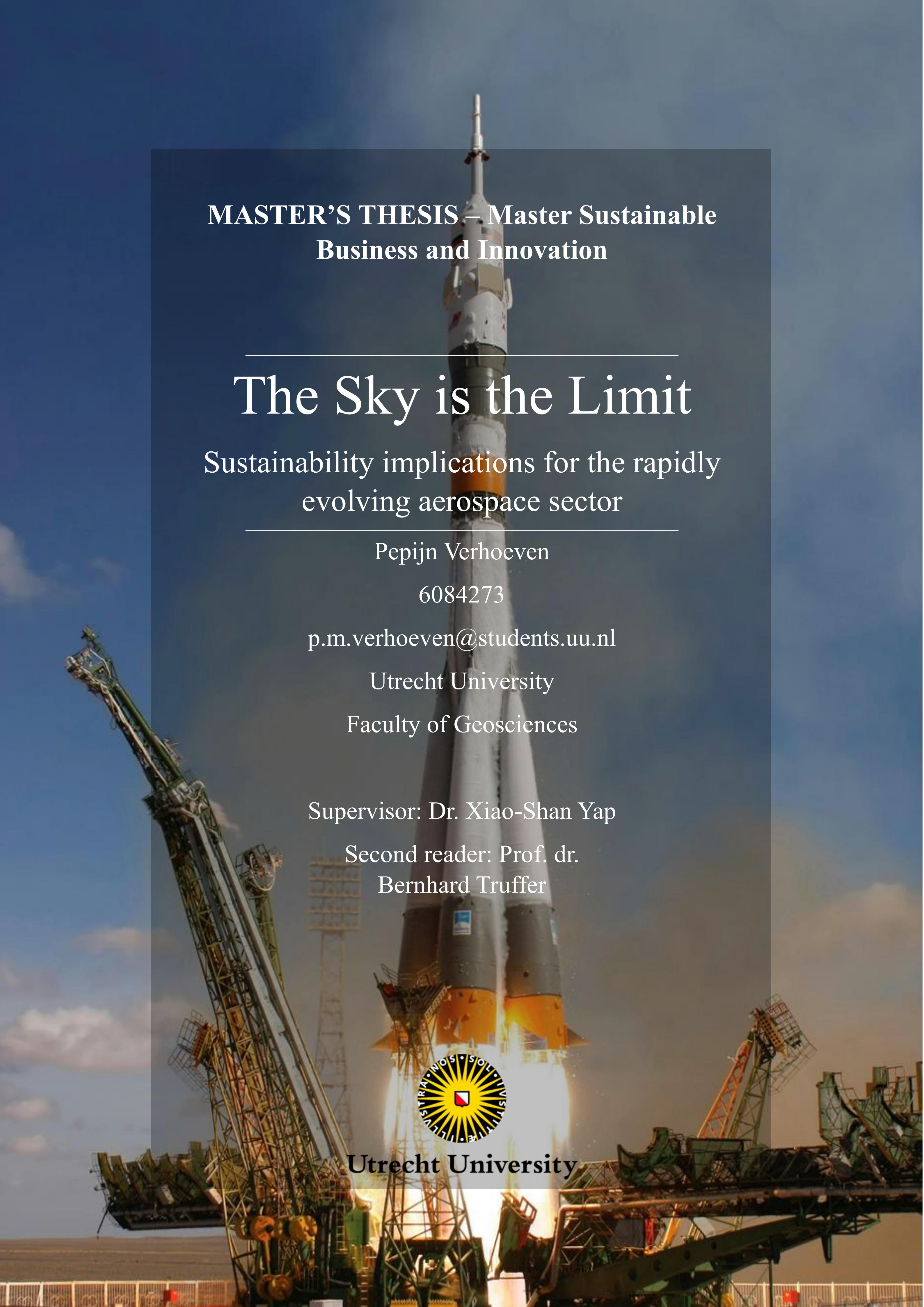

MASTER'S THESIS – Master Sustainable Business and Innovation

The Sky is the Limit

Sustainability implications for the rapidly evolving aerospace sector

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Abstract

With the advent of the New Space era the number of rocket launches and actors within the sector has grown exponentially, and projections indicate that this growth trend will continue over the next decade. Research highlights the significant impact of this development on the environment, such as contributions to climate change and ozone layer depletion. Actors in the sector can be divided into different categories, such as governmental institutions (NASA) and private companies (SpaceX). Different actors have different motivations regarding the use of space, each of which impacts sectoral development. In order to enable a sustainable transition, it is important to gather insights into the values and strategies that are currently driving the rapid development of the global and regional rocket launching sectors.

This research employs the institutional logics approach to gather insights into the norms, values and strategies that actors adopt to pursue their goals and that drive the rapid development of the sector. A multiple case study approach is adopted for the four major regions in the global rocket launching sector across three time phases. This approach maps the dominant value orientations among actors in these four respective sectors, which constitute field logics. The development of the field logics over time in the distinct regions provides insights into the characteristics of the emerging global socio-technical regime.

The results illustrate the dominance of the State Market Field Logic in the final time period across four regions, with values such as commercial development, profit and global leadership being important values driving the further development of the global sector. The results highlight the limited number of actors who adhere strongly to sustainability-related values. The emergent nature of the global regime coupled with the absence of an institutionalised material technological structure, creates the possibility for the global regime to follow different trajectories in terms of technological development. The State Market Field logic is likely to steer the development of the regime's technological structures towards the trajectory of focusing on reusability. The widespread application of the concept of reusability could lead to a greater environmental impact due to more frequent launches and propellant burning. It is therefore necessary to implement policies regarding the number of launches and the mitigation of their environmental impact.

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List of Abbreviations

Abbreviation	*Meaning*
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CNSA	China National Space Administration
ESA	European Space Agency
GWP	Global Warming Potential
FCC	Federal Communications Commission
GSLV	Geosynchronous Satellite Launch Vehicle
IN-SPACe	Indian National Space Promotion and Authorization Center
ISRO	Indian Space Research Organisation
ISS	International Space Station
NASA	National Aeronautics and Space Administration
NSIL	NewSpace India Limited
PSLV	Polar Satellite Launch Vehicle
STS	Socio-Technical System
UNOOSA	United Nations Office for Outer Space Affairs
USA	United States of America

1. Introduction

The number of successful rocket launches increased from 136 in 2021 to 180 in 2022 (Witze, 2023). The space launch sector is anticipated to grow significantly in the forthcoming years, with an estimated growth from a market size of around $447 billion in 2022 to an estimated value of $1000 billion in 2030 (McKinsey, 2023). This exponential growth began with the advent of the New Space Era, which can be defined as a new era of new aerospace companies that have led to the commercialisation of the sector, particularly in the context of space tourism and the emergence of new innovations such as SpaceX's reusable rockets (Lecky, 2016; The Space Foundation, 2023). Companies such as SpaceX and Blue Origin have explicitly expressed their desire to offer launch services to tourists (Chakraborty & Wattles, 2024; Singh, 2024). The space tourism market is expected to grow from $1,248.32 in 2024 to 27,861.99 in 2032 (Polaris, 2024). Companies that are dedicated to the provision of space tourism services aim to increase their profitability by focussing on reducing the cost of rocket launches, which can be achieved through a significant increase in launches (Wainscott-Sargent, 2019). In addition, the high degree of reusability of rockets also contributes to reducing the cost of rocket launches (Brown, 2024). The growth in the number of annual launches is accompanied by increasing environmental impacts, which are becoming more significant, as a result of the increasing accessibility of commercial spaceflight (Dallas et al., 2020). These impacts predominantly consist of atmospheric emissions, ozone depletion and space debris (ESA, 2020; Sirieys et al., 2022; Twiss, 2022).

Atmospheric emissions, such as CO_2, H_2O, NO_X ,soot and alumina particles function as additional greenhouse gasses by trapping heat and absorbing sunlight, which contributes to climate change and affects earth's energy balance (Sirieys et al., 2022; Twiss, 2022). Even though the space sector only burns one percent of fossil fuels burned by the aviation sector, emissions caused by rockets have significant impact, since they are emitted directly in the stratosphere, resulting in having greater magnitude than emissions of other modes of transport (Piesing, 2022; Ryan et al., 2022). Accordingly, an increase in rocket launches and their complementary emissions will have serious consequences (Twiss, 2022). Additionally, substances emitted by rockets deplete stratospheric ozone (O_3) through gas-phase reactions or by endorsing heterogeneous chlorine-activated O_3 loss on aerosol and cloud surfaces (Ross et al., 2009). If the exponential growth of the space sector continuous as expected, rocket launching related ozone depletion could undermine the success of the Montreal Protocol (Ryan et al., 2022). Finally, the amount of space debris caused by rocket launches has steadily grown over time, posing risk to functioning satellites through collisions (ESA, 2020). Collectively, these multiple environmental impacts caused by the rapidly expanding space sector create sustainability challenges on Earth and in space (Yap & Truffer, 2022).

The rocket launch sector can be categorised under the transport sector, since rockets are generally launched to transport payloads, such as satellites, scientific instruments and humans into space (ULA, n.d.). Companies and institutions operating in sectors with large environmental impacts, such as the transport sector, are experiencing stakeholder pressure to transition towards more sustainable practices (Enel, 2023; Lee & Kim, 2015). The transport sector accounted for almost eight gigatonnes, or about 20%, of global CO_2 emissions in 2022 (IEA, 2023). The transport sector is therefore making efforts to transition to clean and sustainable transportation including electrical cars, hydrogen-powered aircrafts, urban design and public transport (Gallucci, 2023; Office of Energy Efficiency & Renewable Energy, n.d.; Schiller & Kenworthy, 2017).

The environmental impacts of the rocket launching sector together clearly indicate that the expected growth of the sector and the increase in launch activities will be problematic. This will hamper efforts to mitigate climate change and the effect of the aforementioned sustainable efforts made within the transport sector. This contradicts the goals set by both the United Nations and the European Union. Hence, the environmental impact of the space launching sector should be minimised and its development should be steered towards sustainable development (Space Generation Advisory Council, 2023). Currently, the sector lacks clear institutional structures that guide sectoral development. For instance, the Outer Space Treaty, which is one of the main legislative structures concerning the use of space, is in urgent need of revision as it dates all the way back to the year 1967 (United Nations Office for Outer Space Affairs, n.d.). This thesis aims to identify the drivers, values and strategies of the actors that are guiding the development of the rocket launching sector, which enables the identification of challenges and opportunities for a sustainable transition to occur. To achieve this, the study employs theories from institutional theory, sustainability transition studies and socio-technical regime studies.

Technologies develop alongside social and institutional elements within socio-technical systems (Geels & Kemp, 2007). Transitions in socio-technical systems highlight how the development of technologies and institutional elements affect each other, which enables a better understanding of the driving values and strategies of actors within the rocket launch sector. More specifically, insights into the socio-technical regime, which refers to the conventions, rules and norms that guide the use of technologies and everyday practices of actors (Geels & Kemp, 2007), can provide valuable insights into the challenges and opportunities for a sustainability transition to occur. The regime encompasses to the set of rules and routines that shape actor's practices within a sector and accounts for the stability of the sector (Geels, 2011). Therefore, understanding the socio-technical regime provides insights into the principles that guide actors' beliefs, values and strategies that determine the current state of the sector. Recent studies suggest that globalisation has made actor networks and institutional rationalities increasingly multi-scalar, influencing transition dynamics beyond national borders (Fuenfschilling & Binz, 2018). To account for these multi-scalar actor networks and institutional rationalities, Fuenfschilling and Binz (2018) introduced the concept of global socio-technical regimes, which enables the identification of the conventions, rules and norms that guide everyday practices of actors on a global level. Studies on the concept of global soco-technical regimes have so far mainly focused on the characteristics of a strong and established global socio-technical regime. However, research on how these global regimes initially come together and on the characteristics of such an emerging regime is limited. This research aims to add to the existing literature on global socio-technical regimes by providing insights into the characteristics of such an emerging global socio-technical regime.

A better understanding of the global socio-technical regime can be achieved through the application of the institutional logics approach (Fuenfschilling & Truffer, 2014). The institutional logics approach allows for identification of actors' value orientations and interests, which consists of actors' beliefs, norms and values. Institutional logics describe that actors incline to subscribe to one or a number of ideal type institutions, which consist of: family, community, religion, profession, the state, the corporation and the market (Fuenfschilling & Truffer, 2014). The combination of one or more institutional sector logics creates field logics. One or more institutional sector logics thus aggregate field logics on a higher level. Field logics constitute coherent bundles of rules, beliefs and values to which actors adhere (Thornton and Ocasio, 1999, as cited in Heiberg et al., 2022). Usually, different field logics co-exist within a system, either complementing each other, or competing with each other, steering the development of the regime (Fuenfschilling & Truffer, 2014). Identifying the different field logics within the rocket launching sector gives insights in the dominant drivers, values and strategies driving the development of the global rocket launching sector. In order to provide a holistic overview of actors' value orientations within the global rocket launching sector this research focuses on the four major regions within the sector, which consist of the United States, China, India and Europe. The selection of these regions is based on their dominant positions in the sector, as expressed by the rocket launch frequencies and market sizes (McDowell, 2023). The analysis of the dominant actors at the global level allows for the provision of policy implications concerning the sustainable development of the global socio-technical regime.

The presented research approach combines the concept of sustainability transitions, socio-technical regimes and institutional logics to provide a holistic understanding of the strategies, drivers and values that determine the development of the socio-technical regime on a global level. Additionally, this study aims to provide insights into potential conflicts or collaborations rising from global competition. This understanding is aimed to be achieved through answering the following research question:

What is driving the rapid development of major countries in the global rocket launching sector and what are the opportunities and challenges for transitioning the sector towards a sustainable direction on a global level?

Answering this research question is done by answering the following more detailed sub questions:

1. *How have the field logics in the rocket launching sectors of the four major regions evolved over time?*
2. *In what ways are the field logics shaping the development of a global socio-technical regime of the rocket launching sector?*
3. *How does the emerging global regime impact the further trajectory of the global rocket launching sector and how does this influence sustainability?*

In order to answer these questions, a qualitative content analysis is used to map the value orientations of the actors over time. In particular, the analysis identifies actors' value orientations from the year 2000, often referred to as the beginning of the New Space era, onwards until 2024, divided into three time periods. This research provides a thorough understanding of the dominant norms, values and strategies among actors through the employment of the institutional logics approach. This offers insights into the characteristics of the emerging global socio-technical regime of the growing global rocket launching sector, which enables the identification of possible development trajectories, thereby enabling the provision of policy implications regarding the opportunities and challenges for facilitating a sustainable transition of the sector. This research builds on the existing literature on global socio-technical regimes by identifying the characteristics of an emerging global regime. Moreover, this research contributes to the growing body of research emphasising the necessity for the space sector to adopt a more sustainable approach. This is done through a particular focus on launch vehicles, which contribute to a significant proportion of the environmental impacts of the broader space sector. This research aims to ultimately provide policy implications that will enable the mitigation of the environmental impact of rocket launches by addressing the possibilities for changing actors' value orientations towards sustainable practices and strategies, in order to contribute to the long-term sustainability of outer space.

Chapter two of this research provides a thorough explanation of socio-technical regimes, sustainability transitions and institutional logics. Chapter three explains the applied methodological approach used in this research. Chapter four presents the results of the data analysis. Chapter five provides the conclusion of this research by answering the research questions. Finally, chapter six provides a detailed discussion of the theoretical implications, limitations and policy implications of this research.

2. Theoretical background

This chapter explains the theoretical background of this study, which consists of theory on sustainability transitions, (global) socio-technical regimes and institutional logics. The complementarity of these theories will be explained, by illustrating how the different concepts complement each other within the scope of this research.

2.1 Sustainability transitions and socio-technical regimes

Socio-technical systems can be seen as "a cluster of elements, involving technology, science, regulation, user practices, markets, cultural meaning, infrastructure, production and supply networks" (Geels & Kemp, 2007, p. 442). These elements interact with each other and in doing so provide a specific service to society, such as transport and energy (Markard et al., 2012). This approach highlights the interrelatedness of technical, social and institutional coordination of infrastructures (Hughes, 1987; Finger et al., 2005).

The concept of sustainability transitions has increasingly gotten more attention and research output (Köhler et al., 2019; Loorbach et al., 2017; Markard et al., 2012). Sustainability transitions can be defined as "long-term, multi-dimensional and fundamental transformation processes through which socio-technical systems shift towards more sustainable modes of production and consumption" (Markard et al., 2012, p. 956). These sustainability transitions are deemed necessary for solving "grand societal challenges", and the problems that generate these societal challenges can be recognised within the socio-technical system (Loorbach et al., 2017). Research seeks to gather deeper insights in the dynamics and mechanisms of sustainability transitions, as well as on the role of agency into these transitions to develop suitable analytical tools and governance strategies (Loorbach et al., 2017). Furthermore, these tools and governance strategies should guide the sustainable development of the socio-technical system. This is particularly important in the early stages of the formation and emergence of socio-technical systems, as it becomes increasingly hard to change development trajectories of established socio-technical systems with a high degree of structurization (Geels & Kemp, 2007). Hence, research on sustainable transition aims to provide potential strategies for escaping unsustainable lock-ins (Loorbach et al., 2017).

The concept of socio-technical regimes allows for deeper understanding of these transitions. Socio-technical regimes can be seen as the conventions, rules and norms that guide the use of technologies and the everyday practices of producers, workers, state agencies and societal groups in the regime, which are responsible for the stability of the socio-technical system (Geels & Kemp, 2007; Lawhon & Murphy, 2012). These rules are, for example, cognitive routines or favourable institutional arrangements. Dominating technologies and practices should not solely be viewed as a matter of economics, but also by looking at these rules (Geels & Kemp, 2007). Since the regime accounts for the stability of the system, changes occur at an incremental level and follow stable trajectories (Geels, 2011). The structuration of a regime can be conceptualised as a process of institutionalisation, where the strength of the regime can be distinguished by the degree of institutionalisation of its main elements (Fuenfschilling & Truffer, 2014). A highly institutionalised structure has reached a high age, scale and degree of acceptance (Tolbert & Zucker, 1996). Highly institutionalised systems have generally less potential to change due to the stability of the system. Existing and established socio-technical systems are characterised by lock-in. Transitions of socio-technical systems require significant changes in the socio-technical regime. Gathering insights into the socio-technical regime can thus be seen as important, since it can help to understand the possibility for change processes to occur.

2.2 Global socio-technical regime

Socio-technical regimes have been shown to develop within a given sector (Boschma et al., 2017). Transition studies tend to focus on radical change in infrastructure sectors, such as energy or transport. Due to globalization, there is growing evidence that these sectors display internationalised actor structures and that these sectors evolve beyond regionally or nationally defined boundaries (Fuenfschilling & Binz, 2018). Overall, this results in the same technology choices driven by the same regime rationality in different regions. Therefore, Fuenfschilling & Binz (2018) introduce the concept of global socio-technical systems, stating that socio-technical regimes can exist in a broader geographical context, due to the wide expansion of institutional rationalities of socio-technical systems via networks. This indicates that actors in socio-technical systems strongly influence the creation, maintenance and disruption of guiding dominant rationalities.

A global socio-technical regime is defined 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*."

Global regimes thus exert validity beyond a specific local or regional context. Stronger global regimes have obtained a higher degree of institutionalisation. This results in an increased mimetic pressure of this global regime. The strength and pressure of a global regime on the development and stability of a sector increases when a dominant rationality has widely diffused into different geographical contexts (Fuenfschilling & Binz, 2018). Global regimes are thus strongest when they have obtained a high degree of institutionalisation, which is expressed by the translation of a dominant widely diffused rationality into binding formal or material structures, such as technologies, policies and routines (Fuenfschilling & Binz, 2018). On the other hand, if a sector depends on multiple competing rationalities in different geographical contexts, which are institutionalised to varying degrees, the global regime can be seen as fragmented. Such a global regime thus has a less widely spread dominant rationality and lower institutionalisation, resulting in a lower mimetic pressure of the global regime.

Research on global socio-technical regimes has so far mainly been conducted on the characteristics of strong and established global regimes. Studies, such as Fuenfschilling and Binz (2018), focus on substantiating the concept of global regimes and provide insights into the characteristics of a strong global regime by applying the concept of a global regime to the water sector. Studies on the applicability of the concept of socio-technical global regimes on rapidly developing high paced sectors, such as the global rocket launching sector, has been limited so far. Additionally, research on how global regimes emerge in the first place and on the characteristics of such emerging global regimes is limited.

The Multi-Level Perspective (MLP) is widely adopted and focuses on the loosening of the socio-technical regime (Geels & Kemp, 2007; Geels & Schot, 2007). The MLP framework is a popular framework for analysing transitions towards sustainability. However, it is often criticised for its lack of and unsystematic approach to operationalisation (Fuenfschilling & Truffer, 2014). The lack of a clear operationalisation of the socio-technical regime often results in the empirical applications of the concept often being too homogeneous (Fuenfschilling & Truffer, 2014). Fuenfschilling and Truffer (2014) illustrate how the concept of institutional logics can be applied to enable an explicit identification of socio-technical regimes, by stating that regimes can be conceptualised as the dominant institutional logic of a socio-technical system (Fuenfschilling & Truffer, 2014; Thornton et al., 2012).

2.3 Institutional logics

Institutional approaches can function as useful complements, as multiple studies point this out by applying institutional conceptualisations on transition studies and policy studies (Jehling et al., 2019).

Institutional theory functions as a foundation for the concept of socio-technical regimes, by providing a theory for analysing the content and dynamics of these regimes. Institutional theory can help to understand the deeper dynamics of transitions and structures (Fuenfschilling & Truffer, 2014). Analysing the structuration of a socio-technical regime, provides insights into the specific content and coherence of the structures in a socio-technical system, such as the relationships between institutions, organisations and other individuals (Fuenfschilling & Truffer, 2014; Thornton et al., 2012).

Institutional logics is an approach that allows for the identification of this specific content and coherence. Institutional logics can be defined as *"the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality"* (Thornton et al., 1999, p.804). Institutional logics provide the rules for actions, interaction and interpretation that lead decisionmaker's actions for succeeding in their organisational tasks while acquiring social approval or penalties (Thornton et al., 1999). A set of assumptions and values are created by these rules on how to see organisational reality, appropriate behaviour and on achieving success (Thornton et al., 1999). Institutional logics describe that actors incline to subscribe to one or a number of ideal type of institutions, which consist of: family, community, religion, profession, the state, the corporation and the market (Fuenfschilling & Truffer, 2014). These ideal types of institutional sector logics shape and guide behaviour of actors, which conform to the social technical regime. Therefore, the institutional logics approach can be used to identify actors' value orientations, which shape and guide their behaviour.

Reconfiguration and translation of these ideal type sector logics in organisational fields creates so-called *field logics,* which are aggregated by basic logics on a higher level (Fuenfschilling & Truffer, 2014). Field logics can be seen as the guiding principles that determine the rules of the game, allocate power and steer towards explicit issues and solutions. They are constituted by a combination of coexisting and competing institutional sector logics (Fuenfschilling & Truffer, 2014; Thornton & Ocasio, 2008). They are specific combinations of basic logics, depending on their respective field, to which a substantial number of groups of actors are subscribed and therefore have the potential to steer the further development of the technological field (Heiberg & Truffer, 2022). When the dominant field logic changes, so will the strategies and problem focus of the subscribed actors (Fuenfschilling & Truffer, 2014). The type of field logic to which actors subscribe significantly impacts the possibility for different type of change processes to occur. On the one hand, actors that are completely subscribed to the current dominant field logic tend to support incremental change, while on the other hand actors that are subscribed to more progressive newer field logics tend to support radical development pathways for the existing regime (Fuenfschilling & Truffer, 2014). Overall, the coherence and likelihood of organisational fields to experience change processes depends on the structuration, which is defined by the institutionalisation, of one or more field logics (Fuenfschilling & Truffer, 2014).

2.4 Theoretical integration for the rocket launching sector

Insights into the socio-technical regime allow a deeper understanding of sustainability transitions. Gathering these insights is crucial because a sustainable transition within the rocket launch sector is necessary. Transition literature aims to describe and capture the dynamics of the regime. Therefore, a clear operationalisation of the socio-technical regime is necessary to strengthen the understanding of a possible sustainability transition within the rocket launch sector. Additionally, transition studies often fail to address the differing dynamics and contexts, political relationships and international economic relationships (Kern & Markard, 2016). Therefore, this study adopts the institutional logics approach to gather deeper insights into the socio-technical regime of the rocket launching sector. Using the institutional logics approach offers insights into the drivers, values and strategies of actors conforming to the existing regime. The institutional logics approach allows for the identification of different value orientations (i.e. their interests) among actors.

The rocket launch sector possibly consists of more field logics, which compete to be the dominant field logic within the sector. Furthermore, there could be differences in the dominant field logics within the different regions that are analysed in this research, due to the current state of these regions' sectors. For instance, America launched 87 rockets in 2022, and the number of launches was strongly dominated by commercial companies. China Launched 64 rockets in 2022, but these mainly consisted of governmental launches. These different dominant actors could be guided by different dominant field logics. Insights into these different field logics provide an understanding of the structures of the global socio-technical regime.

The rocket launch sector can be seen as an unique socio-technical system, since it consists of components and actors that are situated in different regions across the world. These regions possess different characteristics and relate to the socio-technical regime in different ways, but are still connected to each other. Therefore, understanding the socio-technical regime of this sector requires using a global approach, as this allows for a complete picture of its dynamics and interactions. Therefore, this research adopts the concept of a global socio-technical regime in order to provide a comprehensive understanding of the further development trajectories that the global regime encompassing the global rocket launching sector could follow.

Therefore, this study aims to identify the current status of the global socio-technical regime of the global rocket launch sector by indicating the strength and maturity of the global regime. Additionally, this research aims to contribute to the existing literature on global socio-technical regimes by applying the concept to the dynamic and rapidly evolving rocket launching sector and identifying characteristics of a global regime of emergent nature.

The integrative approach of this research thus enables a deeper understanding of different dominant field logics, providing more detailed insights into the emergence of global socio-technical regimes in the context of sustainability transitions. The field logics provide insights into the values, drivers and strategies of the actors within the socio-technical system, which could also provide information on global competition or cooperation. Additionally, these logics provide insights in the factors that are steering the development of the sector, allowing the possibility to constitute policy implications for the future sustainable development of the sector.

3. Methodology

This chapter describes the methodological approach used in this research. This includes explanations of the research design, the specific data collection methodology for this research, the rationale for the quality criteria, and the data analysis.

3.1 Research design

The proposed research questions require a research design that provides in-depth insights into the dynamics of this socio-technical system, which is best supported by a qualitative research design (Bryman, 2016). Furthermore, this research combines aspects of exploratory and explanatory research, as it explores the different rationalities that drive the development of the rocket launch sector and development of the global regime, while also explaining the implications this has for sustainable development. Insights into these rationalities are gathered through a qualitative content analysis, which provides an in-depth qualitative understanding of the norms, values, and strategies that drive sectoral development. A multiple case study approach is used because this research aims to capture the strategies, norms and values of the four major regions on a global scale that drive the development of the sector. Comparing the discourses of actors within these four regions using a multiple case study approach highlights the differences and similarities in rationalities among actors, which is important in identifying global dynamics such as global competition and global cooperation that influence sectoral development.

3.1.1 Geographical scope and case selection

The analysis of the global rocket launching sector focusses on four major regions: the United States, China, India and Europe. These regions have been selected due to their dominant positions within the international space industry. This selection is based on the presence of major space agencies, governmental institutions, and private companies within these regions, as well as high launch frequencies. Quantitative data on the frequencies of rocket launches per region and the market size of national rocket launching sectors indicate that the regions with the largest rocket launching sectors are the United States of America (USA), China, India, and Europe (McDowell, 2023).

The scope of this research encompasses all actors within these regions that are represented by their institutional logics in the analysed articles. The global distribution of these four major regions highlights the necessity of analysing the sector at a global level. Russia is a significant actor in the global rocket launching sector, but is not included as one of the major actors due to a lack of available data as a result of the ongoing war between Russia and Ukraine. However, Russia proves to play a vital role in the European rocket launching sector, as Russia has prevented Europe from further use of Russian Soyuz rockets as a consequence of the political sanctions that Europe has imposed upon Russia in response to the invasion of Ukraine (Mui, 2024). This is discussed in more detail in section 4.4.1.

3.1.2 Temporal scope

The time period analysed for this thesis is from 2000 to June 2024. This research begins with the analysis of data from the year 2000, as this period can generally be seen as the beginning of the NewSpace era. During this era, the global launcher industry began to undergo significant structural and strategic changes. The beginning of this era is characterised by the merging of private space companies, changes in government policy and technological advances.

Furthermore, the analysis of data availability shows a paucity of relevant articles and reports published prior to the year 2000. From the 2000s onwards, the amount of available data began to increase, which can be attributed to an increase in publications due to the achievement of significant milestones within the sector, such as the successful management of the International Space Station (ISS) (Herridge, 2023). The quantity of available data reaches its peak in 2019, driven by the rapid advancements and dynamic developments within the rocket launching sector. From 2020 to 2022 there is a notable decline in the amount of available data, which can be explained by the outbreak of COVID-19, which led to most rocket launch-related activities being temporarily discontinued (Bruno, 2022).

To analyse the development of field logics over time, the temporal scope of this research is divided into three phases. These phases were determined by the occurrence of major events that influence sectoral development as well as the availability of data. Analysis of the rocket launching sectors in all four regions revealed the emergence and development of field logics over time. Each region has followed different development paths over time and has experienced significant influential events at different points in time. It is therefore logical to distinguish minor temporal differences in the phases analysed for each region. This differentiation improves the overall understanding of the evolution of each region's launcher sector throughout the different development phases.

USA

Phase 1 (2000-2009): Shuttle and early commercial ventures

During this phase the American rocket launching sector has been characterised by stability. The National Aeronautics and Space Administration's (NASA) Space Shuttle and ISS, which began its operational phase in the 2000, were the most prominent (NASA, n.d.). The beginning of this period marks the emergence of important private companies, including SpaceX, which developed new launch vehicles, such as the Falcon 1 (SpaceX, n.d.-b)

Phase 2 (2010-2018): Commercialisation

During this phase commercialisation and engagement in public-private partnerships significantly increased. NASA enabled companies such as SpaceX and Boeing to develop transportation systems for the ISS (NASA, 2021, 2024). In 2011 the Space Shuttle was sent into retirement, which led to a greater reliance on commercial partners for accessing space. This resulted in commercial growth within the sector (Wall, 2011). Rockets like the Falcon 9 by SpaceX as well as the Starliner by Boeing became crucial in maintaining operations and missions to the ISS (Howell, 2024).

Phase 3 (2019-2024): New space race and commercial market

This phase is defined by two primary factors. Firstly, during this phase the American rocket launching market transitioned towards an established commercial market, with companies such as SpaceX, Blue Origin and Virgin Galactic being the most dominant actors in the sector (Dvorsky, 2023). Secondly, this phase is characterised as a new space race due to increased competition between the United States and China (Ganote et al., 2024).

China

Phase 1 (2000-2010): Traditional state

This phase is characterised by state-led development. During this phase, efforts were concentrated on establishing foundational infrastructure for future sector growth. This included substantial investments in infrastructure, the development of launch vehicles, and the setting of ambitious state-dominated goals. State-led operations, such as a first crewed mission with the Shenzhou 5, were significant milestones (CNSA, 2021).

