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**INFLUENCING THE DYNAMICS OF AN
INTERNATIONAL SPACE RESOURCE
UTILIZATION REGIME**

A CASE STUDY OF LUXEMBOURG

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When mankind moves out from the earth into space, we carry our problems with us.

Freeman Dyson, "The Greening of the Galaxy" (1979)

Abstract

The legal status of outer space resources and how they can be appropriated and utilized is a subject of current international debate. Status details have always been nebulous, with UN treaties from nearly 50 years ago providing the only recognized clarification. This body of international law, as overseen by the United Nations Office for Outer Space Affairs, can be viewed as the regime controlling the utilization of space resources, and up to this point was considered sufficient to maintain order in this area. However, due primarily to the rapid advance of relevant space resource exploration and exploitation technologies as well as the increasing push of the private sector, there are noticeable frictions and conflicts in this regime with apparent changes in progress.

In contrast to the traditional predominance of great powers in space affairs, this research is interested in the influence that small countries with limited capacity may have on the dynamics of international space resource policy. It specifically addresses the influence that Luxembourg has held, and is currently wielding, regarding this shift in the regime controlling the utilization of space resources because of their unique geopolitical position, proactive legal engagement, and approach to commercialization. Drawing on fundamental concepts of sovereignty and appropriation linked with theories on international regimes, supported by personal interviews and observations conducted in Luxembourg, it will be argued that this nation has an outsized level of influence on the current changes with regard to a regime controlling the use of space resources. The significance lies not only in the potential ramifications for space resource policy development, but also in serving as an example for how similar nations and actors may influence other areas of international affairs.

Keywords: space resources, Luxembourg, regime, international space law

Resumo

O estatuto jurídico dos recursos do espaço exterior e a forma como podem ser apropriados e utilizados é um tema de debate internacional atual. Os pormenores do estatuto sempre foram nebulosos, sendo os tratados da ONU de há quase 50 anos o único esclarecimento reconhecido. Este corpo de direito internacional, supervisionado pelo Gabinete das Nações Unidas para os Assuntos do Espaço Exterior, pode ser visto como o regime que controla a utilização dos recursos espaciais e, até agora, foi considerado suficiente para manter a ordem nesta área. No entanto, devido principalmente ao rápido avanço das tecnologias relevantes de exploração e aproveitamento dos recursos espaciais, bem como ao crescente impulso do sector privado, há fricções e conflitos visíveis neste regime, com aparentes mudanças em curso.

Em contraste com a predominância tradicional das grandes potências nos assuntos espaciais, esta investigação está interessada na influência que os pequenos países com capacidades limitadas podem ter na dinâmica da política internacional em matéria de recursos espaciais. Aborda especificamente a influência que o Luxemburgo exerceu, e exerce atualmente, relativamente a esta mudança no regime que controla a utilização dos recursos espaciais, devido à sua posição geopolítica única, ao seu envolvimento jurídico proactivo e à sua abordagem à comercialização. Com base em conceitos fundamentais de soberania e apropriação associados a teorias sobre regimes internacionais, apoiados por entrevistas pessoais e observações realizadas no Luxemburgo, argumentar-se-á que esta nação tem um nível de influência desproporcionado sobre as atuais mudanças no que diz respeito a um regime que controla a utilização dos recursos espaciais. A importância reside não só nas potenciais ramificações para o desenvolvimento da política de recursos espaciais, mas também no facto de servir de exemplo para a forma como nações e atores semelhantes podem influenciar outros assuntos internacionais.

Palavras-chave: recursos espaciais, Luxemburgo, regime, direito espacial internacional

List of Acronyms

ATS	Antarctic Treaty System
CASC	China Aerospace Science and Technology Corporation
CNSA	China National Space Administration
DSM	Deep seabed mining
EIB	European Investment Bank
ESA	European Space Agency
ESRIC	European Space Resources Innovation Center
EU	European Union
FAI	Fédération Aéronautique Internationale
GDP	Gross domestic product
IIASL	International Institute of Air and Space Law
ILRS	International Lunar Research Station
IR	International relations
ISA	International Seabed Authority
ISRU	In-situ resource utilization
ITU	International Telecommunication Union
JHUAPL	Johns Hopkins University Applied Physics Laboratory
LIST	Luxembourg Institute of Science and Technology
LSA	Luxembourg Space Agency
LSC	Legal subcommittee (of UNCOPUOS)
MOU	Memorandum of understanding
MVA	Moon Village Association
NASA	National Aeronautics and Space Administration
NEO	Near Earth orbit
OST	Outer Space Treaty
PLA	People's Liberation Army
PPP	Public-private partnership
QCA	Qualitative comparative analysis
R&D	Research and development

RF	Radio frequency
SASTIND	State Administration for Science, Technology and Industry for National Defense
SCAR	Scientific Committee on Antarctic Research
SCNI	Société Nationale de Crédit et d'Investissement
SES	Société Européenne des Satellites
SPACE	Spurring Private Aerospace Competitiveness and Entrepreneurship (US Act of 2015)
SRW	Space Resources Week
UAE	United Arab Emirates
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UNOOSA	United Nations Office for Outer Space Affairs
US	United States
USSR	Union of Soviet Socialist Republics

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Introduction

Les ressources de l'espace sont susceptibles d'appropriation.

- Article I, Luxembourg Law of 20 July 2017 (Luxembourg, 2017a)

These are the first words of the Luxembourg national law of 2017 regarding the exploration and utilization of outer space resources. In fact, this sentence is the entirety of Article I of this law. Essentially, it states that space resources can be owned (in other words, subject to appropriation). Although it came on the heels of a similar law in the United States (US, 2015), this simple statement made by a legislative body from a country not traditionally recognized for its space credentials understandably caught international attention. To the casual observer, this action may only appear symbolic coming from such a country seemingly without sufficient power to affect the course of affairs in this matter, and thus merit no further consideration. Upon initial investigation, however, it became apparent that this case deserved a more detailed examination than it had previously been given by the international relations (IR) scholar community.

First, however, the larger space resource debate must be put into context. When addressing this topic, there are many fundamental issues that apply and require appropriate consideration: international law, sources of power, the role of national governments and space agencies, societal views of outer space, the definitions of the resources beyond Earth, sovereignty, property rights, commercial interests, and global distributive justice, just to name a few major ones. Of course, the natural question is that if the space resources debate is so important and touches upon such fundamental issues, why has the greater international community seemed to give it so little regard in the past, and why should they increase their attention now?

With the recent surge in commercial space interests, the world is arguably witnessing the dawn of a new space age, one defined primarily by economic interests (Lutes, 2007: 207). One aspect that will define this age regards the utilization of space resources, and accordingly, the international community now finds itself amid a debate regarding their legal use and appropriation. This discourse revolves around the interpretation of the current outer space international legal framework, primarily composed of several UN treaties created in the middle of the first space age. These treaties are commonly referred to as the Outer Space Treaty (OST),

the Rescue Agreement, the Liability Convention, the Registration Convention, and the Moon Agreement.¹ The treaty that is most relevant to the use of space resources in the context of this research is the OST, or the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (UN, 1966). The wording of the articles in this treaty regarding non-appropriation of outer space was sufficient to govern international behavior for the last half-century, but today the treaty faces an interpretative dilemma. Arguments appear to fall generally into one of three interpretations. On one end, strict non-appropriation or benefit for any nation or private entity; on the other, fair use and appropriation of resources as long as there are no barriers to access; or finally, somewhere in-between, with resource utilization allowed under an international regime with specific conditions. In truth, various interpretations have always existed – up until now, however, it simply did not matter. The most pressing issue during the time of creation was the race to the Moon between the US and the USSR; with reasonable guardrails in place ensuring the winner could not lay national territorial claim to the Moon or begin militarizing it, the immediate securitization concern was addressed. Because the reasonable ability to actually exploit raw materials from the Moon, or any other celestial body for that matter, was not available, there was simply not enough pressure to solve a problem that did not yet exist. Today, this is no longer the case.

This problem has started to gain an extensive amount of attention, with detailed arguments posed for multiple approaches using legal justifications. This research will attempt to examine the problem from a specific angle by asking the following question: *how is the regime governing the utilization of space resources changing in response to current trends in outer space operations, and more specifically, what influences do various actors have on the changes to this regime?* To examine the diverse range of effects of potential actors would involve a project of immense scope; thus, to focus this research and provide sufficient depth of examination, the questions will be viewed through the lens of the specific case of Luxembourg. This does not imply limiting the study to the single actor (namely, the government of Luxembourg), but rather allows influences to be traced to actors that work within and alongside Luxembourg. However, the starting point and central focus for examination will be treating the state as the primary actor.

¹ For the full titles, texts, dates, treaty status, and current list of signatories, see UN Office for Outer Space Affairs, <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html>. Additionally, there are five UN declarations and legal principles that provide additional support, but are generally not considered part of formal international space law.

In line with the interpretations presented above, three potential options exist for national governments to consider. The first option is to support the current order, refraining from making claims to any part of an outer space body or resource until conducting UN discourse. The second option is to ignore the current order, proceeding with legal and operational action unilaterally or with bilateral agreements to serve national interests. The third option is to attempt to establish or follow a normative regime, honoring an interpreted intent of the current international order while establishing multilateral agreements for support. Currently, the US is attempting to lead the regime-shaping effort of option three as evidenced by the Artemis Accords and their own national law of 2015 (US, 2015; NASA, 2020). If, however, a nation not traditionally recognized as a space power (such as Luxembourg) decides that they want a say in this regime, what influence can they have? This points to why Luxembourg was chosen as the case study for this research: it allows a more focused examination of the dynamics involved with various actors stemming from a nation that appears to have an outsized influence in a very specific field.

The starting question and its associated corollaries will provide guideposts and help to focus this research. For the initial direction, the following hypothesis will be used: *small nations not traditionally identified as space powers can still have a significant influence on the shaping of the regime controlling the use of outer space resources, provided they understand the current international dynamics involved, as well as their position within, and adapt their strategy and national efforts accordingly.* This research will attempt to test this hypothesis through a detailed examination of the Luxembourg case and by performing relevant comparative analyses. The veracity of the results, however, will be limited in two main areas. First, because the study focuses on the Luxembourg example, specific application to other cases is a difficult stretch. Second, the primary actions that can be examined are those of policy and laws, whether they are national, international, or transnational. There have been very few meaningful operational actions within the sphere of space resource allocation, so it is not possible to determine what actors will actually *do*. These are important limitations that should be addressed through further research on other cases as well as periodic updates to cover future actions.

This research intends to examine the specific case of Luxembourg in the context of this space resource law, aiming to meet three main objectives. The first two objectives concern themselves with the specific Luxembourg example: first, to identify the factors that drove the creation of this law, including political, economic, social, and security interests; and second, to examine the law's effects, focusing on any recent changes to the corresponding international

dynamic in this field. These two objectives will then support the more extensive, primary objective: to understand this case within the sphere of critical IR theory, and what it could mean for smaller powers in a wider range of space-related fields.

The issue of space resource allocation is an important international debate. Although the realistic ability to commence a profitable operational model for utilizing space resources is likely decades away, the laws and norms that are in development now will determine the potential path and associated consequences for centuries. Specifically, this investigation will attempt to better understand potential influences of nations not traditionally identified as space powers in this area – ones that typically are overlooked by mainstream research and policy analysis.

Initial concepts

Several concepts must be explicitly defined to provide suitable direction and orientation. More detailed constructions will be carried out as appropriate in the following chapters. First, the definition of outer space resources must be addressed – and more fundamentally, what defines *outer space*. This research will use the definition from the Fédération Aéronautique Internationale (FAI, 2004) defining the boundary of outer space as 100 kilometers above earth's surface, which fits a “spatialist” approach for legal purposes (Jakhu, 2017). Taking a definition from US law, outer space *resources* are abiotic substances situated in this definition of outer space that can be extracted (US, 2015). This excludes, of course, human-built objects that would already constitute property of another entity.

Next, the concepts of *space power* and *spacepower* must be explained and differentiated. This research will align the terms with an already defined framework, in which *space power* refers to an actor (or a status), while *spacepower* refers to a set of attributes that an actor can use (or a capacity) (Aliberti et al., 2019: 6). From this same framework, the relative scale of a space power will also be referenced, such that when referring to a nation not traditionally identified as a space power (or for ease of reference, a *non-space power*), this research means to imply countries other than the US, Russia, China, Japan, and India (id: 37). Additionally, this work will utilize a specific definition of spacepower as “the ability to use space to influence other actors and the external environment to achieve one's objectives” (Lutes, 2008: 67). In essence, this research is concerned with whether a country not identified

as a space power can in fact leverage a form of non-traditional spacepower to shape the international dynamic, specifically in the field of space resource utilization.

Finally, the concept of a *regime* in this context, as well as the international law contained within it, must be addressed. Regimes will be covered in depth in chapter 1, but for introductory purposes the current regime controlling space resources must be identified, as well as what would meet the definition of a future regime in this regard. Typically, laws and treaties are a component part of a regime, but in the case of space resources up to this point, the regime is only the collection of international space law as codified by the UN treaties concerning space (UNOOSA, 2002). While this research does not intend to offer an in-depth examination of international law considerations, it must use the current debate regarding the legality of outer space resource appropriation as a foundation. It will treat *international space law* as the collection of agreements, treaties, and principles that govern international activities in space (Steer, 2017: 3). As mentioned previously, the most notable international agreement of interest is the UN OST (UNOOSA, 1966). Customary law and general principles are also important components of an applicable body of space law, but in the area of space resource allocation, these are still in their formative phases. This research, therefore, is mostly concerned with what actions the international community takes in attempting to normalize a body of customary laws and principles with respect to this subject; namely, through interpretations of existing treaties and the creation of national laws. In essence, this forms what can be referred to as *space governance* (Jakhu and Pelton, 2017), which in this context is referenced specifically to the governance of space resource allocation and utilization. These actions thus determine a change to the existing regime, which could take the form of a governing institution, updated or additional treaties, or the general acceptance of norms and procedures as customary international law.

