und die Industrie finanziert die Projekte mit

Crowd-funding neu, aber Problem, dass bei Subsidiarität der Staat nicht tätig werden darf

5. 270 Mio € nationales Raumfahrtsbudget – viele laterale Kooperationen e.g. mit NASA, Rus

6. E-book ESA website alle Projekte mit Tortendiagrammen

Earth Observation wird für die meisten Mitglieder immer wichtiger

Entwicklung der Launcher: für Frankreich am wichtigsten, für D dann am Zweitwichtigsten

- ➔ Independent access to space, selber Satelliten starten, Infrastruktur in Kourou deshlab stark unterstützt

Bemannte Raumfahrt – D trägt beinahe die Hälfte der Kosten

Wissenschaftsprogramme

Appendix 5. Collected Questionnaire Responses

Different versions of the open-questions questionnaire in appendix 2 were sent out to representatives of business, academia and national space agencies. Some respondents responded exclusively by filling in the questionnaire. Some participants preferred to answer the questionnaire in the form of a semi-structured interview. The respondents were given different abbreviations to facilitate citation and allow responses to be analysed more objectively:

P1 … Representative of ESO (interview form) – view full interview in appendix 2

P2 … Representative of NLO (written response)

P3 …Representative of INTA (written response)

P4 ... Representative of DLR (written form; notes – view in appendix 4)

P5 ... Representative of Stellar Space Industries (interview form – view in appendix 3)

P6 … Representative of a work group of the Czech Academy of Sciences (written response)

The collected responses show an image of the different attitudes and ideas concerning cooperation with ESA as viewed from various angles. Frequent or outstanding elements have been used and analysed in the main part of the thesis. The following collection of responses excludes the two interviews which can be found in the appendix separately for reasons of clarity.

1a. How does typical project cooperation with ESA look like?

"NSO is the Netherlands Space Agency. We cooperate with ESA on many levels, ranging from representing Netherlands in ESAs governance structure (Programme Boards) to joint project management for cooperation projects (TROPOMI)" (P2)

"Depending on the scope: when ESA needs any of the capabilities that we have (mainly Ground Segment Stations) contacts directly with us; in ITT proposals, most of the information comes from EMITS, even if in some areas there are permanent contacts by INTA staff with ESA. In some areas we also participate in the Harmonization process." (P3)

1.What do you see as opportunities and advantages in cooperation with ESA?

"Cooperation with ESA is for us essential, since a European space agency can achieve so much more than every country individually can. The Netherlands can contribute its niche capabilities to ESAs projects. In addition, ESA provides a forum to discuss space matters with most European countries." (P2)

"Participating in a European Space framework allows us to have a more coordinated and focused scope with bigger impact." (P3)

2.Where do you see challenges in the cooperation with ESA?

"The challenge in ESA is the same as its benefit, the International environment. ESA must balance the interests of its member states and that is not an easy task. Our challenge is to serve our national interests with respect for all other interests in Europe." (P2)

"I see two challenges: activities outside the framework are abandoned; and entities belonging to the most influencing countries in Europe are privileged against the others." (P3)

"So it varies a lot, with two previous projects I had almost no issues, except the bureaucracy and for example reimbursements were taking them ages. And so many documents, they want a paper for every little thing. Otherwise I had almost no issues, they were very professional in their communication and always very helpful (although some things could have been communicated earlier, but I am just nit-picking now. On the other hand, on the current project we work both with ESA and IKI RAN (Russian Agency) so I don't know to what extent I can blame ESA or Russians, but the major challenge is the communication, personally, I have a lack of information about what I am supposed work on. Not enough technical specifications and requirements, no clear communication on what I am allowed to do and so on." (P6)

4. What do you believe is the best way to increase ESA's budget?

o Increased support from national governments: IIIII

o Increased business and private investments: IIII

o Optional sponsoring of projects by citizens such as via gofundme.com: I

o Increased funds from the European Union: IIIII

"Frankly, any of them are good to increase budget. Maybe the best would be the private investment, but probably it could involve a decrease in scientific projects. For public funding, European Union could be the most reliable entity, better than national governments. In USA, private initiative is allowing acceleration of new development not reachable by other means, which has been possible due to previous contracts of NASA with those companies." (P3)

5. Do you have projects independent from projects in ESA? If yes, for which reason? And do they involve other space agencies?

"We have had projects in the past with other Space Agencies (NASA for instance) and also national projects. These were cases where ESA cooperation was not feasible or not necessary." (P2)

"Yes, INTA has their own developments on space technology and in some cases meet with ESA projects, but not always. INTA has a very good relationship with NASA (INTA manages a NASA Tracking Station in Spain), but normally do not collaborate together. There are also good relations with Ukrainian Space Agency, but not collaboration." (P3)

6. Which project area of ESA is most important to you?(1 being most important; 5 being least important)

Earth Observation: 2 1 1 1 1

Human Spaceflight: 5 2 5 5 2

Telecommunications: 4 1 5

Space Science: 3 1 2

Space Technology and Applications: 1 1 3 2

(Launcher: 1)

b. Can you briefly explain why?

