Universiteit Utrecht

Master's Thesis – Master Innovation Sciences

Space Security and Orbital Sustainability

An Institutional Logics Approach

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Date	2 September 2022
Words	16976

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1. Abstract

Introduction. The advent of the recent surge in human space activity has shed light on several space sustainability problems that compromise the long-term viability of continued space exploitation and exploration. The field of space security is particularly related to issues of space sustainability, as the use of so-called counter space capabilities in pursuit of security in space can significantly contribute to the aggravation of several of such issues. This study maps the dynamics of value orientations within the field of space security over time and uses these to obtain an understanding of the field's development, which can inform policy implications to the benefit of space sustainability. **Theory.** The study uses the theoretical framework of institutional logics to operationalize the sociotechnical regime of the global space security field. **Methodology.** To this end, the study executes a socio-technical configuration analysis (STCA), which involves qualitative coding of connections between actors and concepts in a body of documents. Documents were split into two sensemaking platforms, one containing only news articles and one containing only policy documents. **Results.** The study observes an increasing number of state actors involved in shaping the space security field. Given that state actors have been consistently guided by State logic over time, recent developments indicate a trend of polarization and increasing geopolitical tensions between state actors. The role of commercial space in space security has only recently grown in national policy contexts. **Discussion/Conclusion.** The trend of polarization in the space security field is concerning in the context of space sustainability. Significant events such as the 2007 ASAT test by China can drive political will towards measures that enhance space sustainability. The splitting of sensemaking platforms in this study allows the comparison of actors, value orientations, and preferences in different contexts, which offers insight into the complexity of the global sociotechnical regimes. Furthermore, this methodological approach can shed light on the divergence in interests between developed and underdeveloped/developing countries that would be missed if analysis was limited to one sensemaking platform.

1. Introduction

Innovation management in the space sector has changed drastically since the Space Race era. According to Robinson & Mazzucato (2019), the 'old space' regime of the 1950s and 60s was characterized by strong centralized government control over innovation efforts, in which small groups of expert actors achieved clear end goals using well-defined innovation pathways that valued technical accomplishments more than economic cost-effectiveness (Robinson & Mazzucato, 2019). In the aftermath of the moon landing, a still dominant old space regime combined with diminishing public support and governmental budget allocations for space introduced a period of relative stagnation in the sector's development (Orlova, Nogueira & Chimenti, 2010). Since the year 2000, however, we have seen an unprecedented growth in the space sector, mostly on the commercial side (Orlova, Nogueira & Chimenti, 2010). A combination of institutional change and several innovations such as reusable rockets and modular launch compositions have played major roles in this development.[1] The emerging "new space" regime involves many diverse actors across a large variety of systems and value chains that together exercise decentralized control over the implementation of solutions (Robinson & Mazzucato, 2019). These solutions must consider a diverse set of interests and must be achieved in an economically feasible manner (Robinson & Mazzucato, 2019).

The commercialization of space has contributed significantly to the enhancement of essential functions and applications for humanity through the creation and widespread implementation of innovations. However, the trend has also exacerbated several space sustainability challenges that compromise the long-term viability of continued and growing human space activity (Yap & Truffer, 2022). The challenges reveal the unsustainability of current practices, as they produce negative externalities that are not incorporated into the cost of the activity (Scheraga, 1986). The most significant example of these challenges is collision risk, which grows as the number of objects in space increases (Buchs, 2021). The growing number of objects consists of satellites, but also space debris. Even small pieces of space debris that often cannot be tracked are serious threats to space-based systems due to their relative velocities (Buchs, 2021).[2] The emergence of space sustainability issues makes it clear that the space sector as a whole needs a transition towards sustainability. This transition would be characterized by cooperation between all actors in an attempt to reduce conflict and devise universally agreed upon measures that effectively lower sustainability issues such as collision risk. However, performing research at the level of the entire sector would be too ambitious for a single study, as it requires an understanding of multiple subfields and their interactions (Rosenbloom, 2020). Therefore, this study limits its scope of analysis to a critical case of an organizational field that is strongly tied to issues of space sustainability, i.e., space security.

The space security field is strongly related to space sustainability issues. This is because matters of space security, such as conflicts between space-based systems operated by different actors with different interests, can constitute significant drivers of sustainability problems through the use of certain technologies or counter space capabilities. These technologies

[1] A set of policies introduced by the United States (US) (the Commercial Orbital Transportation Services program and the Commercial Resupply Services program introduced in 2005 and the U.S. Space Act of 2015) heavily stimulated private involvement in space, especially in the areas of space resource utilization, launch systems, and space tourism (Orlova, Nogueira & Chimenti, 2020). This led to a growth of total space sector revenue from $176 billion in 2005 to $360 billion in 2019, most of which was from private space activity (Buchs, 2021). In September of 2021, 70% of all operational satellites and 85% of US operational satellites were in orbit for commercial purposes. The vast majority of these (~ 60%) are for communications purposes, followed by earth observation satellites (~20%) and technology development (~10%) (UCS, 2021).

[2] The number of pieces of trackable debris (larger than ~10 cm) in orbit is 27,000. However, many more pieces that are too small to be tracked but are big enough to constitute a threat to human and robotic spacecraft are present in near-Earth orbits. Also, around 40% of the ~7500 satellites orbiting the Earth are non-operational.

typically fall into one of four categories when considered in the domain of outer space. Firstly, there are physical kinetic counter space capabilities, such as direct-ascent anti-satellite (ASAT) missiles, which are designed to destroy objects in space and have the potential to create large amounts of physical space debris. Secondly, physical non-kinetic counter space capabilities physically affect space objects without making physical contact, and include microwave weapons, lasers, and electromagnetic pulse weapons. Thirdly, non-physical electronic counter space capabilities are technologies that can disrupt the channels through which satellites communicate using data, and include methods of jamming, spoofing, and dazzling. Lastly, non-physical cyber counter space capabilities have the aim of interfering with the data and data systems involved in space systems. Use of counter space capabilities negatively affects the sustainability of space activities, as the extra risk posed to space assets must be considered in risk assessments of space investment projects. Physical kinetic counter-space capabilities can have a particular negative impact on space sustainability, in that their effects are non-reversible and can be permanent depending on the height at which collisions occur. Moreover, the space debris problem can be aggravated even in the absence of further interventions. The 'Kessler syndrome' warns that one collision in space could set off a nightmarish positive feedback loop of continuous collisions, leaving space so cluttered with debris that it could significantly obstruct all future human space activity (Bucks, 2021).

To prevent such unsustainable developments, it is essential to obtain an understanding of the interactions of value orientations and interests among different actors that create and exacerbate conflicts in the space security field. To do so, this study will use useful concepts and theoretical frameworks from the field of sustainability transitions research. The research tradition of sustainability transitions conceptualizes transitions as (re)configurations of socio-technical regimes, which are semi-coordinated and interconnected complexes of societal elements that fulfill certain societal needs and functions, such as the water sector (Heiberg, Truffer & Binz, 2022), the recorded music industry (Jain, 2020), and the shipping sector (Geels, 2002). One way of tracking these (re)configurations of socio-technical regimes is to analyze the institutional logics that are at play in the organizational field under consideration. Institutional logics are ways of conceptualizing how the world works and should work. They include value orientations and interests that actors hold, as well as means for realizing them. An understanding of the present and dominant logics in a field, including how they change over time, can inform policy in important ways for transitions towards sustainability. Understanding the changing socio-technical regime of the field of global space security is therefore critical to derive policy recommendations to help maintain future orbital sustainability. To obtain this understanding, this study will aim to answer the following research question:

How has the socio-technical regime of global space security evolved over time and what are the potential development trajectories?

It can answer this question by answering related sub-questions:

1. Which are the most important interests or value orientations (i.e., institutional logics) that actors adhere to in the field of space security over time?
2. Which clusters of actors based on logics were the most important in each period, and how has this unfolded across different levels of analysis?

3. How can the above developments of the socio-technical regime help identify potential development trajectories of the field?

The questions listed above can be answered by using a recently developed research method called socio-technical configuration analysis (STCA). This method works by (1) selecting a sample of articles that represents the important actors and institutional logics of the field of space security, (2) coding statements made in these articles and assigning them to actors and institutional logics, (3) using this data to construct actor networks and logic networks. Clusters of logics and actors can be identified in these networks. Observations of characteristics and trends in the networks can inform expectations for the future of the space security field. Answering the research questions will therefore derive policy implications to future development trajectories, which will be discussed in the last chapter of this thesis.

2. Theory

2.1. Sustainability transitions and socio-technical regimes

A research tradition that has attempted to understand the intricate dynamics and characteristics of large-scale societal transformations towards sustainability can be found in the sustainability transitions literature. A variety of approaches in this field aim to generate insights that can inform improved transitions management, including the multi-level perspective (Geels, 2002; Smith et al., 2010), the technological innovation systems framework (Hekkert et al., 2007) and the strategic niche management approach (Raven & Geels, 2010). Research investigating the complexities and dynamics of sectoral transitions has generally attempted to illuminate them by performing in-depth historical qualitative accounts of events and/or detailed case studies. These approaches have conceptualized transitions as (re)configurations of socio-technical regimes. A socio-technical regime is a collection of formal, cognitive, and normative institutions that shape the actions and interactions of actors in a certain organizational field (Papachristos, 2011; Geels, 2004). The framework conceptualizes that actors and groups of actors manipulate the material world and its artefacts under influence of institutional structures, thereby emphasizing the role of the tight interdependent relationship between technological and social structures in societal stability and change.

2.2. Global sociotechnical regimes

Historically, research employing the sociotechnical regime concept has generally limited its scope of analysis to narrowly defined territorial boundaries. However, the increasingly globalist nature of organizational fields in modern times calls for a more nuanced approach to the spatial extent of sociotechnical regimes. In recognizing this, Fuenfschilling & Binz (2018) introduce the concept of the global sociotechnical regime, which they define as "the dominant institutional rationality in a socio-technical 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". In this conceptualization, the interactions between multiple organizational scales, which are involved in the creation, maintenance, and dissolution of regimes, are of high analytical relevance (Fuenfschilling & Binz, 2018).

2.3. Institutional logics

Although the conceptualization of socio-technical regimes has offered a tool that helps to recognize the relevance of interdependencies of institutions involved in societal transitions, operationalization of these elements has historically been underdeveloped by studies. The analysis of internal incoherencies and synergies of high-resolution structural elements is valuable as it can offer insights into opportunities and threats to sustainable transitions. To realize this, operationalizing elements of the socio-technical regime concept is required.

The socio-technical regime concept uses institutional theory to conceptualize its institutional structuring. Institutional theory emphasizes the importance of constraints that govern human (inter)action in explaining and predicting the unfolding and propagation of practices (Fuenfschilling & Truffer, 2014). These constraints comprise both written (or formal) rules, laws, and regulations, and unwritten (or informal) norms and values. The institutions form the software "that orient[s] and coordinate[s] the activities of the social groups that

reproduce the various elements of socio-technical systems" (Geels, 2011, p. 5). A useful method to operationalize the institutional structure of socio-technical regimes can be found in the theoretical framework of institutional logics.

The institutional logics approach proposes that socio-technical systems consist of a set of institutional subdivisions that each constitute a distinct way of thinking about how the world works and/or should work, subscribed to in varying degrees by different actors (Fuenfschilling & Truffer, 2014). They can be thought of as metaphysical, epistemological, and ethical beliefs about the way the world operates and/or should operate. The traditional institutional logics framework describes seven institutional logics of primary significance: the the profession, the corporation, the market, the state, the family, the community, and the religion. Each logic has its own set of goals, methods, norms, sources of authority, and mechanisms for the control and maintenance of these elements. Firms pursue profit, scientists pursue publications, and politicians pursue votes.

The seven fundamental institutional logics can be combined and reconfigured to create field logics that pertain to an organizational field. An organizational field is an organizational structure that belongs to a culturally and formally recognized area of society that fulfills certain functions (e.g., the pharmaceutical industry, the water sector, or the music industry). An organizational field often contains multiple field logics that compete with each other. If one field logic is significantly more dominant and therefore more institutionalized than others, the trajectory of the field likely follows the content of the dominant logic. However, if several somewhat equally dominant field logics are present, the field is unstable and likely to change. The degree of structuration or stability of a field is therefore determined by the relative legitimacy of competing institutional logics.

2.4. Socio-technical configuration analysis

A recent cutting-edge method for detecting and tracking institutional logics in an organizational field is socio-technical configuration analysis (STCA). This method is an extension of the priorly established discourse network analysis (DNA) methodology from the political sciences field, which operationalizes the dynamics of policy debates by mapping the relationships between actors and concepts based on public statements in textual sources (Leifeld, 2017). STCA uses the idea of coding statements and applies it to technological and institutional elements, including interests, values, and institutional logics (Heiberg, Truffer & Binz, 2022). It thereby enables the identification of conflicting and/or synergistic value orientations among actors and allows tracking the emergence and/or disintegration of socio-technical configurations over time.

2.5. Integrative view for the field of global space security

The abovementioned theoretical components will be useful in answering the research questions posed by this study. The global sociotechnical regime concept provides a theoretical framing for the goal of this research, which is to obtain an understanding of the development of the global organizational field of space security that accounts for the interrelationship between institutional and technological elements. The concept is useful in the case of space security, partially due to the clear lack of geographical boundaries in the domain of orbital space. However, complete applicability of the concept is limited, primarily because the global sociotechnical regime concept was created as a theoretical tool to help conceptualize regime

reconfigurations, while this study focuses on an emergent regime. Furthermore, due to its emergent nature, the global sociotechnical regime of space security is highly complex, which necessitates the consideration of multiple organizational levels to obtain a more complete understanding of its characteristics and dynamics.

The institutional logics approach provides a method of operationalizing the constituent elements of the sociotechnical regime of space security, which enables the identification of the most important value orientations and logics in the field and provides an answer to research question 1. Furthermore, the STCA method enables the spatial mapping of actors based on institutional logics and subsequent clustering, which allows for the identification of the most important actor clusters across time periods and levels of analysis, answering research question 2. Lastly, pairing the insights gained from these research steps in combination with the preferences expressed by actors will enable the identification of potential development trajectories and answer research question 3. The answers to the research questions can aid in formulating policy implications.

