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Master Thesis

Emerging Institutions in the Global Space Sector

An Institutional Logics Approach

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ABSTRACT

The outer space (hereinafter Space) sector is currently going through major transformation. Since its inception, the sector is characterized by geopolitical interests and tensions. However, new Space-based technologies have shown how the sector can serve as supporter and enabler for accelerating sustainable development. Technological changes such as digitization and miniaturization have reduced the cost of accessing and using space, opening up new opportunities also for private actors. The sector is therefore increasingly competed among different actors with different interests. Given these challenges, the question is whether the current global Space sector can overcome these conflicting values and make a successful transition towards accelerating sustainable development. Therefore, the study aims to identify the emerging institutions of the global Space sector, including not only formal but also informal institutions such as the kind of values and interests actors adhere to, and how they may influence the direction of the sectoral development.

Sustainability transition research has increasingly adopted international perspectives on how sectors may transform over time towards more sustainable direction. However, research on the political dimensions of changing sociotechnical configurations and the interaction at the international level remains limited. This study adopts the institutional logics approach as a medium to incorporate geopolitics in Space and governance literature in the analysis of transitions. More specifically, this study applied a socio-technical configuration analysis (STCA) based on discourses in newspaper articles and government documents, covering two contrasting cases of Earth Observation (EO) and Navigation services to identify different prevailing value orientations among actors.

The results indicate that value orientations between actors differ significantly, resulting in different international collaboration patterns. The Navigation case is characterized by rather incoherent value dispositions. Cooperation serves primarily as tool to support geopolitical strategies, national self-interest and the desire for a dominant competitive position in the global market. Due to the ongoing geopolitical tensions, the sector faces major challenges in achieving a strong directionality in engendering sustainable development in the future. In contrast, the value orientations of the various actors in the EO case are more aligned on a global scale. Actors mainly entered cooperation to pursue common goals at the global level. The field therefore projects stronger directionality in maximizing its potentials to accelerate sustainable development, with presence of similar collective priorities and substantial international cooperation. Overall, the contrasting results show that the future global Space sector will consist of different and partly diverging structures of institutions and cooperation patterns.

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List of Abbreviations

ASEAN	Association of Southeast Asian Nations
APSCO	Asia-Pacific Space Cooperation Organization
BDS	BeiDou System
BRI	Belt and Road Initiative
BRICS	Brazil, Russia, India, China, and South Africa.
CEOS	Committee on Earth Observation Satellites
DLR	Deutsches Luft- und Raumfahrtzentrum (German Space Agency)
ESA	European Space Agency
EO	Earth Observation
ERS	European Remote Sensing satellite
ESG	Earth System Governance
EU	European Union
DNA	Discourse Network Analyzer
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GPS	Global Positioning System
GMES	Global Monitoring for Environment and Security program
GNSS	Global Navigation Satellite System
ICG	International Committee on Global Navigation Satellite Systems
JAXA	Japan Aerospace Exploration Agency
LRZ	Leibniz Rechenzentrum
NASA	National Aeronautics and Space Administration
PNT	Positioning Navigation & Timing
RNSS	Regional Navigation Satellite System
SANSA	South African National Space Agency
SDG	Sustainable Development Goal
SPOT	Satellite Pour l’Observation de la Terre
STCA	Socio-Technical Configuration Analysis
SUPARCO	Pakistan Space & Upper Atmosphere Research Commission
UN	United Nations
UNOOSA	United Nations Office for Outer Space Affairs
UNITAR	United Nations Institute for Training and Research
UNOSAT	United Nations Satellite Centre

1. Introduction

Over the past few years, outer space (hereinafter Space) technologies and applications have become indispensable for tackling a wide range of global issues (Liao, 2016). As a matter of fact, important technological changes such as digitalization, miniaturization and artificial intelligence are disrupting traditional business models in the Space sector, lowering the cost of accessing and using Space, and opening up new opportunities for Space-based infrastructures (Concini & Toth, 2019). These trends also support the development of space-based green application services to tackle social and environmental problems and new Space-based technologies could therefore even accelerate sustainable development (Yap & Truffer, 2021). Recently, a study conducted by the United Nations Office for Outer Space Affairs and the European Global Satellite Navigation Agency found that of the 169 targets related to the UN's Sustainability Development Goals, almost 40% rely on access to Space science and technology (Di Pippo, 2019). Communication, navigation and earth observation satellites play a crucial role in providing enabling services for sustainable development. By using satellites, farmers can be provided with more precise images and data to monitor their crops and improve their yields, the spread of diseases can be monitored and the damage after natural disasters can be assessed (Di Pippo, 2019; Yap & Truffer, 2021).

Meanwhile, Space commercialization appears to be one of the dominant themes of current research and on the agenda of challenges and opportunities in the sector's development. (Robinson & Mazzucato, 2019). A multiplication of new players can be observed due to the privatization of the sector. At the same time, however, Space has become critical to the security and defense of nation-states. The use of satellite technologies, for example to monitor borders but also to control military operations, is becoming indispensable (Concini & Toth, 2019). This further supports the geopolitical tensions that have been inherent in the sector since its inception during the Cold War. Many players in the sector are still influenced by these geopolitical value orientations and seek dominance in Space to strengthen their position of power on Earth (Dolman,1999; Duvall & Havercroft, 2009).

The abovementioned diverse set of economic, ecological, social, and political opportunities offered by satellites leads to an increasing global interest in competing in the Space sector (See, 2017). Thus, the sector is becoming more complex and includes a broad range of actors with different ambitions and motivations as for example the military, civil government, and private commercial ventures, leading to an increased potential for conflict, for example, in terms of legal and political accountability, control and power (Jakhu & Pelton, 2017). Given that the Space sector is inherently geopolitically motivated, the question is whether the current Space sector can overcome these conflicting values and make a successful transition towards realizing its promises in accelerating sustainable development (Yap &Truffer, 2021). If the sector cannot overcome the conflicting values among the multiple set of actors and especially the inherent geopolitical tensions, its vision of accelerating sustainable development will not come to fruition. However, tackling these problems and thus a successful transition of the Space sector requires genuine cooperation among different actors across levels at a global scale with common goals. Otherwise, the rising new tensions and competitions might even lead to unsustainable or potentially hostile use of Space-based technologies in the near future. Therefore, this research aims to better understand the value orientations of different actors in the Space sector - more often than not influenced by (geo)political tensions – to identify where cooperation or conflicts may emerge and how this may or may not lead the sector's development towards the desired direction.

Transition studies are promising to help inform the challenges faced in the current Space sector. It is a multidisciplinary field that deals with emerging radical innovations as well as fundamental socio-technical transformations over a long timeframe (Geels, 2012; Markard et al., 2012). Transition studies refer to the notion of socio-technical configurations as the interrelated set of technologies and institutional elements that can fulfill a specific societal need (Rip & Kemp, 1998). They are also applied in a broader range of issue areas like transforming energy, urban or water sectors (e. g., Kern & Smith, 2008; Liu & Jensen, 2018; Fuenfschilling & Truffer, 2014). These studies analyze the complex interplay between economic, technological, social, and political factors to understand processes that lead to sectoral transformations that are seemingly more sustainable. However, most contributions on shaping, managing, or governing transitions have focused primarily on domestic politics and domestic institutional contexts (Kern & Markard, 2016; Fuenfschilling & Truffer 2014), with little attention to the strong vested interests and conflicts among actors at the global level in the transition area, or to the interaction of international political processes and their influence (Kern & Markard, 2016). The awareness is growing in the last years, but the ways of understanding and analyzing the global political dimensions and the interplay of local, national, and supranational levels remain under-developed in academic literature on transitions (Patterson et al. 2017, Kern & Markard, 2016; Meadowcroft, 2011). This results in the need for a more in-depth account of the influences of the political dimensions, including the interplay of different actors and scales, to examine the transition process of the Space sector.

Understanding the different value orientations and associated political dimensions of the various actors in the Space sector requires a theory-based contextualization of geopolitical options characterized by the interplay of economic, strategic, and physical conditions (Flint, 2021). Therefore, contextualizing the global governance structure of the Space sector may be helpful here to better understand the transition process of Space at a global level, such as the kind of Space law, treaties or regulatory agreements that form the international networks Space actors currently engage in. However, it is important to note that political dimensions in a transition context are not only geopolitical or governance based. Besides formal institutions, transitions also involve a variety of actors pursuing their own interests, driven by different motivations. Although there are several Space laws in place intended to steer the sector's development, they are not keeping pace with the rapid changes in the sector. Therefore, a conventional study of treaties and other agreements and their effects will be insufficient in light of the rapidly changing environment and the constantly fluctuating actors involved. Informal institutions in the form of values, beliefs, and motivations influencing the actors' strategies and preferences need to be studied as well (Fuenfschilling & Truffer, 2014). Understanding the value dispositions of different actors helps to identify common or conflicting interests among multiple types of actors and how they may or may not lead to cooperation on a global level, which is crucial in shaping the sector towards the desired direction of accelerating sustainable development.

Borrowing these conceptual insights, this study asks the following overarching research question:

How do the emerging institutions in the global Space sector look like, and how do they influence the direction of the sectoral development?

To answer the overarching research question, this thesis aims to answer the following sub-questions:

1. *What have been the most important value dispositions among actors underpinning the development of the Space sector over time?*
2. *Who have been the most central actors in influencing the sector's development and how does that change over time?*
3. *How do the different value-dispositions of actors influence cooperation patterns, and how does that influence the direction of the sector's development in the future?*

The field of satellite navigation and earth observation (EO) services serve as two critical case studies to answer these sub-questions. Navigation and EO satellites pose different motivations, conflicts, and therefore cooperative tendencies. Although both starting as inherently geopolitical, on one end, navigation is still strongly dominated by national geopolitical interests whereas on the other end EO has been increasingly reported as guided by the rationale of global sustainable development with rapid commercialization (Belward & Skoien, 2015; Peter, 2006). Therefore, comparing the two extreme cases allows for drawing a more comprehensive view to better understand the similarities, differences, and patterns between the two cases. To specify the various value interests and conflicts of different actors, this study borrows insights from institutional theory to approach the problem and bridge the so far largely unrelated literature streams. Following Fuenfschilling & Truffer (2014), this study applies an institutional logics approach to examine the different value orientations in the proposed two cases with more explicit considerations of the role of national and international (non-) state actors. The institutional logics approach suggests that the society consists of various institutional sectors that include different rationalities, also called institutional logics (Fuenfschilling & Truffer, 2014). These rationales or logics entail a combination of different values, visons, beliefs, norms, rules and practices that that guide an actor's behavior (Fuenfschilling & Truffer, 2014). In particular, using the socio-technical configuration analysis method (Heiberg et al. 2020; Heiberg &Truffer, 2021), the two cases and the associated institutional logics of different actors reveal the different value orientations and help identify potential coalitions and conflicts that influence international cooperative potentials, which is critical in overcoming (geo)political tensions to make a successful transition towards accelerating sustainable development.

This study is organized as follows. A theoretical review is provided in section two, which indicates the background, concepts, and appropriateness of used theories to investigate the research question. This section is closed by combing the different theoretical perspectives into a conceptual approach. A discussion of the methodology follows. Here, the methods of data collection and analysis are described, followed by an explanation, how the research quality is ensured. This is followed by a summary of the sector's historical development, including an overview of governance structure that contextualizes the two cases before presenting the analysis results. Afterwards, the result section follows, which is divided by the cases and closed by a comparison of the EO and Navigation sector in order to identify any similarities or differences in the value dispositions of actors among the two extreme cases that help explain the development of the sector. The thesis ends with a conclusion answering the research- and sub-questions, followed by a discussion of the theoretical implications, policy recommendations, and limitations of this study.

2. Theory

Transition studies are an emerging multidisciplinary research field developed intensely over the past 20 years (Geels, 2012; Markard et al., 2012). The field of sustainability transitions has focused on how sectors are transforming towards more sustainable forms, therefore, providing important insights to addressing the goal of the study to examine how the Space sector has evolved in the recent years and whether or not the sector will eventually deliver its promise of accelerating sustainable development on Earth.

This chapter first provides an overview of transition studies, including its strengths and possible challenges. Recent studies suggest that limitations of transition research include insufficient attention to governance structures, and the interplay of politics between local, national, and supranational levels (Kern & Markard, 2016). Therefore, this section next explores the interface between the previously largely separated streams of sustainability transitions and international relations as well as geopolitics literature.

2.1. Sustainability Transitions

In sustainability transitions literature, the term "sociotechnical system" refers to the fact that technical artifacts do not function in isolation but that these artifacts' functioning is highly dependent on specific and complex constellations of elements in which they are embedded (Geels & Kemp, 2007; Borrás & Edler, 2014). Following Geels & Kemp's (2007) definition, this thesis understands "*systems at the sectoral level as sociotechnical systems, made up by a cluster of elements, involving technology, science, regulation, user practices, markets, cultural meaning, infrastructure, production, and supply networks*. […] *The elements of sociotechnical systems are created, maintained, and refined by supply-side actors (firms, research institutes, universities, policymakers) and demand-side actors (users, special-interest groups, media).*"

Transition research deals with the diverging forces of stability and path dependence on the one side and impulses for radical change on the other (Köhler et al., 2019; Rogge et al., 2017). Transitions are characterized by radical shifts from one sociotechnical configuration to another, involving a broad range of actors, mainly over a long-term horizon and under high degrees of uncertainty (Edmondson et al., 2018). In this context, the concept of sociotechnical regimes was developed to capture the highly institutionalized formal and informal rules that have co-evolved with particular technologies and solidified into practices and routines (Fuenfschilling & Truffer, 2014). The regime refers to the "deep structure" of a sociotechnical system, and transitions can consequently be described as a shift from one regime to another through a combination of landscape pressure and niche developments (Geels & Schot, 2007; Fuenfschilling & Truffer, 2014).

Transitions often occur due to sociotechnical reconfigurations, but they can also arise from purposeful, goal-oriented processes, for example, targeted at addressing environmental problems (Kern & Markard, 2016; van den Berg et al., 2011). Such purposive transitions are intended and coordinated processes, emerging from outside the existing regime to shape the development of sociotechnical systems towards preferred futures (Geels & Schot, 2007; Markard et al., 2012).

But, because sustainability is essentially a public good, private actors inherently have limited incentives to engage in it. Consequently, some scholars argue that public policy should play a central role in governing and shaping the direction of transitions through regulations, standards, and innovation policy (Köhler et al., 2019). However, a wide range of actors and system elements are involved, many of which are outside policymakers' direct control. Therefore, due to their open, uncertain, and complex nature, transitions are difficult to manage and steer (Geels, 2018).

Addressing directionality is a key issue related to steering transitions and, therefore, a core topic in sociotechnical studies. Transformative processes, which enable sustainable development, are intimately linked to the question of direction and require the setting of collective priorities. The direction of change can be defined, for example, by identifying important societal problems (Weber & Rohracher, 2012). Being able to tackle such issues depend, in turn, on the ability of actors to develop not just visions but a broader set of related informal institutional elements. Following the argumentation of Yap & Truffer (2019), this thesis understands directionality as a "*system-level effect, building simultaneously on top-down interventions from governments and bottom-up strategies adopted by industrial companies, civil society actors, professional associations, and researchers*." However, a significant challenge still relies on the influence of power and agency as an essential role in the definition of any vision and the subsequent activities and policies (Weber & Rohracher 2012). Due to the inherent complexity of transitions, an understanding of political processes and governance mechanisms is necessary to provide guidance and direction for transformative processes (Weber & Rohracher, 2012).

In the context of sociotechnical studies, the term governance refers to a non-hierarchical mode of governing with emerging directionality and coordination at the systems level, where non-state actors participate in the formulation and implementation of public policies next to state actors (Mayntz, 2003; Geels, 2018). The emergent character arises from the interaction between multiple social groups as public authorities have unique responsibilities and resources to shape this emergent directionality. Still, they cannot steer it entirely (Geels, 2018).

The governance of sociotechnical systems can be understood as the interplay of the various ways agents intentionally and deliberately interact to influence transformative change processes (Borras & Elder 2020). A range of actors (e.g., government, organizations, research, civil society) play critical roles in shaping desirable transitions through transformative action and governance (Loorbach, 2007). These transformative processes are deeply political and involve power struggles and value conflicts (Patterson et al., 2016). They also involve institutional, social, technological, and economic factors, in addition to mechanisms for collaboration, learning, and knowledge integration (Hölscher et al., 2018). Literature on the governance of sociotechnical change or transition governance offers insights into the complexity of governance processes, especially on the integration of social concerns, the mode of governance, and the role of the state (Borras & Edler, 2020; Oltrogge & Christensen, 2020; Fisher, 2019; Stilgoe et al., 2013; Irwin, 2006). However, the role of power in managing transformation processes is often very complex and therefore difficult to approach. On the one hand, transformations involve shifts in power between niche and regime actors, but on the other hand, they also require higher-level political power to be exercised by proponents in driving change in the direction they deem desirable (Kern & Markard, 2016; Avelino & Wittmayer, 2015).

Kern & Markard (2016) identified International Political Economy (IPE) approaches as a potential pathway to incorporate higher-level politics for expanding transition studies. Drawing on the definition of Cohen (2014b) IPE bridges the gap between economics and political sciences in the study of international relations. The interplay of local, national, and international policy developments has a long history in IPE studies. However, the IPE approach fails to take into account the co-development of institutional, organizational and technological changes and focuses rather on distributional than transformational issues. Kern & Markard (2016) identified few major challenges concerning energy transitions, including the multidimensionality, the inherent uncertainty and complexity, the necessary involvement of public policies, the vested interests and conflicts and the high degree of contextuality. The context dependency and the strong vested interests and conflicts between new and old actors, both at the national and international levels, were identified as particularly important, as transition studies do not fully address these challenges. Kern & Markard (2016) conclude that most contributions in transition studies have focused on domestic politics and on how domestic institutional contexts and legacies shape such processes. Still, there is limited attention to international political processes.

Another way of including international structures in transitions studies was developed by Fuenfschilling & Binz (2018), who introduced the concept of global sociotechnical regimes. Fuenfschilling & Binz (2018) argue that as institutional structures such as cultural-cognitive rationalities, norms, and rules, as well as the actor-networks crucial to their construction and diffusion, are increasingly internationalized, it becomes more plausible that sociotechnical regimes are valid beyond their immediate national context. Therefore, they propose an internationalized conceptualization of sociotechnical regimes in the form of global regimes, which can be defined as *"the dominant institutional rationality in a sociotechnical system, which depicts a structural pattern between actors, institutions and technologies that has reached validity beyond specific territorial contexts, and which is diffused through internationalized networks."* (Fuenfschilling & Binz, 2018). Therefore, global sociotechnical regimes illustrate the complexity of internationalized institutions in shaping transitions. This opens up the question of how politics can intervene in such cases and how global governance arrangements influence sustainability transitions (Fuenfschilling & Binz, 2018).

It becomes evident that transition processes are recognized to be driven by an interplay of economic, social, and political factors. Although the international nature of many transitions is increasingly being recognized, many questions remain unanswered about the political dimensions inherent in the informal institutions of such changing sociotechnical systems, the interaction of international levels, and the role of politics stemming from different actors and institutions in the transition process (Kern & Markard, 2016; Patterson et al., 2017; Fuenfschilling & Binz, 2018).

2.2. International Governance and Geopolitics as part of Transition Processes

This sub-chapter explores various theories related to international relations, geopolitics, and global governance literature to bridge the gap to the limitations of transition studies mentioned above. The section begins with a review of geopolitical theories first in general terms and then on theoretical assumptions applicable to Space. This is followed by a closer exploration of a particular strand of global governance literature.

2.2.1. International Relations and Geopolitics in Space

Understanding the different international governance and policy choices made by various actors in a given sectors, requires a theory-based contextualization that sees all geopolitical options as characterized by the interplay of economic, strategic, and physical contexts (Flint, 2021). As an approach to analyze international politics, geopolitics generally discusses geography's impact on political processes and aims to explore selected cases as deeply as possible and in a global context (Doboš, 2020).

Since the onset of space activities during the Cold War, international relations and the geopolitical context of Space activities have changed dramatically (Peter, 2006). The globalization of the late 20th century seemed to confirm the obsolescence of national borders in general, but the further we move into the 21st century, the clearer it becomes that nationalism is resurgent (Bergesen & Suter, 2018). Countries seek to stabilize or expand their power position in the international context based on four pillars: first, increasing military power; second, the use of economic surpluses to provide aid and invest in other states; third, ideological leadership that serves as a model for other nations; and finally, a cohesive system of governance in which (political) actors are guided by common and consistent goals (Cohen, 2014a).

To understand the geopolitical tensions between states in general, but also in Space, the question of the power and borders of states must be addressed. Navigation satellites can be used for different scientific, sustainable, and peaceful purposes. Still, they also play a crucial role in military actions and are increasingly used to identify and select targets for naval, ground, and air force units (Bergesen, 2018). There is a clear geopolitical focus on national rivalries, arms races, Space races, and security concerns between the United States, the Russian Federation (formerly the USSR), and the Peoples' Republic of China. Moreover, other nations and geopolitical entities entered the field, such as India, Japan, and Europe. Besides these, commercial players are also gaining a foothold in orbital Space, making the area even more contested (Bergesen, 2018). In the last few decades, scholars in the field of international relations have attempted to revive the principles of geopolitical theory and apply them to outer space under the name of **Astropolitics** (Dolman, 1999; Duvall & Havercroft, 2009; Doboš, 2018; Wang, 2009). This has resulted in the development of various models and astropolitical views regarding the international Space system. These include, for example, neo-classical Astropolitics based on realism, Astroeconomics based on neoliberal institutionalism, and critical Astropolitics based on radical constructivism (Wang, 2009; Doboš, 2020). The following subsection will elaborate on these different concepts relevant to the study.

2.2.1.1. Neo-classical Astropolitics

Realism as one school of thought emphasizes the limitations imposed on politics by human nature, which is at its core egoistic, and the absence of international government as well as the role of **competition and conflicts** between state actors (Donnelly, 2000). Thus, the field of international relations becomes a sphere dominated by power and interest. Consequently, states exist within an anarchic international system in which they ultimately depend on their capabilities or power to promote their national interests (Waltz, 1979). **Neo-classical Astropolitics** (Dolman,1999) views Space as full of geopolitical significance, implying that the state must project its power to occupy pivotal positions and exploit resources to dominate Outer Space. In his work, Dolman (1999) develops four regions into which the currently utilized part of Outer Space can be divided with the ultimate target to control the Earth: The Earth, the Earth space up to the geostationary orbit, the lunar space, which ranges from the geostationary orbit to just beyond lunar orbit and the solar space which goes beyond the lunar orbit. Dolman (1999) theorizes that the first power to dominate near-Earth orbits will gain effective control of Space and Earth. Therefore, technologies must be developed that will enable an actor to achieve this level of control. However, many authors have directly challenged this view by taking more critical approaches to the study of international politics. (Wang, 2009; Duvall & Havercroft, 2009; MacDonald, 2007).

2.2.1.2. Liberal Astropolitics and Astroeconomics

The literature strand of (neo-)liberal internationalism and institutionalism assumes that not only national but also **international institutions** play a central role in facilitating cooperation and peace among states (Johnson & Heiss, 2018; Barten, 2015). These institutions can constrain and shape a state's behavior to maintain cooperation, even if they are challenged or reformed by their member states, primarily because the cost of creating a new institution is much higher (Wang, 2009). Institutional governance regimes, therefore, facilitate cooperation and avoid market failure. Under this assumption**, Astroeconomics** refers to cooperation through regulations of international institutions as the most effective and profitable strategy to gain a better share of Space-related markets. In these Astroeconomics, states compete when they interact in a mixed-motive situation in which the costs of cooperation exceed those of competition (Wang, 2009). The work of Deudney (1983, 2002) is one example of this more liberal geopolitical approach. In his view, promoting institutional cooperation among Space powers is a way to promote peace as a form of co-binding practices. Hegemony in Space is thus a danger that must be avoided through cooperation.

The liberal and neo-classical approaches both address international cooperation from a rationalist origin, meaning that the actors' ability to make rational decisions depends on specific constraints, such as imperfect information and asymmetric knowledge. The preferences and behavior of actors are thus determined and guided by the *"logic of expected consequences"* (March & Olsen, 1998): Actors calculate different courses of action based on minimizing costs and maximizing benefits (Wang, 2009).

2.2.1.3. Critical Astropolitics

The **constructivist metatheory** emphasizes the substantial constitutive effects of norms, culture, and identity (Agnew et al., 2003; Doboš, 2020). Actors' preferences and behavior are defined and guided by the "*logic of appropriateness"* (March & Olsen, 1998): Actors want to achieve a rule-based legitimacy, which is associated with their common cultures, collective identities, shared values and norms embedded in institutions or other social structures rather than purely individual interests and rational expectations (Wang, 2009). Various constructivist approaches commonly emphasize the constitutive effect of actors' social knowledge on their perceptions of meanings of interest and power. The more radical constructivist approach further emphasizes the unintended impact of discourse on society and power identities, as all social identities are seen as effects of power operations and materialize through discourse (Wang, 2009).

Constructivism based critical Astropolitics focus on the constitutive effects of cultural context on actors' identity in the form of role-specific understandings and expectations about self to a larger social group and the world and virtual practices (Wang, 2009). In their essay, Havercroft & Duvall (2009) present an alternative to more traditionalist approaches by focusing on the “constitutive” consequences of Astropolitics. They argue that the US geopolitical strategy of attempting control concerning orbital Space has the strong potential to transform the sovereignty of modern territorial states and leads to a new form of hegemony. The authors draw attention to issues such as counterbalance, resistance to the hegemon, and the inability of the majority of the population to influence the future development of Space. “*In place of an anarchic system of sovereign territorial states—capable either of great power competition or federation through collaboration—we see the likely development of a new form of empire, administratively deterritorialized, but centralized in locus of authority (Havercroft & Duvall, 2009).”* Therefore, Havercroft & Duvall (2009) conclude that, should a single entity have control over weaponization in Space, a new form of power could emerge in the form of a Space-based empire, capable of exercising complete control over the entire planet.

2.2.1.4. Existing combination of geopolitical perspectives for Space

In general, it can be assumed that the neo-classical approaches to Astropolitics were developed first. As a countercurrent to this very anarchistic view, liberal Astropolitics then developed, followed by critical approaches that attempted to approach the problem from a behavioral rather than a state-centered perspective. However, rather than just focusing on one of these dynamics, this thesis will seek to balance all three since each view in itself is insufficient to analyze the dynamic geopolitics of satellite navigation and EO systems in Outer Space. While the neo-classical approach omits non-state actors and cooperative settings, astroeconomics neglect power rivalry, and critical geopolitics disregards material factors and engages in purely normative discourses, based on the humans' value systems. However, as each school has undeniably provided essential points for understanding the social reality of Space, the combination helps to understand the geopolitical drivers, but also to incorporate informal institutional perspectives, e.g., by including behavioral perspectives also known as institutional rationalities or value orientations in transitions studies, see more details in section

There have already been several approaches to linking the different schools of thought, as many authors have worked on combinations to explain the sector's diversity. These insights further contribute to a better understanding of geopolitical approaches in Space and, in addition, map the manifoldness of policy approaches and mindsets. One approach is the realist school of thought, identified by Wang (2009), which stands somewhere between the basic positions. Wang follows a “realistic” approach and rejects the radical ideas about the inevitability of conflict versus the dominance of one state over the other presented by the neo-classical geopolitical perspective. Additionally, he challenges the notion that Space creates an entirely new kind of political environment defined by a cooperative nature of relationships. The author concludes that outer space is not a unique cooperative domain as Europe and the US regard outer space as a critical source of geopolitical interest and a symbol of technological superiority. However, conflicts are shaped by technological, environmental, and economic factors and are tied to terrestrial geopolitics. Therefore, an equal partnership with symmetric technological capabilities, interdependent contributions to technologies and infrastructure components, and participation in Space-based systems and technology management might be a way to reduce conflicts in the Space sector (Wang, 2009).

Another approach is the systematic geopolitical analysis from Doboš (2018), which attempts to utilize geopolitics as a neutral method for analyzing politics in Space. Unlike Wang (2009), this approach assumes that outer space is an independent geopolitical domain and should be analyzed as such. Doboš (2018) sees Space as a physical, socio-economic space and military-diplomatic area and offers insights into different actors' behavior and strategies by utilizing Dussouy's (2010) systemic geopolitics to show the geopolitical landscape. Dussouy (2010) has a holistic vision of geopolitics as a system of spaces that includes all human activity areas and physical features. However, Doboš (2018) focuses mainly on Space as a physical, natural space, a military-diplomatic field, and a socio-economic field. He concludes that four clear cornerstones determine the European strategy: Cooperation, strategic independence, the commercialization of Space activities, and Europeans' participation in the frontier missions of Space science and policy.

In another paper, Doboš (2020) additionally points out that different determinants influence the Astropolitics in the 21st century: the issue of actorness (number and type of actors); nature of the relationship between the Space powers (next to the actor diversification, there are still leading Space powers which characterize the field); the level of technological progress (there cannot be a power projection without technological progress); possibility of introducing weapons into outer Space (E.g., dual-use nature of Space technologies); utilization of natural resources; and the issue of sustainability of Space activities (e.g., Space traffic management and orbital debris issue).

2.2.2. Global Governance Context

Within the area of global governance research, transformations towards sustainability are becoming central. In particular, the earth system governance (ESG) approach, developed by Biermann and colleagues (2009b), helps this study contextualize transitions in the kind of global governance structure or networks in which multiple actors are embedded. This is especially important for sectors that have strong international implications such as the Space sector. The ESG approach centers around the emergence, design, and effectiveness of 'environmental' governance systems as well as the effectiveness of the associated architectures. ESG can be understood as "*the sum of the formal and informal rule systems and actor-networks at all levels of human society that are set up in order to influence the co-evolution of human and natural systems in a way that secures the sustainable development of human society"* (Biermann, 2005). The involved actors consist of public and private actors at all decision-making levels, ranging from expert networks, multinational corporations to agencies (Biermann, 2005). The concept of global governance architecture is introduced as an overarching system of public and private institutions that are valid in a given issue area of world politics, which comprises organizations regimes and other forms of principles, norms, regulations, and decision-making procedures (Biermann et al. 2009a).