Current state of the art

Relevant bodies of work in this area focus on how nation-states interact and compete over space resources, sovereignty, and power (which can be political, economic, or military). Current works can be roughly divided into three clusters at different levels of analysis. A more thorough literature review focusing on theoretical foundations will be conducted in chapter 1, but to start, a broad overview of these groups will help funnel the effort of this research.

The first cluster revolves around perhaps the most fundamental debate for space development: the question of which IR theories will dominate the course of future outer space actions. Most research incorporates a neo-realist model for understanding international dynamics in this area, with attempts to understand the balance between great-power politics and liberal ideals for international order. Some of the most prominent arguments at this level are those of Everett Dolman's *astropolitics* (2002), with international relations in space defined by an extension of traditional realist theories of *Realpolitik*. Aligning with this view are works regarding the fundamental importance and security imperative of treating space as a strategic national asset (Sadeh, 2013; Johnson-Freese, 2017; Lupton, 1998; Oberg, 2000; Gray, 1996). In this regard, space resources are mostly treated as an extension of Earth-based resources – although operationally different, they will inevitably be subject to the same theoretical models that have dominated historic international resource competition. These works pull both from strategic authors such as Thucydides (1954) and Alfred Thayer Mahan (1890) to build their interpretation of the relevant dynamics, as well as more classical works of Thomas Hobbes (1983) and David Hume (1978). They support these theories and analyses with the writings of prominent realist thinkers such as E. H. Carr (1939), Hans Morgenthau (1978), and Kenneth Waltz (1978).

However, there is a growing body of work to suggest a greater influence of regimes, institutions, interdependence from global commercialization, and cooperation on driving actions in this field. The spacepower theories of Lutes (2008) and analyses from writers such as James Moltz (2019) and Santiago Rementeria (2021) take a more diverse array of factors into account in constructing a broad theory of current international space dynamics, and investigations into European dynamics tend to fall in this category (Aliberti et al., 2019; Sagath et al., 2018). Such works often draw support from theorists such as Robert Keohane and Joseph Nye (1989), and the thoughts on regimes by Stephen Krasner (1995) and Andreas Hasenclever, Peter Mayer, and Volker Rittberger (1997). Regardless of the relative weight of these lines of arguments, this collection of work is especially significant in how it shifts the debate to factors specifically relevant to economics of space resource utilization.

The second cluster is an often-overlooked debate regarding the actual desirability of space exploitation efforts. Much attention is given to the first cluster debate about what shape the international dynamics will take, but relatively little is given to the more basic question of what benefits and dangers these efforts pose to society. Daniel Deudney (2020: 7) offers a counterweight to the assumed inevitability of space expansionist efforts by arguing how space presents a more dangerous domain for realist power struggles with potentially disastrous

consequences for society. Here, space resources are given a balanced outlook in that if proper restraint is not exercised, they could form the basis of the destruction of society, thus illuminating a primary reason for the need to fill an apparent space governance vacuum.

This argument brings to light the question of why should space be treated differently than Earth, as well as the discussion over what will happen if it is not held to a different standard. This critical line of analysis is continued with authors such as Jill Stuart (2014), Edyth Weeks (2007), Columba Peoples (2009), and Julie Klinger (2020). These normative approaches construct a diverse array of questions to examine the issue in different lights by pulling from critical writings such as those of Gramsci (1959), Foucault (1980), Charles Beitz (1979), Robert Cox (1981), Ernst Haas (1975), and Emanuel Adler (1997). When funneling down to the specific debate about space resource utilization, these works are especially relevant when considering approaches to sovereignty, appropriation, benefit distribution, and global justice.

The final cluster regards the actual building blocks required to tackle the practicality of space resource utilization. This group can be further broken down into political, economic, and legal arenas. Prominent research includes how space law is situated in the context of society and politics (Brünner and Soucek, 2011), and the perceived predominance of international politics, as opposed to other factors, in determining national-level space operations and decisions (Sheehan, 2007). These set the stage for more focused debates regarding how space resource utilization should proceed, with some prominent arguments in support of current commercialization efforts (Lewis and Robbins, 1997; Steffen, 2022) and others taking a questioning approach (Svec, 2021; Krolikowski and Elvis, 2019; Mallick and Rajagopalan, 2019). While the first two clusters are more theoretical in nature, this third group is characterized by an operational focus, taking the realities of the current scenario and rationalizing solutions to achieve the best outcomes. These authors build upon and utilize the aforementioned theories in their justifications to construct potential solutions in areas of international and national law, cooperation, and commercial development. This cluster includes works that attempt to organize the current discourse (Tepper, 2019) and recommendations of working groups (The Hague, 2019), as well as national and organizational inputs into the ongoing UN Working Group on the Legal Aspects of Space Resource Activity (UNOOSA, 2023; US, 2023; Luxembourg, 2022; ESA, 2022).

Each cluster contains significant work regarding the future of space resource allocation and its implications. However, most of these works look at the problem through the lens of major space powers – typically, via actions of the US (by far the most prominent), China,

Russia, and to some extent the EU. Thus, there exists an apparent gap in current research regarding the role of nations not identified as space powers in shaping a potential order. When examining the specific case of Luxembourg, there is an acknowledged tendency of the author to want to apply a neo-realist lens to assess contributing factors and follow-on effects. One of the main goals of this research is to attempt to place this example within the context of a more complex theoretical framework (to be developed in the next chapter) to identify larger-scale implications for the international order regarding space resource utilization.

There are several works dealing with activities of Luxembourg in the space resource policy sector, although they mostly focus on the specific legislative actions and legal framework. Of note, there are both summary space law reviews (Calmes et al., 2021) and in-depth legal commentary (Hoffman et al., 2022), as well as a legal impact case study of Luxembourg space resource policy from a Russian viewpoint (Popova, 2019). These works do not, however, construct a comprehensive link from IR theory to analysis of the potential influence of Luxembourg on the space resource utilization regime.

Methodology and chapter structure

This research utilizes a range of methods to approach the starting questions. First, the central themes must be understood in the context of several theoretical debates, starting from most general to more specific. This is accomplished through a broad literature review, highlighting prominent authors of relevant theories first – to include great power competition, regime theory, and critical theories addressing sovereignty – then focusing on the works of authors in the specific fields of space policy, strategy, and law. Funneling down the debates through this review enables a more complete construction of a theoretical framework, carried out in Chapter 1, through which the problem can be addressed. Building off the three clusters of research mentioned above, this chapter will address how the topic of space resource utilization fits into larger debates, then construct the framework for viewing the specific Luxembourg case in a novel way.

Chapter 2 details the empirical data collection for a single case study. The focus of this research is on a unique case, starting with a detailed look at the factors surrounding the Luxembourg national law regarding the use of space resources in 2017. It will trace the development of Luxembourg's space policy, highlighting any UN treaties or other agreements that the country accepted or rejected. It will then examine the status of their national space

program as well as any supporting commercial enterprises. Assessing a broad spectrum of factors from political, economic, social, and security angles, it will attempt to understand why the law was enacted and what the country hopes to achieve. This case study will be supported by field work, consisting of interviews with relevant officials within the government of Luxembourg and their national space agency, with the intent of gaining direct insight into decision-making factors for the policies of interest.

The example of Luxembourg was the driving reason behind the start of this work, and thus is used as the primary case study. The data gained from an examination of this case is grouped into two main areas: the first area involves a thorough review of publicly-available information and documents, while the second area consists of first-hand supporting interviews. The review of available information led to a historical trace of Luxembourg with respect to the space resource question, including areas of government, foreign policy, economic factors, security issues, and space development efforts. To truly add a deeper understanding to the current body of literature, it was necessary to employ additional tools and methods.

It was determined that conducting field work through supporting interviews would add valuable depth to the assessment of the Luxembourg case. To more fully understand the thought process and motives behind the legislative and policy actions of Luxembourg with respect to space resources, relevant officials with direct involvement in these policies were sought out. As Brian Rathbun argues, interviews can be the most important, perhaps necessary, factor in determining motivations and preferences of applicable agents (2008: 690). Due to the proximity of Luxembourg to the location of the researcher, in-person interviews were deemed both desirable and feasible. Practicalities of the interviews, as detailed below, were decided in general agreement with those presented in Chapter 29 of the *Oxford Handbook of Political Methodology* (Rathbun, 2008).

The types of interviews were chosen to be mostly informal and semi-structured. This allowed the best flexibility between efficiently gathering data with officials on a limited timeframe while also allowing the interviewees to talk more freely and comfortably. Some initial correspondence and was via email and phone calls, while the actual interviews were conducted in-person at the Space Resources Week (SRW) held in Luxembourg from April 19-21, 2023. Twelve candidates from multiple organizations within Luxembourg were desired, with nine interviews actually conducted. All interviewees agreed that their full name and position could be referenced. No audio or video recording was performed, but notes were taken

by the author throughout each interview. All interviewees were asked if they would like to view any applicable part of this thesis prior to submission, but all declined.

Interviewees were chosen from specific organizations in Luxembourg with relevant interest to the space resource subject. The primary organization of interest was the Luxembourg Space Agency (LSA) and the advisory board on space resources, but unfortunately members of this board were not in attendance at the conference and were not accessible for interviews. Next, attention was given to the European Space Resources Innovation Center (ESRIC), which is an initiative sponsored by the Luxembourg Institute of Science and Technology (LIST) and LSA, and is based in Luxembourg (ESRIC, 2022). Although the composition of the ESRIC team was more scientific and technology-driven, it was useful to interview members at the direction and management level. Some of the interviewees had also been members of The Hague International Space Resources Governance Working Group. This working group, based in the Netherlands, was formed in 2016 to build a foundation for an international governance framework on space resources (IIASL, 2022). By interviewing members of this working group with Luxembourg connections, the author could maintain ease of in-person access and focus on the case study while also adding depth of experience from an international organization. Additionally, a member of this working group also worked within the Ministry of Economy (which has direct sponsorship control over the LSA), thereby giving specific insight into current government policy and the government's relationship with LSA. Appendix A contains a detailed list of the interviews conducted, including relevant information about the interviewee (organization and title), type of interview, and date conducted.

The overall goal of the interview phase was to gather complementary information to enhance and elaborate on data collected from publicly-available information and documents. There were several main objectives inherent to each interview, plus more specific secondary objectives based on the interviewee. These objectives drove the creation of potential questions and led to the decision of a semi-structured format. The first main objective was to identify motivating factors behind the creation of the Luxembourg space resource law, as well as follow-on policy actions in the development of the space resource utilization field. Another goal was to acquire first-hand assessments of program progress and implications, including insight into future plans and goals. A final objective was to gain a broader understanding of how various actors within relevant agencies viewed the placement of their organizations and actions within a larger sphere of influence, to include that of the EU, ESA, the UN, and the US efforts in establishing the Artemis Accords. There was also the additional benefit of attending

the conference for general observations regarding conduct and interactions of actors within the space resource area of expertise.

Initial questions were generally open-ended, focusing on allowing the interviewee to expand on their job, role within the organization, and past experience. Next, more direct questions were asked to identify their proximity to Luxembourg policy decisions in the last five years, with more open follow-up questions regarding their opinions and future outlooks. Concluding questions were based on responses and receptiveness to previous questions, as well as allowing ample opportunity to speak on related topics or unaddressed areas.

Analysis is conducted in Chapter 3, which consists of several comparative analyses utilizing data collected from the case study. This section also attempts an extrapolation of findings from the case study into the wider scope of the theoretical framework constructed in Chapter 1. The intent is to apply this theory in a novel way to the area of policy development for the utilization of space resources, uncovering potential international implications.

Data analysis was performed in two phases. The first phase consisted of qualitative comparative analysis, taking the findings from the Luxembourg case study and viewing them in relation to the policies and actions of other countries regarding the utilization of space resources. Although the potential for this analysis is vast, the scope of this research only involved a relatively simple comparison for the purpose of data exploration (Rihoux, 2008). This research examines both the laws and current actions of major traditional space powers, as well as smaller space powers similar to Luxembourg, with particular emphasis on the rest of the EU. It attempts to highlight which other countries have followed in creating similar laws, or absent of national legislation, which ones are taking specific actions in support of similar policies. The comparison with small space powers, including the other EU members, is an attempt to show whether Luxembourg is a relative outlier, or if they have set a desired model to follow. Although this research is focused on the effect of small space powers, qualitative comparison with large space powers is necessary to show proper causal relationships.

The second phase was a comparative-historical analysis utilizing a small set of cases for the purpose of causal assessment and examining processes over time (Mahoney and Terrie, 2008). Two historical cases were chosen based on similarities to the space resource debate: the issue of deep seabed mining and sovereignty claims in Antarctica. Brief historical traces of the international debate regarding these cases were conducted, focusing on the roles of small powers compared to large powers in shaping the current international order. The results were

then compared to the debate on space resources and associated regimes, highlighting major differences and identifying what factors might be causing the divergence.

The final piece of the research puzzle is the drawing of conclusions from the data analysis. By merging the results from the described methods, general conclusions could be made at various levels. Although the specific case study and interviews were limited in scope, the qualitative comparative analysis and comparative-historical analysis allowed for a greater understanding of the problem within the context of the chosen theoretical framework. These conclusions, of course, are mostly limited by the scale of research and the small number of countries considered, and specific limitations of each method are addressed in their appropriate section. The compound results, along with the author's opinions regarding future prospects, are summarized here.