3. Methodology

3.1. Research Design

Most sustainability transitions studies have so far aimed to understand the complex structures and transitions of socio-technical regimes by means of historical analyses of qualitative case studies. However, to understand the complex interrelationships between a large set of strongly linked and interdependent variables in a systematic fashion, these classical approaches are not adequate. The method of socio-technical configuration analysis (STCA) method developed by Heiberg, Truffer, & Binz (2022) offers a useful methodology because it enables the graphical representation of an organizational field and the dynamics of its institutional logics. More specifically, the method enables the modelling of concept congruence networks, which are networks that illustrate connections between concepts that are present in the discourse within an organizational field. In addition, it can generate actor congruence networks, which reflect the importance of actors and the intensity of ties between them in an organizational field. Applying statistical concepts from the field of network analysis allows us to derive the degree of institutionalization of certain actors and logics. The input data are statements made by field actors which are coded according to the seven basic institutional logics and combinations thereof. This project will obtain statements from a sample of articles from the LexisNexis database, produced by a search string that selects a set of articles that appropriately represents the discourse belonging to an organizational field of interest.

3.1.1. Case description

Before describing the historical development and characteristics of the field of global space security, setting the boundary of analysis is important. The Space Security Index (SSI) defines space security as "the secure and sustainable access to, and use of, space and freedom from space-based threats", which is based on the agreements made in the 1967 Outer Space Treaty.[3] Threats to space security include offensive actions, such as anti-satellite strikes, hacking or targeted jamming of radio signals, that disrupt the operational functioning of satellite systems. They also include accidental collisions between space-bound objects, unintended radio frequency interference, and space weather. As the salience and meaning of threats to different actors change due to changing sectoral conditions, the set of actors that are involved in the discourse in the field of space security varies over time. The meaning of the term space security, therefore, also changes over time. This is important to consider as this project attempts to capture qualitative data by means of a search string that applies the same constraints to data produced in the year 2000 and to those produced in 2020.

As discussed previously, there are four types of counter space capabilities. Physical variants of counter-space capabilities developed earlier than non-physical variants. We can trace this emergence by the occurrences of security-compromising events of each counter-space capability type.[4] The emergence of non-physical capabilities, especially cyber variants, has made entrance into the counter-space domain significantly easier for non-state actors with low access to investment capital. In addition, the low traceability of non-physical offensive counter-space actions challenges the regulation of aggression in space. These factors have led to the

[3] https://spacesecurityindex.org/space-security/

[4] https://aerospace.csis.org/counterspace-timeline/

involvement of a much larger set of actors, blurring the line between private and public involvement in the space security field. This blurring trend is noticeable across the space security field. Both military and non-military parties use the same space-based infrastructure and technologies, such as communications and data/surveillance systems, and in-orbit service satellites (Burke, 2020). They also make use of the same rockets, as modular payload construction models used by private companies have made launches more commercially viable (Burke, 2020). Contracts between the public and private sector have also changed such that commercial players are now taking over more responsibilities in design, construction, and operations (Burke, 2020).[5] The changes experienced by the space security field mean that any contemporary analysis of it can no longer be limited to the domain of national security only but must consider the role of private actors as well.

3.2. Data Collection & Preparation

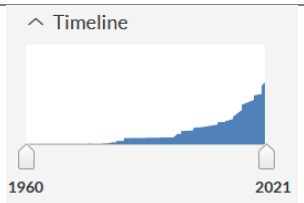
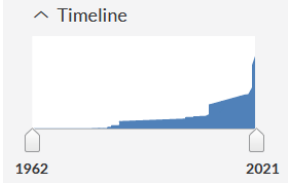
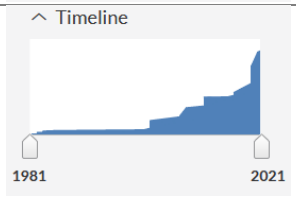
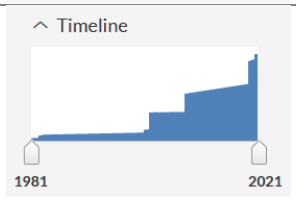
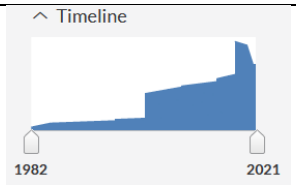
3.2.1. Search strings

To obtain a sense of the number of articles related to the topic of interest contained within the LexisNexis database, the terms "space" and "outer space" were first tried as search queries, producing more than 10,000 results each. Strings targeting articles with "space" or "outer space" resulted in the same outcome. It was deemed important to include "space" in the title because its presence would indicate that the main focus of the article is "space" in some form. "Outer space" was included in the search string because it would further ensure that results are concerned with outer space and not some other interpretation of the term "space" (cyber space, space jam, safe spaces, etc).

The content of reports on space defense and space security were utilized to inform additional search terms to narrow down results further. The terms "defense" and "security" were added to narrow down the field of interest while keeping a certain degree of generality. Much attention was given in the reports to the potential weaponization or militarization of space, arguably because weapons and military capabilities constitute the means of attacking or defending. Therefore, the terms "militar*" and "weapon*" were added, separated by an OR operator. The asterisk symbol is used to allow for some flexibility as to the endings of "militar" or "weapon", such as "military", "militarize", "weaponry", "weaponize", etc. Additionally, the search string was extended with the terms "cooperation", "conflict", "peace" and "war", all separated by OR operators. The number of times these collections of terms should occur in the sources was determined on a "trial-and-error" basis, considering that the final number of articles (estimated by total amount of resulting articles and the percentage of these results that are relevant) should be of manageable size for this study. It was determined in consultation with the supervisor that approximately 200 relevant articles would be sufficient. Some extra articles were included to allow for the possibility of manual refinement.

[5] In fact, public actors are now contracting private companies to host full space-based military applications such as satellite systems for tracking ballistic and hypersonic missiles (Erwin, 2021).

Table 3.1. The sequence of search strings used to obtain a representative sample of articles.

#	Search string	News	Time trend	Evaluation
1	title(space) and "outer space"	10,000+		Rejected
2	title(space) and "outer space" and defense or security	8,445		Rejected
3	title(space) and "outer space" and atleast5(defense or security)	1,602		Rejected
4	title(space) and "outer space" and atleast5(defense or security) and atleast5(militar* or weapon*)	732		Rejected
5	title(space) and "outer space" and atleast6(defense or security) and atleast5(militar* or weapon*) and atleast6(cooperation or conflict or peace or war)	262		Accepted: Around 80% useful

3.2.2. Time periods

In order to enable the documenting of the (re)configuration of the space security regime over time, the data were split into three periods based on significant events that had a significant effect on field dynamics.

Period 1: 2001 – 2006

Period 1 starts with the publication of a report by the Space Commission mandated by Congress and chaired by Secretary of Defense Donald Rumsfeld in January of 2001.[6] The report argued that the United States was unaware of and unprepared for attacks on its space assets. It stated a potential attack could have major consequences to a variety of critical systems, including those used for purposes of national security. Accordingly, the publication of the report ushered in a trend of organizational restructuring of the Air Force that would consider air and space as distinct mission arenas, each with their own organizational and operational needs. This period therefore represents a shift in the strategic posture of the United States, which was characterized by higher threat awareness and programs of organizational restructuring within the Department of Defense.

Period 2: 2007 – 2015

Period 2 begins with the testing of a direct ascent ASAT missile by China in 2007, creating 900 pieces of trackable debris (an increase of 10% in total manmade debris in orbit) in orbits from 125 miles to about 2,300 miles. The event elicited a wave of international condemnation and ignited concerns for the sustainability of human space exploitation, along with fears of a potential arms race in space fueled by geopolitical competition.

Period 2 ends with two events that happened close to each other. On 25 November 2015 US President Barack Obama signed the SPACE Act of 2015, which stimulates private spaceflight by awarding private companies the ability to own material resources obtained in outer space. A second event marking the end of this phase is the landing of the Falcon 9 booster by SpaceX on December 22, 2015, which was the first recovery of a commercial VTVL (vertical takeoff and vertical landing) orbital booster rocket. Both events are important hallmarks that paved the way for the recent surge in commercial space activity.

Period 3: 2016 - present

Period 3 is mostly characterized by the election of Donald Trump as the 45th president of the United States in 2016. While the impacts of this event were in no sense limited to the organizational field of space security, the policy changes regarding space security made under the Trump administration were significant. The most documented of these changes was the establishment of the US Space Force in December of 2019. In addition, the National Space

[6] Rumsfeld, D., Andrews, D., Davis, R., Estes, H., Fogleman, R., Garner, J., ... & Wallop, M. (2001). Report of the commission to assess United States national security space management and organization. *Government Printing Office, Washington, DC*. https://aerospace.csis.org/wp-content/uploads/2018/09/RumsfeldCommission.pdf

Council, a body that aims to guide the US space program by bringing together specialized space professionals that operate in separate governmental divisions, was reinstituted under Trump in June of 2017.

3.2.3. News and Policy sensemaking platforms

In consultation with the supervisor, it was deemed valuable to categorize articles based on their publication sources. The split was made such that articles published by news sources (newspaper articles, web-based news publications, etc.) were categorized as belonging to the "News" sensemaking platform, while articles published by national and international governing institutions (UN hearings, US congressional hearings, etc.) were categorized as belonging to the "Policy" sensemaking platform. A sensemaking platform is a platform that actors use to collectively interpret and make sense of the world. It is a socially distinct level at which collective sensemaking is shaped by platform-specific conditions. Splitting of the two sensemaking platforms allows analytical comparison between platforms that can illuminate differing characteristics in actor configurations and their institutional logics and preferences.

3.3.Data Analysis

The landscape of field logics was methodically derived by tracing logics embedded in actor statements in the sample of news articles, reports, and governmental documents obtained from the LexisNexis database. The statements were coded according to categorical characteristics of the applicable basic logics (Table 1). The logics of *Family* and *Religion* were left out as they were deemed irrelevant within the scope and context of this study.

Since news articles and policy documents have a different format, in consultation with the supervisor it was determined to code the two differently. Actor-concept links identified in Policy documents were coded discursively, meaning that only statements made directly by actors were considered. Policy documents are typically longer than News articles, its format allows faster coding if coding is done discursively. Actor-concept links identified in News articles were coded substantively, meaning that in addition to direct statements, statements by actors about other actors were considered as well. This coding method was chosen because the format of News articles, in addition to containing quoted statements, generally also contains statements that actors make about other actors. A short example for each method of analysis is given below.

The representative of the US expressed worry over the Chinese threat to universal space access for all nations, stating that China is developing a wide range of counter space capabilities to advance its national interests, including direct-ascent ASAT missiles, cyber weapons, and space-based lasers.

Discursive:
Representative of the US – Community & Ecology logic (space as a common resource)

Substantive:
Representative of the US – Community & Ecology logic (space as a common resource)
China – State logic (general national interest)

The construction and adaptation of coding labels was allowed during the collection and analysis phases of the data with the goal of arriving at a coding structure that is more representative of the organizational field under consideration. This is compatible with principles of grounded theory (Dey, 2004). Grounded theory emphasizes the importance of empirical grounding of social science studies. To that end, it allows the continuous modification of categorical frameworks such as coding schemes, driven by data observation and analysis. The software NVivo will be used to code and categorize statements.

After coding all statements, the resulting data was transformed into an unweighted two-mode affiliation matrix in NVivo, a table with actors as rows and logics as columns, where entries into the table signify the strength of actor-concept links. The numbers in this table represent the number of unique articles or documents that contain at least one co-occurrence between an actor and a concept. This way, the strength of an actor-concept link was not overemphasized by articles where an actor mentions one concept many times but was indicated by the presence of this actor-concept link across several articles or documents.

Next, the matrix was converted into a one-mode actor network based on value-based proximity between actors using the software *R* and *Visone*. Following this, actors were grouped into clusters based on value-based proximity using an algorithmic approach called Ward's

Method. The number of clusters appropriate for each sensemaking platform and period was chosen jointly with the supervisor. Analysis of the networks with clusters revealed the characteristics of the actor constellations and more valuable insights into the dynamics in the field under study. Lastly, results of the two sensemaking platforms were compared to assess the differences in network characteristics.

3.4. Research Quality

The research quality of this study is dependent on its repeatability, reliability, and internal and external validity. The reliability and repeatability of this study are determined by the degree of transparency in communication of thought processes and methodology, and access to the external data and sources required for successful research execution. This study used publicly available software and data, which increases repeatability. Furthermore, it aims to be specific and transparent in its descriptions of steps to optimize its repeatability and reliability. The internal validity of this study is determined by the degree to which conceptualized and operationalized causal relationships are trustworthy (McDermott, 2011). The study aims to optimize internal validity by ensuring that the methodology and results are derived from a robust theoretical grounding, but also allowing for alteration of coding schemes and interpretative frameworks to arrive at the most suitable method for analyzing the data under consideration. To that end, there were multiple interactions with the supervisor along the research process, where the coding scheme was built in an iterative form. The external validity of this study is determined by the degree to which insights gained are generalizable across cases, socio-technical regimes, and sectors (McDermott, 2011). Although obtained insights were specific to the space sector, it is worth considering the extent to which insights into institutional elements or dynamics might be applied to other sectors.

4. Results

Coding all articles yielded four major logics and 24 logic value orientations in which were used as categories to classify actor statements (Table 4.1). In addition, statements were also coded in terms of preferences, which could not be categorized neatly in terms of logics. These preferences were further categorized as either policy, strategic, or technology preferences. Based on co-occurrences between actors and logic value orientations, actor congruence networks were generated, and network clusters were calculated. Results also include frequency distribution charts for logic value orientations and frequency tables for preferences. For each of the three time periods, results are presented for both the News and Policy sensemaking platforms, which allows for comparison. The study uses these results to construct a coherent storyline that tracks the development of the space security field from 2001 to 2022.

Each period will feature, firstly, an analysis of the News platform results, followed by an analysis of the Policy platform results. The News platform analysis will offer a wide perspective that will include a high variety of actors. It will also include coded statements made by actors about actors, since coding is done substantively. This means that in addition to an actor's own expression logics and preferences, it will also be considered what other actors say about that actor's linkages to logics and preferences. The analysis of the News platform will be followed by an analysis of the Policy platform, which will present a perspective of the discourse around space security in the policy domain. The analyses of the platforms contain a tracking of the institutional logics and associated preferences adhered to by clusters and actors, and placement of these in their historical context.

Notes on results

Due to the nature of the News platform, and the choice for a substantive coding style, a variety of actors at different levels of analysis will be included in the final results. For instance, in addition to the inclusion of US governmental bodies, substantive references were also made to the US as a country. In line with this, both the US as a national actor and its subsidiary governmental bodies are included as actors in the News networks.

In consultation with the supervisor, the number of clusters for the News networks was set to 3 and the number of clusters for the Policy networks was set to 2. The number was not set the same for all networks belonging to the same sensemaking platform a priori but was determined for each network individually. The number of clusters was determined based on whether the split between actors provided sufficient detail for subsequent analysis while not providing unnecessary or irrelevant detail that did not contribute to analytical cogency.

Table 4.1. Identified fundamental logics and their sub-logics.