Phase 2 (2011-2017): Progression phase

During this phase China steadily progressed their sector, achieving significant sectoral development. This progress is highlighted by multiple milestones, including the deployment of the first Chinese lunar rover and the successful mission to the far side of the moon (CNSA, 2016).

Additionally, this phase marked the first step towards the commercialisation of space activities, caused by the publication of "Document 60" by the Chinese government (Liu et al., 2019; Patel, 2021). This policy document facilitated broader private investments across various sectors of the Chinese economy, including the space sector (Foust, 2020). Even though the government remained strongly dominant, the release of Document 60 led to a rapid increase in the founding of new companies within the space sector (Foust, 2020).

Phase 3 (2018-2024): Guided commercialisation

This phase is characterised by further state-guided commercialisation and increased support by the Chinese government for private investments and companies. During this phase this led to significant overall sectoral growth (ESA, 2021b). Furthermore, this phase is characterised by what can be described as a new space race, driven by increased competition with the United States for global leadership in space (Jones, 2024).

India

Phase 1 (2000-2010): National Development

During this phase, India concentrated on using space and rocket launching capabilities to achieve national development, with a particular emphasis on the development of indigenous launch vehicles (Confederation of Indian Industry et al., 2010). The first indigenous launch vehicles were launched in 2001. Throughout this phase, the understanding of the possibilities for using space for further development grew. This led to Indian actors focussing on enhancing its space capabilities (Confederation of Indian Industry et al., 2010).

Phase 2 (2011-2018): Horizon expansion

During this phase the Indian Space Research Organisation (ISRO) continued focusing on developing India's space sector by focusing on the development of launch vehicles, including those capable of carrying heavier payloads. During this phase India achieved their first major milestones. This includes the successful launch of the Mars Orbiter Mission, which reached Mars on its first attempt. This marked India as the first country to achieve this, earning India significant global recognition as a space power (Goyal, 2019; Gunia, 2024). Additionally, India increased its engagement in space-related activities overall, by making space-related activities and rocket launching a larger part of their national development strategy. Furthermore, the Indian Government initiated stronger collaboration with private companies (ISRO, 2023).

Phase 3: (2019-2024): Growth and commercialisation

The Indian government focused on the commercialisation of its rocket launching sector during this phase. The Indian government founded the Indian National Space Promotion and Authorization Center (IN-SPACe). IN-SPACe was founded to help facilitate the commercialisation of the sector by providing guidance and support to private companies, such as Skyroot Aerospace and Agnikul Cosmos, by providing necessary policy and infrastructure (ISRO, 2023a). Skyroot successfully launched the first privately developed Indian rocket during this phase (Narang, 2023). Additionally, this phase is characterised by market growth. Over 40 space start-ups were founded during this phase, which contributed to a more commercially driven space ecosystem (Gunia, 2024).

Europe

Phase 1 (2000-2010): Capability consolidation

During this phase the European Space Agency (ESA) focused on the development of its Ariane 5 rocket, aiming to maintain a strong position in the global launch market (ESA, 2024). Milestones included the launch of the Ariane 5, as well as various scientific missions, such as the Mars Express mission (ESA, 2024). In summary, this phase was characterised by stability, due to the reliable performance of the Ariane rockets, as well as continuous capability development.

Phase 2 (2011-2017): Expansion and international cooperation

During this phase, the European sector strongly focused on international cooperation and space exploration missions. ESA engaged strongly in cooperation with NASA, focusing on the development of the Orion spacecraft, aiming to enhance capabilities for deep space exploration (Wohrer, 2024). During this period European-Russian cooperation increased, with Russian Soyuz rockets being frequently used by ESA. The planned retirement of the Ariane 5 rocket and the postponing of the Ariane 6 rocket led to

Europe using Russian Soyuz rockets for launching European payloads into orbit from French Guiana (ESA, 2024; Wohrer, 2024). At the start of this phase in 2012 ESA expressed their commitment to having a leading role regarding the sustainable development of the space sector (ESA, 2012).

Phase 3 (2018-2024): From international collaborations to regaining autonomy

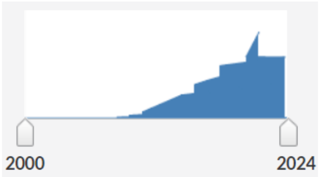
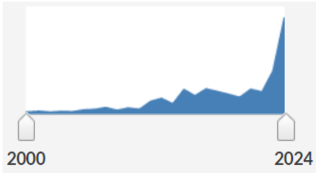
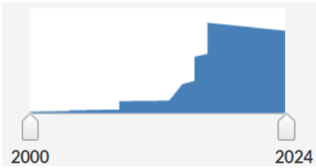
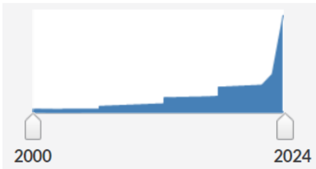
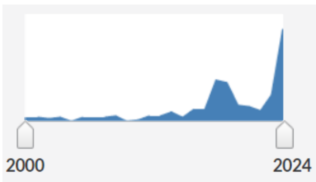
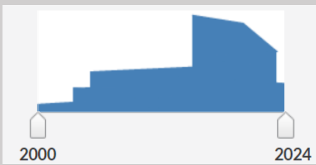
During the beginning of this phase Europe continuously focused on international cooperation, continuing the strategies as applied in the previous phase. Russian-European partnership continued, as well as partnerships between ESA and NASA. However, this changed in 2022 due to the geopolitical tensions caused by the conflict between Russia and Ukraine. This resulted in Europe being denied the use of Russian Rockets, due to sanctions imposed on Russia by Europe. As a result, European actors strongly focus on regaining autonomous access to space during the final years of this phase, embracing technological development to achieve this goal. This accentuates the importance of Europe's ability to access space in a self-reliable manner (Nicoli et al., 2023; Wohrer, 2024). Ariane 6 is expected to launch in 2024, after numerous postponements. The possible utilisation of Ariane 6 is expected to play a vital role in achieving autonomous access to space. Furthermore, Europe focused on enabling the transportation of commercial cargo to enhance its competitive capabilities and boost the transformation of Europe's rocket launching market towards a more competitive and commercial space sector (Nicoli et al., 2023). Finally, during this phase Europe continued to express its commitment to sustainability by focusing on sustainable development and global environmental monitoring efforts (Nicoli et al., 2023).

3.2 Data collection

This study analyses secondary data collected through desk research. The data consists of news articles, academic literature, company reports, and institutional reports. The primary data source for this study is news articles on the global rocket launching industry and its major players. These news articles are retrieved using Nexis Uni, a database that includes documents such as journals, magazines, and newspapers, all published in English. Nexis Uni uses search strings to systematically narrow down the number of articles. Selecting the appropriate search string for this study requires entering specific key words, resulting in a collection of relevant articles on rocket launching that is neither excessively broad nor too narrow. The final dataset of this study consists of four smaller datasets corresponding to the four major global players. Search string trials have been conducted for each of the four datasets to identify the most relevant news articles for these major regions. Through search string trials this approach proves to provide more detailed information on each of the four regions, as opposed to more general information encompassing all regions collectively. This approach facilitates tracing of discourses of relevant actors for all four regions. The results of the search string for the USA are presented in table 1, while Search strings for China, India and the EU are presented in Appendix C. To maintain a manageable and structured coding process, the total number of articles was identified to be around 300, with each smaller dataset containing approximately 75 articles. The duplicates and irrelevant data were manually deleted from the data set, which ensures a relevant and high quality dataset. The same type of process was conducted for all four datasets, ensuring uniformity among the four smaller datasets.

Table 1: Search string for the USA case

Number of search	Search string	Results	Time development	Study suitability

1	(Rocket launching) AND (America) AND (SpaceX) AND (blue origin) AND (NASA)	1026		Too many articles, and not specific enough articles
2	(Rocket launching) AND (America) AND atl2(SpaceX) OR atl2(blue origin) OR atl2(NASA) AND atl2(manage!)	2183		Nice development over time, but way too many articles
3	(Rocket launching) AND (America) AND atl2(SpaceX) OR atl2(blue origin) OR atl2(NASA) AND atl2(sustainab!)	346		Too many articles, relevant topics
4	(Rocket launching) AND (America) AND atl4(SpaceX) OR atl4(blue origin) AND atl4(NASA) AND atl2(manage!)	139		Too many articles and too steep incline
5	(Rocket launching) AND (America) AND atl4(SpaceX) OR atl4(blue origin) OR atl4(NASA) AND (Strateg!)	1363		Nice development, relevant articles, but too many articles
6	(Rocket launching) AND (America) AND atl2(SpaceX) AND atl2(blue origin) AND atl2(NASA) AND atl2(Strateg!) OR atl2(manag!)	46		Not enough articles
7	atl2(Rocket launching) AND (America) AND atl4(SpaceX) OR atl4(blue origin) OR atl4(NASA) AND atl3(manage!)	130		Not enough relevant articles
8	atl3(Rocket) AND atl3(space) AND (America) OR (United States) AND atl4(SpaceX) OR atl4(blue origin) OR atl4(United Launch	133		✓

	Alliance) OR atl4 (Northrop Grumman) OR atl4(Virgin Galactic) OR atl4(Rocket lab) AND atl2(NASA) AND atl3(sustainab!) BUT NOT (Armaments) AND NOT (Commercial Aerospace)

Search string trial number 8 has been selected for this research, since it offers the optimal number of relevant articles, providing comprehensive insights in the region's rocket launching sector, and is a feasible amount to analyse. It also incorporates a substantial number of recent publications, which is crucial for capturing the latest developments of the rapidly evolving sector. The downward trend in the last years can be attributed to the aforementioned impact of COVID-19, which caused the temporarily discontinuance of most rocket launching-related activities. The search strings that were used for the data collection for China, India and Europe are provided in Appendix C.

Additionally, complementary data on the major actors in the four regions was collected from governmental and company reports using search engines such as Scopus, and Google. A targeted search strategy was employed in order to optimize the relevance of the information gathered. All reports used in this study are required to be published in English or officially translated by the respective companies or institutions. Translations performed using automated tools such as Google Translate may introduce errors and inaccuracies.

The reports and studies were assessed for their relevance in addressing the research questions and systematically stored in a database for further use in the coding phase, which is explained in more detail in section 3.3. An overview of the used reports is presented in table 3. The temporal coverage of relevant reports varies significantly among different companies and institutions. Furthermore, reports from key private companies, such as SpaceX or Blue Origin, are not publicly accessible. Due to these variations in temporal scope and the absence of reports from crucial companies, news articles served as the primary data source for this research, while the company and institutional reports were used to address data gaps and provide supplementary information, thereby aiding in the triangulation of the qualitative content analysis results.

The data collection process for this research was approached in an iterative manner, to ensures that newly published articles and reports relevant to the research are continuously monitored. Newly published reports or news-articles were included in the dataset if beneficial for the quality and comprehensiveness of this research. This iterative process, which involves going back and forth between data and theoretical reflection, enhanced the quality of the study (Bryman, 2016; Fossey et al., 2002). An overview of the reports used in this study is provided below.

Report type	**Coverage**
USA	
Space Florida annual report	2016 & 2019

NASA Sustainability report	2012 & 2017
NASA Sustainability strategy	2024
China	
CNSA space program	2006, 2011, 2016 & 2021
CASC social responsibility statement	n.d.
India	
ISRO annual report	2021-2022 & 2022-2023
Indian Space Situational Assessment Report	2024
EU	
ESA Corporate responsibility and sustainability report	2015-2016 & 2020-2021
ESA annual report	2022
Arianespace CSR report	2014-2015 & 2022

Table 2: Triangulation reports

The final number of reports and articles that were analysed as a result of the previously described data collection methodology is presented in table 3.

	Articles	**Reports**
USA	77	5
China	80	5
EU	82	5
India	83	3
Total	322	18

Table 3: Total amount of analysed reports

3.3 Data analysis

This research adopted institutional logics as the foundation for analysing the norms, values and strategies of actors within the rocket launching sector. The ideal type institutions, as outlined in chapter 2, served as the basis for developing the specific logics utilized in the study's coding scheme. Consequently, the coding process began in a deductive manner, with the ideal type institutions forming the core of the coding scheme. These ideal type institutional logics consist of *family, community, religion, state, market*, *profession* and *corporation* (Fuenfschilling & Truffer, 2014; Thornton et al., 2012). However, *Family* and *religion* were identified as insignificant for this research. The remaining ideal type institutional logics were employed as the foundation for the coding scheme of this research.

Further development of the coding scheme was undertaken during the coding of actors' discourses, applying an abductive approach that involved continuous iteration between data, emerging patterns and existing theory. As more articles were coded, a more specific coding scheme emerged. Analysing the data in this study required a systematic approach, facilitated by the use of NVivo, a software application designed for coding qualitative data. NVivo enables the coding of qualitative content across multiple levels of codes, enabling extensive analysis of the norms, values and strategies to which actors adhere.

The data set of this research comprises a substantial number of newspapers. Consequently, the coding for this research distinguished between substantive statements, which are statements concerning an actor, and discursive statements, which are statements that are made by an actual actor. This research focused on substantive statements, as news articles frequently discuss relevant topics descriptively rather than quoting the actors directly. Consequently, using substantive statements provides a more comprehensive overview of value dispositions of actors within the rocket launching sector. During the coding process, some statements represented multiple logics. In such cases, the different logics within the statement were coded separately, to ensure a complete overview of all logics present within the data.

Following the coding phase, the logics and values were re-evaluated and aggregated, resulting in the final coding scheme. During the coding process, it was observed that the Corporation discourses were almost invariably driven by *market*-related values. The basis of strategy for the Corporation logic is to increase the size and diversification of the firm, which in the rocket launching sector is often done in order to increase efficiency profit, which is the basis of strategy for the Market logic. Therefore, In the final coding scheme, the ideal type Corporation logic was aggregated under the Market logic. The methodology outlined above resulted in the final aggregated coding scheme, as presented in table 4. This table only provides the top-level codes of the coding scheme. A comprehensive and detailed coding scheme, which includes all top- and sub-level codes is provided in appendix A.

Logic	Value		Description
Community			
	Community building		Engaging in rocket launching activities to build a community regarding operations and missions.
	Societal development		Engaging in rocket launching activities to drive positive change and improve the well-being of society.
Market			
	Market dynamics		All processes than impact the status of the region's rocket launching market in terms of dynamics between actors and goals of actors.
	Profit		Rocket launching related activities aiming to gain financial profit of these activities.
	Public-private partnerships		The formation of partnerships between a government and a private enterprise as joined forces for achieving market growth.
	Corporation		
		Cost-effectiveness	When mentioning the strategical focus on improving the cost-effectiveness of processes.
State			
	Autonomy in space		Focussing on achieving self-reliance and sovereignty in space.

	International collaboration	Engaging in international collaboration with the goal of bettering or maintaining the country its position.
	National economic gains	Aiming to boost or improve the country its economy through rocket launching activities.
	Global leadership	Actively pursuing the goal of becoming or maintaining leadership of outer space for national interest.
	National security	Rocket launching activities used for ensuring the safety of people and resources of a nation.
	Strong developed national plans	Actively pursuing the goal of becoming a strongly developed nation in the space sector.
Profession		
	Science and Innovation	Actively engaging in science and innovation for improving and developing rocket launching.
	Skilled workforce	Engaging in the active mobilization of skilled individuals for developing rocket launching activities.
Sustainability		
	Multi-planetary life	Rocket launching for establishing human life on multiple planets, such as Mars or the Moon.
	Environmental impact management	Making efforts towards the minimisation of environmental impacts.
	Sustainable development	Focusing on developing the rocket launching sector in a sustainable way, focusing on the environmental impact of rocket launching.

Table 4: Aggregated coding scheme

After the coding process of the news-articles was completed, the analysis of the company and institutional reports started.

This process aims to address the data gaps that were identified during the qualitative content analysis of the news articles. This was achieved through qualitative analysis of the reports, systematically identifying the main takeaways of the reports in a table. This process was carefully discussed with the thesis supervisor to ensure the inclusion of relevant additional information. After systematically analysing and presenting the results of the coding stage, systematically, the field logics for the four regions were derived using a social studies qualitative content approach. The identification of field logics was rigorously monitored and guided by the research supervisor. These results are employed to analyse the underlying strategies, norms and values as projected by the field logics of each region, thereby addressing the research questions comprehensively.

3.4 Data quality criteria

This research adheres to the quality criteria for qualitative research as outlined by Bryman (2016). To ensure research quality, this study employed the criteria of trustworthiness, which encompasses four components: credibility, transferability, dependability and confirmability. Table 5 provides an overview on the definitions for these criteria along with an explanation of how they are applied in this study (Bryman, 2016; Lincoln & Guba, 1985).

	Definition	In this research
Credibility	Refers to the accurate collection of data and representativeness of the studied phenomena.	In order to ensure that this study meets the criteria, this study employed a variety of sources, including company reports and news articles, with the objective of obtaining data triangulation. This approach is recommended for the purpose of assuring the credibility of research.
Transferability	The potential for the transfer of findings to other contexts. Qualitative findings can be contextualised in order to reflect the specific characteristics of the context in which they are studied.	The methodology used in this study is applicable on other sectors. Researchers in other sectors can utilize the coding scheme employed for the analysis of the diverse logics operating within different soco-technical systems.
Dependability	Refers to sufficient in-depth descriptions of the processes and the methodology of the study.	This research provides a comprehensive account of the applied methodology, including detailed descriptions of all processes, coding schemes and comprehensive data overviews. This ensures the possibility for replications and a sufficient degree of dependability.
Confirmability	Refers to the absence of participant and research bias effecting the results.	This criterion is met by providing an audit trail and continuous supervision by an expert in the field of this research.

Table 5: Data quality criteria

4. Results

The results are analysed by presenting an overview of the field logics for the rocket launch sector that have shaped the development of each region's launch sector over time. This analysis begins with a chronological overview of the development of these logics in the four distinct regions. Such an approach facilitates a more nuanced understanding of the chapters that follow. These field logics are expressed by the predominant values, beliefs and strategies that drive sectoral development. The evolution of the field logics across the various time phases is examined, by illustrating how they develop over time. This examination is based on the critical events and underlying mechanisms that have caused the development of these field logics over time. The analysis is based on the coding framework detailed in Table 1, Appendix A, and is supported by the triangulated data as presented in Appendix B. Lastly, the implications of the current field logics for the further development of the rocket launch sectors are discussed.

USA

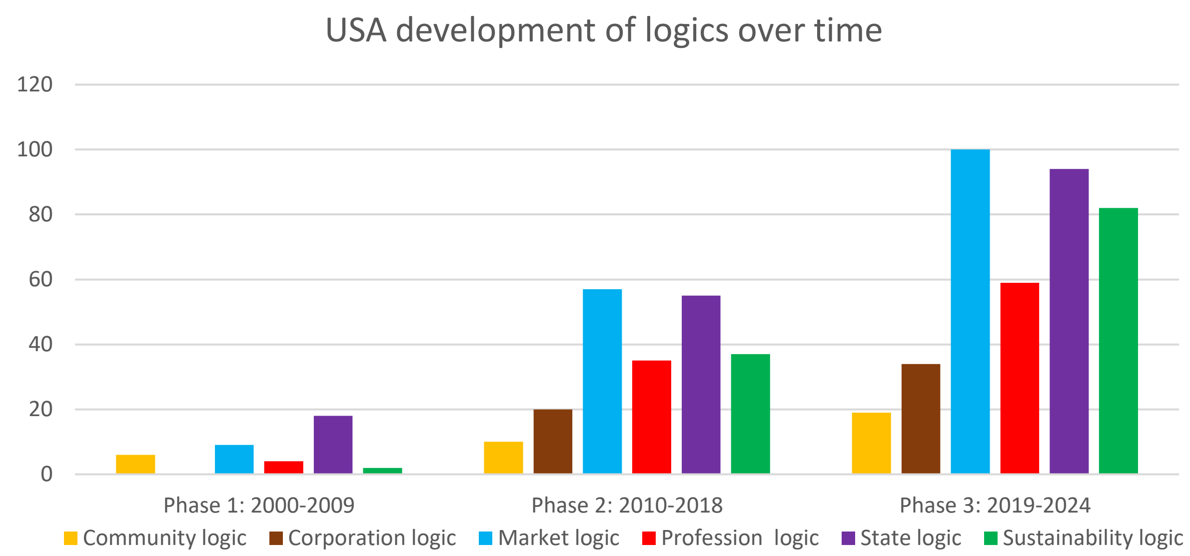


Figure 1: Development of institutional logics over time within the United States' rocket launching sector

China

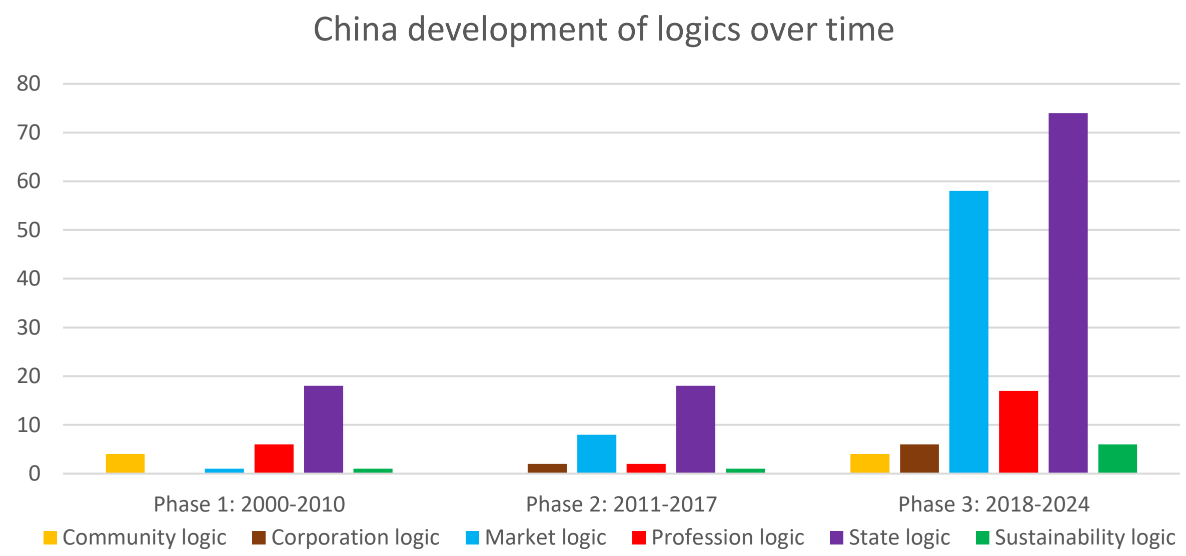


Figure 2: Development of institutional logics over time within China's rocket launching sector

India

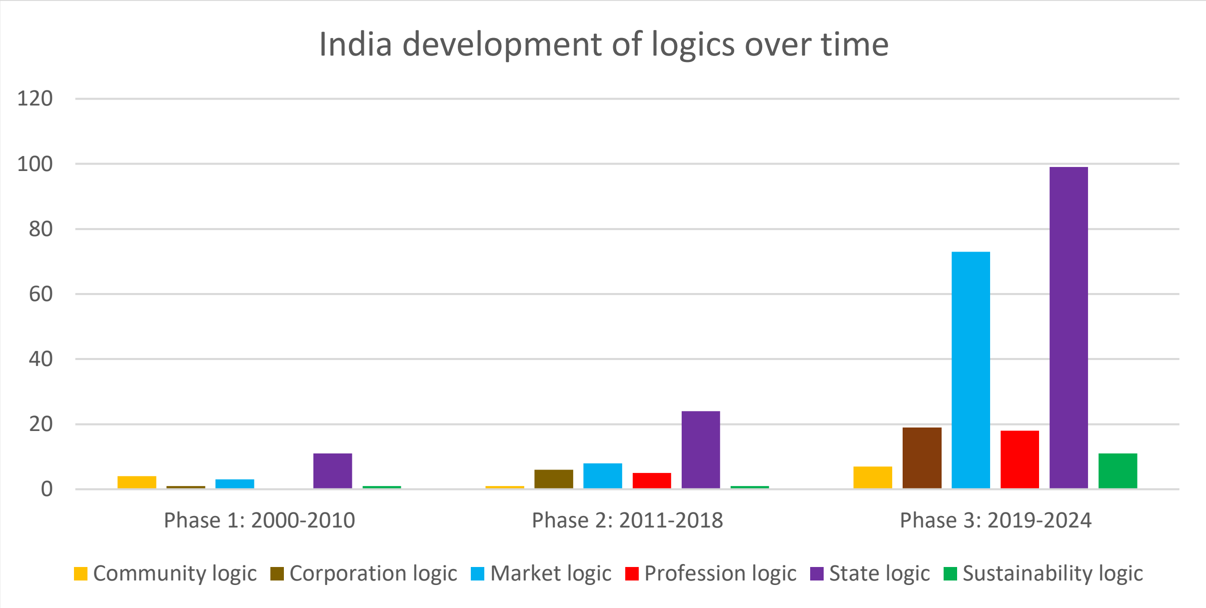


Figure 3: Development of institutional logics over time within India's rocket launching sector

Europe

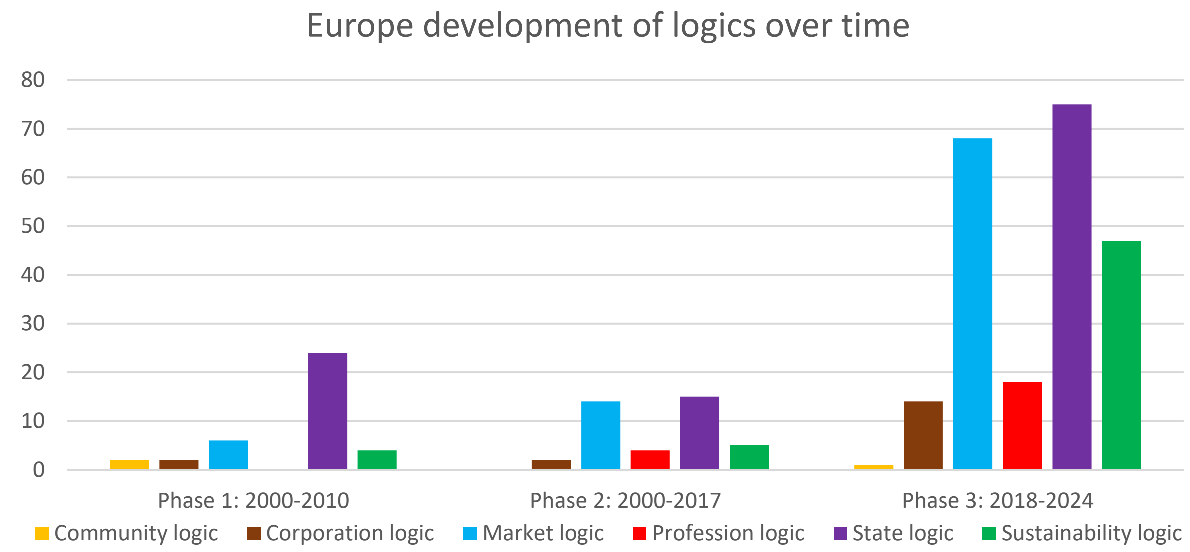


Figure 4: Development of institutional logics over time within the European rocket launching sector

Table 6: Overview of all regions' development of logics over time

4.1 The United States of America (USA)

During the analysis a total of 28 relevant actors were identified. These actors can be divided into two overarching categories, namely governmental institutions and companies. An overview of the most dominant actors is presented in table 7. Furthermore, an overview of the development of field logics is presented in figure 1. This provides an overview of the development of the ideal institutional logics over time, from which the field logics during this phase can be derived.

Private companies	**Governmental institutions**
SpaceX	National Aeronautics and Space Administration
Blue Origin	Commercial spaceflight federation
Airbus	Federal Communications Commission
Boeing	
Rocket Lab	
United Launch Alliance	
Northrop Grumman	
Orbital ATK	
Virgin Galactic	
Sierra Nevada Corporation	

Table 7: Overview of actors in the American rocket launching sector

4.1.1 Phase 1 (2000-2009) State-actor dominance

A total of 12 relevant actors were identified during the analysis of value orientations during this phase. The most prominent actors in the discourses during this phase are the United States Government and NASA. NASA's Space Shuttle Program is the primary means of launching into space, which is used extensively to transport components to the International Space Station (ISS). Actors strongly adhere to the value of *international collaboration*, since the engagement in the ISS requires actors to actively collaborate with foreign space agencies and actors (Herridge, 2023). Furthermore, the analysis reveals the emergence of New Space, which can be defined as the new era of new aerospace companies that have led to increased privatisation of the sector (Lecky, 2016). Consequently, in addition to the predominant influence of the American rocket launching sector, which is guided by NASA and the American government, the commercial space sector began to gain momentum with the establishment of private companies such as SpaceX and Blue Origin (Blue Origin, n.d.; SpaceX, n.d.). However, the qualitative content analysis indicates that these new private actors have not yet attained a dominant position within the sector, and therefore do not currently exert a significant influence over the development of the rocket launching sector.