Governance architectures emerge from incremental and lengthy processes of institutionalization that are decentralized and hardly planned (Biermann et al., 2009b). The various forms of governance architecture are influenced by several factors, e.g., the degrees of institutional fragmentation, polycentricity, hierarchy, and the overarching structure of values that exert influence on social and political action (Biermann & Kim, 2020). Especially the aspects of fragmentation are of particular use for this study in order to understand the setup of specific structures in different policy domains. In particular, governance fragmentation argues that many policy domains are marked by a "*patchwork of international institutions that are different in their character (organizations, regimes, and implicit norms), their constituencies (public/private), their spatial scope (from bilateral to global), and their subject matter (from specific policy fields to universal concerns)"* (Biermann et al. 2009b). Fragmentation is an inherent structural feature of governance research since there is no policy area where all relevant provisions are located under a single institutional umbrella with universal membership (Zelli & Asselt, 2013).

The ESG literature, therefore, inspires this study in the context of transition studies by including cooperation forms and patterns that go beyond the conventional studies of treaties. Thus, ESG literature serves as a guide to include the various forms of local, bilateral, and multilateral cooperation and shed light on the associated international political structures.

2.3. Bridging the theoretical perspectives with the Institutional Logics Approach

2.3.1. Institutional logics

To analyze the structuration of a sociotechnical regime and its effect on actors and technologies as well as the impact of institutionalization on transformative processes, Fuenfschilling & Truffer (2014) used concepts from institutional theory and embedded them in transition studies. In this context, the structure is considered a generic term for factors that influence the perception and behavior of an actor as well as the diffusion of practices, e.g., rules, norms, values, culture, actors, or practices. The structuration degree, and therefore the strength of a regime, can be identified by the degree of institutionalization of its core elements. A structure is highly institutionalized when it attains a high age and a high level of scope and acceptance (Fuenfschilling & Truffer, 2014; Tolbert & Zucker, 1999). To analyze the specific content and coherence of structures in a sociotechnical system, Fuenfschilling & Truffer (2014) make use of the institutional logics concept (Thornton & Ocasio, 2008). Thornton & Ocasio (2008) describe institutional logics as *"the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality."*

The basic logics that can be generally distinguished are profession, state, market, community, corporation, religion, and family (Friedland & Alfords, 1991). By reconfiguring these ideal-type basic logics, new logics emerge as a combination of institutional sectors/basic logics in a given field (Thornton & Ocasio, 2008). These institutional logics shape and create the rules of the game and the means-ends of relationships by which power and status are gained, maintained, and lost (Thornton & Ocasio, 2008).

These distinct societal logics develop in co-existence and competition and therefore constitute an organizational field (Friedland & Alfords, 1991). Drawing on the work of DiMaggio & Powell (1983), an organizational field can be described as a conglomerate of those organizations that together form a recognized sector of institutional life, including state and non-state actors, consumers, regulatory agencies, and other competitive organizations that produce similar services or products. Therefore, the concept of organizational fields describes the institutional environment by including the totality of all relevant actors that share a common meaning system and act in the same institutional arena (Fuenfschilling & Truffer, 2014). As sociotechnical systems have a specific focus on the interrelatedness of material and social elements, including their structural environment, the organizational field can be treated synonymously with sociotechnical systems (Fuenfschilling & Truffer, 2014).

An institutional logic includes, therefore, a combination of values, visions, beliefs, and rules that guide an actor's behavior in a sociotechnical regime. Thus, the institutional logics approach focuses on how competing societal level belief systems shape both individuals and organizations and, therefore, on a broader scale, influence the regime (Powell & Bromley, 2015). The combination of the various basic logics to which a significant group of actors adheres, creates what is known as **field logic** (Fuenfschilling & Truffer, 2014; Heiberg & Truffer, 2021). While not everyone needs to be represented by the exact same set of values, a pattern of similar values emerges that can grow into a field logic. Borrowing insights from Heiberg & Truffer (2021), the institutional logics approach can therefore help to identify groups of similar actors based on the proximity of shared values and beliefs in form of field logics, leading to so-called "value-based proximity" (Heiberg & Truffer, 2021, p. 25). According to Fuenfschilling & Truffer (2014), internal mechanisms in the regime can lead to change in the form of conflicting field logics. If there is only one dominant field logic, the possibility of change is relatively low. If there are different field logics, regimes have chances of change. Therefore, within a sector, field logics can compete, co-exist, complement or contradict each other, thereby reinforcing or weakening the structural elements in a sociotechnical regime (Fuenfschilling & Truffer, 2014).

2.3.2. An integrative View for the global Space sector

Transition studies are strong in acknowledging the interplay of organizational, institutional, and technological change. Still, they often neglect the vested interests and conflicts as well as the variety of contexts at a global level and the international economic and political relationships (Kern & Markard, 2016). This study will adopt the institutional logics approach as a medium to incorporate these identified broader considerations. Insights from international relations and more specifically geopolitics in Space will help identify the broader political dimensions or criteria that form as part of value orientations among actors. In other words, astropolitical theories are used to enrich the institutional logics approach in order to understand value dispositions of different actors in the Space sector. Thus, the ideal-type basic logics can be extended and averted as needed. This provides insights on, for instance, the drivers of different actors, the different political interests, and the distinguishable preferences in terms of cooperation or collaborations.

ESG literature (Biermann et al. 2009) additionally allows to contextualize the transition process of the global Space sector in a broader fragmented global governance structure. This contextualization becomes especially helpful when considering the international levels of actor constellations as well as associated cooperation and conflict patterns. The fragmentation of governance structures serves as a context to understand how actors from different institution bodies pursue common or very different goals. While astropolitical perspectives are directly related to logics and value orientations, the global governance structure serves more as a background context to understand the actor identities representative of the governance networks in which they are embedded and, therefore the kind of cooperative patterns they might pursue.

The integrative approach, therefore, also provides an opportunity to identify the willingness of actors to cooperate, the reasons for cooperation, as well as to examine the potential for conflict and identify the possible causes. Overall, the institutional logic approach enables the mapping of the value dispositions to which different actors adhere. This can provide information about how similar or opposed actors are in their value disposition and thus indicate a possibility to cooperate or to engage in conflict. Therefore, the conceptual approach proposed in this study is promising to help better understand whether or not the global Space sector will be able to transition from a (historically) geopolitically driven field towards one that draws on genuine globally integrated efforts to offer multiple Space-based infrastructures that accelerate sustainable development.

3. Methodology

This chapter describes the methodology used to answer the research question by first explaining the research design, case description, and data collection and analysis. Lastly, an overview of how the quality of the research will be assured is given.

3.1. Research Design

This study follows a combination of deductive and inductive reasoning to address the identified research problem and uses a mixed-method research design based on secondary data (Schoonenboom & Johnson, 2017; Bryman, 2006).

So far, most transition studies used historical or qualitative case studies to approach the complex and systemic nature of socio-technical transformation (e.g., Geels, 2002; Ernst et al. 2016, de Haan & Rotmans, 2011). However, these studies remain restricted to reconstructions of transition processes in specific regional or national contexts while undermining the international political arena processes (Heiberg et al., 2020). Building on the Discourse Network Analysis (Leifeld, 2017), Heiberg, Truffer, and Binz (2020; 2021) developed a semi-quantitative relational methodology called socio-technical configuration analysis (STCA), which allows tracing the number of competing logics by which different actors are driven. The STCA aims to capture various institutional, social, and technical elements, such as infrastructure solutions, policies, or sector norms, to shift the focus towards broader and less coherent advocacy coalitions that assemble around different technologies, institutions, and logics in a socio-technical regime (Heiberg et al. 2020). Thus, the STCA can map (dis)alignments between actors, institutions, and technologies in transformation processes. By adopting this method, synergies and conflicts between actors and norms were captured.

Case Selection

The Space sector can serve as a crucial exemplary case study to address the research gap, as it is once strongly driven by geopolitical influences and will now have to transition towards international cooperation to engender sustainable development. Three main developments characterize the global Space sector: first, the use of satellites to enable sustainable development on the Earth; second, increasing geopolitical tensions between various stakeholders and third, the increasing competition and commercialization of the Space sector. The sector is challenged by conflicting interests such as intensified competition, the lack of cooperation, and missing coordination in capacity building on Space technologies for providing reliable data (Radojevic, 2020; Kumar et al., 2020). To provide a holistic overview of the challenges and opportunities in the satellite sector, two extreme case studies were selected: the case of satellite navigation services and the case of earth observation services. Although both fields have been strongly geopolitically driven from the beginning, they have developed in very different directions over time. While Earth observation services are increasingly characterized by commercialization and private participation, especially in the field of sustainable development, navigation services are still subject to strong geopolitical tensions between mainly state actors. The actors involved in navigation and EO services are therefore characterized by different logics and thus by different motivations, tensions, and cooperation tendencies.

Using the evidence from multiple cases with contrasting characteristics is considered more compelling and robust (Yin, 2004). Therefore, this comparative approach allowed for the analysis and synthesis of the similarities, differences, and patterns between the two cases and thus allowed to cover two ends of the spectrum.

In terms of navigation satellites, this study will mainly look at the four *Global Navigation Satellite Systems* (GNSS), which provides free positioning and timing services worldwide: The Global Positioning System (GPS) of the USA, GLONASS under Russian operation, BeiDou as the Chinese navigation system and the European GNSS Galileo. Historically, the Global Positioning System (GPS) was the first navigation system developed by the United States as a military system. Since 1993 it is a "dual-use"-system with military and civil applications used in international air, sea/road traffic, as well as many other economic and non-economic areas (Hegarty, 2017). Additionally, there are several Regional Navigation Satellite Systems (RNSS) and Satellite-Based Augmentation Systems (SBAS), which use geostationary communications satellites to provide differential correction data and integrity information in place (Langley et al., 2017). In the last decades, it became evident that GNSS data poses enormous potential for sectoral transformations (Langley et al., 2017). However, recent discourses in the media show the tensions based on geopolitical competitions. For example, the increasing development of various regional navigation satellite systems (RNSS) illustrates that more countries are trying to reduce their dependence on the global GNSS (Gu et al., 2019). Moreover, the cooperation of GLONASS with GPS and Galileo has slowed due to different political conflicts. On the other hand, China and Russia are working on the compatibility of their systems (Radojevic, 2020). Overall, this shows that the field of satellite navigation has been strongly driven by geopolitical interests since its beginning, challenging sectoral opportunities to accelerate sustainable development on Earth.

EO-satellites have unprecedented potentials in improving climate and earth surface monitoring (OECD, 2019). The development of EO services began between 1960 and 1980 when multispectral sensors were used to observe the Earth's surface, stimulated in part by the declassification of military satellites that used infrared and microwaves (Tatem et al., 2008). After the US National Aeronautics and Space Administration (NASA) and the US National Academy of Sciences studied the benefits of Earth observation for forestry and agriculture, NASA launched their first EO satellite, Landsat 1, in 1972 to monitor the Earth's land areas (Tatem et al. 2008). However, over time, the hegemony of a few actors, in terms of the domination of one state over another in the 1970s and 19080s, was breaking. Since then, a radical geopolitical expansion of ownership could be observed (Belward & Skoien, 2015). EO satellites were constantly improving and provided high spatial, temporal and spectral resolution, stereo-mapping, and all-weather-imaging capabilities. However, the field was challenged by opposing developments. On the one hand, multisensor platforms like Copernicus (Europe) and EOSDIS (USA) dominate the industry. On the other hand, the number of smaller, lower-cost national satellites is increasing significantly, many of which are operated by commercial operators (Tomás & Li, 2017). The multiplication of affordable microsatellites, and the reduced cost of access to Space, have enabled new actors in Space to acquire and operate EO satellites with moderate investment compared to the early EO systems of the 1970s and 1980s (Peter, 2006). The growing number of EO-satellites and the increasing performance, complexity, and resolution lead to an increased amount of data (OECD, 2019). Therefore, challenges in Earth observation therefore include data management, including handling, access, and sharing. Governments are taking steps to make E.O. data accessible to external users. Still, over 30% of the EO-missions are characterized by restricted data access, providing exclusive national, regional, or commercial access (CEOS, 2021). Another challenge is the lack of capacity in many countries and regions, especially developing countries, to use data to assess local resources and monitor agricultural production and land change (Belward & Skoien, 2015). This overall shows that the field of EO, although started with geopolitical tensions and the hegemony of a few actors, is now strongly driven by increasing commercialization aiming at accelerating sustainable development and deliver data to inform decision-making.

The years 2000 until 2020 have been chosen as the timeframe for the Navigation case. The year 2000 can be seen as a critical year, as many important events took place, such as the start of the first phase of BeiDou in China or the publication of a position document which formally assessed "GPS-Galileo Cooperation" as having failed, revealing the difficulties between the USA and Europe (more details in section 5.1.1.).

At the end of 2000, the Earth Observing One (EO-1) satellite was launched as a technology demonstration mission in NASA's New Millennium Program (Middleton et al., 2013). In 2001, the EU and ESA endorsed the Global Monitoring for Environment and Security program (GMES) to gather and use data to support sustainable development policies, which counts as the first manifesto for developing a Space-based environmental monitoring system in Europe (Haarler, 2020). These events determined the timeframe for the EO-case from 2001 to 2020 (more details in section 5.2.1.).

3.2. Data Collection

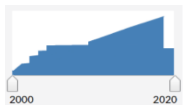
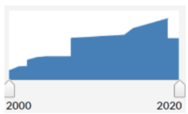
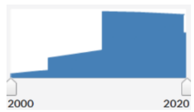
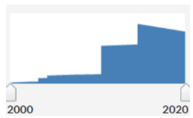
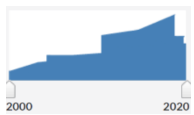
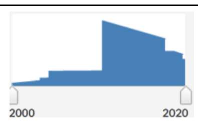
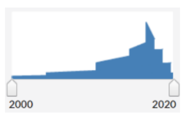
The STCA is built on the coding of actor statements recorded in publicly available document repositories (Heiberg et al., 2020). For the data collection, various publicly available articles and government documents were collected from Nexis Uni, a provider of legal government and business information, as well as daily news. In addition, Nexis Uni offers document stocks over long periods and across various spatial ranges, enabling the reconstruction of longer-term developments and comparing geographical units.

3.2.1. Data Collection - Navigation Case

A search string was defined to find relevant articles that map the sector's actors and developments, previously identified with a literature review. A summary of search string trials regarding the Navigation Case, their evaluation, temporal development, and spatial spreading can be found in *table 1.*

The first and second searches were broadly defined to obtain an overview of the reporting and its development over the last decades. Search terms like "*conflict, cooperation, or geopolitic**" helped reduce the number of articles. The asterisk symbol is used as a placeholder, which can be replaced by any word, letter, or phrase. However, especially the phrase *geopolitic** is too specific since several relevant articles disappeared in the results compared to the initial searches. Moreover, other articles dealing with general geopolitical tensions were included, which affected the search quality, and thus it was decided not to use the term despite some relevance. Search string five led to a collection of articles that offered applicable content since they addressed a broad range of actors and states as well as navigation alliances. The next step was to refine the search string's content so that the results are maximized in their content relevance and minimized in terms of number of articles to ensure the feasibility of the study. Therefore, a minimum number of occurrences for the terms *conflict* and *cooperation* was set up. Besides, a trial & error procedure was used to test different word combinations. By continually monitoring the results, it became apparent that relevant articles were always related to one of the four GNSS. Therefore, the four global navigation satellite systems, GPS, BeiDou, GLONASS, and Galileo, were integrated into the search. Search number seven offered the first potential set of data given a more manageable number of articles. Preliminary cleaning of the data left 190 articles that are relevant to the case. From this, it can be deduced that the search string is still too broad since many articles (~500) were not relevant. Additionally, the time trend was questionable and suggested a bias in the data.

To enable a more precise fit between search and intended results, quotation marks were used to refine the search string. The quotation mark operator is used to filter for a specific word or word combination; therefore, the results will only include articles with the exact words in the same order as those inside the quotes. Search strings nine and ten are the most promising ones as they offer a good fit between search and intended results. Due to the better temporal as well as spatial distribution and the number of relevant articles, search string ten is used for data analysis. The spike in articles in 2010 can be explained by the fact that the Chinese GNSS (BeiDou) website went online that year. BeiDou is considered a serious competitor to the US GPS. Especially on the American side, this change of the sector and its dynamics raised the fear of losing dominance in Space.

#	Search string	News	Time Trend	Geogr. Distribution	Evaluation
1	atleast4(satellite navigation system) AND conflict	1052		International: 753 USA:300	X
2	atleast4(satellite navigation) AND conflict*	2323		International: 1521 USA:700	X
3	atleast5(satellite navigation) AND atleast4 (conflict* OR cooperation)	2354		International: 1870 USA:419	X
4	atleast4(navigation systems) AND geopolitic* AND cooperation OR conflict	470		International: 271 USA:166	X
5	atleast5(satellite navigation) AND conflict* OR cooperation	9665		International: 7024 USA:2000	X
6	atleast5(satellite navigation) AND atleast4 (conflict* OR cooperation) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo	1305		International:1009 USA:252	X
7	atleast5(satellite navigation system) AND atleast4 (conflict* OR cooperation) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo	740		International: 592 USA:130	X
8	atleast5("satellite navigation") AND atleast4 (conflict* OR cooperation) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo	79		International:64 USA:9	X

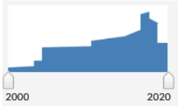
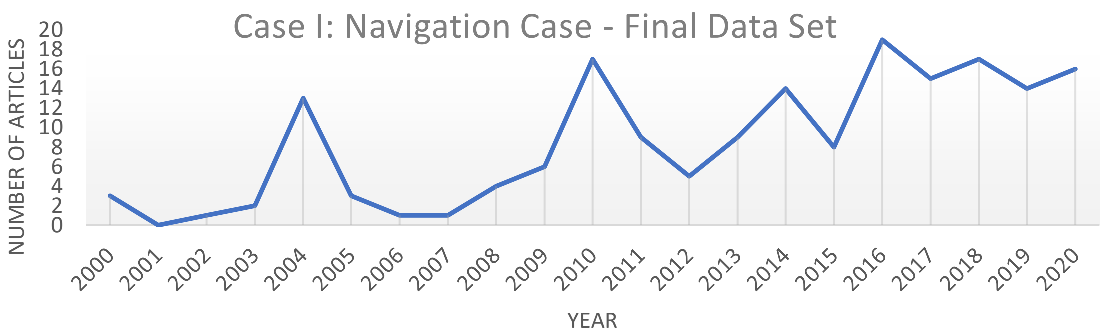
9	atleast3("satellite navigation") AND atleast3 (conflict* OR cooperation) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo	201		International: 168 USA:22	✓/X
10	atleast3("satellite navigation" OR "navigation satellite" OR "navigation system") AND atleast3 (conflict* OR cooperation OR tension) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo OR BDS	375		International:303 USA:63	✓

Table 1: Possible Search Strings Navigation Case

The time trend of search sting 10 can be find in Figure 1. The slight decline in numbers in recent years can be explained, among other things, by the fact that more attention has been paid to emerging Internet satellite constellations and the problem of Space debris. Additionally, many articles from 2020 onwards focused on the emerging coronavirus. However, a general positive trend can still be confirmed by the increase in the number of published news items in 2021.

In the next step, the preliminary results were filtered to avoid irrelevant and duplicate articles. The final dataset used for the analysis, therefore, included 177 articles, divided into 35 government documents and 142 newspaper articles.



atleast3("satellite navigation" OR "navigation satellite"OR "navigation system") AND atleast3 (conflict OR cooperation OR tension) AND GPS OR BeiDou OR GLONASS OR GNSS OR Galileo OR BDS*

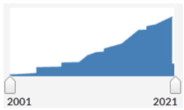
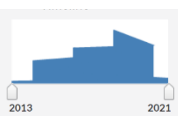
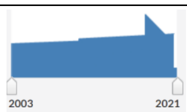
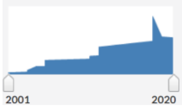
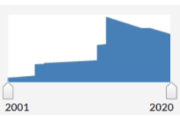
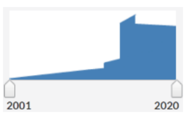
Figure 1: Navigation-Case Final Dataset

3.2.2. Data Collection- Earth Observation Case

Similar to the Navigation-Case, an iterative process was conducted to find a fitting search string for the EO-Case. However, unlike the Navigation case, the EO field today is not majorly affected by geopolitical tensions but by the challenge to deliver data to inform decision-making better and disaster management processes, monitor land/water-use change and control the use of resources to promote food security and sustainable development (OECD, 2019). Additionally, the literature review showed a trend in satellite design towards smaller, cheaper national satellites and cooperation with commercial operators (Tomás & Li, 2017). Preliminary desk research showed that these diverse challenges are also mirrored in the medial discourses.

Based on a broad initial search string, the number of articles dealing with EO data indicates a strong positive trend. However, by further focusing on data management, it can be seen that big data and Space data are topics developing just recently. Additionally, it can be seen that geopolitics only plays a minor role in the EO field (search string Nr. 4 in *table 2*). By keeping the term *data* rather broad and focusing on terms like *cooperation* and *conflict*, many articles concentrate on problems related to *data access* or *sharing*. Therefore, in the next step, these terms were included. Search string six was the first to indicate a potential dataset. Preliminary cleaning of the data left 173 articles that fit the case. From this, it can be deduced that the search string is still too broad since many articles (~400) were not relevant. Additionally, the downwards trend is questionable. However, this can be interpreted as a favorable sign since issues of cooperation or conflict have been less in the focus of media discourse, indicating that different tensions prevail in the EO case compared to the Navigation case.

In the next step, *EOSDIS* and *Copernicus*, the two major multisensor-EO platforms, were included. However, this led to a neglect of smaller satellites and other countries. Therefore, the design of the search string went into the next round. After multiple trials, it was finally found that the focus must mutually be on terms such as *data management, space data, big data,* or *earth observation data,* as the challenges in the EO Case are linked to collection, access and sharing of EO-Data. An upward trend for the number of articles were derived (search string Nr. 8). Previously identified problems such as data access or data sharing were incorporated but did not narrow the search too much. To refine and finalize the search string and maximize relevance, the next step was to define a minimum number of occurrence of the terms *data management*, *space data, Big Data,* and *Earth observation data* in combination with satellite AND earth observation OR earth monitoring

#	Search string	News	Time Trend	Geogr. Distribution	Evaluation
1	Atleast4(satellite AND earth observation OR earth monitoring) AND data AND management	1137		International: 610 USA: 446	X
2	atleast4(satellite AND earth observation OR earth monitoring) AND space data	88		International: 58 USA: 20	X
3	atleast4(satellite AND earth observation OR earth monitoring) AND Big data AND management	97		International: 57 USA: 28	X
4	atleast4(earth observation or earth monitoring) AND geopolitic*	79		International:41 USA:22	X
5	atleast3(satellite AND earth observation OR earth monitoring) AND data AND cooperation OR conflict	1036		International: 547 USA:387	X
6	atleast4(satellite AND earth observation OR earth monitoring AND data) AND cooperation OR conflict OR geopolitic* OR data access	528		International: 227 USA:190	X
7	Atleast3(satellite AND earth observation OR earth monitoring AND data) AND cooperation OR conflict OR geopolitic* OR data access AND EOSDIS OR Copernicus	205		International: 116 USA:35	X

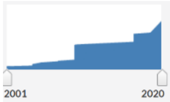
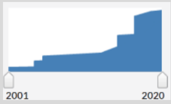
8	atleast4(satellite AND earth observation OR earth monitoring OR remote sensing) AND atleast3 (data management OR space data OR big data OR Earth observation data)	721		International:362 USA:276	X
9	atleast5(satellite AND earth observation OR earth monitoring) AND atleast4 (data management OR space data OR big data OR Earth observation data)	378		International:160 USA:128	✓

Table 2: Possible Search Strings EO-Case

The preliminary results (search string Nr. 9) were filtered to avoid irrelevant and duplicate articles in the next step. Thus, the final dataset used for the analysis included 172 articles, divided into 144 newspaper articles and 28 government documents. The Increasing interest over time can be seen in the temporal development of articles published in *Figure 2.*

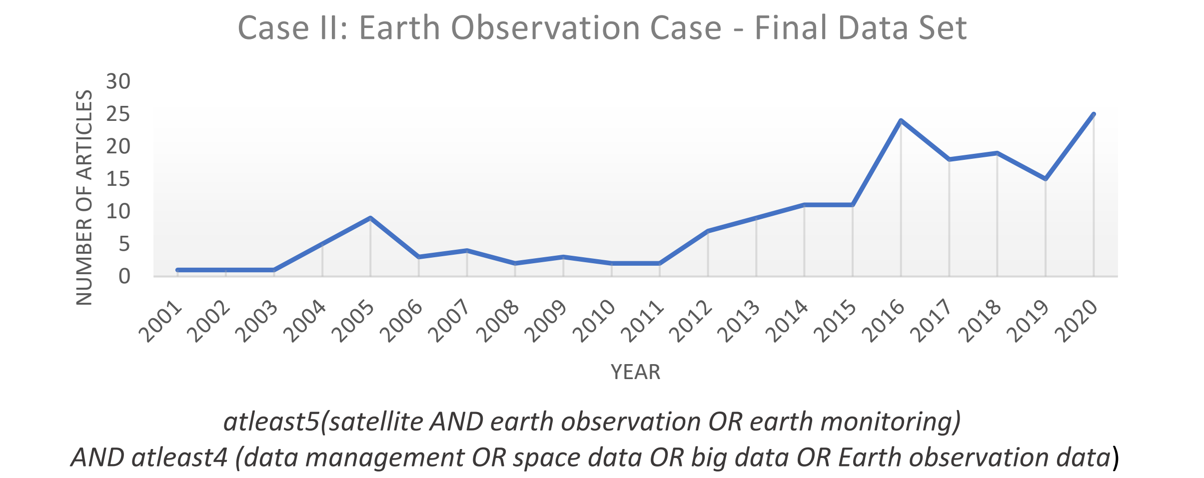


Figure 2: EO-Case Final Dataset

3.3. Data Analysis

To answer the research question, this study adopts the institutional logics concept from transition studies to map value dispositions in the form of so-called actor and concept networks. Therefore, value dispositions in the form of logics were identified in news, reports, and policy and regulatory documents. They were subsequently coded using the qualitative content analysis- software *NVivo*. The coding scheme for mapping the logics was inspired by the different geopolitical theories as well as discussions on conflicts and cooperation implied in transitions and ESG studies mentioned earlier (the coding scheme can be found in *Appendix C & D*). The coding process was iterative, including comparing, (re)evaluating, and (re)categorizing logics multiple times to re-evaluate to process constantly before arriving at a final set of the coding scheme.

The qualitative content analysis aimed to provide a comprehensive overview of all the major structural features of the emerging institutions of the Space sector on a global level, i.e., the actors (in this case, governments, authorities, organizations, agencies) as well as the associated technologies, projects, and their evolution over time. Second, for each actor, the technology preferences, collaboration partners, and potential tensions were identified. Third, statements were assigned to individual logics based on which values individual actors were driven by. The coding started first deductively with the derivation of basic logics used in the research of Thornton & Ocasio (1999) and Fuenfschilling &Truffer (2014), with extended dimensions or criteria as inspired by the geopolitics and global governance literature. Therefore, understanding the literature has helped provide information on what to look for in the data, e.g., multilateralism, bilateralism, national security interests, national economic interests, technological dominance, cooperation and conflict tendencies. Subsequently, revisions and adjustments were made to the coding scheme inductively according to the empirical evidence of the cases. The final coding scheme for institutional logics in this study includes the following main Logics: State, Market, (multilateral) Cooperation, Sustainable Development, Governance & Regulation, Science and Community. The State Logic is divided into National Self-Interest and Bilateral/ Geopolitical Interest. The cooperation logic is divided into general multilateral interests and multilateral cooperation for sustainable development. The market logic is divided into market development and competitive interests for the Navigation case and government or private market development interests for the EO Case. Thus, it can be seen that each case has, if necessary, specific sub-logics tailored to the prevailing value dispositions of the actors. The detailed coding scheme per case including the sub-logics and explanations, can be found in *Appendix A* for the Navigation case and in *Appendix B* for the EO case.

Guided by the geopolitical and governance considerations presented in the theory section, and informed by empirical evidence, the different basic logics (hence different value orientations actors adhere to) were identified. This way, one or more basic logics were assigned to any individual actor. The coding step additionally distinguished between statements made by clearly identifiable actors (discursive statements) and general statements referring to particular actors (i.e., substantive statements). Given that many articles were ambiguous about who was making certain statements, it was agreed with the supervisor that the codes for the subjects under discussion would be selected for analysis. *Table 3* provides an exemplary representation of the coding, and the resulting actor-logic affiliations can be found in *Figure 3* (see Heiberg & Truffer 2021 for a similar application of the STCA method).

Text Sample	**Logic**	**Subject**	**Statement by**
During ϕ-week, ESA's Director of Earth Observation Programmes, Josef Aschbacher, said, "We see that there is huge interest in ϕ-Sat and thanks to our partners, it is ready to be launched. "We live in exciting times, the pace at which digital technology is developing coupled with the wealth of satellite information being delivered and, indeed, the growing demand for such data, means there are many opportunities to make a step change for the future of Earth observation. And, with ϕ-Sat – Europe's first artificial intelligence in space – we are going to do just this."	Science Government supports Market Development	ESA	ESA Official
"The expertise available at DLR in earth observation and data processing is fundamental for the successful establishment of the European data center planned by ESA," explained Prof. Hansjorg Dittus, DLR management board member responsible for space research and technology	Science	DLR, ESA	German Scientist DLR

"With the blessing of Allah, the launch process was completely successful, and DubaiSat-1 is now carrying the UAE's flag into space. DubaiSat-1 is undoubtedly a sterling addition to the UAE's strategic accomplishments and what we have achieved so far can be attributed to the hard work and dedication of our national engineers and scientists. While the moon landing was a huge leap for humanity, DubaiSat-1 is a huge leap for the UAE's science and technology initiatives, and for our nation's aspirations," Al Mansoori added.	State [Self-Interest]	Arab States (UAE)	Director EISAT (UAE)

Table 3: STCA- Coding actor-Logic affiliations (Examples EO-Case)

After coding all relationships between actors and basic logics, following the value-based proximity approach of Heiberg & Truffer (2021), the data were transformed into unweighted two-mode affiliation matrices, whereas each row represents an actor, and each column represents a basic logic. Affiliations occurred through common references to specific logics. Cells of the affiliation matrix consist of ones if actors are associated with a particular logic, and zeros if not. An R-written script was used to identify value-based proximity by projecting a "one-mode" network of actors, where the links between actors represent common affiliations to institutional logics. The similarity between the actors was determined using the Jaccard index. The Jaccard similarity index between two actors is the result of dividing the number of common properties, here logics, by the number of properties (Niwattanakul et al., 2013):

$$j = \frac{|A \cap B|}{|A \cup B|}$$

Thus, if two actors have the exact same profile of logic, the value will be 1 and will converge to 0 the more dissimilar the logics are. A link is established when two actors share the same logic *(see figure 3)*, which served as the basis that forms the actor networks. To visualize the actor-network, the software *Visone* was used.