Logic	Value orientations	Explanation
Community & Ecology	Critical infrastructure	Valuation of space infrastructure that fulfils critical functions for the benefit of all of humanity. These functions can include civil, military, and/or commercial functions.
	General sustainability	Valuation of sustainabilty in the broadest sense, meaning a valuation of the continued existence of human life and the proper structuring of systems and processes that allows this.
	Global economic development	Valuation of the development of the global human population in terms of economic welfare.
	Global security	Valuation of security at a global level. This encompasses international security and peace.
	Humanitarianism	Valuation of general human welfare, human life, and/or human rights.
	Space as common resource	Valuation of the proposition that space can and should be used to benefit all of humanity by providing access to space-derived resources and services to all, especially undeveloped and developing countries.
	Space safety & security	Valuation of the security of the space environment, the presence of peace, and the absence of conflict, an arms race, and weapons in this domain.
	Space sustainability	Valuation of sustainability in the space domain. A state of sustainability in space means the elimination of threats to the indefinite continuation of human space activities, such as space debris.
Market	Commerce and competition	Valuation of commerce and competition, because they are reasoned to benefit price, speed of innovation, technological and scientific progress, etc.
	Leveraging commercial sector	Desire expressed by public actors to outsource technologies or services to markets because they can provide them faster and cheaper. Public-private partnerships is a commonly associated preference with this value.
	Lower private risk	Valuation of lowering risk to private actors, because this stimulates commercial activity. Risks to private actors come from a wide variety of sources, such as policy barriers and conflict in space.
Science & Engineering	Scientific & technological development	Valuation of general scientific & technological development.
State	Critical infrastructure	Valuation of space infrastructure that fulfils critical functions for the benefit of the State. These functions can include civil, military, and/or commercial functions.
	Foreign relations interests	Valuation of the State's relations with foreign state actors.
	Freedom of operation in space	Valuation of freedom to operate according to State interests in the space domain, free from interference by others.
	General national interest	Valuation of the State's general national interest.
	Independent sovereign space capabilities	Valuation of the State's independence in terms of the space infrastructure and services that it uses to fulfil its national interests
	National economic development	Valuation of national development in terms of economic welfare.
	National industry development	Valuation of development of national industry, specifically regarding the space industry and associated technologies and systems.
	National security	Valuation of national, military security.
	National supremacy	Valuation of national supremacy and dominance over other state actors.
	Space access	Valuation of national access to space, specifically where other state actors are preventing this access.
	Space exploration & exploitation	Desire to exploit and explore space for the benefit of the State.

Table 4.2. Identified preferences and categorization of preference type.

Type	Preference	Clarification
Policy	Against binding arms control agreements	Opposed to the establishment of a binding arms control agreement.
	Against US national space force	Opposed to the establishment of the US national Space Force as separate military branch.
	Binding arms control agreement	In favor of the establishment of a binding arms control agreement in the context of counter space capabilities.
	Code of Conduct	In favor of establishing an informal code of conduct in UN settings.
	EU Code of Conduct proposal	The proposal by the delegation of the EU for a code of conduct.
	National space force or command	In favor of establishing a national space force or command as distinct military functions.
	Policy for commercial space stimulation	Policy that aims to facilitate commercial activity in space.
	Space norms or standards	In favor of establishing informal norms of behavior and standards of conduct regarding interactions between actors in the space domain.
	TCBMs	In favor of establishing Transparency & Confidence Building Measures (TCBMs)
	Transfer of STM to civil agency	In favor of transferring control over national space traffic management to a civil agency.
	Transfer of STM to Department of Commerce	In favor of transferring control over national space traffic management to the Department of Commerce.
	Loosening US technology licensing policy	In favor of removing policy barriers to commercial development by loosening technology licensing restrictions.
	Verifiability of agreements	In favor of the need for verifiability, or the ability to monitor and verify actions of potential perpetrators, of agreements.
Strategic	Allied cooperation	In favor of cooperative interactions with countries that are allied to the actor's nation.
	Deterrence	In favor of having the ability to deter hostile actions by adversaries.
	Developing counter space capabilities	In favor of developing counter space capabilities.
	Diplomacy	In favor of using diplomacy to advance actor interests.
	International cooperation	In favor of international cooperation regarding space.
	Less bureaucracy	Opposed to inordinate bureaucratic structures.
	Military exercises	In favor of performing military exercises that present potential scenarios where military space plays a large role.
	Non-allied cooperation	In favor of collaborative interactions with countries that are not allied to the actor's nation.
	Offensive actions	In favor of the potential use of offensive actions in space to advance interests.
	Optimizing space acquisition	In favor of institutional reform within the US DoD that enables better technology acquisition processes for space.
	Public-private partnerships	In favor of public-private partnerships.
	Resilience of space-enabled services	In favor of enhancing the resilience of space-enabled services.
	Security cooperation	In favor of cooperation with other countries within the domain of space security.
	Sharing information and capabilities	Willingness to share information and capabilities to advance interests.
	Space traffic management	In favor of enhancing and bettering the national space traffic management program.
	Strategic restraint	In favor of exercising strategic restraint by not testing or deploying counter space capabilities.
	Strengthen global legal space regime	In favor of strengthening the global governance of space.
Technology	Active debris removal technologies	Valuation of active debris removal technologies.
	Against missile defense systems	Opposed to missile defense systems.
	Co-orbital drones	Valuation of co-orbital drones.
	Counter space capabilities	Valuation of counter space capabilities in general.
	Directed energy	Valuation of directed energy counter space capabilities .
	Lasers	Valuation of laser-based counter space capabilities.
	Electronic counter space systems	Valuation of electronic counter space capabilities (jamming, spoofing, etc.)
	Launch systems	Valuation of launch systems
	Missile defense systems	Valuation of missile defense systems
	Physical kinetic ASAT	Valuation of physical kinetic anti-satellite counter space capabilities
	Small satellites	Valuation of micro or nanosatellites
	SSA capabilities	Valuation of space situational awareness capabilities

4.1. Period 1

4.1.1. News

US actors occupy central position in regime

An analysis of the News sensemaking platform results shows that US actors are grouped in a central cluster (cluster 3) in the field of space security in period 1. Other countries are not represented significantly in the News platform, likely because their power to shape the space security regime is much lower than that of the US in period 1, leading news sources to consider them less in their reporting on the space security field. US actors were found to adhere strongly to State logic, especially the value orientations of *national security*, *national supremacy*, and *critical infrastructure*. In particular, military US actors are very recognizant of the strong relationship between these values, as the US is dependent on space infrastructure to assure national military objectives more than any other nation in the world. US governmental actors view the strategic preferences of *deterrence* and *developing counter space capabilities*, and the technology preference of *missile defense systems* as ways to fulfil their State logic value orientations. This is because they perceive counter space capabilities and missile defense systems as weapons that can constitute effective deterrence mechanisms against adversarial aggression by threat of retaliation. This strategy is partially captured by the quote:

"The Houston Chronicle reports, "Rumsfeld's plan grew out of a commission he headed last year that warned that the United States was vulnerable to a 'space Pearl Harbor' strike against satellites." The Chronicle adds, "The new measures were consistent with U.S. policy that calls for the development of defensive systems to 'preclude an adversary's hostile use of space,' Rumsfeld said.""[7]

The strong adherence to abovementioned value orientations and preferences by US governmental actors was partially fueled by the commission report issued by Secretary of Defense Donald Rumsfeld in January of 2001, which argued the US was unduly vulnerable to attacks on its space assets. Additional concern was driven by the events that occurred on September 11th of the same year. Shortly after the latter event, the Bush administration announced that the US would be stepping out of the Anti-Ballistic Missile Treaty, an arms control treaty between the US and the Soviet Union established in 1972. Stepping out of this treaty would give the US the freedom to build national missile defense systems and counter-space capabilities which would ensure its ability to protect its national interests.

Adherence to Market logic was not present among US governmental actors in period 1 in the News platform. The Stimson Center, a US based nonprofit and nonpartisan think tank concerned with issues of international peace and security, is the only actor in the News platform that adheres to Market logic. It argues for a non-aggressive posture by the US that would include not flight-testing or deploying counter space weapons. This strategy would benefit US national security by safeguarding foreign relations with both allies and non-allies (China and Russia), thereby protecting US commerce in space against potential escalations of conflict. Accordingly, its adherence to State value orientations of *national security* and *foreign relations interests* and

[7] The Bulletin's Frontrunner (2001). Rumsfeld Declares Defense Of Space A Priority.

adherence to Market value orientations of *commerce & competition* and *lower private risk* drive an adherence to the strategic preference of *strategic restraint*. This collection of value orientations is by no means shared by US governmental actors, who advocate a State logic based and aggressive strategic posture approach to protect national interests, while showing no interest in the protection of commercial activity.

4.1.2. Policy

Political gridlock between C&E-driven UN actors and State-driven US actors

In contrast to the News platform in period 1, a variety of countries are represented in the Policy platform as UN actors. Almost all UN actors in period 1, contained in cluster 1, are predominantly concerned with preventing conflict in space and ensuring universal accessibility to a peaceful space environment so that all countries can benefit economically and technologically. This is exemplified by the high number of references to the C&E logic value orientations of *space safety & security*, *space as a common resource*, *global economic development*, and *critical infrastructure (world)*, and the S&E logic value orientation of *scientific & technological development*. Part of this stance is captured by the quote from the Cuban UN representative to the Fourth Committee:

"Cuba's representative described the existing legal regime as insufficient for ensuring the prevention of an arms race in outer space. New mechanisms must be adopted for the verification of space law. An arms race in outer space would not only violate the principle of outer space as a "common heritage", but would also jeopardize collective security. The principles guiding the exploration and uses of outer space must be based on the need to preserve its peaceful use."[8]

The dissimilarity between UN and US actors that can be derived visually from both the network and logics distribution chart of the Policy platform, and which is confirmed algorithmically by clustering, results from a perceived incompatibility between C&E and State values among all actors. It was found that UN actors fear that battles for space dominance between state actors could lead to the 'weaponization of space', which could severely threaten the ability of humanity to benefit optimally from space.[9] Accordingly, they advocate for the establishment of a binding arms control agreement that would limit the placement and use of weapons in space. Russia and China are the most vocal advocators of such an agreement and can be seen supporting this policy preference in the News platform as well. Notably, while news

[8] M2 PRESSWIRE (2002). UN speakers warn against potential outer space arms race, as Fourth Committee continue debate.

[9] Although numerous references to the 'weaponization of space' are made throughout the dataset, there is no widespread consensus as to the exact definition of this condition. This is partially because many so-called weapons in space are embedded in dual-use technologies, which raises questions about what qualifies as a weapon and how the placement of weapons in space should be avoided. Additionally, weapons that have a potential effect on space assets do not have to be placed in space, as is the case with ground-based ASAT missile and laser systems, for instance. It is important to note that the Outer Space Treaty established in 1967 only prohibits the placement of weapons of mass destruction (WMDs) in space. It does not prohibit the placement and/or defensive use of other types of weapons.

articles report high advocacy by the two countries, this adherence does not appear to be driven by C&E logic in the News platform.

US governmental actors, contained in cluster 2 of the Policy platform, are fervently against a binding agreement, because they view such agreements as preventing the US from pursuing its State-driven interests. These competing interests between UN actors and US governmental actors has historically culminated in a political deadlock in UN discussions over space security. This stance by the US is captured by a quote of the US representative in the UN Conference on Disarmament:

"ERIC M. JAVITS (United States) reiterated that his country saw no need for new outer- space arms-control agreements and opposed the idea of negotiating a new outer space treaty. His Government believed that the existing outer space regime was sufficient. (…) Member States simply would not engage in efforts to reach consensus if they believed it would undermine their own national security needs and goals or those of their allies and friends."[10]

Some UN actors, in an attempt to stimulate universal support for limiting measures, have turned to informal measures based on voluntary compliance, such as Transparency and Confidence Building Measures (TCBMs) or a Code of Conduct. However, these two types of informal measures have not garnered any support by US governmental actors in period 1. UN actors, furthermore, place broad emphasis on *international cooperation* and *sharing information and capabilities* as strategic preferences that they view as helpful in both establishing cooperative relationships between space powers and redistributing space benefits towards developed and developing countries.

US governmental actors show slim support for these strategic preferences, instead valuing the strategic preference of *deterrence* as a strategy that can prevent conflict without the need for binding or voluntary measures. They believe this deterrence is to be provided by threats of retaliation using missile defense systems and counter space capabilities but also by improving the resilience of space-enabled services, as attacking a highly resilient system does not yield a strategic advantage. Using constellations of *small satellites* instead of a few large satellites increases resilience by spatially distributing the risk of collision or attack, hence some adherence to the preference of *small satellites* by US actors. US actors also consider space situational awareness (SSA) capabilities as deterrents against adversarial aggression. SSA capabilities enable the effective tracking and mapping of objects in space, enabling more accurate identification and attribution of aggressive behavior. In addition, SSA capabilities also enhance the resilience of space infrastructure, as tracking information can be used to inform evasive maneuvers and prevent collisions.