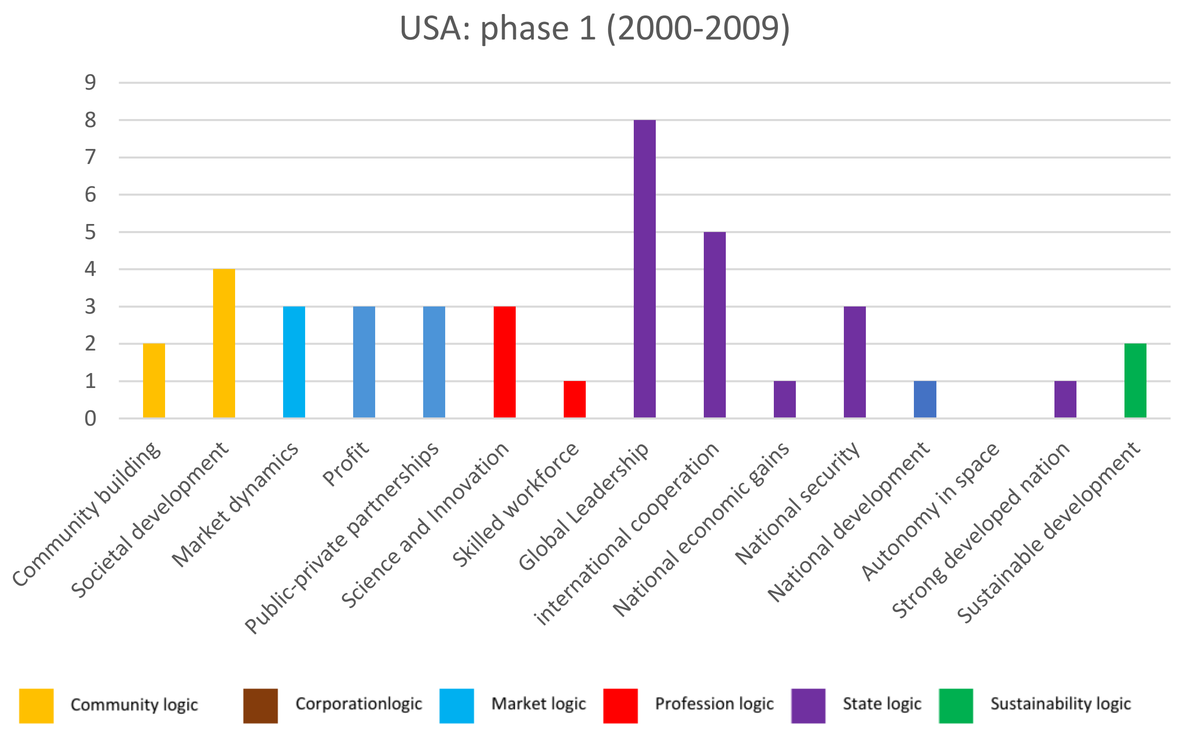


Figure 5: Distribution of basic logics during phase 1 in the United States

Figure 5 above shows that the sector during this first phase is dominated by state-related values, which are guiding the development of the sector and thereby influencing the formation of the **State Field Logic.** The most dominant value orientation during this phase is *global leadership*. Actors actively pursue the goal of maintaining a global leadership position in space, through the launch of a significant number of American-developed launch vehicles. These rockets are utilised to deliver payloads into orbit, mainly consisting of large quantities of satellites, which can be grouped together to form mega-constellations. The mega-constellations are capable of providing insights into the developments of global connectivity and communication, which can contribute to societal development. The utilisation of space to facilitate societal development is exemplified by the following statement by representative Giffords of the Space and Aeronautics Committee:

"The importance of space and the future of this country and the importance generally of overall U.S. leadership in exploring and utilizing space that has been borne out over the intervening years. It's clear that the space capabilities that have been created around the world can play a constructive and significant role in addressing the many societal challenges we face today." [1]

[1] Federal News Services (November 19, 2009): HEARING OF THE SPACE AND AERONAUTICS SUBCOMMITTEE OF THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE; SUBJECT: "THE GROWTH OF GLOBAL SPACE CAPABILITIES: WHAT'S HAPPENING AND WHY IT MATTERS"

Furthermore, American actors aspire to become global leaders in deep space through the utilisation of American launch vehicles, with the objective of reaching the Moon once more with a manned mission before competitors from other countries are able to do so. Additionally, they aim to be the first country to reach Mars with a manned mission. The statement demonstrates a general consensus among actors to pursue the goal of maintaining a competitive advantage on a global scale, particularly in the context of rocket launching to facilitate space exploration. The following statement by Marty Houser, vice president of Washington operations at the Space Foundation, clearly refers to a *global leadership* driven value orientation which portrays the **State Field Logic**:

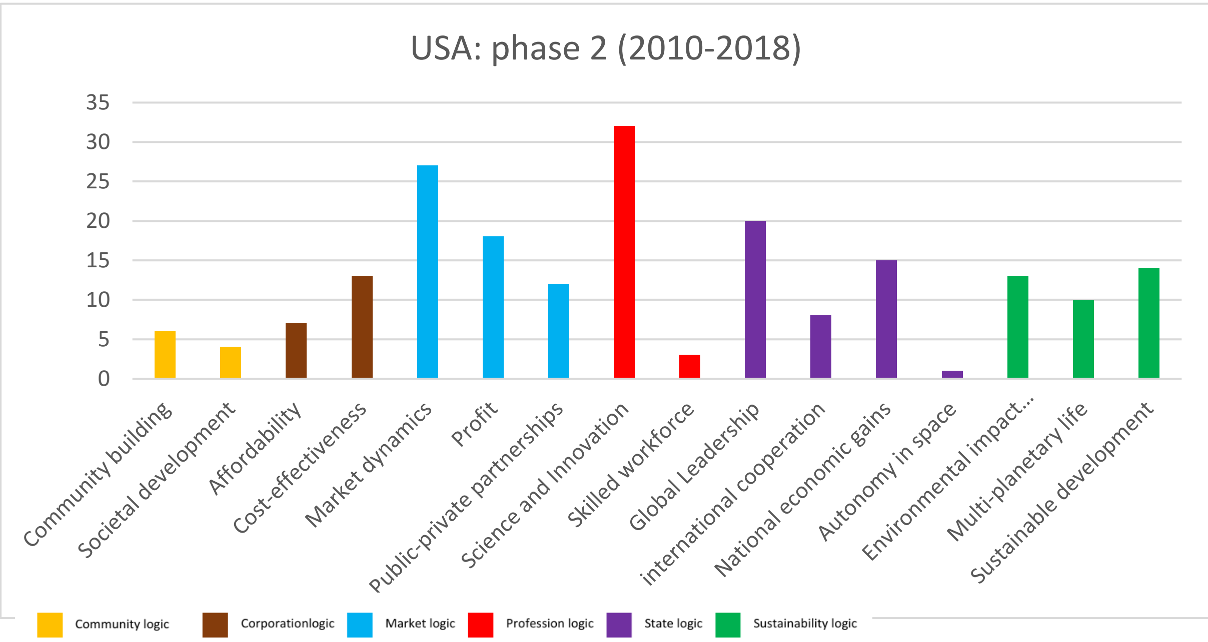
"To continue being the global space leader we must bite the financial bullet, roll up our sleeves, and get to work. If we apply our great minds and our great talent, find better and smarter ways, we make the trade-offs to do what is necessary to get to and work in space, rebuild international partnerships and share costs where no one else can. We stand up and lead the way we always have. We innovate, we educate, we produce, and we lead." [1]

The concept of "biting the financial bullet" in this context refers to the necessity of making significant investments in the development of innovative new launch vehicles. This focus on development of launch vehicles and innovation will continue during the next phase.

4.1.2 Phase 2 (2010-2018) Innovation driven commercialisation

A total of 24 relevant actors were identified during the analysis of this phase. NASA remains one of the most dominant actors of this time phase. In the beginning of this time phase NASA's Space Shuttle Program came to an end, retiring their launch vehicles that they had been using since the 1980's. As a result, the USA became temporarily reliant on Russian Soyuz rockets. The retirement of the Space Shuttle Program also opened new opportunities, by paving the way for the emergence of private companies like SpaceX and Blue Origin. These companies grew significantly during this time phase, achieving multiple important milestones such as the commercially developed rocket to dock with the ISS, and the first recovery of the Falcon 9 rocket's first stage, which demonstrated the potential for reusability in space (Chang, 2012). As a result of these successes and this growth, private companies have greatly increased their influence and relevance during this period.

Figure 6: Distribution of basic logics during phase 2 in the United States



This resulted in both state-related actors, such as NASA, and private companies, such as SpaceX, increasingly subscribing to market-related values. In particular, during this phase there is an exponential increase in *Market Dynamics*, which is strongly led by the value orientation *Commercial Development*.

Furthermore, during this phase actors strongly engage in *Innovation* for the development of new rocket launching vehicles to shift towards a *Cost-effective* business model and further push the commercialisation of the sector. This results in the dominance of the **Profession Market Field Logic** during this phase. Employees of the Federal Communications Commission (FCC) have been mentioned alongside a focus on innovation for the development of the sector, in which private companies are dominant:

"Driven by innovation from both established commercial enterprises and new entrepreneurial endeavours, a new landscape for the private space industry is emerging."[2]

Overall, actors are increasingly investing in research and development (R&D), aiming to obtain a dominant position in the market by providing affordable access to space, which will benefit them on the long-term, aiming to work towards profit. This strategy of using innovation to obtain a better market position is not only adopted by private companies, but by NASA as well. NASA started to see innovation as a as driving mechanism for increasing affordability, to further grow and develop the national space sector, which is illustrated by the following quote by Charles Bolden, administrator of NASA:

"With the president's new vision, the NASA budget will invest much more heavily on technology R&D than recent NASA budgets. This will foster new technological approaches, standards, and capabilities that are critical to enable next generation space flights. Under this program the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems."[3]

Building on these insights, not only does NASA pivot towards this innovation-driven strategy that private companies widely started applying, but they also started to in *Public-private partnerships,* utilizing the large private funding that companies, such as SpaceX, started to make. With this, NASA boosts its technological capabilities as well as obtaining affordable access to space, putting them ahead of their international competitors. The following quotes by David Thompson, CEO of Orbital ATK, underscores this focus on public-private partnerships:

"Similarly, over the past several decades NASA has pioneered an array of successful public-private partnerships that have resulted in accelerated innovation and new more affordable space capabilities for both government missions and commercial applications."[4]

&

"You have the opportunity to help accelerate low-Earth orbit and deep-space efforts by employing public- private partnerships to yield speedy and efficient results."[4]

The demand for rocket launching services and capabilities by NASA strengthened America's position in the international market. This supports America's desire for *global leadership* by providing innovative technological capabilities and launch vehicles. This is essential for the continuous improvement of

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[2] US Official News (November 20, 2018): FCC Launches Review of Rules to Mitigate Orbital Space Debris

[3] Federal News Service (February 25, 2010): HEARING OF THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE; SUBJECT: NASA'S FISCAL YEAR 2011 BUDGET REQUEST AND ISSUES

[4] CQ Transcriptions (October 5, 2017): VICE PRESIDENT MIKE PENCE HOSTS THE NATIONAL SPACE COUNCIL

American competitiveness with respect to the technologies and launch vehicles of other regions. Global leadership is still a strong value orientation during this phase, but is not the driving force for the actors during this phase, since the values of *R&D* and *Commercial Development* were more dominant, which constitutes the **Profession Market Field Logic**.

Furthermore, during this phase actors started to orientate towards value orientations that are linked to sustainability. Actors started mentioning the importance of managing the environmental impact of the sector on a larger scale, and increasingly stated the importance of *sustainable development* of the sector. Furthermore, the number of codes for sustainability-related values is significantly influenced by Elon Musk's goal of creating a sustainable human presence on the moon and mars, creating *multi-planetary life* for humans. This does thus not relate to sustainability in means of mitigating environmental impact or developing sustainable innovations, but rather to sustaining multi-planetary life on other planets. This view will continue to unfold further during the next time period and will be discussed in more detail in this section.

4.1.3 Phase 3 (2019-2024) Private company dominance and new space race

A total of 27 relevant actors were identified during the analysis of actors' value orientations during this phase. NASA remains a dominant actor in the sector alongside numerous private companies that have taken a dominant position through large amounts of private funding, which sparked innovation and capability development. These companies include SpaceX, Blue Origin and Virgin Galactic. NASA

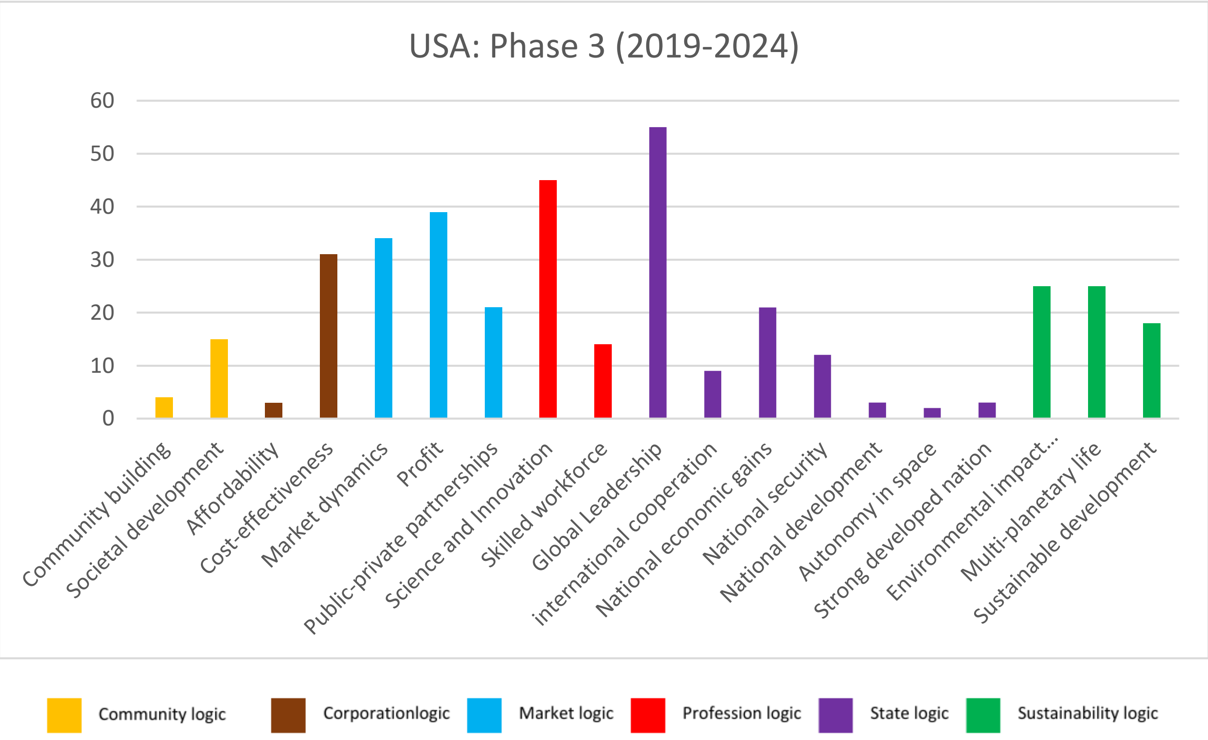

Figure 7: Distribution of basic logics during phase 3 in the United States

facilitates all launches and actively participates in public-private partnerships to ensure technological supremacy and leading capabilities, which enables them to launch important scientific missions and satellites into orbit. Private companies are still applying the strategy, as explained in the previous time phase, of heavily investing in innovation and R&D to bring down the cost of launching rockets, aiming to obtain a large market share. However, since this strategy has consistently been applied for over a decade now, some of these private companies have already obtained a dominant position in the sector.

Hence, they are now starting to subscribe increasingly to the value orientation *Profit*, financially benefiting from investments made in the past through their now dominant position in the sector. This is for instance depicted in the persuasion of offering *Space Tourism* services, aiming to work towards maximization of revenue, which reinforces Market Dynamics such as commercial development and market growth. Actors like Elon Musk, Jeff Bezos and Richard Branson, founders of SpaceX, Blue Origin and Virgin Galactic respectively, have been referred to as key actors for boosting the rocket launching market by offering space tourism services:

"This privatization revolution driven by the transformation of NASA and the emergence of entrepreneurs like Musk, Branson and Bezos applied a dramatic boost to the business of civil space exploration."[5]

&

"In 2022, the Commercial segment held a dominant market position, capturing more than a 57.3% share. Companies like Virgin Galactic and Blue Origin, offering suborbital space tourism experiences, have been pivotal in driving this segment's growth."[6]

The *market dynamics* value orientation remains strong for most actors, since private companies such as Virgin Galactic and Blue Origins recognise the importance of continuously improving the commercial competitiveness of the sector to stay ahead of global competition. Commercialisation has enabled America to remain global leaders in rocket launching and in space. Therefore, the focus on the value *Global Leadership* remains strong. Especially recently, since China has emerged as a serious contender for global leadership in the space sector. This is caused by the Chinese government embracing the development of privately funded companies, providing China with innovative highly competitive launch vehicles (section 4.2.3). The exponential growth of the Chinese rocket launching sector has sparked a sense of urgency and importance on Global Leadership. This has resulted in America and China engaging in a new space race, both aiming to return to the moon first, and get to Mars first. This engagement in *Global Competition* has largely re-sparked the value orientation *Global Leadership* among American actors. The following statement by congressman Michael Waltz highlights this focus on maintaining global leadership:

"I think hearing and seeing some of the things that we have seen over the last couple of months, particularly with the landing of a rover on Mars, it's very clear that China is looking to outpace the United States and it's imperative that we do everything that we can to invest in research and development, in exploration to ensure that that doesn't happen."[7]

Overall, the combination of actors subscribing to market logic related value orientations, such as *profit, space tourism* and *market competition* and actors increasingly subscribing to the global leadership value orientation in response to China's space ambitions results in the formation of the **State Market Field Logic.**

During this phase actors started to increasingly pivot towards sustainability-related value orientations. This is mainly shown in the *environmental impact management* and *sustainable development* value orientations, which often complement each other. The following statement illustrates that private companies like Blue Origin and Virgin galactic are discussed to be engaging in sustainability by

[5] CE Noticias Fianancieras English (November 26, 2021): How did space exploration move from state to private hands?

[6] Leisure & Hospitality Monitor Worldwide (January 19, 2024): Space Tourism Market Poised to Hit Striking USD 17,742.4 Million Valuation by 2033 | CAGR of 36.6%

[7] CQ Transcriptions (June 23, 2021): House Science, Space and Technology Committee Holds Hearing on Fiscal 2022 Budget Request for NASA

managing the environmental impacts of rocket launching, through focusing on the sustainable development of technologies.

"Companies like Virgin Galactic and Blue Origin are focused on developing space tourism programs using renewable energy sources such as solar panels, while others are working towards creating greener fuel alternatives for traditional aircrafts."[8]

SpaceX, and Elon Musk in particular, believe strongly in a different dimension of the concept of sustainability. One of his ultimate goals of engaging in rocket launching is achieving multi-planetary life for humans, establishing civilization on both the moon and on mars. SpaceX and, more specifically Elon Musk, are often discussed to be focussing on achieving multi-planetary life, as illustrated in the following statement:

"After all, what price can you really put on setting up humanity in another world? Especially if it means we can significantly improve our chances of long-term survival in the universe. It will take a lot of work and material to actually get equipment and, ultimately, human beings onto Mar's surface."[9]

Overall, the sector shows a gradual pivot towards values regarding sustainability over time, which is supported by the triangulation process, as can be seen in table 8. However, these value orientations are still not as dominant for driving the development of the sector as market- or state-related value orientations are. Hence, the current field logic remains the **State Market Field Logic**.

Type of report	Main takeaways
	USA
Space Florida annual report (2016, 2023)	- Emphasis on *Commercial Development* through value orientations such as *Space Tourism* and *Profit.* - Continue transition from a government-led sector to a commercial sector. - *Stronger emphasis on National Security.*
NASA sustainability report (2012, 2017)	- Highlight Sustainability-related value orientations as core drivers for the development of the sector, focussing on *Sustainable Development*. - Integrate sustainability in all organizational activities.
NASA Space sustainability strategy (2024)	- Validates the belief that NASA has centralize sustainability as a core value. - Mostly focusses on the earth's orbit and neglects a more holistic approach for managing environmental impact.

Table 8: Triangulation results USA

[8] Newstex Blogs (February 16, 2024): From the skies to space: How an aerospace companies are shaping the future of aviation
[9] Newstex Blogs (May 28, 2022): SpaceX Mars City: Why is Elon Musk planning to build a city on Mars? - Interesting Engineering

4.2 China

A total of 26 relevant actors were identified during the analysis. These actors can be divided into two overarching categories, being government and *governmental institutions* and *companies*.

Private companies	Governmental institutions
Ispace	China Aerospace Science and Technology Corporation (CASC)
Galactic Energy	China National Space Administration (CNSA)
Space Pioneer	China Aerospace Science and Industry Corporation (CASIC)
Landspace	
Onespace	
Orienspace	
Link Space	

Table 9: Overview of Actors within the Chinese sector

4.2.1 Phase 1 (2000-2010) State-driven development

A total of five relevant actors were identified during the analysis conducted during this phase. The most prominent actors during this phase are the Chinese government, the China Aerospace Science and Technology Corporation (CASC) and the China National Space Administration (CSNA). All of these actors are state-led, thereby indicating the dominance of the state during this period. Since these actors are all state-led, the values that are related to the state logic are the most dominant ones by far. These values are *global leadership* and *strong developed national plan*, which are interrelated in this particular case, as China's strategy is referred to by actors as obtaining global leadership as part of the national plan.[10] These dominant value orientations during this period constituted the **State Field Logic**.

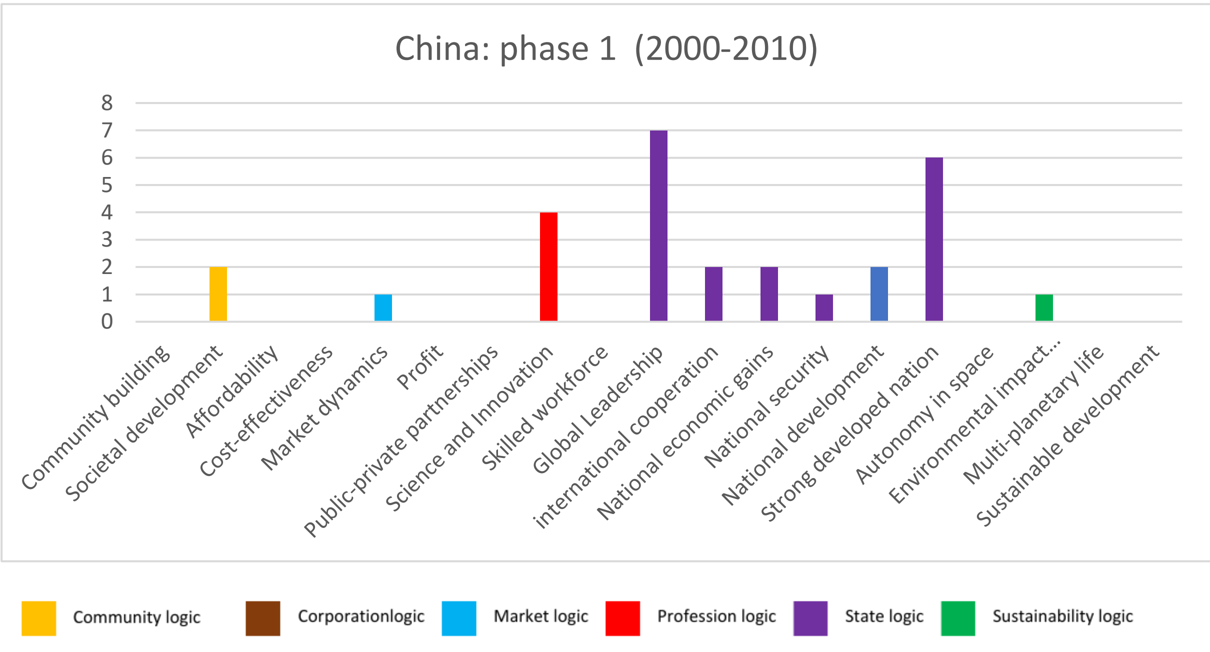

Figure 8: Distribution of basic logics during phase 1 in China

[10] Space Daily (August 6, 2004): White Paper: China's Space Activities

This is supported by the triangulation process, which points out that China's rocket launching sector in the early 2000's was strongly government-led. During this period China was working on building a foundation for future expansion of their rocket launching sector by developing advanced rocket launching technologies and capabilities. The Chinese government has been observed to be setting up favourable conditions, such as policies and legislation, for the rocket launching sector to grow in the coming decades, as illustrated in the following example:

"The state has strengthened legislation work and policy management, enacted laws and regulations and promulgated industrial policies for the space industry to ensure orderly and standardized development of space activities."[10]

Throughout this phase, China's orientation on the long-term stays persistent, which is to become a global leader in the global rocket launching sector. This is already visible in the early 2000's when China starts to embrace the idea of competing with the USA. Chinese actors have been mentioned alongside a strong focus on global competition, as illustrated by the following statement:

"Regardless of whether launch vehicles are used for commercial or military purposes, experts said China's capability in producing launch vehicles was posing competition for other space powers, such as the United States."[11]

As pointed out by actors' value orientations during this phase, there are hardly any value orientations that are not state-related. The limited number of statements during this phase expressing value orientations that are not directly state-related are still supervised and guided by state-related actors. The Chinese government has been mentioned to focus on improving the state's position in the global sector, as exemplified in the following statement:

"Space activities for public welfare and R&D work with commercial prospects are also supported by the state, and the state's supervision over space activities is being continuously strengthened."[10]

The beliefs, values and strategies that are driving the development of the sector during this phase are all heavily impacted by state actors, as pointed out by actors' value orientations and by the triangulation process.

4.2.2 Phase 2 (2011-2017) Continuous state dominance and commercial investigation

A total of nine relevant actors were identified during the analysis conducted during this phase. The most dominant actors during this phase remain state-related, with the Chinese government and CASC predominantly guiding and performing all rocket launches. This is mainly the case in the early years of this phase. As a result, state-related value orientations remain to be dominant drivers of actors in the Chinese rocket launching sector. The aspiration of obtaining *global leadership* is still heavily imbedded in the strategy that these actors implemented during this phase, as Chinese actors are frequently mentioned along the interest of becoming the most dominant player in rocket launching and space. However, during this phase actors have started actively pursuing the goal of obtaining global leadership in contrast to the more passive approach of the Chinese government and CASC in the previous phase. This focus on boosting the competitive power of the Chinese industry is expressed by the following statement made by Wu Yanhua, vice head of the State Administration of Science, Technology and Industry for National Defence:

[11] Agence France Presse – English (September 24, 2003): China develops its first solid-fuel satellite rocket

"The successful launch of the Belarusian satellite will boost the Chinese aerospace industry's global competitive power and pave the way for the export of Chinese satellites, rockets and space equipment."[12]

This launch helps China to actively take power and work towards their goal of becoming a global leader in space. This also illustrates how China is strategically engaging in specific events that will help actors to increase their *global competitive power*, aiming to outcompete the USA over time in terms of presence in space and rocket launching frequencies. Chinese actors have been mentioned alongside strategic planning and anticipation on events that influence the power of the USA in space, such as:

"When the ISS comes down, China will maintain the predominant presence in space, and will have successfully overshadowed a number of NASA's previous achievements while at the same time establishing a considerable distance over other countries space programs."[13]

Figure 9: Distribution of basic logics during phase 2 in China

In the later years of this phase, value orientations of actors start shifting towards market-related values. This is a result of two events. First of all, the Chinese government and other actors saw the great success of private companies in the USA. Therefore, Chinese actors started thinking about applying a similar strategy of embracing commercialisation as a means of growing their rocket launching sector. Second, as a result of these observations, the Chinese government published "Document 60", which is a policy document that enabled broader private investments in different parts of the Chinese economy, including space (Foust, 2020). This publication highlighted the mechanism of the Chinese government-led actors slowly embracing privatization of the sector. As a result, in the later years of this phase, the number of private companies in the sector and their development strongly increased, involving completely private companies such as Expace, Landspace and Onespace. However, state-related actors remain the driving actors of the sector, since this act of embracing privatization and commercialisation is accurately and actively monitored and guided by both the Chinese government and CASC. Private companies are not dominant during this phase, as most are start-ups that still need to further develop their technological and financial capabilities in order to strongly influence the development of the sector, even though the strongest value among these actors is *Market Dynamics*. The continuous

[12] China Daily - Africa Weekly (January 17, 2006): China to debut new carrier rockets
[13] Eurasia Review (December 22, 2016): China's Race To 'Dominate' Space - Analysis

dominance of the Chinese Government and CASC and the strong desire for obtaining global leadership constitutes the dominance of the **State Field Logic**. However, it should be noted that there is increasing influence of market-related values. The following quote by Hao Zhaoping, vice-president of China Academy of Launch Vehicle Technology (CALT), highlights the strong guidance of government-led actors on the commercialisation process:

"We will continue to push forward with the internationalization and commercialisation of the academy's space sector through more participation in the international space market and introduction of private capital," Hao said. "The government also encourages industry players to develop commercial satellites and their applications, commercial launch services and space tourism."[14]

During this phase sustainability is not identified as an important value that influences the development of the sector. Actors do not mention the necessity of sustainability and do not subscribe to value orientations that actively take sustainability into account. The triangulation process does not identify sustainability as a core value within the sector during this phase, even though it is mentioned, the lack of detail illustrates the lack of commitment to sustainability.

4.2.3 Phase 3 (2018-2024) State guided commercialisation

A total of 24 relevant actors were identified during the analysis conducted during this phase. Besides the continuous dominance of state-related actors such as CASC and the Chinese government itself, this phase also contains private actors that have obtained a dominant position within the Chinese rocket launching sector. These actors consist of iSpace, Landspace and OneSpace, which are all private companies. Due to the duality of categories of dominant actors, there are both strong state-related and market-related dominant value orientations to which actors subscribe. These value orientations consist of *global leadership, national development* and *commercial development*. This constitutes the **State Market Field Logic**. The growth of the sector has been achieved through efforts to commercialize the sector, however this process was heavily guided by sate actors. This period is therefore referred to as **State Guided Commercialisation**. This state guided commercialisation has proven to be a successful means for China to grow their rocket launching sector and space sector. Actors are found to be subscribing to a combination of values such as *market growth, commercial development, global leadership* and *global competition*. The Chinese government has been mentioned to foster state guided commercialisation as a facilitating strategy for growing the sector:

“The rapid growth has been possible thanks to the government's efforts to foster the commercial space sector and encourage participation from private companies.”[15]

&

“Since the beginning of China's space industry, the research and development of carrier rockets has been tightly held by State-owned enterprises. However, in the wake of private firms' rise in the global space sphere, the Chinese government has realized that it is necessary to introduce new players to stimulate innovation and competition and to fill gaps in the market left by State-owned contractors.”[16]

These efforts have been successful, since China’s rocket launching and space sector have grown exponentially, which is clearly shown in terms of number of launches and efforts of China. Rocket

[14] China Daily (October 20, 2016): Space program advances in heavens and on Earth
[15] Xinhua General News Service (July 25, 2019): 3rd LD-Writethru-Xinhua Headlines: China's commercial space industry takes off with successful orbital launch
[16] China Daily (March 13, 2019): Private firm planning first orbital launch

developers working at CASC highlight the rapid advancements that the Chinese rocket launching sector has made over time:

"According to the rocket developers with the state-owned space giant China Aerospace Science and Technology Corporation (CASC), the first 100 launches took place over 37 years, but then things started to heat up: the next 100 took seven and half years, the third took four years and three months, and the fourth only took two years and nine months"[17]

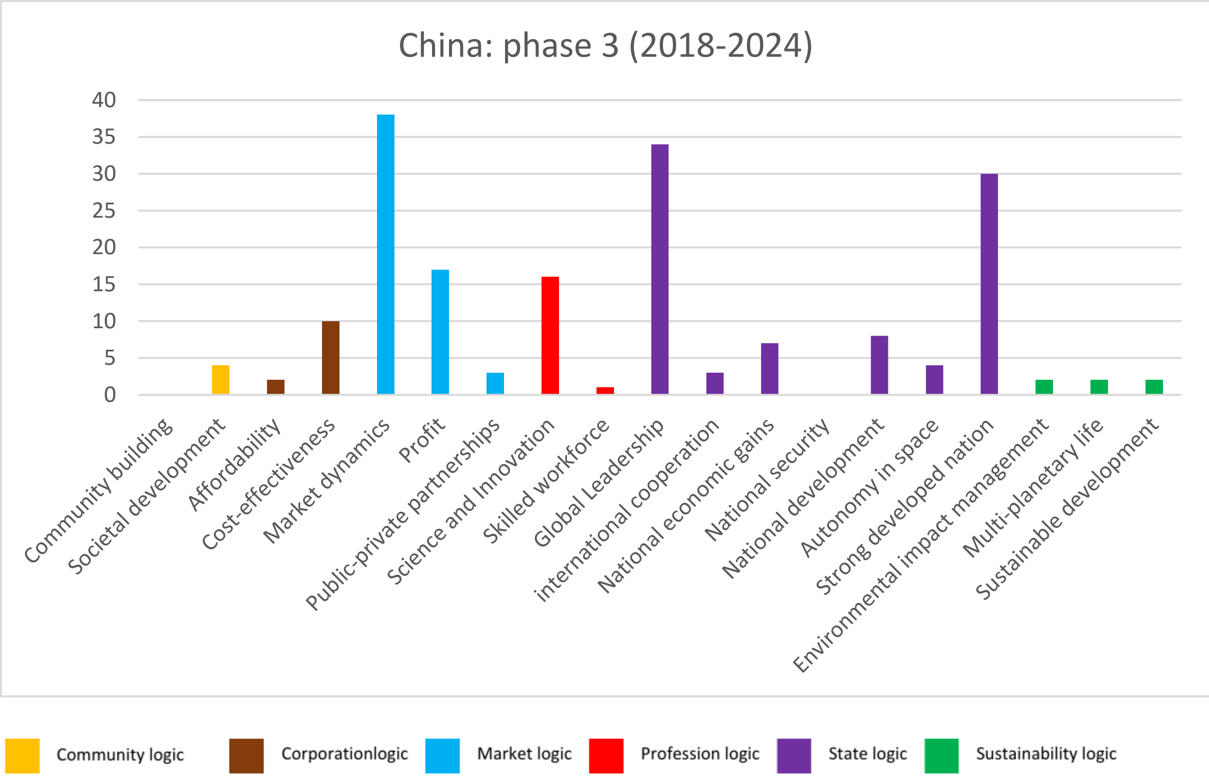

Figure 10: Distribution of basic logics during phase 3 in China

As mentioned above, China's long-term strategy throughout the different phases has always been to establish itself as a global leader in space, as reflected in the dominant value of *global leadership*, which is mainly constituted by the value orientation of *global leadership competition*. To achieve this, the strategy of state guided commercialisation has led to China being a strong and established power in rocket launching and space. This puts China on the global map to be in competition with the United States for leadership in rocketry and space. Chinese and American actors are increasingly seen as engaging in competition that will continue and intensify in the coming years, as illustrated by the following statements*:*

"In 2018, China and the US entered not only a trade war but also a new heated space competition."[18]

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"There is little doubt that China's space ambitions present the US with a daunting challenge to check the rise of China as a soaring power even if the US possesses a limited range of immediate and long-term options as a response."[13]

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[17] Global Times (China) (January 28, 2021): Long March rockets to support exciting phase of China's space work in 2021

[18] Asia Times-English (September 1, 2022): US-China in a heated tit-for-tat moon race

&

"China has invested heavily in its space programmes as it presses on with plans to become a space power, particularly in competition with the United States."[19]

According to actors' value orientations, the competition with the USA, through a strategy of state guided commercialisation, is currently the main driver of the development of the Chinese rocket launching sector.