Chapter 1: Theoretical Framework

Human history demonstrates that people do what suits them and seek rationalizations afterwards.

- James Oberg, *New Earths* (1981)

Looking back at the starting question and key concepts identified in the introduction, a theoretical context for examination must now be developed. As a focal point, the key interest is the current shifting of the international space regime for the utilization of space resources, with specific attention on the role of the smaller space power of Luxembourg. In constructing this theoretical framework, more fundamental questions and how they situate themselves in the greater IR debates must first be considered. A key discussion to start with, and perhaps the one that drives this author's passion for the subject, is how do international societies appropriate natural resources? Apart from how this has actually been done historically, philosophical issues of property, appropriation, and justice need to be examined to understand what is happening and what may become of this specific regime. Also of interest is the question of who are the actors of concern. The starting point is often the sovereign state, but a regime analysis must examine organizations and actors both above and outside of the state. This research in particular also attempts to gain insight to individual actors who hold specific agency within the Luxembourg case. Additionally, if there exists a set of rules to govern space resource appropriation, who gets to make or change them, and what are the consequences for acting outside of these rules? Specifically, what effect on this order can less powerful actors have, such as in the Luxembourg case? To start answering these questions, a framework grounded in broad IR theory must be constructed.

The driving purpose behind this research is to better understand the dynamics at work to help inform future potential actions. Although the primary intent is not to provide opinion for these future actions or necessarily predict what will take place, it is important to set definitions on potential outlooks. When assessing possibilities, there are three separate but related questions: what can happen, what should happen, and what will happen. The purpose of theory is to examine what has already happened and develop explanations, which can then serve as a tool to assist decision-makers for future outcomes (Lutes, 2008: 67). The 'should' question, however, is more of a moral judgement. In both developing this framework and

conducting this research in general, there will be an attempt to avoid taking a stand on this subjective aspect as much as possible, save for some concluding thoughts. Of course, it would be naïve to think that the author's own biases would not be a factor in at least constructing the lens through which the problem is viewed. Being an American with a military background, there admittedly exists a presupposed realist, security-minded method of approaching both IR in general, and outer space development specifically. However, international exchange experience, and especially the ability to conduct this current research with a European focus while attending a university in Portugal, has allowed a more broadening perspective. Although key elements of critical and constructivist influence are somewhat apparent, the author's general approach to international relations is still more weighted to a rationalist line of thinking, with a blended balance between neorealist and neoliberal pull.

Since the concept of regimes and associated dynamics is a focal point, a framework needs to be established that allows sufficient evaluation of this concept in the context of outer space resource utilization. One proposed balanced theoretical approach to examining international regimes is to divide schools of thought into three classifications: approaches that are power-based approaches, interest-based, and knowledge-based (Hasenclever et al., 1997). These lines of thinking roughly correspond to predominant theories of realism/neorealism, neoliberal institutionalism, and constructivism. Although these authors acknowledge that some synthesis between these approaches is possible (Hasenclever et al., 2000), for simplicity each one will be examined individually initially, addressing how each can be used to view the historical development of the regime governing the use of space resources and the current shifting trends. From there, an aggregate lens can be constructed through which the effects of a smaller space power can be viewed in the specific case of Luxembourg.

First, however, a few important concepts and their relationships should be explored in more depth than was covered in the introduction. One of these concepts is *sovereignty*, which when examined in the context of international relations, it is often assumed that the term applies to individual nation-states. In its most fundamental definition from Enlightenment thinkers, sovereignty refers to the ultimate authority of a specified body (Locke, 1988; Rosseau, 1994). For the purposes of this subject, the issue of sovereignty within a state is not as much of a concern, but rather its role in interactions between states, and how the concept exists at a level above the state. Fundamentally, the concern is with how states (or perhaps, a non-state organization) make claims of sovereignty over a specific object or resource. How sovereignty applies to the realm of outer space resources, and especially how traditional notions of this

concept may be transforming and detaching from the state-centric view, will be covered in the following sections.

Another concept around which the debate centers is *appropriation* – more specifically in this case referring to the allocation of space resources. From a general perspective, this concept is concerned with deciding and regulating “who gets what” in an international context. As a central historical IR theme, this concept transcends the spheres of law, politics, economics, and security. From the standpoint of critical theory, the very fundamental ideas of how appropriation is deemed acceptable must be examined. This will tie-in closely with theories of global distributive justice (Beitz, 1979), which will be examined in more detail in the section concerning knowledge-based approaches. It is not the intent of this research to argue for or against a specific approach, but rather to highlight the presence of this concept in this subject.

The concept of resource allocation has been critical since the dawn of humanity. All forms of life must naturally compete for resources that are necessary for survival, and humanity is no different. If those resources are limited, then an actual or perceived scarcity will inevitably affect the behaviors of humans. Additionally, actions of humanity are also affected by the accumulation of wealth and power, which can flow from resources that are not critical for survival. The distribution of these secondary resources has also shaped the course of events throughout human history. There are, however, many intervening variables in human society that make the distribution issue very complex. Fundamental concepts of social interaction, political theory, government, and law can all trace back to the basic question of how humans should allocate resources. Humans have the capacity to cooperate, organize, and decide how this should be done, but also the ability to inflict great harm upon each other to force their will. There of course exist numerous theories on the very nature of humans, their societal interactions, and the best way that society can hope to address the issue – these core issues of international relations will be referenced in each applicable approach section as they apply to thinking about a regime for the utilization of space resources.

There are some historical parallels that can be drawn upon in this regard, but it is important to distinguish the uniqueness of the space environment from these past cases. Ages of European exploration and colonization are the most prominent examples, consisting of the claiming and allocation of territories and their resources by powerful empires and nation-states. A seemingly constant fact throughout the history of mankind has been the conflict over limited land and resources. Be it tribes, civilizations, empires, or nations, the prizes were the spoils of

those that had the power and will to seize them, often with violence against another group. It is one of the fundamental principles of writers such as Thomas Hobbes, which set up the most formative bedrocks of realist international relations theory (Hobbes, 1983). Are territories and resources in space to be treated any differently?

The uniqueness of the space environment will shape this answer. Notably, for any known examples of locations of potential space resources, there are no indigenous residents that could already claim sovereignty – in essence, it is a clean slate. Thus, a more apt comparison would be with deep-sea floor mining or Antarctica. The logistical and physical challenges of exploiting space resources are certainly a differentiating factor as well. This factor does not significantly impact the setting of a policy or law addressing appropriation. However, it is important when considering any restrictions that the international community imposes on the potential use of space resources. Since the lead time, cost, and risk of an endeavor targeting these resources are so high, organizations (of any type) would be very hesitant to invest and pursue potential avenues, curbing overall development efforts. Additional aspects of market considerations will be examined, mostly in the interest-based approaches section.

Building off the concepts of sovereignty and appropriation, now it is important to consider how they apply to the issues of property and ownership. Taking *property* as a general term for rules determining access and control of material resources in this case, there are three broad categories of arrangement, determined by the types of social rules that govern the resources: common, collective, and private (Waldron, 2020). For common property, the rules seek to secure access and availability of the resource to all society members; collective property utilizes rules determined by the community as a whole based on social interest; private property is based on authority granted to individuals or private organizations to enact decisions (ibid). The starting point for this research is the Humerian assumption that people have been in conflict over resources since the dawn of time (Hume, 1978), and thus issues of property arrangements tie directly to social conflict. Specific philosophical views on property will be covered in the following sections as they apply to the aforementioned schools of thought on international regimes, but first a few significant contributors and themes will be highlighted.

Ancient authors debated the virtues of property arrangements, with Plato arguing for the necessities of collective ownership and Aristotle promoting the idea that private ownership breeds responsibility (Waldron, 2020: 4). Correlated law definitions of common property can

be traced back to the Roman law concepts of *res communis* and *res nullius*, and in particular the writings of Grotius contain foundations for international laws for unclaimed oceans (Edwards, 1981; Dolman, 2002). Thomas Aquinas expanded the ancient ideas, but added moral elements of both obligations of the rich and rights of the poor (Waldron, 2020: 4).

Key contributions occurred during the Enlightenment period with the works of Hobbes, Hume, John Locke, Immanuel Kant, and Jean-Jaques Rousseau. Hobbes based his property rules around a sovereign authority, which was the only way to address the selfish state of nature and allow for any reduction of conflict (Hobbes, 1983). Hume also acknowledged the lack of anything natural defining private property, but he thought that principles of justice derived from social interactions could define stabilizing rules (Hume, 1978). Locke was interested in the moral problem of private entitlement, to which he applied a theory of first occupancy with his own view of ownership through labor and the emphasis on productive capacity – in essence, writing that Earth resources are the communal property of mankind, which can then become the private property of the laborer who transforms those resources (Locke, 1988). Both Kant and Rousseau take a more abstract view, but essentially emphasizing the requirement for social consent of the general will to form a civil constitution that settles ownership in a fair way (Kant, 1991; Rousseau, 1994).

Finally, the nineteenth- and twentieth-century authors Georg Hegel, Karl Marx, John Stuart Mill, John Rawls, and Garrett Hardin feature prominently. Hegel (1967) focuses on the role of property in the development of the self, as part of instilling a larger social responsibility. Marx transforms this sense into a focus on social development, with the end-goal of massive labor cooperation in a collective economy that abandons private ownership ideas (Marx, 1972). Mill gives fair treatment to socialist and private property arguments, but also stresses that society has yet to settle on laws of property that actually conform to the ideals that are used to justify private property arrangements (Mill, 1994). Rawls attempts to shift the focus of debate to justice, arguing that specific property questions are essentially secondary issues that are more aptly dealt with practically, whereas philosophical energy should instead be spent on justice principles that apply to institutions in general (Rawls, 1999). In *Tragedy of the Commons* (1968), Hardin makes an often-cited consequentialist argument in favor of private property allocation. He presents a fundamental problem with the concept of English Common Law for tracts of land allocated for communal use based on a realist perspective, assuming a limit exists on the resource in question. Starting with a Hobbesian view of man as an uncooperative, non-regulated economic maximizer who by nature would incline towards ruin, he argues that only

organization and law can effectively manage the commons, with an overall increase in utility if it divides those commons into private parcels (Hardin, 1968). The most significant critiques of this view fall into two areas. First, following the Hobbesian anarchy mindset, if government control (assumed via the state) is placed upon a common resource, it would follow that there is no logical regulation of this government's action (Dolman, 2002: 89). Thus, the question must be asked if it is better to have no regulation at all, or unregulated control by a state government. Assuming that perhaps the generality that people are better off via a private property regime than any presented alternative is valid, the second critique asks which people that would apply to, and under which conditions (Waldron, 2020). In terms of arguments for private property arrangements versus collective, historical examples of the durability of liberal free market ideologies, and the efficiency of market controls versus centralized organization, seems to point in favor of the former. This of course does not alleviate the predicament of justification when presented with classes of people without property ownership, who also lack a certain recognition in society (ibid).

It is important to keep in mind that despite arguments in favor of one arrangement over another, there can certainly be no all-or-nothing approach in both domestic and international society. There are plenty of examples of all three types of arrangements existing within hierarchical government systems – what they have in common is that to be successful, there must be a level of thought and analysis applied to their specific context to put in place a system that protects the arrangement (Waldron, 2020: 3). This debate over how to first define the commons of outer space, then establish regulation for their use, forms a philosophical foundation for the development of a general outer-space regime, and especially one with regards to space resource utilization.

With these fundamental conceptual debates in mind, the focus will now shift to developing the theoretical lens through which to view the changing regime dynamics controlling the use of outer space resources. The three approaches previously mentioned will be taken as a starting point, although with less rigidity of definition used by those authors. In this case, it will serve as a structure for organizing thoughts and situating greater IR debates within the specific context of the space resource utilization regime.

1.1 Power-based approaches: the gravity of the realist paradigm

This framework will start with the power-based approach of thinking about international regimes, mostly because this author will argue (particularly in light of his background) that in the current international system, this approach carries a weight that is impossible to ignore and must be at least acknowledged and addressed before any productive engagement on regime development. It does not presuppose that this is the most important or definitive way to view the dynamics of the outer space resource utilization regime, but merely a consistent starting point given the history of civilization.

Power-based approaches to thinking about regimes center around IR theories of realism and neorealism (Hasenclever et al., 1997). These angles encompass a combination of Krasner's modal and modified structuralist strands of regime thought (Krasner, 1995). Structuralist thinking is rationalist in assuming egoistic actors in a realist system, focusing on great power hegemony in strategic regimes striving for relative gains (id: 6). In this way, a prominent critique of regime analysis argues that less importance should be placed on regimes since they are merely a by-product rather than a primary element of analysis (Strange, 1982). In the modified structuralist view, rational actors can sometimes conclude that cooperation is the most reasonable action, and that regimes serve as an intervening variable with their own compliance pull (Krasner, 1995: 7). This falls more in line with a neorealist (or structural realist) view, whereby the structure created by regimes carries more influence on state actor behavior than their realist tendencies (ibid). First, the elements of the realist and neorealist theories therein will be deconstructed, focusing on concepts of power and geopolitics. Then this line of thought will be applied towards the specific topic of outer space resources.