In the Policy platform, the only actors adhering to Market logic are the Satellite Industries Association and the US Department of Commerce. The Satellite Industries Association views the Market value orientations of *commerce & competition* and *lower private risk* as conducive to the C&E value orientation of *global economic development* and the State value orientation of *national economic development*. The Department of Commerce values the relationship between Market and State value orientations, as it believes that lower private risk to commercial

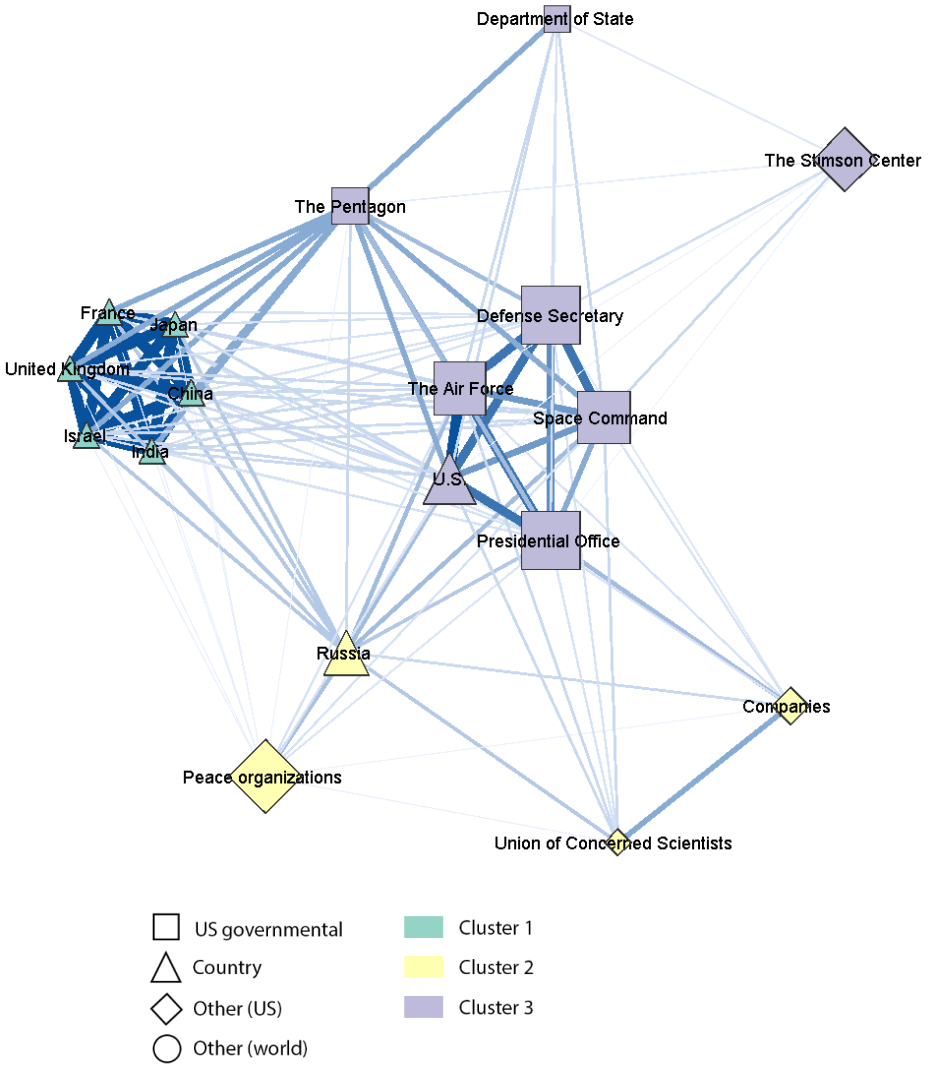
[10] M2 PRESSWIRE (2002). Conference on Disarmament concludes; Second part of 2002 session; Russian Federation, China present joint working paper on prevention of deployment of weapons in outer space; Germany assumes presidency of conference.

actors is beneficial to State values of *national economic development*, *national industry development*, *national security*, and *national supremacy*. This is logical, as this department is a government actor that values State interests while being concerned with commerce and the economy. Driven by their Market logic values, both actors make references to the policy preferences of *policy for commercial space stimulation* and *loosening of technology licensing*. They view that current policy concerning the licensing of technology put US innovation at a competitive disadvantage internationally, as any product that could be used for multiple uses (military or civil) was licensed as a weapon, and extensive legal product requirements in the interests of national security slowed down the time-to-market. This shows that some actors in the US Policy sphere, including a governmental actor, are pushing for regulation that would stimulate commercial space activity in period 1.

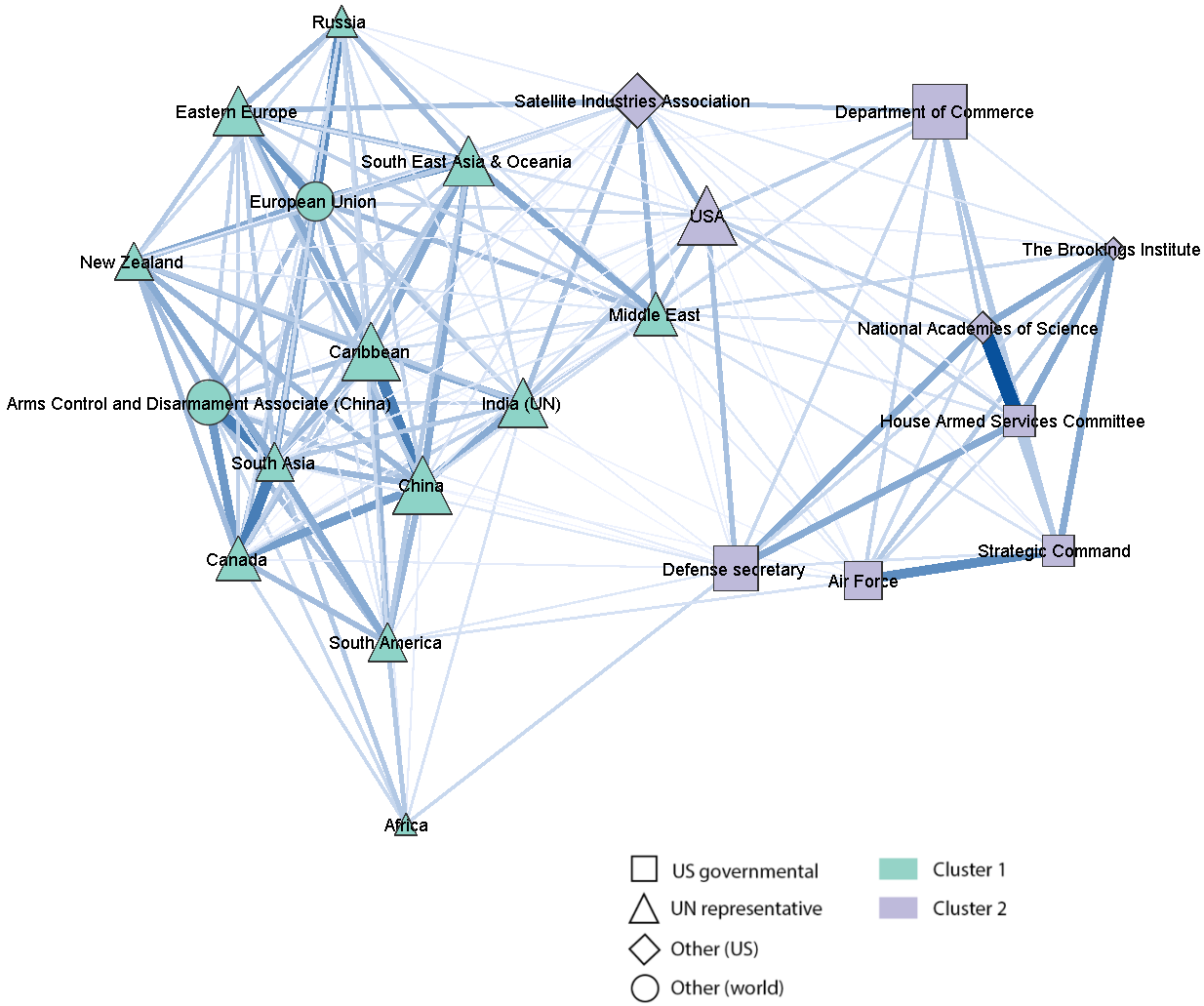
NETWORKS

PERIOD 1

NEWS



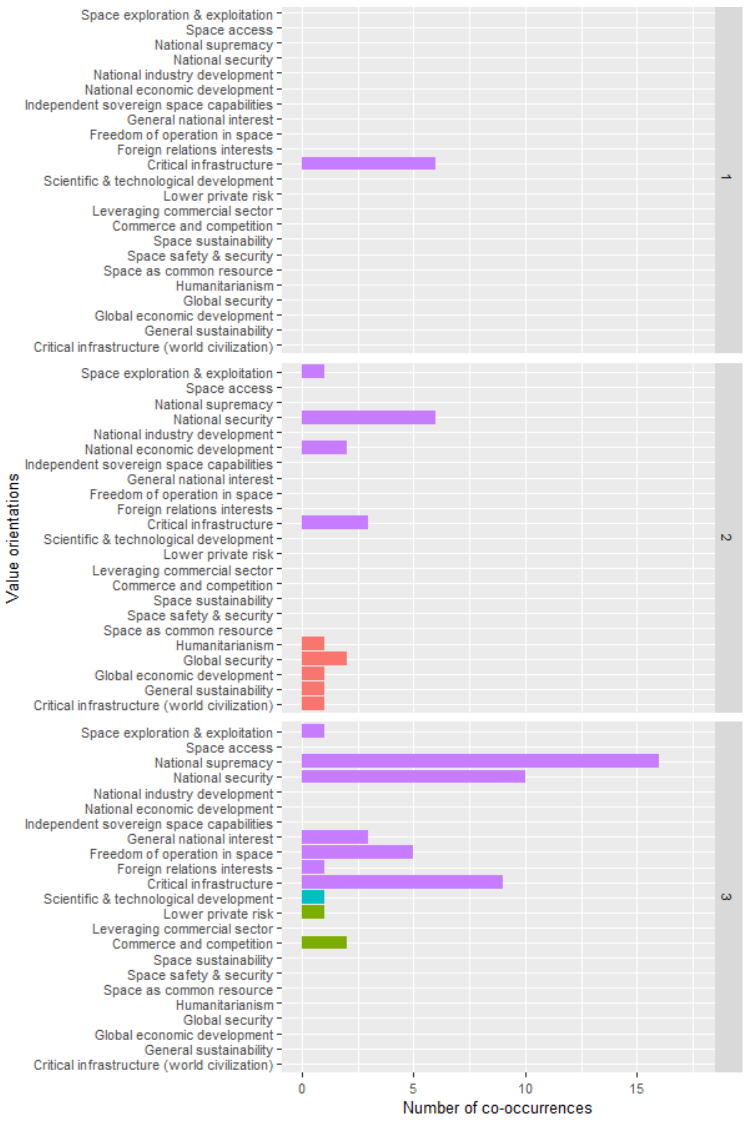
POLICY



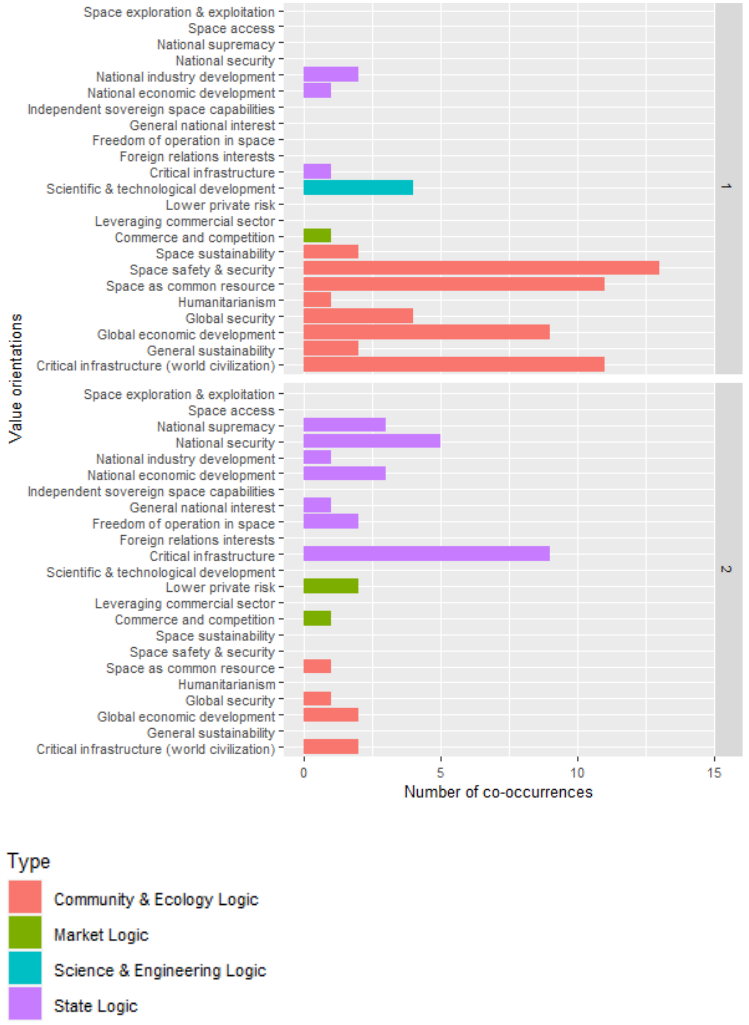
LOGICS DISTRIBUTION BY NETWORK CLUSTER

PERIOD 1

NEWS



POLICY



PREFERENCE DISTRIBUTION TABLES BY NETWORK CLUSTER

PERIOD 1

NEWS

POLICY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Against binding arms control agreements	0	0	0	0	2	33.3
Binding arms control agreement	5	100	7	70	1	16.7
Code of conduct	0	0	0	0	2	33.3
National space force or command	0	0	2	20	1	16.7
Verifiability of agreements	0	0	1	10	0	0

STRATEGIC PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Allied cooperation	0	0	0	0	2	6.9
Deterrence	0	0	0	0	5	17.2
Developing counter space capabilities	1	100	1	16.6	16	55.2
Diplomacy	0	0	1	16.6	0	0
International cooperation	0	0	2	33.3	0	0
Military exercises	0	0	0	0	1	3.4
Non-allied cooperation	0	0	0	0	1	3.4
Offensive actions	0	0	0	0	1	3.4
Sharing information and capabilities	0	0	1	16.6	0	0
Strategic restraint	0	0	1	16.6	3	10.3

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Counter space capabilities	0	NA	0	0	1	3.33
Directed energy (laser)	0	NA	1	50	5	16.67
Missile defense systems	0	NA	1	50	22	73.33
SSA capabilities	0	NA	0	0	2	6.67

POLICY

POLICY PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Against binding arms control agreements	0	0.0	3	33.3
Binding arms control agreement	19	73.1	2	22.2
Code of conduct	1	3.8	0	0.0
Policy for commercial space stimulation	0	0.0	2	22.2
TCBMs	5	19.2	0	0.0
US tech licensing loosening	0	0.0	2	22.2
Verifiability of agreements	1	3.8	0	0.0

STRATEGIC PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Deterrence	0	0.0	2	25
Developing counter space capabilities	0	0.0	1	12.5
Diplomacy	1	8.3	0	0
International cooperation	6	50.0	1	12.5
Resilience of space-enabled services	0	0.0	3	37.5
Sharing information and capabilities	4	33.3	1	12.5
Space traffic management	1	8.3	0	0

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Against missile defense systems	0	NA	1	12.5
Counter space capabilities	0	NA	1	12.5
Missile defense systems	0	NA	1	12.5
Small satellites	0	NA	1	12.5
SSA capabilities	0	NA	4	50

4.2. Period 2

Period 2 is a critical period in which major shifts in the space security field happen. These shifts were preceded by the 2007 Chinese ASAT test, which received widespread condemnation by the international community.

4.2.1. News

Changing configurations, US remains in central posittion but more state actors involved

In period 2, US actors are still the most important players but seem to be losing internal coherence and central positions in the overall space security discourse, as judged from the News platform results. Countries other than the US such as China, Russia, India, and Japan are starting to play a bigger role, while also being driven State logic value orientations, primarily by those of *critical infrastructure* and *national security*. US actors seem to have lowered their adherence to the value of *national supremacy* relative to other State logic values, while China now strongly adheres to this value. In addition, China and Russia strongly value the role of space in terms of their national economic development. In terms of C&E value orientations, *space as a common resource* and *space safety & security* are valued by China and the US, but it was found that this is only the case in the context of their desire to gain soft power by helping other countries to build their space capabilities.