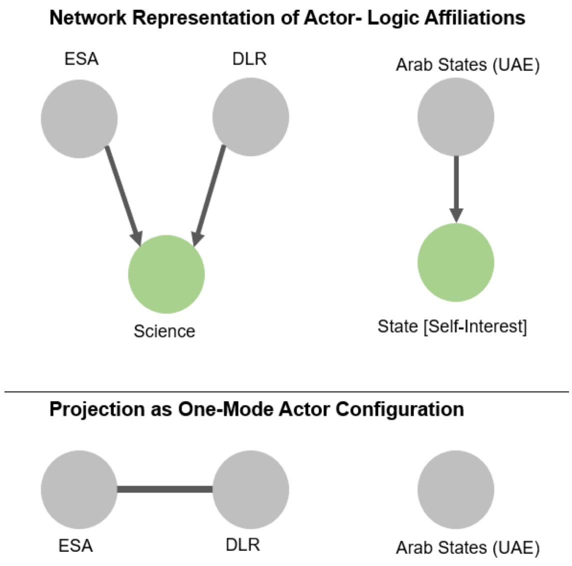


Figure 3: STCA network representation from affiliations to one-mode projections (illustration inspired by Heiberg & Truffer (2021)

In the subsequent analysis step, the node-level value-based proximities between certain actors are aggregated to the field level (Fuenfschilling & Truffer, 2014). In other words, similar actors are identified based on value-based proximity and aggregated as groups. Therefore, an agglomerative clustering approach, called Ward's Method, was used. This algorithm first assigns an independent cluster to each object and then searches iteratively for the most similar cluster pairs, based on the sum of squares, and merges them into a single cluster (Hirano et al., 2004). This process was repeated until all actors ended up in a cluster, creating a hierarchical tree of possible groupings (Heiberg & Truffer, 2021). Subsequently, a decision was made jointly with the supervisor as to how many clusters in each time period were deemed optimal to represent the number and characteristics of the field logics that best reflected the evolution of the cases. It was possible to determine whether different sets of values are aligned or conflicting by applying this process. Based on the use of use substantive statements, logics were assigned, and the actor networks of both cases were derived. As a result, is was possible to identify the actors who are more or less 'present' in central discourses, indicating which actors have the most influential role in shaping the development of the two fields. Lastly, by analyzing the different field logics, the value orientations of the different more or less important actors can be better grasped, and thus where potential collaborations/coalitions and conflicts may arise.

3.4. Research Quality

This research represents a mixed methods research design as it includes both quantitative and qualitative research elements. Even though this study follows a semi-quantitative approach, ensuring the four quality criteria based on Lincoln and Guba's (1985) findings for a qualitative research design seem most suitable to provide a valid and reliable study.

First, credibility refers to how well the results match reality. By relying on different sources and triangulating the results, credibility, also known as internal validity, can be ensured (Bryman, 2012; Sale & Brazil, 2004). To ensure the internal validity of the study, the coding scheme was revised back and forth several times, which was closely monitored by the supervisor. To ensure transferability, in quantitative research designs, also referred to as external validity or generalizability (Sale & Brazil, 2004), all data used, and the coding scheme is provided so that readers can assess whether the results are transferable to other settings. Since this study is tailored to the specific Space sector, the generalizability of the results to other contexts is limited. However, the conceptual approach developed in this study can be implemented in a different context as it is not limited to the dynamics of a specific sector. The next criterion, also called dependability (Sale & Brazil, 2004), addresses whether sufficient details are provided about the methods used so that the study can be reviewed and replicated. The use of multiple data sources for triangulation and the review of the research process by Dr. Yap, who is knowledgeable about the method and transition studies, dependability is ensured.

Furthermore, by validating empirical data with theoretical concepts, reliability is ensured as interpretive flexibility of the researcher's data becomes limited. Lastly, confirmability needs to be achieved to ensure that the study's findings are concerned with reaching the highest possible state of objectivity by excluding personal values in the analysis process (Sale & Brazil, 2004). This is achieved by an iterative and reflective working process of linking the data with theoretical concepts, along with the professional guidance of Dr. Yap.

4. Background Study of the Navigation and Earth Observation Cases

Satellites can be categorized as communication, navigation, and earth observation, also called Remote Sensing satellites. Overall, satellites offer the largest and most attractive opportunities for the use of Space, especially for terrestrial applications. (Hobe, 2010). The development of navigation as well as EO services started in 1957 when the Soviets launched Sputnik. This was the beginning of the so-called Space Age. The term “Space-age” was coined by US politicians and reporters who recognized that the entry into Space marked the beginning of an entirely new era in international politics (Quinn, 2008). Additionally, satellites can be categorized according to the mission type (governmental vs. commercial mission), and to the orbit, they are operating in (the high Earth or Geostationary Orbit, the Medium Earth Orbit, and the Low Earth Orbit). From the beginning of the development of the Space sector, the industry evolved in different cycles, from the first Space Race to the international cooperation on the ISS and today’s ubiquitous use of Space applications in various fields depending on all types of satellites (OECD, 2016). Several developments are pushing the traditional boundaries of the Space sector. The commercialization of Space appears to be one of these dominant themes in current reporting and research, alongside rising geopolitical tensions (Robinson & Mazzucato, 2019).

Before presenting the data analysis and results of this study, the next section provides an overview of the Navigation and Earth observation fields, followed by a review of their respective fragmented governance structure, to put the analysis in perspective. A summary of existing hard institutions in form of legally binding treaties and soft institutions including for example declarations, resolutions, guidelines or standards of conduct in the Space sector is given in *Appendix E* (Jakhu & Pelton, 2017; Boyle, 2006).

4.1. The Case of Navigation

4.1.1. General Development of the Satellite Navigation Field

Navigation satellites were developed for purely military purposes, and to this day, most GNSS systems are under military control; however, civilian users account for 86% of GNSS use (Larsen, 2015). On a technical level, each GNSS is composed of a constellation of satellites (Space segments), ground segments in the form of a ground-based network of control facilities, and lastly of the user segment in the form of terminal equipment (Kong, 2016).

The US Global Positioning System (GPS) was the first GNSS and remains the most widely used today, operated by the US Department of Defense. The initial phase started in 1973, with the prototype launched in 1978. In 1995, the system became fully operational (Hegarty, 2017). Since 1978, 67 GPS satellites were successfully launched, out of which 31 are operational today (National Coordination Office for Space-Based PNT, 2021).

Shortly after the US, the development of the Russian GNSS GLONASS started in 1982 and was fully operational in 1995 (Revnivykh et al., 2017). By the decree of the President of the Russian Federation, GLONASS received dual-use status. However, due to the short lifespan of the Russian satellites, the quality dropped in 2002. Since then, in order to enable performance improvement, GLONASS preservation and enhancement activities have been carried out within the framework of the long-term GLONASS federal program with a secured budget (Revnivykh et al. 2017; Information and Analysis Center for Positioning, Navigation and Timing, 2021). Within the following decade, regular launches and extended lifetimes of the new GLONASS-M satellites helped gradually increase the number of operational satellites. Therefore, after the modernization of GLONASS, the system was again fully operational in 2011 (Hein, 2020). In 2007, a decree of the President of the Russian Federation declared that the GLONASS service would be available to all national and international users without restrictions. In parallel, it was requested that federal authorities use GLONASS-based navigation equipment in national security interests (Revnivykh et al., 2017).

Europe has also recognized the strategic, economic, social, and technological importance of satellite-based navigation. In 1994, the European Council, together with the European Commission, sought various initiatives to contribute to satellite navigation. One aim was to extend the already existing first-generation GNSS (i.e., GPS and GLONASS), which resulted in developing the European geostationary navigation overlay service (EGNOS). However, the main goal was to develop an independent navigation system to reduce the dependence on others, which is why the European Union (EU) called for "*initiating and supporting the preparatory work for the design and organization of a global navigation satellite system for civil use*." (Hofmann-Wellenhof et al., 2008).

At first, the EU headed for close cooperation with the US to develop the next-generation GPS and active participation in its control and development. However, GPS was always considered a safety-critical infrastructure. Foreign involvement in the definition and control of GPS was therefore unacceptable to the United States. By contrast, Europe sought maximum control to ensure its sovereignty, autonomy, and competitiveness and decided to develop its GNSS (Hofmann-Wellenhof et al., 2008). The European GNSS was designed as a self-standing satellite-based positioning system for worldwide service by the European Commission and the ESA. The development of the Galileo program was separated into four phases: the definition phase, the development and in-orbit validation phase, the deployment phase, and the operation phase.

The definition phase of Galileo ended in 2003 and was a focal point in designing and defining the European GNSS compatibility of Galileo with the existing satellite navigation system (European Commission 2000). Therefore, the EC established a task force in 2001 to support signal definition and interoperability. This resulted in the 2004 agreement between the USA and Europe to implement a common signal structure to facilitate both systems' combined use. At the same time, security concerns in the USA led to a separation of the military GPS M code and the Galileo Public Regulated Service signal (Hofmann-Wellenhof et al., 2008). The in-orbit validation phases started with the launch of the first satellites in 2005 and 2008 to test the functionality and technology in the MEO environment. This was subsequently followed by the deployment phase, during which the first two operational satellites were launched in 2011. The system started its initial services in 2016 (EC, 2021). Today, Galileo has 26 Satellites in Orbit, from which two are inoperable because of technological reasons, and the other two are retired (European Union Agency for the Space Programme, 2021).

The last of the four GNSS is the Chinese BeiDou, also called the BeiDou Navigation Satellite System. The project started in 1994 to build up an independent and self-reliant GNSS to diminish the dependence on GPS (Radojevic, 2020, Chukwunonso et al., 2021). However, until 2010 when the official website went online, little official information was publicly available.

According to the CSNA (2010), the development of the system was carried out in three steps: the experimental phase, the regional coverage, and the global coverage (Chengqi, 2012). The first phase was characterized by constructing the BeiDou Navigation Satellite Demonstration system, including the first satellite launch in 2000. Major components were the setup of the Space constellation, ground control segments, and user terminals (CSNO, 2012). The second step was the actual construction of BeiDou to offer regional services. Lastly, global coverage was reached in 2020 (CSNO, 2012).

Since July 2020, the BeiDou system is officially operational globally with 30 functional satellites in orbit. BeiDou is also the central part of the Chinese Belt and Road initiative (BRI) and China's Space Silk Road. The aim is to create an entire range of Space capabilities as satellites, launch services, and ground infrastructure (Dotson, 2020). Therefore, BeiDou is a crucial part of the Chinese diplomatic outreach and geopolitical presence (Dotson, 2020). To be part of this initiative, many countries, including Pakistan, Saudi Arabia, and Indonesia, have signed bilateral contracts to establish the system domestically (Chukwunonso et al., 2021).

4.1.2. Fragmented Governance of the Global Navigation Satellite Field

The regulation of GNSS is mainly directed by hard legal mechanisms such as the general Space law treaties, but also by national enabling laws and regulations and the International Telecommunication Union (ITU) legal regime that manages radio frequencies, signal interference, and orbital slots (Larsen, 2021; Mountin, 2014; von der Dunk, 2017)). However, none of these laws is designed explicitly for regulating GNSS. While the respective national governments control GPS, GLONASS, and BeiDou, Galileo is managed by the EU and partially delegated to ESA (Larsen, 2015). Thus, to understand how Space law affects GNSS, examining five essential elements of GNSS from an overarching legal perspective is necessary: ground stations; radio signals; satellites launched and operating in Space; position, navigation, and timing (PNT) signals; receivers to calculate positioning and navigation information (van der Dunk, 2017). Ground stations and receivers are not subject to Space law, as they fall under the sovereign jurisdiction of the state in which the stations or receivers are located (van der Dunk, 2017). Radio signals, as well as PNT signals, are dealt with by the ITU constitution mentioned above (Larsen, 2021). However, ITU's legal involvement in GNSS satellites remains limited to this coordination of frequencies and associated orbits (van der Dunk, 2017). Therefore, the satellites launched and operating in Space are the main subject of Space law.

Although the Outer Space Treaty does not explicitly mention GNSS satellites, they can be included by how the treaty is worded. As such, Article III of the Outer Space Treaty obligates compliance with general international law, and Article IX obligates to make reasonable efforts to avoid harmful interference with other legitimate Space activities. Finally, Article XI imposes an obligation to share with the international community all relevant scientific information. Because all four GNSS offer open and freely available signals to civil society, GNSS contributes to the benefits of Space for all humanity. However, if GNSS were used to support the unlawful use of force, there would be a violation of Article III of the Outer Space Treaty. This would include, in particular, the use of force other than in the exercise of the right of self-defense (van der Dunk, 2017).

However, according to international Space law, the legal regime remains fairly general and limited in its specific guidance of GNSS operations and activities. In Europe, the legal situation regarding Galileo and accountability is very precarious. While the ESA is able to register satellites, the leading role of the European Union remains unclear when it comes to accountability, liability, or similar responsibilities. The critical impact of national sovereignty in the area of international law is a major concern as the field is mainly influenced and steered by the four states (including the EU) (e.g., Article VII of the Outer Space Treaty and more detailed the Liability Convention[1] (Kong, 2018). Besides the four leading GNSS operators, other states lack sovereign control over applications on their territory or airspace. Furthermore, due to the potential consequences, for example, in terms of liability, these states are reluctant to take full advantage of GNSS (van der Dunk, 2017; Kong, 2019).

However, next to the "hard laws," GNSS are increasingly regulated by informal "soft" legal guidelines. One example of a soft law mechanism is the International Committee on Global Navigation Satellite Systems (ICG), established in 2005 through the United Nations Office for Outer Space Affairs. The ICG aims to promote the use and application of GNSS on a global basis and encourage coordination among providers of GNSS core systems to ensure greater compatibility and interoperability (Hobe, 2010). Each year, the ICG reports to the Scientific and Technical Subcommittee of the COPUOS Technical Subcommittee on the progress of the ICG towards Interoperability and Compatibility (Larsen, 2015). The ICG membership is limited to the major GNSS system providers and the providers of Space-based regional or augmentation systems. The recommendations are not intended to create legal obligations nor to establish standards (Hobe, 2010). In 2007, the ICG established a voluntary but separate GNSS Provider Forum, which served as a discussion platform for providers to coordinate agreed guidelines for open GNSS services (Larsen, 2015). Thus, they established international practices that converged with the standards and created international soft law on GNSS.

Overall, the governance structure behind GNSS is very fragmented, encompassing the technical elements combined with the divergent domain of international actors, with legal implications that include relevant contractual relationships, intergovernmental institutions, multi-model certification schemes, and multi-jurisdictional liability disputes (Kong, 2016). Therefore, harmonization and coordination among individual state and non-state actors are needed to work toward the common good (Kong, 2016).

4.2. The Case of Earth Observation (EO)

4.2.1. General Development of the Earth Observation Field

For Earth Observation, a key development from 1960 to 1980 was the development of multispectral sensors, stimulated in part by the release of military satellites. NASA's pioneering research led to the development of the first Landsat satellite in 1972 (Tatem et al., 2008). The Landsat 1, also called the Earth Resources Technology Satellite (ERTS-1), was the first multispectral remote sensing instrument in Space (Acker et al., 2014). Landsat 2, 3, 4, 5, 7, and 8 followed, providing near-area coverage observations with increasing spectral and spatial accuracy. The latest Landsat series, Landsat-8, launched in 2013 and Landsat 9 is scheduled for 2021 (NASA, 2021). Up until today, the Landsat series record is seamless, with most land locations acquired at least once per year since 1972 (Roy et al., 2014).

Each year since the first launch of NASA's EO program, there has been a steady increase in the global Earth observation activities. Initially, the US was the only nation with EO capabilities.

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[1] ***Simple regime of strict liability:*** *When damage is caused on Earth by an object in space or formerly in space, under the Liability Convention, the state that launched the object is presumed liable - even if it had no hand in bringing about the damage (Appendix E)*

Over time, however, more and more sovereign nations as Russia, Europe or Japan but also emerging economies such as India and China followed. As with GNSS development, the seemingly hegemonic ownership of EO satellites changed over the past several decades, and a rapid geopolitical expansion of ownership occurred (Belward & Skoien, 2015).

In 1988, the European Commission announced its future focus on earth observation. Later, the Copernicus program was developed on this basis. Such a focus was primarily associated with advances in the development of Earth observation technologies, such as Meteosat, the French SPOT (Satellite pour l'Observation de la Terre), and later ERS (European Remote Sensing) (Haarler, 2020). In 2002, the first European environmental satellite ENVISAT, operated by ESA, was launched (ESA, 2021). Although ENVISAT was the largest civil Earth observation mission ever launched, over time, the nature of missions has shifted, and the large multi-purpose missions such as ERS and ENVISAT have been replaced by smaller, less expensive, and single-purpose missions (Venet, 2011). The Copernicus program officially started in 2014, led by the European Union, represented by the European Commission (EC), with the European Space Agency (ESA) as the main partner and coordinator of the Space component. The Copernicus program consists of several components, also called sentinels, developed to meet the EO needs of users (Jutz & Milagro-Pérez, 2020). Today, Copernicus is one of the biggest providers of Earth Observation data all around the world.

By 2013, 33 other nations had EO satellites in Space (Belward & Skoien, 2015). Particularly African countries have made great strides in expanding their EO capacities in recent years. Over 36 EO satellites have been launched so far by eleven African countries, such as South Africa, Nigeria, Rwanda, and Egypt (Woldai, 2020).

Already several decades ago, a trend towards commercialization in the EO field became apparent. The launch of SPOT 1 in 1986 already indicated the beginning of the commercialization of EO services, as the French government and CNES decided to use a commercial model for image distribution (Denis et al., 2017). The potential role of commercial satellites in supporting intelligence missions was demonstrated by SPOT 1 two months after its launch in 1986. The satellite was able to capture the first 10-meter images after the explosion of reactor No. 4 at the Chernobyl nuclear power plant. Neither civilian satellites nor US spy satellites were able to witness the reality of the disaster and provide images of similar quality, resulting in France's leading commercial market position (Denis et al., 2017). The launch of Ikonos-2, owned by a US private company, in 1999 put the US at the forefront of the race for higher resolution. Ikonos-2 was the first commercial Earth observation system capable of collecting images with a ground sampling distance of less than one meter (Schreier & Dech, 2005). Until today, US commercial players such as Digital Globe offer the best resolution, with less than 30 cm (Denis et al., 2017). In 2005, Google Earth was introduced, which opened the door for full private investments from non-Space players (Denis et al., 2017). These developments contribute to increasing competition among private companies for resources for their own benefit and drive the commercialization of space activities, thereby influencing also the national economic development (See, 2017). Thus, governments encourage the increasing role of the private sector in Earth Observation (McGuire et al., 2001). Today, we see new developments in hybrid services and solutions between public, private, civil, and defense actors rather than clearly distinguishable options.

The driving dynamics from the scientific community, private sector, and government that has fostered the current development of the EO field are numerous and complex. Lauer et al.

(1997) identified the need for better information about the Earth, national security, commercial opportunities, international cooperation as well as international law as the most compelling factors influencing the development of EO services. Additionally, Belward & Skoien (2015) proposed four additional factors: promoting innovation, securing independent data supply, falling mission costs and changing technology, and reinforcing national identity.

4.2.2. Fragmented Governance of the Earth Observation Field

National Space law generally aims to implement a state's responsibilities imposed by the UN Outer Space Treaties to authorize and supervise public and private sector space activities. The national Space law in the EO domain focuses primarily on the launch and in-orbit operations of Earth observation systems, not primarily on the data produced by the systems (Larsen, 2015; Harris & Baumann, 2021). However, with respect to EO activities, for example, the question of the jurisdiction of the actual state that applies to the satellite might seem even more delicate since EO satellites generate data that immediately become subject to rights and regulations (Mayence, 2008). This becomes even more complex as the EO field matures, and only a few states have enacted laws governing private EO activities (Harris & Baumann, 2021). Recent technology and market developments in Earth observation pose challenges for national regulation of EO systems and the data they generate.

Therefore, the governance of EO satellites is divided into two parts: First, regulations for satellite launch, frequency use, and orbit allocation, where effective interference control mechanisms should be established to fully utilize frequency and orbit resources. Second, regulations for remote observation and data applications for EO (Zhang et al. 2020). Current regulatory approaches usually attempt to create a complex balance between policies that promote commercial Space activities on the one hand and national security, defense, and foreign policy interests and concerns on the other hand (Harris & Baumann, 2021).

The earliest soft law instrument still exerting influence on the sector today is the *United Nations (UN) Resolution Relating to Remote Sensing of the Earth from Outer Space*, which was adopted in 1986. In the absence of other binding instruments governing the same subject matter, United Nations resolutions can have considerable political weight as well as incipient legal validity, even if they have non-binding status (van der Dunk, 2002). The Remote Sensing Principles established the basic principles of data acquisition, but the rights of remote sensing countries in remote sensing activities were not clearly defined (Zhang et al. 2020). It is, for example, not required to consult with the remotely sensed country in advance to obtain the consent. In addition, similar to the Navigation case, the current legal system in the form of the Outer Space Treaty and the Liability Convention does not provide clarity on liability issues (Zhang et al. 2020).

However, the International Charter on Space and major disasters, introduced in 2000 by the ESA and the French Space Agency (CNES), is an example of a very successful voluntary soft law instrument by national Space agencies that provide satellite EO data and information free of charge to disaster-affected nations (Clark, 2017). Up to now, through international cooperation using nonbinding principles and multilateral instruments, the charter has been activated over 700 times and has provided data to 129 countries in need (International Charter Space and Major Disaster, 2021). Under the charter, national Space agencies collaborate with each other and with private satellite companies to provide free EO data.

While most soft law mechanisms and instruments support open data policies, many of these instruments still allow for a variety of exceptions. Reasons cited for the exceptions and noncompliance with Open Data policies include, for example, international relations and foreign policy, national security, defense, and intellectual property rights (Harris & Baumann, 2015).

Currently, the number of countries and non-state actors possessing EO capabilities is steadily increasing, and the release or sale of data is becoming more commercialized and thus competitive. Many agencies and private companies have emerged in the field of data production, processing, and value-added services. However, the current regulatory framework cannot effectively promote or regulate remote sensing activities and does not explicitly address the rights and responsibilities of all parties involved, especially in terms of liability and open data policy (Zhang et al. 2020). In short, the governance structure of the field of EO is equally considered fragmented, including the divergent domain of international public and private actors, the legal implications that include relevant contractual relationships and the intergovernmental institutions.

5. Analysis Results

The empirical analysis is divided into three main sections. First, the Navigation case is examined. For this purpose, an overview of the major events over the last two decades is provided to justify the choice of the different time periods, followed by the analysis of the field logics. This is followed by the analysis of the EO case. Again, an overview of the major events in the last two decades is provided to justify the time periods, followed by the analysis of the field logics. The analysis of both cases includes a description of the empirical findings and the connected field logics based on the value-based proximities method (described in section 3.3. Data Analysis) between the actors in the respective periods per case. The representation takes place in so-called actor networks. It was examined how the dominant field logics guide the inclination of actors towards different issues, including cooperation options and how that influenced the development of the respective fields. Additionally, the potential for conflict was identified to reveal the different tensions in the respective fields. The final part of the results provides a comparative view of the two cases to identify any similarities and differences in terms of value orientation trends among actors, the evolution of field logics, and the potential implications to cooperation patterns in the two fields.

5.1. Data Analysis of the Navigation Case

5.1.1. Major Events in the Navigation Field over the last two Decades

Based on the main events identified through desk research and more detailed distribution of data drawn from Nexis Uni (*Figure 4*), three subsequent time periods were distinguished for the analysis of this study.

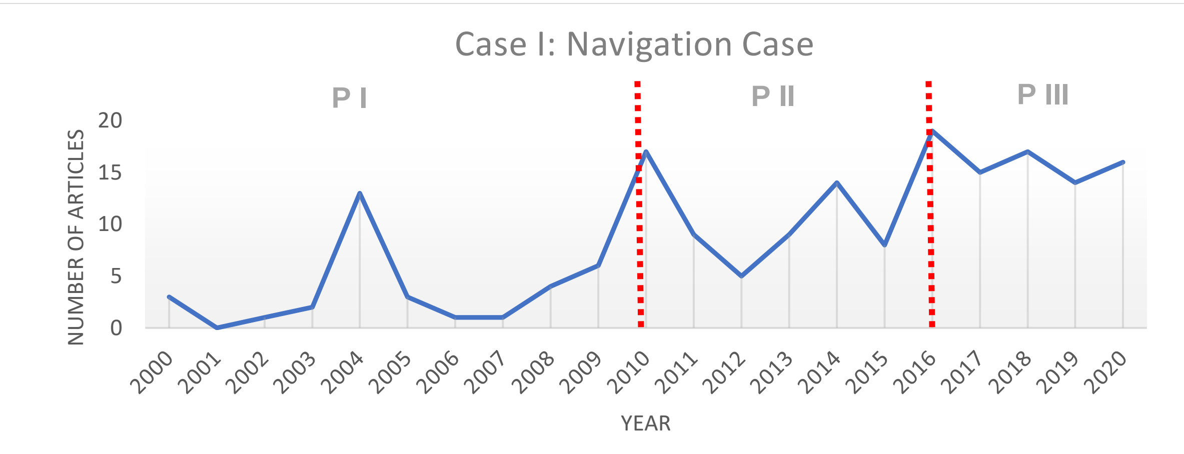

Figure 4: Main Phases in the development of the Navigation field

The first period ranges from 2000 to 2009 and is characterized by the fact that the supremacy of the USA is challenged by emerging competition. At the beginning of the period, the navigating services were dominated by the US GPS. As the only fully functional GNSS at the time, it was at the forefront of navigation, with a position of technological as well as political and military power in terms of access to positioning, navigation, and timing (PNT) data. A major development in 2000 was the discontinuation of the US DoD's Selective Availability policy. "Selective Availability" was activated by the US government in 1990 to intentionally degrade the quality of the GPS signal and reduce its accuracy for users other than the military (Baijal &

Arora, 2001). The decision of the discontinuation was part of a larger initiative to make GPS more accessible to civilian and commercial users and driven by the fear that the continuation of Selective Availability will diminish the perceived willingness of the US to provide the critical global infrastructure (Lewis, 2004). However, access to the government-controlled global navigation satellite systems was not guaranteed, especially in hostile situations, as happened in 1999 when the Indian military was dependent on the American Global Positioning System (GPS) during the Kargil War (Nain et al., 2019). Many authors see this as a starting point for different countries to pursue the setup of their navigation systems to reduce their dependence on the US (Choudhary et al. 2021, Lewis, 2004). Next to the US, Europe, Russia, and China entered the field of GNSS. In particular, the intended development of the European Galileo system initially put the US under pressure. Tensions and cooperation efforts between the United States and Europe regarding the future compatibility of the two systems were a major debate in this period (Alkan et al., 2005; Lewis, 2004).

The next period, ranging from 2010-2015, was characterized by intense competition between the main actors. In 2010, the official BeiDou website was published. According to the China National Space Administration (2010), the development of the system is carried out in three steps: the experimental phase, the regional coverage, and the global coverage (Chengqi, 2012). Although the first BeiDou satellites were launched in the early 2000s, the website's publication was the first time official information about the system's development was released to the public. At this time, the BeiDou demonstration system was transferred to the BeiDou navigation system, including RDSS positioning, timing, and short message-communication services (Chengqi, 2012). In 2010, GLONASS reached a milestone in the development of an independent navigation system as well, as it was possible to cover 100% of the Russian territory. In the same year, the crash of a rocket carrying three GLONASS satellites resulted in a significant setback, so that the GLONASS system achieved full global coverage only after a considerable delay (Bokov et al., 2014). In this period, Russia struggled to be competitive and play a significant role in the global GNSS arena, but with only moderate success.

The last period (2016 – 2020) is characterized by the completion of the development of BeiDou and Galileo, and thus next to the GPS and GLONASS, all 4 GNSS reach global coverage. During this time, market development and competition between the leading players have intensified and gained importance. Both Galileo and BeiDou are rapidly catching up with GPS in terms of technological advancement and availability, and GLONASS is about to close the gap with the modernization of its satellite infrastructure (Gu et al., 2019). In particular, the rapid development of the Chinese system created enormous pressure on the other players. As a critical component of the "One Belt and One Road" initiative (BRI), BeiDou plays a significant role in deepening the strategic partnership between China and the Arab League. Within the BRI, China is building the Space Silk Road complementary to the Maritime and Land Silk Roads. The objective of the BRI, in general, is to develop infrastructure and accelerate the economic integration of countries along the route of the historic Silk Road (Lele & Roy, 2019). In 2016, the China-Arab State Cooperation Forum was held on the future cooperation between the states as well as the further development of the BRI. This cooperation represented a unique opportunity for China as well as the Arab states. Almost 400 million people live in the 22 member states of the Arab League. These include the financially strong Gulf states, but also countries such as Egypt, Algeria, and Morocco, which have a low per capita GDP but a large population and market potential. This created very good external conditions for promoting the BeiDou system in the Arab world, but also worldwide (Sun & Zhang, 2016). Although the US and the European Union tried to use their own technological advantages and widen the gap between them and other powers in the field of satellite navigation, China's BeiDou was gaining momentum and, in particular, the internationalization in terms of multilateral and bilateral agreements and the fast development of the system was creating opportunities for the promotion of the BeiDou system (Sun & Zhang, 2016).