As already highlighted, the key issue of interest around which everything in this research orbits is the allocation of resources, with specific concern for the regime controlling the allocation of space-based resources. There is a close link between *resources* (including issues of ownership, collection, and allocation) and the concept of *power*. To have a meaningful discourse on the issue of resource allocation, ample attention must first be given to the issue of power. Since most dimensions of international relations revolve in some way around how states and other actors use power – referencing a broad definition of the ability to influence others to achieve one's purpose or goals (Nye, 2007) – it is essentially unavoidable to address. Therefore, general theoretical approaches to power, control, and governance will first be examined, eventually narrowing down their application to the outer space realm. The objective

is to incorporate theories of spacepower in the debate around space development, and more specifically the utilization of outer space resources. Although more commonly referenced in security and military contexts, examining spacepower theory is useful in this context because of its utility in explaining relationships and anticipate shifts between space ages, which can then be used to enable favorable shifts by informing practice and policy (Lutes, 2007).

Building upon Hobbesian views of human nature and states existing in an anarchic system, as well Machiavellian views of separation of morals from power and viewing the world as it actually is, classical realism from such theorists as E. H. Carr (1939) and Hans Morgenthau (1978) determined a prominent mode of thought towards international regimes following World War II. They argued that the ultimate decisions for the allocation of resources within state borders belong to the government of that state, and between nations there will always exist a perpetual state of competition for limited resources, with stress given to the unchanging nature of man that drives this competition and behavior towards resources (Carr, 1939; Morgenthau, 1978). Neorealists tend to push aside the human nature argument due to its lack of empirical methodology, instead favoring the explanation of behavior through the existing international structure of political anarchy (Waltz, 1978). Cooperation among states is possible, perhaps even desirable, within this structure, but ultimately it serves merely as a guise for competition: the state will still act based on its self-interests, but under certain conditions it may be in the best self-interest to cooperate (Dolman, 2002: 166). Regardless, proponents generally agree that seeing this issue through such a lens is not necessarily what they would prefer or hope for, but rather an acknowledgement of reality and an attempt to contain and manage conflict.

Realist geopolitical theories have developed to support the state's endeavor to acquire and exercise power towards achieving its self-interests. Thucydides (1954) described the natural imperatives that drove the development of the city-states of Athens and Sparta during the Peloponnesian War, which also gave support to the realist issue of the security dilemma commonly referenced in the Cold War. In the realm of the sea, Alfred Thayer Mahan (1890) was the first geostrategic advocate of sea power, putting particular attention on coastlines, harbors, chokepoints, and notably the character of a nation's people. Halford Mackinder (1919) was a notable land geostrategist, prophesizing the end of naval dominance while referencing the railroad as the geographic pivot of history, espousing the idea of a heartland and power through denial of control to adversaries. Notable air theorists included Giulio Douhet (1921) with focus on an air power revolution and the importance of air operations routes, as well as

William Mitchell (1925) with an extension of air power theory to practice. These theorists noted that full control by one power would be extremely difficult, so they professed that states that wished to remain sovereign must at least strive to prevent others from gaining control of strategic locations and resources. The extreme extensions of this geopolitical line of thinking are organic state theories, social Darwinism, and geodeterminist mindsets, which propose that states and peoples who can expand and dominate ultimately will and have the right to (Dolman, 2002: 42). The enhanced resources and power gained from additional conquests fuels pride, which is then transformed into justification for domination.

The most complete extension of this realist geopolitical theory into the outer space realm is Dolman's *Astropolitik* (2002). In it, he defines astropolitics as "the study of the relationship between outer space terrain and technology and the development of political and military policy and strategy" (Dolman, 2002: 12), which requires six dimensions to be considered in order to form a space strategy: society and culture, political environment, physical environment, military and technology, economic base, and theory and doctrine. He further refines this into the theory of *Astropolitik*, a realist vision of state competition in outer space, specifically the development of a legal and political regime (id: 13). He acknowledges the negative implications of this line of thought, but stresses that it is a probable outcome that can only be ignored at one's peril. Channeling tenants of Waltz's neorealism, he addresses the "great social dichotomy" of cooperation and competition as both being impossible without the other – acknowledging that cooperation can and does exist in outer space policy, but only as a guise for competition and achieving one's ends by enhancing image, building international support for an agenda, buying time, or more efficiently pursuing economic goals (Dolman, 2002: 168).

One way to consider spacepower theory is to split lines of thought between two schools: that of space as a sanctuary, and that of space as the ultimate high ground (Dolman, 2002: 148). The predominant mode of thinking among American authors is that of the latter. James Oberg (2000) posits in his spacepower theory six criteria: geographic size, location, wealth, population, appetite for technology, and political will, with the most important being the will of the nation's people. Lupton (1998) seems to have one of the first generalized spacepower theories, which situates itself firmly in a securitized realist paradigm of Cold War rivalry. Joan Johnson-Freese (2007; 2017) argues for a balanced approach to spacepower utilizing all tools of national power due to the complexity of the space environment, but with a US-centric realist mindset. The path of development of US national space strategy, including the creation of a

Space Force, although inconsistent and sporadic, has continued to march along the lines of thought of the realist paradigm. Multiple editions of US space policy, notably in 2006, have used some form of a statement such as “those who effectively utilize space will enjoy added prosperity and security and will hold a substantial advantage over those who do not.” (US, 2006). The most current policy edition takes a broader and more international approach to space development, but still clearly highlights the US military role with tenants of control and the ability to apply force (US, 2020b). This line of thinking about spacepower is dominated by a military mindset holding the security aspect as the primary focus. From this view, the other school of thought – that of space as a sanctuary – is deemed impossible to achieve and therefore it would be illogical to not view space as the ultimate high ground.

Now that geopolitics have been traced to the outer space realm, the definition of *spacepower* itself must be examined. Colin Gray (1996) defines spacepower as the ability to use space while denying its reliable use to any foe, while David Lupton (1998: 4) writes that spacepower is the ability of a nation to exploit the space environment in pursuit of national goals and purposes. While recognizing the primacy of this realist paradigm in spacepower, other theorists expand the notion to accommodate transformations in the current space development. Sadeh incorporates a broader definition, suggesting that it is ability to exert influence in or from space (Sadeh, 2013). Specifically, the issue of wealth creation in space (as opposed to the previous paradigm of generating wealth from space) could be giving rise to a “fourth wave” of human development (Toffler, 2006). Lutes acknowledges states as remaining the dominant power broker and thus defines spacepower as the ability to use space to influence other actors and the external environment to achieve one’s objectives (Lutes, 2007). However, he opens the lens of securitization to offer eight strategic approaches, notably expanding the concept: strategic space dominance, regulating space, cooperative interdependence, collective security, dissuasion and deterrence, asymmetric approaches, and free riding (Lutes, 2008: 69-72). Most significantly, he assesses new markets, the importance of technology, and how spacepower and economic power influence each other, thus enabling space to potentially enhance the international system through collective action. Although this expanded theory allows better divergence into other approaches to space regimes (as will be explored further in the next section), it is clear that power still matters – simply the definition of what goes into that power calculation has been broadened.

Nations build upon their notion of spacepower in order to construct effective strategy, utilizing three major motivations for space investment: essential national infrastructure, engine

for economic prosperity, and dual use applications (Gibbs, 2012: 279-332). These motivations drive space policy laws to set directions for government conduct, priorities, and guidance, which then leads towards space strategy (Shabbir et al., 2021). The importance of space strategy is that it links power to purpose, serves and fulfills policy, and provides a means for maintaining advantages for states (Sadeh, 2013). Moreover, a space strategy's purpose is to coordinate, integrate and prioritize space activities across security, commercial, and civil sectors – in other words, it is a roadmap for connecting ways and means to the ends established by policy, and thus a whole of government approach is critical (id: 1).

Taking these theories of geopolitics and spacepower into consideration, the specific issue of thinking about the regime for the utilization of outer space resources can be considered. Stripped down to fundamental geopolitics, it is impossible to ignore the pure weight of the realist paradigm. At some level, a state is going to view outer space resources in a similar manner as resources here on Earth – a vast potential source of wealth, and by extension, power for those actors that can exploit them. A state can either assess that it has the ability to exploit these resources, and therefore will at a minimum feel the inclination to do so, or it will assess that it does not, and thus will at least sense the need to ensure other states cannot dominate their utilization – essentially forming one of Dolman's astropolitical dictums (Dolman, 2002). From this approach, the development of the original UN space treaties that encompass the current regime for the utilization of space resources, most notably the OST, can be viewed as a compromise that served the interests of the US and USSR, the two space giants of the first space age. The capabilities of the two superpowers, combined with the extensive distrust of the other, created an example of a bipolar balance of power where both recognized that they may not be able to gain the upper hand over the other – essentially, they did not know if they had the ability to win a race for a claim of resource sovereignty – thus it was deemed better to create a regime that would at least prevent the other from being able to do so (Dolman, 2002). In essence, it follows, the principles of non-appropriation and treating space objects as the common heritage of mankind were simply means to prevent a relative gain for one state. From this view, other states, with little to no capacity to drastically affect space operations at the time, also viewed this as the most acceptable way to keep the two superpowers in check, and were thus happy to at least support the fundamental principles of the OST in this regard. In this power-based approach, regardless of what a state or its constituents actually thought about space or what it should represent, this regime that essentially removed the state's ability to claim sovereignty and appropriate space resources arose as an acknowledgement of the realist

geopolitical situation and a suitable compromise to prevent potential conflict escalation. This approach would suppose, alternatively, that if one of the superpowers assessed it had the superior technology and capabilities to gain the immediate upper hand in utilizing space resources (say, for example, colonizing the moon), it would have simply done so – that is, oppose the creation of a regime that limited this ability, or lead the creation a regime that was more supportive.

This approach can also be used to interpret the current challenges to this existing regime and its changing dynamic. There now exists a much wider range of space actors than when the OST was enacted, including ones outside the state, but this approach views non-state actors as still subservient to a state to which space equipment is registered in line with the current regime (Hasenclever et al., 1997). The overall range of general space strategy options available to a given state are varied, falling roughly in-line with the spacepower strategies that Lutes proposed (2008). For the specific issue of policy towards a space resource usage regime, however, the power-based approach offers more limited options – either a state has the capacity to exploit resources, or if not, it must choose whether to “bandwagon” with a more powerful state, or put up resistance through coordination in a balance of power strategy (ibid). The catalyst for a change in regime, in this view, would be the technological capacity to realistically consider space resource exploitation, along with the explosion of commercial capital willing to take the risk. This commercial capital then pushes national governments to create a framework conducive to resource appropriation. Accordingly, US actions such as the 2015 SPACE law (US, 2015), the 2020 Executive Order promoting international support for space resource utilization (US, 2020a), and the Artemis Accords (NASA, 2020) represent the US recognizing its unrivaled capacity to exploit space resources, acknowledging that the current regime is too restrictive, and attempting a hegemonic control of shaping an updated regime. Cooperative attempts are then mostly a veil to legitimize this control, and other signatories then are merely aligning themselves with US hegemonic interests in recognition of the changing dynamic and in an attempt to best position themselves for future benefit.

Regarding a smaller state realist perspective utilizing balance of power theory, one argument is that due to the growing asymmetries of national space capabilities (caused by the space technology multiplier, especially in the military domain), the use of space in the future will be a story of “elephants and mice” (Huntley, 2009: 148). The perspective of a larger space power (notably the US) is that these smaller powers will match their policies with larger powers based on material factors, and their own decisions to collaborate will be shaped by niche

capabilities and security alliances; however, the smaller states look at the world differently, developing relationships with peers to avoid being trampled by the “deaf giants” (id: 164). This balance of power dynamic is especially present in space due to the proximity of the domain and its equivalent interest and usefulness to all users separate from their capabilities. These smaller powers therefore prioritize collaboration through alliances or regimes and generally avoid the arena of military space, prioritizing instead relationship-based civil space activities (ibid).

The realist mindset would view the most effective regime as that of a benevolent hegemon, in this case the US, with rough tenets of hegemonic stability theory. Following from Dolman’s arguments (2002), the most stable and beneficial course is for the US to take control of creating the rules and enforcing them. Since there is no body with sufficient authority to create an effective regime, neglecting to do so only invites inefficient chaos and incentivizes actors with bad intentions to seize the initiative. The neorealist perspective takes a step back, acknowledging the rational value of cooperation and the potential compliance pull of intervening regimes. The order would still be hegemonic, but under an offensive realist mindset the hegemon can utilize the institutions to build international support while striving towards their own goals and objectives (Mearsheimer, 2001: 35). For both lines of thinking, the current body of outer space law regarding the utilization of space resources is prohibitively restrictive, to the actual detriment of all. Their argument is that by effectively removing the ability to allocate any outer space resource, there are no incentives for any actor to pursue investments and assume risks of attempting to exploit those resources (Dolman, 2002). As such, overall space development has been stifled, and humanity will gain no benefit from their potential wealth.

A realist approach may view the apparent weakness and lack of precision of the current regime as an opportunity. A great power hegemon could simply depart from the regime (essentially withdrawing from the OST), recognizing that their absence would leave it almost meaningless, freeing them to do what they see fit. Or, they could leave the regime in place while exploiting advantageous loopholes, deliberately avoiding the creation of a more restrictive and precise set of rules that would be disadvantageous to their interests. A neorealist approach, in contrast, would recognize the potential for conflict that these scenarios would create, and instead favor a more stable regime for the main purpose of avoiding the extreme costs that such conflicts could bring. Although a state might assess that they have sufficient power to act unilaterally, it is in their better interests to cooperate on creating stronger

institutions to enforce a regime that allows for the establishment of property rights while prioritizing deconfliction – in essence, recognizing the value of “stickiness” in such a regime, and leveraging it to their benefit (Ikenberry, 1998: 45).