With lowering their adherence to the State logic value of *national supremacy*, US governmental actors have adopted a softer foreign policy approach. This is evidenced partially by a significant decrease in adherence to the strategic preference of *developing counter space capabilities*. In addition, US governmental actors also displayed greater adherence to the strategic preferences of *international cooperation* and *sharing information & capabilities*, and are increasingly open to cooperate with state actors that are not traditionally allied with the US, such as China and Russia. Moreover, US actors show increased emphasis on the importance of diplomacy as part of the US foreign relations strategic approach. The stance by US actors in period 2 is captured partially by the following passage:

"The National Space Policy of the United States of America, released in June 2010, "put a heavy emphasis on responsible space behavior," Samson said. It emphasizes use of space for the benefit of all, through international engagement and cooperation. Military and security agencies subsequently updated their own strategies and guidance within this framework."[11]

China, on the other hand, parallel to its strong adherence to State logic values, displays a more aggressive foreign relations strategy. It has increased its adherence to the strategic preference of *developing counter space capabilities*, and the technology preferences of counter space capabilities and cyber capabilities. It was found that Chinese governmental view counter space capabilities as a way to gain an asymmetric strategic advantage against the US, as China could use these capabilities to exploit critical vulnerabilities in US space systems. This would enable China to prevent the US from interfering with Chinese national interests. Governmental US actors are conscious of vulnerabilities to their space systems, and accordingly view the Chinese pursuit of counter space capabilities as a threat. In turn, they themselves view their

[11] US Official News (2013). Washington: Stronger International Cooperation Needed To Address Growing Threat of "Space Junk".

strategic development of counter space capabilities as way to deter aggression by China and other adversaries. The growing role of China and other state actors in the space security field, combined with Chinese strong adherence to State logic value orientations, especially *national supremacy*, and a growing interest by China in the acquisition of effective counter space capabilities, contributed to the aggravation of an arms-race-like geopolitical dynamic between the US, China, and other state actors in period 3.

The presence of Market logic in period 2 is low in both the News and Policy platforms. The only News actors adhering to this logic, specifically to the value orientation of leveraging the commercial sector are Japan and the Heritage Foundation (US). Japan expresses this value in concert with its adherence to the State logic value of *national industry development*, as it believes that government investments into the commercial space sector can benefit the national industry. The Heritage Foundation believes that SSA capabilities can be improved by outsourcing the development of these capabilities to the commercial sector, which would allow for faster innovation due to competition.

4.2.2. Policy

Convergence between UN and US actors

A comparison of the Policy platform between period 1 and period 2 indicates a trend of convergence in logic-based value orientations in the total group of actors. Firstly, this is reflected by decreased distance and stronger connections between the two clusters, which can be confirmed visually. Secondly, the trend of convergence can be inferred from the logics distribution bar chart, which shows that actors in cluster 1 (containing mostly UN actors) increased their adherence to State logic values relative to their adherence to C&E logic values, while actors in cluster 2 (containing mostly US actors) increased their adherence to C&E logic values relative to their adherence to State logic values.

The convergence in logics is paralleled by an increased willingness among all actors to explore policy mechanisms that are more likely to garner universal support than a *binding arms control agreement*. Support for a *binding arms control agreement* remains high among UN actors in the Policy platform, and China and Russia in the News platform, while US actors continue to oppose strongly in both platforms. However, increased support is expressed by many actors in both platforms for voluntary measures such *TCBMs* or *space norms and standards*. In the Policy sphere, the policy preference of a *Code of Conduct* receives high support from UN actors, while US actors also show support, though less enthusiastically. The US stance is captured partially by the following quote by Garold N. Larson, US representative to the UN First Committee:

"Over the past two years, the United States has had fruitful and forthright exchanges with European experts regarding the European Union's proposal for a "Code of Conduct for Outer Space Activities." Looking ahead, the United States will continue to work with the European Union and other like-minded nations in efforts to advance a set of voluntary TCBMs that is acceptable to the greatest number of countries."[12]

[12] Federal News Service (2009). Statement by Garold N. Larson, U.S. alternate representative to the First Committee, in the First Committee of the sixty fourth session of the United Nations General Assembly.

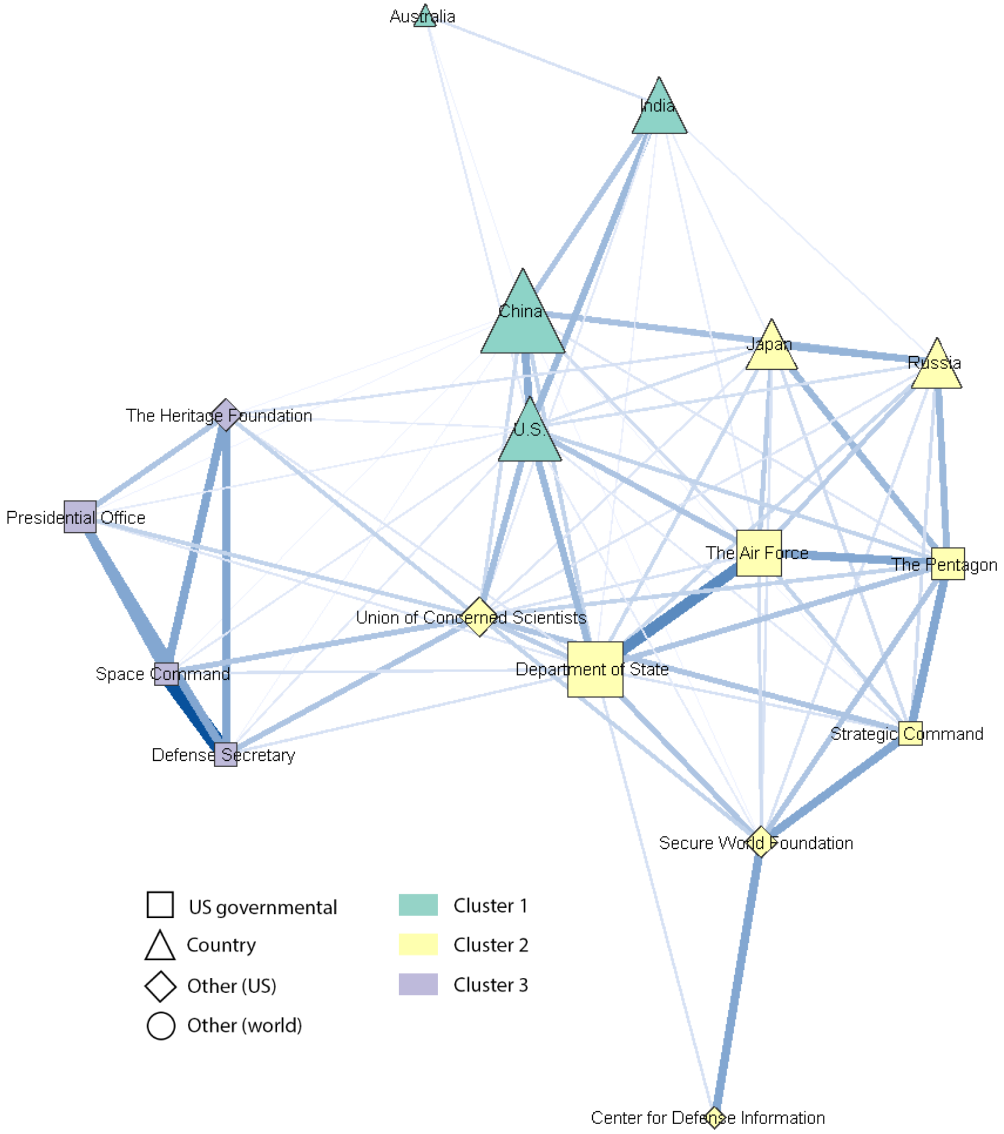
The convergence in logics and associated increased willingness to explore policy alternatives emerged in the aftermath of the 2007 ASAT test by China. The event made apparent an urgent need to establish measures to enhance the sustainability and military security of space in the international policy sphere, which is reflected by the many references made to this event in both the Policy and News platforms in period 2.

Similar to the News platform, adherence to Market logic is sparse in the Policy platform as well, where only the Center for Defense Information (US) and Fudan University (China) adhere to its values. The Center for Defense Information expresses concern for the risk that the development of physical kinetic ASAT weapons has on commercial activity, as increasing space debris elevates risk of collisions and decreases expected returns on investments for private players. Accordingly, it adheres to the value orientation of *lower private risk*. Fudan University representatives expresses adherence to the value orientation of *commerce & competition* in connection with China's development of its Beidou system. They argue that competition between different navigation satellite systems promotes innovation and enhances the quality of these systems. This would benefit China individually, as well the wider global community.