Due to this strong focus on obtaining global leadership and global competition with the USA, China is not engaging in sustainability related efforts. There are almost no statements concerning sustainability, and the triangulation offers only very limited, superficial insights in the sustainability strategy of China in space and rocket launching.

Type of report	Main takeaways
	China
CNSA space program (2006, 2011, 2016 & 2021)	- Clear development over time from a solely state dominated sector towards a sector that is embracing *Commercial Development.* - Strong *State Guidance* and involvement during this transition, focus on *Global Leadership.* - Weak engagement in sustainability, there is no clear connection between China's goals and vision and sustainability in these reports.
CASC social responsibility statement (n.d.)	- Provides general statements on social responsibility. - Active stance concerning topics such as environmental protection. - Strong Global Leadership-related value orientations are integrated in this report. - Lacks detailed elaboration on goals and visions concerning sustainability.

Table 10: Triangulation results China

4.3 India

A total of 27 relevant actors were identified during the analysis. These actors can be divided into two overarching categories, being government and *governmental institutions* and *companies*.

Private companies	**Governmental institutions**
Agnikul Cosmos	Indian Space Research Organisation (ISRO)
Dhruva Space	Indian National Space Promotion and Authorization Center (IN-SPACe)
Bellatrix Aerospace	NewSpace India Limited (NSIL)
Godrej & Boyce	Indian Space Association
Larssen & Tourbo	
Pixxel	
Skyroot	

Table 11: Overview of actors in the Indian rocket launching sector

4.3.1 Phase 1 (2000-2010) Capability focused development

The analysis conducted during this phase identified a total of three relevant actors. The most influential actor during this phase is the Indian Space Research Organisation (ISRO), which is the national space agency of India. At the beginning of this phase, India has not yet obtained a strong presence in space. However, this phase is characterised by capability development. India's focus laid on the development

[19] South China Morning Post (October 1, 2021: New rocket a 'giant leap' for space programme

of numerous launch vehicles for them to utilize, such as their Polar Satellite Launch Vehicle (PSLV) and their Geosynchronous Satellite Launch Vehicle (GSLV), aiming to achieve self-reliance. On the long-term, this will enable India to become a large player in the sector, and to be a competitive player in the market. However, this was not yet the case, as actors during this time were not driven by market-related values. The following statement underscores the ISRO as having a strong potential for achieving significant market growth, but being held back by a lack of recognition of market opportunities:

"If ISRO's newfound prowess is to grow then it has to demonstrate this through economic viability. It has all the potential to be a big player but it needs money to compete."[20]

Indian actors achieved a large degree of self-reliance through the development and operationalisation of both their PSLV and GSLV. The PSLV functioned as India's workhorse during this phase, while the GSLV was designed to launch heavier payloads into orbit. Indian actors are often referred to as focusing on further optimalization of both the PSLV and the GSLV India to achieve the ability to be self-reliant, launching their own payloads into orbit, as illustrated in the following statement:

"Integration into the three-stage GSLV booster will take another year, but the indigenous engine will enable the booster to launch 2.5t-class satellites into geosynchronous transfer orbit (GTO) and help India end its dependence on Arianespace for launching its Insat series of domestic satellites."[21]

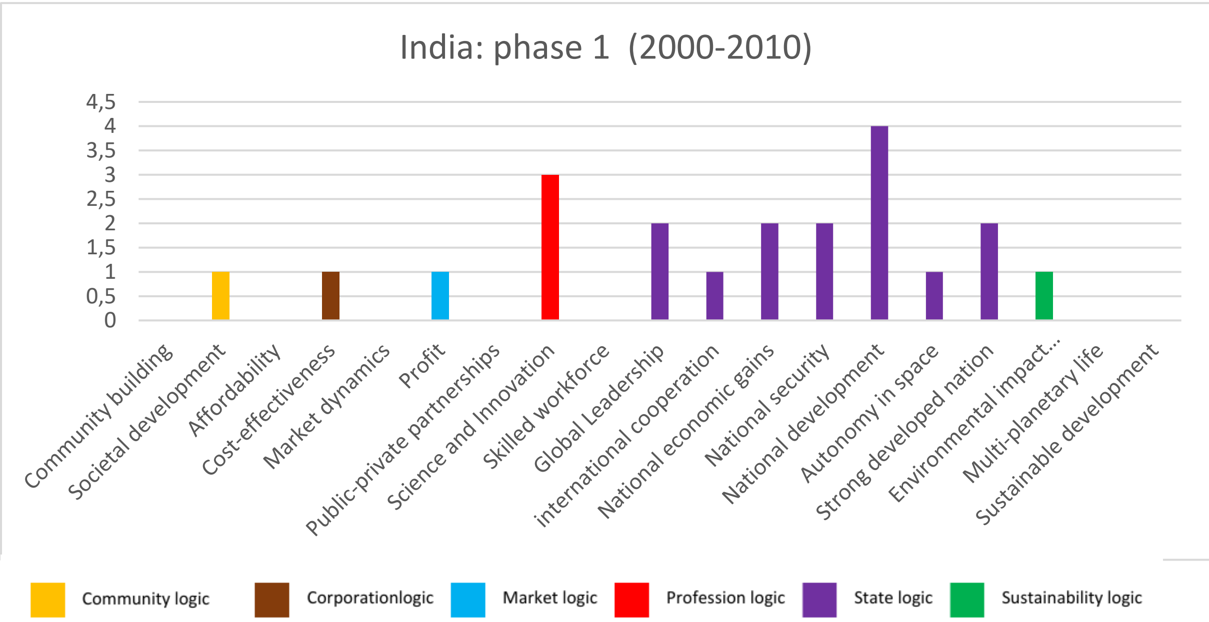

Figure 11: Distribution of basic logics during phase 1 in India

India's goal was to obtain a significant position in space, with the overall goal of space assets helping to foster *national development*, which was a dominant value during this period. The main objective of Indian actors during this phase was to focus on developing their rocket launching capabilities through innovative optimalization of launch vehicles in order to obtain a significant position in space, to be able to contribute to national development. The value orientations *of science and innovation*, *strong developed national plan* and *national development* were dominant values during this phase, which is expressed by ISRO's desire to focus on innovation and technological development of rocket launching capabilities in order to contribute to national development. These values constitute the **Profession**

[20] India Today (April 30, 2001): GSLV Launch: India Is Now A Space Power
[21] Flight International (February 17, 2004): Emerging power; India's slow but steady progress in technology has put it near the forefront of the regional space race...but will it decide to launch a manned programme?

State Field Logic. The following statement mentions the ISRO's is focus on the development of their own launch vehicles, to achieve a high degree of self-reliance, enabling actors to offer competitive services to customers, to help national development:

"More specifically, ISRO is developing the GSLV-Mk III to enhance the capability of the country to be a competitive player in the multi-million dollar commercial launch market. It will also allow India to become less dependent on foreign rockets for heavy lifting."[22]

4.3.2 Phase 2 (2011-2018) Space for national development

The analysis conducted during this phase identified a total of seven relevant actors. The most dominant actor during this phase remains the ISRO. During this phase, the main mechanisms that drove the development of the sector remained the same. There was an even stronger focus on the value orientations *national development* and *R&D*, as India focused on the development of their Nation's capabilities in a broad sense through a focus on innovation and he further development of launch vehicles. The focus on improving rocket launching and space capabilities in order to obtain a strong position in the global rocket launching sector increased. Furthermore, the belief of utilising space as a means of driving national development increased.[23] This period included diversifying the capabilities that India's PSLV and GSLV possessed, which resulted in numerous milestones for the country's sector. The most important milestone was the successful launch of the Mars Orbiter Mission, reaching Mars orbit. This made India only the fourth country in the world to achieve this milestone. The continuous focus on technological development and national development continues the constitution of the **Profession State Field Logic**.

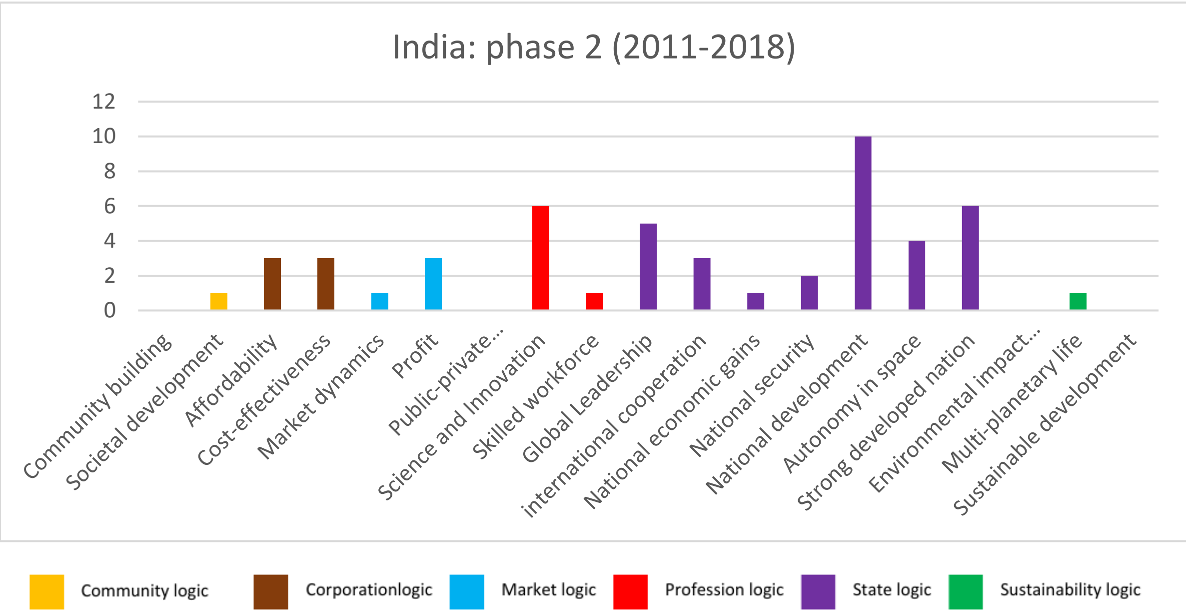

Figure 12: Distribution of basic logics during phase 2 in India

During this phase the first private companies began to emerge. Companies such as Skyroot were founded during this phase with the aim of entering the global commercial market in the long term. These companies saw the great successes of the American players, which inspired the founders of these companies to try to follow the same path as the American companies. The following statement

[22] The Financial Express (February 15, 2010): Gearing up for future
[23] The Times of India (TOI) (July 6, 2017): Defying gravity staying grounded

illustrates that the Indian government has been referred to as limiting the vendors of private players within the Indian rocket launching sector:

"Private Sector has revolutionized the Space Sector: Companies like SpaceX, Blue Origin, Virgin Galactic have revolutionized the space sector by reducing costs and turnaround time. In India however, players within the private space industry have been limited to being vendors or suppliers to the government's space program."[24]

As portrayed in this statement, these private actors were limited in their ventures, due to the strong control of the ISRO and the Indian government. Private actors want to subscribe to market related value orientations, such as commercial development, but are prevented from doing so due to the strong influence of the state. The Indian government in combination with the ISRO withheld the occurrence of commercial development, since it was not one of their priorities. The following statement made by the ISRO chairman AS Kiran Kumar illustrates how commercial ventures and launches are deemed as less important than governmental launches:

"*Our country has a lot of demands. Commercial launches are secondary. That's why we offer spare space in the rocket to carry other satellites. There have been complete commercial launches for Singapore and the UK, but those were exceptions."*

The following statement by Ajey Lele, senior fellow at the Institute for Defence Studies and Analyses, illustrates how the governmental control as exerted by ISRO prevents private companies from emerging:

"ISRO is a fully integrated government-run organisation. It does research, develop spacecraft and rockets, make them and even launch them. It also markets services like remote sensing images. While there are private players who have emerged in India's space industry, they haven't scaled up due to ISRO's control over the ecosystem."[25]

At the end of this phase, Indian private actors started to lobby for increased possibilities for commercialisation, which will continue to have effect in the next time phase. Furthermore, at the end of this phase, India has established themselves as a strong power in space, possessing over advanced space capabilities and rocket launching vehicles. As a result, the necessity of further technological development decreases, resulting in *innovation* being a less dominant value, while *national development* remains a dominant value driving the development of the sector.

4.3.3 Phase 3 (2019-2024) Market growth for national development

The analysis of this phase identified a total of 25 relevant actors. The most dominant actors during this phase include the ISRO, IN-SPACe, Skyroot and Agnikul Cosmos. This phase is characterised by a growing influence of private companies, such as Skyroot and Agnikul Cosmos. This is due to the Indian government opening up the sector for private companies, investments and innovation. The following statement made by the Indian Prime Minister Narendra Modi expresses the government's approach regarding growth for the Indian rocket launching sector:

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[24] The Insurance Times (October 11, 2023): India's Recent Landing On Moon & Related Titbits Of Satellite Insurance

[25] Economic Times (September 8, 2019): THE GREAT MOON CHASE

"First, the freedom of innovation to the private sector; second, the role of the government as an enabler; third, preparing youth for the future and fourth, to see the space sector as a resource for the progress of the common man."[26]

As stated, the government played a vital role in this growth, functioning as an enabler. This was done by establishing NewSpace India Limited (NSIL) in 2019, functioning as a commercial arm of the ISRO. The intention of the foundation was to facilitate private companies in space activities, such as launch vehicle development, to participate in the sector. NSIL thus actively guided the emergence and participation of private companies in the rocket launching sector. This paved the way for the emergence of numerous space start-ups. The following statement highlights Indian start-ups being mentioned to be crucial for the transformation and growth of the Indian rocket launching sector:

"The transformation that the country's space sector is witnessing is not led by ISRO but by the private sector, specifically, by start-ups."[27]

Even though the ISRO did not actively lead the transformation of the sector, they still created favourable conditions for start-ups to emerge. Especially through the establishment of The Indian National Space Promotion and Authorisation Centre (IN-SPACe), which regulates and promotes the commercial space sector. This is done by allowing private actors the usage of ISRO facilities and infrastructure, ensuring compliance with international space regulations and providing technical support. Through the establishment of IN-SPACe the Indian government did play an active role in the start of the commercialisation of the sector. All this enabled the rise and growth of private companies in the Indian rocket launching sector, which quickly resulted in the first successful rocket launch by a private company. Skyroot launched their Vikram-S rocket in 2022. The following statement made by Pawan Kumar Chandana, co-founder of Skyroot, expresses the launch of this private rocket as an important milestone, marking an important step in the commercialisation process of the sector:

"We made history today by launching India's first private rocket. It is a symbol of new India, and just the Prarambh (the beginning) of a great future," Skyroot co-founder Pawan Kumar Chandana said in a YouTube video. Pawan Goenka, the head of the government agency IN-Space, which coordinates with private space firms, said the "perfect" launch was the "first step of private industry's entry into space."[28]

IN-SPACe is often projected by Indian actors as having played a major role in the transformation of the Indian rocket launching sector, as highlighted by the following statement:

"The historic launch is enabled by the Indian National Space Promotion and Authorization Center (IN-SPACe), Department of Space (DOS), following their authorization of the maiden flight of a private Launch Vehicle by the Hyderabad based space start-up Skyroot Aerospace. This heralds a new age for the Indian space programme and etches a significant milestone in accordance with the policy reforms the Government of India is envisaging for the sector."[29]

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[26] New Delhi Times (November 28, 2022): ISRO to focus on R&D: Indian Private sector reaches new landmark with launch of indigenous Rocket

[27] Indian Defense News (January 19, 2023): Start-Ups Are Powering India's Space Odyssey 2.0 Start-Ups Are Powering India's Space Odyssey 2.0

[28] EFE - English Newswire (November 18, 2022): India successfully launches first privately-built rocket; INDIA SPACE

[29] Indian Aviation News (November 22, 2022): IN-SPACe facilitates maiden flight of India's first privately designed and built rocket, as Skyroot's Vikram-S Rocket takes off from Satish Dhawan Space Centre, Sriharikota

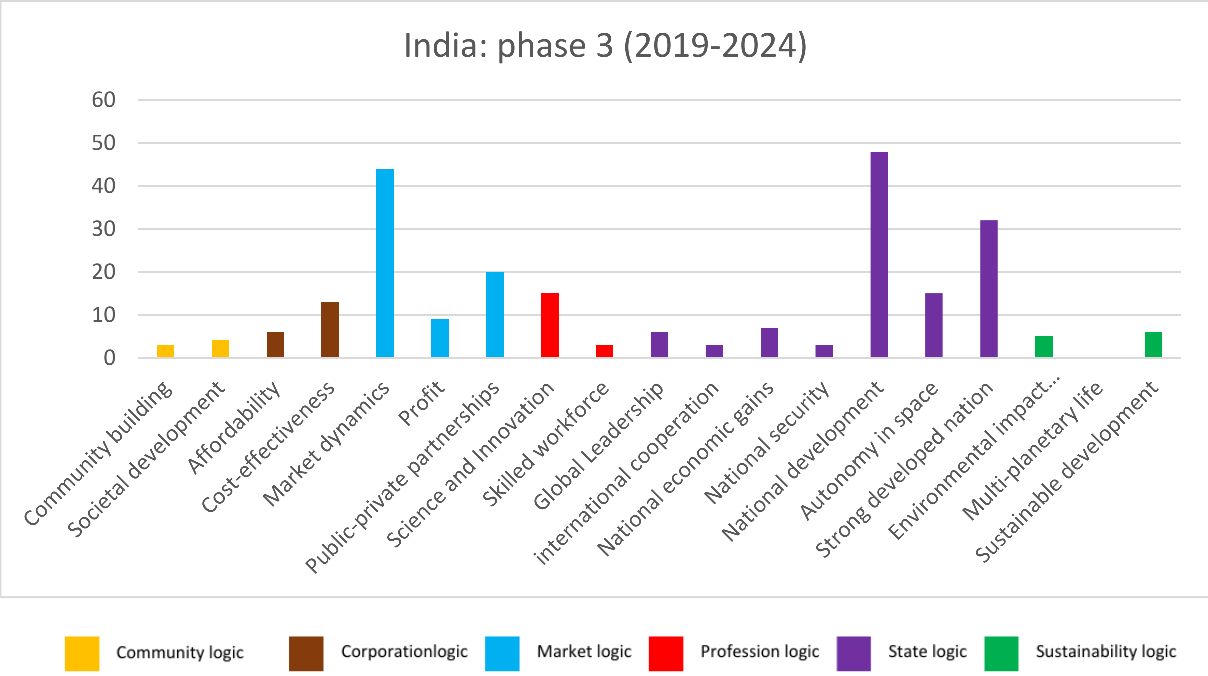


Figure 13: Distribution of basic logics during phase 3 in India

As a result of increased commercialisation efforts, the value orientations *commercial development* and *market growth* became dominant values driving the sector. These value orientations are connected to the strong value *national development*, since Indian state actors increasingly see commercialisation as a means of contributing to being a strong developed player in the sector. This results in the constitution of the **State Market Field Logic**.

The Indian sector has thus also been developed through a degree of state guided commercialisation. However, this process significantly differs from the state guided commercialisation that occurred in the Chinese sector. China's long-term goal is to obtain global leadership, whereas Indian actors do not share this aspiration. Indian actors aim to utilise a strong position in space for maximizing *national development,* developing their sector as a means of contributing to the problems of society. The following statement made by Vikram Sarabhai, founder of the ISRO, highlights the self-awareness of India's limitations and lack of desire to compete for global leadership in space:

ISRO's founder, Vikram Sarabhai, said as much when arguing that a developing nation like India would need space: "We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or other planets or manned space-flight," he said, "but we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."[30]

Indian actors are often mentioned not to strive for global leadership in the rocket launching sector, but rather focus on utilising rocket launches for national development, as outlined by the following statement:

[30] Slate Magazine (March 17, 2017): Stories from Slate; It isn't just about the country's rising nationalism.

“Unlike US and Soviets, India never saw outer space as a battleground for supremacy, since the primary idea was to use space technology for developmental purposes. The Indian space programme, since its inception, has been primarily a "civilian" space programme.”[31]

Type of report	Main takeaways
	India
ISRO annual report (2021-2022, 2022-2023)	- Focus on value orientations such as *National Economic Gains* and *Commercial Development*. - ISRO aims to develop its space sector substantially in the next decade, embracing the commercialisation of the sector. - Active participation in *space debris mitigation*, showing stronger connections to sustainability value orientations.
Indian Space Situational Assessment Report (2024)	- Focus on *International Cooperation* to achieve *Long-term Sustainability of Outer Space.* - States the importance of mitigating the amount of space debris in orbit. - Overall stronger focus on sustainability, focussing on sustainability as a necessity for being able to achieve a strong position in the global space market on the long-term.

Table 12: Triangulation results India

4.4 The European Union

During the qualitative content analysis, a total of 25 relevant actors were identified. These actors are divided into two categories, which are *governmental institutions* and *private companies*. An overview of the most important actors within the European rocket launching sector is provided below.

Private companies	Governmental institutions
PLD Space	European Space Agency (ESA)
Arianespace	Italian space agency (ASI)
HyImpulse	UK Space agency
Rocket Factory Augsburg	
Orbex	
Avio	
Skyrora	
Isar aerospace	

Table 13: Overview of actors within the European rocket launching sector

4.4.1 Phase 1 (2000-2010): International cooperation for dominance

A total of seven relevant actors were identified during the analysis of the discourses during this phase. The most influential actors during this phase were the European Space Agency (ESA), Arianespace and the European union.

[31] The Financial Express (January, 2018): A century for ISRO: Why it's time to celebrate

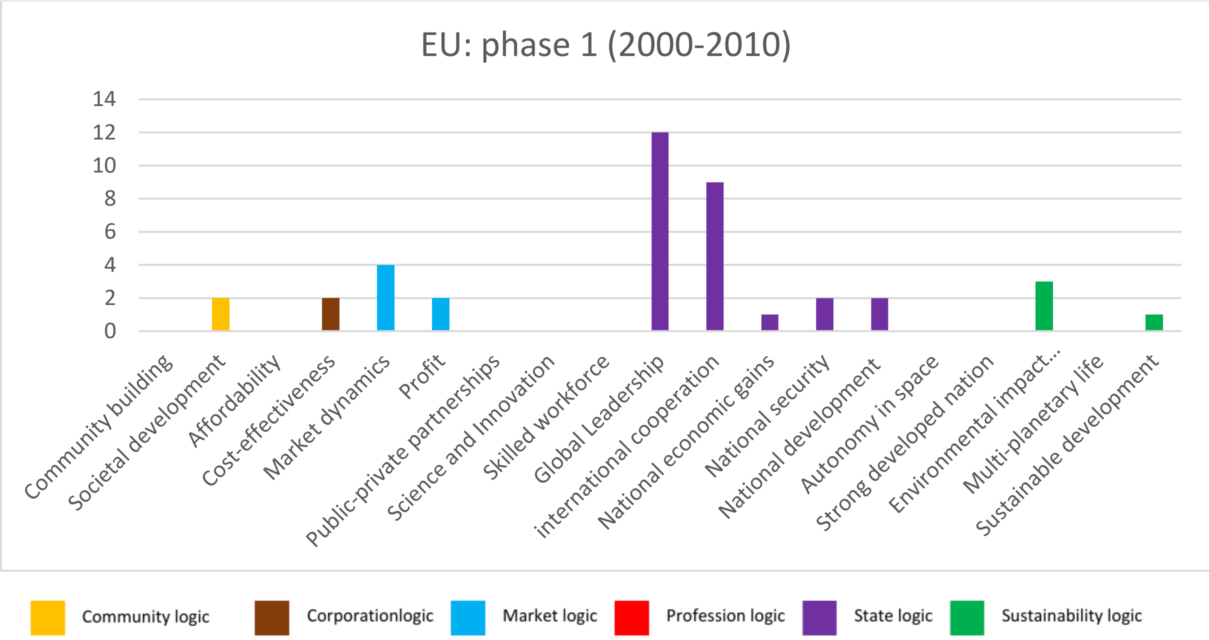


Figure 14: Distribution of basic logics during phase 1 in Europe

During the beginning of this phase European actors had a strong position in the global market, utilising their flagship Ariane rocket family. The Ariane 5 rocket was introduced in 2002 and enabled Europe to remain competitive in the global launch market. Due to this technologically advanced rocket, European actors during this time subscribed to the value orientation *global leadership*, wanting to take advantage of Europe's strong market position and technologies, which is strengthened by Europe's independent access to space. The following assertion made by Jean-Yves Le Gall, CEO of Arianespace, underscores the importance of self-reliance in order to make Europe independent on different actors:

"Understandably, the commercial success of Arianespace instills feelings of pride among its workforce and across a wider European space community. "From the political standpoint," states Le Gall, "it's because we are so successful commercially that we can guarantee independent access to space for Europe, which is Arianespace's 'raison d'être."[32]

Furthermore, this phase is strongly characterised by the value *international cooperation*. During this period, actors highlight the importance of collaboration between space agencies. Overall, since the European rocket launching sector consists of multiple national space agencies, overarched by ESA, strong and well-define coordinated cooperation between countries is crucial for sustaining a strong and dominant position in the sector, Hence, European actors are overall more oriented towards collaboration and partnerships than actors in other regions. This results in European actors more easily being able to identify the opportunities and benefits of international collaboration between different space agencies, as outlined by the following statement made by Jean-Jacques Dordain, director-general at ESA:

"ESA is ready to cooperate with nations and organizations around the world. This is one of my priorities. However, cooperation developed by ESA shows that planned activities may be outside its

[32] Aerospace America (September, 2010): ARIANE SPACE; Thirty years and growing...

control. ESA is cooperating with NASA on science, the space station, Earth observations, and very soon -- I hope -- on launch systems."[33]

Actors subscribing to the dominant values global leadership and international partnership constitutes the **State Field Logic**.

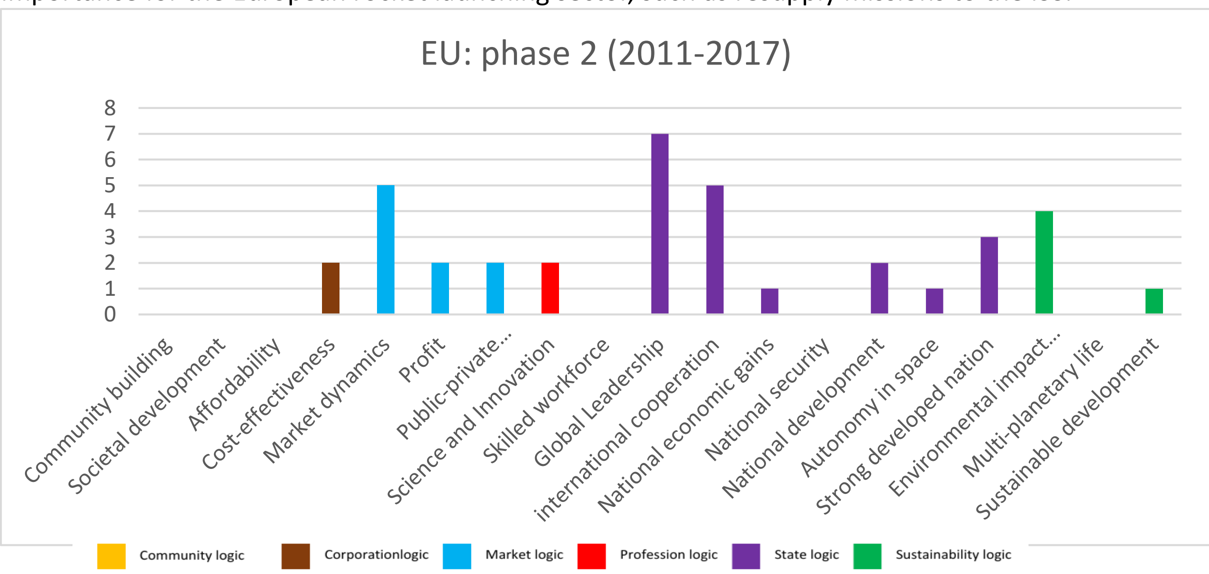
Furthermore, during this phase European actors started facing challenges. This included increased competition from other global players, such as the USA, and the necessity of continuously striving for technological advancements. As a result, at the end of this phase Arianespace and ESA announced the start of the development of the Ariane 6 rocket. The new improved Ariane 6 should replace the Ariane 5. This aimed to ensure Europe's continued competitiveness within the global rocket launching sector, as a response to the increased competitive pressure from actors within the United States. This resulted in the increased engagement of ESA with the *global competition* value. The following declaration made by Francoise Bouzitat, secretary general of Arianespace, highlights the increased competition:

"The competition is hard, but it is fair. The competing players have been very responsible and have shown a mutual respect. We must admit that, for some time, our American colleagues have been ferociously fighting to recover the part they have lost in the launch services business."[34]

Overall, this phase was characterised by sectoral development. During this phase the European rocket launching sector evolved from being a stable space power engaged in international cooperation to having a less stable position responding to intensified global competition by focusing on enhancing launch capabilities and infrastructure. All of this is mainly driven by the value *orientations global leadership, international competition* and *international cooperation*, with the goal of increasing the competitive capabilities of the European sector, therefore constituting the **State Field Logic**.

4.4.2 Phase 2 (2011-2017) commercialisation in response to increased competition

A total of nine relevant actors were identified during the analysis of the discourses during this phase. The most dominant actors during this phase remain ESA and Arianespace. The dominant value orientations from phase 1 remain dominant during phase 2. These values are *global leadership* and *international cooperation*. The Ariane 5 rocket remained the backbone of Europe's heavy-lift launch capabilities. The Ariane 5 successfully launched numerous high-profile missions, staying of critical importance for the European rocket launching sector, such as resupply missions to the ISS.