From this, it can be argued that the neorealist angle, or Krasner’s modified structuralist strand (1995), is the more predominant path among power-based approaches to general outer space regimes. Moreover, its constitutive building blocks of astropolitics, spacepower, and space strategy as they relate to the interests of individual states give this line of thinking a significant weight that is impossible to ignore, even if it seems counterintuitive to that nation’s goals. The gravitational pull, so to speak, of this neorealist paradigm towards a space resource regime represents a logical starting point for approaching the issue. Regardless of whether this premise is the predominant explanation, it is hard to deny the seemingly constant presence of this line of thinking for states in approaching the space resource policy question, if not at the forefront, then always in the background. This realist core thus forms a source of gravity that, if left unacknowledged and unchecked, will likely pull states into a familiar scenario of intense competition, almost inevitably leading to military confrontation and counterproductive results for society as a whole.

1.2 Interest-based approaches: the neoliberal institutionalist counterweight

With the heavy pull of the predominant realist power-based approach to thinking about an outer space resource regime as a starting point, the approaches that provide the most direct counterweight can be examined. Interest-based approaches to thinking about international regimes align most closely with neoliberal institutionalism and Krasner’s description of the Grotian strand of thought (1995). As opposed to the structuralist (modal) and modified structuralist angles, the Grotian strand focuses on social factors, arguing that regimes are unavoidable features of international life and actors are constrained by rules, norms, and patterns of behavior (id: 8). The influence of Grotius references his works on expressing the idea of a society of states bound by rules and mutual agreements rather than simply through force, and evidenced by the Peace of Westphalia (Edwards, 1981). Regimes in this sense can be more informal and cover a wide range of issues across a diffuse regime continuum.

Here presents the opportunity to examine various regime definitions. John Ruggie (1998) describes regimes as a set of mutual expectations, rules and regulations, organizational

entities, plans, and financial commitment that are accepted by a group of states. According to Krasner, they are “explicit or implicit principles, norms rules, decision-making procedures around which actor expectations converge in a given issue area” (1995: 2). Breaking this down further, principles can be seen as beliefs of fact or causation, norms imply standards of behavior (such as rights or obligations), rules mean actual prescriptions for action, and decision-making procedures would be the prevailing practices for collective choice action (Stuart, 2014: 13). Additionally, the difference between a regime and more constitutive agreements and treaties are that agreements can be considered ad hoc, or relating to a specific event, whereas a regime is viewed more holistically as a longer-term arrangement to facilitate achieving those agreements (id: 13). These regimes can be formal – that is, governed, maintained, and monitored by international organizations – or informal, suggesting a convergence in participant objectives with mutual self-interest and surveillance (id: 15). Oran Young clarifies further that these can be classified as spontaneous, negotiated, or imposed, as well as encompassing non-state actor influence but keeping an assumption of actual membership being reserved for sovereign states (1986: 110-111).

The first great debate in IR holds that liberalism is the traditional counter to realism. While maintaining a common starting point that the state holds prominence as the critical actor, liberalism rejects the power politics and security presumptions of realism as the only possible outcomes, arguing instead for the mutual benefits of cooperation that can be achieved through international structure and institutions. Neoliberalists take the cooperation and international institution argument a step further, arguing that democracy and capitalism create an interdependence of mutual benefits and thus reduces conflict potential among states that share in those political and economic systems (Keohane and Nye, 1989). The facet of this area of theory that will be examined focuses on neoliberal institutionalism, which has been commonly associated with regime theory – which, according to Stuart (2013), seeks to explain under what conditions rational actors will determine that it is in their interests to cooperate despite anarchy in the international system. Along this line of thought, the concepts of regimes and institutions, in the context of space resource utilization, form a counterweight to the pull of the realist paradigm previously described.

As opposed to the bipolar options for space perspectives presented by Dolman, Sheehan suggests three viewpoints: space as a sanctuary, as an environment, or as a theater of war (Sheehan, 2007). These roughly correspond to more general theories of post-structuralism, liberalism, and realism. The last approach, the securitized viewpoint of space as the ultimate

high ground, was covered extensively in the previous section. Although it encompasses the bulk of theoretical thought on space development, there are numerous strategists and theorists who advocate a different approach, or who blend aspects of other theories. Bruce DeBlois (1999) argues that space warfare is not inevitable, and that a space as a sanctuary strategy can be pursued with a rule-governed approach. Nancy Gallagher (2013: 53) posits that there are three strategic logics for space cooperation: treating space as a global commons, the desire for strategic stability, and the need for governance for global security. James Vedda (2009) argues in favor of using space to primarily benefit life on earth, rather than new exploration. Johnson-Freese (2007), although mostly leaning towards the realist paradigm, also argues for rules of the road, liberalizing commerce, and a Space Exploration Partnership. Other writers focus on the need for cooperation and institutions from a security angle, such as Wolter's (2006) proposals for a Treaty on Common Security in Outer Space.

Perhaps the most resounding counter to the realist paradigm is that of Deudney (2020), who argues that humanity's collective push into space development will have dark consequences that are not given proper examination. The emerging space boom, which he calls a second golden age of space, is defined by great power military rivalry and deep-pocketed private sector and support, but with very little critical assessment or opposition. He posits, "are traditional realist versions of geopolitics really a sound guide for steering statecraft with planetary and species consequences?" and in critiquing Dolman, asserts that other states will not simply accept an American grab for planetary hegemony (id: 25). He labels those who view space as the military high-ground and that human nature is fixed as "Astro-Archimedean," and that applying their principles would lead to rivalry occurring over anything of value, and that violent conflicts over mining earth resources will simply expand into space (id: 177). Political order is examined as a triadic typology: anarchy, hierarchy, and "negarchy" – essentially the republican argument to avoid the pitfalls of either end of the anarchy-hierarchy spectrum. This movement brings with it regimes, be they incidental, supplementary, or complementary (id: 290). This critical line of thinking will be addressed more in the knowledge-based approaches section, but is important to introduce here when comparing neorealist and neoliberalist angles.

On many issues, including in the space realm, there is a considerable degree of convergence between neorealist and neoliberalist thought, considering they are both rationalist theories that take states as their baseline actor. Where the significant divergence occurs with respect to space resources is on the issue of cooperation, particularly its motivations and

mechanisms. Outer space can be viewed as a frontier and a power vacuum with weak controlling authority, and certainly an ample opportunity for actors with material capacity (as well as capacity for violence) to seek power through control – but the neoliberalist stance insists that a path of mutual restraint is both feasible and necessary, and must be viewed as yielding the best long-term benefits for state actors (Deudney, 2020). In this sense, space cooperation is a valid security strategy in that it sustains peaceful relations while spreading enormous costs, with the evolution of national space programs proceeding through four quadrants, starting from security competition, moving towards competition in the civil area, then civil cooperation, and ultimately ending with security cooperation (id, 249).

The core of neoliberalist ideological thought, however, revolves around the market institution. Although there are numerous works highlighting the dangers of the realist approach, it is difficult to envision that these warnings will be enough to counteract the pull of that power-based paradigm. What seems to be of more appeal to states, particularly in the area of developing a regime for the utilization of outer space resources, are the potential benefits of cooperation under liberal free market ideals and establishing institutions and rules that are conducive to them. Herein, actors are more likely to find the value of interest-based approaches to thinking about such a regime, in line with the new space age centered around wealth that Lutes describes (2008: 67). Shabbir writes that in general, space programs are transitioning away from a focus on national prestige and military aspects to social development and civil/commercial focus, with specific emphasis on nascent space powers – those who have limited space technological resources yet have a footprint in space (Shabbir, 2021). Moltz (2019) posits that when examining nascent space powers, collaboration is the best strategy to overcome financial and technological constraints. Europe has perhaps been an example of this line of thought, as evidenced through the EU Code of Conduct for Outer Space Activities, the Euro Space Policy of 2007, and ESA’s Space Resources Strategy, which outline process as a goal and highlights the strong interconnectedness between the economic and strategic dimension of space policies (Sadeh, 2013; ESA, 2019).

In pure idealist terms, the issue of outer space resource utilization would be managed by a system of global government. The neoliberalist update, however, is that because this ideal is either not yet possible or not actually desirable, other forms of institutional structure must be used as a substitute to counteract the realist paradigm. This brings us to the concept of regimes as a workable solution, and the bulk of regime theory typically falls in this neoliberal institutionalist camp. In her critique of Hardin, Elinor Ostrom (1994) highlights the importance

of examining under what conditions can institutions be created that make it possible for actors to cooperate. As Stuart writes, having the current body of outer space law define space as a global commons has not defined how it is governed (2014: 9).

Looking at the historical space resource utilization regime from this interest-based approach, the regime itself is not simply the creation of the series of UN treaties, but rather the embodiment of the shared interest of having a higher level of control over an issue of global importance. Even if the rules, norms, and principles of the regime do not necessarily conform to the full material interests of a state, the regime itself as a coordinating agent is a motivating factor in itself to drive that state's behavior towards support. Although there are significant differences, under this approach the regimes created for seabed mining, Antarctica, and satellite telecommunications can be used as justification for the value of the regime itself on international behavior, separate from the specific rules created. This view is still rationalist at its core in arguing that states are still making a logical choice based on interests – just that a key driving factor happens to be the shared interest of having a regime in place that sets the rules of the road. Thus, all nations, regardless of their spacepower status, had a shared interest in ensuring that a generally-accepted regime was established such that they could all ensure some form of absolute stability. At that point in time, the shared interest of preventing rivalry and conflict by holding space resources off-limits to appropriation outweighed any relative gain interests of specific countries. Here again, the regime “stickiness” concept can be seen in explaining how this imperfect regime continued well after its creation (Ikenberry, 2002).

To explain the current changing trends, this approach would argue the increased influence of neoliberal ideology, market factors, globalization, and interdependence on a space resource utilization regime. The current regime arguably removes all incentives for nations to take risks towards the pursuit of space resource exploitation. There is of course debate over the applicability to transnational corporations and if they are beholden to the same restrictions, but regardless of the interpretation, the lack of government support undoubtedly restricts private actors as well. These restrictions, the argument follows, prevent any benefits from being reaped from space resources, and removes any chance of increased wealth to society here on earth from their extraction. This liberal market ideology way of thinking posits that it is in everyone's interest to pursue absolute gains from the potential wealth generation in space, and the most effective way to do that is to establish a regime that supports order based on free market principles. This represents the approach to the public commons problem with the allocation of property rights. This path would then avoid the problems of the extreme approaches – that of

either not allowing anyone to utilize the common spaces, or allowing everyone to use them without any restriction. An ideal regime, in this view, would utilize international consensus to construct a system that assigns property rights to celestial bodies, with enough freedom for the market institution to set value. For instance, perhaps the regime assigns a country rights to a specific property, but has no means to extract resources from it – the market institution would then allow that country to either lease or sell those rights to someone with more capability. Thus, the international push for change to this regime is not driven by a desire to abolish it in favor of leveraging power for relative gain, but rather the common interest for global absolute gains derived from new sources of wealth.

These interest-based approaches to thinking about regimes appear to be a hopeful counterweight to the realist paradigm described previously, and perhaps offer a fruitful explanation to the changing dynamic of the space resources regime that allow a path away from potential conflict that would prove counterproductive. However, the critiques of this approach are numerous, which is why it is vital to consider the third way of thinking about regimes to gain a complete picture of the issue.

1.3 Knowledge-based approaches: a critical balancing with constructivism

The final piece of the framework involves a more critical approach to the question of how to allocate space resources. Following an examination of the rationalist power- and interest-based approaches, the more normative knowledge-based approaches can be used to balance the full picture of how to think about a regime controlling the utilization of space resources. These approaches focus on social theory to explain identities, interests, and divisions that are part of international regimes (Weeks, 2007). A summary of this line of thinking is described by Nicholas Onuf (1989), who follows a social constructivist vein in that the acquisition of knowledge is a societal process based on individual motives, and thus decisions about space policies are shaped by worldviews about what space represents. Knowledge-based approaches can be aligned with a general cognitivist view, which critiques both the realist and neoliberal convergence of treating actors' perceived options and preferences as assumed, rather than theorizing about the beliefs of the actors themselves (Hasenclever et al., 1997: 5). Additionally, there is distinction between weak cognitivists, who emphasize the role of causal beliefs in regime dynamics, and strong cognitivists, who focus on social character of

international relations and align with the terms of reflectivists and constructivists (Hasenclever et al., 2000). In the realm of space development, a modernity viewpoint supports the application of human reason to reveal the universe, such as through the creation of space programs (Sheehan, 2007: 17). The post-structuralist critique of this modernity deconstructs ways of thinking about space, arguing that in the world of ideas there exists a structure that artificially sets limits to what is considered possible (id: 17).

A specific constructivist approach to the concept of regimes is espoused by the English School. This line of thinking posits that despite anarchy, states are members of an international society (different from simply an international system) where those members accept a limited responsibility towards each other and the society (Bull, 1977). Here, institutions take on a more normative, ideational, and constitutive role that is broader than regimes – of particular importance are the primary institutions, as described by Barry Buzan's taxonomy (2004): sovereignty, diplomacy, balance of power, and nationalism. Although it contains similar elements as the mainstream regime theory described in the previous section, the English School line of thought can provide a decidedly knowledge-based approach to the specific issue of a space resource regime.