5.1.2. Navigation (Period I): Analysis of Field Logics

The first phase identified 33 actors actively engaged in shaping the navigation field by analyzing discourses amongst Space actors in the selected dataset. This period is characterized by the fact that the supremacy of the USA is challenged by emerging competition. This is also apparent in the actor-network (*Figure 5*).

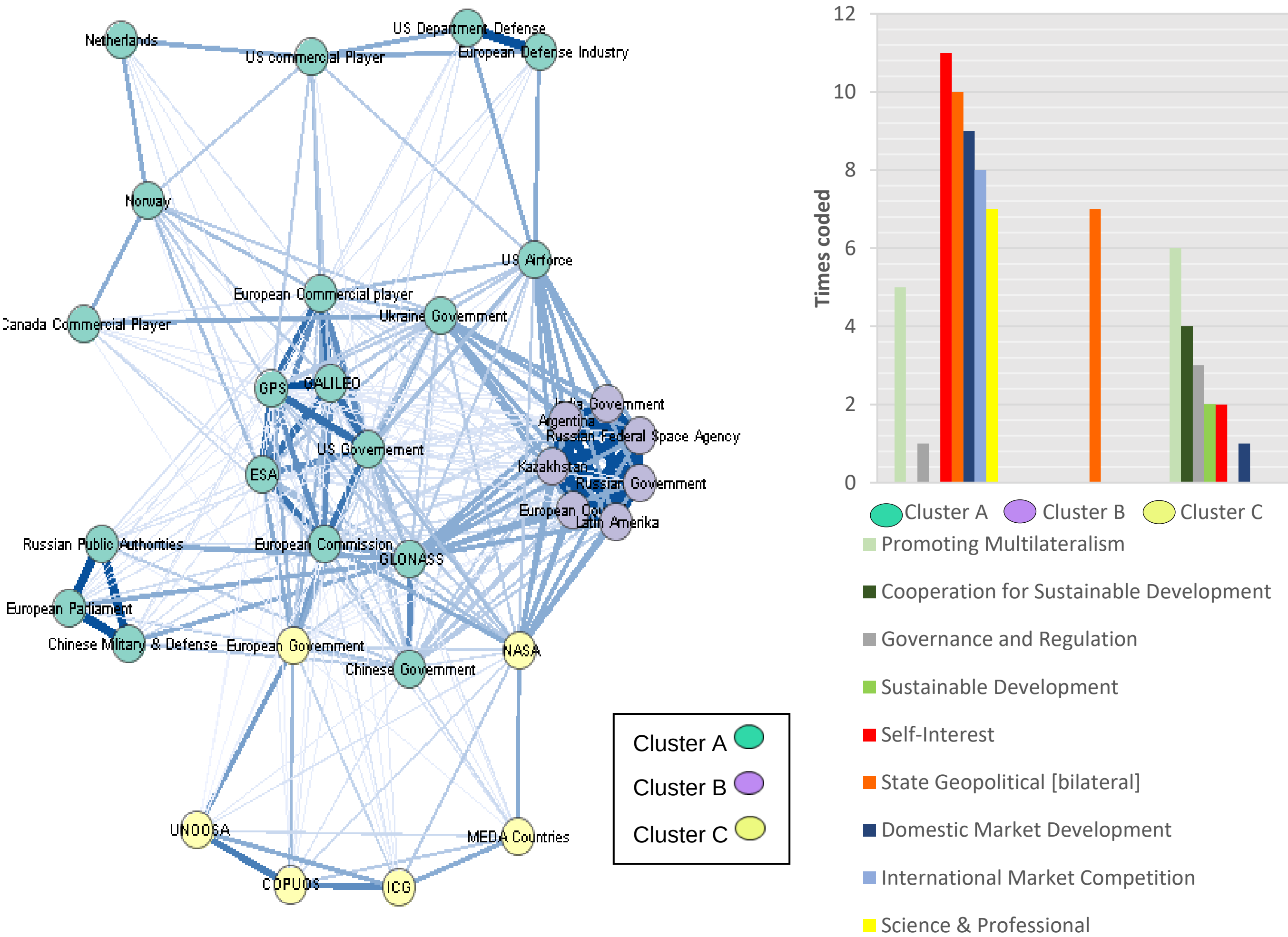

Figure 5: NC Actor-Network & Field Logics P I

The network is mostly dispersed, besides the very dense cluster on the right side. Not only are the main players geographically dispersed, but their desires in the emerging global navigation markets vary. The GPS and the US government are still among the major players, as reflected in their central location in the network. Still, players such as the European Commission and the European Galileo system were entering the field. As a result, a few players were at the center of the network, and most players are scattered around the network's periphery.

The use of GPS was increasingly criticized, and as many countries sought to reduce their dependence, the desire for independent navigation systems became stronger. While there were bilateral agreements on the use of GPS, such as with India, US officials criticized that the current Space cooperation between the countries is far from reaching its full potential.[2] Additional topics of discussion were the development of the European Galileo system and the expansion of the Russian GLONASS system.

Using the Ward cluster coefficient, three different groups with different value dispositions were identified. **Cluster *A*** contains **19 actors,** the second **Cluster B** consists of **7 actors**, and **Cluster C** of **6 actors.**

Cluster A

Cluster A is **the dominant cluster** and includes the most actors, with the key players located in the center. A field logic can be described as dominant if most actors or the most important actors follow this particular logic, which thus leads to a clear value disposition that drives the development of navigation services.

Actors in this Cluster subscribe to a set of different value orientations/ dispositions (see *Figure 5*), yet a clear tendency can be seen when looking at the dominant basic logics. The cluster seems to be dominated by actors who adhere to what is called a **State National Geopolitics** field logic. In this cluster, there is a strong focus on the **state logic,** on the one hand, driven by the desire for independence, power, and security and the search for strong bilateral partners. However, there were also smaller tendencies towards a **market logic**, which is primarily determined by economic interests but also by the own position in global competition. Actors on the left side of the cluster subscribe more to the self-Interest guided logic, with smaller economic-guided influences. Actors on the top and the right side sought market development and a stronger competitive position but are also influenced by a state-driven logic. In the middle of the cluster, the main actors, as the US and their GPS, as well as the European Commission, the ESA, and Galileo, can be found. Navigation systems are distinguished from their respective governments and agencies, as these cluster members often differ in their value disposition. For example, the ESA is usually more driven by scientific values than the European government, and Galileo is therefore usually influenced by scientific and market, and state-driven values.

The development of Galileo is among the most critical events driving the discourse and led to more concerns among US market leaders. The European Parliament underlined the importance of an own GNSS and agreed on "*the necessity of Galileo for autonomous European Security and Defense Policy operations, for the Common Foreign and Security Policy, for Europe's own security, and for the E.U.'s strategic autonomy."*[3] In general, the development of Galileo not only served the purpose of autonomy but also gave impetus to the European industry for the development of devices and applications: "*The Commission has estimated that Galileo will create more than 150,000 jobs in Europe alone. This is, therefore, a project of huge economic and commercial significance and one which will set technological standards globally over the next decade.*[4]" This shows a strong adherence of European

[2] State Department (2004). State's Morin Encourages Greater U.S.-India Space Cooperation; Highlights benefits for economic development (Dataset NC)
[3] Aerospace America (2009). Satellite navigation newcomers Cooperation or competition? (Dataset NC)
[4] State Department (2004). Powell Hails U.S.-EU Agreement on GPS-Galileo Cooperation; Powell at signing June 26 (Dataset NC)

government actors to the logic of national self-interest, but also market-oriented tendencies, and explains their affiliation with **State National Geopolitics field logic**.

Cluster B

Cluster B is the most densely connected cluster compared to the overall network. All actors have in common that they subscribe to **a bilateral geopolitical logic**; therefore, this study identifies actors with this value dispositions part of the **State-Bilateral** field logic. The actors included in this cluster are cooperation partners of the US and Europe, which expresses the need for the main players to seek worldwide cooperation partners to build powerful alliances or secure infrastructural needs. Also, Russia and the Russian Federal Space Agency formed this cluster. As the development and expansion of GLONASS had to contend with various organizational and technical problems, Russia attempted to increase its competitiveness through various measures, with limited success on a global scale. The Russian government and the Russian Space Agency ROSCOSMOS sought especially for bilateral agreements to increase their technological competencies and because they were dependent on other locations for ground infrastructure development. The below statement shows that bilateral agreements were crucial for Kazakhstan as well as Russia and underlines the affiliation to the **State-Bilateral** field logic.

"The possibility of using existing Kazakh space systems, including KazSat, has been analyzed theoretically and will soon be worked through in practical terms. The satellite 'is suspended' in a geostationary orbit over the territory of the republic, which, putting it in simple terms, makes it usable as a re-transmitter of signals from the ground-based monitoring system," Kazakh National Space Agency chief Talgat Musabayev said. In effect, KazSat may become GLONASS' 25th satellite, he added." [5]

Cluster C

A countervailing trend characterizes this cluster as this logic profile of this cluster is clearly distinguished from the other two and driven by values of cooperation and sustainability. Therefore, **Cluster C** consists mainly of international organizations and is dominated by what this study calls a **Global-Mission** field logic. Rather than being driven by an interest in advancing themselves, more and more international organizations were entering the field, guided by a desire to strengthen multilateral cooperation, often with a mission to promote sustainable development and the peaceful use of Space. At the same time, these organizations often have the purpose of regulating the field and motivating the actors to cooperate peacefully. COPUOS, ICG, and UNOOSA are the leading international organizations influencing the field. These organizations were created primarily to shape the GNSS field so that all of humanity can benefit. For this purpose, various soft and hard law instruments were designed, and the various mainly state actors were encouraged to support them. The membership of different states is therefore indispensable for compliance with these rules. The affiliation to the **Global Mission** field logic by the International Committee on Global Navigation Satellite Systems (ICG) and the Outer Space Committee can be found in the statement below:

[5] Central Asia & Caucasus Business Weekly (2008). Kazakhstan: The final frontier - Astana outlines space industry (Dataset NC)

"It (the International Committee on Global Navigation Satellite Systems) was also making progress in encouraging compatibility among global and regional navigational satellite systems and their integration into countries' infrastructure, particularly developing ones. Also encouraging had been the progress made in considering the spin-off benefits of space exploration and the role of the Outer Space Committee in promoting international cooperation in ensuring that outer space was maintained for peaceful purposes."[6]

5.1.3. Navigation (Period II): Analysis of Field Logics

The second phase identified 35 actors actively engaged in shaping the navigation field by analyzing public discourses. During this time, it became increasingly clear that the US was losing prominence in the global discourse while China and its BeiDou system were gaining momentum. This is also apparent in the actor-network (*Figure 6*). Because of these new developments, the field logics identified in the first period changed, disappeared, or new ones appeared.

The first **Cluster A** (green) contains out of **11 actors**, the second **Cluster B** (red) consists out of **12 actors**, and **Cluster C** (violet) out of **7 actors**. The last **Cluster, D** (yellow), contains **5 actors.**

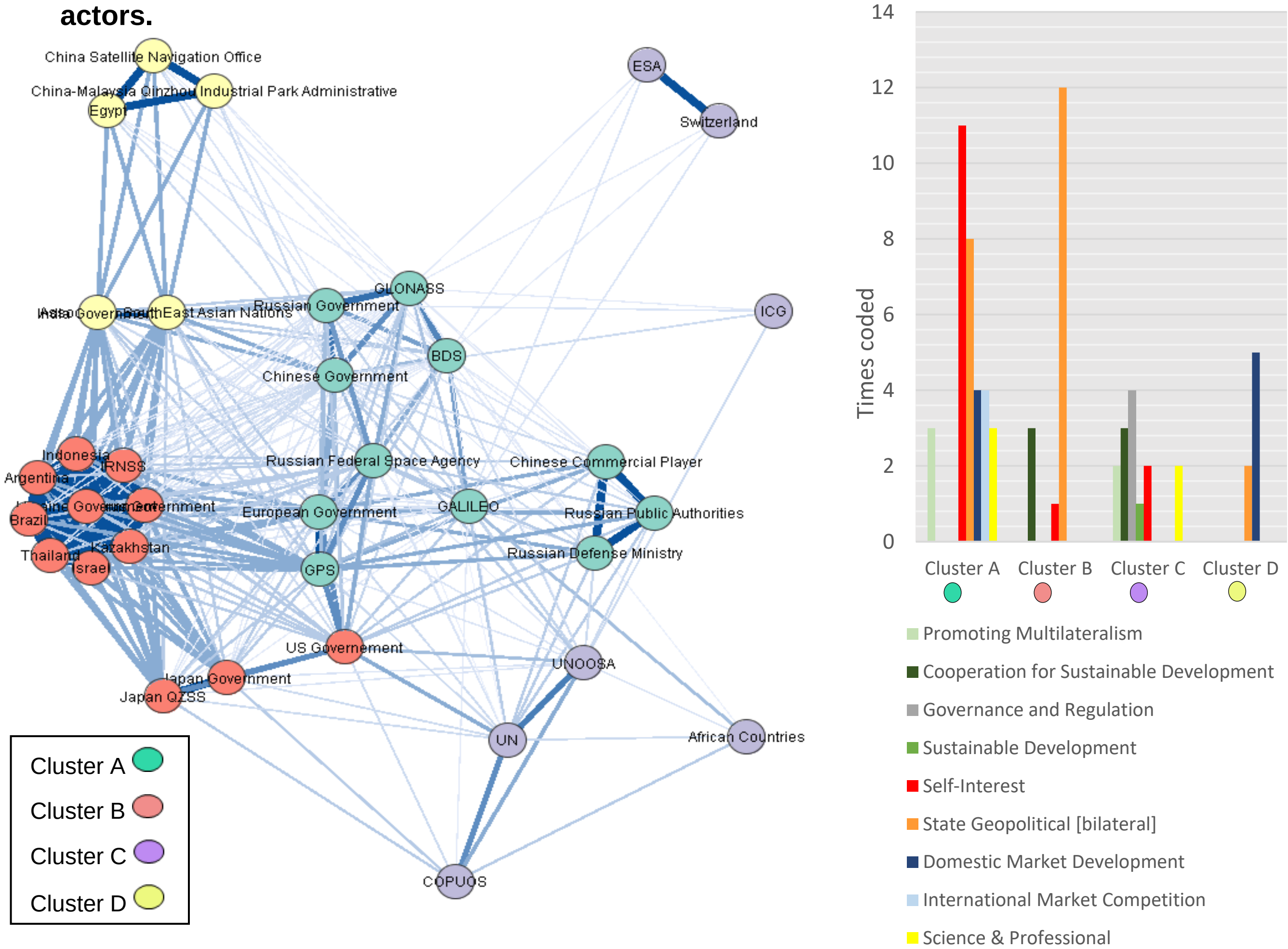

Figure 6: NC Actor-Network & Field Logics P II

[6] US Fed News (2008): Space Technologies indispensable to challenges of climate change, food security, health, Fourth Committee hears during Debate on Peaceful Uses of Outer Space (Dataset NC)

Cluster A

Cluster A is dominated not only by **geopolitical, bilateral** tendencies but also by values shaped by the **state,** such as power, security, and independence. **Market development and competition** only play a minor role in this logic profile. Based on this inherent logic profile, it can be inferred that Cluster A is a continuation of cluster A from period I. Overall, this cluster is therefore dominated by what is called a **State National Geopolitics** field logic. However, compared to period I, this cluster loses its dominant position and now competes with cluster B for dominance.

In this period, the cluster also includes GLONASS and the Russian Space Agency and government. Therefore, all four GNSS are located in this central cluster. The centrality shows both the importance of the actors in the discourse and the connection with other actors. The actors that dominated the discourse, and thus the cluster, were primarily the Chinese and Russian navigation systems and the respective governments.

With the publication of the official website about the BeiDou System (BDS), official information about the development of the new system became free and accessible. Through the successful deployment of the system, China has an independent Navigation System, which is essential for military applications, navigation of ships and aircraft, but also for the development of related industries. The Xinhua News Agency reported: *"The time when China needed foreign satellite navigation systems in the past. Began the era of the "Beidou".*[7] To further support and expand its position in the GNSS market, China actively sought cooperation partners. In 2014, China and Russia also began negotiations on future cooperation. By ensuring compatibility between the systems, both nations could strengthen their competitive positions. The Russian Deputy Prime Minister Dmitry Rogozin stated: *"Our system is more suitable for northern, polar latitudes. The Chinese system is more southerly. Their complementarity would result in the biggest and most powerful competitor to any navigation system."*[8] Strong adherence of the Chinese and Russian actors to the logic of national self-interest and bilateral geopolitical interest can be seen in the statement above and support their affiliation with **State National Geopolitics** field logic.

Cluster B

Cluster B comprises all actors that can be characterized by a **bilateral** value disposition but are also driven in part by values associated with multilateralism. Compared to period I, it can be clearly seen that cluster B has a similar logic profile as cluster B in period I. Although the value disposition changes minimally, one can clearly speak of a continuation of cluster B from period I. Therefore, actors in this cluster adhere to the **State-Bilateral** field logic. It is the most densely connected cluster compared to the overall network since other values than bilateral interests only insignificantly influence actors in this cluster. This cluster evolves into a co-dominant field logic during this period, competing for dominance with Cluster A. This is mainly due to the fact that periode two is clearly characterized by the development trends of the

[7] Military Review (2013). China used European Technology (Dataset NC)
[8] China Daily (2014): Satellite navigation pact agreed with Russia (Dataset NC)

different GNSS. Actors try to drive and secure future development by entering into bilateral contracts.

This cluster is mainly formed by the cooperation partners of Russia and China. Russia saw a unique opportunity to shorten the technological gap between itself and the West through bilateral agreements with Israel, Argentina, Brazil, Ukraine, and Belarus. Also, China sought for different partnerships to strengthen its regional position. One goal was to support members from the Association of Southeast Asian Nations (ASEAN) and enable them to develop applications for BeiDou. The below statement from Li Yao, the chairman of the China-ASEAN Investment Cooperation Fund, shows that bilateral agreements were crucial for China and the ASEAN member states and support the affiliation to the **State-Bilateral** field logic.

"*Promoting the BeiDou system in ASEAN is also in accordance with China's efforts to strengthen bilateral cooperation in areas of transportation and telecommunications."*[9]

The actors in the lower part of the cluster are influenced not only by bilateral interests but also by multilateral tendencies. An example is the US government, which sought to strengthen its position and maintain technological superiority through bilateral agreement agreements with Japan and Europe but also supports the establishment of international organizations to promote GNSS regulation, multilateral cooperation for sustainable development.

Cluster C

Similar to period I, **Cluster C** is a highly diversified, decentralized, semi-coherent cluster at the network's periphery. It is characterized primarily by the need for more control mechanisms and regulation and a tendency to increase and promote international cooperation for scientific and sustainable development. However, in comparison to period I, the logic profile is still dominated by the same basic logics, even though the distribution changed partly. Actors in this continued Cluster C are therefore subscribing to the **Global-Mission** field logic. Included are international organizations but also nations that followed the goal of mission-driven cooperation and served as a tool to help govern the field. The EU, for example, supported different initiatives for technological cooperation with different African countries to support global sustainable growth. The United Nations Office for Outer Space Affairs, for example, stated that support for developing countries must be increased through, among other things, training and development of regional capabilities. The following statement of a Lybian official shows the affiliation of the United Nations Office for Outer Space Affairs to the Global-Mission field logic and underlines the role of governance and regulations mechanisms:

The United Nations Office for Outer Space Affairs had an important role to play in allowing States to benefit from space activities, regardless of their level of development. His country also stressed the vital importance of Committee on the Peaceful Uses of Outer Space in laying down international criteria that would legally regulate activities in outer space. The ongoing development of space law and of a code of conduct for space activities would help to ensure that space activities were in line with General Assembly resolutions.[10]

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[9] Global Times China (2013). China aims to grow ASEAN market for BeiDou system (Dataset NC)
[10] State News Service (2013). Speaker in fourth committee calls for democratic management of Outer Space, as efforts intensify to galvanize advances in Space Science and Technology. (Dataset NC)

Cluster D

Cluster D is characterized above all by the fact that it is clearly driven by economic thinking, leading to a clear **Market**-field logic, partly influenced by bilateral tendencies. In comparison to period I, it can be seen that market-driven values decreased in the logic profile of Cluster A of period II, while they increase in Cluster D. Therefore, it can be deduced that **Cluster D** is a spin-off of Cluster A from period I. **Cluster D** is becoming **a market-oriente**d cluster.

The Chinese Satellite Navigation Office, for example, was trying to tap and expand the market in surrounding ASEAN countries to push the use of BeiDou and develop related downstream industries. Also, the collaboration between the Indian and Egyptian governments and Russia's GLONASS aimed to actively develop navigation applications to expand the use of Glonass in the global market. The Russian navigation system General stated about both projects: *"We are in talks, including with Egypt, on the production of GLONASS-based gear. Several pilot projects will be launched in Egypt and one of them is to equip tourist coaches and passenger vehicles with GLONASS receivers,"*[11] . About the agreement with India, he stated that the goal was to "*set up this joint venture adding that the Russian space navigation system GLONASS's entry on the global market is key to its survival. Because the Russian market is small, we need an expansion to foreign markets,"* [12]

Both statements show the desire for market development and thus underline the affiliation to the **Market-**field logic.

5.1.4. Navigation (Period III): Analysis of Field Logics

The final period is characterized by the completion of Galileo and BeiDou, providing global coverage through four fully operational systems. In this period, the market development and competition between the main players became more intense and gained importance. However, the field was still strongly politically influenced and dominated by the intrinsic motivation of power and security and bilateral cooperation tendencies. As can be seen in the empirical evidence, 45 actors were active in shaping the field. Based on the Jaccard-normalized relationships and by using the Ward cluster coefficient, four different clusters with different value dispositions were identified, which can be found in *Figure 7*.

The first **Cluster A** (yellow) contains **18 actors** and is the most central cluster compared to the overall network. The second **Cluster B** (red) consists of **7 actors**, and **Cluster C** (violet) is of **10 actors**. **Cluster D** (green) consists of **10 actors**.

[11] Russia & CIS Defense Industry Weekly (2010). Interfax Russia & CIS defense Industry Weekly
[12] Russia & CIS Military Daily (2010). Interfax Russia & CIS Military Daily

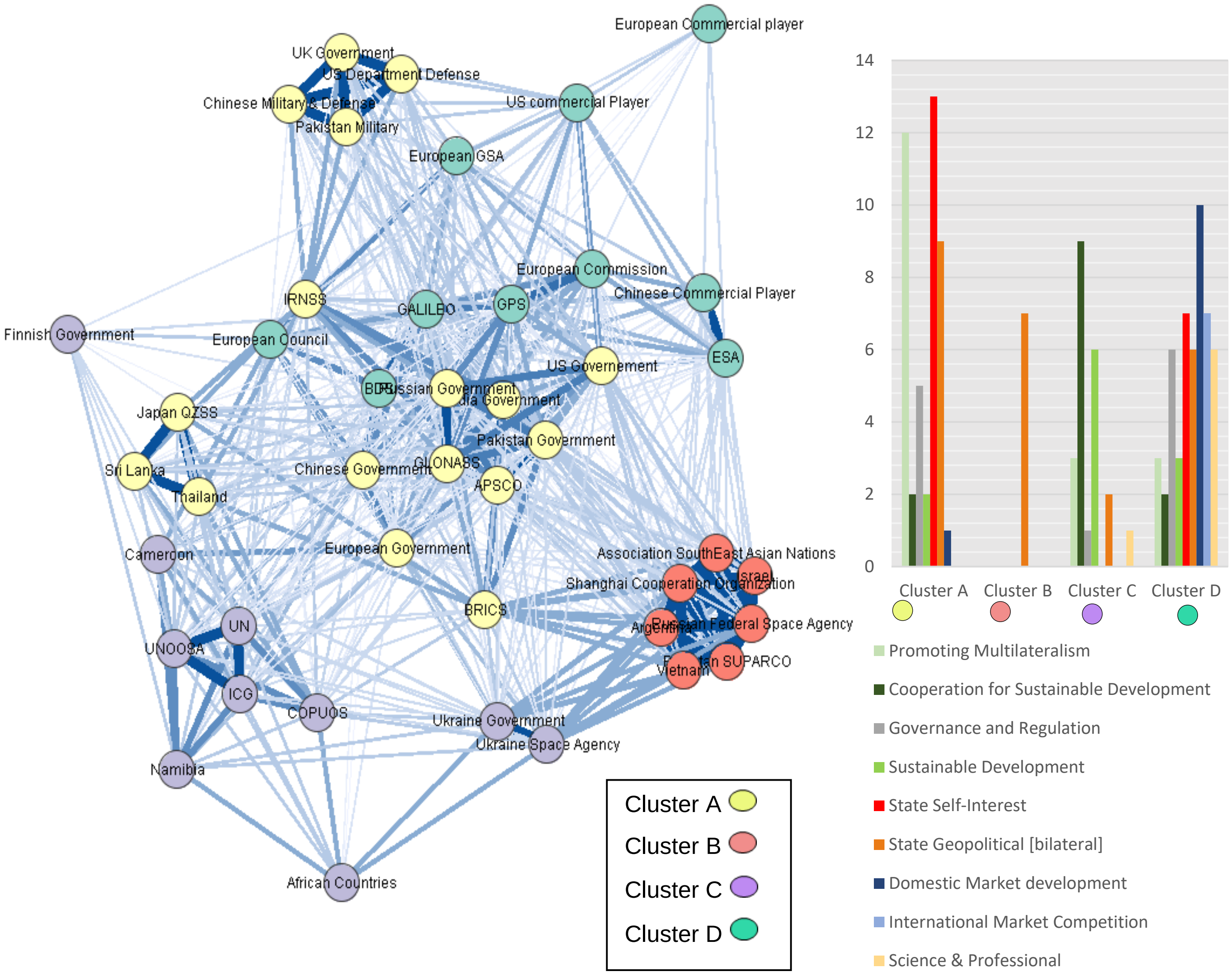

Figure 7: NC Actor-Network & Field Logics P III

Cluster A

Cluster A is with 18 actors, the largest cluster and predominately influenced by state-driven value propositions. Most of the actors in this cluster are state actors, such as governments, but the military and the defense ministries of various states are also represented. This cluster is still a continuation of cluster A from periods 1 and 2, as can be seen in the logic profile. The trend from period II of market interests playing a subordinate role continues, while national and geopolitically driven interests are on the rise. Those actors, therefore, mainly adhere to the **State National Geopolitics** field logic. In period III, Cluster A competes with Cluster D for dominance, although it still has the most players. The upper part of the clusters tends to be dominated by values such as power and security, while either bilateral or multilateral values dominate actors in the lower part of the cluster. Next to bilateral and self-guided interests, also multilateralism gains importance. Both the Chinese and European governments emphasize the need for international cooperation in the future use of GNSS. However, these interests can often be served by supporting their supremacy. As Wang Wenbin, a chiniese politcan stated:

“Today is a day of pride and invigoration for the Chinese people. This morning, President Xi Jinping attended the ceremony marking the completion and launching of the BeiDou-3 Satellite

Navigation System (BDS-3) and announced the commissioning of this system that's independently built and operated by China. This opens a new chapter where the system's quality service will benefit people all across the world."[13]

As this statement indicates, the state's own interests are clearly evident. However, the Chinese politician also emphasizes the international benefits. This is strongly related to the position in the global competition and is thus also influenced by national self-interests. Therefore, this statement underlines the affiliation to the **State National Geopolitics** field logic. An important initiative that promotes bilateral and multilateral cooperation in the Asian region is the Asia-Pacific Space Cooperation Organization APSCO. However, APSCO is strongly committed to the promotion of the BeiDou system and tends to seek bilateral agreements in order to support China's supremacy. The following statement shows the clear affiliation of APSCO to the State-National Geopolitics field logic:

"APSCO members hold conferences, engage in joint training efforts, and cooperate on multilateral research and development projects. These efforts allow China to position itself as a purveyor of space technology and expertise to less-developed states. China's leaders also use Beijing's central role in APSCO to promote the export of its space technology and services in order to gain support for its space goals from the Asia Pacific region"[14]

The American government and the US Department of Defense are also driven by this field logic, as the following statement of a US official shows:

"On a personal level, I note the value of U.S. leadership in space far exceeds that of achieving technical superiority or a high "medal count" in space exploration for its own sake. Having grown up in the 1960s and early 1970s, I can attest to the powerful impact the Apollo program had on me and on many other Americans, and the sense of patriotism and national purpose it inspired. In addition to the security and commercial reasons for U.S. leadership in this domain-the "ultimate high ground" according to experts in China-a visionary U.S. space exploration program can again strengthen our national purpose, inspire new generations of leading scientists and engineers, and continue to benefit mankind. As I consider this issue from my vantage point at the U.S.-China Commission, examining China's expanding activities in space, the need for continued U.S. leadership becomes even more imperative."[15]

Cluster B

Cluster B, as continuation of Cluster B in period I and II , includes all actors that are driven by a bilateral geopolitical logic. Therefore actors in this cluster subscribe to the **State-Bilateral** field logic. An increasing number of cooperation partners, however, enter into bilateral agreements with China and the associated BeiDou system.

BeiDou is a crucial part of several political strategies of China, such as the Belt and Road Initiative. This strategic plan also includes cooperation with Russia. The agreement between the states stated that the countries would continue to exchange information regularly to explore new areas of cooperation and projects to promote the exchange of results and cooperation for

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[13] Thai News Service (2020). China: Foreign Ministry Spokesperson Wang Wenbin's Regular Press Conference on July 31, 2020 (Dataset NC)
14 CQ Congressional Testimony (2016). U.S.-China Space Race; Committee: House Science, Space, Technology; Subcommitte:Space (Dataset NC)
[15] CQ Congressional Testimony (2016). U.S.-China Space Race; Committee: House Science, Space and Technology; Subcommittee Space

mutual benefit between the systems. In some cases, not only individual states but the political alliance of certain countries that pursue the same strategic goals entered bilateral cooperation. These include, for example, ASEAN. Also included, based on bilateral cooperation with China, are federal Space agencies such as SUPARCO (Pakistan Space & Upper Atmosphere Research Commission) or Roscosmos.