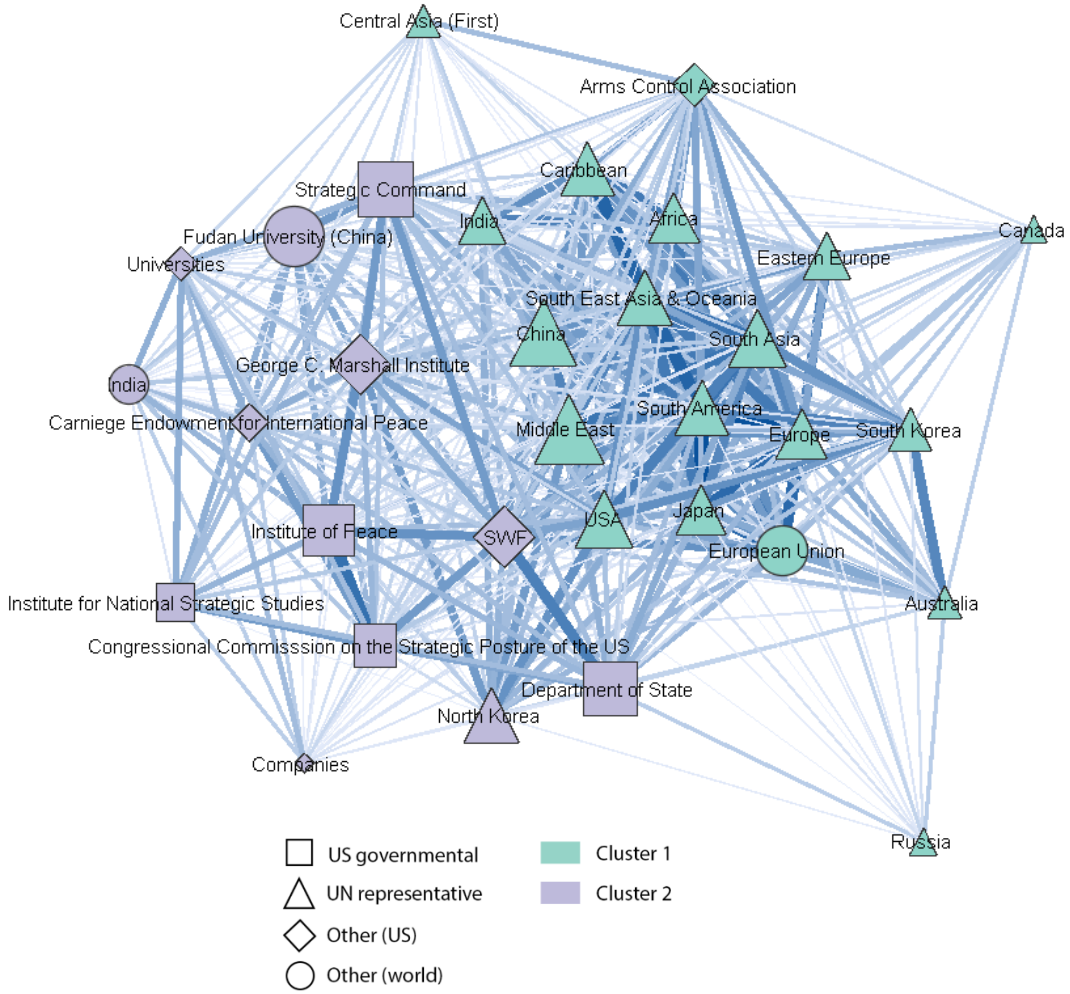
NETWORKS

PERIOD 2

NEWS



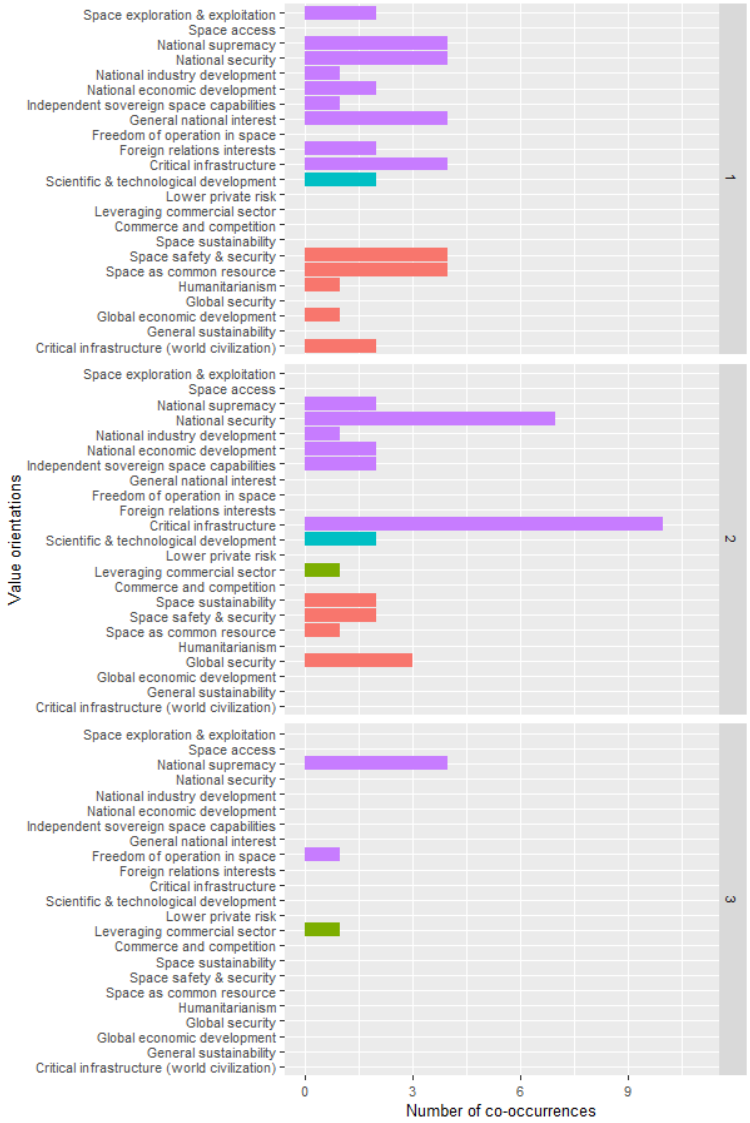
POLICY



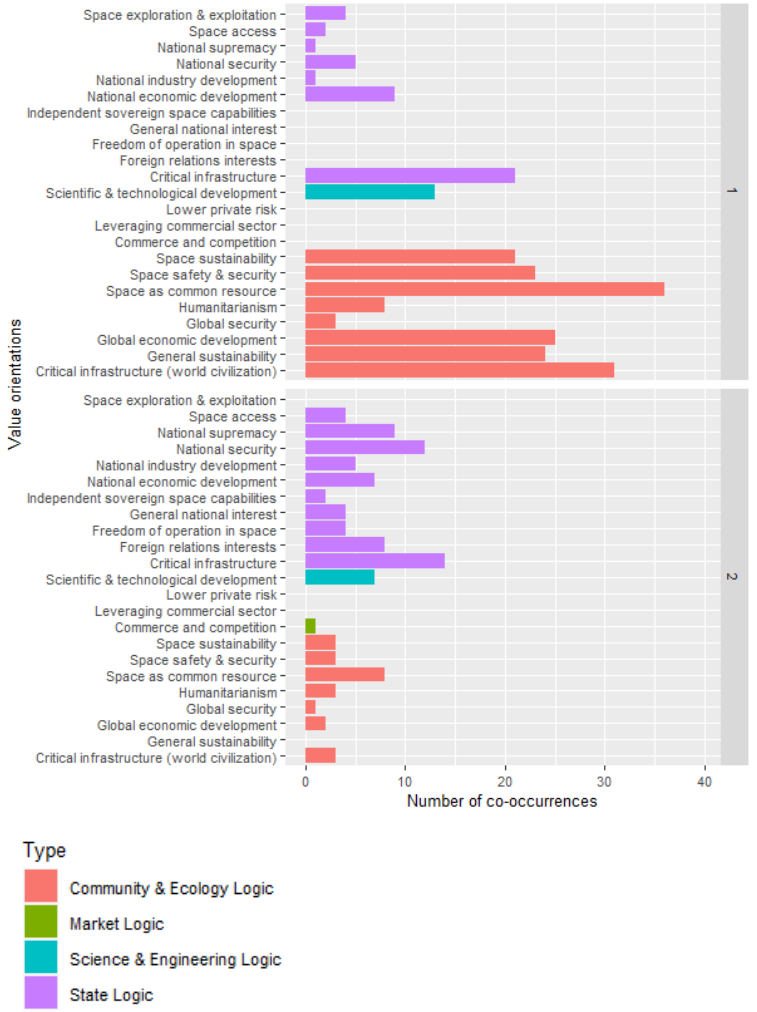
LOGICS DISTRIBUTION BY NETWORK CLUSTER

PERIOD 2

NEWS



POLICY



PREFERENCE FREQUENCY TABLE BY NETWORK CLUSTER

PERIOD 2

NEWS

POLICY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Against binding arms control agreements	3	27.3	1	8.3	2	100
Binding arms control agreement	3	27.3	6	50	0	0
Code of conduct	1	9.1	1	8.3	0	0
TCBMs	2	18.2	2	16.7	0	0
Verifiability of agreements	2	18.2	2	16.7	0	0

STRATEGIC PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Allied cooperation	7	28	3	13	1	20
Deterrence	0	0	2	8.7	1	20
Developing counter space capabilities	3	12	1	4.3	2	40
Diplomacy	1	4	3	13	0	0
International cooperation	5	20	3	13	0	0
Non-allied cooperation	2	8	2	8.7	0	0
Resilience of space-enabled services	0	0	3	13	1	20
Security cooperation	6	24	2	8.7	0	0
Sharing information and capabilities	0	0	2	8.7	0	0
Space traffic management	1	4	1	4.3	0	0
Strategic restraint	0	0	1	4.3	0	0

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Co-orbital drones or service satellites	1	7.7	0	0	0	0
Counter space capabilities	1	7.7	1	8.3	0	0
Cyber capabilities	5	38.5	0	0	0	0
Directed energy (laser)	0	0	0	0	1	33.3
Launch systems	1	7.7	5	41.7	0	0
Missile defense systems	0	0	3	25	0	0
Small satellites	0	0	1	8.3	0	0
SSA capabilities	5	38.5	2	16.7	2	66.7

POLICY

POLICY PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Against binding arms control agreements	1	1.1	7	26.9
Binding arms control agreement	26	29.2	5	19.2
Code of conduct	12	13.5	2	7.7
EU CoC proposal	15	16.9	0	0.0
Space norms or standards	8	9.0	3	11.5
TCBMs	24	27.0	3	11.5
Verifiability of agreements	3	3.4	6	23.1

STRATEGIC PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Allied cooperation	1	1.8	2	5.4
Deterrence	0	0.0	5	13.5
Developing counter space capabilities	0	0.0	3	8.1
Diplomacy	1	1.8	4	10.8
International cooperation	27	48.2	6	16.2
Military exercises	0	0.0	1	2.7
Non-allied cooperation	0	0.0	4	10.8
Public-private partnerships	1	1.8	0	0.0
Resilience of space-enabled services	0	0.0	5	13.5
Security cooperation	0	0.0	1	2.7
Sharing information and capabilities	23	41.1	3	8.1
Space traffic management	2	3.6	0	0.0
Strategic restraint	0	0.0	3	8.1
Strengthen global legal space regime	1	1.8	0	0.0

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Active debris removal technologies	1	16.7	0	0.0
Against missile defense systems	3	50.0	3	18.8
Electronic counter space systems	0	0.0	1	6.3
Missile defense systems	1	16.7	2	12.5
Small satellites	0	0.0	1	6.3
SSA capabilities	1	16.7	9	56.3

4.3. Period 3

4.3.1. News

Distributed power to shape regime among State-driven state actors

Period 3 captures the rapid increase in the number of actors involved in the space security field. The News platform network captures the rapid growth of the number of actors involved in the space security field and shows the formation of more complex network configurations. China, Russia, the UK, Japan, and India seem to have assumed a more central role in the field, reflecting that the power to shape the space security regime has grown increasingly distributed and decentralized in period 3.

These state actors, including US governmental actors, are increasingly driven by State logic compared to period 2, especially by values of *national supremacy*, *national security*, and *critical infrastructure*. A notably high number of references to *national supremacy* is made by the Presidential Office of the US, and China. Support for these State logic value orientations is paralleled by valuation of the policy preference of a *national space force or command*, which receives agreement from the majority of state actors, suggesting that there is a widely shared sense among states that the characteristics of the geopolitical environment in period 3 justify the organization of military space as a separate military branch. Again, adherence to this preference is especially high from the Presidential Office of the US. The unusually high number of references to the preference of a *national space force or command* made by the Trump administration is partially due to the high political controversiality of the issue and subsequent high coverage by news articles. Nevertheless, support for these values and preferences is ubiquitous among other US governmental actors in period 3. This widespread government support led to the establishment of the US Space Force in December 2019.

Part of the wide trend towards nationalistic values is the broad support among state actors for the strategic preference of *developing counter space capabilities*, especially by China, Russia, and US governmental actors. This observation indicates the presence of an arms-race-like dynamic between these three geopolitical powers in period 3, partially aroused by Chinese support of *developing counter space capabilities* in period 2 in combination with the revivified strategy of deterrence employed by US governmental actors in period 3. Further evidence for this dynamic is captured by the higher and more varied valuation of specific counter-space capabilities by the three countries. The most referenced counter space capabilities are physical kinetic counter space capabilities such as kinetic ASAT missiles and co-orbital drones. Physical kinetic counter space capabilities are the most destructive and permanent variant and are therefore the most threatening to space sustainability and security, which accounts for the high number of actor-concept links to this preference. In addition, high emphasis is placed on laser weapons by the three countries. The strong connection between State logic adherence and the development of counter space capabilities is captured by the quote:

"General John Hyten, head of United States Strategic Command, stated on Aug. 8, 2017: "The No. 1 problem we face is being outpaced by our adversaries. The actions we take today will assure continued American dominance, especially in the critical domain of space." Thus, the argument goes, the U.S. military must pour resources into preparing to fight in this domain, including building offensive weaponry based on the ground and in space."[13]

[13] National Post (2017). The terrible thought of war in outer space.

In period 3, state actors are increasingly aware of the role of commercial space in fulfilling, mostly, State logic value orientations. This is evidenced by adherence to Market logic, especially the value orientation of *leveraging the commercial sector*, by state actors in the News platform, including the US, Japan, China, and Australia. Within the US, governmental actors, especially those operating under the Department of Defense, are conscious of the dependence of the US military on the commercial space sector. In addition, they point to the value of enhancing the resilience of space infrastructure by leveraging the commercial sector (for example, through the use of constellations of small satellites):

"Furthermore, the NSS [National Security Strategy] promotes expanded partnerships with the commercial sector to improve resilience of the US space architecture. The US will also "consider" extending national security protections to private sector partners. Once again, this statement is meant to obscure US response plans to a space attack and, in turn, increase enemy uncertainty when considering an attack."[14]

4.3.2. Policy

Strong polarization between US and UN actors returns

The divide between US and UN actors in the Policy platform that was seen in period 1 has returned in period 3, after a period of relative convergence in period 2. Part of this division due to the stronger adherence to State logic relative to C&E logic by US actors. In addition, the People's Liberation Army (PLA) of China is included in the cluster with US actors, capturing the high adherence to State logic relative to other logics by this actor as well. This observation substantiates the assertion that greater Chinese military influence in the space security field as seen in the News platform also applies in the Policy domain. In particular, this concerns the domestic policy discourse within the US.

In contrast with greater State logic adherence by US actors and the Chinese PLA, UN actors are adhering more strongly to C&E logic relative to State logic in period 3 compared to period 2. Policy preferences that follow from the logics profile of UN actors have changed relative to period 2. From the cluster preferences it appears that UN actors have decreased their support for a code of conduct and have doubled down on their adherence to the policy preference of a *binding arms control agreement*, while support among these actors for TCBMs has stayed the same.

US actors still do not support binding arms control agreements, have stopped supporting any code of conduct altogether, have lowered their adherence to TCBMs, and have instead increased their support of the policy preference of *space norms or standards*. Especially US military actors such as the Defense Secretary are highly in favor of establishing nonbinding voluntary norms and standards of behavior in space, who see them as substitutes for binding agreements that are perceived to limit the US in pursuing its national interests. Furthermore, These actors also strongly adhere to the strategic preference of enhancing the resilience of space-enabled services. The stance of US governmental actors is exemplified by the following quote by Frank A. Rose, Assistant Secretary of State:

[14] Japan Economic Foundation (2018). Making Space Safe Again: National Security Space Policy in the Trump Era.

"Sir, I think we need a comprehensive response. It needs to include norms of behavior so we prevent activities like China's ASAT test. It needs to include resilient U.S. systems that can operate in outer space and we need to be able to respond if there is an attack on U.S. space assets."[15]

Strong surge in Market logic adherence at national policy level

In the Policy platform, the presence of Market logic has dramatically increased among US actors. This reflects a growing importance of commercial space within policy contexts, especially in US domestic policy discourse. US military actors such as the Air Force and the Defense Secretary and other actors such as the Companies and NASA emphasize the importance of outsourcing the provision of national security services by leveraging the commercial sector. Actors stressing the importance of *lower risk to private actors* in the space industry are primarily the Companies and NASA. The Chinese PLA also values *commerce & competition* and *leveraging the commercial sector* along with its high adherence to State logic. This indicates that the relationship between State values and Market values is increasingly apparent in Chinese policy settings as well and might suggest that this is also the case in national policy settings of other countries.

Adherence to the preferences of *policy for US commercial stimulation, less bureaucracy, transfer of space traffic management (STM) to civil agency or the Department of Commerce, and US tech licensing loosening* by many US governmental actors follows from their increased adherence to Market logic, as these preferences are perceived to enable wider commercialization. Companies are also highly in favor of removing regulatory barriers posed by security classification regulations, which were highly applicable during the Cold War, when US satellites were strictly classified in the interest of national security. The US governmental stance is shown by the following quote by Doug Loverro, Assistant Secretary of Defense for Space Policy:

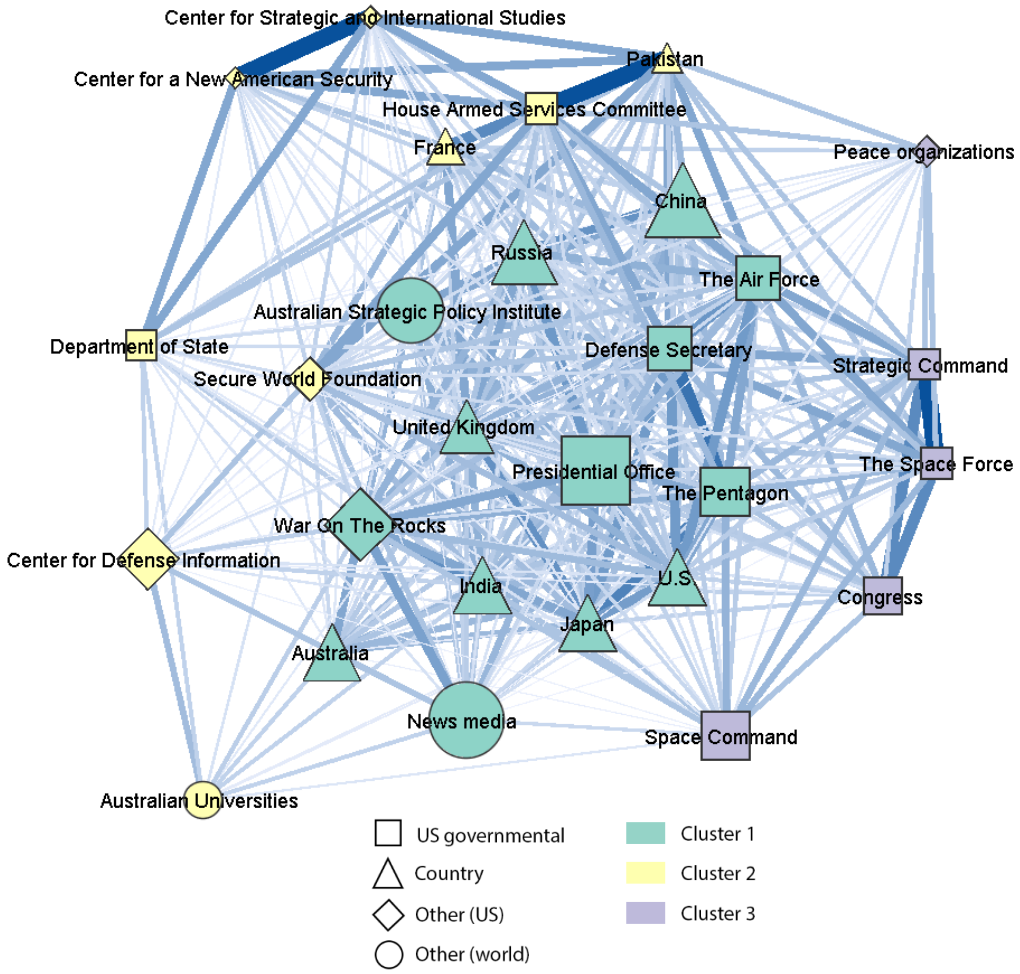
"And that means we have to go ahead and change policies in -- with regard to licensing to make it easier for people to go ahead and invest in advanced space capabilities within the U.S., because that frees up the entrepreneurial spirit that we see in the U.S., and it would allow those new space services to come to the -- the market more quickly, more rapidly, more agilely."[16]

[15] CQ Transcriptions (2019). Future Visions and Current Issues.
[16] CQ Transcriptions (2016). The Center for Strategic and International Studies Holds A Discussion on the U.S. Military and Commercial Space Industry.