Another critical approach involves examining the issue of sovereignty itself. Stuart examines the unbundling of this concept in outer space affairs, including challenges to traditional notions of the relationship between sovereignty and the state, by identifying two approaches: regime theory and cosmopolitan sovereignty (2009: 9). The regime theory approach holds that the regimes codified in current outer space theory have already demonstrated a significant shift away from the traditional view of state sovereignty through positivistic behavior, while the cosmopolitan sovereignty approach is normative, holding that individuals are the primary political agents in the system that is starting to show a cognitive and wider societal shift (id: 14-19). Here, the idea of space as a common heritage of mankind presents a shift to an idea of liberal sovereignty, where transnational issues undermine the traditional states and societies are opened up to judgement by general standards (Held, 2002 apud Stuart, 2009) – however, these common humanity shifts may possibly be swallowed up by elites, since potential space exploitation will naturally exclude most actors (Stuart, 2009: 19). Regardless of the approach, the argument here is that understanding the politics of outer space requires moving past the classical Westphalian state concept, and that current space developments may be contributing to a wider global shift in the conceptualization of sovereignty (Stuart, 2014: 229).

Similarly, Jonathan Havercroft and Raymond Duvall (2009) take a critical look at what they consider to be two prominent and distinct models of astropolitical theories and how they engage with contemporary critical theories of sovereignty: Dolman's realist *Astropolik* (2002) on one side and Deudney's liberal-republican view (2020) on the other. Against Dolman, they critique the preference for good competition as a "hallmark of empire logic," the idea that US benevolence due to its responsiveness to its citizens as presumed, and the treatment of space as a resource to be exploited – in essence, constituting an example of O Tuathail's "geopolitical gaze," or simply imperial control through hegemony, bringing into question the constitution of sovereignty (Havercroft et al., 2009). Towards Deudney, although they acknowledge his desire to avoid space-based hegemony through state cooperation, they critique his ignorance of power, as well as asymmetries of aspirations and capacities for control. They argue instead the value of critical astropolitics following the line of thinking from authors such as Agnew, Dalby, and O Tuathail, as well as more foundational works of Foucault and Derrida (id: 50-51). Here, geopolitical discourse can be viewed in terms of power and knowledge relationships, where geo-power mutually supports imperial institutions in which they were produced, and thus there exists a normative implication of space-based imperialism. They highlight critical theories of sovereignty through works from Foucault (1980), with bio-power operating at the micro and macro levels, as well as Agamben, Hardt, and Negri with an erasure of boundaries under a space-based empire focused on earth-control. (Havercroft et al., 2009: 52). Along a similar vein, Columba Peoples (2009: 92) references Harcuse, Adorno, and the Frankfurt School line of critical theory when examining the intrinsic connection between technology and domination, pointing out the need to acknowledge and understand the tendency to conceive of space within a military/security framework in the first place, in addition to assessing the consequences of specific development efforts.

Edyth Weeks (2007) takes these knowledge-based approaches a step further in applying them to outer space regimes. She distinguishes between cognivists, like Adler (1997) and Haas (1975), who argue that the belief systems of individual decision makers shape perceptions of reality and behavior, and constructivists who argue that ideas are shared forms of practice from which people can construct meaning (Wendt, 1992). She then applies a Gramscian approach to reviewing outer space regimes in an attempt to understand the influence of the neoliberal ideology hegemon, which pulls from applicable Gramsci writings in prioritizing questions of equality, justice, legitimacy, moral credibility, and movement (Gramsci, 1959; Gill, 1993; and Hoare and Smith, 1971). Leveraging anti-hegemonic themes from Gramsci, Cox (1983)

highlights the concept of hegemony as an ideological legitimation of norms and consensus. Also of particular importance is Gramsci's idea of the historic bloc, with interacting elements of super and substructure (Gramsci, 1959). In the context of US space dominance, Weeks highlights the concept of consent through the US leading concessions, shaping perceptions, and appearing compatible with a wide range of subordinate groups to maintain their hegemony (Weeks, 2007). She argues that there is a problematic relationship between neoliberal ideology, capital, law, institutions, state power, and the privatization of space, focusing her analysis on what she calls the 3rd epoch, or the hyper-privatization of space (id: 136). Key actors have allowed space law to remain vague on property rights in order to take advantage of gaps, which only serves the interests of a space transnational capital class – in this sense, privatization, commercialization, and globalization of space is seen as the norm, with discourse relying heavily on free market capitalism and US rhetoric designed to manufacture consent (id: 138-140). This critical economic angle is particularly significant for space resources, especially the Luxembourg case.

Along the same critique of space privatization, Deudney (2020) observes that the current regime codified by the 1967 Outer Space Treaty (OST) is under attack by small but powerful special interests who seek to appropriate asteroid resources for private economic gains. To summarize his arguments regarding privatization, competitive pressures must be minimized, profits distributed to avoid exacerbating international stratifications, and that the fundamental cost-benefits equation of space mining should be called into question to counter proponents who argue that endeavors will mark the start of a third industrial revolution that will change the rules by providing a boundless increasing-sum game and affluence for all (Deudney, 2020; Lewis, 1997). Moreover, an often-cited gap in the OST is that it makes no mention of corporations, other than that a state is responsible for space actions conducted within it, which gives way to interpretation by transnational corporations (UNOOSA, 1966). As more new space actors embrace privatization, this area of critique holds increased significance.

Following this line of thought, and assuming there are vast amounts of wealth that can be gained from space resources, perhaps the most prominent critical element that concerns a controlling regime is that of global distributive justice and international development. Here lie important links to greater IR debates regarding dependency and inequality, challenges against legitimacy of a system built on an imperialist structure, benefit distribution, and the North-South system. Even in simply defining classification frameworks and priorities for spacepower

measurement, there is a bias of the global north – other states may then follow the blueprints of those states with superior spacepower classifications, even if not in their best interests (Oniosun and Klinger, 2022). The argument from lesser developed countries is that the current system established a framework that codifies inequality, hindering those countries will little or no capacity to join the space club due to numerous difficulties such as capital, people, scientific base, and stable political support (Sheehan, 2007). Similarly, politics are always at the heart of the space agenda and will remain so, and approaches have precisely mirrored those of terrestrial preoccupations – thus the key question becomes is space a ‘final frontier,’ or has society merely replicated divisions and tensions by bringing our frontiers into space? (Sheehan, 2007: 183). In addressing the distribution question, Deudney references a “golden rule” for justice advocates concerned with distribution of wealth and power: that space exploration should be carried out in a way as to reduce, not aggravate, tensions in human society (Hartman, 1984 apud Deudney, 2020). For developing countries, the common heritage of mankind principle is often viewed as a tool for protecting critical space resources from sole exploitative control of a few developed nations and powerful corporations. To them, it is worth preserving these sentiments of the OST, because if they are discarded, they fear the threat of increased inequality and continual lack of access to benefits. The critique of this mindset is that developing countries use this as way to delay economic development in space, preferring instead the prevention of any state from utilizing space resources (Brünner et al., 2011).

The historical development of the space resource regime can now be looked at using such approaches. Ideally, the non-appropriation and common heritage of mankind principles in both the OST and the other UN space treaties would embody the true spirit of the space as a sanctuary argument – that is, treating space by a different set of norms than what has transpired between nations here on Earth. Doing so, by this line of thought, would be the only way to at least curb terrestrial problems from spilling over into space, with potential disastrous consequences. Additionally, it would represent a fresh start – in essence, preventing the remnants of a colonial system from continuing into space, thus locking-in its effects for the foreseeable future. These treaties, it follows, were the most just and reasonable way to ensure that things would be done differently, or at least delay actions to the contrary until a more suitable solution could be obtained. However, a critical approach would certainly downplay the idealist sanctuary notions, despite whatever rhetoric was used at the outset. From such a view, the superpowers were still controlling the narrative, and states with no spacepower had little choice but to follow. The UN system itself was still state-based, and any space agreements

made were inevitably weighted heavily towards the relative power structure of those states. Although there was perhaps a guise of cooperation, the underlying state system was always a given, with favor always given to those who already wielded power, in a way that continued that ensured the continuation of that dominant structure.

Looking at the potential change in this regime, these approaches can critique the challenges and possibly explain why the current regime has not been overturned. Although the neoliberal institutionalist pressure to adapt the current regime, as described in the previous section, would certainly seem like a preferable alternative to the realist paradigm, knowledge-based approaches would argue that it actually represents an extension of the same paradigm with neoliberal ideological assumptions. Individual decision-makers, both within governments and non-state organizations, are heavily influenced by the prevailing free-market ideological views that espouse the benefits of globalization and absolute gains. These views are supported by the fact that the US has been a de facto space development hegemon for the past 30 years, whose worldviews underpin most actions taken in this arena. Individuals then act through their respective organizations upon these assumptions, even if they do not hold the best interests for society as a whole. A proposed change to the regime to encompass property rights and allow exploitation, however packaged, would have terms and agendas still dominated by a neo-imperialist mindset. The timing of this change can be explained by the compounding of technological factors and increased influence of transnational corporations. The Artemis Accords, by this line of thinking, are a reflection of this – the US has an underlying agenda as represented by its national laws and statements, and they can use their spacepower to package a new regime proposal that continues to favor the current system. Regardless of how much international appeal it achieves, it would still heavily favor the more developed nations who are better suited to exploit and benefit from new space resources, thus contributing to greater inequality and an enhancement of the dominant-subservient system.

This can also be used as an explanation as to why the current regime has remained, and despite the challenges, has not been disposed of. The institutions created as part of this regime are a societal construct, but they have also had a constructive effect on society. What is called the collective international society, when acting in the space realm, seems to behave differently. This line of thinking would posit that individuals within this society feel some sort of obligation to it. The choices and behaviors of individuals are molded by this sense, who then act through their organizations and institutions to shape policy. Despite the gravity of the power-based realist paradigm, or the interest-based pull of neoliberalist ideology, there remains a sense (at

least at the level of individual beliefs) that space is, and should continue to be, treated differently than affairs here on Earth. The reason that the treaties and their established principles remain, it follows, is not simply because actors rationally determine that it is in their best interests to not dispose of them, but rather that there exists a weight of societal obligation to hold space, and specifically the appropriation of space resources, in a higher regard. A rebuttal to this, of course, would be that the criticism and pressures of the lesser developed countries have caused a stalemate in the UN, to the point where the only hope for any progress is to carefully act outside of it while using creative justification to arrange international support for a new de facto set of norms. This resistance can be thought of in Gramscian counter-hegemonic terms, whereby nations with less power recognize the actions of the US hegemon will continue to keep them subservient – although not in the same manner as colonial rule, but with the same skewed power relationships based on access to resources and wealth (Weeks, 2007: 266). Their best recourse, then, is to group together to uphold at the very least the principles of the current regime.

1.4 A combined framework to assess effects on the space resource regime

Having viewed the changing dynamic of a regime for the utilization of space resources through the three aspects of power-, interest-, and knowledge-based approaches, these viewpoints must now be taken into consideration to construct a synthesized framework through which the specific case of Luxembourg and their possible influence on that dynamic can be assessed. Although there is some possibility of synthesizing significant parts of these three approaches to thinking about international regimes in general, it would be very difficult to combine all three in harmony without sacrificing some significant principle of at least one approach (Hasenclever et al., 2000). However, it would also be difficult to treat the three approaches in isolation, since a complete explanation to any international regime would likely require a blending of aspects that would prevent a distinct separation. Perhaps there are case-by-case differences, whereby a specific approach would seem better suited to explain the associated dynamics, but this would defeat the purpose of building a theory to assist with the analysis of any case. For the purposes of constructing a framework to view the regime for space resources, the main arguments and critiques of each approach as they relate to both the historical development of the regime as well as the current trend towards change will be

reviewed. In order to test the most convincing explanations, the framework to ensure suitability for specific case studies can be refined.

When looking at the creation of the regime for space resources at face value, specifically the OST and UN involvement, it would be easy to assume a genuine appreciation for the space as a sanctuary principle and the ideal of the common heritage for all mankind was paramount. This argument is not convincing, however, when viewing the larger context in which this creation took place. The level of intense rivalry between the two superpowers of the US and USSR drove the milestones of the first space age, and these nations held the most power in the creation of any international norms. Almost paradoxically, the power-based approach to thinking about this regime creation is the most convincing when considering the special case of bipolar powers with opposing worldviews against the backdrop of potential doomsday conflict. Balance of power theory is especially applicable: the superpowers wanted to ensure that the other was kept in check, and other nations had a vested interest in checking both superpowers. This was applicable to multiple issues in the outer space treaties, so taken as a whole these treaties can be seen as composing a diffuse outer space regime, of which the non-appropriation of resources and the common heritage of mankind principles were a part. Focusing on that specific issue, both superpowers assessed that the technological means were not nearly sufficient to make sense of the cost versus benefit calculation for trying to exploit space resources, so treating them in such a manner posed no adverse effects on their own country at that time.

Changes in this regime, and their most plausible theoretical explanations, can now be considered. A logical start is to look at the Moon Treaty of 1979, why it was put forth in the UN, and why it failed to gain sufficient support to become part of the body of international law (specifically from the major space powers at the time). The agreement reaffirmed the non-appropriation and common heritage principles with specific application to the moon, but gave specific clarification to the right of states to collect materials from it for scientific purposes (UNOOSA, 1979). More importantly, it would establish control over the management of moon resources through an international regime. The main friction point cited by most major powers was the mandate that this regime would include “an equitable sharing” of any benefits gained from those resources among all states. Here, it can be seen that soon after a nation has demonstrated repeated capability to conduct human activity on the moon, the issue of exploitation of resources on it moves into focus. Although the existence of the moon was of course known well prior, the symbolic and practical value of actually having humans explore

it and return can be likened to that of colonial maritime explorers on Earth. The proposed agreement seems to be a critical assessment, at least from countries with little to no spacepower, that a different set of rules must be in place to govern activities there to avoid repeating patterns of the past. The resistance to the equitable sharing clause is completely understandable, although it can be reasonably argued that even absent of that phrase, there would still be ample resistance by the fact that control over the management of resources would be handed over to an international regime. The overall failure of this proposed agreement, despite seeming to advance the ability of nations to potentially exploit moon resources and perhaps establish a framework for the management of other resources as well, can again be best explained with a power-based approach. The proposed regime for managing moon resources would have removed elements of power from the equation, along with economic incentives for taking risk. Countries essentially made a spacepower assessment of themselves, asking if they already or would soon have the capacity to exploit those resources, or if they were prepared to leverage their abilities to take advantage of countries that did in some way. To them, the idea of this type of regime would have been detrimental – although a controlling regime was deemed necessary and beneficial, they wanted to have more influence on its actual creation, essentially molding it to their liking.