[33] Aerospace America (September, 2004): With Jean-Jacques Dordain
[34] Aerospace America (November, 2000): With Francoise Bouzitat

Figure 15: Distribution of basic logics during phase 2 in Europe

In response to the evolving launch market and the increased global competition, ESA initiated the development of the Ariane 6 rocket in 2014, which aimed to provide Europe with more flexible and affordable access to space. This focus on affordability was a direct response to the focus of American actors on cost-efficiency and aimed to increase Europe's competitive capabilities within the global launch sector. European actors are increasingly mentioned alongside the need for cost reduction of launch vehicles in order to respond to increased competition, as demonstrated by the following remark:

"Europe needs to bring down the cost dramatically to compete SpaceX. For instance, SpaceX offers launches for 50 million euros, compared to 130 million euros launch price for Ariane 5. With the next-generation Ariane 6, the ESA plans to bring down the cost to 60-70 million euros."[35]

To complement the launch range offered by Ariane 5, ESA introduced two additional launch vehicles, the Vega and the Soyuz. The Vega was developed by a private company called Avio. This was a cost-effective option for the launch of earth observation and scientific payloads. The Soyuz rocket, part of a broader cooperation between ESA and Russia, provided additional launch capabilities and flexibility, reinforcing Europe's position in the global rocket launching sector through strong international cooperation. ESA and the European Commission are mentioned to have streamlined collaborations among member states to facilitate these advancements, as demonstrated by the following statement:

"Two facets of transition appear to be well in hand: the introduction from 2019 of a new family of launchers, as well as the development of a working relationship between ESA and the European Commission. Both define Europe's response to a third facet, which is a changing global competitive landscape."[36]

Furthermore, actors increasingly subscribed to the *market dynamics* value orientations, which in this case consists of the values *market growth* and *commercial development*. With increased competition from private companies in the US, European private companies started to emerge and grow, working closely with larger organisations as subcontractors. This includes the founding of Orbex (United Kingdom), the founding of Rocket Factory Augsburg (RFA) (Germany), PLD Space (Spain) and the growth of Isar Aerospace (Germany). ESA and national space agencies increasingly engaged in public-private partnerships, to share risks and costs associated with developing new launch technologies. Public funding plays a crucial role in this process, helping companies advance their technologies, resulting in increased innovation and cost-reduction, enabling Europe to stay competitive. The following assertion highlights that European private companies are mentioned to help reduce the cost of rocket launches, as this is identified as the most important factor in responding to the increased competition:

"That competitive challenge, as anyone who's spent any time around the launch industry over the past decade knows very well, is not about rocket performance; it is about responding to US start-up SpaceX, whose Falcon 9 launchers have undercut prices and proved mostly reliable in service."[33]

The actors during this phase represent a mix of established firms and start-ups, all increasingly subscribing to market-related values, while state-related values remain dominant in the sector as well. This results in the **State Market Field Logic**.

[35] Financial Services Monitor Worldwide (December 2, 2014): Europe Rushes To Fund Ariane Rocket To Fight SpaceX

[36] Flight International (May 3, 2016): To remain in the space race, Europe needs added speed

Finally, actors during this phase started actively engaging in sustainable practices, projecting strong interest towards *environmental impact management*, mitigating the environmental impact that these actors caused by their activities. While ESA actively participated in the mitigation of space debris, Orbex was one of the first and most well-funded company to pursue the goal of minimising the environmental impact of rocket launching by developing greener fuel alternatives and circular design. As pointed out by the qualitative content analysis as well as the triangulation process, this phase marked the start of an increasing concern for rocket launching's environmental impact, expressed by the centralization of the value orientation *sustainable development* in sustainability reports by ESA and Arianespace. However, these values were not strong enough to dominate the development of the sector, as they were just starting to gain momentum in terms of amount of actors that express the importance of sustainable-related values.

4.4.3 Phase 3 (2018-2024) Autonomy regeneration and market competition

A total of 23 relevant actors were identified during the analysis of the discourses during this phase. The dominant actors during this phase are ESA, ArianeGroup and national governments. Additionally, private companies have gained a more dominant position in the market. Private companies such as PLD space, Isar Aerospace, Orbex, Skyrora and Rocket Factory Augsburg have increased in size and have received increasing amounts of funding. These stronger positions are obtained as a result of incentives by ESA and the European commission to embrace the process of commercialisation and privatisation of the rocket launching sector. Leading state-led actors realised the importance and the power of private companies pushing the sector forward through enhanced innovation and focus on cost-efficiency, resulting in stronger competitive capabilities in the global rochet launching market.

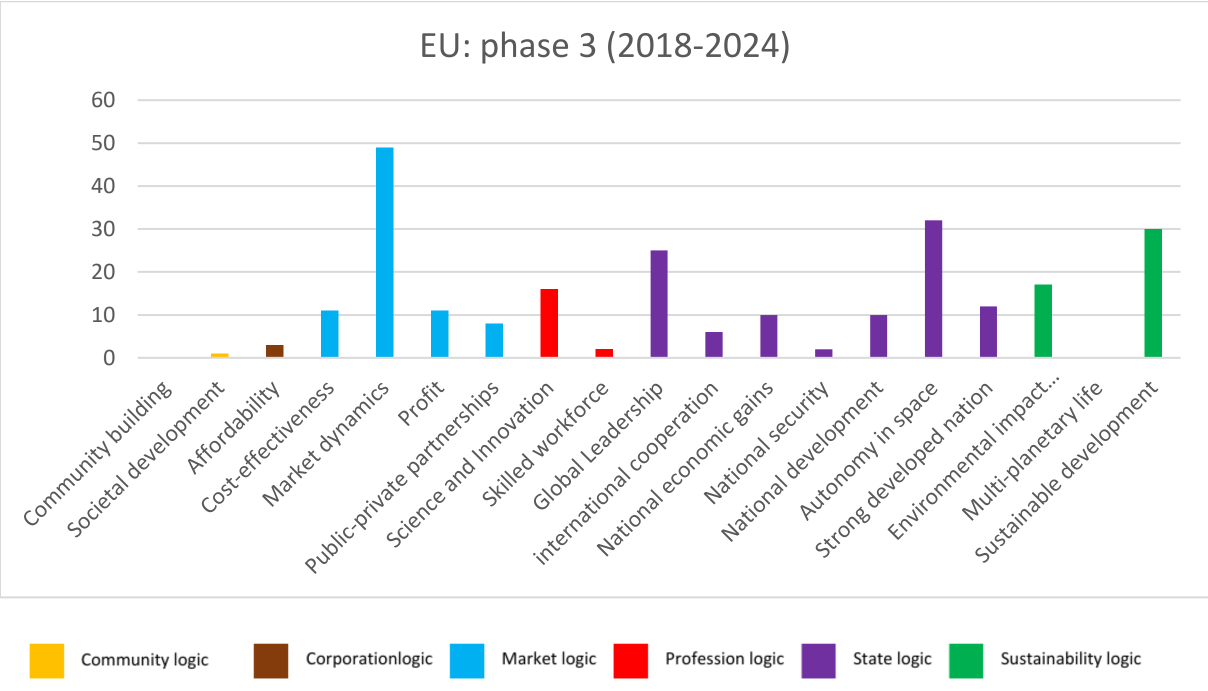


Figure 16: Distribution of basic logics during phase 3 in Europe

Looking at the successful implementation of this model in the US, European actors identified the successes and growth that the American sector had achieved by embracing market-related values. As a result, actors understood the importance of engaging in the commercial development of the sector. Hence, state-led actors increasingly implement this model of opening up the sector to private companies, enhancing market-related value orientations, such as *market competition,* within its own sector to increase technological development and improve Europe's position in the global market. The following remark made by Josef Aschbacher, the Director General of ESA, exemplifies this strategy of giving the sector more freedom to develop:

"We will act as an anchor customer and no longer define and develop the rocket from start to finish, but rather define user requirements precisely and develop important technology components. This will give the industry more freedom to develop itself. It's a competition for the best rocket for Europe. In principle, we are actually doing exactly what has been successfully implemented in America. The result is well known."[37]

Furthermore, this phase is characterised by a loss of autonomy in space for Europe. With Ariane 5's services comping to an end, Europe was aiming to start utilising the Ariane 6 as a replacement directly after retiring the Ariane 5 after its final launch. In the years prior to the last Ariane 5 launch, ESA mainly used European Ariane 5 rockets and Russian Soyuz rockets for their heavy lift launches. Ariane 5 played a vital role for European heavy lift launches, but the launches with Ariane 5 were very expensive, especially when compared with launches from American competitors. Hence, Ariane 6 was designed to be more affordable and cost-effective than the Ariane 5. However, the Ariane 6 was delayed multiple times due to technological setbacks, which heavily impacted Europe's position in the global market (Castel, 2024). Due to the multiple delays of the more affordable Ariane 6, it was hard for Europe to compete with the level of affordability that American competitors, such as SpaceX, have achieved. Furthermore, it left Europe with a gap between the retirement of the Ariane 5 and the first launches of the Ariane 6, as expressed by Josef Aschbacher, Director General of ESA:

"Last month, ESA's director general Josef Aschbacher acknowledged there would be a temporary gap in launch capability in Europe, marking the period between Ariane-5's final flight and the beginning of the Ariane-6 service."[38]

As a result, Europe was set to be completely dependent on the Russian Soyuz rockets for operating their heavy lift-launches. However, with Russia invading Ukraine, geopolitical tensions between Europe and Russia rose. The European Union heavily sanctioned Russia in multiple ways, punishing Russia for invading Ukraine. As a response, Russia denied Europe, more specifically ESA, access to their Soyuz rockets:

"In response to sanctions imposed on Moscow by the European Union, Russia suspended space launches from French Guiana with its Soyuz rocket launchers and withdrew its technical personnel. In the absence of an alternative, ESA has been forced to turn to SpaceX to launch two scientific missions."[39]

This led to Europe temporarily losing access to heavy-lift launch services. Therefore, Europe has to look at alternative ways of launching, resulting in them contracting out missions to SpaceX, which is one of Europe's main competitors. This results in Europe's strengthening of the rapid need for the development of their own heavy-lift launch vehicle. Toni Tolker-Nielsen, director of space transportation at ESA expresses his concerns regarding ESA's reliance on SpaceX, as expressed by the following statement:

[37] Die Welt am Sonntag (English) (December 17, 2023): "There is a vision"; The head of the European Space Agency ESA, Josef Aschbacher, considers Europe's space industry to be too slow in some areas. The biggest problem is the lack of launch vehicles

[38] The Independent (United Kingdom) (July 6, 2023): Ariane-5 rocket launches one final time as Europe faces space launch gap

[39] India Engineering news (March 9, 2023): Vega-C rocket lost after lift-off in Europe space setback

". It expects to contract out four missions to SpaceX. Yet reliance on the Tesla billionaire will be uncomfortable. Concerns about the dominance of Starlink, SpaceX's constellation of internet satellites, have contributed to the EU's decision to invest in its own rival The New York Times reported recently."[40]

Europe's inability to launch their own heavy-lift missions into space highlighted the importance of regaining *autonomy in space* by developing their own heavy-lift launch vehicle. The following declaration made by Josef Aschbacher expresses the lack of launch capability as seriously problematic:

"Josef Aschbacher, director-general of the European Space Agency, has described the lack of launch capability as a "crisis" for Europe's sovereign access to space."[41]

Multiple ministers attending a summit of ESA are projected as having a strong desire for autonomous access to space facilitated by newly developed rockets, as indicated by the following statement:

"Ministers attending today's European Space Agency (ESA) summit in Seville (south) endorsed its roadmap for ensuring Europe's autonomy and access to space, which includes a more competitive next generation of rockets and cargo vehicles capable of getting to and from the space station."[42]

Overall, over time European actors are increasingly subscribing to market-related value orientations such as market competition and commercial development. However, as a result of technical delays and external geopolitical influences, Europe's focus shifted strongly towards the regeneration of autonomy is pace, which is strongly state-related. This dual focus on the regeneration of autonomy and on commercial market growth constitutes the **State Market Field Logic.**

Finally, during this phase European actors are actively pursuing the integration of sustainability in the way they develop their sector, which is driven by ESA's strong interest and general goals concerning sustainability (ESA, 2021a). Hence, as pointed out by the triangulation process (table 11) sustainable development is integrated as a central value for future projects. ESA functions as a frontrunner concerning sustainability commitments in the global rocket launching sector, setting clear and ambitious goals, which are followed by private companies such as Orbex. Sustainability related values are therefore also significantly influencing actors in the sector, outperforming global competitors on this front. However, sustainability is not seen as one of the most dominant drivers for the development of the sector, since sustainability-related values are overshadowed by the urgent need for regaining autonomy in space.

[40] The Daily Telegraph (August 14, 2023): Europe forced to turn to Musk's rockets in global space race; Critical ESA launch delays mean Brussels must negotiate with SPACEX for use of the billionaire's Falcon 9. By Matthew Field

[41] Financial Times (February 4, 2024): Rocket revolution threatens to undo decades of European unity on space

[42] CE Noticias Financieras English (November 6, 2023): Europe to develop a new generation of rockets and vehicles for the space station

Type of report	Main takeaways
	EU
ESA Corporate responsibility and sustainability report (2015-2016 & 2020-2021)	- Focusses on Europe being and sustaining a position as frontrunner concerning the integration of sustainability in their wide-spread rocket launching activities. - *Sustainable Development* as an important driver for the way future projects are being developed and planned. - *Societal Development* as a stronger value, being an important goal for ESA to achieve during future missions. - Projects the most detailed goals, visions and achievements among the four regions
ESA Annual report (2022)	- *Regaining Autonomy* in space and in rocket launching is presented as one of the most important drivers for the development of the sector. - Strong emphasis on *Market Dynamics*, to obtain this autonomy. - Strong lobby for commercialisation of the European rocket launching market, aiming for *Economic Development.*
Arianespace CSR report (2014-2015 & 2022)	- Sustainability policy of Arianespace is in line with ESA policy, focussing on *Sustainable Development*. - Certification of sustainability approach by ISO 14001, providing evidence of their commitment. - Strong emphasis on *Societal Development*, as visualised by Arianespace's focus on boosting local economies and providing job opportunities. - Focus on different stages of rocket launching, already implementing sustainability in the design phase of their rockets.

Table 14: Triangulation results Europe

4.5 A global approach

This section presents an analysis of the global dynamics of the global rocket launching sector between the four major players. The analysis of the dominant field logics across different time periods reveals the fact that field logics within the four distinct regional rocket launching sectors have evolved over time. This section illustrates that field logics are subject to change as a consequence of external influences, which can result in regional differences in the way field logics are formed. Moreover, the characteristics of the global socio-technical regime are discussed. The influence of the global regime on the possible technological trajectories that the global rocket launching sector could follow is discussed. Finally, the implications on sustainability of these different trajectories are examined.

4.5.1 Field logic development and State Market typology

As outlined in section 3.3 on global socio-technical regimes, transitions tend to follow similar trajectories in different regions, despite different material and social preconditions (Fuenfschilling & Binz, 2018). This is also applicable to the global rocket launching sector. This concept will be applied and explained in this section.

The USA has been the global leader in space and in rocket launching for a substantial length of time. This accounts for the entirety of the period that was analysed during this research. Consequently, the USA leads the way in the development of the global rocket launching sector. The other major players in the global sector seek to emulate the strategies that are implemented by successful dominant actors in the American rocket launching market. The United States has demonstrated that the strategic incorporation of private sector capabilities and commercial development can effectively stimulate the growth of the national aerospace sector. The success of American actors implementing this strategy is clearly illustrated by the number of rocket launching missions and the considerable market share that the United States has in the global aerospace market. The strategy as described above enabled the United States to retain its position as global leaders in the global rocket launching market. As a result, the other regions began to adopt a similar strategy. All regions are currently embracing the commercialisation in their respective national rocket launching market, facilitating the growth of private companies. This is evidenced by developments in Europe:

'We are currently in a launcher crisis and we have to emerge stronger from this crisis,' said Aschbacher, who stressed that what is 'going to be done now in Europe is very similar to what NASA did a few years ago' when it opened the space rocket market to competition."[43]

This also accounts for China, being highly inspired by American companies:

"Companies like SpaceX, Blue Origin and Virgin Galactic are developing cost-effective carrier vehicles with the aim to make space travel possible for ordinary people. They have also inspired Chinese entrepreneurs.
Founded in June 2015, LandSpace, a private rocket-maker, has gained investment of more than 500 million yuan (about 78.61 million U.S. dollars). Its technicians are former state-owned aerospace industry workers. 'This is the best time for China's commercial space companies.'"[44]

And finally, India pursues a slightly different strategy, adapting the concept of privatisation and commercialisation on their own sector. However, their overall strategy is still largely inspired by the strategy of the US:

"Considering the Indian scenario, replicating the US model of total privatization would be irrelevant, as US firms are military-funded and we in India don't have a worthy aerospace industry. However, like Europe we can have government funding, along with industry support."[45]

As illustrated, all regions strive to commercialise their aerospace sector in response to the successes of the United States. This strong degree of commercialisation in conjunction with the influence of geopolitical and national interests, gives rise to the State Market Field logic. As illustrated in table 15 below, the State Market field logic has become dominant in all four regions during the final phase that was analysed during this research. Despite the fact that not all regions had the same field logics during the first two phases, the State Market field logic ultimately became dominant in all regions, which is driven by the strategy as employed by the United States.

	USA	**China**	**India**	**Europe**
				
Phase 1	State	State	Profession State	State
Phase 2	Profession Market	State	Profession State	State Market
Phase 3	**State Market**	**State Market**	**State Market**	**State Market**

Table 15: Overview of the development of field logics

[43] CE Noticias Financieras English (November 10, 2023): ESA hopes competition will allow it to catch up with U.S. on rockets
[44] Xinhua General News Service (May 13, 2018): China Focus: Sunrise for China's commercial space industry?
[45] Zee News (May 28, 2020): Private players welcome in India's space journey but ISRO needs an organizational revamp to focus on R&D

Despite the dominance of the State Market Field Logic in all regions, significant discrepancies between regions with regard to the way this field logic is constituted remain. The formation of field logics and the development of the region's rocket launching sectors are significantly influenced by culture, regional differences and major events. This results in the emergence of different types of the State Market Field Logic. A typology is used to illustrate the different dimensions of the different types of State Market Field Logic. The typology, as illustrated in figure 17, consists of four different State Market field logics and their characteristics, as indicated by the bullet points in each quadrant. It should be noted that all quadrants demonstrate a clear emphasis on both market-related values and state-related values.

The terms on the axis of the typology consist of concepts that apply to both quadrants on that part of the axis. For instance, the concept of global leadership applies to both the USA and China, while the concept of state guidance applies to both China and India. *Global leadership* refers to the strong desire of actors within the region that represent that quadrant to obtain global leadership in rocket launching and space in terms of rocket launching frequencies and presence in space. *State guidance* refers to the strong influence and guidance of state actors on the development of the region's rocket launching sector. On the other hand, *Entrepreneurial freedom* refers to the freedom of private companies to develop and commercialise the region's rocket launching sector without strong interference and guidance from state actors. *Autonomy* refers to the desire of actors within these quadrants to possess a high degree of self-reliance in launching their own rockets and payloads.

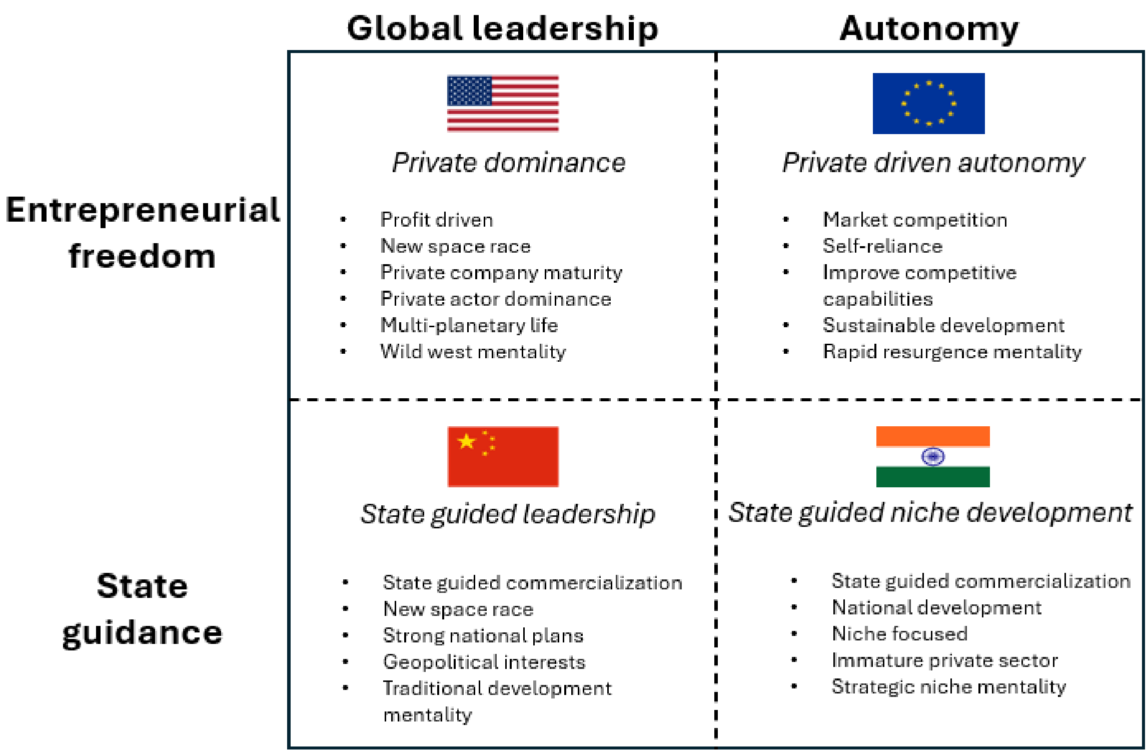


Figure 17: Typology of State Market strategies

Private dominance (USA)

This quadrant is constituted by dominant influences of the values of global leadership and commercial development. Actors in the United States emphasise the significance of maintaining global leadership in response to the mounting external pressure exerted by China.[46] With American actors engaged in the new space race for dominance in space with China, actors espouse state-related values with the objective of maintaining the United States' pre-eminence over China in terms of dominance in space. American actors embrace the commercialisation of their sector as a means of achieving this goal.[47] In this process, private companies are afforded the autonomy to develop and expand without significant intervention from state actors. With a strong focus on innovation to achieve cost-effectiveness and market growth, American private companies have become the dominant actors in the sector, achieving a strong position in the global market, aiming to commercialize space by offering space tourism services.[47]

This quadrant thus comprises the provision of a highly free environment for private companies to flourish and work towards offering the most affordable launch services for market growth, with the objective of attaining a position as a global leader in the global rocket launching sector. It is significantly influenced by external pressure in the form of competition for global leadership and is driven by strong geopolitical motivations.[48]

State guided leadership (China)

This quadrant is constituted by the dominant values of global leadership and state guidance on commercial development. Actors in China have a strong aspiration to surpass the United States in space, with the objective of obtaining a position as global leader in this sector. China's aspiration to obtain global leadership in space is strongly geopolitically driven, since China aims to utilize space in order to facilitate geopolitical influence in other sectors.[13] This quadrant is characterised by the concept of state-guided commercialisation, which can be described as embracing the commercialisation in the rocket launch sector, with this process being subject to significant influence and guidance from dominant state actors.[48] In this process, state actors retain significant influence over decision-making and the trajectory of sectoral development. This process is driven by China's clear goals, represented by the value strong national plan.

This quadrant thus comprises a highly controlled environment by state-actors. In this environment the strength of private companies is utilised for increased innovation and cost-effectiveness, resulting in stronger competitive capabilities for the state. The state-led commercialisation process aims to enable geopolitical influence in terms of strategic economic advantages and national security on a higher level, facilitated by obtaining global leadership in space.[1, 13]

State guided niche development (India)

This quadrant is constituted by the dominant influences of the values of autonomy and state guidance. India's private rocket sector opened up in 2019. Consequently, state actors continue to exert a dominant influence over the sector, as private companies have yet to attain the necessary degree of maturity to obtain a dominant position, with many of the private companies being start-ups.[49] State actors actively guide the growth and development of these private companies through interactions with overarching governmental institutions, such as IN-SPACe.[50] The development of these private companies is regarded as an important step towards the goal of offering affordable launch services on the global market. India aspires to attain a position of complete autonomy with regard to their launch vehicles, as they embrace the value of self-reliance as a crucial factor in the successful realisation of

[46] CQ Transcriptions (October 21, 2021): Senate Commerce, Science and Transportation Subcommittee on Space and Science Holds Hearing on International Collaboration and Competition in Space
[47] Satellite Today (August 15, 2019): The Coming of Space Tourism
[48] Beijing Review (November 29, 2018): Trial and Error
[49] Business Line (April 3, 2024): India's private space sector boom and ISRO's role
[50] Open (January 13, 2023): 2023: A Space Odyssey

their ultimate objective of driving national development. Self-reliance is part of India's strong national plan to obtain a niche position in the small launch vehicle market, specialising in providing space missions of small launch vehicles in compressed timeframes.[28] Hence, there is a strong connection between the values strong developed national plan, commercial development and public-private partnerships.

This quadrant thus comprises of a highly controlled environment for the development of private companies, which are intended to provide the state with a strong position in the global rocket launching market. Furthermore, this typology emphasises the importance of autonomy in the global rocket launching market as a means of national development.

Private driven autonomy (Europe)
This quadrant is constituted by the dominant influences of the values of autonomy and free commercialisation. In the final phase of this research Europe was influenced by multiple events, causing them to be in a launcher crisis.[38]As a result of technological setbacks causing the postponement of the Ariane 6 rocket and the event of Russia invading Ukraine, which resulted in Russia denying Europe access to their Soyuz rocket due to European sanction for Russia, Europe became dependent on other actors for launching their rockets.[39]This resulted in a very strong realisation that Europe has to regain autonomy over their own launches as soon as possible in order to maintain a relevant and competitive position in the global market.[51] Europe aims to achieve this by embracing the concept of commercialisation by creating an environment in which private companies can develop and grow without strong state interference, adopting the model that was successfully implemented in the USA.[45] Europe thus has a strong developed national plan, that encourages market competition among private companies with the objective of fostering commercial growth and innovation. This initiative aims to reduce the cost of launching vehicles, thereby enhancing Europe's competitive capabilities. This strong aspiration for autonomy has the effect of overshadowing the objective of sustainable development, which is also part of Europe's comprehensive national plan.

This quadrant thus comprises the idea of encouraging the emergence and growth of private companies, which will result in the creation of new launch vehicles. The goal of this approach is to enable the immediate recovery of autonomy for the launch of rockets into space. This typology demonstrates a susceptibility to external influences, which will have a significant impact on the future trajectory of the sectoral development.

4.5.2 Global socio-technical regime

The differences between the typology's quadrants illustrate the existence of different variations in the way that the State Market Field logic is shaped. Each quadrant, and thus region, constitutes the State Market Field Logic in a distinctive manner, driven by different norms, values and strategies. The typology described above illustrates the existence of competing rationalities, as reflected by the bullet points in figure 17, as well as the presence of overlapping values derived from the statements of actors within the respective regions. These substantial differences in the formation of the State Market Field Logics highlight the fact that the global rocket launching sector depends on numerous competing rationalities, which have been institutionalized to varying degrees. These competing rationalities can coexist in a globally fragmented regime, exemplified by the regional regimes of the four major players in the global sector. The existence of competing rationalities that are institutionalised to different

[51] EuroNews (January 17, 2024): Europe's access to space 'guaranteed' after 'painful' lessons of Ariane 6 delay, says ESA head

degrees in different geographical locations indicates that the mimetic pressure from the global regime can be expected to be lower, which is indicative of a weaker global socio-technical regime (Fuenfschilling & Binz, 2018). Given the considerable differences between the regional regimes, the global regime can be identified as a fragmented global regime.

Figure 18, which draws inspiration from the work of Fuenfschilling & Binz (2018), illustrates the applicability of the concept of a fragmented global socio-technical regime by highlighting the different values that constitute the State Market Field Logic. The darkest inner circle represents the core of the region's regime, which exerts the greatest influence on the region's sector. The elements on the peripheries of the circles exert far less influence on the regime and on the sector. These institutional rationalities are much more unstable and less influential (Fuenfschilling & Binz, 2018). These rationalities could move from the outer layers towards the regime core as a consequence of actors increasingly aligning with these values, thereby exerting more influence on the sector. The different logics and values of the region's regimes, as depicted in figure 18, are derived from the field logics and value orientations that were identified during the qualitative content analysis and the triangulation process. The dimensions of the shapes that represent the types of values to which actors subscribe reflect the number of codes for that value. If the shape is larger in size, the value was coded more often during the qualitative content analysis. The linkages between the values represent the connections between values that constitute the different types of State Market Field logics, which are represented by the four different quadrants of the typology. The thickness of the linkages indicates the strength of the connections between values.