Next to Russia, important collaboration partners for China are the Arab states like Pakistan, the United Arabic Emirates, and Saudi Arabia. *"Any type of bilateral cooperation [with China] can be considered part of the Belt and Road."* [16]So far, most countries covered by BeiDou are participating in the BRI. Still, various related services such as port traffic monitoring and disaster and rescue services have been provided to nearly 120 countries worldwide. A 2019 report by the US-China Economic and Security Review Commission said that any services under the Space Silk Road could deepen China's dependence on Space-based services at the expense of US influence. The statement below shows a strong adherence of Chinese National Space Administration and Pakistan's Space and Upper Atmosphere Research Commission (SUPARCO) to bilateral driven values and explains their affiliation with **State-Bilateral** field logic:

"For decades, Pakistan's space programme has lagged behind regional countries. In 2012, Pakistan's Space and Upper Atmosphere Research Commission (SUPARCO) and China National Space Administration (CNSA) agreed to a 2012-2020 programme for joint cooperation. Under this programme in 2013, Pakistan adopted BeiDou, China's indigenous satellite navigation system, for military applications."[17]

Cluster C

Values of mission-driven cooperation and sustainability drive the logic profile of Cluster C; therefore, most actors in this cluster adhere to the **Global Mission** field Logic, similar to period I and II. COPUOS, ICG, and UNOOSA are the prominent international organizations influencing the field, next to different African countries. In this period, sustainable development and collaboration are gaining even more importance. This is partly due to the SDGs published in 2015 but also due to raising more awareness for the use of PNT-technologies in the field of climate change and sustainable development. International organizations, in particular, drew attention to how critical these technologies can be in the global environment. The opportunities for developing countries are manifold and can offer prospects for a better, more secure future. One example is the Office of Outer Space Affairs' efforts to promote the use of GNSS through capacity building and information dissemination, particularly in developing countries.[18] Also, the role of ICG in coordinating the planning of various projects is indispensable. In a 2019 press release, UNOOSA announced a workshop to explore the use of GNSS for a variety of applications that can demonstrate sustainable, social, and economic advantages, particularly for the benefit of developing countries. The goal of the workshop is to: "*introduce GNSS and its applications to transport and communications, aviation, surveying, mapping and Earth science, management of natural resources, the environment and disasters, precision agriculture, high precision mobile application, as well as space weather effects on GNSS and dual-frequency resources; promote greater exchange of actual experiences with specific*

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[16] Silkroute News (2020). China's Belt and Road push brings risks, rewards to Mideast (Dataset NC)
[17] Strategic Studies (2020). Pakistan-China Relations: Beyond CPEC (Dataset NC)
[18] Impact Service News (2019). UNO Official Document System (ODS): DRAFT REPORT: ADDENDUM (Dataset NC)

applications; encourage greater cooperation in developing partnerships and GNSS networks, in the framework of the regional reference frames; define recommendations and findings to be forwarded as a contribution to ICG and a 'Space2030'agenda, particularly, in forging partnerships to strengthen and deliver capacity-building in the use and applications of space science and technology."

This demonstrates the clear **Global Mission**-driven field logic that UNOOSA and the ICG follow.

Cluster D

Lastly, **Cluster D** represents a broad collection of almost all basic logic; however, market-driven mechanisms predominate, next to state-driven influences. Therefore most actors in this cluster subscribe to the **Market** field logic. Comparing the development of the clusters over time, it can be seen that the market interests in the other clusters decrease while they increase in this cluster. Based on this trend and the logic profile from period II, it can be seen that this is a continuation of cluster D from period II. Since this cluster comprises the main GNSS such as GPS, Galileo, and BeiDou, but also includes European and US commercial and political actors, as well as Chinese commercial actors, it can be called a co-dominant cluster to Cluster A. The centrality of BeiDou indicates its dominance in media discourses and China's aspirations toward domestic market development and competitive leadership. In addition, China plans to accelerate its application in downstream industries. Ran Chengqui indicated that *"in terms of the application promotion, China will develop a new generation Beidou/GNSS products and promote their application in the public market with 100 million yuan. The downstream application is a bottleneck in the BDS industry."[19].* This shows a clear affiliation to the **Market** field logic.

Also, the European Union is investing more and more financial resources to promote the domestic industry application and market development related to Galileo to ensure macro-economic benefits for the EU. In the working Document of the Interim Evaluation of Galileo and EGNOS programs, the Commission showed their clear affiliation to the **Market** field logic and stated in 2017:

"The added value of the European GNSS lies not only in ensuring Europe's independence with regard to a critical technology but also in securing important macro-economic benefits for the European Union, catalyzing the development of new services and products based on GNSS and generating technological spin-offs beneficial for research, development and innovation.[20]"

5.1.5. Evolution of Field Logics and Implications to the Navigation Case

The following section provides a description of the evolution of field logics and implications to the Navigation field. The evolution of the different logics from 2000 to 2020 can be found in *Figure 8.* The star around a particular field logic indicates that one field logic dominates over

[19]Xinhua Financial News (2017). BDS speeds up in global application (Dataset NC)

[20]Impact News Service (2017). Register of Commission documents: COMMISSION STAFF WORKING DOCUMENT INTERIM EVALUATION of Galileo and EGNOS programmes and evaluation of the European GNSS Agency Accompanying the document Report from the Commission to the European Parliament and the Council (Dataset NC)

the other. If the line is dashed, two or more field logics are co-dominant. This means that they strongly influence players in the field and compete with each other for predominance.

The first period of the Navigation case is characterized by three field logics to which 33 actors are assigned. Over the three periods studied, the number of actors involved in the discourse analyzed by this study increased only slightly to 45 active players.

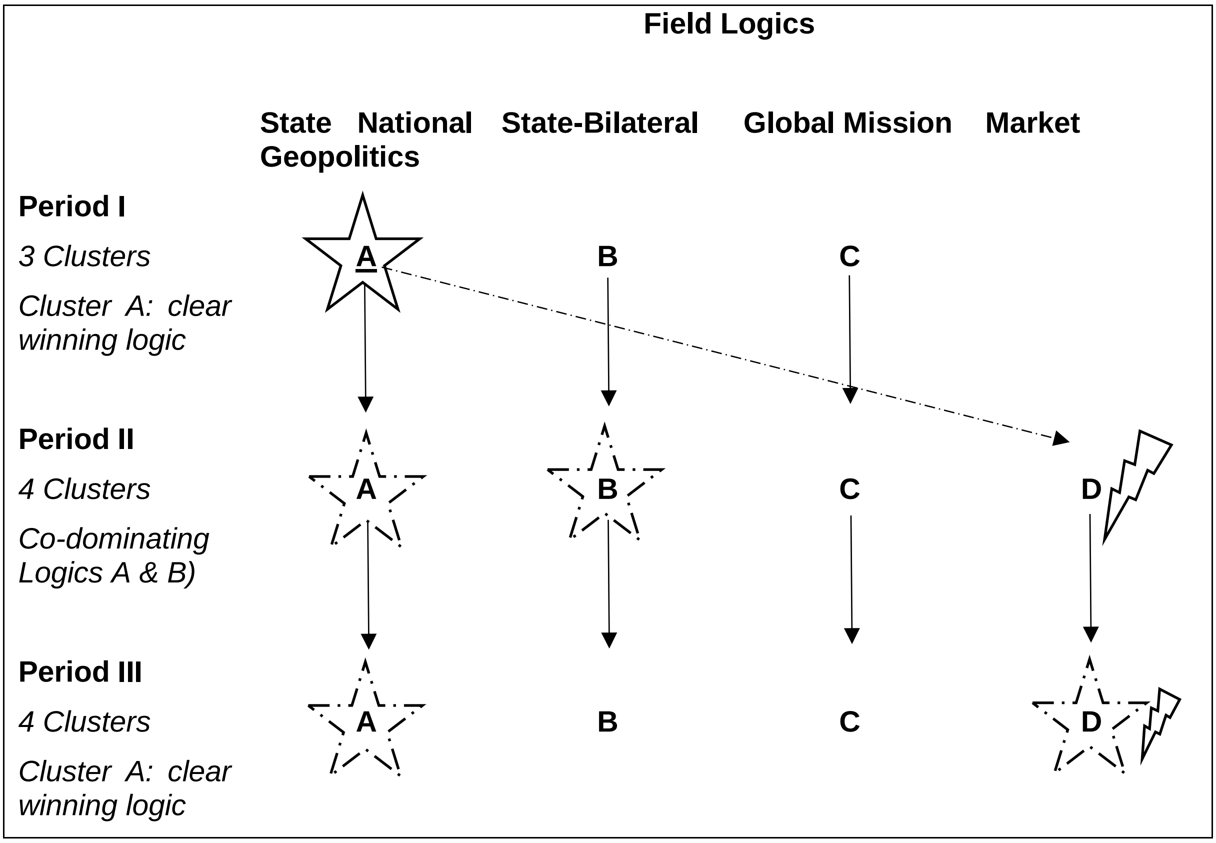

Figure 8: Evolution of Field Logics in the Navigations Case

Cluster A is defined by its centrality as well as by the affiliation of the main players. Due to its size and central location in the network (see *Figure 5*, 6, 7), the value disposition can be described as dominant over the other field logics. The first period was characterized by a dominant GNSS challenged by the development of new GNSS systems. The USA became increasingly concerned about losing its dominance in the GNSS field. Europe's entry into the field confirmed and even reinforced this. European and American Actors, including their governments and defense authorities, adhered to the predominant **State National Geopolitics** field logic to strengthen their own national position. This value-disposition influenced the conflict potential but also the willingness to corporate for mutual benefits, which can be seen in particular in the relationship between those two actors. The development of the European Galileo system was a significant event in the first period, challenging US dominance. The European government clearly stated that they would be interested in exchanging information with the US to make both systems compatible and counteract possible geopolitical tensions. In 2000, representatives of the European Commission (EC) met with the US delegation in Washington, DC, to negotiate further cooperation. However, at the beginning of the discussions, the US disapproved of the development of Galileo and stated that the GPS is enough to cover the world, and Galileo would be redundant:

"The United States Government sees no compelling need for Galileo because GPS is expected to meet the needs of users around the world for the foreseeable future. Nevertheless, should

Europe decide to go forward with Galileo, the United States would be interested in cooperation to ensure that Galileo is interoperable with GPS and benefits users on both sides of the Atlantic.[21]*"*

The statement shows how the US government, driven by national self-interest, affected the relationship between the actors. On the one hand, the US was opposed to cooperation and, on the other, was not prepared to abandon a possible future partnership completely. In general, the entire development of this cluster is mainly influenced by such national self-interests, affected by the desire for more independence but also political and technological dominance in Space. This value disposition was further supported and continued in the second period by, among other things, the official entry of the Chinese GNSS BeiDou. Russia also managed to catch up with the technological deficit, which meant that competition became increasingly fierce. In periods II and III, however, the increasing importance of China dominated the discourse in the analyzed newspaper and articles. Several documents stated that China was on its way to becoming an information power as the authoritarian regime influenced various information and communication technologies. By developing its own Space capabilities, China significantly increased its power, and the speed with which China has built its satellite system has put pressure on other nations. The statement by Jeffrey L. Fieder, commissioner of the US-China Economic and Security Review Commission, highlighted the competition between the two countries and the rising potential for conflict. This strongly demonstrates the affiliation to the **State National Geopolitics** field logic by which the United States and China are primarily dominated:

"Although China is mostly playing catch-up to the United States in space capabilities, China poses a number of challenges to U.S. activities in space. First and foremost is China's development of new counterspace technologies that could disable or destroy U.S. satellites and their support architecture. In a decade, China may lead the only international space station fully deployed, its own dual-use satellite navigation system and serve as the primary space launch partner for many international customers."[22]

To support their respective positions in global competition, China, Russia, Europe, and the US sought bilateral partners to leverage their territories for ground station installation, support international use and acceptance, and increase their technological capability. This can be seen in the increasing importance of **Cluster B** and the affiliated **State-Bilateral** field logic in periods I and II. This value disposition played a role, especially during the development of GNSS. period I was mainly determined by bilateral cooperation tendencies of the European Union with other nations, such as Ukraine and South and Latin America. In contrast, periods II and III mainly reflect the bilateral efforts of China and Russia. In particular, the bilateral agreement between Russia and China in period II and the associated technological as well as political and economic advantages for the parties led to an increased potential for conflict on the part of the United States, as it feared the loss of its technological and power leadership. When the development of the systems was completed in period III, the co-dominant position of the field logic (**A & B**) also ended.

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[21] State Department (2002). Text: Media Note Explains U.S. Position on GPS-Galileo; Talks on cooperation, interoperability are ongoing. (Dataset NC)
[22] CQ Transcriptions (2015). Jeffrey L. Fiedler and Senator James M Talent hold a Hearing on China's Space and Counterspace Program (Dataset NC)

However, in period II, a new cluster (**Cluster D**) was emerging, showing a change in the overall field logics as well as new pools of interest. Actors in cluster D adhered to the **Market** field logic. During the first period, market interests were evident in Cluster A, however, only to a smaller degree. Primarily, this was because only the US had a fully operational GNSS, while the others were still in the early stages of development or, like Russia, faced technological challenges. Market developments were, therefore, of secondary concern. However, this changed in the second period, and a small cluster, mainly dominated by economic values, developed. Furthermore, it can be seen that market-driven values decreased in the logic profile of Cluster A of period II and almost completely disappeared in period III. From this, it can be inferred that Cluster D is a spin-off of Cluster A, based on the separation of market and state geopolitical interests. The two separated clusters were strong enough to lead to a new clustering of interests that could exist independently of each other.

In period II, the BeiDou system was in the regional development stage to expand its use from China to the Asia-Pacific region. Therefore, China was trying to develop internationally and establish cooperation, especially in the Asian region, to promote market development. The cooperation between the Chinese Satellite Navigation Office (CSNO) and the China-Malaysia Industrial Park Qinzhou shows how the economic interests of the players can drive collaborative trends:

"Besides, the International Cooperation Center of CSNO and China-Malaysia Qinzhou Industrial Park Administrative Committee and Guilin University of Electronic Science and Technology signed a Letter of Intent on Joint Establishment of BeiDou/GNSS Exhibition Center in an effort to promote multi-satellite navigation system compatibility, popularity of satellite navigation technology and satellite navigation application and industrial development in Malaysia and other ASEAN countries."[23]

Cluster D and the associated market field logic became even more important in period III. Both the number of actors and the number of coded statements connected to this field logic increased considerably in only a short period of time. The main reason for this was the completion of the BeiDou system and Galileo. This led to a change in perspective towards more economic intentions. Major players such as the European Galileo system, ESA, or BeiDou no longer subscribed to the **State-National Geopolitical** field logic but to the **Market** field logic.

China, in particular, continued to expand its position in global competition by entering bilateral agreements and by developing the upstream and downstream application sectors, especially in countries belonging to the BRI. On the other hand, Europe focused mainly on domestic market development, while bilateral agreements outside Europe only played a subordinate role.

However, internal political tensions influenced the speed of market adaptation in Europe, showing that national self-interest and geopolitical tensions still influence actors to some extent. The EU and ESA have been impacted in recent years by the impending withdrawal of the UK from the EU, which has led to uncertainty about the future use of Galileo and the role of the UK. Brussels had already taken initial steps to exclude the UK from the Galileo program by moving a backup control center from the UK to Spain and preventing UK defense firms from

[23] Xinhua Economic News Service (2014). China, Thailand sign MOU on BeiDou satellite navigation cooperation (Dataset NC)

bidding for contracts related to it. The UK immediately responded to this action by considering options for its own global navigation satellite system in the case that the UK and the EU did not reach an agreement that respects both the EU's decision-making autonomy and the U.K.'s sovereignty. The statement of the Brexit Secretary David Davis in 2018 shows the dependence from European countries in shared projects and also the inherent potential for conflict:

"Our negotiating partners have a choice: they can treat us as a third country according to existing precedents, creating something that falls well short of our existing relationship, or they can take a more adaptable approach in which we jointly deliver the operational capability that we need to tackle the ever-evolving threats to our shared security. […]To protect our citizens' security, we need to look beyond existing precedents and find a solution that allows us to continue to work together. There is no legal or operational reason why such an agreement could not be reached."[24]

This event shows how the State-National Geopolitics field logic still strongly influences actors and how great the desire for autonomy and independence is. However, market growth will gain even more interest in the coming years as the global competitive position is also closely linked to who is more successful in the global application market. It can therefore be assumed that in the next few years, the **State National Geopolitics** and **Market** field logics will continue to co-dominate and compete with each other.

The development of **Cluster C**, however, must also be addressed. Since the first phase of the study, the field logic of the **Global Mission** has become increasingly important. This can be seen on the one hand by the growing number of actors but also by the number of coded statements. In addition, a large part of the actors remains the same. The prevailing field logic in this cluster is driven by a desire for more sustainability but also a desire for more multilateral cooperation. International organizations, as well as international initiatives in particular, are part of this. Soft law mechanisms such as the ICG are important to achieve exchanges among global actors to ensure the peaceful use of outer space. The association of actors in such initiatives and organizations such as the ICG is therefore important factors for the development of the field. Although this field logic does not occupy a dominant position, it is nevertheless present and growing, which is desirable.

[24] Express Online (2018). BREXIT THREAT: Britain warns EU of damaging its security over Galileo stalemate (Dataset NC)

5.2. Data Analysis of the EO Case

5.2.1. Major events in the EO field over the last two decades

As for the Navigation case, a subdivision was also made here inspired by the time trend of Nexis Uni data and by identifying significant events using desk research, which can be found in *Figure 9*.

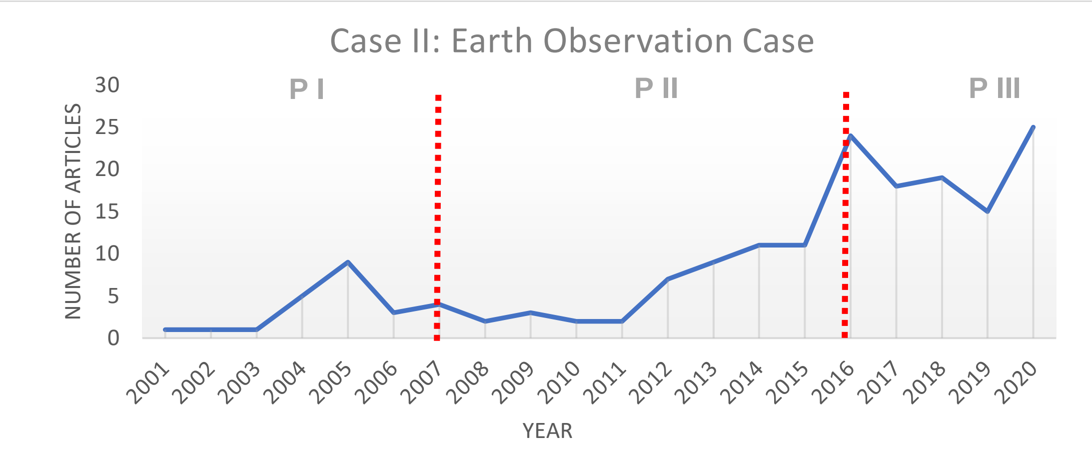

Figure 9: Main phases in the development of the EO field

The first period is ranging from 2001 to 2007. In the late 1990s, the E.U. began developing, next to satellite navigation, their earth observation program. In 2001 the ESA and the E.U. endorsed the Global Monitoring for Environment and Security (GMES), later called Copernicus, to gather, interpret, and use data and information to support sustainable development policies (Haarler 2020). At the end of 2004, the Indian Ocean earthquake and tsunami destroyed parts of Indonesia, Sri Lanka, Thailand, India, and many more Asian countries. According to a European Space Agency press release, immediately after the first tsunami struck in the Eastern Indian Ocean, three different agencies invoked the International Charter on Space and Major Disasters and cooperated using EO-Data to offer help soon as possible. The first periods end with the introduction of the first European Space Policy in 2007 and the Cape Town Ministerial Summit, which supported the establishment of a process intending to reach a consensus on the implementation of the Data Sharing Principles for the Global Earth Observation Systems of System (GEOSS) (Group on Earth Observations, 2007).

The second period (2008-2015) starts with the preoperational and initial operational stages of the Copernicus Programme. Additionally, the US announced in 2008, based upon a change in data policy, that all new and archived Landsat data have been made freely available over the internet to any user (Woodcock et al., 2008; Wudler et al., 2012). Finally, the phase ends with introducing the 17 SDGs at the Sustainable Development Summit in New York, which explicitly calls for new data collection and the use of a wide range of data sources to support implementation and cite E.O. data as a crucial data source (Anderson et al., 2017).

The last period (2016-2020) starts with the take-off phase of Copernicus, which can be described as the exploitation of the opportunities of Space-based applications for the E.U. economy and towards addressing grand societal challenges (Haarler 2020). Additionally, the G7 Environment Ministers' Meeting in Toyama, Japan, has issued the necessity of robust E.O.

to enhance the ability to measure and monitor climate change (G7 Environment Ministers Communique 2016; Anderson et al. 2017).

5.2.2. EO (Period I): Analysis of Field Logics

Unlike the navigation field, the EO field is far more diverse from the beginning of the first period. However, conflicts and tensions also existed. These issues and the willingness to cooperate are not limited to a few main state actors and involve countries, private companies, and international organizations. Based on the empirical findings, an actor-network, which can be found in *Figure 10*, was derived. The actor-network of period I is based on the value-based proximities between the 34 active actors. Using the Ward cluster coefficient, two clusters of actors with similar value dispositions were identified.

The first **Cluster A** (green) contains 19 actors, and the second **Cluster B** (violet) consists of 15 actors. The respective logic- profile can also be found in *Figure 10.*

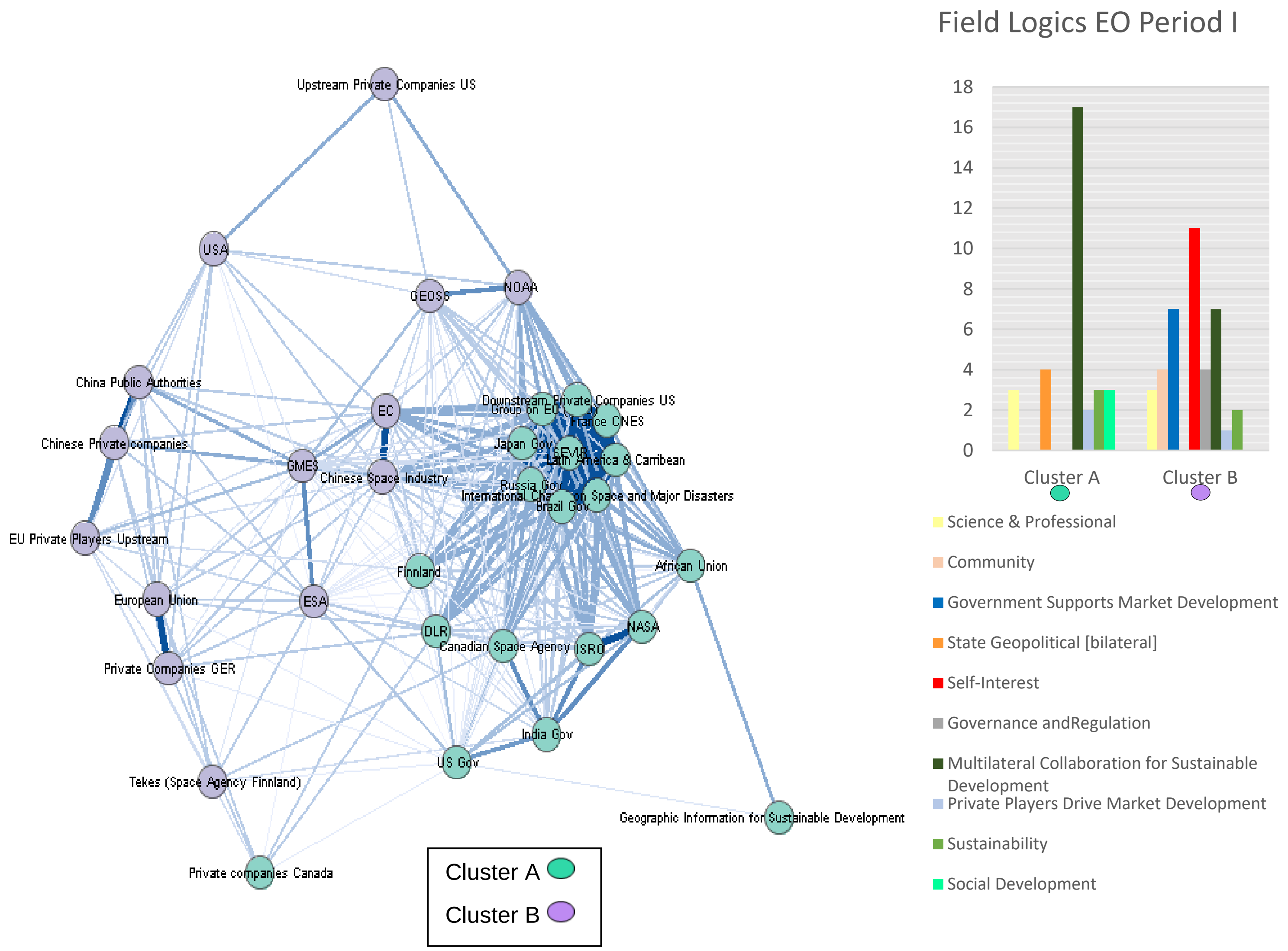

Figure 10: EO Actor-Network & Field Logics EO P I

Cluster A

Cluster A is dominated by **sustainability-sensitive mission-driven** tendencies to cooperate. Actors in this Cluster mainly adhere to what this study refers to as **Global Mission** field logic. Actors in this Cluster are very well connected, meaning that they share a very similar value disposition. Multilateral cooperation for sustainable development clearly drives actors in this cluster; other basic logics influence actors only marginally. Initiatives as the Charter on Space and Major Disasters, SERVIR, and the GEO are located under this cluster. The industry experienced a boom in late 2004 when the Indian Ocean earthquake and tsunami devastated parts of Indonesia, Sri Lanka, Thailand, India, and many other Asian countries, creating an unprecedented demand for EO data. Various actors joined forces and provided first aid, clearly driven by the Global-Mission field logic. One example is the International Charter on Space and Major Disasters, established in 2000, which facilitated collaboration on a global level. Their mission is to provide immediate access to EO data for countries in need from participating Space agencies in the case of a disaster. Agencies participating in the Charter, who also adhere to the **Global-Mission** field logic, are ESA, the NSA, the German Space Agency (DLR), and the Canadian Space Agency. A 2005 ESA press release shows their apparent adherence to the Global Mission field logic:

"The recent tragedy striking the coastlines of the Indian Ocean has highlighted the benefits of international cooperation in Earth Observation for the management of disaster relief, while demonstrating the scope for improved cooperation in the future."[25]

The EO field showed that mission-driven multilateral cooperation played a significant role. One example next to the Charter was the establishment of the Group of Earth Observation (GEO) between 2003 and 2005, which provided a platform for planning and coordinating new projects and investments in EO. Already at its inception, the initiative consisted of more than 50 states and 30 international organizations. The partnership is voluntary and addresses both state and non-state actors. In addition, the group aims to build the Global Earth Observation System of Systems (GEOSS). US Secretary of the Interior Dirk Kempthorne's statement in 2007 highlights the affiliation with the **Global Mission** field logic:

"Turning Earth into a new frontier, GEOSS is cutting across borders, sectors, and disciplines to open a world of possibilities. This initiative is enabling scientists, policymakers and the public to envision a world where more people will be fed, more resources will be protected, more diseases will be mitigated or prevented, and more lives will be saved from environmental disasters"[26]

Cluster B

Cluster B is mainly driven by national self-interest and market development intentions. Therefore, most actors in this cluster subscribe to what this study describes as a **State-Market**-field logic. For members of this cluster, the use of EO data is related to civil security and the interest in protecting the own country if necessary and keeping up with the global competition. For example, the European Union stresses that in the future, national security forces, civil

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[25] State Department (2005). Global Space Cooperation Helps Tsunami Relief Effort; International satellite data allow quick damage assessment (Dataset EO)
[26] States News Service (2007). Kempthorne-led U.S. Group on Earth Observations announces scientific initiatives (Dataset EO)

protection organizations, and armed forces of European countries will increasingly rely on satellite information as part of their missions. However, the rising demand for Earth Observation Data and the awareness of the potential market for EO data and applications are also driving actors belonging to this cluster.

ESA emphasizes the importance of investing in the key program Global Monitoring for Environment and Security (GMES), showing the clear affiliation to the **State-Market** field logic. Volker Liebig, head of earth observation at ESA states:

"We feel that earth observation satellites and data are now used in many applications, and it is based mainly so far on scientific satellites, and we have now to operationalize them, similar to what we have done in meteorology. "[27]

In addition, private companies were entering the field and competing or cooperating with national Space agencies, depending on the case. As such, Alcatel Alenia, a French aerospace products manufacturer, is supplying EO data acquisition systems to the China State Radio Monitoring Center (CSRMC), China's national network of Earth observation stations. In the statement of Alcatel Alania's managing Director Alain Van Doninck, it is clear to see how both private and government actors subscribe to the **State-Market** field logic.

"'Our experience and drive for innovation, supported by funds of the Belgian Federal Science Office and under the technical supervision of the European Space Agency, made possible the development of this solution. Our system ranks amongst the world's most powerful and flexible solutions for earth observation data acquisition. […] The contract signed with Integrated Systems (CSRMC's purchasing vehicle) strengthens Alcatel Alenia Space's position in the growing Chinese market."[28]

5.2.3. EO (Period II): Analysis of Field Logics

The second phase identified 45 actors actively engaged in shaping the EO field by analyzing public discourses. EO-data is gaining popularity among a diverse confluence of players, including government actors, federal Space agencies, private actors, and many different international organizations. An actor-network, which can be found in *Figure 11*, was designed based on the data analysis. The actor-network consists of 45 active actors who shape the field in different ways. Using the Ward cluster coefficient, three different groups of actors with similar value dispositions were identified.