The final analysis involves the current trend towards privatization. The current space resource regime challenges are characterized by individual state laws towards resource appropriation, as well as more international efforts of the Artemis Accords and The Hague Space Resources Governance Group. Specific national laws, starting with that of the US and including the Luxembourg law of specific interest to this research, appear to be an attempt to fill a gap left in the OST in a manner that is suitable to those nations. These are not attempts at a new regime in themselves, but serve several purposes. First, although it is up to interpretation whether the national laws would hold up against international law, it serves as both a domestic and international signal – helping to align the commercial sector and bringing in potential outside corporations with capital who now have evidence that the government will at least be supportive in their efforts to exploit space resources. They can also serve as drivers and influence other similar-minded nations to take similar action, perhaps generating a consortium of thought that will steer the direction of a more palatable regime. This is not to suggest that the current regime dominated by the OST is detested – arguably the opposite, in that maintaining its lack of precision potentially allows these actors to operate in the gray zone. These actors do of course desire a regime that governs specific activities to their liking, but

they are happy to operate in this way until a such a regime is constructed, recognizing that a high level of international agreement is needed for its creation. These national laws, taken by themselves, fall into a power-based approach towards regimes, in that nations feel that their own interests still outweigh those of the regime, and that they may be able to use their power of influence to shape the regime. One example of this gray zone operation would essentially be a state government acknowledging that it would not lay any sovereign claim in space, and thus not seek to appropriate any resources there, but that it will not prevent any individuals or corporations from seeking to utilize resources to their own desire.

The Artemis Accords seem to be an attempt at this new construction, albeit driven specifically by the needs of NASA's Artemis moon program. These pull more elements from the interest- and knowledge-based approaches, and instead of seeking to dispose of an old regime and create a new one, it proposes more of an operational clarification while supporting collective outer space heritage and the benefits to all humankind from the peaceful exploration of outer space (NASA, 2020: sections 1, 8 and 9). It holds the OST as still the defining source of international law for the use of space resources, and as such proposes that any utilization would be done in accordance with the OST, which would not automatically constitute a national appropriation of that resource (id: section 10.2). It also creates the idea of safety zones, which could be used for the purposes of activity deconfliction, but details are left somewhat nebulous (id: section 11). Critics would argue that the line of thinking with regards to the OST is another example of taking advantage of a gray area, and that the safety zone concept could be used as a way of establishing exclusive sovereignty over an area. Additionally, it can be argued that this is simply a veiled way for the US hegemon to attempt to shape the regime using its dominant spacepower position. From a theoretical standpoint, it appears to be at least a recognition of the need for international support and the value of institutions already in-place. It seems to be a separate line of effort than exploitation considerations on the economic front – one that falls more in line with the English School of thought on regimes, acknowledging an individual's responsibilities to a society in the unique context of space (Bull, 1977). The accords also pull from the shared-interest mindset, in that it does recognize and emphasize “global benefits of space exploration and commerce” (NASA, 2020: introduction). The building blocks proposed by The Hague International Space Resources Governance Working Group was a more focused effort on driving suitable regime change (The Hague, 2019), but the question remains: for whom will these efforts actually benefit? Although this appears to be a broad international effort that showed great progress in setting up a foundational framework,

the specific participants and outcomes need to be examined more critically. Further examination, including Luxembourg's role in it, will be conducted in the next chapter.

Taken in aggregate, the theoretical lens can be synthesized through which the specific influence of Luxembourg on the changing dynamics of the space resource utilization regime can be viewed. The creation of the regime, embodied primarily by the OST, can be thought of best through a power-based approach. Its broad initial support can be explained with elements from knowledge-based approaches, as well as a general staying power as argued through interest-based approaches, although resistance to further updates within the UN can be viewed again from the power perspective. The timing now for a push to implement changes can be explained from the technology boom that allows for potential generation of wealth that would exceed costs and risks, implying again power-based explanations. However, the actions pursued by actors for making such changes are falling more in line with interest-based approaches. The normative aspects of knowledge-based approaches offer appropriate critiques that keeps these actors in check, and serves to explain why such change is proving difficult to execute.

The next chapter begins the actual investigation into the question of where does Luxembourg fit in this regime equation. An attempt is made to leverage this framework when examining historical actions of Luxembourg, its current geopolitical situation, and its future goals and strategy in order to help explain what has happened and articulate to what level they have impacted this changing regime dynamic.

Chapter 2: Luxembourg Case Study – Data Collection

The central focus of this report is to examine the specific case of Luxembourg to characterize its role and influence in the current shift in the international regime controlling space resource utilization. The study is divided between this chapter, which focuses on data collection, and the following chapter, which is concerned with analysis. The data collection consists of a broad overview of the relevant geopolitical aspects of Luxembourg, as well as a primary source document review, including press releases and national policy statements, to allow process tracing for the development of its space program and space resources initiative. Additionally, relevant relationships with industry and other organizations are explored. This data is supported by observations and informal interviews conducted while attending the Space Resources Week (SRW) conference in Luxembourg from 19-21 April 2023.

2.1 Geopolitical overview

The country of Luxembourg is by itself an interesting case study of a small county that holds vast wealth and influence within the European sphere. Culturally, there is a predominant mix of French and German influence, with adoption of those languages for administrative and judicial purposes. The national “mother tongue”, however, is the native Luxembourgish, which is required for nationalization (Erpelding et al., 2023). With a population in 2022 of just under 650,000, it is one of the least-populated countries in Europe, but with the highest growth rate (OECD, 2023). Most notably, foreigners make up nearly half of this population (including over 18% Portuguese), and the labor force includes a large sum of commuters from bordering regions of France and Germany (ibid). Although voter turnout is generally high (almost 90%), the *voting* population of Luxembourg, that is national citizens over 18 who are eligible to vote in national elections, is less than 60% (and in the urban area of Luxembourg City less than 40%) of the total population, due to the large segment of foreign nationals living and working there (IFES, 2023). When looking at the actual *working* population, Luxembourg citizens only make up about one-third, with foreign residents and commuters accounting for the other two-thirds (OECD, 2023).

The government is a representative parliamentary democracy headed by the Grand Duke and a cabinet of ministers, with a constitutionally established unicameral Chamber of Deputies and a Council of State made up of ordinary citizens to advise on draft legislation (Erpelding et al., 2023). The country consistently ranks at the top by GDP per capita, currently at over \$140,000, with an economy characterized by stability with low inflation and unemployment plus high innovation (OECD, 2023). Historically, the rich iron-ore fields in the southern Red Lands area led to a burgeoning steel industry, with diversification to chemicals and rubber following a decline in the 1970's, shifting to an economy defined by significant growth in the financial and banking sectors (Erpelding et al., 2023). Luxembourg is now the world's second largest investment fund center, and arguably the most prominent banking center within the eurozone, with evidence of high-tech investment through regional headquarters placement of international corporations (ibid).

Luxembourg's investment and prominence in the telecommunications industry is most notable. As a hub for all major European internet exchanges and data centers, Luxembourg is currently considered second in the world in the development of information and communication technologies, as well as a financial technology hub leader in Europe (OECD, 2023). Luxembourg is also a major shareholder and the uplink home to SES (formerly Société Européenne des Satellites), a carrier of major European satellite services (SES, 2023). With 70 satellites in geostationary orbit (GEO) and medium earth orbit (MEO), SES was the first multi-orbit communications satellite network and Europe's first private satellite operator (ibid). Luxembourg's support of SES is a logical lead-in to the development of their space program.

2.2 Space program and strategy development

The event that commenced the relevant discussion of the Luxembourg space program was the creation of the SpaceResources.lu initiative in February 2016. Essentially, this initiative set funding structures for a national space budget and announced the intention of establishing a legal framework which would allow the nurturing of a space resource utilization industry (Luxembourg, 2016a). Today, the initiative is a specific focus area of the Luxembourg Space Agency (LSA), with concentrations on space resource legal issues, establishing a legal and regulatory framework, and financial support (LSA, 2020). Soon after in 2017, the Luxembourg government signed a national law regarding the exploitation and utilization of

space resources (Luxembourg, 2016b and 2017a). This law was a landmark moment, since Luxembourg was only the second country (behind the US) to enact such legislation (Luxembourg, 2016b). The law was a central development of the SpaceResources.lu initiative, thus accomplishing one of its founding objectives of creating a legal and regulatory framework for private companies seeking to mitigate risk for space resource technology investments (LSA, 2023a).

Interestingly, the LSA was officially launched on 12 September 2018 – *after* both the Spaceresources.lu initiative in 2016 and the national space resources law of 2017 (Luxembourg, 2018b). The stated missions of the LSA are to develop the nation’s space ecosystem, synergies with business, and organization outside of the space sector (LSA, 2019a). The agency also assists in the development of key skills and expertise, creates jobs, and contributes to the economy, while promoting the national space sector domestically and internationally through public relations and space potential outreach programs (Luxembourg, 2018b). Its core activities include the implementation of a national space development strategy and policy, leading the Spaceresources.lu initiative, managing international relations with respect to the space industry, representing the country in the ESA and EU space affairs, supporting space activities of the UN, managing national space research and development, and providing focus for public and private stakeholders (LSA, 2019a). There exists a long list of formal partners, most notably SES, the University of Luxembourg, the Luxembourg Institute of Science and Technology (LIST), the Chamber of Commerce, and the Société Nationale de Crédit et d’Investissement (SCNI) (LSA, 2022b). The organization is composed of a supervisory Board of Directors, under the oversight of the Ministry of Economy, with a small group of agency leadership composed of a mix of directors, project managers, policy officers, department heads, and advisors (LSA, 2020).

At its inception, the LSA promoted Luxembourg as “a catalyst for collaboration, technological innovation and the commercial development of space”, through which both expertise and financing can be fused to generate “a sustainable space economy,” in addition to claiming that their space sector’s contribution to the nation’s GDP is amongst the highest among European countries (Luxembourg, 2016a, 2016b, and 2018b). The primary policy objectives loosely match LSA’s stated mission: to develop the nation’s “space ecosystem” while creating “synergies” with both the private sector and other organizations outside of the space sector, develop required skills and expertise, and enhance Luxembourg and its space

sector internationally (Luxembourg 2020b). This led to their initial space strategy guiding long-term decisions based on four “pillars”: expertise, innovation, skills, and funding (LSA, 2019a).

2.3 Current space strategy and accomplishments

The *Luxembourg Space Strategy 2023-2027* was in draft at the start of this research, with general information provided through a press release (LSA, 2022a) and interviews conducted at the SRW conference; recently, however, the full official French version has become publicly available (LSA, 2023b). This is the first standalone document that establishes an overall space strategy for the government of Luxembourg, and it contains several important shifts. One thing that has remained constant, however, is that the primary political objective is to make space one of the economic pillars of Luxembourg (Luxembourg, 2018b; LSA, 2023b). The government claims to have over 70 space actors, both public and private (LSA, 2022b). The major shift is represented in the commitment to sustainable development. As a secondary objective, they desire their space sector to contribute to sustainable earth activities and to favor a responsible approach to space operations (LSA, 2022a). The strategy emphasizes Luxembourg’s adoption of the UN’s 17 Sustainable Development Goals through their “Luxembourg 2030” national plan, through which they recognize the UN “Space 2030 programme: Space as a driver of sustainable development” (LSA, 2023b: 2). The key word now is *sustainability*, and their approach to space resources fits as one of four priorities in this structure: sustainability of earth activities, sustainability of activities in space, sustainability of economic activities, and sustainable and responsible use of space resources (id: 3). The key change highlights how the previous pillars of strategy that primarily supported the diversification and enhancement of the Luxembourg economy now fit into a larger picture of contributing to sustainable, responsible activities on Earth and in space. Throughout the SRW conference in Luxembourg, other terms that were stressed in addition to sustainability were *space economy*, *space ecosystem*, and *synergies*. These represent a movement away from focusing only on the mining and use of space resources, and their repeated use in public statements and policies suggests a level of intent that places a premium on the importance of language and public perception.