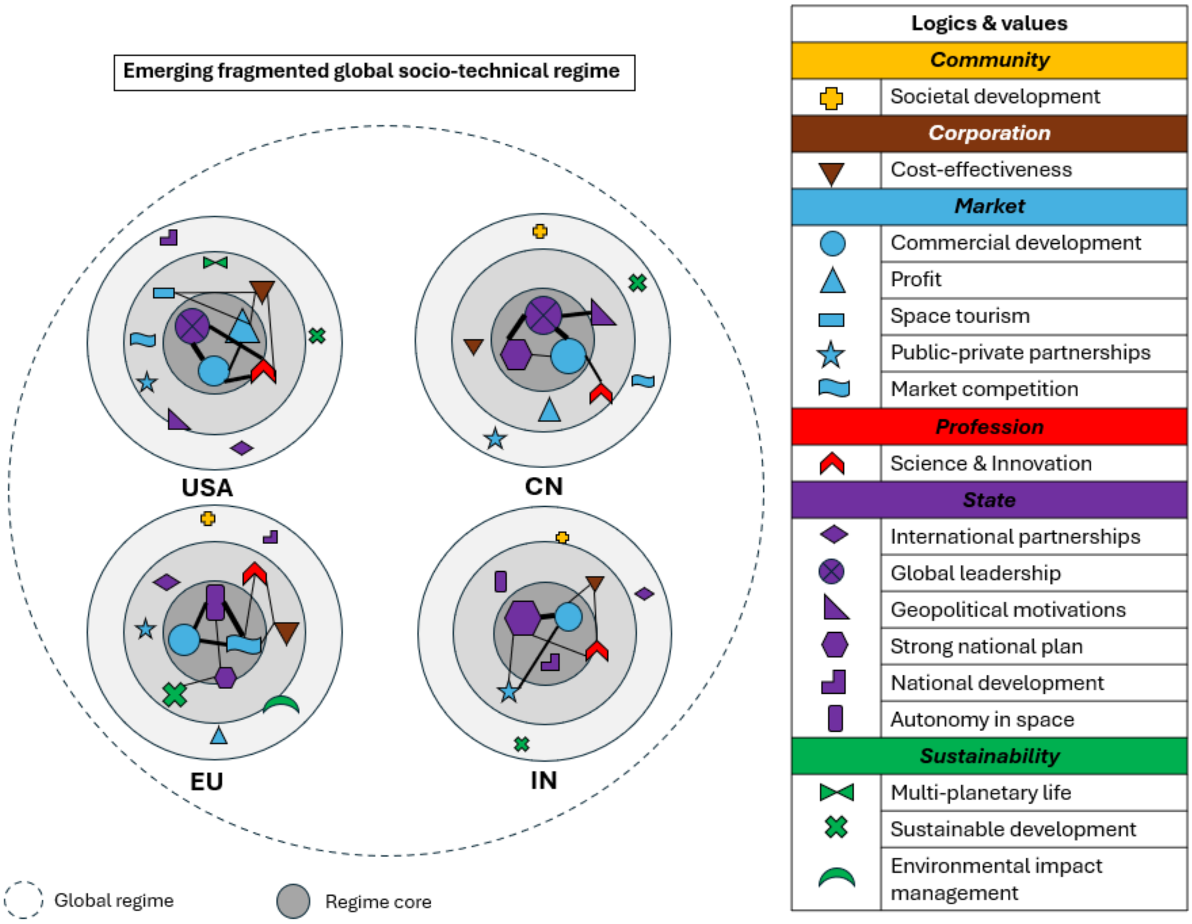


Figure 18: Fragmented global socio-technical regime of the global rocket launching sector

		China		India		Europe	
Global Leadership	55	Global Leadership	34	National development	48	Autonomy in space	32
Commercial development	40	Commercial development	30	Strong national plan	32	Market competition	28
Profit	39	Strong national plan	30	Commercial development	33	Commercial development	27

Table 16: Number of codes for the values in the region's core regimes

As illustrated, the core of all regional regimes is comprised of market and state-related value orientations. This emphasises the general diffusion of the State-Market field logic across all four regional regimes, which together make up the global socio-technical regime, as illustrated by the dotted circle. However, the value orientations present within the regime cores do not correspond to one another, as illustrated by the different shapes in each region's regime core. To illustrate, the core of the United States regime is constituted by profit, global leadership and commercial development, while the core of the Indian regime is constituted by commercial development, a strong national plan and national economic gains. Despite the relative instability and influence of the two outer layers, they still influence and constitute the region's regime. These layers also indicate notable differences, demonstrating the influence of different rationalities on the region's regime. For instance, the European regime is more strongly shaped by the value of sustainable development than other regional regimes. Despite actors in all regions largely adhere to the State-Market Field Logic, these notable differences in rationalities influencing the region's regimes illustrate the limited extent to which dominant rationalities have diffused across the different regions and have been translated into international technical standards and norms of the rocket launching sector.

Strong and stable regimes are characterised by a high degree of institutionalisation, expressed by the translation of rationalities into binding formal or material structures, including technologies, policies and routines (Fuenfschilling & Binz, 2018). The global rocket launching sector demonstrates a lack of such binding formal and material structures, as there is no evidence of clear policy implementation and Europe is currently limited in the use of rockets, which represents the material structures. This indicates not only a low degree of institutionalisation, but also that the sector has not yet reached a stable regime in this sector. This is demonstrated by the lack of regulatory frameworks and policies addressing the rapid advancements and changes within the global rocket launching sector. These advancements and changes consist of technological advancements, private sector involvement, increased launch frequencies and increased environmental concerns (Ganote et al., 2024; Mansfield, 2024). Consequently, actors increasingly mention the urgent need to improve and update space-related policies to address these advancements. For example, through the implementation of rocket launch management regulations to cope with increased space traffic, or policies to manage space debris generated by rocket launches. The following statement made by Jim Bridenstine, former NASA administrator, highlights the lack of a regulatory regime for space and rocket launches:

"And when you have a race like this and everybody's operating - it's the prisoner's dilemma. Everybody's operating to benefit themselves, and at the end, everybody loses. It's the tragedy of the Commons. And I think that's what we're facing right now in low Earth orbit. And there is no regulatory regime that manages that appropriately, and there's certainly not an international regime to manage it appropriately."[48]

Furthermore, there is a lack of a clearly defined technological structure that is consistently applied across all regions. Actors in all regions possess a variety of rocket launching capabilities and rocket launching vehicles. For instance, American actors such as SpaceX place significant emphasis on the reusability of rocket launch vehicles. On the other hand, European actors, such as ArianeGroup, do not incorporate the reusability aspect into the development of their latest rocket launch vehicles, but rather produce expendable rockets. Chinese start-ups tend to adopt the reusable design of American actors, while other actors, for instance in India, tend to implement a strategy similar to that of European actors, focusing on heavy lift launch vehicles. Actors in the global sector continue to engage in significant technological innovation and research and development activities. They are exploring a range of potential avenues for the future development of new launch vehicles, design methods and the types of fuels used. This continuous focus on innovation reflects the absence of institutionalised technological structures.

For example, actors are engaged in the development of reusable launch vehicles, 3D printing of significant amounts of launch vehicle compartments, advanced and complex new engine systems, in-space launch platforms, system automation, rocket design for space mining systems, and rocket design for space tourism, among other areas.[44,52,53] While these potential developments hold promise, they

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[52] Flight International (August 7, 2017): ANALYSIS: Reusability just one factor in cutting launch costs; Europe's bid to slash the cost of access to space has received a boost in the form of a reusable rocket engine intended to cost just 1 million ($1.1 million) – compared with the 10 million cost of the disposable Vulcain2 that powers the Ariane 5 heavy lifter. (Database)

[53] Indian Express (August 18, 2023): Private rockets and 3D-printed engines: What to know as another pvt firm prepares for space launch; After Skyroot Aerospace successfully launched its Vikram-S rocket, Agnibaan from Agnikul Cosmos could follow. There are strong reasons for private companies to enter the space sector.

have to be proven completely effective, resulting in a degree of uncertainty regarding the trajectory of the global regime's technological structures.

This broad focus on different technological development processes indicates the absence of an optimal technological trajectory within the global rocket launching sector. The technological trajectories could still go in different directions. This mainly accounts for the type of launch vehicles which becomes the state of the art, but also for the fuel, for which there is a great deal of research currently being conducted on different fuel types. Despite the existence of a generalised rationality across the various regions, being the State Market Field Logic, there is not yet an established, robust and stable regime. This is illustrated by the differences observed across the core of the regional regimes and the peripheries of the region's regimes, as illustrated in figure 18. Consequently, this research demonstrates that the concept of an emerging fragmented global socio-technical regime is applicable to the global rocket launching sector. This indicates that there are still different development trajectories possible, which is illustrated in figure 19.

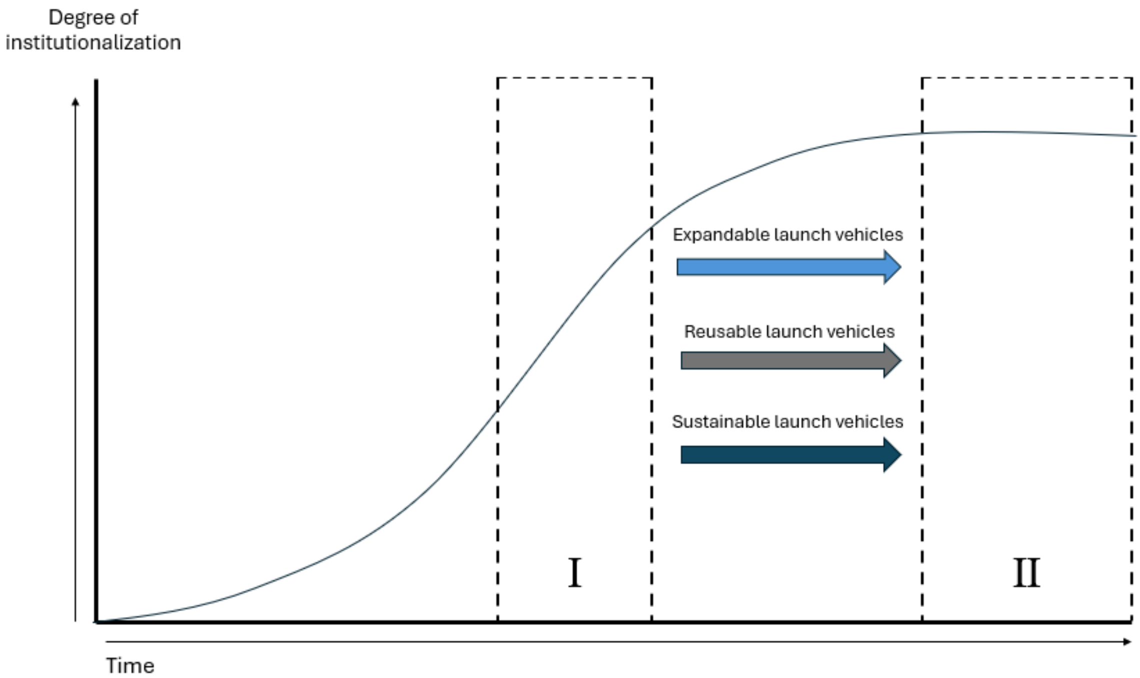

Figure 19:Development of emerging global socio-technical regime

Area Ⅰ illustrates the currently emerging global socio-technical regime of the global launcher sector. Here, the global regime has not yet achieved a high degree of institutionalisation and is not yet strong, consisting of various competing rationalities that exert limited mimetic pressure on sectoral development on a global level. Area Ⅱ illustrates a strongly established global regime, which has reached a high degree of institutionalisation and exerts strong mimetic pressure on sectoral development. The coloured arrows indicate the different possible trajectories that the emerging global regime could follow to become a strong and established regime in terms of technological trajectories.

4.6 Implications on sectoral development and sustainability

4.6.1 Actors' engagement in sustainability

The prevailing State Market Field logics within the global rocket launching sector exert a significant influence on the further development of the sector, as actors adhere to strong values that constitute this field logic. Actors in most regions do not strongly adhere to sustainability-related values, since they adhere to values related to the State Market Field logic. This is displayed in discourses of actors' value orientations, which include value orientations such as *Commercial Development, Market Competition, Cost-effectiveness, National Development* and *Global Leadership*. These are explained in section 4.1 through section 4.4. Despite adherence to the State Market Field logic by actors in all regions, there are notable differences in the degree to which actors in the different regions engage with sustainability-related values. Among the four regions, European actors are the most engaged in sustainability, as evidenced by the relatively high number of codes for sustainability-related values during the data analysis. China and India are not strongly engaged in sustainability, as the number of sustainability-related discourses identified within the news-articles that were coded for both China and India was notably low. The USA is becoming increasingly engaged in sustainability, particularly focusing on achieving multi-planetary life, which is coded under sustainability. However, this does not refer to environmental sustainability, but to achieving and maintain a human presence on multiple planets. The relative strong sustainability engagement of European actors can be explained as a result of having generally stronger sustainability policies and more structured stakeholder engagement mechanisms, which is reflected in the EU's comprehensive regulatory frameworks, legally binding commitments and policy-making processes, for instance in the form of the European Green Deal (European Environment Agency, 2024). The implementation of comprehensive frameworks and commitments result in actors increasingly adhering to sustainability-related values, such as *Environmental Impact Mitigation* and *Sustainable Development.* In general, from the midpoint of the second phase, actors were increasingly subscribing to sustainability-related values. There seems to be a slight trend towards sustainability, as pointed out by the reports that were analysed during the triangulation process. This is exemplified by the ambitious sustainability-related goals that have been set. For instance:

> "*Leading the integration of environmental considerations within the space sector is one of ESA's main objectives in terms of environmental responsibility. Reducing ESA's environmental impacts on Earth and in space and anticipating environmental requirements are two essential elements of the Agency's environmental sustainability policy*."[54]

Furthermore, this modest trend is exemplified by the emergence of private companies specialising in achieving the minimum environmental impact with the launch of rockets. For instance, Orbex, a European launch service company, is committed to ESA's clean space initiative. It is developing one of the most environmentally friendly space launch vehicles ever constructed, with a particular focus on environmental impact reduction, as state by Martin Coates chief executive of Orbex:

> *"Orbex Prime will be the world's most environmentally friendly space rocket, and a single launch of the rocket will produce up to 96 per cent less carbon emissions than comparable space launch systems using fossil fuels."*[55]

[54] ESA (August, 2017): Corporate Responsibility and Sustainability 2015-2016 report

[55] Scotsman (December 13, 2023): Scotland could lead way in sustainable commercial space flight activity in Europe after £6.7m funding boost

Overall, there appears to be a growing interest among actors, especially in Europe, regarding sustainability. However, the values regarding sustainability within the global rocket launching sector remain relatively weak. This is supported by the lack of updated regulatory frameworks concerning the long-term sustainability of outer space.[48] This leaves the space sector open for unsustainable practices for actors across the globe.[56]

The immediate necessity for autonomy regeneration in space as a result of the geopolitical tensions between Russia and Ukraine as well as the future delay of Ariane 6 resulted in a reorientation of strategies among actors.[53] Consequently, the state-related value of *Autonomy regeneration* eclipsed the sustainability-related value orientations. This highlights the fact that the values regarding sustainability are not yet strong enough to remain a central value when confronted with external pressure.

4.6.2 Possible development trajectories of the emerging global regime

The emerging global socio-technical regime could follow different trajectories before becoming strong and established. Since strong and established global regimes are paired with institutionalised technological structures, which is not yet the case, the global rocket launching sector could potentially follow different trajectories resulting in a variety of institutionalised technological structures. Currently there is no singular dominant type of launch vehicle, fuel or design methodology for rocket launches. Different trajectories of varying technological development consist of the emergence of different dominant institutionalised technological structures, which could contribute to a stronger global regime. For instance, different types of rockets can be classified into several categories based on their function, design, purpose and propulsion mechanisms. Types of rockets consist of Launch vehicles, both expandable (single-use) and reusable (multiple-use), suborbital rockets, orbital rockets and interplanetary rockets (Johnson, 2018; NASA, 2023). These rockets can be single-stage, or multi-stage, and carry different types of payloads, such as satellites, crewed missions and cargo missions. Propulsion systems, utilise various types of fuels, including chemical rockets, electric propulsion and nuclear thermal rockets (Navaan & Pranith, 2023). As illustrated in figure 19, these types of rockets are divided into three possible development trajectories, consisting of reusable launch vehicles, expandable launch vehicles (single-use) and sustainable launch vehicles. These three trajectories have been selected since they encompass the multiple rocket types as described above. They display different possible aspects of the developing global regime, consisting of reusability, heavy-lift focus and sustainability while representing technological diversity. Reusable launch vehicles refer to launch vehicles of which stages are reused after re-entry, such as the Falcon 9 (SpaceX, n.d.-a). Expandable refers to heavy-lit single-use rockets, which are discarded after being used for one mission, like the Ariane 5 (Gebhardt, 2018). Sustainable launch vehicles refer to rockets that are design in order to minimise the environmental impact of rocket launches, such as Orbex's rockets (Belkovska, 2024).

The current overall trend within both the global and regional rocket launching sectors illustrates a shift within actors' value orientations towards a predominantly market-oriented approach during the final phase that was analysed during this research. This is caused by the globally applied strategy of commercialisation and privatization of national rocket launching sectors implemented to improve the region's position in the global sector, as outlined in section 4.5. This mechanism is driven by a set of values that include *commercial development, market competition, global leadership, private investments* and a focus on *cost-effectiveness*. This strong focus on Market-related values is probable to persist in the development of technological structures. Consequently, the affordability and cost-effectiveness of rocket launches are significant factors in the design and development of launch

[56] The New York Times (January 11, 2024): The New Space Race Is Causing New Pollution Problems

vehicles. This is done to increase market competition and facilitate commercial development, which ultimately contributes to national development and global leadership. Even though there are multiple trajectories that illustrate different launch vehicles becoming dominant, a technological trajectory that supports the values as described above is most likely to be followed.

The focus on market-related values and the low degree of adherence to sustainability-related values is not only applicable on launch vehicle design, but on all stages concerning rocket launching. This includes all stage that were included in an additional coding scheme for this research, consisting of the *design phase, manufacturing phase, propellant production phase, launch phase* and *re-entry phase.* A strong focus on market-related values dominates throughout all phases, which leads to these values being implemented in the different stages of rocket launches. This is especially important in the design phase, since this phase strongly determines the focus of all other phases of rocket launching. This includes the environmental impacts in terms of emissions through production, propellant burning and in the amount of resources used (Bellier et al., 2022). A focus on market-related values in the design phase translates to a focus on market-related values in the other phases of rocket launching. This is applicable on this research, as highlighted by the coding scheme in Appendix B and the number of codes for market-related values. Table 17 below shows the frequency of codes for the design phase of rocket launching. This highlights that the largest number of codes, such as design for cost-efficiency and reusability for profit, are related to the State-Market Field logic, therefore empirically substantiating the fact that the State Market field logic impacts all phases of rocket launching. Additionally, the coding scheme highlights the importance of the concept of reusability, which is specifically mentioned multiple times in different contexts.

Life-cycle stage		Times coded	Description
Top level	*Sub-code*		
Design phase			
Design for Cost-efficiency		48	Aiming to maximise the cost-efficiency of the cost of rocket launching.
	Reusability for cost reduction	21	Incorporating a high degree of reusability in the design of rockets in order to bring down the cost.
Design for leadership		5	Designing rockets that can enable dominance and leadership in space.
Design for Sustainability		7	Rocket designs that focus on mitigating environmental impact through integration of sustainable concepts.
	Design for debris mitigation	3	Rocket designs aimed to minimise the creation of space debris caused by rockets.
Design for profit maximisation		19	Rocket design that aims to facilitate the potential to increase and maximise profit generation though a single rocket launch.
	Reusability for profit	13	Incorporating a high degree of reusability as a means to increase profit.

Table 17: Coding scheme rocket launching stages

These market related values are best exemplified in the incorporation of a high degree of reusability in the design of launch vehicles. The concept of reusability for launch vehicles was popularised by SpaceX, with the first re-launch of a recovered first stage in the year 2017 (Yuhas, 2017). This milestone resulted in the concept of reusability gaining popularity quickly, caused by its potential to contribute to a high degree of cost-effectiveness and increased competitive capabilities of both the firm and the sector.[57,58]

Because of this potential, the successful implementation of a largely reusable rocket is increasingly regarded as a crucial factor for success within the global rocket launching sector.[59] The United States is widely regarded as the global leader in the field of reusable rockets, with SpaceX being the first private company to apply the concept of reusability on a large scale.[54] Given that China, India and Europe tend to emulate the strategy that has been proven to be successful by the USA, namely commercialisation and development of dominant private companies, it seems probable that these regions will also adopt a similar approach to implementation of the reusability concept within the design of their launch vehicles. To a certain extent, this is already the case, since companies such as Landspace (CN), iSpace (CN), PLD space (EU) and Skyroot (IN) are pursuing the potential offered by the concept of reusability.[56,57,60]

The tendency towards reusability of launch vehicles has implications for sustainability. Rocket launching on its own impacts the environment in numerous ways, as previously mentioned in the introduction of this research. It is widely perceived that the integration of the concept of reusability for launch vehicles has the potential to reduce the environmental impact associated with rocket launching and increase sustainability.[61] This is caused by a reduction in manufacturing emissions, resulting from a diminishing need for the manufacturing of rocket stages. Additionally, reusable launch vehicles are associated with a reduction in resource depletion (Dominguez Calabuig et al., 2022). Furthermore, reusable rocket design has the potential to decrease debris left in space, since fewer discarded rocket stages remain in orbit. When compared to single-use launch vehicles, reusable launch vehicles tend to score better in all impact categories, with a lower Global Warming Potential (GWP), ranging from a 20% to 40% reduction depending on the fuel type, according to the latest Life-cycle assessment (LCA) reports (Dominguez Calabuig et al., 2024).

However, the decrease in environmental impact of reusable launch vehicles tends to be overestimated. LCAs indicate that launch emissions and re-entry emissions dominate the environmental impact that is associated with rocket launching, resulting in considerable emissions of greenhouse gasses such as CO_2 and CH_4 (Dominguez Calabuig et al., 2024). Propellant choice might be the driving factor in the context of space transportation eco-design. With the advent of reusable launch vehicles, the cost of space flight has decreased significantly, potentially leading to more frequent launching of vehicles into space. As a result, environmental impact could face rebound effects caused by these larger number of launches, resulting in increased ground operations, larger propellant consumption and recovery operations (Dominguez Calabuig et al., 2024).

Furthermore, there is still a considerable degree of uncertainty regarding the specific impacts of emissions such as aluminium oxides and BC at higher altitudes. These high altitude emissions could

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57 Global Times (China) (November 9, 2020): China's private space sector grows
58 EuroNews (April 7, 2023): SpaceX competitor? A Spanish start-up is ready to launch Europe's first reusable rocket
59 Targeted News Service (October 25, 2017): Senate Commerce, Science & Transportation Committee Issues Testimony From SpaceX
60 Times of India (December 11, 2022): These Hyderabad startups want to be your ticket to space
61 Congressional Documents and Publications (March 27, 2019): House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies Hearing; "NASA's Budget Request for FY2020."

result in a significantly higher environmental impact, up to 1000 times higher than current estimates, due to the significantly higher GWP of the emissions at a higher altitude (Dominguez Calabuig et al., 2024). Moreover, the increased number of launches could lead to increased depletion of the ozone layer (Goldstein, 2022; Ryan et al., 2022). These increased environmental impacts could result in the surpassing of Earth's carrying capacity supported by its planetary boundaries (Dominguez Calabuig et al., 2024).

Therefore, although reusability reduces the amount of manufacturing emissions and resource depletion, reusable launching still has considerable environmental impact, particularly when it results in an increase in the volume of rocket launches.

5 Conclusion

The objective of this thesis was to identify the norms, values and strategies that guide the development of the global rocket launching sector, to identify the possibilities and challenges for a sustainability transition to occur within this sector. This was done by employing the concept of institutional logics. The completion of the qualitative content analysis and triangulation process provided a comprehensive overview of the development of Field logics across the four regions over time, as well as the Field logics that are driving the current development of the sector. Insights into the field logics allow for an extensive understanding of the four regional socio-technical regimes, which collectively aggregate the fragmented global regime. This offers insights into the possible development trajectories of the global sector and the associated implications for sustainability. This was addressed by focusing on the following overarching research question:

What is driving the rapid development of major countries in the global rocket launching sector and what are the opportunities and challenges for transitioning the sector towards a sustainable direction on a global level?

This question was addressed by adopting the concept of institutional logics as proposed by Fuenfschilling and Truffer (2014). Institutional logics depict the norms, values and strategies that actors subscribe to within a socio-technical system. The combination of values that actors subscribe to give rise to field logics within the sector. News articles and company-and institutional reports were analysed in order to gain insight into the institutional logics to which actors within the global rocket launching sector subscribe. This was conducted for the four major players within the global rocket launching sector over three different time phases. These statements were then subjected to coding, thereby providing insights in the evolution of field logics over time, as well as on the current dominant field logics within the region's sectors. These field logics were used to analyse what the current regional socio-technical regimes looks like, and how it translates to the global socio-technical regime. The analysis of the field logic enables analysing the global socio-technical regime, which provided insights into the possible trajectories of sectoral development. To address the overarching main research question, three sub-questions were addressed in order to provide more comprehensive insights in the dynamics of the global rocket launching sector:

1. *How have the field logics in the rocket launching sectors of the four major actors evolved over time?*

The results of this research indicate that the four major region's rocket launching sectors have evolved over time. The evolution illustrates different field logics being dominant during different phases. All regions portray different development pathways that are shaped by different value orientations that actors tend to prioritise.

For the *United States*, the State Field logic was dominant during the first phase, with state-centric actors like NASA and the U.S. government emphasising global leadership and international cooperation. A significant emphasis was placed on maintaining the status of a global leader in space following the advent of the New Space era. The advent of the New Space era introduced the emergence of important private companies. In the second phase the Profession Market field logic took over, driven by technological and commercial development, which is exemplified by companies such as SpaceX and Blue Origin prioritising the development of cost-efficient launch vehicles, aiming to facilitate market growth. During the third phase the State Market field logic became dominant, characterised by the dominance of private companies, driven by values such as profit and commercial development. Additionally, the aspiration to attain global leadership in space reignited due to the increasing global competition with China in a new space race.

For *China*, the State Field logic was dominant during the first phase. State actors remain complete control over the norms, values and strategies that drive sectoral development. State actors' value orientations mainly consisted of global leadership and national development, ultimately aiming to compete with the USA for global leadership in space and rocket launching. The second phase is characterised by continuous dominance of the State Field logic. Sectoral development is driven by the strong developed national plan for obtaining global leadership in space. The successes achieved by the United States through the commercialisation of their space sector led to the Chinese state to consider the potential benefits of this approach. This resulted in policy being enacted to facilitate state-led commercialisation, resulting in the emergence of the first private companies. During the final phase, the Chinese rocket launching sector underwent further commercialisation, with the state utilising the strength of private companies to challenge the United States for global leadership in space. This constituted the State Market Field logic.

For *India*, the Profession State Field logic was dominant during the first phase, which was constituted by the values of national development and technological development. Indian actors aim to develop launch vehicles in order to become self-reliant and to become an established player in space. This trend persisted throughout the second phase, which was characterised by the continuous dominance of the Profession State Field logic. Private companies are limited in their ventures, due to strong state actor control over the development of the sector. During this phase, India has significantly advanced its launch capabilities, thereby obtaining a strong position in the global market. In the third phase, the Indian government recognised the potential benefits of commercialisation for national development. Consequently, the Indian state facilitated the emergence of private companies by provided necessary infrastructure. This marked a shift towards the dominant State Market field logic, with a strong focus on commercial development, market growth and national development.

For *Europe*, the State field logic was dominant during the first phase. Actors strongly adhered to values such as international collaboration and global leadership, aiming to strengthen their advantageous position in the global launch sector by increasing launch capabilities through international collaboration. During the second phase, European actors responded to increased competitive pressure from private companies offering affordable services, such as SpaceX, by enhancing commercial development of the sector, resulting in a significant increase in private companies. As a result, the State Market Field logic became dominant by actors subscribing to values such as commercial development, market growth and market competition. This trend of commercial development continued throughout the third phase. The European sector lost self-reliance regarding the launch of rockets into space, as a consequence of the prohibition on using Russian rockets and the further delay of the Ariane 6. Europe shifted their focus to re-establishing autonomy in launch capabilities through the enhancement of rocket development by private companies. This strong focus on autonomy of the region's launch abilities and on values such as market growth and commercial development constitutes the State Market field logic.

The State Market Field logic has become dominant during the final phase for all regions, despite the fact that the State Market field logic is constituted by different value orientations and motivations within these different regions.

2. *In what ways are the field logics shaping the development of a global socio-technical regime of the rocket launching sector?*

The advent of the New Space era marked a shift in dominance within the rocket launching sector, with a transition from state actors to private actors. This has resulted in a focus on values such as affordability, cost-efficiency, market growth and global leadership, all facilitating the overall trend towards the State Market Field logic. This emphasis on affordability, cost-efficiency and global leadership has resulted in the increased competitive nature of the global rocket launching sector. The competitive nature of the global sector is driven by both market competition and global competition, which refers to state-motivated competition, as exemplified by the new space race in which the USA and China are engaging.

The State Market transition consists of the commercialisation of the rocket launching sector in order to increase the region's position within the global rocket launching market. However, this research highlights the significant differences between the four regions in terms of foundational values which constitute the State Market Field Logic. Hence, this research proposes a typology, illustrating four distinct types of State Market Field logics. This typology highlights the differences in norms, values and strategies that actors within the different regions embrace. The different quadrants of the typology consist *of private dominance, state guided leadership, state guided niche development* and *private driven autonomy*. *Private dominance*, as exemplified by the United States, refers to the highly free environment for private companies to develop launch vehicles with a focus on cost-efficiency. This aims to enhance the sector's competitive capabilities in order to facilitate global leadership within the sector. *State guided leadership*, which is applicable to the Chinese case, refers to the highly controlled environment in which the development of private companies is strongly guided. This guided development of private companies aims to develop cost-efficient launch vehicles in order to facilitate global leadership in space for China's broader geopolitical interests, consisting of economic advantages over other regions and enhanced national security. *State guided niche development*, as exemplified by the Indian case, refers to strong state control over the development of private companies. This development of private companies is aimed at providing the Indian sector with a strong and highly self-reliant position in the global sector, enabling it to focus on the niche of launching small rockets with small satellites into space for the development of the nation. *Private driven autonomy*, as exemplified by the European case, refers to embracing the development of private companies in order to develop new launch vehicles for the state, enabling the state to regain their autonomy concerning the launch of European rockets and payloads into orbit.

The strategies and values of actors as expressed by the different quadrants of the typology show significant differences among the different types of State Market Field logic. This highlights the differences among values within the regime cores of the four regional regimes. The values within the core of the regional regimes also illustrate varying interrelationships among values. The regional regimes together translate to the global regime on a higher level. The dominant values within the core of the regional regimes demonstrate alignment to a limited extend, which illustrates the absence of one widely spread dominant rationality within the global regime. Furthermore, the global rocket launching sector lacks both a strongly institutionalised technological trajectory and binding formal structures, such as updated policies on the mitigation of space debris caused by the launch of rockets. The absence of one widely spread dominant rationality, strongly institutionalised technological structures and binding formal structures indicates that the global socio-technical regime of the global rocket launching sector is not yet strong.

However, there is an overall diffused strategy, as outlined by American actors, of commercialisation of the regional rocket launching sector to increase the region's position in the global sector. This is illustrated by the fact that the core of all regional regimes consists of state or market-related values and by the strong interrelationships between these values. Due to the overall diffusion of the commercialisation strategy as described above, the low degree of institutionalisation and the significant regional differences in terms of dominant value orientations as illustrated by the typology, this research proposes the concept of a fragmented emerging global socio-technical regime.

As the emerging global regime lacks a strongly institutionalised material structure in the form of technological structures, the emerging global regime could follow different technological trajectories that can become institutionalized technological structures of a strong global regime. The insights derived from this research can serve as a foundation for analysing which trajectory is most probable to be followed taking into account the influences of the State Market Field Logic.

3. *How does the emerging global regime impact the further trajectory of the global rocket launching sector and how does this influence sustainability?*

The State Market Field Logic is constituted by values such as market growth, profit, cost-efficiency and global leadership, all of which contribute to the highly competitive nature of the current global rocket launching sector. These values are best represented through the implementation of the concept of reusability, since reusability is believed to significantly increase the cost-efficiency and affordability of rocket launching. This enables profit maximisation, a strong position within the global sector, and the possibility to compete for global leadership. The overall trend indicates that the United States leads the way concerning the implementation of a high degree of reusability within their sector. Other regions are following their example due to the successes that companies such as SpaceX have achieved by the implementation of this concept. This has led to private companies in all regions modifying their launch vehicles design to integrate the concept of reusability. Reusability can thus be expected to play a significant role in the further development of the technological structures within the global rocket launching sector, as the concept of reusability aligns with supports the prevailing dominant State Market Field logic.

The concept of reusability is presented as a way to enhance the sustainability of the sector in terms of its environmental impact, due to a reduction in manufacturing emissions, resource depletion and space debris. However, actors seem to overestimate the environmental impact reduction that is achieved by the implementation of reusability in launch vehicles design. The latest Life-Cycle Assessment (LCA) studies highlight that the cost-reduction achieved by reusable rockets could lead to an increase in launch frequency. The environmental impact of rocket launches is significantly influenced by propellant burning during the launch and re-entry of rockets, resulting in an increase in emissions. The environmental impact of rocket launching could achieve break-even points compared to conventional single-use launches. This is due to the fact that more frequent launches result in increased propellant consumption and increased ground and recovery operations, which in turn result in higher emissions.