The first **Cluster A** (green) contains **21 actors**, and the second **Cluster B** (yellow) consists of **13 actors**, and the last **Cluster C** contains **11 actors**. The respective logic profiles of the clusters can be found in *Figure 11.*

[27] Satellite News (2005). Europe's Earth Observation Programs Face Key Funding Decisions (Dataset EO)
[28] AFX Asia (2006). Alcatel delivers Earth observation satellite systems to China (Dataset EO)

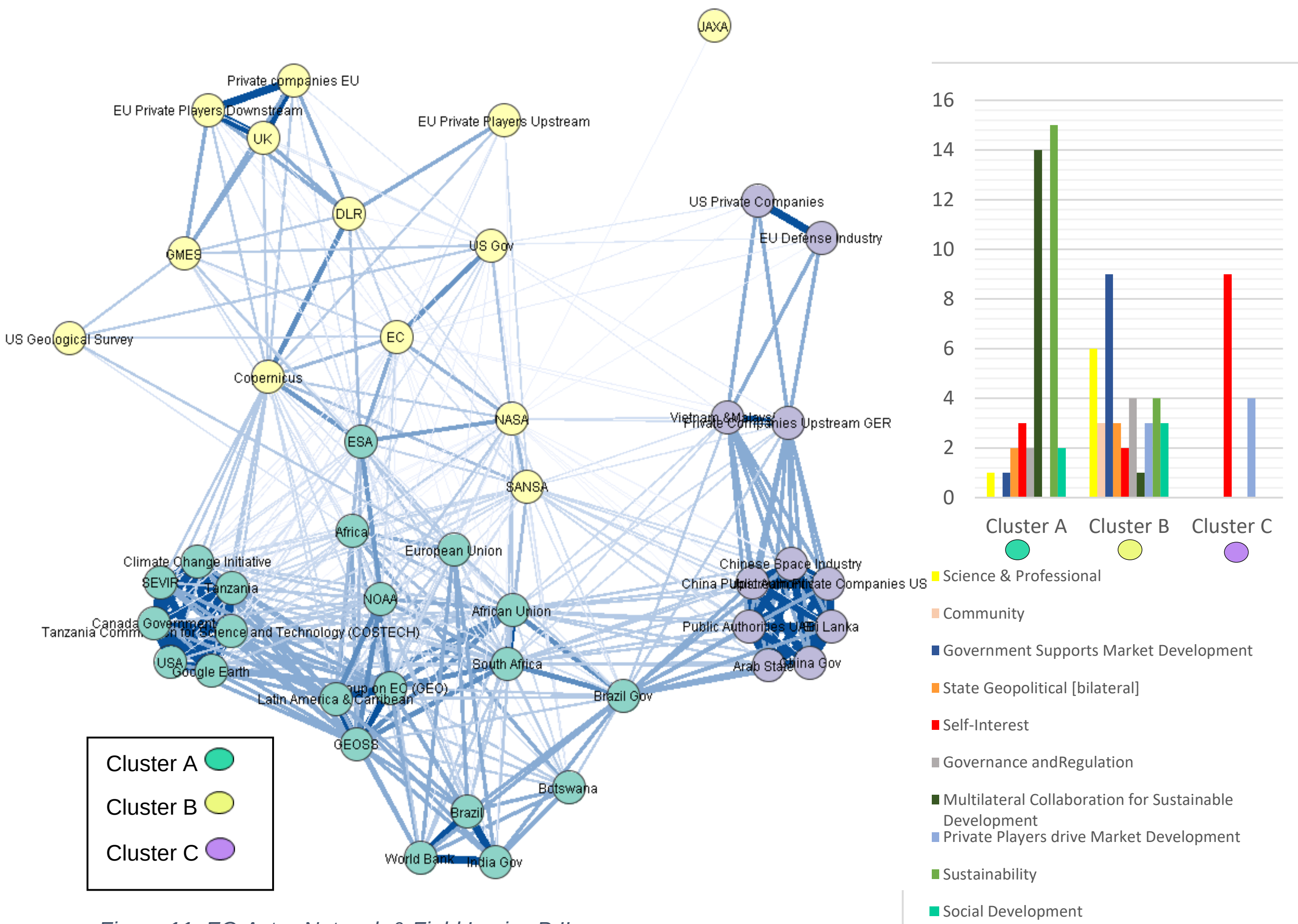

Figure 11: EO Actor-Network & Field Logics P II

Cluster A

This cluster is driven by the goal of making EO data globally accessible to support sustainable development. Based on the distribution of the basic logics in the logic profile, Cluster A is a continuation of Cluster A in period I. Thus, actors belonging to this cluster subscribe to the **Global-Mission** field logic. Initiatives as GEO, SERVIR, the CCI, and the GEOSS are located under this cluster, additional to many developing countries such as South Africa, Tanzania, Botswana, India, and Brazil. Supporting sustainable development plays a significant role in this cluster. Many actors strive for a better future and emphasize how significant the role of EO data is to achieve this goal. The development and continuation of various initiatives is an important measure in the process of multilateral cooperation in order to designate the mission and to be able to act in a targeted manner. The Monitoring of the Environment for Security in Africa (MESA) initiative in Botswana is an example of multilateral collaboration to support environmental capabilities within the Southern African Development Community. The Botswanan Minister of Environment, Wildlife and Tourism, Mr. Mokaila stated in 2014:

"The Monitoring of the Environment for Security in Africa initiative brings satellite technology and infrastructure to SADC member states, including Botswana to allow continuous monitoring of our environment for hazardous natural disasters such as floods, wildfires and drought."[29]

[29] Botswana Daily News (2014). Initiative to support environmental monitoring capabilities (Dataset EO)

Actors such as ESA and the European Union support these types of initiatives as the statement from a European official shows: *"[…] the launch was a true reflection of the EU's commitment to support regional integration throughout the African continent. The EU is fully committed to supporting the implementation of MESA and to ensuring its success."*[30]

A strong affiliation of the EU and Botswana to the logic of sustainability and multilateral cooperation for sustainable development can be seen in the above statements and supports the affiliation to the field logic of **Global-Mission.**

Cluster B

Government interests in market development influence actors in **Cluster B**. In addition, due to the rapid development of technologies, more and more knowledge can be generated about new uses of EO data, and thus the value of **scientific knowledge** in promoting this progress is becoming increasingly important. In comparison with the field logics, as well as the respective logic profiles from period I, it can be seen that cluster B split into two clusters in period two. Cluster B in this period is, therefore, a spin-off from cluster B from period I. Actors associated with this cluster are affected to a large extent by the **Market** field logic.

American and European private players but also the Copernicus system and its predecessor GMES are driven by this field logic. Government-coordinated programs such as Copernicus are also gaining momentum. While governments no longer play the sole role in developing such technical capabilities, they continue to have an essential part in promoting and commercializing them, as well as in developing the market. In the following statement of the Vice President of the European Commission Antonio Tajani about the development of Copernicus, the affiliation to the **Market** field logic is evident.

"The use of satellite imagery is an important and fast growing business. This Directive will facilitate commercial Earth observation and access to satellite data within the EU, accelerating the development of this innovative sector and the creation of new products and services. Our economy will benefit from increased competition by improving free circulation of satellite data throughout the EU. "[31]

However, the rising awareness that federal Space agencies and state authorities can no longer carry out the acquisition of EO data is characterizing for the actors in Cluster B. Private companies in the upstream and downstream industries and cooperation between public and private actors are gaining importance. In the following statement, the role of public actors in the market development can be seen and thus clearly shows the affiliation with the **Market** field logic.

Cluster C

In addition to these economically driven interests, the desire for more security and power through the launch and use of EO satellites is also increasing among many actors. **Cluster C** is driven primarily by these **national self-interests**. At the same time, however, there is a smaller tendency for private actors to be responsible for providing the necessary technologies. Based on this logic profile, it can be seen that cluster B from period I has split into clusters.

[30] Botswana Daily News (2014). Initiative to support environmental monitoring capabilities (Dataset EO)
[31] European Union News (2014). EU enhances commercial access to Earth observation data (Dataset EO)

Part of the basic logic is represented in cluster B and another part here. Therefore, this cluster C is a spin-off of cluster B from period 1. The cluster is mainly dominated by actors subscribing to what this study calls a **State** field logic. Players emerging in this cluster are especially countries from the middle east, but this value disposition drives the Chinese players as well.

During this period, China is extremely expanding its fleet of EO satellites and emphasizing its technical superiority. Another example is South Africa's National Space Agency's development in 2010 to participate in the Space industry actively. According to the founding Chief Executive Officer of the South African National Space Agency, *"SANSA focuses on four key themes, namely, Earth observation, space science, space operations, and space engineering. Data obtained through Earth observation is provided to government to facilitate resource management and planning."*[32]

Furthermore, new actors are entering the field. These include, for example, states such as the United Arab Emirates, which are also willing to become active in the EO domain, whether it is for prestige but also for strategic civil or military purposes. The Dubai Police Department[33]., for instance, uses Earth observation data and geospatial mapping technologies to support its law enforcement and security activities, showing a clear affiliation with the **State** field logic.

5.2.4. EO (Period III): Analysis of Field Logics

In the third phase, public discourses identified **74 actors** actively involved in defining the EO field. Therefore, the number of active players has nearly doubled in only a brief time. The EO field was on the rise, and more and more different actors wanted to participate actively and thus help shape the field. The actor-network of period III is very complex and interconnected. During this period, values connected to the willingness to cooperate, particularly in the context of sustainability, were dominating the field. However, the so-called New Space movement was becoming more prominent. Private actors were beginning to dominate the field, and there were signs of a shift in the government's role. Government actors were increasingly inclined to enter into public-private partnerships as a desired form of collaboration to fund potential projects and, at the same time, participate and enable them. An actor-network based on these empirical findings was designed, which can be found in *Figure 12*. Using the Ward cluster coefficient, three different groups with similar value dispositions were identified.

The first **Cluster A** (green), contains **38 actors**, and the second **Cluster B** (yellow) consists of **19 actors**, and the last **Cluster C** (violet), contains **18 actors**. The respective logic profiles of Clusters A, B, and C can be found in *Figure 12.*

[32] Aerospace America (2011). South Africa opens new routes to space (Dataset EO)
[33] Islamic Finance News (2013). Global Space & Satellite Forum, Milsatcom Middle East Open Today in Abu Dhabi (Dataset EO)

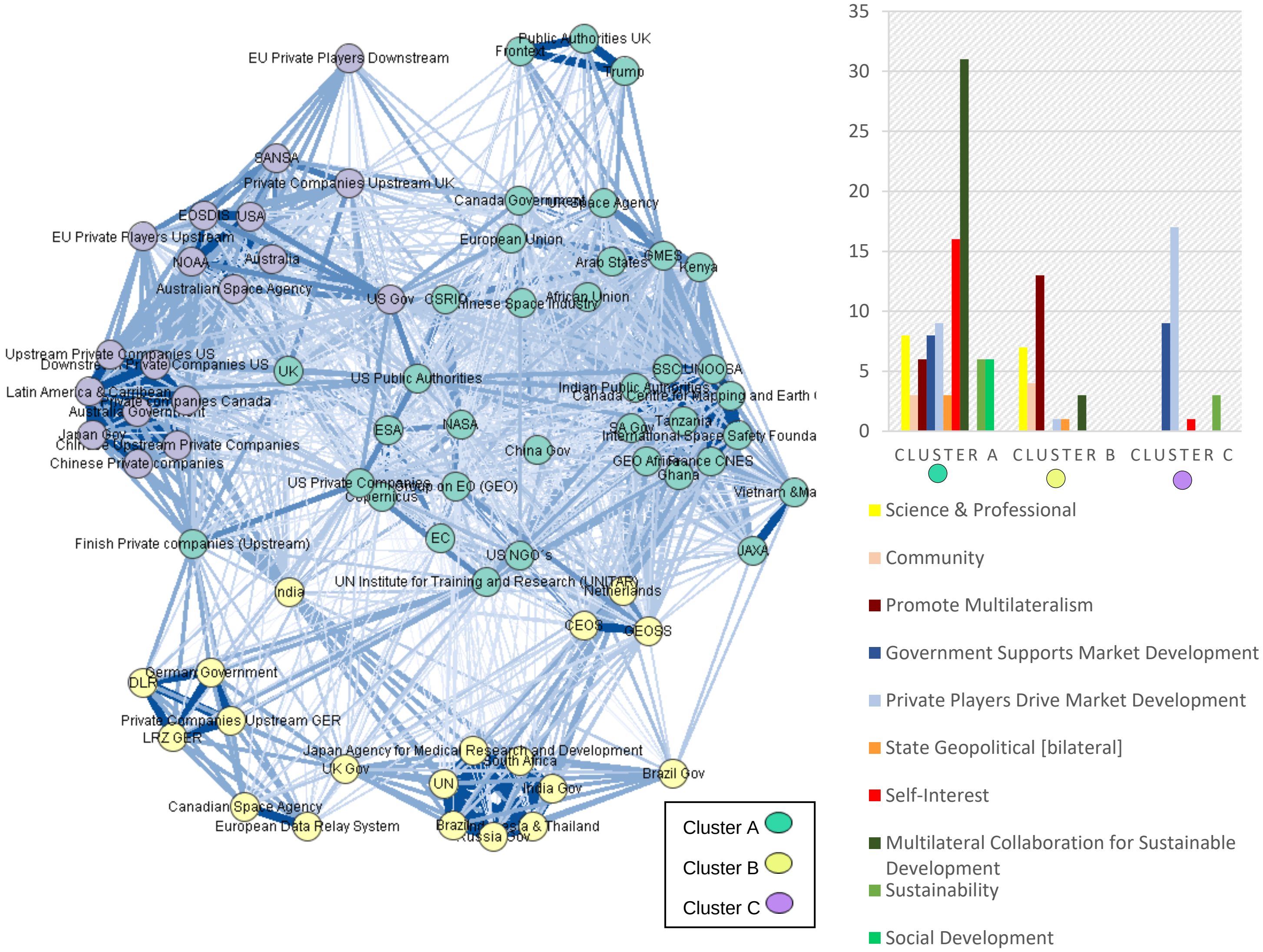

Figure 12: EO Actor-Network & Field Logics P III

Cluster A

Actors belonging to **Cluster A** mostly agree on **cooperating for sustainable development;** however, there are also **state-led national self-interest values** influencing the actors in this cluster**.** Addressing specific environmental issues becomes secondary, while general mission-driven cooperation becomes paramount. Based on this distribution of basic logics, it can be seen that Cluster A is a continuation from periods I and II. Therefore, actors in this cluster were mainly adhering to the **Global-Mission** field logic. This cluster has the most members, which shows the enormous importance of this value disposition in the EO field. The UAE, for example, is guided by the belief that a sustainable approach to the environment is not only crucial for its nation and its health but is also beneficial to the broader global population. As the UAE Space Agency Chairman announced in 2016, the country sees the membership in line with its efforts to support the Space sector and strengthen the UAE's global presence by building international relationships in line with the country's strategic goals[34]. *"The UAE SA*

[34] MENA English (Middle East and North Africa Financial Network) (2016). UAE becomes member of Group on Earth Observations (Dataset EO)

strongly believes in the value of a sustainable healthy environment and will endeavor as part of its mandate to promote all the above-mentioned Space activities not only for the benefit of the UAE as a nation but for the benefit of all human kind and for all future generations by safeguarding the health of our precious plant Earth."[35] Based on this statement, it can be seen that national self-interests, such as the use of EO to support one's own power position in Space and coordinated strategic goals, can thereby represent further reasons for cooperation in such initiatives, thus underscoring the affiliation of the UAE with the **Global-Mission**-field logic.

The Copernicus system is at the center of the network and is mainly influenced by the **Global-Mission** field logic. As part of GEOSS, which aims to integrate different EO systems globally to strengthen Earth monitoring, data is available on a dedicated portal for the global community. As the initiator of GEOSS, GEO already counts 110 countries and over 60 global activities as members. In 2020 the organization announced a collaboration with Google Earth Engine to support EO-projects on a global level further. Gilberto Camaras, Director of the GEO Secretariat, clearly underlines in his following statement the affiliation with **the Global-Mission** field logic, as he emphasizes the importance of the global mission and the impact of collaboration for sustainable development:

"GEO is very proud to be supporting these projects in collaboration with Google Earth Engine and EO Data Science. I am thoroughly impressed with the number, quality, and the diversity of proposals we received. The diversity in terms of the topics, regions, and approaches is a testament to the fact the Earth observations are instrumental for a wide range of applications and solutions. The results of these projects will help GEO fulfill our mission globally to improve decision-making with EO data. Several of the winning solutions are focused on GEO's priorities around Climate Change, Disaster Risk Reduction, and Sustainable Development. We look forward to their evolution and the open solutions they produce."[36]

However, the triangle of actors in the upper part of the cluster seems to be an outlier, as there is no connection with the rest of the actors here. This part of the cluster should be viewed in isolation, as these actors, driven by purely selfish values, are not even remotely driven by a willingness to cooperate.

Cluster B

Actors in **Cluster B** are primarily dominated by tendencies for international cooperation. However, **cooperation tendencies** are not linked to sustainability. **Cluster B** is strongly driven by the tendencies towards general **international cooperation**, partly for **scientific purposes;** therefore, actors in this cluster mostly adhere to what this study calls a **Science & Cooperation** field logic. Based on this distribution of basic logics, it can be concluded that cluster B represents a completely new cluster, which is, however, still influenced by market development and cooperation tendencies.

The collaboration between the German Space Agency (DLR) and the Leibniz Computing Centre shows the clear affiliation of both actors to the **Science & Cooperation** field logic as can be seen in the following statement of the Director of the LRZ:

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[35] MENA English (Middle East and North Africa Financial Network) (2016). UAE becomes member of Group on Earth Observations (Dataset EO)

[36] Targeted News Service (2020). Group on Earth Observations and Google Earth Engine Announce Funding for 32 Projects to Improve Our Planet (Dataset EO)

"The collaboration between these two leading research institutions brings together two partners that complement each other perfectly and contribute their relevant expertise, resources and research topics. The Leibniz Computing Centre has proven experience as an innovative provider of IT services and a high-performance computing center. It is also a reliable and capable partner for Bavarian universities and will, in future, cooperate with DLR and its institutes in Oberpfaffenhofen."[37]

Furthermore, China and the Space agencies of Brazil, Russia, India, and South Africa have jointly supported and actively promoted cooperation in the BRICS remote sensing satellite constellation.[38] The U.K. government additionally states that collaboration, education, and training are necessary to address the rapid growth of the EO field. Therefore, the country supports the training of several Ph.D. students in climate change modeling, atmospheric science, and monitoring of land, forest, ice, and oceans. The statement of the Head of EO and Climate at the UK Space Agency below shows the clear affiliation to the Science & Cooperation field logic:

"The rapid growth of the Earth Observation sector means we need to attract thousands of people with the right skills over the next 10 years. This new Centre for Doctoral Training - SENSE - is very exciting. Working with NERC we will support students to spend time with the European Space Agency to learn from their wealth of experience and put their academic learning into real world examples. I am very much looking forward to working with the SENSE team to make this new and ambitious initiative a success for the students and for the UK space sector."[39]

Cluster C

Cluster C is purely **market-dominated**. It can be seen that this cluster is a partial merger of clusters B and C from period II. Here, the economic interests were combined, while state-oriented logics now only play a minor small role. Since it was primarily private actors that drove market development, the actors associated with this value disposition are part of what this study refers to as market field logic. Technological progress was leading to a new development in the EO field. Notably, the use of artificial intelligence in processing data was gaining increasing attention. Many startups were specializing in applying AI to digital images to expand the application focus even more. The capacity to generate such development lay mainly with private actors. This mix consists of private upstream industry players as well as data processing and consulting companies in the downstream application field. And the EO field is expected to grow even more in the next years on a global level. The statement below shows the clear affiliation with the market field logic and shows how private and public actors are driven by economic values and the wish for future prosperity:

"Although our private EO upstream and downstream industry capabilities are currently small, they are world leading, and if they were enabled with government-industry support in a way that the, the / and do, we could build this sector. If Australia is to participate in the 'Space 2.0'

[37] Targeted News Service (2019). German Aerospace Center: Terra_Byte - Top Computing Power for Researching Global Change (Dataset EO)
[38] China Daily (2916). Unremitting pursuit of space dream (Dataset EO)
[39] Targeted News Service (2020). Natural Environment Research Council: New Doctoral Training Centre for Earth Observation of Environmental Challenges (Dataset EO)

economy, we need to act now and set clear goals for the next five, ten and 20 years"[40]

The development of cheaper and smaller satellites in the form of Cube- or Microsatellites positively impacted the entire industry. There is an increasing number of private players entering the emerging microsatellite field, opening up diverse economic opportunities for both large companies and startups. European private companies profit from this development and adhere, therefore, to the **Market** field logic, as the following statement shows:

"This innovative product has generated an outstanding interest among leading prime contractors, like Airbus Defense & Space, emerging Microsatellite Manufacturers, like Berlin Space Technologies and GomSpace, space systems integrators, like Deimos Space and Everis, and Earth Observation data users, like Telefonica. More than 2100 small Earth Observation satellites will be launched in the next decade, 8 times more than between 2006-2015."[41]

5.2.5. Evolution of Field Logics and Implications to the Earth Observation Case

Based on the empirical findings described above, a change over time in the respective field logics can be observed. EO services undergo significant changes in the period under review. Most notable is the substantial increase in the number of players over time, ranging from 34 actors in period I to 74 actors in period III. In period I, two co-dominant field logics were identified. Cluster A was driven by what this study labeled a Global-Mission, and Cluster B was guided by a so-called State-Market field logic. Both clusters had a similar number of actors involved. Thus, in this first period, no winning field logic could be identified, and both logics competed for dominance. This trend can be observed throughout the entire development of the field. On the one side, the field is driven by a strong sustainability driven value disposition, including strong cooperation tendencies. On the other hand, the field is characterized by a multitude of market interests emanating from both private and public actors.

Figure 13 below shows the trends in the development of the EO field. The star around a particular field logic indicates that one field logic dominates over the other. If the line is dashed, two or more field logics are co-dominant. This means that they strongly influence players in the field and compete with each other for predominance. The lightning bolt indicates that a new field logic is emerging.

[40] Global English (Middle East and North Africa Financial Network) (2017). Australia relies on data from Earth observation satellites, but our access is high risk (dataset EO)
[41] TendersInfo-Project Notices (2017). iSIM: Integrated Standard Imager for Earth Observation Microsatellites (dataset EO)

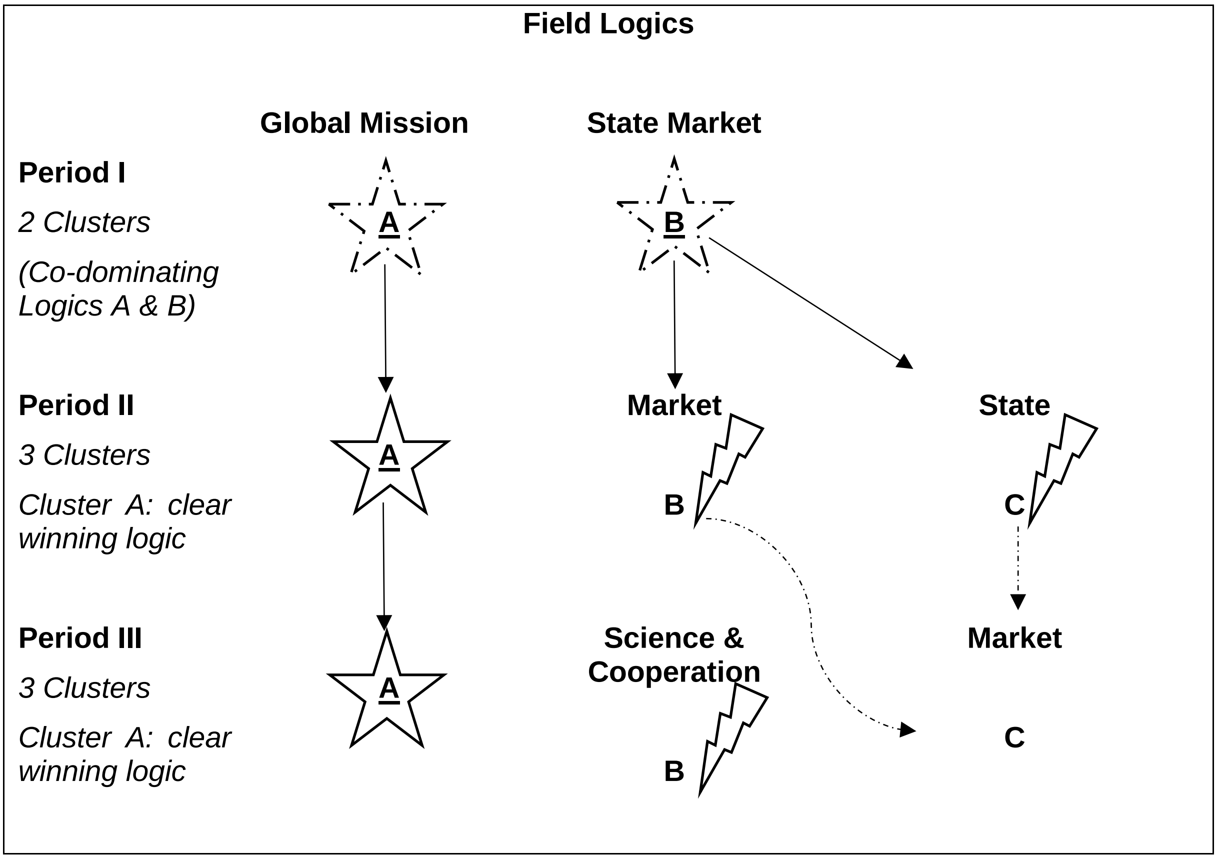

Figure 13: Evolution of Field Logics in the EO Case

The **Global mission** field logic (**Cluster A**) drives the first-mentioned development of the field. This logic continues to (co-)determine the entire research field over time. Earth Observations satellites, as the name suggests, are used to monitor the Earth. Based on various natural disasters, it has been recognized that cooperation is a necessary tool to provide emergency assistance but also to monitor climate change. Therefore, especially in the field of EO, many initiatives have been established at the global level. Participation in such associations is mostly voluntary, but because there is a majority consensus to network in disaster relief and sustainable development, the initiatives register many participants. Initiatives as the Charter on Space and Major Disasters, SERVIR, and the GEO aim to connect actors worldwide. The basis of cooperation is mainly connected to the access to Earth Observation data and other connected instruments. Especially developing countries lack EO-based informed decision-making in critical areas such as weather forecasting, disaster management, air pollution, and fire monitoring. Therefore, international organizations are important in the overall development of the field as they promote the standardization of disparate data sets from different sources and satellites and data sharing across international boundaries. This also further explains the continuous (co-) dominant position of the **Global Mission** field logic. In his statement on future cooperation with China, Jan Wörner, Director General of ESA, emphasizes the importance of collaboration and data sharing and how it can lead to benefits for all parties involved:

"I'm arguing in favor of that because if you have, for instance, data concerning C02 emission, if this comes just from one country, whatever that country is worldwide, it will not be accepted by the other ones. If you exchange the data, you get two things. First of all, you get higher

frequency of information, which is good to see as the sources of C02. And secondly, you get trust that you accept the data of the others if you give your data."[42]

However, also smaller collaboration projects as for example, the one between ESA and the World Bank, demonstrate how Earth observation can influence international collaboration to enable sustainable development. This small-scale project used three ESA satellites to monitor parts of the Tunisian capital where the land was subsiding, undermining the city's ability to withstand storms, earthquakes, and extreme weather conditions. In her statement below, the manager of the World Bank's Urban Development and Resilience Department underlined the importance of mission-driven collaboration to enable policy makers to make information-based decisions:

"The results from the satellite data were stunning. They were quick, cost-effective, and technically sound. They gave us visually impressive products that easily communicated the magnitude of the problem to our counterparts in government. As a result, the government immediately incorporated smart risk mitigation policies into the city's adaptation and resilience plans."[43]

Additionally, another example of a small-scale cooperation tendencies to enable sustainable development on a global level is the collaboration of the United Nations Institute for Training and Research (UNITAR) and the Radiant.Earth foundation. Combining UNITAR's Operational Satellite Applications Program (UNOSAT) with the expertise of the Radiant.Earth Foundation, an American private nonprofit organization, founded in 2016 focusing on expanding Space technologies to explore innovations in Earth observation data, established an example of successful collaboration between public and private entities in support of sustainable development. With *Radiant. Earth's* imagery processing capabilities, and UNOSAT's experience in satellite imagery analysis and capacity development, the two parties worked together to make data and solutions available to the global community to support the Sustainable Development Goals[44].

At the same time, however, the field has been strongly influenced by market-driven values, with a tendency for an increase in their importance over time. In the first period, these market interests are also influenced by state-driven values. However, based on the ward clustering analysis, it can be observed that the separation of **Cluster B** (**state-market** field logic) into two clusters in period II resulted in a new overall distribution of actors which separated **State** and **Market** field logic. Both clusters are still influencing each other, but at the same time, they are clearly distinguishable. An actor's affiliation with the state-field logic is primarily characterized by national self-interest, while market interest is reduced to a minimum. The **Market** field logic in period II, on the other hand, is still clearly driven by the role of governments, but with a focus on market development. Copernicus' role in pushing and supporting the development of private sector applications through various programs such as the Copernicus Master’s Program is one example of how governmental actors drive market development and push for cooperation with private actors.

"Through the Copernicus Masters, we're aiding visionary companies in bringing their innovations to market. Working with the European Space Agency and its ESA incubation

[42] Aerospace America (2018). Facilitator in chief. Q&A Jan Wörner. (Dataset EO)
[43] News Press (2013). High Above Earth, Satellites Help Direct Ground-Breaking Development Work (Dataset EO)
[44] PR Newswire (2017). UNITAR-UNOSAT and Radiant.Earth Partner for Greater Impact from Earth Observations (Dataset EO)

program (ESA BIC) has enabled us to assemble an ideal platform for providing these projects with long-term support. We're proud to have witnessed a constant rise in the startups involved in commercializing Earth observation services since the Copernicus Masters was initiated in 2011 and are confident that the number will continue to grow with the launch of further Sentinel satellites."[45]

However, at the same time, there is a growing awareness that government agencies and public actors are struggling to keep pace in terms of technological development with private actors since the latter can better benefit from the market and are less dependent on government agencies and political decisions. As a result, a growing number of public actors have sought to purchase privately developed technologies or to pursue public-private partnerships for research and development. The testimony of the US Representative Brian Babin demonstrates the increasing reliance on private companies and their role in future cooperation patterns:

"Over the past decade, the United States private space-based remote sensing sector has made significant improvements in technology, products, and services, leveraging commercial off-the-shelf technology, borrowing ideas from the information technology community, and developing innovative low-cost solutions with high performance outcomes, the private sector is demonstrating new capabilities that could be used to address many of NASA's Earth observation data needs. […] It is time for NASA to initiate constructive dialogue with the private sector to assess the viability of public-private partnerships for all the provision of space-based Earth observation data to meet NASA program requirements."[46]

This trend becomes even stronger in period III and includes actors at all levels of the field, as private actors not only drive market development but also play an important role in public missions and become increasingly active in initiatives and organizations to enable sustainable development. In Period III, it can be seen that **Clusters B** and **C** from period II reunite, or rather realign, in the form of cluster C. Compared to period II, **Cluster C** in period III was dominated by market values with a new focus on the role of private actors, while national self-interest played only a minor role. Thus, market interests are becoming increasingly important, while national self-interest plays a less important role in the discourse on Earth observation. This can be explained mainly by the fact that EO satellites are increasingly in private hands, while government interest in EO tends to stagnate or even decline, as their usefulness for government purposes is rather limited and, if needed, data can be obtained via Public-Private Partnerships (PPP) or acquisition. Collaborations between private and public actors occurred all over the field, mostly in the form of projects or market-oriented developments.