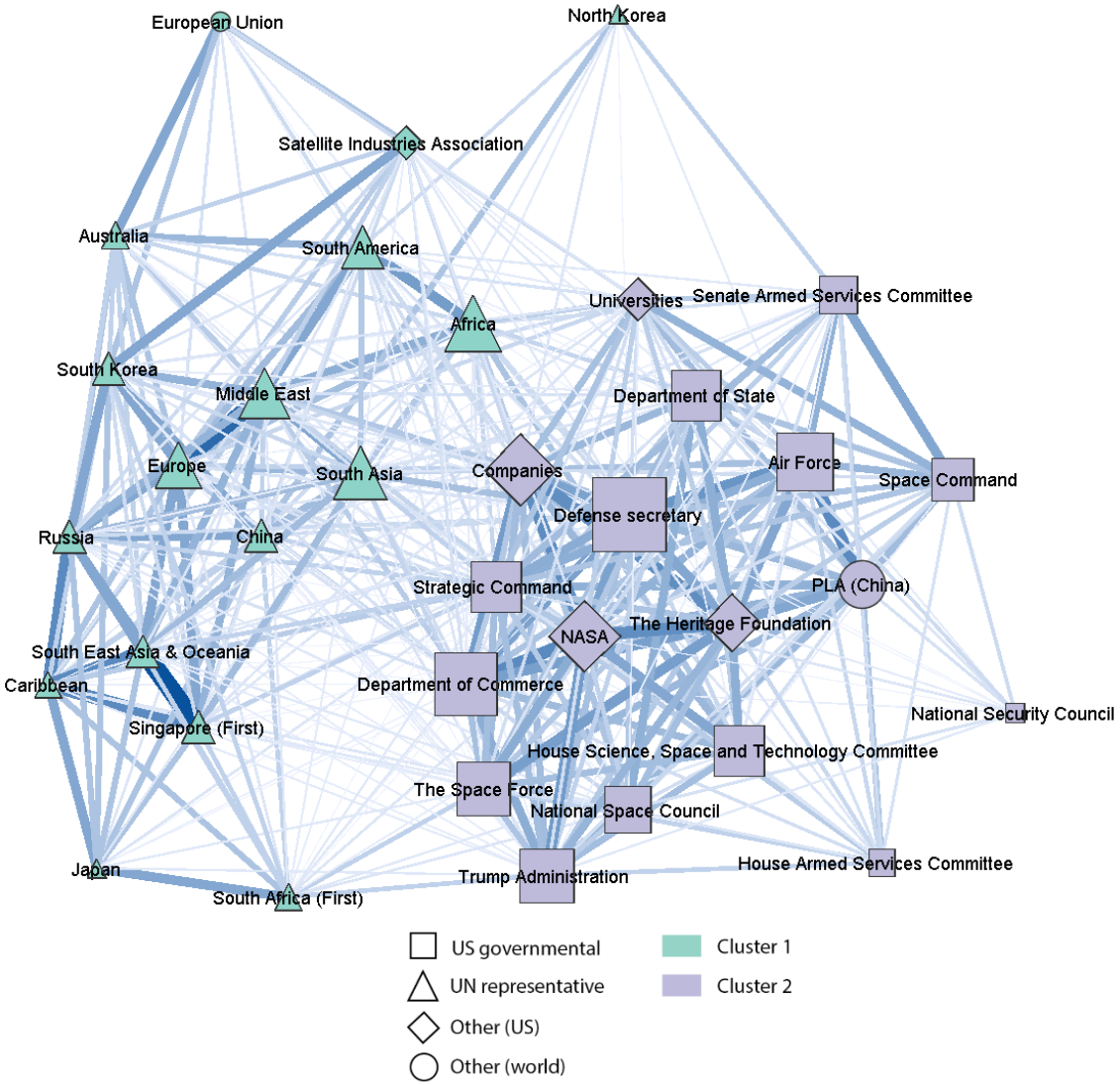
NETWORKS

PERIOD 3

NEWS



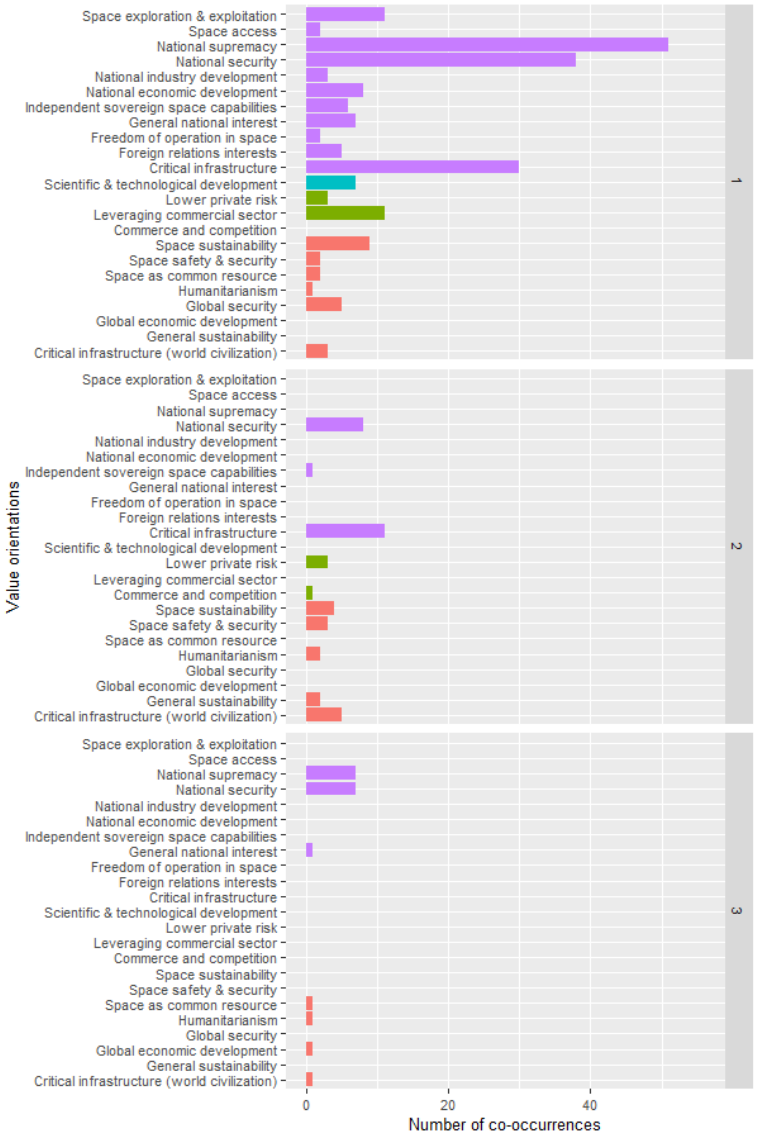
POLICY



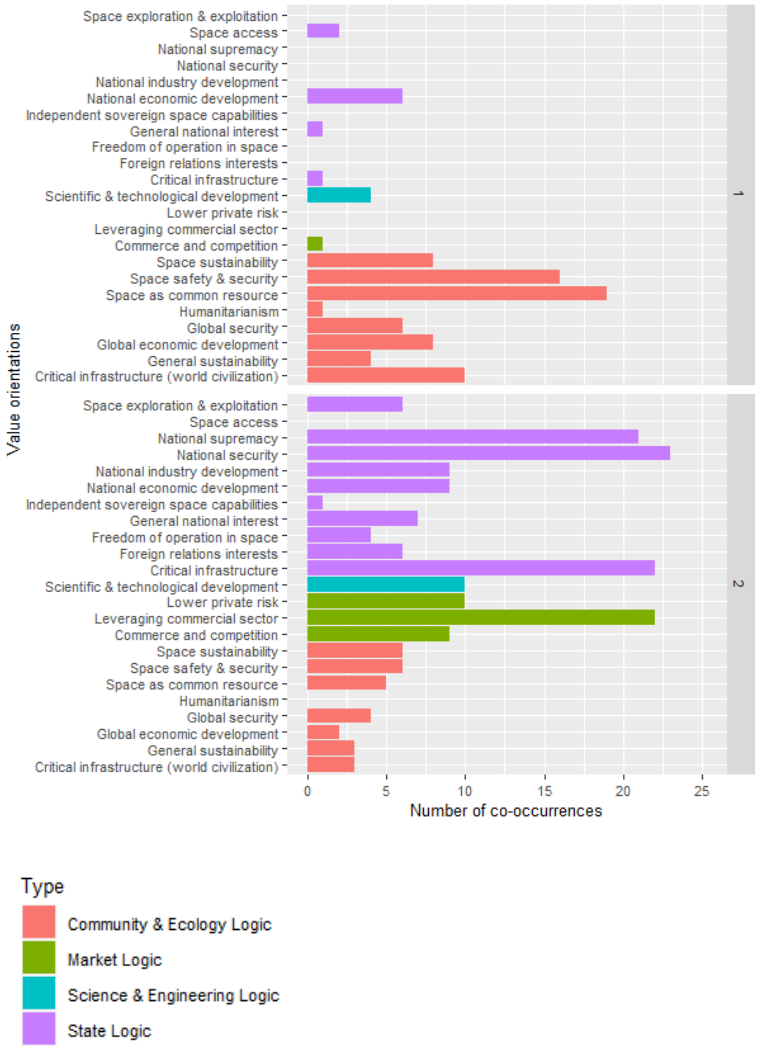
LOGICS DISTRIBUTION BY NETWORK CLUSTER

PERIOD 3

NEWS



POLICY



PREFERENCE FREQUENCY DISTRIBUTION BY NETWORK CLUSTER

PERIOD 3

NEWS

POLICY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Against binding arms control agreements	0	0.0	1	5	0	0
Against US national space force	8	9.2	2	10	1	16.7
Binding arms control agreement	12	13.8	1	5	0	0
Code of conduct	1	1.1	0	0	0	0
Ground-based ASAT limits	5	5.7	1	5	0	0
National space force or command	49	56.3	12	60	3	50
Policy for commercial space stimulation	2	2.3	0	0	0	0
Space norms or standards	8	9.2	3	15	2	33.3
TCBMs	1	1.1	0	0	0	0
Verifiability of agreements	1	1.1	0	0	0	0

STRATEGIC PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Allied cooperation	21	14.4	1	7.7	0	0
Deterrence	20	13.7	0	0	2	50
Developing counter space capabilities	42	28.8	4	30.8	1	25
Diplomacy	5	3.4	3	23.1	0	0
International cooperation	8	5.5	0	0	0	0
Less bureaucracy	4	2.7	2	15.4	0	0
Military exercises	9	6.2	1	7.7	0	0
Non-allied cooperation	3	2.1	0	0	0	0
Offensive actions	1	0.7	0	0	0	0
Optimizing space acquisition	2	1.4	0	0	1	25
Public-private partnerships	2	1.4	0	0	0	0
Resilience of space-enabled services	15	10.3	0	0	0	0
Security cooperation	4	2.7	2	15.4	0	0
Sharing information and capabilities	8	5.5	0	0	0	0
Strategic restraint	2	1.4	0	0	0	0

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2		Cluster 3	
	#	% of total	#	% of total	#	% of total
Active debris removal technologies	1	0.9	0	0	0	0
Co-orbital drones or service satellites	22	19	0	0	0	0
Counter space capabilities	8	6.9	0	0	0	0
Cyber capabilities	5	4.3	0	0	0	0
Directed energy (laser)	11	9.5	0	0	0	0
Directed energy (general)	6	5.2	0	0	0	0
Electronic counter space systems	8	6.9	0	0	0	0
Launch systems	1	0.9	0	0	0	0
Missile defense systems	14	12.1	0	0	2	100
Physical kinetic ASAT	19	16.4	0	0	0	0
Small satellites	8	6.9	1	50	0	0
SSA capabilities	13	11.2	1	50	0	0

POLICY

POLICY PREFERENCES	Cluster 1		Cluster 2	
	#		#	% of total
Against binding arms control agreements	0	0.0	3	6.8
Binding arms control agreement	26	55.3	1	2.3
Code of conduct	1	2.1	0	0.0
EU CoC proposal	1	2.1	0	0.0
National space force or command	0	0.0	6	13.6
Policy for commercial space stimulation	0	0.0	11	25.0
Space norms or standards	2	4.3	10	22.7
TCBMs	13	27.7	2	4.5
Transfer of STM from DOD to civil agency	0	0.0	2	4.5
Transfer of STM from DOD to Department of Commerce	0	0.0	4	9.1
US tech licensing loosening	0	0.0	4	9.1
Verifiability of agreements	4	8.5	1	2.3

STRATEGIC PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Allied cooperation	0	0.0	12	13.5
Deterrence	0	0.0	11	12.4
Developing counter space capabilities	1	6.7	4	4.5
Diplomacy	0	0.0	2	2.2
International cooperation	5	33.3	5	5.6
Less bureaucracy	0	0.0	5	5.6
Military exercises	0	0.0	4	4.5
Non-allied cooperation	0	0.0	2	2.2
Offensive actions	0	0.0	2	2.2
Optimizing space acquisition	0	0.0	5	5.6
Public-private partnerships	0	0.0	8	9.0
Resilience of space-enabled services	0	0.0	13	14.6
Security cooperation	0	0.0	3	3.4
Sharing information and capabilities	8	53.3	7	7.9
Space traffic management	0	0.0	5	5.6
Strengthen global legal space regime	1	6.7	1	1.1

TECHNOLOGY PREFERENCES	Cluster 1		Cluster 2	
	#	% of total	#	% of total
Active debris removal technologies	2	16.7	1	3.1
Against missile defense systems	5	41.7	0	0.0
Co-orbital drones or service satellites	0	0.0	1	3.1
Counter space capabilities	0	0.0	1	3.1
Cyber capabilities	0	0.0	1	3.1
Electronic counter space systems	0	0.0	1	3.1
Launch systems	0	0.0	5	15.6
Missile defense systems	2	16.7	5	15.6
Physical kinetic ASAT	1	8.3	0	0.0
Small satellites	0	0.0	2	6.3
SSA capabilities	2	16.7	15	46.9

4.4. Summary of results

News

The development of the space security field has been overarchingly characterized by a movement of decentralization in the power to shape the regime, consistent with observations by Robinson & Mazzucato (2019). This is exemplified by an increasing number of state actors being involved in shaping the space security regime over time, as exemplified by the analysis of the News platform. The emergent multi-national regime is characterized by strong adherence to State logic value orientations and a growing consideration of space as a domain for potential military conflict. This is evidenced by widespread willingness among state actors to establish national military branches for space and to pursue development of counter-space capabilities, especially the physical kinetic variant. This is concerning in light of the space sustainability issues of space debris and orbital congestion. The growing atmosphere of geopolitical military competition in space has come along with slightly increased adherence to Market logic by state actors in the News platform in period 3, particularly to the value orientation of *leveraging the commercial sector*, suggesting that the decentralization of power to shape the regime is driving commercialization.