Additionally, the considerable uncertainty of specific emission types, such as BC, suggests that the environmental impact that is associated with rocket launching could be of even greater magnitude. This includes the specific impact on ozone depletion and the increase in GWP due to the high altitude of the emissions.

Conclusively, the rapid development of the major countries in the global rocket launching sector is driven by the State Market Field Logic. The development is driven by a variety of value orientations that fall under this dominant State Market Field logic. These value orientations include, but are not limited to, *commercial development, profit, market growth, national development, global leadership* and *cost-efficiency.* The differences among the region's dominant driving sectoral development, the absence of highly institutionalised formal and material structures and the lack of one dominant widely diffused rationality support the applicability of the concept of an emerging fragmented global socio-technical regime. The global sector, and global regime, could follow different trajectories with respect to the technological structures, in the form of launch-vehicle technology, which can become dominant and form the highly institutionalised material structures of a strong established global regime. These trajectories differ in terms of launch vehicles technologies, with a focus on reusability being the most probable. Overall, sustainability does not yet appear to be a primary factor within the rocket launching sector, as proven by the European case. The European sector has demonstrated the strongest commitment to sustainability. However, value orientations regarding sustainability are not strong and dominant enough yet. When the sector was confronted with geopolitical issues and lost its self-reliance, actors shifted their focus towards the goal of regaining autonomy. The probable trajectory of transitioning towards a strong focus on reusability cannot be identified as strongly led by sustainable-related values. Reusability does not appear to significantly reduce the environmental impact that is associated with rocket launching. In fact, it could potentially increase the environmental impact due to the likelihood of more frequent launches. Therefore, transitioning towards a sustainable direction requires substantial interference on regulatory level, guiding actors towards the pursuit of sustainability as a strong dominant driver that is more persistent to external pressure than current sustainability-related values.

6 Discussion

6.1 Theoretical implications

This research has contributed to the existing literature in numerous ways. The existing literature concerning the sustainability of rocket launching and the possibility to increase its sustainability mainly takes a technical approach. For instance, by measuring the environmental impact of rocket launches in terms of emissions, contribution to space debris and ozone depletion. These studies propose technological solutions for achieving a decrease in environmental impact. However, studies on sustainability transitions that apply a socio-technical perspective regarding the sustainability of rocket launching is limited. Such an approach allows understanding technological change in relation to the social and institutional elements that influence sustainability transitions. This research contributes to the limited availability of research using this social perspective by providing insights in the norms, values and strategies of actors within the rocket launching sector of the four major regions. This highlights the importance of the social dimension of sustainability transitions by analysing the behaviours and principles that actors adhere to within a socio-technical system. This was done by employing an institutional logics approach, which enables mapping the strategies and beliefs of actors connected to rocket launching. The institutional logics as proposed by Fuenfschilling and Truffer (2014) were adopted as an initial coding scheme. Once the data analysis process emerged these institutional logics were expanded upon and adapted in order for the codes assigned to the institutional logics to best represent the coded statements of actors, which enables a deeper understanding of the beliefs and dynamics within the sectors. Thus, this research builds on the existing literature on institutional logics and illustrates how these original institutional logics can be built upon in order to better fit the analysis of specific sectors, allowing for a more in-depth analysis of these sectors.

Furthermore, this research contributed to the existing literature by contributing to a better understanding of global socio-technical regimes. More specifically, the current literature on global socio-technical regimes highlights the characteristics of strong global regimes, using case studies to contribute to a better understanding of what strong regimes look like. These case studies were mostly conducted on stable and established sectors with a strong global socio-technical regime. However, research on the characteristics of an emerging global regime of a dynamic and rapidly developing sector has been limited. This thesis contributes to the concept of global socio-technical regimes by providing empirical evidence on the characteristics of an emerging global regime. The analysis of multiple regions within a global interconnected sector suits the gathering of these insights well, since this approach allows for the identification of regional differences that can be aggregated to the global level. This research illustrates the use of a typology for identifying these differences in four regional regimes. Strong differences indicate that the global regime is not yet strong and highly institutionalised, exerting lower mimetic pressure. Less differences could indicate a stronger regime, with higher mimetic pressure causing regional regimes to be more the same. The analysis of the global rocket launching sector points out that there are significant regional differences among the four regions in terms of dominant values that drive sectoral development. Therefore, this research identified the current global regime as fragmented, weak and emerging, due to the absence of strongly institutionalised formal and material structures, the significant differences among regions in terms of dominant values and the widely spread State Market rationale. An emerging fragmented global regime can thus be described as having significant differences in actors' dominant value orientations among the different fragmented regional regimes. An overall general strategy, as depicted by the State Market field logic, has diffused, but there is a limited degree of alignment of institutional structures (i.e. value orientations and norms) among the different regional regimes. Over time, these institutional structures can become more aligned, resulting in a polycentric global regime. A polycentric global regime refers to a global regime which consists of multiple, interconnected centres of actors and decision-making, in which actors' value orientations are in alignment with each other across these different centres. Polycentric global regimes are stronger than fragmented regimes due to a higher degree of institutionalisation, as the dominant values, norms and strategies are in alignment across the different locations, indicating that one dominant rationality has spread across all regions. This builds on theory on polycentric governance theory by Ostrom (2010), which uses the term of polycentric for referring to multiple overlapping authorities that operate at different scales and are capable of self-organisation. Future studies could look into the practical applicability as well as the more detailed characteristics of such polycentric global socio-technical regimes.

Furthermore, the global regime is not yet highly institutionalised due to a lack of formal structures, such as policies, and technological structures, such as a dominant launch vehicle. This emerging global regime could still follow different trajectories over time in terms of technological structures, in this case launch vehicles, which become dominant over time and constitute a strong global regime. This research thus adds to the existing literature by illustrating how an emerging weak global regime could develop over time, and how strong global regimes come together in the first place.

Having insights into the dynamics and maturity and strength of a global regime allows for more precise and better applicable policy implications, since weaker regimes are easier to change than stronger regimes, since weaker regimes are less characterised by a high degree of institutionalisation, consisting of less established formal structures, such as policies. Therefore, changing weak regimes requires a different approach than changing strong regimes.

6.2 Quality indicators, limitations and further research

This research has ensured high quality through the adoption of the qualitative research quality criteria as outlined by Bryman (2016) based on research by Lincoln and Guba (1985), consisting of: credibility, transferability, dependability and confirmability. Credibility has been assured by using multiple data sources, which consisted of news articles and governmental reports. The results of the analysis of the news-articles were triangulated with company and governmental reports to ensure that all relevant topics were covered and that data gaps were filled in. Transferability has been assured by the complete documentation of all necessary data. This includes the coding scheme for the analysis of the news articles, the news articles themselves and the additional reports that were used for the triangulation process, which are all provided in the appendix. However, since the coding scheme was adapted to this specific sector it might not be applicable as a whole on all other sectors. Researchers should assess the applicability of the coding scheme to each specific sector. Dependability has been assured by complete documentation of all processes of this research, which is comprehensively outlined in the methodology section. To ensure a high degree of dependability the methodology section has precisely been adapted to the execution of this research. Finally, confirmability has been assured through the continuous monitoring of the research processes by an expert in both the fields of space and transition studies. This support resulted in adaptations of the coding schemes, data sets and interpretation of the results.

Even though this study consists of a proper research process including the persuasion of a significant degree of credibility, transferability, dependability and confirmability, this research has some limitations. First, data filtration using Nexis Uni resulted in a database solely consisting of English articles. The language barrier refrained news articles from other regions to be analysed. Including news articles from other regions in different languages could lead to an even more comprehensive overview of value orientations from actors within the sector. Hence, further research in this sector should include data in multiple languages to better represent the global nature of the sector. Moreover, the use of Nexis Uni allows for provision of only a limited type of data, mainly providing news articles, which results in data homogeneity, which refers to a lack of diversity in data sources. Also, the use of mainly news articles allows for influence of the media. Therefore, discourses could be subject to influence of these media channels. However, to increase data heterogeneity and limit media influence on the results of this research this study triangulated the results of the news articles analysis with additional reports published by relevant actors themselves. In order to maximise data heterogeneity further research could execute interviews with different type of stakeholders. Furthermore, manual coding and qualitative content analysis in general are sensitive to subjectivity, resulting in relevant date not being observed. However, this limitation is mitigated by continuous supervision of an expert in transition research and by the continuous iteration of the coding scheme, ensuring flexibility in the observed phenomena.

This research is unique in terms of the types of results that have been gathered. Even though the methodology is transferable to other future studies, by using the same coding scheme, the same results could not have been gathered using a different approach. For instance, conducting a Life Cycle Assessment (LCA) could offer in-depth insights into the environmental impact of all stages of rocket launching, which could enable policy makers to focus on the most impactful stages. However, this does not use a social perspective that provides insights into the different norms, values and strategies that guide sectoral development. This allows for policy implications that could change the fundamental institutional structures of the global regime, allowing for a deeper foundational change in the strategies and values that actors pursue, rather than just managing the environmental impacts of rocket launches.

This research has provided a foundation on the understanding of emerging global socio-technical regimes. Further research on these characteristics is recommended in order to empirically strengthen the allocated characteristics of emerging global regimes. This can be achieved by conducting research on emerging global regimes in different types of global sectors, which can help improve the understanding of the development of global regimes and its characteristics over time. Research could work towards the quantification of the degree of institutionalisation of a global regime. Measuring the degree of institutionalisation provides information on the strength of the global regime, which enables the possibility to draft tailored policy aiming to facilitate a sustainability transition. Consequently, research on the governmental level of the sector could be beneficial. This research has focused on identifying the values to which actors subscribe to, which drive sectoral development. While this study underscores the lack of updated regulation and policies within the global rocket launching sector, further research could identify the specific global as well as regional regulatory infrastructure that is necessary to enable a sustainability transition.

6.3 Policy implications

The results of this study can function as a solid foundation to guide policy development in numerous ways. The identification of the dominant field logics within all four regions provides detailed insights into the guiding principles of their respective sectors. Possessing a comprehensive understanding of the values to which actors within a given sector adhere enables the opportunity to propose specific policy implications.

As underscored in this research, the rocket launching sector is currently underregulated, providing the possibility for new updated policy to be developed in order to support sustainable development of the sector. The results of this research highlight that actors in all sectors are not strongly subscribing to sustainability-related values, indicating that this is not one of the major drivers of sectoral development. Sustainability is represented in actors' interests, mainly within the European case, but are illustrated to lack strong unconditional support, being subject to change as a result of external pressure. On the other hand, State-Market values are dominant in all four rocket launching sectors, thereby strongly influencing sectoral development, with most actors adhering to values such as profit, commercial development and global leadership. All these values support a strong growth rationale, which supports an increase in rocket launching-related activities. Actors increasingly engage in rocket launching in order to support these values and strategies, such as profit maximisation or obtainment of global leadership in space. More frequent rocket launches increasingly impacts the environment due to an increase in emissions and ozone depletion. This remains the case even in instances where a high degree of reusability is integrated into the process of rocket launching. Therefore, implementing a higher degree of reusability does not translate to a higher degree of environmental sustainability as a result.

Moreover, the insights into the dynamics constituting the core regimes of each region within this study highlights the mechanisms that constitute the current regime which supports this growth rationale. For instance, the strong connection between the values of commercial development and profit within the USA support the strategy of increasing the frequency of launch-services to maximise profit and further develop the commercial sector. These connections provide policy makers with additional insights into the dynamics of the regimes, facilitating the constitution of policy that takes these interactions into account, or even utilises them.

Furthermore, the global rocket launching sector has evolved from a state-centric model to a market-oriented model, which has led to a focus on providing cost-effective launch services, through the commercialisation of the sector. As a result, the sector has become a highly competitive global environment in which actors are engaged in a race to offer the most affordable and efficient launch services. This high degree of competitiveness is driven by the pursuit of strong values such as commercial development and market growth, with the ultimate goal of establishing a dominant position in the global sector. Overall, the global sector has evolved into a highly competitive landscape where actors aim to provide the most cost-effective launch services on a global scale. This competitive landscape is characterised by the new space race between the United States and China, which consists of technological, economic, strategic and also strong geopolitical dimensions. On the other hand, global cooperation is less dominant among actors in the global sector. However, there are still global cooperation efforts ongoing, for instance the Space Debris Mitigation Guidelines of the United Nations for the joint mitigation of space debris management, to improve orbital sustainability. The competitive landscape as shaped by the dominant State Market field logic proves to support the growth rationale of the sector, which proposes challenges for a sustainability transition to occur due to increased environmental impact caused by the desire for sectoral growth. Embracing global cooperation can provide opportunities for a sustainability transition to occur, for instance through the implementation of shared standards and guidelines, such as the space debris mitigation guidelines, joint research and development and improve monitoring and enforcement upon each other.

Policies should refrain from supporting this increasing growth rationale, driven by the current dominant values within the sector, since the persuasion of these values and strategies increasingly impacts the environment. Therefore, policies should focus on minimising the environmental impact of rocket launches, by for instance aiming to facilitate the concept of degrowth within the sector, aiming to guide the sector towards only launching rockets that are deemed crucial for maintaining and increasing overall global sustainability and societal development. Moreover, policies should aim to decrease the competitive nature of the global rocket launching sector, since this competitive nature proposes challenges for a sustainability transition. Policy developers should therefore aim to facilitate increased global cooperation, as the sustainability challenges caused by rocket launching are global challenges and require a collective and organised response.

Additionally, this study highlights the fact that the global regime of the global rocket launching sector cannot be characterised as strong. This is advantageous for the possibility for a sustainability transition to occur, since weaker regimes are more subject to change, meaning that proper and timely implementation of policies guiding actors towards sustainable value orientations could significantly impact the global regime. If actors strongly adhere to sustainable values, these values become more impactful and could move to the core of the global regime. However, due to the strong trend towards state and market-related values and the highly competitive nature of the current global rocket launching sector, the implementation of policies supporting sustainability in a short period of time is not likely.

In order for a sustainability transition to occur strong fundamental regulatory changes are therefore necessary. Governments should facilitate an intended sustainability transition, which is in agreement with Markard et al. (2012), in order to overcome the strong state and market relate values, thereby centralising sustainability-related values among actors' interests. Such policies could include subsidies to encourage sustainable investments and strong environmental regulations on the maximum allowable environmental impact of rocket launch-related activities. The implementation of such policies refrains from the continuous growth rationale that is currently dominant in the global rocket launching sector and ensures the mitigation of the environmental impact of rocket launches, which contributes to the long-term sustainability of both Earth and outer space.

7 References

Belkovska, M. (2024, June 28). *Orbex Space: Sustainable Space Launches with Bio-Propane Innovation*. Net Zero Compare.

Boschma, R., Coenen, L., Frenken, K., & Truffer, B. (2017). Towards a theory of regional diversification: combining insights from Evolutionary Economic Geography and Transition Studies. *Regional Studies*, *51*(1), 31–45. https://doi.org/10.1080/00343404.2016.1258460

Brown, M. (2024, February 20). *SpaceX: Elon Musk breaks down the cost of reusable rockets*. Inverese.

Bruno, T. (2022). COVID Disrupted Everything—Even Rocket Launches. *Scientific American*.

Bryman, A. (2016). *Social Research Methods - Alan Bryman - Google Boeken*. 5th. https://books.google.nl/books?hl=nl&lr=&id=N2zQCgAAQBAJ&oi=fnd&pg=PP1&dq=Social+Research+Methods+bryman&ots=dqIuBWH2tf&sig=EQIPYrsNpK0mjeIQ8XvVWL4-6ok&redir_esc=y#v=onepage&q=Social%20Research%20Methods%20bryman&f=false

Castel, F. (2024, June 24). *Europe aims to end space access crisis with Ariane 6's inaugural launch*. SpaceNews.

Chakraborty, D., & Wattles, J. (2024, May 20). *Blue Origin launches six tourists to the edge of space after nearly two-year hiatus*. CNN.

Chang, K. (2012). First Private Craft Docks With Space Station. *The New York Times*.

CNSA. (2021). *China's Space Program: A 2021 Perspective*.

Confederation of Indian Industry, Antrix Corporation Limited, & Deloitte. (2010). *Antrix Corporation Limited*. www.deloitte.com/in

Dallas, J. A., Raval, S., Alvarez Gaitan, J. P., Saydam, S., & Dempster, A. G. (2020). The environmental impact of emissions from space launches: A comprehensive review. *Journal of Cleaner Production*, *255*, 120209. https://doi.org/10.1016/J.JCLEPRO.2020.120209

Dominguez Calabuig, G. J., Wilson, A., Bi, S., Vasile, M., Sippel, M., & Tajmar, M. (2024). Environmental life cycle assessment of reusable launch vehicle fleets: Large climate impact driven by rocket exhaust emissions. *Acta Astronautica*, *221*, 1–11. https://doi.org/10.1016/j.actaastro.2024.05.009

Dvorsky, G. (2023, September 8). *Beyond SpaceX: The Rising Stars of the U.S. Rocket Industry*. Gizmodo. https://gizmodo.com/beyond-spacex-the-rising-stars-of-the-u-s-rocket-indu-1850780443

Enel. (2023). *2023 Energy Trend: Stakeholder Pressure for Sustainability | Enel North America*. https://www.enelnorthamerica.com/insights/blogs/stakeholder-pressure-for-sustainability

ESA. (2012). *ESA SP-1327 Sustainable Development: 2011–12 Report*. The European Space Agency.

ESA. (2020). *ESA - The current state of space debris*. https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris

ESA. (2021a). *Corporate responsibility and sustainability report*.

ESA. (2021b, April). *China's Space Sector: Commercialisation with Chinese Characteristics*. https://space-economy.esa.int/article/102/chinas-space-sector-commercialisation-with-chinese-characteristics

ESA. (2024). *Key dates 1960-2024*. https://www.esa.int/About_Us/ESA_history/Key_dates_1960-2024

European Environment Agency. (2024, July 4). *Sustainability*. EEA. https://www.eea.europa.eu/en/topics/at-a-glance/sustainability#:~:text=The%20European%20Green%20Deal%20covers,person%20or%20place%20left%20behind.

Finger, M., Groenewegen, J., Ku¨nneke, R., & Ku¨nneke, K. (2005). The Quest for Coherence between Institutions and Technologies in Infrastructures. *Competition and Regulation in Network Industries*, *6*(4), 227–259. https://doi.org/10.1177/178359170500600402

Fossey, E., Harvey, C., McDermott, F., & Davidson, L. (2002). Understanding and Evaluating Qualitative Research∗. *Http://Dx.Doi.Org.Proxy.Library.Uu.Nl/10.1046/j.1440-1614.2002.01100.x*, *36*(6), 717–732. https://doi.org/10.1046/J.1440-1614.2002.01100.X

Foust, J. (2020, January 27). *Assessing China's commercial space industry*. https://www.thespacereview.com/article/3872/1

Fuenfschilling, L., & Binz, C. (2018). Global socio-technical regimes. *Research Policy*, *47*(4), 735–749. https://doi.org/10.1016/J.RESPOL.2018.02.003

Fuenfschilling, L., & Truffer, B. (2014). The structuration of socio-technical regimes—Conceptual foundations from institutional theory. *Research Policy*, *43*(4), 772–791. https://doi.org/10.1016/J.RESPOL.2013.10.010

Gallucci, M. (2023). *The first hydrogen-powered planes are taking flight | Canary Media*. https://www.canarymedia.com/articles/air-travel/the-first-hydrogen-powered-planes-are-taking-flight

Ganote, S., Burns, S., Finke, J., Van Hooren, K., Lord, K., Penn, A., & Wickham, T. (2024). *4 TRENDS THAT WILL MAKE 2024 A PIVOTAL YEAR FOR SPACE*. OliverWyman. https://www.oliverwyman.com/our-expertise/insights/2024/jan/four-trends-shaping-the-space-sector.html

Gebhardt, C. (2018, September 25). *Arianespace conducts its 300th mission with the 100th Ariane 5 launch*. NasaSpaceFlight.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/J.EIST.2011.02.002

Geels, F. W., & Kemp, R. (2007). Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society*, *29*(4), 441–455. https://doi.org/10.1016/J.TECHSOC.2007.08.009

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/J.RESPOL.2007.01.003

Goldstein, L. (2022, April 7). *The Environmental Impacts of the New Space Race*. The Georgetown Environmental Law Review.

Goyal, S. (2019, July 15). *ISRO's Space Programme: Timeline from 1960s to 2019*. https://www.jagranjosh.com/general-knowledge/isros-space-program-timeline-1562938305-1

Gunia, A. (2024). *'Cabs to get into space': How this Indian startup wants to revolutionize satellite space travel*. https://edition.cnn.com/2024/04/23/business/india-space-startups-skyroot-aerospace-hnk-intl/index.html

Heiberg, J., & Truffer, B. (2022). Overcoming the harmony fallacy: How values shape the course of innovation systems. *Environmental Innovation and Societal Transitions*, *42*, 411–428. https://doi.org/10.1016/J.EIST.2022.01.012

Heiberg, J., Truffer, B., & Binz, C. (2022). Assessing transitions through socio-technical configuration analysis – a methodological framework and a case study in the water sector. *Research Policy*, *51*(1), 104363. https://doi.org/10.1016/j.respol.2021.104363

Herridge, L. (2023). *The 2000s: Challenging Goals Reached - NASA*. NASA. https://www.nasa.gov/centers-and-facilities/kennedy/the-2000s-challenging-goals-reached/

Howell, E. (2024, May 1). *2 astronaut taxis: Why NASA wants both Boeing's Starliner and SpaceX's Dragon*. https://www.space.com/nasa-boeing-starliner-spacex-dragon-iss-astronaut-mission-redundancy

IEA. (2023). *Transport - Energy System - IEA*. https://www.iea.org/energy-system/transport

ISRO. (2023). *Opening Up Indian Space Sector For Private Sector –Reforms*. https://www.isro.gov.in/Reforms.html

Jehling, M., Hitzeroth, M., & Brueckner, M. (2019). Applying institutional theory to the analysis of energy transitions: From local agency to multi-scale configurations in Australia and Germany. *Energy Research & Social Science*, *53*, 110–120. https://doi.org/10.1016/J.ERSS.2019.01.018

Johnson, S. (2018, March 13). *What Are the Different Kinds of Rockets?* https://sciencing.com/different-kinds-rockets-8552176.html

Jones, A. (2024, April 19). *China to leverage growing commercial space sector to launch megaconstellations*. https://spacenews.com/china-to-leverage-growing-commercial-space-sector-to-launch-megaconstellations/

Kern, F., & Markard, J. (2016). Analysing Energy Transitions: Combining Insights from Transition Studies and International Political Economy. *The Palgrave Handbook of the International Political Economy of Energy*, 291–318. https://doi.org/10.1057/978-1-137-55631-8_12

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M. S., … Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental Innovation and Societal Transitions*, *31*, 1–32. https://doi.org/10.1016/J.EIST.2019.01.004

Lawhon, M., & Murphy, J. T. (2012). Socio-technical regimes and sustainability transitions: Insights from political ecology. *Progress in Human Geography*, *36*(3), 354–378. https://doi.org/10.1177/0309132511427960/ASSET/IMAGES/LARGE/10.1177_03091325114279 60-FIG1.JPEG

Lecky, W. (2016). *New Space and the role of public support*.

Lee, S. Y., & Kim, Y. H. (2015). Antecedents and consequences of firms' climate change management practices: Stakeholder and synergistic approach. *Sustainability (Switzerland)*, *7*(11), 14521–14536. https://doi.org/10.3390/SU71114521

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry - Yvonna S. Lincoln, Egon G. Guba* -. https://books.google.nl/books?hl=nl&lr=&id=2oA9aWlNeooC&oi=fnd&pg=PA7&dq=lincoln+and+guba+1985&ots=0vjwQdVdyl&sig=keao1srbfLvxWOjKqIuRhQeNkw4&redir_esc=y#v=onepage&q=lincoln%20and%20guba%201985&f=false

Liu, I., Linck, E., Lal, B., W. Crane, K., Han, X., & J. Colvin, T. (2019). Commercial Space Policies and Drivers in China. *Evaluation of China's Commercial Space Sector*.

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change. *Https://Doi.Org/10.1146/Annurev-Environ-102014-021340*, *42*, 599–626. https://doi.org/10.1146/ANNUREV-ENVIRON-102014-021340

Mansfield, S. (2024, April 15). *Private Sector Innovation and Its Impact on the Space Industry*. Space Daily.

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955–967. https://doi.org/10.1016/J.RESPOL.2012.02.013

McKinsey. (2023, January 19). *A giant leap for the space industry*. https://www.mckinsey.com/featured-insights/sustainable-inclusive-growth/chart-of-the-day/a-giant-leap-for-the-space-industry

Mui, C. (2024). Europe debuts a new rocket. *Politico* .

NASA. (n.d.). *News & Events*. Retrieved May 30, 2024, from https://www.nasa.gov/budgets-plans-and-reports/

NASA. (2021). *NASA Updates Pricing Policy to Full Value for Commercial Activities on Space Station*. https://www.nasa.gov/humans-in-space/nasa-updates-pricing-policy-to-full-value-for-commercial-activities-on-space-station/

NASA. (2023, November 21). *Guide to Rockets*. https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/guide-to-rockets/

NASA. (2024). *NASA's Commercial Partners Deliver Cargo, Crew for Station Science*. https://www.nasa.gov/missions/station/iss-research/nasas-commercial-partners-deliver-cargo-crew-for-station-science/

Navaan, S., & Pranith, A. (2023). Basics and Types of Rocket Propulsion: A Review. *International Research Journal of Education and Technology* .

Nicoli, F., Sekut, K., & Porcaro, G. (2023, July 5). *Can Europe make its space launch industry competitive?* https://www.bruegel.org/analysis/can-europe-make-its-space-launch-industry-competitive

Office of Energy Efficiency & Renewable Energy. (n.d.). *Sustainable Transportation and Fuels | Department of Energy*. Retrieved November 28, 2023, from https://www.energy.gov/eere/sustainable-transportation-and-fuels

Ostrom, E. (2010). Beyond Markets and States: Polycentric Governance of Complex Economic Systems. *American Economic Review*, *100*(3), 641–672.

Patel, N. (2021, January 21). *China's surging private space industry is out to challenge the US*. MIT Technology Review .

Piesing, M. (2022). *The pollution caused by rocket launches - BBC Future*. https://www.bbc.com/future/article/20220713-how-to-make-rocket-launches-less-polluting

Polaris. (2024). *Space Tourism Market Share, Size, Trends, Industry Analysis Report*.

Ross, M., Toohey, D., Peinemann, M., & Ross, P. (2009). Limits on the Space Launch Market Related to Stratospheric Ozone Depletion. *Astropolitics*, *7*(1), 50–82. https://doi.org/10.1080/14777620902768867

Ryan, R. G., Marais, E. A., Balhatchet, C. J., & Eastham, S. D. (2022). Impact of Rocket Launch and Space Debris Air Pollutant Emissions on Stratospheric Ozone and Global Climate. *Earth's Future*, *10*(6), e2021EF002612. https://doi.org/10.1029/2021EF002612

Schiller, P. L., & Kenworthy, J. R. (2017). An introduction to sustainable transportation: Policy, planning and implementation: Second edition. *An Introduction to Sustainable Transportation: Policy, Planning and Implementation: Second Edition*, 1–420. https://doi.org/10.4324/9781315644486

Singh, N. (2024, May 1). *SpaceX unveils cosmic tourism: Here's how to book your ticket to space*. Business Standard.

Sirieys, E., Gentgen, C., Jain, A., Milton, J., De Weck, O. L., Stevens, C. A., & Benning, F. M. C. (2022). *Space sustainability isn't just about space debris: On the atmospheric impact of space launches*. https://doi.org/10.38105/spr.whfig18hta

Space Generation Advisory Council. (2023). *Environmental Impacts of Rocket Fuel*. https://doi.org/10.1016/j.jclepro.2020.120209

SpaceX. (n.d.-a). *Falcon 9 First Orbital Class Rocket Capable of Reflight*.

SpaceX. (n.d.-b). *Missions*. Retrieved May 30, 2024, from https://www.spacex.com/mission/

The Space Foundation. (2023). *Space Foundation Releases The Space Report 2023 Q2, Showing Annual Growth of Global Space Economy to $546B*. https://www.spacefoundation.org/2023/07/25/the-space-report-2023-q2/

Thornton, P. H., & Ocasio, W. (2008). *Institutional Logics*.

Thornton, P. H., Ocasio, W., Fligstein, N., Friedland, R., Haveman, H., Land, K., Luchow, L., Palmer, D., Scott, D., Smith, J., Thornton, J., Tiryakian, E., Tuma, N., Wilson, J., & Thornton, P. (1999). Institutional logics and the historical contingency of power in organizations: Executive succession in the higher education publishing industry, 1958-1990. *American Journal of Sociology*, *105*(3), 801–843. https://doi.org/10.1086/210361

Thornton, P. H., Ocasio, W., & Lounsbury, M. (2012). *The Institutional Logics Perspective: A New Approach to Culture, Structure ... - Patricia H. Thornton, William Ocasio, Michael Lounsbury - Google Boeken*. https://books.google.co.uk/books?hl=nl&lr=&id=0eeMBAAAQBAJ&oi=fnd&pg=PP1&dq=institutional+logics&ots=cSsN3Jf7k-

&sig=r676UP6LUTxsJfX_b9DeHJze4y0&redir_esc=y#v=onepage&q=institutional%20logics&f=false

Tolbert, P. S., & Zucker, L. G. (1996). The Institutionalization of Institutional Theory. *Cornell University ILR School*. https://digitalcommons.ilr.cornell.edu/articles/423

Twiss, S. (2022, April 7). *The Environmental Impacts of the New Space Race | Georgetown Environmental Law Review | Georgetown Law*. https://www.law.georgetown.edu/environmental-law-review/blog/the-environmental-impacts-of-the-new-space-race/#_ftn14

ULA. (n.d.). *ROCKET SCIENCE*. Retrieved July 25, 2024, from https://www.ulalaunch.com/explore/rocket-science

United Nations Office for Outer Space Affairs. (n.d.). *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*.

Wainscott-Sargent, A. (2019). *The Coming of Space Tourism*. Via Satellite.

Wall, M. (2011, July 8). *Shuttle Retirement Is Not the End of Human Spaceflight, NASA Chief Says*. https://www.space.com/12215-nasa-bolden-human-spaceflight-future.html

Witze, A. (2023). 2022 was a record year for space launches. *Nature*, *613*(7944), 426. https://doi.org/10.1038/D41586-023-00048-7

Wohrer, P. (2024). *Geopolitics of Technology Program 2024: A Pivotal Year for the Space Sector? Key Takeaways*. www.senat.fr.

Yap, X.-S., & Truffer, B. (2022). Contouring 'earth-space sustainability.' *Environmental Innovation and Societal Transitions*, *44*, 185–193. https://doi.org/10.1016/j.eist.2022.06.004

Yuhas, A. (2017, March 31). *SpaceX becomes first to re-fly used rocket*.