The newly emerging **Cluster B** in period III, on the other hand, is characterized by a completely new value disposition of **Science & Cooperation**. However, similarities and connections to the other two clusters dominated by the **Market** and **Global Mission** field logic can be identified, resulting in three distinguishable but dynamically congruent and aligned field logics, since they mostly share the interests in deploying the EO data for downstream application services in order to accelerate sustainable development across different places on Earth. Based on the interests represented in this cluster, it can be assumed that this cluster will slowly disappear if or realign with the other two clusters. Based on the previous development, however, it can be expected that it might develop primarily in the direction of the market-

[45] FinancialWire (2015). Munich Start-up Building Radar Wins Copernicus Masters Competition

[46] CQ Transcriptions (2015). Rep. Jim Bridenstine and Rep. Brain Babin hold a joined hearing in Earth Science Investments (Dataset EO)

dominated cluster, while a smaller part of the actors might adhere to the Global Mission field logic. The current scientific and cooperative efforts are primarily directed at developing and advancing the field, which will allow EO services to further mature. This will primarily support market interests in the future.

5.3. Comparison between the Navigation and the Earth Observation Cases

The analysis of both cases showed how the two fields have evolved in the last few years and by what different challenges it has been affected. The change in (co-)dominant field-logics, by which the different clusters were driven, showed the changing interests over time. In this way, it was possible to identify the different or even contradictory value positions of different actors and how this shapes cooperation patterns of the sector.

The navigation field has been characterized mainly by geopolitical influences and competition between the four GNSS operators. Although cooperation tendencies could also be identified in the navigation field, they were usually characterized by politically strategic and later market interests. The development of the Chinese BeiDou system, in particular, has impacted the development of the global navigation satellite field and led to increasing competitive pressure. Geopolitical and national self-interests were closely linked to the development and use of GNSS, as was also evident in the prevailing field logics. The events of the last few years and the related prevailing field logics show that the field is still evolving. This is further confirmed by the rapid growth of the market field logic in recent years targeted at accelerating downstream application services. However, with the completion of all GNSS, it can be assumed that the navigation services will also reach a certain level of technological and market maturity in the coming years, albeit at a different level than the EO field, as market development will also continue to be mainly steered by the four GNSS operators.

While the EU believes that cooperation and compatibility between all four GNSS are more necessary than ever, this is difficult to achieve given the ongoing geopolitical tensions between the US and China. Several newspaper documents[47],[48] in the most recent months (not included in the data analysis of this study), stated that geopolitical tensions would continue to exert pressure on the development of navigation services. One typical example of geopolitically driven competition is the export controls on Chinese technology companies (e.g., Huawei and SMIC) that were put in place under former President Donald Trump. Many of these restrictions have been maintained under the new President Biden, who is actively seeking to increase investment in US research and development so that the US can compete with China[49]. Nayed Al-Rohdan, Head of the Geopolitics and Global Futures Programme at the Geneva Centre for Security Policy, recently addressed the impact of GNSS on security in Space and on Earth:

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[47] Al-Rohdan, N. (2021). Global Navigation satellite systems: a symbiotic Realist paradigm (https://www.thespacereview.com/article/4123/1

[48] Starlin et al. (2021) The future of security in space: A thirty-year US strategy (https://www.atlanticcouncil.org/content-series/atlantic-council-strategy-paper-series/the-future-of-security-in-space/)

[49] Lee (2021). China races to rival the US with its own GPS system- but one analyst say it wont overtake the US yet (https://www.cnbc.com/2021/06/01/tech-war-chinas-beidou-gains-market-share-challenges-us-gps.html)

"Given humanity's increasing and irreversible dependence on outer space for daily critical needs, any insecurity or conflict in space, even if unintentional, will compromise space and terrestrial security for everyone."[50]

The statement clearly shows the role of GNSS in the overall Space sector and highlights how security concerns are increasingly arising.

The EO field can be clearly distinguished from developments in the navigation field, as EO services are mainly influenced by actors who use EO data primarily for purposes in the context of sustainable development, and security discussions and national competition between a few actors play no or only a minor role. The use of EO data for sustainable development is evidently very close to the actual function of EO satellites. It also shows that this purposeful use connects a wide variety of actors and enables or even drives cooperation globally. Cooperation tendencies were not only to be found among the developed, Western nations. More and more actors from the global South, such as Africa or South America, but also countries like Pakistan or the UAE, wanted to be part of the EO field, not only to use the EO data but also to actively participate and shape the field.

Another development that characterizes the EO field was the growing commercialization. Technological change and associated advances in the design of smaller and cheaper satellites made it easier for private actors to participate actively in the development of EO services. In addition, private actors tended to be more open to further developments as they had more financial capacities and were often given more freedom in research and development than public institutions. As a result, governments and federal agencies could hardly keep up and were dependent on cooperation, for example, in the form of Public-Private Partnerships (PPP).

These developments demonstrate how the EO field is maturing in a similar way to communication satellites years ago (Denis et al., 2017; Radiant Earth Foundation, 2019). This is characterized above all by the fact that the field is no longer dominated by a few state actors but that a large, steadily growing number of (private) actors steer and actively shape the sector.

While the global EO field is clearly characterized by tendencies to use Space for sustainable development, (geo)political tensions significantly influence the global navigation field. This overall shows a clear link to Astropolitics, which was presented in the theory chapter. Arguments such as that of Dolman (1999), who theorizes that the first power to dominate Earth orbits will gain effective control over Space and the Earth, point to a connection between neo-classical Astropolitics and the development of the GNSS field. Earth Observation, on the other hand, tends to share similar values as the (neo-)liberal internationalism and institutionalism strand of literature, as it assumes that international bodies, in particular, play a central role in enabling cooperation and peace between states. This view can be related to the predominant global-mission field logic in the EO Case. Thus, as just shown, trends can be distinguished between the cases, however, the Navigation case also exhibits neoliberal views, which manifest themselves, for example, in international initiatives such as the ICG, which want to encourage the coordination among the providers of GNSS, regional systems, and augmentations in order to ensure greater compatibility, interoperability, and transparency (UNOOSA, 2021). And while the EO field is dominated by neoliberal views, neo-classical views are also present, as the steady development of national self-interests shows. The UAE, for

[50] Al-Rohdan, N. (2021). Global Navigation satellite systems: a symbiotic Realist paradigm (https://www.thespacereview.com/article/4123/1)

example, is building up its own Space industry, especially in the EO segment, to use EO data for defense and police missions, and South Africa is expanding its own Space Agency to promote domestic market development in the EO field.

The comparative view, therefore, shows that the prevailing Astropolitics currently shaping the Space Sector are neither purely neo-classical nor neoliberal. Additionally, drawing on the argument of critical Astropolitics, the preferences and behavior of actors are mostly determined and guided by the "logic of expected consequences" or the “logic of appropriateness,” depending on the inherent value dispositions of actors (March & Olsen, 1998).

The ever-changing environment in the Space sector shows how different actors are constantly exerting influences that force the industry to deal with multiple pressures. The comparative approach showed how the sector is shaped by various developments. On the one extreme, geopolitical tensions were present, especially in the navigation field. Some conflicts dissipated over the period under study, while others became increasingly intense. In addition, the geopolitical situation also led to increased interest in cooperation between different states or state alliances, for example, to strengthen one's own position of power or due to infrastructural dependencies. On the other extreme, geopolitical disputes and interests are also evident in the EO field, but only to a very limited extent. Moreover, no large-scale patterns of cross-state cooperation could be identified in the EO field in order to support the power position of one single country. In addition, infrastructural dependencies are not really present since the function of EO satellites is not tied to ground segments, as it is for navigation satellites (see section 4.1.1.).

The increasing commercialization of Space can be observed in both cases, including the use of data and the increasingly privatized ownership of satellites. However, differences in market interests can also be identified here. In the navigation field, satellites are owned by the states, and market development is therefore also heavily dependent on state interests. Although PNT data is becoming attractive to more and more industries, such as smart agriculture, smart logistics, or autonomous driving, data collection is always done through government-owned satellites. However, the ownership of EO satellites has changed in recent decades. While government agencies are still active in EO, as for example, through the Copernicus program, the participation of private parties is increasing. In addition, the number of private players increased significantly in the area of satellite manufacturing but also in the downstream application segment.

Further supported in part by the publication of the SDGs in 2015, the use of satellites to support sustainable development on Earth has become increasingly popular. Support for sustainable development, e.g., in the form of disaster management, information-based decision-making, and support for land management, has long been an important part of EO and also of navigation satellites. Especially in the field of EO, this focus has a strong impact on the willingness to cooperate between actors. The mission orientation on a global level motivates the actors and also facilitates cooperation since the common focus already defines elements of possible cooperation. The potential for conflict, meanwhile, tends to be on a smaller scale, e.g., in the form of data access and exchange between actors. Large-scale conflicts, e.g., between states or for dominance in the EO field, are not observable in the study. Although navigation satellites are also frequently used for sustainable development purposes, this use plays only a minor role in the documents analyzed. While international initiatives as the ICG and the UNOOSA have advocated for collaboration among state actors on collaborative projects for sustainability purposes, this appears to have been only moderately successful at the global level. While there are smaller-scale projects between the four GNSS operators and other countries, this does not affect the overall sector structure. Therefore, while the structure of the EO field is increasingly shaped by international or global-local cooperation, the structure of the navigation field remains quite stable.

In other words, the mission that Space can contribute to the acceleration of sustainable development is evident in both cases from the first period studied, as can be seen in the presence of the Global Mission Field Logic. However, based on the analysis of the public discourses and the overview of the development of the sectors, it was possible to identify that in both cases state driven motivations and the hegemony of a few were the departure point. Thus, over time, both fields developed very differently, and a conundrum appeared. While in the Navigation case, state and geopolitical self-interests consistently take on an important role, the EO case shows how state interests are overtaken by market interests. State self-interest and geopolitical factors are becoming less important in the field of EO services, as they are countering the general development of the sector. Over the period studied, the EO field matured, and it became apparent that multilateral cooperation must be sought to support and strengthen sustainable development. Geopolitical tensions and national self-interest, therefore, only hinder the development of the sector. This also applies to the commercialization of the EO field. If only state actors, driven by national self-interest and influenced by geopolitical tensions, are present, commercialization of the sector by private actors cannot take place.

Overall, these different developments illustrate that although the two fields share some similar development tendencies, they are very contrasting. Based on the described evolution of the fields, it can be assumed that the sector will experience a strong increase in market development in the coming years. In this particular context, both fields are likely to converge, as the combined use of EO and navigation data is promising in many areas. However, looking at the geopolitical development of the last few years, it can be concluded that there will continue to be tensions, especially in the area of navigation. China's dominance and the increasingly close cooperation with Russia when it comes to Space-based issues will continue to challenge the USA in particular, but also Europe. This is contrary to the trends in the EO field, where sustainable development requires and drives global cooperation. It is therefore expected that the abovementioned trends will continue and lead to diverging positions of the two fields and the future global Space sector will therefore consist of different and partly diverging structures of institutions and cooperation patterns.

6. Conclusion

The aim of this thesis was to better understand the value orientations of different actors in the Space sector - more often than not influenced by (geo)political tensions – to identify where cooperation or conflicts may emerge and how this may or may not lead the sector's development towards a desired direction. Overcoming the conflicting values among the multiple set of actors and especially the inherent geopolitical tensions is necessary to realize the vision of accelerating sustainable development. For this purpose, the literature on transition studies was reviewed and expanded with insights from international relations as well as and geopolitical approaches in order to identify different value orientations of actors and how they influence the direction of the sector's development. Hence, the following research question was addressed:

RQ: How do the emerging global institutions in the space sector look like, and how do they influence the direction of the sectoral development?

Two case studies in the form of navigation and earth observation services were selected to illustrate the contrasting developments and provide insights into the sector as a whole, thus answering the research question. The comparative approach allowed for drawing a more comprehensive view to better understand the similarities, differences, and patterns between the two cases. To specify the various value interests and conflicts of different actors, this study applied the institutional logics approach to address the problem and bridge the so far largely unrelated literature streams of transition studies and international relations, more specifically, geopolitical and global governance approaches. ESG literature (Biermann et al. 2009) allowed for the contextualization of transition processes of the global Space sector in a broader fragmented global governance structure to better understand the international levels of actor constellations as well as associated cooperation and conflict patterns. The astropolitical perspectives were directly related to logics and value orientations in order to understand value dispositions of different actors in the Space sector and extend or avert the ideal-type basic logics when needed. Value dispositions of different actors were identified by tracing logics in in news, reports, and policy and regulatory documents. Using the socio-technical configuration analysis method (Heiberg et al. 2020; Heiberg &Truffer, 2021), logic-based actor networks were designed based on existing and emerging values in the Space sector. Through Ward clustering, the study could identify different prevailing field logics, which in turn helped to identify potential coalitions and conflicts that influence international cooperative potentials. To answer the overall Research question, three sub-questions were developed:

SQ1: What have been the most important value dispositions among actors underpinning the development of the Space sector over time?

The findings of the study show that that the Space sector has been dominated over time by different value dispositions. The first period of the Navigation case was characterized by a dominant GNSS challenged by the development of new GNSS systems. Most actors in period I adhered to the predominant State National Geopolitics field logic with the goal to strengthen their own national position. In the second period, the actors belonging to the State-Bilateral field logic gained importance. This intermediate phase was characterized by the development phase of most GNSS. Actors such as Russia and China increasingly sought bilateral partners to drive and secure the development of their systems. However, the actors following the logic of State-National Geopolitics continued to influence the field to a great extent, as the main actors continued to pursue the goal of taking the lead in the global competition among the four GNSS. This suggests that geopolitical tensions in the navigation field intensified over time. The last period studied was characterized by the completion of the Galileo and BeiDou, which led to new challenges in the sector. During this period, especially the Market field logic gained importance and is expected to grow further in the coming years as the global competitive position is closely linked to who is more successful on the global application market. It can therefore be assumed that in the next few years, the State National Geopolitics and Market field logics will continue to co-dominate and compete with each other. However, an opposite trend has been observed since the beginning of the period under study in the form of Global Mission Field Logic. Over time, this field logic has gained in importance. Here, the desire for more sustainability, but also by the demand for more multilateral cooperation, is included. Although this field logic is not dominant, it is still present and growing, which is desirable.

The Earth Observation field, on the other hand, is less influenced by the State National Geopolitical field logic and the State-Bilateral field logic. Although national self-interest in particular was part of the value disposition of various actors in periods one and two, market and cooperative interests clearly predominated over time. In the first period, both the Market and Global Mission field logics were co-dominating. The Global Mission field logic is shaped by sustainability-sensitive mission-driven tendencies to cooperate. This logic continues to (co-)determine the entire EO case over time. Earth Observations satellites, as the name suggests, are used to monitor the Earth. It has been recognized that cooperation is a necessary tool to provide emergency assistance but also to monitor climate change. At the same time, however, the EO field has been strongly influenced by market-driven values, with a tendency for an increase in their importance over time. This includes the interest in market growth, e.g., through the support of governments, but also the increasing influence of private players. Based on the value dispositions presented, it can be assumed that the Market field logic and the Global Mission field logic will continue to dominate the field, while other value dispositions will become less important.

SQ2: Who have been the most central actors in influencing the sector's development and how does that change over time?

Over the course of its development, the navigation field went through various phases with alternating dominant players. In general, the development of navigation services is clearly led by the four nation-states. These include the USA, China, Russia, and Europe. In the beginning, the field was clearly characterized by the supremacy of the USA. The US government continued to play a dominant role throughout the sector's development. Over time, however, the US has had its supremacy challenged several times. In the first period, the European Galileo system put pressure on the position of the US. To further participate in the forefront and also benefit from the development, cooperation between those actors was sought. In the second period, the Chinese government published for the first time freely accessible information about its own efforts to develop a global navigation system. China was already involved in the first period; however, it only became a dominating player during the second period. China has secured a strong position in global navigation competition, partly through bilateral agreements but also through BeiDou’s mature technology and is thus clearly in a position to compete with the USA. Moreover, through the BRI initiative, the BeiDou system is finding more and more users and is being applied increasingly at the global level. At the regional level, the Asia Pacific Space Cooperation Organization (APSCO) could be identified as a major player in the GNSS field. The APSCO was founded by China in 2008 and is a formal, membership-only organization headquartered in Beijing, but gained more importance recently when the BeiDou system entered the regional development phase. Bangladesh, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey are the seven members of the APSCO. APSCO aims to promote the export of Chinese space technology and services to gain support in the Asia-Pacific region. Pakistan, for example, became one of the first countries besides China to use BeiDou for military purposes. In addition to the well-known players, the International Committee on Global Navigation Satellite Systems (ICG) is taking on an increasingly prominent role. The UN advocates the role of the ICG and underlines its potential as a role model in the field of international cooperation. The ICG operates at the global level and counts the four core system providers, and the UN member states as members. This gives the ICG an almost a unique position of connecting actors on a global level in the field of global navigation.

The EO field is characterized by contrasting developments. The central role of international initiatives was already apparent in the first period of investigation. These international initiatives/organizations as for example the Group of Earth Observation (GEO) and their Global Earth Observation System of Systems (GEOSS), SERVIR and the International Charter on Space and Major Disasters are important in the overall development of the field as they promote the standardization of disparate data sets from different sources and satellites and data sharing across international boundaries. GEOSS, for example, enables participants to develop a shared vision and includes a broad range of private and public actors with the goal of sharing environmental data (GEO, 2021). In addition, governmental actors and agencies such as the US government, the EU and the NASA, and the ESA, as well as the Copernicus mission, are in the focus of the analyzed media. Many developments in the EO field, especially in Europe, are coordinated and controlled by ESA. ESA is in constant exchange with the national Space agencies on the further development and expansion of the EO field. In addition, it can be seen that private actors are also becoming increasingly important over time. While they play only a minor role in the first period, their influence grows stronger over time. Included are big upstream players like Alcatel Alenia Space, EADS Astrium, and smaller emerging Microsatellite Manufacturers, like Berlin Space Technologies and GomSpace. Additionally, also downstream players like Atos, Building Radar GmBh, Amazon Web Services, or Ursa are included. Those players mostly from the US or Europe, but also private players from Canada, the U.K., and China are playing an increasingly important role.

SQ3: How do the different value-dispositions of actors influence cooperation patterns, and how does that influence the direction of the sector's development in the future?

The contrasting results show that the future global Space sector will consist of very different and partly diverging structures of institutions and, therefore, cooperation patterns, depending on the application focus. The inclination of actors to collaborate differs significantly, based on the affiliation to a certain field logic. However, if actors are sharing similar goals, the possibility for cooperation seems to be higher.

Actors in the navigation field cooperate based on a variety of reasons, such as scientific exchange, improvement of technological competencies, and efficiency, but also for economic and political-strategic reasons. In general, however, two main trends can be identified. First, government actors such as China and Russia cooperate primarily through bilateral agreements in order to expand or stabilize their own national position at the global level. Russia, in particular, was looking for bilateral cooperation to strengthen its position. These include, for example, the cooperation with Kazakhstan to use the Baikonur Spaceport. Later, however, the country entered into a bilateral agreement with China, which was of great advantage for Russia to maintain and expand its technical and economic competitiveness. However, bilateral collaborations have also proven profitable for actors in the Global South, such as Argentina, which has benefited from more than $300 million in investments from the Chinese government to build ground stations. Therefore, the bilateral form of cooperation is usually sought, for example, to achieve technological supremacy, to be competitive, but also because of infrastructural dependencies. Second, there are also collaborations based on multilateral agreements. These types of cooperation are mostly characterized by participation in international organizations/initiatives with the aim of supporting and strengthening the peaceful and sustainable use of Space technologies. These two patterns of cooperation are not mutually exclusive and tend to take place side by side. China, for instance, is strengthening its position through bilateral agreements with a large number of countries, especially with countries participating in the BRI, and, at the same time, has been participating in the ICG for several years. Overall, navigation services are occupied with rather incoherent value dispositions among actors from different countries. The sector therefore faces some major challenges to achieve strong directionality in engendering sustainable development in the future, due to persistent geopolitical differences.

Cooperation patterns in the EO field are mostly different in terms of intensions but also show commonalities. Actors in the field of EO cooperate for various reasons, such as scientific exchange, improvement of technological competencies and efficiency, but also for economic reasons. Two main trends can also be identified in Earth observation. First, Cooperation in the EO field is often based on multilateral agreements. However, these are mostly driven by the intention to support and promote sustainable development. Therefore, from the beginning, it is clear why certain actors cooperate with each other. This mission-driven cooperation facilitates the international pooling of skills, knowledge, and competencies to address climate change and similar challenges, for example in countries of the global south. Therefore, this form of cooperation shapes collective priorities, including, for example, an open data policy. Second, In addition to mission-driven collaboration for environment related issues, patterns of public-private partnerships continue to grow. They represent the desired form of cooperation in many areas, as public actors can thus keep pace with the rapid technological development of the private sector. Overall, this study found that the EO field consists of more aligned value orientations among different actors across countries as compared to the navigation field. The EO field, therefore, projects stronger directionality in maximizing its potentials to accelerate sustainable development in the future, with presence of similar collective priorities and substantial international cooperation.

7. Discussion

This final section will first discuss the theoretical implications drawn from this study. This is followed by a reflection on the methodology used. Next, the quality criteria and limitations of this study are discussed. Finally, policy recommendations are provided based on the findings of this study, and possible implications for further research are drawn.

7.1. Theoretical implications

This thesis has made several contributions to the theoretical development of transition studies, specifically on the empirical approach and the linkage to the former rather unrelated schools of thought, i.e., international relation, more specifically geopolitics and global governance literature. First of all, this study is one of the firsts to apply the institutional logic approach to the Space domain, expanding the current range of topics such as the transformation of energy, water, or urban systems. Most contributions on shaping, managing, or governing transitions have focused primarily on domestic politics and domestic institutional contexts. However, this study is characterized above all by an innovative approach that expands transition studies to include dimensions of international relations and geopolitical research and takes a new progressive approach in analyzing transitions on a global level. Thus, to bridge this gap between the different theories, the institutional logic approach was used. Using geopolitical and governance insights to enrich the institutional logic approach, this study was able to identify new field-logics many actors in the Space domain adhere to. This enabled the political dimensions of transition studies to be uncovered and extended to a global level while at the same time seeing the national dynamics. The contextualization of governance fragmentation was helpful to understand the international levels of actor constellations as well as associated cooperation and conflict patterns. Therefore, this study takes a new, progressive path that is seen as very promising for informing future transition research.

Following Heiberg & Truffer (2021), the analysis of socio-technical alignments and field logics based on network topologies allowed for a better understanding of the (mis-) alignments between actors and institutions in the sector. Therefore, combining insights of the institutional logics approach, the analysis of value dispositions and the identified field logics could help understand the development of the sector. Through the visual mapping of actor-networks, it was possible to identify actor groups based on similar interests or value orientations, thereby allowing for a better understanding of the cooperation patterns in the sector. Thus, t The analysis of different time phases shows how the evolution of field logics shape the direction of a sector’s development over time.

7.2. Quality indicators, limitations, and further research

The quality of the research has been ensured by assessing the four quality criteria based on Lincoln and Guba's (1985) findings for a qualitative research design. First, credibility was assured by relying on various data sources in the form of newspaper articles, government documents, and triangulation with other relevant secondary data that has not been included in the STCA analysis, such as some latest news reporting on the sectors. In addition, the triangulation of the data was supported by the supervisor, Dr. Xiao-Shan Yap, who has experience in the field of transition studies, is familiar with the case of Outer Space and has contributed to the development of the STCA method.

For internal validity, the study involved back and forth revisions of the coding scheme, with close monitoring by the supervisor through multiple checks and discussions. To ensure transferability, in quantitative research designs also referred to as external validity or generalizability (Sale & Brazil, 2004), the coding scheme and the list of documents analyzed is provided in the appendix so that readers can assess whether the results are transferable to other settings. However, because the coding scheme was built for the purpose of this particular study, it is possible that a replication of this study would yield a slightly different result.

A potential point of criticism is the database used to collect the data. LexisNexis includes a wide range of news and government reports, but many news sources, for example, from other regions or in other languages, are not included. Therefore, in the next step, future studies could benefit from data collection by other sources and in the form of interviews. Moreover, the proposed approach of combining transition studies, international relations, and geopolitics of Space and analyzing the results from such a perspective is still new and needs to be more thoroughly clarified and empirically tested in further studies. Moreover, while this study mainly used transition studies and expanded it by astropolitical approaches, it would be important to include global governance perspectives in future studies, given that the Space sector is facing major governance challenges (as presented in section 4 and Appendix E). This study already pointed to the shortcoming of hard law mechanisms and the chances of soft laws. Examining the governance architecture would bring light in still open questions and expand the used approach. Since the Space sector is a rather unique case as compared to other transitions studies, it is expected that the transferability/ generalizability of this study is quite mainly limited to geopolitically driven fields. However, this means opening up some new important topics and issues to transitions studies, such as the increasing geopolitical tension in the global digital world, new energy resources, etc., all of which can be important to enhance our understanding on sustainability transitions. The study has ended by providing some expectations about the future development of the sectors. Although those are rather speculative expectations, they are based on solid understanding of value orientations of core actors in the sector derived from the analysis of the study. Additionally, the use of two case studies represented only a part of the Space sector and cannot be generalized to the entire Space sector. However, the two extreme cases still allow to cover the spectrum of possibilities concerning geopolitics in transitions. The STCA (Heiberg et al., 2020; Heiberg & Truffer, 2021) provided many insights into a value-based structure of a sector, revealed potential actor coalitions and enhance our understanding on cooperation patterns. The application of the methodology to other sectors should therefore be further explored in future research.

7.3. Policy implication

Therefore, the approach presented in this study can be considered very promising and enables future transition research to include critical international political dimensions. The methodological approach was an important factor in the success of this study. The network analysis allows capturing the alignment of various value interests/ orientations among different actors, as well as potential conflicts. This type of analysis provides a very good tool to support policymakers in their policy development. The visual representation of the actors and their logic affiliation facilitates information-based decision-making. The study showed that for the EO sector, particularly, strong vision and commitment from policymakers are needed to engage stakeholders through a common ambitious goal. This is a bit more challenging in the navigation area. Due to the tense geopolitical situation and the striving for political and technological supremacy in Space, it can be concluded that this area will continue to raise security concerns to some states in the future. The reveal of actor coalitions based on clustering of value orientations may help inform about how to effectively design policies that foster multilateral cooperation and agreements, all of which are crucial to align future development of the sectors towards contributing to sustainability transitions.

In terms of global governance of the Space sector, it is essential to revisit the existing soft & hard law mechanisms in the future and to adapt them to the current situation, at least to the extent that there is less room for maneuver in the interpretation of the content of the law and new dynamics such as the increase of private actors as well as changing responsibilities. At the same time, the participation of private actors as well as nation states in international organizations as the ICG and others should be supported further. This may help to also frame the use of PNT technologies for sustainable purposes. The analysis revealed that navigation technologies had received little attention in the context of sustainable development as only a few articles and documents dealt with the use of navigation data for such purposes. Other than in the EO case, sustainable development was rarely addressed in the Navigation case and if so, without further details. In the future, the support of measures that identify and reveal the potential of navigation satellites will help maximize the potential of the technology.

In addition, upstream and downstream industry development, in particular, will play a significant role in the coming years. The EO market has developed very rapidly in recent years. Particularly in the field of EO, the upstream market segment and associated competencies are increasingly being carried out by private entities. However, also investments in Downstream applications seem to be very promising. The focus of many private companies on satellite data collection, but also on making the data usable, is essential so that different actors in different roles can make use of this data. The main challenge will soon be to make the data from different data sets compatible and enable uniform processing and interpretation. In addition, data policies are an important factor in driving the sector forward. Open Data Policies are becoming increasingly important and challenging for the commercialization of EO data. The same applies to the use of data in the navigation sector, which faces more challenges in widespread commercialization as compared to the EO sector due to strong geopolitical tensions.