"I can not really rank the nrs. 1 individually. The reason Human Spaceflight is slightly less important is that it generates less benefits for us than the other programmes. Our goals for ESA projects is to generate added value for the Netherlands and for Europe, be it economic, scientific or societal (or a combination). On that ground we decide on our contribution to ESA programs or projects." (P2)

"For INTA, the most important item is to develop technology. Earth observation is a much demanded expertise of INTA and is also of importance for us. Space Science is of interest but there are no many scientific missions to embark experiments. Telecommunications and Human Spaceflight are the less interesting for us." (P3)

Appendix 6. Data Table for Figure 2 and Figure 3

Countries with growing interest in space; data for 2015	GDP per country in million US $	Population	National space agency (abbreviation)	National space agency - full name	Approximate annual budget of the space agency (estimate used if not available)
United States	18.036.648,00	321.418.820,00	NASA	National Aeronautics and Space Administration	18010
Japan	4.383.076,30	126.958.472,00	JAXA	Japan Aerospace Exploration Agency	1540
China	11.007.720,59	1.371.220.000,00	CNSA	China National Space Administration	2000
Russian Federation	1.331.207,75	144.096.812,00	ROSCOSMOS	Roscosmos State Corporation for Space Activities	1700 in 2015; (5600 in 2011)
India	2.095.398,35	1.311.050.527,00	ISRO	Indian Space Research Organisation	1200
South Korea	1.377.873,11	50.617.045,00	KARI	Korean Aerospace Research Institute	180 (1800 in 10 years until 2021)
Iran	-	79.109.272,00	ISA	Iranian Space Agency + Iranian Space Research Center	1000

Source: (GDP per country in million US $ … GDP (current US $). The World Bank 2017; Population … Population, total. The World Bank 2017; National space agency – abbreviation; full name … compiled by the author; Approximate annual budget of the space agency … De La Cruz 2016, Dickerson 2015, ESA Budget 2015, Kang 2015, Transition of budget …,With 10% of NASA's Outlay...)

Appendix 7. Data Table for Figure 4

Country Name	GDP per Country in million US $ in 2015	Population in 2015	Budget for ESA in US $ in 2015	Budget for ESA in percentage of GDP in 2015
ESA countries (not including Hungary and Estonia in 2015)	16.898.641,40	486.619.089,00	3468,191	0,0205%
European Union	16.311.897,17	509.668.361,00	160,29	0,0010%
Austria	376.950,25	8.611.088,00	55,11	0,0146%
Belgium	455.085,73	11.285.721,00	202,77	0,0446%
Czech Republic	185.156,36	10.551.219,00	15,19	0,0082%
Denmark	295.091,33	5.676.002,00	28,68	0,0097%
Estonia	22.459,44	1.311.998,00	*no full member in 2015*	-
Finland	231.949,65	5.482.013,00	20,97	0,0090%
France	2.418.835,53	66.808.385,00	768,47	0,0318%
Germany	3.363.446,82	81.413.145,00	853,22	0,0254%
Greece	194.851,32	10.823.732,00	12,95	0,0066%
Hungary	121.715,20	9.844.686,00	*no full member in 2015*	-
Ireland	283.703,22	4.640.703,00	19,26	0,0068%
Italy	1.821.496,96	60.802.085,00	352,99	0,0194%
Luxembourg	57.793,61	569.676,00	24,61	0,0426%
Netherlands	750.283,91	16.936.520,00	79,93	0,0107%
Norway	386.578,44	5.195.921,00	63,99	0,0166%
Poland	477.066,45	37.999.494,00	32,10	0,0067%
Portugal	198.923,26	10.348.648,00	17,87	0,0090%
Romania	177.954,49	19.832.389,00	27,18	0,0153%
Spain	1.199.057,34	46.418.269,00	140,92	0,0118%
Sweden	495.623,70	9.798.871,00	85,92	0,0173%
Switzerland	670.789,93	8.286.976,00	144,34	0,0215%
United Kingdom	2.858.003,09	65.138.232,00	344,86	0,0121%
Canada	1.550.536,52	35.851.774,00	16,59	0,0011%

Source: (GDP per Country in million US $ in 2015; Population … World Bank Statistics 2015; Budget for ESA in US $ in 2015[10] … ESA Budget 2015; Budget for ESA in percentage of GDP in 2015 … Compiled by the author)

[10] Numbers changed from Euros to US $ with an exchange rate of 1,07 according to estimated 2015 averages.

Appendix 8. Data Table for Figure 5

Average amount spent on ESA per citizen per country in 2015	Population in 2015	Budget used for ESA activities and programmes in € in 2015 (excluding EUMETSAT)	Average ESA Membership Contribution per Citizen in 2015
ESA members average	486.619.089,00	3241,3	6,66
European Union	509.668.361,00	149,8	0,29
Austria	8.611.088,00	51,5	5,98
Belgium	11.285.721,00	189,5	16,79
Czech Republic	10.551.219,00	14,2	1,35
Denmark	5.676.002,00	26,8	4,72
Finland	5.482.013,00	19,6	3,58
France	66.808.385,00	718,2	10,75
Germany	81.413.145,00	797,4	9,79
Greece	10.823.732,00	12,1	1,12
Ireland	4.640.703,00	18	3,88
Italy	60.802.085,00	329,9	5,43
Luxembourg	569.676,00	23	40,37
Netherlands	16.936.520,00	74,7	4,41
Norway	5.195.921,00	59,8	11,51
Poland	37.999.494,00	30	0,79
Portugal	10.348.648,00	16,7	1,61
Romania	19.832.389,00	25,4	1,28
Spain	46.418.269,00	131,7	2,84
Sweden	9.798.871,00	80,3	8,19
Switzerland	8.286.976,00	134,9	16,28
United Kingdom	65.138.232,00	322,3	4,95
Canada	35.851.774,00	15,5	0,43

Source: (Population in 2015, Budget used for ESA activities and programmes in € in 2015 … World Bank Statistics 2015; Average ESA Membership Contribution per Citizen in 2015 … Compiled by the author)