8 Appendices

Appendix A: Coding scheme for rocket launching sector logics

Logic		Times coded	Description
Top level	*Sub-code*		
Logic – community			
Community building		15	Engaging in rocket launching activities to build a community regarding operations and missions.
	Inspire Youth	5	Trying to build a community by inspiring youth for rocket launching activities.
Societal development		34	Engaging in rocket launching activities to drive positive change and improve the well-being of society.
	Address societal challenges	16	When mentioning the goal of improving the quality of life by addressing solutions for challenging societal challenges.
	Improve quality of life	5	Pursuing the goal of improving vital components that influence the quality of life of humans.
Logic – Market			
Market dynamics		211	All processes than impact the status of the region's rocket launching market in terms of dynamics between actors and goals of actors.
Commercial development		128	Growth and expansion of businesses and activities related to rocket launching for commercial purposes, reacting to the increasing demand for access to space.
	Commercial collaboration	13	Collaboration between two or more parties aiming to further push the commercial development of the rocket launching market.
	Private investments	27	Financial investments by individuals for supporting the commercial development of the rocket launching market.
	Commercial LEO expansion	16	Pushing the development of the rocket launching market with the goal of achieving the commercialisation of the LEO.
Market competition		39	Engagement in competitive relationships between two or more actors, aiming to push the commercialisation of the market through competition.

	Market growth		11	Aiming to frow the demand for rocket launching services, aiming to ultimately fulfil this demand.
Profit			105	Rocket launching related activities aiming to gain financial profit of these activities.
	Resource mining		14	The process of mining space recourses in order to profit of these resources.
	Space tourism		29	Engaging in rocket launching activities by providing space tourism services in order to obtain financial profit.
	Reusability for profit		20	Aiming to increase profit by applying the concept of reusability of rocket compartments.
	State contracts		5	Pursuing contracts issued by the state for ensuring financial inflow and gaining profit.
Public-private partnerships			69	The formation of partnerships between a government and a private enterprise as joined forces for achieving market growth.
Logic – Corporation				
	Cost-effectiveness		88	When mentioning the strategical focus on improving the cost-effectiveness of processes.
		Cost minimization	52	Focussing on minimizing costs of various processes for optimizing company circumstances.
	Risk management		8	Managing potential risky circumstances for maintaining the position of a firm.
	Affordability		24	Focussing on improving the affordability of space access.
Logic – State				
Autonomy in space			61	Focussing on achieving self-reliance and sovereignty in space.
International cooperation			75	Engaging in international collaboration with the goal of bettering or maintaining the country its position.
National economic gains			72	Aiming to boost or improve the country its economy through rocket launching activities.
	Space economy for national development		20	Investing in the national space economy for the development of the nation.
	Jobs and commerce		22	Engaging in rocket launching activities for generating jobs and commerce on a national level.
Global leadership			189	Actively pursuing the goal of becoming or maintaining leadership of outer space for national interest.
	Technological leadership		13	Pursuing the goal of technologically being ahead of other nations.

	Global competition	40	The act of a nation engaging in competition with other nations with the goal of establishing itself as a superior global leader.
	Military supremacy	9	Utilizing space for obtaining military supremacy over other nations.
	Geopolitical motivations	16	Geopolitical motivations for obtaining global leadership in the global sector.
	Regulation for leadership	72	When discussing regulation for influencing the development of the national or international space sector.
National security		31	Rocket launching activities used for ensuring the safety of people and resources of a nation.
Strong developed national plans		99	Actively pursuing the goal of becoming a strongly developed nation in the space sector.
	Policy for commercial development	34	Discussing the implementation of policy that supports and pushes the development of the commercial space sector of a nation/region.
	Modernize legislation and regulation	8	Modernizing legislation and regulation to influence the development of the national space sector.
	State guidance on commercial development	73	Active guidance of the state on pushing the commercial development for achieving the region's long-term goals.
Logic - Profession			
Science and Innovation		144	Actively engaging in science and innovation for improving and developing rocket launching.
	Space Capabilities	15	Innovation for developing new or better space capabilities.
	Technological development	23	Innovation for developing better technology.
	Resource mining for science	15	Mining space resources for gathering new scientific insights.
Skilled workforce		25	Engaging in the active mobilization of skilled individuals for developing rocket launching activities.
Logic – Sustainability			
Multi-planetary life		38	Rocket launching for establishing human life on multiple planets, such as Mars or the Moon.
	Sustainable human presence on the moon and mars	26	Working towards launching rockets to the moon and mars with the goal of achieving and sustaining human presence.
Environmental impact management		72	Making efforts towards the minimisation of environmental impacts, such as pollution decrease and space debris mitigation.

	Space debris mitigation	22	Focussing on mitigating the amount of space debris as a result of rocket launching activities for ensuring the longevity of space.
	Climate change observations	25	Rocket launching for monitoring climate change phenomena.
	Long-term sustainability of outer space	15	Focusing on utilizing space in a sustainable way for ensuring longevity of outer space for future generations.
Sustainable development		74	Focusing on developing the rocket launching sector in a sustainable way, focusing on the environmental impact of rocket launching.
	Environmental stewardship	11	Actively managing improving and taking into account the environmental impact of rocket launch related activities.
	Reusability	9	Engaging in reusable rocket launching for improving the environmental sustainability of launch activities.
	Cooperation for sustainable development	7	Engaging with other actors in order to improve the sustainable dimensions of sectoral development.

Appendix B: Coding scheme for life-cycle stages

Life-cycle stage		Times coded	Description
Top level	*Sub-code*		
Design phase			
Design for Cost-efficiency		48	Aiming to maximise the cost-efficiency of the cost of rocket launching.
	Reusability for cost reduction	21	Incorporating a high degree of reusability in the design of rockets in order to bring down the cost.
Design for leadership		5	Designing rockets that can enable dominance and leadership in space.
Design for Sustainability		7	Rocket designs that focus on mitigating environmental impact through integration of sustainable concepts.
	Design for debris mitigation	3	Rocket designs aimed to minimise the creation of space debris caused by rockets.
Design for profit maximisation		19	Rocket design that aims to facilitate the potential to increase and maximise profit generation though a single rocket launch.
	Reusability for profit	13	Incorporating a high degree of reusability as a means to increase profit.
Manufacturing stage			
Self-reliant manufacturing		6	Expressing being self-reliant in the manufacturing of rockets as an important value that actors adhere to.

Cost-reduction in manufacturing	47	Focusing on reducing the cost of the manufacturing processes of launch vehicles.
3D printing for cost reduction	16	Using 3D printing to reduce the manufacturing costs of launch vehicles.
Cooperation for cost reduction	6	Cooperation of different actors, utilising each actors' strengths to bring down the manufacturing costs of launch vehicles.
Profit maximisation	11	Aiming to maximise profit through increased efficiency of manufacturing processes.
In-space manufacturing	5	Manufacturing launch vehicle components in space in order to reduce costs of deep space exploration missions.
Propellant production phase		
Efficient propellant production	5	Focussing on increasing the efficiency of propellant in terms of distance travelled per quantity of propellant.
In space propellant production	12	Producing propellant to bring down the cost of propellant production and to enable deeper space missions.
Sustainable propellant production	23	Aiming to produce propellant that is more environmentally sustainable, which produces less greenhouse gasses wen burned.
Launch phase		
Launching for national security	5	Launching rockets to enhance national security, for instance for increased GPS tracking by satellites.
Launching for science	18	Launching rockets in order to enable scientific missions in space.
Launching for commercial development	8	Launching rockets into orbit to enhance the commercialisation of the sector.
Launching for profit	13	Offering rocket launch services to customers to deliver payloads into orbit aiming to achieve financial profit.
Launching for cost reduction	17	Increasing launch frequency in order to bring down the cost associated with a single rocket launch.
Re-entry phase		
Re-entry for reusability (Cost-efficiency)	13	Re-entry of launch vehicle compartments in order to reuse them for future rocket launches to bring down the costs of rockets.

Appendix C: Comprehensive results of the triangulation process

Report type	**Triangulation insights**
USA	
Space Florida annual report (2016, 2023)	The General findings are in line with the results of the qualitative content analysis. The reports emphasize the importance of *Commercial Development,* as shown in the persuasion of *Space Tourism, Profit*, *Innovation* and *Global Leadership* as driving

	value orientations for the development of the American rocket launching sector. This supports the dominant **State Market Field Logic**. For instance, the importance of *Commercial Development* is clearly portrayed in the following statement: *"Over the last year, Florida's aerospace industry has grown at a record pace, continuing the transition from solely a government-led sector to a dynamic commercial market."* In addition, the reports focus on national security as an important driver of the rocket launching industry, as the following example illustrates: *"The decision by the U.S. Air Force reflects the strategic importance of Florida's historic position in advancing national security and defense in space, which reaffirms this critical role in advancing the nation's space and military capabilities."* The actors mentioned in the reports also mention a commitment to *Sustainable Development* by "*supporting the development and deployment of clean hydrogen and related technologies for aerospace and space industry launch applications."*
NASA sustainability report (2012, 2017)	NASA's 2012 and 2017 Sustainability Reports indicate value orientations that focus on sustainability, as illustrated in the following examples: *"To help transform Kennedy Space Center (KSC) into America's premier 21st century sustainable spaceport, sustainability concepts and philosophy are inherent in our mission and goals, as outlined in the 2012 Kennedy Space Center Sustainability Plan. Our objective is to "promote, maintain, and pioneer green practices in all aspects of our mission, striving to be an Agency leader in everything we do."* And *"Sustainability is becoming embedded into our culture and mission."* These examples highlight sustainability as a core value driving the development of the sector. This provides additional insights, as this is not clearly presented in the analysis of news articles. This approach does not contradict the dominance of the **State Market Field Logic** but adds an additional focus on sustainability as an integrated complementary value to value orientations such as *Commercial Development* or *Global Leadership.*
NASA Space sustainability strategy (2024)	This report emphasises the need to maintain the ability to conduct space activities in a safe, peaceful and responsible manner that does not harm the space environment for future activities. NASA is implementing a strategy that aims to *"to focus on advancements the Agency can make that address the mounting space sustainability challenges posed by the rapidly changing space environment and that are aligned with NASA's mission as a science and technology organization".* This strategy again highlights the centralization of sustainability as a core value. In this sustainability strategy NASA focuses on Earth's orbit and neglects a holistic earth-space system approach. Sustainability as a core value driving strategy does not contradict the current dominance of the **State Market Field Logic.** Moreover, the triangulation suggests the value orientations *Innovation* and *Sustainable Development* being complementary important drivers of the sector.
China	

CNSA space program (2006, 2011, 2016 & 2021)	The CNSA reports clearly show development over time. In the older reports, coming from 2006 and 2011, the CNSA is mainly driven by State-related values, such as *Global Leadership* and *National Economic Gains.* This is because China wants to be an independent player in space, and it wants to achieve this by focussing on national comprehensive strength. *"China will center its work on its national strategic goals and strengthen its independent innovative capabilities."* The more recent reports, 2016 and especially 2021, show a transition from State-related values to market-related values, such as *Commercial Development* and *Market Dynamics*. The CNSA is actively pursuing this transition and guiding the rocket launching industry towards controlled commercialisation, as shown in the following example: *"The Chinese government has been proactive in developing the space industry, through policy measures and well-thought-out plans for space activities. Better alignment between a well-functioning market and an enabling government gives full play to the roles of both, endeavouring to create a favourable environment for the growth of a high-quality space industry."* The content of these reports supports the findings of the analysis, showing a transition from a **State Field Logic** towards a **State Market Field Logic**. The reports show some commitment to sustainability, but the CNSA does not provide detailed statements or explanations on the role sustainability plays for the Chinese rocket launching sector. This means that sustainability is not one of the core driving values of the Chinese rocket launching sector.
CASC social responsibility statement (n.d.)	This social responsibility statement is limited in terms of in-depth analysis and presentation of detailed goals for their further development. Even though an active attitude is held concerning topics such as peaceful development and environment protection, these statements lack considerate substantiation and evidence on current achievements. State-related value orientations are clearly attached to these social responsibility statements, as shown in the following example: *"Focus on the peaceful use of outer space, while also defend national interests, and enhance comprehensive national power."* There is a clear connection here with value orientations such as *National Security* and *Strong Developed Nation*. Additionally, the following example shows the lack of detailed input concerning their environmental statements: *"CASC actively undertakes its social responsibility. The company research, develops and promotes new resources, new materials, and energy-saving technology and products, bringing the advantages of aerospace technology into full play."* These types of statements are re-occurring and lack detailed explanations or reasoning. The results of the triangulation align with the results of the news articles analysis, resulting in a **State Market Field Logic** with weak adherence of actors towards sustainability-related values.

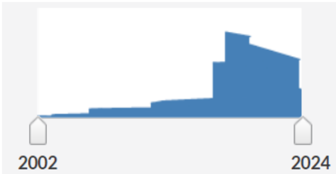
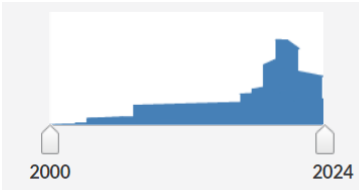
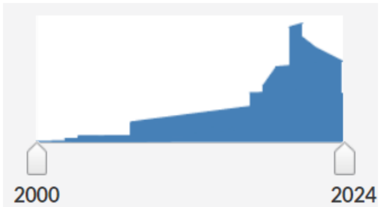
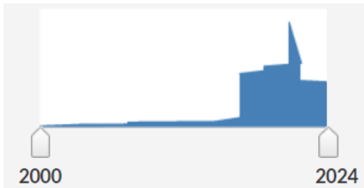
India	
ISRO annual report (2021-2022, 2022-2023)	The general findings of the triangulation are consistent with the results of the analysis of the news articles. Value orientations such as *National economic gains* and *Commercial Development* are dominant among the actors of the Indian rocket launching sector. *"Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country."* Furthermore, the value orientations *State Guidance For Commercial Development* and becoming a *Strong Developed Nation* are also dominant value orientations among actors. *"IN-space will permit and oversee the activities of private enterprises and start-ups. It regulates space activities, including the building of launch vehicles and satellites and providing space-based services as per the definition of space activities."* The reports show more commitment to sustainability than the news articles by actively engaging in space debris mitigation through the NETRA project as well as in earth observation. However, these value orientations are far from being dominant, which results in a **State Market Field Logic.**
Indian Space Situational Assessment Report (2024)	The ISRO takes an active attitude towards value orientations that have not been shown to be significant during the analysis of news articles. These value orientations consist of *International Cooperation* and *Long-term sustainability of outer space*. The ISRO recognizes the necessity of mitigating the amount of space debris for ensuring the safety of vulnerable space assets, as explained in the following example: *ISRO's SSA activities include close approach assessment of satellites and launch vehicles, prediction of atmospheric re-entry, the study of the evolution of space object population to safeguard national space assets, and also promoting responsible behaviour while conducting operations in outer space.* The ISRO believes in engaging in international cooperation for ensuring the LTS of outer space. This strong lean towards international cooperation is not strongly shown in the news articles but is relevant for the further analysis of the Indian rocket launching market. The strong notion towards international cooperation is portrayed in the following example: *"ISRO is an active participant in many international fora such as the Inter-Agency Debris Coordination Committee (IADC) with 13 space agencies, the International Academy of Astronautics (IAA) space debris working group, International Astronautical Federation (IAF) space traffic management working group, International Organization for Standardization (ISO) space debris working group and UN-COPUOS scientific & technical sub-committee/ legal sub-committee, for discussing space debris issues, related studies and the long-term sustainability of outer space activities."*

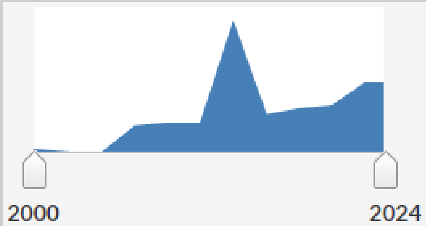
	However, it should be noted that this approach does not address sustainability in terms of the minimization of environmental impacts, but in terms of ensuring investments and technologies that have been sent into space. Nonetheless, this does not conflict the dominant **State Market Field Logic**, but the value orientations of Long-term Sustainability of outer space should be taken into consideration during the further analysis of the Indian rocket launching market.
EU	
ESA Corporate responsibility and sustainability report (2015-2016 & 2020-2021)	Both ESA reports show a strong sustainability determination, proposing sustainability as a dominant value driving the development of the EU rocket launching sector. ESA proposes values such as Environmental Management as core values, being embedded within the whole organisation, as clearly portrayed here: "*Leading the integration of environmental considerations within the space sector is one of ESA's main objectives in terms of environmental responsibility. Reducing ESA's environmental impacts on Earth and in space and anticipating environmental requirements are two essential elements of the Agency's environmental sustainability policy*." This strong sustainability engagement is supported by their actions, as shown in their active persuasion of being a sustainability frontrunner as show in initiatives such as Clean space, which has: *"Enabled ESA to become a global pioneer and leader in the sustainable use of space, in particular by adopting a system level approach that addresses the entire lifecycle of the Agency's various space projects".* Additionally, both reports show a stronger connection between ESA and the value orientation *Societal development*, focusing more on the development of society than the results of the news articles analysis show: "*Thus, the Agency will ensure that it increases even further the contribution of space programmes to the sustainable development of society and that investments in space continue to deliver benefits to the citizens of Europe and the world."* Conclusively, ESA maps sustainability commitments best among the four regions, focusing on a holistic approach by integrating LCA, metric and clear goals and visions. Hence, values such as *Sustainable Development* and *Environmental Management* are developing to be one of the most dominant value propositions that are driving the development of the EU rocket launching sector.
ESA Annual report (2022)	The report presents regaining autonomy in space as one of the main objectives of the European rocket launching sector, which became also apparent during the analysis of the news articles. Being able to independently launch rockets into orbit is something that Europe currently lacks, but aims to regain as soon as possible: *"The independent capability to fly Europe's institutional missions is critical to Europe's autonomy and resilience as a space power."* This need for autonomy was strengthened as a result of the war between Ukraine and Russia, highlighting the influence of geopolitical conflicts on the availability of rockets.

	As a result of the need for autonomy and the increased global competition that Europe has faced the last decade, ESA has increased their budget to once again boost their space economy, adhering to value orientations such as *Market Dynamics* as well as *National Economic Gains*: "*The overall outcome of CM22 in Paris was a decision to increase ESA's budget by a record 17%. This funding will help boost space in Europe, kicking off a new era of ambition, while enabling ESA to continue to invest in industries that create jobs and prosperity in Europe."* Furthermore, ESA is actively working on the commercialisation of the European rocket launching sector, aiming for an additional boost to the European space economy: *It was very apparent from the outcome of CM22 that ESA Member States have endorsed and embraced the commercialisation priority set out in Agenda 2025, by deciding to proceed with more than €1.3bn of programmes with a commercialisation focus. The ScaleUp programme, which will provide a coherent framework and catalyst for ESA's commercialisation offer, was oversubscribed by 18% with €118m.* Finally, the annual report highlights ESA's approach concerning sustainability, integrating sustainability in the organisation's operations, resulting in *Sustainable Development* being a key driving value.
Arianespace CSR report (2014-2015 & 2022)	Arianespace their sustainability commitments are in line with ESA their policies. Most notably, Guiana Space Center received ISO 14001 and ISO 50001 certifications for their approach on minimization of environmental impact for their environmental and energy management systems. One of the stronger values driving the sustainability commitments of Arianespace is *Societal Development* by boosting local economies and providing job opportunities and wealth to French Guiana: *"Arianespace's activities at the CSG launch base in French Guiana generate some 1,700 jobs at nearly 40 different firms. In turn, these direct jobs help create five times as many «indirect» jobs in the local economy."* ESA focusses on sustainability throughout different stage of their rocket launchers. Sustainability is being integrated in different stages of the life cyle of their rockets: *Preliminary work on eco-design has been carried out by ArianeGroup in partnership with ESA and CNES as part of the discussions on Ariane Next. Two directions are currently being explored: launcher reuse and the use of propellants that have less impact on the environment.* Overall, sustainability van be seen as a driving value for the actor Arianespace. Commitments are in line with ESA, however the specificity of their commitments is weak, with statements like: "*The improvement process is ongoing and new energy reduction goals have been set."* Hence, the triangulation results do not contradict the results of the analysis of the news articles.

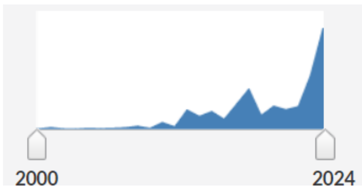
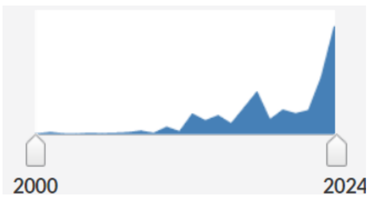
Appendix C: Search strings for the China, India and Europe cases

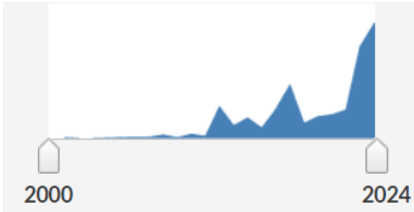
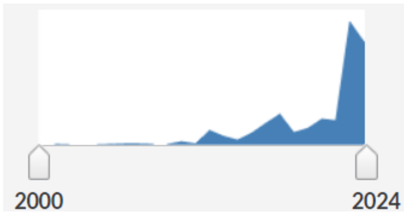
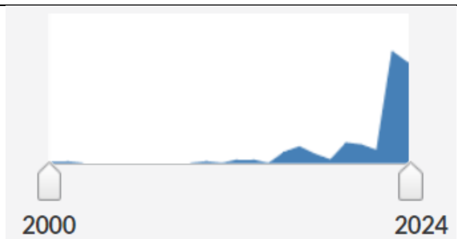
China search string

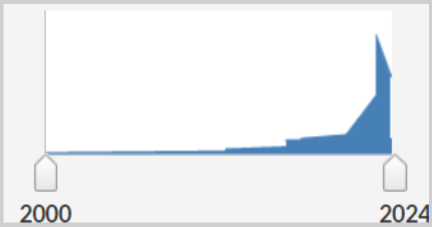
Number of searches	Search string	results	Time development	Suitability
1	(Rocket) AND (Space) AND (China) OR (Chinese) AND (China Aerospace Science and Industry Corporation) OR (CASIC)	1079		X
2	(Rocket) AND (Space) AND (China) OR (Chinese) AND (China Aerospace Science and Industry Corporation) OR (CASIC) OR (China National Space Administration) OR (CNSA)	4046		X
3	atl2(Rocket) AND atl2(Space) AND (China) OR (Chinese) AND (China Aerospace Science and Industry Corporation) OR (CASIC) OR (China National Space Administration) OR (CNSA)	2150		X
4	atl2(Rocket) AND atl2(Space) AND atl2(China) OR atl2(Chinese) AND atl2(China Aerospace Science and Industry Corporation) OR atl2(CASIC) OR atl2(China National Space Administration) OR atl2(CNSA)	640		X
5	atl4(Rocket) AND atl4(Space) AND atl2(China) OR atl2(Chinese) AND atl2(China Aerospace Science and Industry Corporation) OR atl2(CASIC) OR atl2(China National Space Administration) OR atl2(CNSA)	221		
6	atl2(Rocket) AND atl2(Space) AND atl2(China) OR atl2(Chinese) AND (I-space) OR (Expace) OR (Orienspace) OR (Galactic Energy) OR (Space Pioneer) AND (China Aerospace Science and Industry Corporation) OR	124		X

	(CASIC) OR (China National Space Administration) OR (CNSA)			
7	atl2(Rocket) AND atl2(Space) AND atl2(China) OR atl2(Chinese) AND (I-space) OR (Expace) OR (Landspace) OR (CAS space)OR (Orienspace) OR (Galactic Energy) OR (Space Pioneer) AND (China Aerospace Science and Industry Corporation) OR (CASIC) OR (China National Space Administration) OR (CNSA)	179		X
8	atl8(Rocket) AND atl8(Space) AND atl7(China) OR atl7(Chinese) AND atl3(I-space) OR atl3(Expace) OR atl3(Landspace) OR atl3(CAS space)OR atl3(Orienspace) OR atl3(Galactic Energy) OR atl3(Space Pioneer) OR atl3(China Aerospace Science and Industry Corporation) OR atl3(CASC) OR atl3(China National Space Administration) OR atl3(CNSA)	100		✓

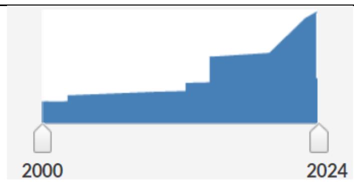
India search string

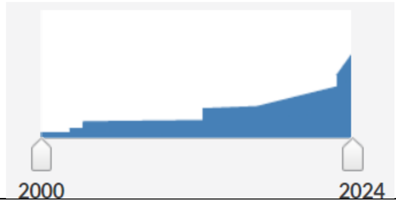
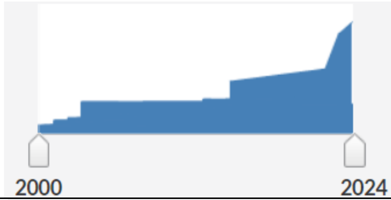
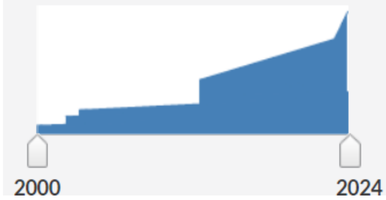
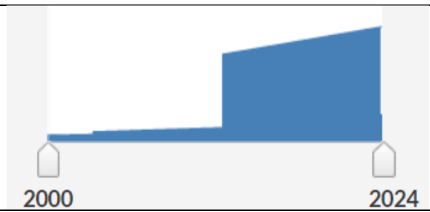
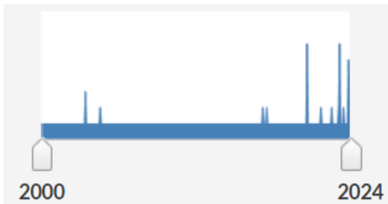
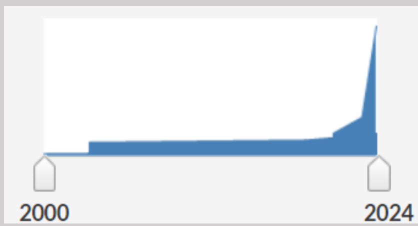
Number of search	Search string	results	Time development	Suitability
1	atl4(Rocket) AND atl4(Space) AND atl4(India) OR atl4(Indian) AND atl4(ISRO) OR atl4(Indian Space Research Organisation)	2059		X
2	atl4(Rocket) AND atl4(Space) AND atl4(India) OR atl4(Indian) AND atl4(ISRO) OR atl4(Indian Space Research Organisation) OR atl2(Indian Space Association) OR atl2(ISpA)	2083		X

3	atl6(Rocket) AND atl6(Space) AND atl4(India) OR atl4(Indian) AND atl4(ISRO) OR atl4(Indian Space Research Organisation) OR atl2(Indian Space Association) OR atl2(ISpA)	1045		X
4	atl6(Rocket) AND atl6(Space) AND atl4(India) OR atl4(Indian) AND atl4(ISRO) OR atl4(Indian Space Research Organisation) OR atl2(Indian Space Association) OR atl2(ISpA) OR atl3(Hindustan Aeronautics Limited) OR atl3(Ananth Technologies) OR atl3(Godrej Aerospace)	1047		X
5	atl6(Rocket) AND atl6(Space) AND atl4(India) OR atl4(Indian) AND atl8(ISRO) OR atl8(Indian Space Research Organisation) OR atl2(Indian Space Association) OR atl2(ISpA) OR atl2(Hindustan Aeronautics Limited) OR atl2(Ananth Technologies) OR atl2(Godrej Aerospace) OR atl2(Larsen & Oubro) OR atl2(Larsen and Oubro) OR atl2(NewSpace India) OR atl2(Skyroot) OR atl2(Bellatrix Aerospace) OR atl2(AgniKul Cosmos) OR atl2(Dhruva) OR atl2(Pixxel)	758		X
6	atl8(Rocket) AND atl8(Space) AND atl8(India) OR atl8(Indian) AND atl4(Indian Space Association) OR atl4(ISpA) OR atl3(Hindustan Aeronautics Limited) OR atl3(Ananth Technologies) OR atl3(Godrej Aerospace) OR atl3(Larsen & Oubro) OR atl3(Larsen and Oubro) OR atl3(NewSpace India) OR atl3(Skyroot) OR atl3(Bellatrix Aerospace) OR atl3(AgniKul Cosmos) OR atl3(Dhruva) OR atl3(Pixxel) OR atl12(ISRO) OR atl12(Indian Space Research Organisation)	112		X

7	atl8(Rocket) AND atl8(Space) AND atl8(India) OR atl8(Indian) AND atl4(Indian Space Association) OR atl4(ISpA) OR atl3(Hindustan Aeronautics Limited) OR atl3(Ananth Technologies) OR atl3(Godrej Aerospace) OR atl3(Larsen & Oubro) OR atl3(Larsen and Oubro) OR atl3(NewSpace India) OR atl3(Skyroot) OR atl3(Bellatrix Aerospace) OR atl3(AgniKul Cosmos) OR atl3(Dhruva) OR atl3(Pixxel) OR atl15(ISRO) OR atl15(Indian Space Research Organisation)	98		X
8	atl7(Rocket) AND atl7(Space) AND atl7(India) OR atl7(Indian) AND atl5(Indian Space Association) OR atl5(ISpA) OR atl5(Hindustan Aeronautics Limited) OR atl5(Ananth Technologies) OR atl5(Godrej Aerospace) OR atl5(Larsen & Oubro) OR atl5(Larsen and Oubro) OR atl5(NewSpace India) OR atl5(Skyroot) OR atl5(Bellatrix Aerospace) OR atl5(AgniKul Cosmos) OR atl5(Dhruva) OR atl5(Pixxel) OR atl15(ISRO) OR atl15(Indian Space Research Organisation)	107		✓

Europe search string

Number of searches	Search string	results	Time development	Suitability
1	(Rocket launching) AND (space) AND (Europe) OR (EU) OR (European Union) AND (ESA) OR (Ariane)	1773		X

2	atl2(Rocket) AND atl2(Space) AND atl2(Europe) OR atl2(EU) OR atl2(European Union) AND atl2(ESA) OR atl2(Ariane)	3202		X
3	(Rocket) AND (space) AND (Europe) OR (EU) OR (European Union) AND (ESA) AND (Ariane)	3093		X
4	atl4(Rocket) AND atl4(space) AND atl2(Europe) OR atl2(EU) OR atl2(European Union) AND (ESA) OR (Ariane)	1736		X
5	atl4(Rocket) AND atl4(space) AND atl4(Europe) OR atl4(EU) OR atl4(European Union) AND atl4(ESA) OR atl4(Ariane)	484		X
6	atl6(Rocket) AND atl6(space) AND atl6(Europe) OR atl6(EU) OR atl6(European Union) AND AND atl4(ESA) OR atl4(Ariane) OR atl4(Arianespace) OR atl4(Avio) OR atl4(Skyrora)	236		X
7	atl6(Rocket) AND atl6(space) AND atl6(Europe) OR atl6(EU) OR atl6(European Union) AND AND atl4(ESA) OR atl4(Ariane) OR atl4(Arianespace) OR atl4(Avio) OR atl4(Skyrora) BUT NOT (Armaments)	83		X
8	atl5(Rocket) AND atl5(space) AND atl5(Europe) OR atl5(EU) OR atl5(European Union) AND atl10(ESA) OR atl10(Ariane) OR atl10(Arianespace) OR atl3(Avio) OR atl3(PLD space) OR atl3(HyImpulse Technologies) OR atl3(Rocket Factory Augsburg) OR atl3(Orbex) OR atl3(Latitude) OR atl3(Skyrora) OR atl3(Isar) AND NOT (armaments)	101		✓