8. References

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Appendix A: Coding Scheme of Institutional Logics for the Navigation Case

	Sub-Logic	Conceptual Description	Example
Market	Market Development	Inspired by common economic theories as neoclassical Economics The Market development Logic centers around the influence of governments and private players and their ability to influence industry development. Processes driven by this logic are focused on achieving market growth, economic welfare, and wand to enhance the market's future development. (ROLE Government mainly)	*Downstream application to speed upRan indicated that in terms of the application promotion, China will develop a new generation Beidou/GNSS products and promote their application in the public market with 100 million yuan. The downstream application is a bottleneck in the BDS industry.*
	Market Competition	Economic Competition between actors. Different state and non-state actors compete to gain a more significant market share.	*However, some European defense firms are likely to refrain from selling weapons to China in order not to risk jeopardizing their ability to compete in the U.S. defense market, which is the largest in the world*
State	Self- Interest (including national technology supremacy, national security interests, …)	Inspired by Neo-classical Astropolitics. The sector becomes a sphere dominated by power and interest. Consequently, states exist within an anarchic international system in which they ultimately depend on their capabilities or power to promote their national interests (Waltz, 1979; Dolman, 1999). National interests are driven by the wish for independence, power, security, and domestic welfare in general.	"*The US has been using its national power to suppress China's technology rise. What if the US suspends GPS service to rising economic powers, just like it ordered Google to cut Android supplies to Huawei? What if GPS sends wrong signals to disrupt normal economic activities?" an industry insider said.*
	Bilateral/ Geopolitical (including bilateral interests for cooperation, mainly due to economic or political strategic reasons)	Inspired by Neo-classical Astropolitics. Sovereign territorial states expand their power position through bilateral cooperation. Developing dominance as a goal, given that space is considered a crucial source of geopolitical interests and a symbol of technological superiority. Therefore, the actors will seek partners with complementary technology capabilities, contributions to critical path technologies, and infrastructure components.	*This is because she, like many other people in the Arab world, sees the huge potential and opportunities provided by the growing space cooperation between China and the Arab states. The two sides are jointly building a "Space Silk Road" led by the BDS application within the framework of the Belt and Road Initiative (BRI) proposed by China in 2013*
(Multilateral) Cooperation	Promoting Multilateralism (including interests for multilateral collaboration e.g. to support scientific collaborations)	Inspired by Liberal Astropolitics and Astroeconomics States choose and design institutions to encounter collective action problems that can be solved through institutional arrangements. Promoting institutional cooperation among space powers is a way to promote peace as a form of co-binding practices. Hegemony is thus a danger that must be avoided through cooperation (Deudney, 1983, 2002).	*China advocates international cooperation in the development of satellite navigation and stands ready to share achievements with other countries, formulate standards and promote the application of satellite navigation systems worldwide in order to provide an impetus for global economic growth, Liu said.*
	Cooperation for Sustainable Development	Similar then "*Promoting Multilateralism*" but additionally clearly mission driven. Sustainable Development as a goal and reason to collaborate. Use of Space technologies to achieve sustainable development of Earth together.	*The protection of such areas was directly linked to climate change, he said, emphasizing the need for cooperation in helping to prevent the rise in global temperatures, as provided for in the Paris Agreement on*

			climate change.
Sustainable Development		Awareness that countries and other actors can leverage space and space technologies to achieve Sustainable Development and manage social and ecologic challenges.	*The EU supports a number of new initiatives for technological cooperation and development in the space sector, to secure the achievement of global sustainable growth.* *Space technologies, infrastructure and services could play a positive role in the developing world to favor sustainable development and growth, to facilitate good governance of resources and to contribute to the implementation of policies in various fields such as food security, health and education, not to mention the important role they can have in disasters management and climate change adaptation.*
Science (professional)		The logic of science focuses on aspects such as competence and reputation, research quality, and the development of new technologies.	*China encourages and supports the construction and development of key laboratories for satellite navigation application technologies, research centers of engineering (technology), technology centers of enterprises, and other innovative bodies, enhances the capacity of engineering experiment platforms and achievement transformation platforms, supports relevant enterprises, and makes more efforts to protect intellectual property rights, so as to form a technology innovation system which relies on the enterprise as the main body and combines the efforts of universities, research institutes and application.*
Governance & Regulation		Space is a construct of legal mechanisms and decision-making procedures for initiating political processes and instances that affect peace and security and social and economic development	*She further stressed that space exploration and uses should be conducted within a legal framework and that efforts should be made to close the gap in the existing legal regime.*

Appendix B: Coding Scheme of Institutional Logics for the EO Case

Main Logic	Sub-Logic	Description	Example
Market	Government supports Market Development	Governments can influence the sector through monetary and fiscal policies, subsidies, and taxes to encourage greater market development.	*Following substantial financial efforts, the EU has become a global player in terms of space-based earth observation and navigation services. But these services are not yet used widely enough in the EU internal market', said Mihails Kozlovs, the member of the European Court of Auditors responsible for the audit.'Our audit will determine in particular if the European Commission's promotion measures have been effective in maximizing the benefits of this public investment for EU taxpayers and the economy as a whole.*
	Private Players drive Market Development	"New space" entrepreneurs and SMEs profit from upstream and downstream space businesses and influence the growth of the space industry	*"Over the past couple of years, SkyWatch built key enabling technologies for the future of Earth Observation capture and distribution. Today, we are excited to announce that we'll be able to commercialize and scale that technology globally, thanks to the closing of our Series A financing," said James Slifierz, SkyWatch's CEO and cofounder.*
State	Self-Interest (including national technology supremacy, national security interests, …)	Inspired by Neo-classical Astropolitics. The sector becomes a sphere dominated by power and interest. Consequently, states exist within an anarchic international system in which they ultimately depend on their capabilities or power to promote their national interests (Waltz, 1979; Dolman 1999)	*The major enthusiasm in the Middle East for Earth Observation is a new development, be it for civil, governmental, or military purposes. The first country to make the move in high resolution will become the envy of its neighbors, generating a strong demand for these services in the region.*
	Bilateral/ Geopolitical (including bilateral interests for cooperation, mainly due to economic or political strategic reasons)	Inspired by Neo-classical Astropolitics. Sovereign territorial states expand their power position through bilateral cooperation. Expanding dominance as a goal, given that space is considered a crucial source of geopolitical interests and a symbol of technological superiority. Therefore, the actors will seek partners with complementary technology capabilities, contributions to critical path technologies, and infrastructure components.	*In order to strengthen the relationship between the U.S. and India in civil space cooperation, the Joint Working Group continues to serve as a useful mechanism to endorse proposals for enhanced cooperation, promote understanding of government policies and procedures, and facilitate collaboration by addressing issues promptly.*
(Multilateral) Cooperation	Promoting Multilateralism (including interests for multilateral collaboration e.g. to support scientific collaborations)	Inspired by Liberal Astropolitics and hybrid Astropolitical Approaches States choose and design institutions to encounter collective action problems that can be solved through institutional arrangements. Promoting institutional cooperation among space powers is a way to promote peace as a form of co-binding practices. Hegemony is thus a danger that must be avoided	*GEO is an Intergovernmental Partnership of 111 countries and coordinates over 60 global activities in the GEO Work Programme. GEO's mission is to inform decision making and enable better policies through open Earth observation data, information and knowledge. The GEO network will ensure that the beneficiaries receive support as they deliver data, insights and key findings to reach critical decision makers across the globe.*

		through cooperation (Deudney, 1983, 2002).	
	Cooperation for Sustainable Development	Similar then "*Promoting Multilateralism*" but additionally clearly mission driven. Sustainable Development as a goal and reason to collaborate. Use of Space technologies to achieve sustainable development of Earth together.	*In fact, during the Rio+20 United Nations Conference on Sustainable Development in Brazil in June 2012, delegations from around the world specifically recognized the importance of space-technology-based data and reliable geospatial information for sustainable development and recognized the need to support developing countries in their efforts to collect environmental data.*
Sustainable Development	Social Development	Awareness that countries and other actors can leverage space and space technologies to achieve the Sustainable Development and related to the big social challenges today.	*Space assets can be utilized to provide access to all levels of education to students that might not otherwise have access. African nations are working with other nations around the world to provide a variety of tele-education services by connecting leading African and foreign universities to remote classrooms.*
	Sustainable Development (Ecologic)	Awareness that countries and other actors can leverage space and space technologies to achieve the Sustainable Development and manage ecologic challenges.	*The network of satellites upon which the United States and the world have relied for indispensable observations of Earth from space is in jeopardy. These observations are essential for weather forecasting, hurricane warning, management of agriculture and forestry, documenting and anticipating the impacts of global climate change, and much more.*
Science (professional)		The logic of science focuses on aspects such as competence and reputation, research quality, and the development of new technologies.	*"Science data from space allows us to better see and understand our planet. The Canadian Space Agency is encouraging researchers, industry and all Canadians to develop creative applications using this data; applications that will improve our lives on Earth and advance our knowledge of the issues impacting our planet.*
Governance & Regulation		Space is a construct of legal mechanisms and decision-making procedures for initiating political processes and instances that affect peace and security and social and economic development	*Perhaps one of the most beneficial actions we can take for ensuring sustainability and security in space would be adopting of an International Code of Conduct. The United States is working with the European Union and other nations to develop an International Code of Conduct for Outer Space Activities*
Community		The logic of community is driven by different principles such as the unity of will, ideology, emotional attachment, group membership, strong focus on community-based values and arrangements as well as a belief in trust and reciprocity	*"The EDRSSpaceDataHighway offers a new dimension of data access from our Sentinel satellites, allowing faster access to images as well as a back-up capacity to classical ground receiving stations. This becomes increasingly important to satisfy the increasing demands of our user communities," says Josef Aschbacher, ESA's Director of Earth Observation Programmes.*

Appendix C: Coding Scheme for additional Aspects in the Navigation Case

Approach	Main Concept	Sub-Concepts II	Sub-Concepts III	Times coded	Explanation
International Relations	Conflict	UK vs EU		9	*Main identified Conflicts between main Actors*
		USA vs. China		23	
		USA vs. EU		9	
	Cooperation	Dependence on private companies		3	
		Domestic Strategy and political Motivation		53	
			Dependence	24	
			Improvement International Relations	23	
			Power Alliances	33	
		Economic Benefits		36	
			Better Competitive Position	25	*Reasons for different Actors to cooperate*
			Better Trade relations	4	
			Financial Support	2	
			Market Development	24	
			Resource Sharing	18	
		Infrastructure		74	
		Personal Training		18	
		Scientific Exchange		61	
		Tech. Benefit, Improved Efficiency		101	
	Cooperation & Conflict Dimensions	Conflict Potential	Knowledge Spillovers	12	
			Security Risks	43	*When conflicts arise --> Why*
			Signal Structure and Interferences	33	
			Space Race	23	
		International Cooperation	Anti-Militarization	4	
			Dependence	25	
			Extension Ground Infrastructure	18	
			Peaceful exploration and usage of space	15	*What leads to international Collaboration*
			International Usage and Acceptance	35	
			Power Alliances	35	
			Strengthening International Cooperation	35	
		Legal Needs	Legal framework necessary		
			Need for standardization		*Are there any legal Needs, If yes, which and why?*
			Regulation & Governance Needs		

Level of Competitiveness	International Industry Leadership	Strategic / Tech. Weakness	Inefficient funding	2	*Weaknesses compared to others*
			Lack of Competitiveness	14	
			Lack of Time	1	
			Lock in	4	
			Tech. Falling behind	39	
		Tech. Trajectories/ Applications	Agriculture	22	
			Civil Use	52	
			Commercial Use	41	
			Damage & Disaster Management	8	
			Geospatial Function	19	*Application area of different GNSS, what can PNT technologies do?*
			Military function	58	
			Security Function	29	
			Safety for Life	12	
			Transport Sector	30	
			Use for sustainable Development	55	
			Use for digital Applications	7	
		Tech. Trajectories/ Characteristics	Complementary GNSS	7	
			Global Coverage	40	*How do different GNSS stand to each other, when did they reach global coverage*
			Interoperable GNSS	78	
	Legitimacy	Legitimacy by state	Mandatory national use	17	
			National Security	37	
			Need for Investment (Security Risks)	14	*GNSS are a tool in order to increase the own power position, Support the wish for security and independence*
			Power in Space	33	
			Strategic Independence	71	
			Upgrade military Capabilities	27	
			Upgrade National Space Infrastructure	58	
		Market & Economic Development	Domestic Downstream Industry Development	73	
			Educational Training	6	
			Foreign Industry Development	26	
			Foster R&D	11	*GNSS should be used to support the market development and strengthen the own economic position*
			Increasing market Potential	20	
			Need for Investment (Competitive Advantage)	50	
			Private Firms as drives/ leaders	48	
			Upstream Industry Development (Domestic)	10	
		Sustainable Development on Earth	Addressing Environmental Problems	12	
			Social Development	17	
			Supporting Developing Countries	39	*GNSS should be used to*

			Sustainable Development	19	*increase and support sustainable Development on Earth*
Institutional Theory	Institutions	Formal Institutions	Bilateral Agreements	89	*All formal Institutions, Actors entered, based on different reason (see Reasons to collaborate)*
			MoU	9	
			Multilateral Agreements	14	
			BRI	36	
			Treaties	7	
		Informal Institutions	Logic Cooperation for Sustainable Development	27	
			Logic Promoting Multilateralism	56	
			Logic Governance & Regulation (legal)	32	
			Logic Market Competition	33	*By which Logic are different Actors guided*
			Logic Market Development	83	
			Logic Science	29	
			Logics geopolitical (Bilateral)	138	
			Logic National Self-Interest	192	
			Logic Sustainable Development	32	

Appendix D: Coding Scheme for additional Sspects in the EO Case

Approach	Main Concept	Sub-Concepts II	Sub-Concepts III	Times coded	Explanation
	Cooperation	Strategic Preferences for cooperation	Changing Role of the Government	23	*When entering a cooperation agreement, what is the strategic preference of working together (especially when private and public actors collaborating)*
			Dependence on Private Companies	30	
			PPP	30	
			Public / Private Funding	14	
		Cooperation Dimensions	International Usage	2	*Different Dimensions on how cooperation agreements are focusing*
			International collaboration	12	
			Need for international Collaboration	10	
			Inter-Agency collaboration	14	
			Third parties	6	
		Reasons for Cooperation	Market development	20	*Reasons why actors collaborate*
			Scientific Exchange	19	
			Resource Sharing	9	
			Personnel Training	8	
			Tech. Benefits, Improved Efficiency	8	
			Infrastructure	6	
			Dependence	9	
			Domestic Strategy & Political Motivation	4	
Tech Dimension	Use Of EO Data / Industry Leadership	Sectoral Transformation	Accessibility of data	88	*Tech. possibilities stemming from EO and EO Data → Changing the sector*
			Data Acquisition	27	
			Develop Expertise EO	9	
			Digital Transformation	7	
			Foster R&D	13	
			Global Coverage	3	
			Tech. Leadership	36	
			Technologies are getting smaller, cheaper	27	
			Data Platform	22	
		Application	Agriculture	55	*The use of EO Data*
			Civil Use	8	
			Commercial Use	46	
			Emergency Services	76	
			Forestry	16	
			Geospatial function	14	
			Industrial Use	14	
			Insurance & Finance	8	
			LBS	3	
			Marine Use	15	

			Military Function	26	
			Scientific Use	20	
			Transport	4	
			Urban Usage	12	
			Use by Defense Authorities	16	
			Monitoring Climate Change	92	
			Forest Carbon Tracking	5	
			Biodiversity Observation	7	
			Understand how the Planet functions	15	
			Resource usage and scarcity	10	
			Wildlife protection	2	
			Essential Climate Variables	13	
			Social use	56	
			Land monitoring	16	
			Support SDGs	7	
			For decision making industry related	15	
			For decision Making Social benefit	71	
		Data related Challenges			
			AI for better transformation	20	
			Big amount of data	43	
			Free of charge	27	
			fast data transfer	21	
			Activities by user	13	
			Gaps in Quality and Continuity	13	
			Interpretation of data	9	
			Knowledge /Skills development	25	
			Need Interoperability Data sets	10	*Challenges related to the usage of EO data*
			Flexibility and Robustness	16	
			Open Data	25	
			Privacy Issues	1	
			Transformation of data into useable insights	55	
			Up to now information	22	
			Need for Data solutions	1	
			Need to restore EO-capabilities	6	
			Data Sharing	21	
			need for maintenance	4	
	Legitimacy	Legitimacy by state			
			Civil Security	31	*EO as tool to increase the own power position, Support the wish for security and independence*
			Building Resilience	4	
			Strengthen Conflict Prevention	4	
			Showing off capabilities	1	
			Strategic Independence	11	

			Upgrade National Space industry	30	
		Market/Economic Legitimacy	Private firms as drivers/leaders	90	
			Domestic Market development	27	*EO should be used to support the market development and strengthen the own economic position*
			Need for Investment Competitive Advantage	29	
			Market Growth	22	
			International Market development	3	
			EO as Investment Opportunity	16	
			Need for governmental Support	8	
		Sustainability Dimension	Support of developing Countries	23	*EO should be used to increase and support sustainable Development on Earth*
			Need for Investment Sustainable Development	10	
	Institutions	Formal Institutions	African Space Strategy	1	
			Bilateral Agreements	20	
			Contracts with Private Players	32	*All formal Institutions, Actors entered, based on different reason (see Reasons to collaborate)*
			MESA Initiative	4	
			MoU	4	
			Multilateral agreements	5	
			Policy for free data sharing	14	
		Informal Institutions	Logic Community		
			Multilateral Cooperation for sustainable Development	77	
			Promote Multilateralism	17	
			Logic Governance & Regulation (legal)	5	
			Government supports Market Development	62	
			Private Players drive Market development	86	*Logic to which different Actors adhere*
			Logic Science	51	
			Logic State [Self-Interest]	58	
			Logic Geopolitical (bilateral)	5	
			Logic Social Development	20	
			Logic Sustainable Development (ecologic)	44	

Appendix E: Review Hard & Soft Institutions

Global Space Governance

As with global governance, global space governance consists of legal mechanisms such as norms, rules, institutions, and decision-making procedures to initiate political processes and entities that affect peace and security as well as social and economic development (Biermann et al., 2009). Besides formal governance mechanisms, which can also be defined as hierarchical institutions with legitimacy to execute mandatory laws, there are also informal governance mechanisms, in particular informal codes of conduct, informal agreements of standards of conduct, and private-public agreements (Patrick, 2014).

Global space governance essentially emerged with the establishment of international law and international organizations in the 20th century, associated with the emerging space activities in the 1960s (Jakhu & Pelton, 2017). International law and global governance were initially made by and between independent states, but over time evolved to include non-state actors to create, change, and end the norms, rules, and institutions (Jakhu & Pelton, 2017).

The current existing global space governance system focuses not only on physically located activities in outer space. Activities in space will remain in the foreseeable future, terrestrially contextualized (use of space technologies related to the application on earth), thus dependent on national governments, international organizations, and other actors on Earth (Jakhu & Pelton, 2017). The global public interest in outer space, which focuses on the exploration and use of outer space for the benefit and in the interest of all states, regardless of their level of economic or scientific development, needs to be guided by international law, including legal mechanisms and political processes (UNGA 1962 (XVIII); Outer Space Treaty; Jakhu & Pelton, 2017).

Nowadays, space governance is still characterized by a mix of international agreements adopted during the space race between the US and Russia in the 20th century (bipolar setting). Most treaties and resolutions (Table 1) were set up by the General assembly, which established the UNCOPUOS. The committee was created one year after the launch of the first Sputnik satellite. Both the United States and the Soviet Union considered an international body necessary to provide the legal framework for the use and exploration of space. In addition, non-binding principles and guidelines were created by other international organizations to address specific issues as they emerged. However, the sector evolved after the space race and is no longer bipolar but multipolar. Many state and non-state actors with opposing interests entered the field and played an active role in shaping the space sector. Today, there are several UN bodies involved in space governance; however, due to the fast progressive development of the sector, they have become less and less effective (Jakhu Pelton, 2017).

Hard Law- in Space: Summary of the Existing Five U. N. Space Law Treaties

A major part of international space law is the result of the Cold War and the fear of being left behind in the race for space (Quinn 2008). Since then, several states and international organizations, as the United Nations, consistently advocate new binding instruments. However, the five treaties (*table p. 101*), developed by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) between 1967 and 1979, are still the only hard laws, there sector is dependent on and were established over thirty years ago. While some of these treaties are referred to as “agreements” or “conventions,” there is no difference between these terms under international law, as they are all legally binding treaties (Jakhu & Pelton, 2017).

Treaties act like international contracts between states and are binding because those states, by signing and ratifying them, formally agree to their terms (Jakhu & Pelton, 2017). If a state breaches a treaty, any other state that is a party to the treaty can bring a claim to the International Court of Justice without having to prove harm, since some obligations contained in the five space treaties could be considered obligations to the international community as a whole *[Articles on State Responsibility, art. 42(a)].* One of the weaknesses of this regime, however, is that there are very few enforcement mechanisms, except economic and trade sanctions or political pressure, mainly through the United Nations (Jakhu & Pelton, 2017).

However, the legal regime of space was not updated since different international actors and states were not successful in negotiating new treaties as some other States have become less willing to subject themselves to new binding norms (Urban 2016, Freeland, 2011). Already the key treaties were not signed or ratified, especially by many non-space faring countries. An additional difficulty arises due to the difference between international and national law. For individual states, their federal laws should be consistent with international treaties. If this is not the case, the state must decide whether to follow national or international law, which might lead to conflicts. Without the implementation of international laws into the national laws of individual states, treaties have been argued to be an insufficient mechanism to ensure stability in space (Urban, 2016).

Nevertheless, the Outer Space Treaty and the four other, more specific multilateral treaties form the basis for space law we have today. The next subchapters shortly discuss their content, acceptance, weaknesses and strengths, followed by the need for soft law.

<u>*The 1967 Outer Space Treaty*</u>

Based on the non-binding United Nations General Assembly (UNGA) Resolution containing the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space in 1962 the UNCOPUOS adopted the Outer Space Treaty in 1967. This treaty contains the core legal principles governing space activities and is regarded as the corner stone of international space law, signed by 104 state parties, which mirrors the board international participation (Jakhu & Pelton, 2017). As such, it establishes a set of seventeen fundamental principles that provide the basic framework for the exploration and use of space which can be summarized as follows (Qizhi, 1997):

1. *The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interest of all countries.*
2. *Outer space shall be free for exploration and use by all states on a basis of equality.*
3. *Outer space shall not be subject to appropriation by claim of sovereignty, by means of use or occupation, or by any other means.*
4. *Activities in the exploration and use of outer space must be carried out in accordance with international law, including the Charter of the United Nations in the interest of maintaining peace and security.*
5. *No nuclear weapons or any other kind of weapons of mass destruction shall be placed in orbits of the earth.*

6. *The Moon and other celestial bodies shall be used by all state parties to the treaty exclusively for peaceful purposes.*
7. *Astronauts shall be given every possible assistance.*
8. *State parties bear international responsibility for national activities in outer space.*
9. *State parties keep jurisdiction and control over launched objects and personnel recorded in their register.*
10. *State parties shall avoid harmful contamination of outer space, celestial bodies and the environment of the earth, and shall consult with other state parties regarding potential harmful experiments.*
11. *The UN Secretary-General must be informed about space activities and shall disseminate such information to the public and the international scientific community.*
12. *International cooperation and understanding are to be promoted.*

Although the articles of the treaty cover a range of topics, they essentially govern the use, occupation, and appropriation of outer space with the primary goal of preventing any claims of sovereignty in space and on celestial bodies (Quinn, 2008). The treaty is challenged by various interpretations by different actors. One such example is one of the core principles of the Outer Space Treaty, namely the use of the Moon and other celestial bodies for peaceful purposes. There is an ongoing debate about whether this should be interpreted in terms of "exclusively non-military purposes" or only "non-aggressive purposes", which means that for the latter one, military activities could be included (Jakhu & Pelton, 2017). Given that most satellites today are dual use, with both military and civilian purposes, it cannot be said that states do not act militarily in space (Hurewitz, 1994). Because of these different interpretations of the "Outer Space Treaty," also the phrase "common heritage" has been interpreted in different ways. While non-space actors typically interpret this proposition to mean that space, all of its resources, and all of its resulting benefits should be equitably distributed, for space actors the proposition simply refers to space exploration with no limitations (Quinn, 2008). In addition, the treaty only addresses state actors and has not been updated regarding the responsibilities of commercial and other non-state actors. With the increasing number of government and private stakeholders, the space economy is changing at an accelerating pace, leading to more and more pressure on the quality of the treaty as a governance tool.

The 1968 Rescue Agreement

The Rescue Treaty, with only 10 articles is the shortest of all treaties. It has been ratified by 94 States and amplifies Article V of the Outer Space Treaty and addresses "concerns of international cooperation and humanity" by creating procedures for the return of both astronauts and space objects to their sovereign nation (Quinn, 2008). The goal of this treaty is to ensure that astronaut safety takes precedence over competition between nations and to promote cooperation and mutual assistance in the recovery of space objects (Jakhu & Pelton, 2017). In front of recent developments however, it is questionable if "space tourists" will fall under the same special designation, as there is no definition of "astronaut" in any of the core space treaties.

The 1972 Liability Convention

In in 1972, the Liability Convention was adopted by COPUOS to address the Liability for damage caused by space objects. Up until today, the Liability Conventions has 92 state parties and further 21 states as signatories. When damage is caused on Earth by an object in space or formerly in space, under the Liability Convention, the state that launched the object is presumed liable - even if it had no hand in bringing about the damage. The convention was designed to build upon the terms of the Outer Space Treaty and broadly defines “damage” as “*loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organization*s.” (UN GA, 1972).

The Liability Convention imposes a simple regime of strict liability with no dispute about who is legally responsible for harm under the regime. However, the treaty is strongly criticized due to the blindness to the possibility of intervening acts and its consequent misattribution of responsibilities (Kehrer, 2019). This is from particular importance in the light of increasing private and commercial space activities (Trepczynski, 2007).

The 1974 Registration Convention

The fourth treaty, prepared by the United Nations COPUOS, has 63 states as parties and four signatories and elaborate the Articles V, VIII, and XI of the Outer Space treaty and addresses issues relating to state parties’ responsibilities concerning their space objects and information for registration of launchings (Pečujlić, 2020). Article VII of the Outer Space Treaty refers to national registries for objects launched into space to identify the state that has jurisdiction over such an object to trace liability, control, as well as return astronauts and salvaged space objects (Jakhu & Pelton, 2017). Such information is needed to safely plan launches and entry into orbital slots, which is especially necessary since the increased traffic and the existence of space debris (Jakhu & Pelton, 2017). However, the national disaggregation of registries is difficult, as various differences in the design of registries exist at both the national and international levels, making comparability difficult. In addition, compiling information can be problematic because the units of measure for time and distance are different in each national record. There is only a general requirement to register the purpose of a spatial object. Another problem occurring with the increasing commercialization of space is the changing ownership after the launch, which indicates that the launching actor might not be the one who has control or jurisdiction over it (Schrogl & Davies, 2002).

The 1979 Moon Agreement

The 1979 Moon Agreement is the last of the five UN space treaties with the smallest number of participants and the most negligible impact. 18 states are parties, and only four states are signatories. The treaty reaffirms and elaborates on many of the provisions of the Outer Space Treaty applied to the Moon and other celestial bodies. It states that those bodies should be used exclusively for peaceful purposes, that their environments should not be disrupted, and that the United Nations should be informed of the location and purpose of any station established on those bodies. Additionally, it states that the Moon and its natural resources are the common heritage of mankind and that an international regime should be set to govern the exploitation of such resources when such exploitation is about to become feasible (UN, 2021). The treaty has received increased attention recently due to advances in national legislation regarding the rights of private commercial companies to mine the Moon or asteroids and make profits from such activities (Jakhu & Pelton, 2017). However, it appears that the national legislation of a few spacefaring nations is currently the driving force behind any regime encouraging economic activity in space mining (Nelson, 2011). Therefore, there is a distinct risk that the global governance system is failing here by disregarding Article 1 of the Outer

Space Treaty, which states that the benefits of space exploration should be shared for the benefit of all nations and that the exploration and use of space, including the Moon and other celestial bodies, should provide services to all humankind (Jakhu & Pelton 2017; UNGA, 1967).

Soft Law mechanisms in Space

To handle this regulatory void of hard law, the number of non-binding "soft law" norms created by a wide range of entities increased drastically (Freeland, 2011; *see table 1*). Typical soft-law instruments can occur in different forms as for example declarations, resolutions, guidelines or standards of conduct (Boyle 2006). Some actors, including the United States and the European Space Agency, have incorporated some of these policies into their national laws. Although they are not binding, they were often intended to serve as guidelines for later international treaties (Urban, 2016). There are several explanations for why these soft laws were never converted into treaties (Urban, 2016).

One reason is that the United Nations Legal Subcommittee has not created new binding laws because many countries did not support new treaties on the subject. Another argument is that soft laws are used to help translate new issues into already existing treaties. Many soft law instruments as for example the Resolution on the guidelines related to space debris mitigation (2007) and the Safety framework for Nuclear Power Source Application in Outer Space (2009) assist in interpreting articles of the Outer Space Treaty. Thus, soft laws and treaties can interact in a complex regulatory framework (Boyle, 2006).

Since drafting treaties requires a lot of compromises, time, discussion, and power, the need for new treaties needs to be reviewed constantly. On the other side, the great advantage of soft laws is that they create technical standards in a particular area without having to go through the hard law-making process. By creating regulatory standards and recommended practices, stakeholders can further develop and expand already existing soft laws (Freeland, 2011; Urban, 2016). Today, coordination and cooperation is mostly designed by those kind of non-binding guidelines and codes of conduct. Therefore, the existing space law is characterized and refined by soft-law instruments (Nadarajah, 2020).

Year	**Hard Law (HL)** **Soft Law (SL)**	**Agreement/ Resolution/ Treaty**
1962	S.L.	UNGA Resolution containing *Declaration* of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space. *[Basis for Outer Space Treaty 1967]*
1967	HL.	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other celestial Bodies *(Outer Space Treaty)*
1986	HL.	Agreement om the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Autor Space *(Rescue & Return Agreement)*
1972	HL.	Convention on International Liability for Damage Caused by Space Objects *(Liability Convention)*
1975	HL.	Convention on Registration of Objects Launched in Outer Space *(Registration Convention)*
1979	HL.	Agreement Governing the Activities of States on the Moon and Other Celestial Bodies *(Moon Agreement)*

1982	SL.	Resolution on *principles* related to satellite TV broadcasting
1986	SL.	Resolution on *principles* related to satellite remote sensing
1992	SL.	Resolution on principles related to nuclear power sources
1996	SL.	Resolution on the Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries
2000	SL.	International Charter on Space and Major Disasters
2004	SL.	Resolution on the concept of the “launching State”
2007	SL.	Resolution on the guidelines related to space debris mitigation
2009	SL.	Safety framework for Nuclear Power Source Application in Outer Space
2013	SL	UNGA-Report of the GGE on TCBMs in Outer Space Activities
2014	SL.	International Code of Conduct for Outer Space activities
2016	SL.	Resolution on No First Placement of Weapons in Outer Space
2016	SL.	Resolution on prevention of an arms race in outer space

Collection of Hard and Soft Laws defining space sector (own illustration based on Urban (2016); Jakhu & Pelton (2017))