Policy

Efforts to prevent the risk of conflict in space in UN policy contexts has been characterized by a political stalemate, as the US has considered binding policy mechanisms undesirable in light of national interests. In the aftermath of the 2007 Chinese ASAT test, period 2 of the Policy platform was characterized by higher convergence in logics between clusters, a higher shared willingness to seek solutions to the political stalemate through nonbinding agreements, and a softer foreign policy posture by US governmental actors. However, period 3 was again characterized by polarization between US and UN actors, which happened in the aftermath of the transfer of power from the Obama administration to the Trump administration. Along with this increasing polarization, US policy discourse in period 3 showed high adherence to Market logic by US governmental actors, mostly regarding the outsourcing of national security services to the commercial sector. This increased adherence to Market logic is not only driven by international geopolitical competition between state actors but is also a result of public budget cuts and a resulting need for public agencies to verifiably improve their cost-effectiveness (Robinson & Mazzucato, 2019).

Comparison between platforms and the theoretical approach

The methodological splitting of multiple platforms in this study enables the comparison of platforms and yields insights into the complexity of global socio-technical regimes. For instance, comparison of different platforms shows that the US is generally consistent in its adherence to State logic in policy environments at national and international levels, and also at the level of public media publications. In contrast, Russia and China are less consistent, as their preference for a binding arms control agreement is substantiated through different logics based on the sensemaking platform under analysis. The two countries justify their support for this policy preference by C&E logic in the Policy platform, while they are primarily driven by State logic in the News platform. In the latter platform, they view a binding agreement as a way to

slow down development of counter space capabilities by the US and thereby lower the US's capacity to deter actions by China and Russia. Additionally, China and Russia support the policy preference of a *national space force or command* and the strategic preference of *developing counter space capabilities* in concert with their desire to establish a binding arms control agreement that limits such developments. These observations suggest that actors can have links to different and contradictory logics and preferences in different sensemaking platforms. This is because sensemaking platforms differ in conditions that shape how information is processed: who mediates and produces information, and to whom this information is transferred. This points to the complexity of the global sociotechnical regime of space security and reveals the necessity of including multiple sensemaking platforms into the methodological approach for its analysis.

5. Conclusions & Discussion

5.1. Research questions

The study intended to answer the research question, which reads:

How has the socio-technical regime of global space security evolved over time and what are future policy implications?

In pursuit of answering this research question, this study has undertaken a socio-technical configuration analysis of a body of texts that represent the discourse of the organizational field of space security across two different sensemaking platforms. It then placed the resulting findings into a coherent storyline that tracked the development of the space security regime from 2001 to 2022. This process enables the answering of the research question in three sub questions:

1. Which are the most important interests or value orientations (i.e., institutional logics) that have been shaping actors' strategies in the field of space security over time?

The most significant logic that has shaped the field of global space security over time has been State logic, primarily the value orientations of *national security*, *national supremacy* and *critical infrastructure*. In the News platform, State logic was centrally important in all periods while the actor configurations changed. In the policy platform, State logic and C&E logic have constituted strongly opposed forces during all periods. Some convergence took place in the Policy platform during period 2, but period 3 was characterized by strong polarization in terms of these two logics. Market logic was not featured significantly in the News platform during any period, with only slightly higher adherence in period 3. However, policy discourse at national levels showed high presence and central importance of Market logic, especially concerning the value orientation of *leveraging the commercial sector*, indicating that commercial space has become increasingly important at the level of national policymaking in the field of global space security in recent times.

2. Which clusters of actors based on logics were the most important in each period, and how has this unfolded across different levels of analysis?

In the News platform, the relative importance and centrality of US actors in the space security regime has decreased in comparison to to that of other actors, as the most important cluster in each sequential period featured lower presence of US actors. Conversely, the relative importance and centrality of other state actors, such as China, Russia, India, Australia, Japan, and the UK, has grown. While these observations are indicative of a trend of decentralization in the power to shape the space security regime, central actors have consistently been characterized by high adherence to State logic, especially value orientations of *national security*, *national supremacy*, and *critical infrastructure*. In addition, period 3 is characterized by higher adherence to Market logic by state actors and an increased appreciation of the relationship between national interests and commercial space activity.

In the Policy platform, the clustering algorithm has consistently split actors into two important clusters, one containing mostly UN actors, and the other containing mostly US actors, evidencing a clear split between policy discourse at the international and national US level. The two clusters were strongly opposed in relative adherence to State logic versus C&E logic in

period 1, while evidence was found for logics-based conversion in period 2 in the aftermath of the 2007 Chinese ASAT test. The policy network in period 3 was again characterized by strong polarization between UN and US actors. The divide between these groups of actors across periods constitutes logics-based evidence for the continuous inability to establish multilateral measures that has characterized international policymaking around space security. Lastly, within national policy contexts, the role of commercial space has recently gained much attention, where policy actors are increasingly cognizant of the benefits of leveraging the commercial sector in accordance with national interests.

3. How can the above developments of the socio-technical regime help identify potential developmental trajectories of the field?

In the News platform, changes in preferences indicate that US actors were more conflict-averse and more cooperation-seeking in period 2 than in period 1. This is evidenced by lower adherence to the strategic preference of *developing counter space capabilities* and the technology preference of *missile defense systems*, and higher adherence to the strategic preferences of allied cooperation and non-allied cooperation. Furthermore, US actors displayed an increased willingness to pursue alternatives to binding arms control agreements, which is captured by increased adherence to policy preferences of *TCBMs* and a *code of conduct*. However, in period 3, this conflict-averse posture disappeared, as both US actors and other state actors increasingly valued the establishment of national space forces and commands, in addition to development of national counter space capabilities, specifically physical kinetic capabilities such as co-orbital drones and ASAT missiles. Furthermore, state actors including US actors were less open to cooperation with non-allied nations but remained supportive of cooperation with allied nations in period 3, signaling a trend of polarization between allied groups of nations in the geopolitical sphere.

The policy platform was characterized by a continuous strong tension between UN and US actors. UN actors showed strong consistent support for binding arms control agreements, while US actors consistently opposed. In period 2, US governmental actors showed more openness to potential substitutes for binding agreements in the form of TCBMs or a code of conduct but were less enthusiastic than UN actors. US actors showed greater support for norms and standards as substitutes than UN actors. This support remained in period 3 while support for other informal policy mechanisms by US actors decreased. The presence of Market logic in the US and Chinese national policy spere and associated preferences shows that the role of commercial space within national policy contexts, especially in relation to space security, is growing.

The developments described above in combination with the current state of the field of global space security can help to identify potential development trajectories. A trend of continuous growth in the number of state actors involved in the field was observed in the News platform across time periods. This growing number of actors consistently displayed strong adherence to State logic. In the aftermath of the 2007 ASAT test by China, US actors in displayed more willingness to seek informal policy solutions as well as a generally softer foreign policy approach in period 2. However, this was displaced by a more aggressive posture in period 3 driven by strong State logic adherence. The role of commercial space in the space security field became apparent in period 3, especially in the Policy platform where state actors increasingly viewed leveraging the commercial sector as beneficial to national interests. The

emerging global space security regime is characterized by a multitude of important state actors and an increasing importance of commercial space in national policy environments.

5.2. Limitations

This study was characterized by a number of limitations that have to be considered in the context of its reliability. The quality of data analysis is limited by the quality of the data used. Firstly, the search string that aimed to obtain an accurate representation of the discourse within the space security field limits the dataset used for analysis and might have excluded important articles as a result. Secondly, the number of sources was limited based on the time allotted to data analysis, which might again have excluded important articles. Third, due to the nature of the database, which featured English articles only, the obtained dataset was considerably US-centric. This limits the study in the perspective that it can obtain over other countries and regions. However, this limitation is partially mitigated by the fact that substantive coding used in the News sensemaking platform can enlarge this perspective by including statements that actors make about other actors. Fourth, the quality of the analysis of individual sensemaking platforms was limited by the splitting of sensemaking platforms, as the splitting resulted in fewer sources allotted to each platform. However, the splitting of sensemaking platforms allowed for a multi-level analysis of the global sociotechnical regime of space security, which added analytical value.

Furthermore, this study relies on coding by researchers, which is subject to subjective interpretation and possible bias. To ensure internal validity, the study was characterized by periodic and iterative adjustment of the coding scheme in consultation with the supervisor. To ensure external validity, or transferability, the study provides instructions for obtaining the same data sample from the database, together with the coding scheme for both logics and preferences. In addition, this study uses software that is freely accessible by university staff and students. However, it is possible that analysis of the same body of texts using the same coding scheme can generate different results, as coding is done by a different researcher at a different time.

5.3. Theoretical implications

This study is the first study to apply the institutional logics approach and STCA method to the field of space security. It has thereby contributed to the understanding of geopolitical dynamics in space through the lens of transition studies. The main theoretical contribution of this study is captured by the methodological splitting of sensemaking platforms. Division of articles based on the context of their publication has enabled the analysis of discourse around space security in different domains of collective sensemaking. It has shown that actors differ in their adherence to logics and preferences based on the platform under study. Thereby, this approach can shed light on the complexity of global sociotechnical regimes, which involve interactions in a variety of sensemaking platforms at different analytical levels. In this way, this study contributed to the understanding and conceptual framing of global sociotechnical regimes.

5.4. Policy implications

The combination of the trend of decentralization in the power to shape the space security regime across state actors and the continuous strong adherence to State logic value orientations and

associated preferences is concerning in light of space sustainability issues such as space debris and orbital congestion. The absence of a clear global regulatory regime that would limit military conflict in space has stemmed from a continuous political gridlock in UN contexts. However, the analysis of period 2 in the Policy platform showed that the establishment of informal institutions is not unthinkable given enough political will. The question is whether such measures will be successfully adopted and implemented before the space infrastructure they are designed to protect is lost as a result of the aggravation of space sustainability issues to to escalations of conflict. There is currently no indication that such measures will be established soon, as the continuous trend of State-driven fragmentation between state actors is associated with polarization between national and international policy contexts. However, this study found that significant events that bring attention to the issues of space sustainability, such as the 2007 ASAT test by China, can potentially generate political will to establish measures in international policymaking arenas.

Continuous focus on enhanced SSA capabilities, at first by US actors, and recently also by other state actors, is promising when considering that a shared ability to monitor the space environment could enable better space traffic management, more effective deterrence of hostile actions in space, and enhanced enforcement and verification of negotiated agreements. Additionally, focus on enhancing the resilience of space infrastructure through the leveraging of the commercial sector, expressed by US governmental actors in period 3, shows that commercial space can constitute a driver of space sustainability through improving conditions for space security. This is because enhanced resilience constitutes a deterrent of attacks on space assets, decreasing the risk of escalations of conflict in space. Thereby, resilience could prevent creation of space debris and contribute to amelioration of space sustainability issues. Furthermore, resilience also limits the significance of damage in the case that an attack does occur.

The inability of international policymaking circles to establish measures that protect ensure space security and space sustainability is especially concerning from the perspective of underdeveloped and developing countries. This is because the aggravation of space security and space sustainability issues are potentially detrimental to space services that such countries have grown critically dependent on in recent times. Simultaneously, their power to shape the space security regime according to their interests is negligible, as exemplified by the News sensemaking platform. Despite representation of their interests in the Policy sensemaking platforms in UN contexts, their power to shape the space security regime is small when considering that the five permanent members of the UN (China, France, Russia, the United Kingdom, and the United States) have the power to veto resolutions if they are not aligned with national interests. These observations support the utility of including multiple sensemaking platforms in the methodological approach of this study, as it allows for the representation of interests that would be missed when only analyzing one sensemaking platform.

5.5. Take home message

The development of the space security field is characterized by a trend of decentralization of power to shape the regime among an increasing number of state actors. Strong adherence to State logic by these state actors is potentially concerning in the context of space sustainability issues. However, this study has shown that significant events, such as the 2007 ASAT test by China, can generate political will that might culminate into the establishment of measures to enhance space sustainability. Such measures will likely be of an informal and voluntary nature,

judging from the long-lived political gridlock in UN contexts around binding agreements. Furthermore, by splitting sensemaking platforms, this study has shown that actors can associate with different value orientations and preferences based on the conditions of sensemaking platforms. Additionally, different actors are included and excluded from discourse around space security based on sensemaking platforms. Thus, this study has provided insights into the complexity of the global socio-technical regime of space security and added to the theoretical understanding of global socio-technical regimes.

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7. Acknowledgements

This thesis could not have been delivered without the help of Dr. Xiao-Shan Yap, who was very involved during the research process and whose supervision and expertise were of incredible value to the final product. Her motivating force, moral support, and kind-hearted advice made the research experience much more pleasant than one would hope to expect. Besides offering her great help, she kindly facilitated a research trip to Zurich, Switzerland, which proved to both be a wonderful experience and a very fruitful opportunity in terms of research progress. Furthermore, I would like to extend gratitude to Prof. Dr. Bernhard Truffer, who offered his time to provide help with understanding the methodological approach and interpreting results, in addition to his kindness during my stay in Zurich. Additionally, I would like to thank Johan Miörner for his efforts in writing and publishing the STCA guide, which has been of great value in understanding the methodology and bringing it into practice. Lastly, I would like to extend gratitude to members of the research team at Eawag whose work has indirectly contributed to this thesis.