Within this structure, the SpaceResources.lu initiative now aims to utilize a sustainable development approach to promote peaceful exploration and use of space resources, ideally

through international engagement to establish a respectful framework that ensures benefits for all of humanity (LSA, 2023b). They stress the important role of their multinational Space Resources Advisory Board in making recommendations, as well as the efforts of ESRIC through research & development, commercial cooperation, and financing frameworks (LSA, 2022a; ESRIC, 2022). Their implementation avenues involve areas of funding (such as the prominent LuxIMPULSE program), talent development (through programs such as the University of Luxembourg’s Space Master program), international cooperation (both bilateral and multilateral), legal and regulatory framework evolution, and communication (LSA, 2019b and 2023b). Their current strategic projects include the LSA Data Center, which facilitates open access to Copernicus earth observation data, and the Space Campus for providing an attractive commercial environment for the space sector (LSA, 2023b). The SRW conference, held annually since 2019, represents a compilation of all these implementation strategies.²

Another key accomplishment of the SpaceResources.lu initiative was the creation of the ESRIC in Luxembourg in August 2020 (Luxembourg, 2020a). Following a Memorandum of Cooperation between ESA and the Luxembourg government, this organization is a joint establishment between LSA and LIST with ESA as a strategic partner (ibid). ESRIC is advertised as a “national innovation centre in the field of space resources,” with the objective of becoming an internationally acclaimed focal point for space resource-related expertise (ESRIC, 2022). The organization centers around four pillars of research and development, business support, knowledge management, and community support (ibid). ESRIC had the lead in running the SRW conference in April 2023 which this author attended, although with close support from LSA and LIST. Additional events with support from the LSA include the Summer Space Festival, NewSpace Europe, LSA and commercial enterprise “open door” events, the ESA-ESRIC Space Resources Challenge, and representation at the International Astronautical Congress (ibid).

The current trajectory can also be referenced to a new paradigm of space operations through a vision of what ESA calls “space 4.0,” which relies on a joint recognition of benefits to humanity to enhance international collaboration and promote technical innovation (ESA, 2019). In the words of members of the advisory board, Luxembourg fits into a unique position that allows it to build on international collaboration to “make others believe in space resource exploration” (LSA, 2020a). An important element of continuing momentum along this path

² For details about the SRW conference, including presentations and summaries of previous editions, see <https://www.spaceresourcesweek.lu/>.

appears to be the building of support among European organizations to recognize Luxembourg as a knowledgeable and proactive leader in this field with the global impact potential.

2.4 Legal framework

Luxembourg defines international space law through international treaties and non-binding agreements such as UN assembly resolutions and customary international law (LSA, 2023a). They recognize the UNCOPUOS as the primary forum for the development of this body of law, and they have ratified both the OST and Liability Convention, accessed the Registration Convention, and are working towards becoming a party to the Rescue Agreement (LSA, 2023a). They, along with most other countries, are not party to the Moon Agreement (ibid).

Luxembourg's legal framework covering all space activities is made up of three national laws: the law of 15 Dec 2020 regarding space activities, the law of 2017 regarding exploration and use of space resources, and the law of 1991 regarding electronic media (LSA, 2023a). The space resources law of 2017 is the driver behind this research. The 2020 space activities law is essentially a legal framework that outlines management and liability for all space activities. For space resource missions, the 2017 law is still primary, but the 2020 law clarifies object registration and tax provisions. The 2020 law, according to the LSA website, "contributes to providing a safe and attractive environment for operators, investors and entrepreneurs" (ibid). The need for the law was driven by commercial interests, and full responsibility for supervision of space activities has been handed to the Ministry of the Economy. The electronic media law of 1991 is still used as a legal framework for electronic frequency allocation (ibid).

Regarding international law specifically towards space resources, Luxembourg views the current treaties as "untested" towards who would own physical resources found in space, mainly because past missions have been overwhelmingly scientific in nature and there was not a pressing need for clarification (Luxembourg, 2022). In their view, space mining and commercialization beyond near Earth orbit (NEO) is not possible unless investors can be assured of material rights (ibid). Their 2017 law looked to fill that gap by establishing "an efficient legal and regulatory framework" in this sector (LSA, 2016b). They are quick to point out a recurring statement highlighting their lead role in this area:

The Grand Duchy is the first European country, and the second worldwide, to offer a legal framework on the exploration and use of space resources, ensuring that private operators can be confident about their rights on resources they extract in space. (LSA, 2023a).

However, they are also very deliberate in emphasizing that this law does not intend to promote national appropriation of outer space or celestial bodies, but simply that it makes clear their own stance regarding the status of resources therein. Moreover, the details of this framework include necessary regulations regarding authorization and supervision of space resource-oriented missions, in meeting the requirements of the OST.

2.5 International Hague Space Resources Governance Working Group

This working group was formed in 2016 and consisted of two phases, the second of which concluded in 2019 with the publishing of the Building Blocks for the Development of an International Framework on Space Resource Activities (The Hague, 2019). Their mission was to “assess the need for a governance framework on space resources and to lay the groundwork for such framework” (ibid). The intent was not to compile an executable solution, but rather to form a basis for international negotiations for either a new agreement or a non-binding instrument, as well as make recommendations for implementation strategy. The host Consortium consisted of various dispersed organizations, the primary of which was the Institute of Air and Space Law of Leiden University (Netherlands). Other partners were the University of Luxembourg, Catholic University of Santos (Brazil), Secure World Foundation (US), Ten to the Ninth Plus Foundation (US), Nishimura Institute of Advanced Legal Studies (Japan), Indonesian Centre for Air and Space Law of Padjajaran University, and the University of Cape Town (South Africa) (ibid). The body of the working group consisted of thirty members, which included varied organizations from state governments, commercial enterprise, and universities. Notable additional countries represented were the UAE, China, Nigeria, France, and the UK. The group also included over ninety observers with direct interest in the space resource field, including representation from India, Russia, Canada, and numerous additional organizations from the US and China (ibid).

The formation of the building blocks was driven by a perceived need to clarify a framework to address the rapid development of space resource activities, and presumably, the recognition that this issue was not being addressed sufficiently (or in a suitable timeline) at the UN-level, specifically within the Legal Subcommittee (LSC) of UNCOPUOS (The Hague,

2019). Additionally, the structure of this working group was weighted heavily to non-governmental organizations, rather than strictly state representation at the UN. The obvious advantage is in the ability to promote multi-stakeholder dialogue and cooperation with less influence from traditional structural bounds or international prejudice. However, while the Consortium included global representation, the group of members and observers seemed limited to those that had a perceived interest and chose to participate, and whose organizations represented a narrow band of motives and outlooks. The limits of this participation are evident in the shape that the building blocks took, as well as how these can actually be implemented.

The building blocks include key sections on definitions, principles, responsibilities, priority rights, resource rights, harmful impacts, corresponding interests of all humankind, sharing of benefits, registration, liability, institutional arrangements, and monitoring (The Hague, 2019). Of note, many definitions in section two are also referenced for this research, including *space resources*, *utilization*, and *activity*. Notable principles include the requirement for legal certainty and predictability for investors and operators, and *adaptive governance*. This latter principle – that a regime should incrementally implement regulation based on need at the appropriate time – continues to appear in this debate (ibid). The desire to adhere to this principle is an attempt to balance the need for regulation without stifling innovation and development, especially considering unknown future challenges. The sections on priority rights and resource rights make a decisive interpretation of the OST in favor of utilizing and appropriating resources as part of fair use and exploration, while avoiding national appropriation of actual territory and establishing an international body for registration, monitoring, and control of best practices. Sharing of benefits is presented in terms of voluntary promotion by operators for participation from developing countries, as well as incentives for technological development, exchanging of information, and international funds. However, mandatory monetary sharing is avoided, as well as any dividing of rights or reservation of areas for developing countries. In combination with the commentary which includes details on each section and discussed alternatives (Neto et al., 2020), the building blocks document represents the most complete international proposal for a space resource utilization framework to date.

A question of this research regarding this working group would be to what degree did Luxembourg possibly influence the resulting building blocks? The timing of the formation of the group nearly coincided with the creation of the SpaceResources.lu initiative, and deliberations were held nearby in Netherlands with a heavy European representation. The University of Luxembourg was a Consortium partner, and membership included both

representation from the Ministry of the Economy and ispace Inc., a Japan-based firm with European headquarters in Luxembourg that now operates closely with LSA through a Memorandum of Understanding (Luxembourg 2017b). Luxembourg also had at least five observers, which although not driving conversation, demonstrated their relative level of interest (The Hague, 2019).

2.6 UNCOPUOS legal subcommittee space resources working group

The UNCOPUOS acts through the United Nations Office for Outer Space Affairs (UNOOSA) with annual meetings of its 95 member states (UNOOSA, 2023). The LSC holds separate annual meetings regarding outer space legal affairs, through which most debates and conversations regarding space resource utilization are conducted. Responding to proposals following informal consultations, the LSC during its 2022 session created the Working Group on the Legal Aspects of Space Resource Activity (ibid). The creation of this working group is a significant marker – prior to this point, COPUOS member nations were implicitly satisfied with non-binding principles. Now, the working group’s mandate represents a change, in that there is an explicit acknowledgement that the OST is not sufficient for managing current space resource activities, and now member states are favoring a new instrument of governance.

The call for initial input from the working group leadership was met with formal responses from 18 countries and seven observer organizations (UNOOSA, 2023). Luxembourg’s response is useful in illustrating their vision, interest, and potential influence within this field. Building heavily from their SpaceResources.lu initiative, Luxembourg outlines what they have done since 2016 with respect to the five pillars of their initiative (Luxembourg, 2022). They describe their own working definition of space resources, their view of current international space law, and the considerations behind their own national laws. The key basis for their law lies in the distinction between outer space resources that may lie within celestial bodies, and the celestial bodies themselves. In promoting relevant factors for the working group, they lean on the principle of adaptive governance to address priority areas of individual rights recognition for space resources, and interference considerations. The goal should be to achieve a transparent framework to bound all actors to the same rules that is “responsible yet permissive,” created with the widest possible international consensus (ibid). They are also very clear in their commitment to the building blocks created in the Hague

working group (of which they were an active member), as well as the Artemis Accords (to which they were a founding signatory). They are prompt in pointing out their belief that both the building blocks and Artemis Accords are currently the most valuable tools to advance effective discussions at the UN level, but also careful to underline how specifically the Artemis Accords are a completely separate political declaration meant to enhance UN efforts, rather than supplant them (ibid). To emphasize the point further, they restate their commitment to engagement within UNCOPUOS and the working group mandate.

2.7 Other organizations and working groups

There are numerous other organizations and working groups represented at the SRW conference that actively participate in the space resources discussion. The predominant interests leaned toward commercial, technical, and business aspects, with most focused on the near-term operational environment on the moon. However, almost all had vested interest and focus areas that directly tied into legal and regulatory aspects. These included the Moon Village association with their Global Expert Group on Sustainable Lunar Activities with an adaptive governance working group, the Lunar Surface Innovation Consortium with ties to NASA and Johns Hopkins University Applied Physics Laboratory (JHUAPL), the International Lunar Resource Evaluation Campaign, the Colorado School of Mines Space Resources Graduate Program, NASA's In Situ Resource Utilization (ISRU) group, and the Euro2Moon organization. Although the specific objectives, expertise, team composition, and geographic locations were diverse, they all had several commonalities: they wanted a reliable framework under which to conduct or promote space resource activities, and they were represented at the SRW conference. For debates at the UN level, these organizations at best can be observers or consultants to state parties, but at a conference such as SRW they can actually drive discourse. Moreover, through casual observation at the conference, there was an interesting individual dynamic at play between representatives of the various diverse organizations with the aforementioned shared interest. These individuals tended to already know one another, as in there seemed to be a specific set of "power players" who were regarded as having a certain gravity, or perhaps gatekeepers through which truly relevant discourse passed.

Additionally, Luxembourg was instrumental in working with the UN to establish the Space Law for New Space Actors project in order to assist new spacefaring nations with

national legislative efforts (Calmes et al., 2021). Recognizing the need for integrating the space sector in pursuit of the Sustainable Development Goals, the UNOOSA established this project with the intent of building capacity in new and emerging spacefaring nations, specifically by advising the requesting member states on drafting national laws in concordance with the prevailing international frameworks (UNOOSA, 2019). The initiation of this project was possible through a funding agreement between UNOOSA and Luxembourg's Ministry of Development Cooperation and Humanitarian Affairs (ibid). Although it is unclear what exact level of influence Luxembourg holds in steering this project, as the initiator and one of only five donor stakeholder nations it is reasonable to assume that their effect is significant.

2.8 Research and industry relationships

It is important to understand how the government of Luxembourg, not only through the LSA but also in conjunction with other organizations, interacts with commercial space resource enterprises and the research and development (R&D) sector both domestically and internationally. Within Luxembourg, there is a very strong relationship with both research and industry. The government of Luxembourg has been a significant shareholder of SES since 1985, demonstrating a successful example of a public-private joint venture that they hope to continue into the space resources sector (Luxembourg, 2018b; SES, 2023). As of 2022, Luxembourg listed over 65 domestic companies (or transnational companies with operations in Luxembourg) and 8 separate research organizations in their space industry directory (LSA, 2022b). A visual representation of this, aligned by sector and grouped by domain of activity, is shown in Figure 1 below.

This visual makes several important points. First, it shows the wide range and significant amount of commercial development in the general space industry in Luxembourg within a relatively short period of time. Second, there is significant crossover in domains of activity, as shown by the majority listed under cross-domain and the number of companies listed under several domain areas. While the segments representing solely space resources and exploration are relatively small at present, the crossover influence is significant because space resource exploration and utilization operations naturally build upon a foundation of many other technologies. There is significant blending within the industry regarding mission area, scope, and benefits. Although specific companies with space resource focus can be identified, the fact

is that the space industry is closely tied together through supporting technology applications and enablers. Any space resource utilization mission would rely on technologies developed in areas of propulsion, communication, and navigation, in addition to the obvious novel developments in resource collection, transformation, and transportation. For example, a mission to explore resource potential on the moon – such as the ispace lunar mission (inspace, 2023) – would rely on outsourcing to already-established launch, telecommunications, and navigation capabilities to achieve success. Expeditions led by national governments (or unions) utilize industry contracts to tie capabilities together; in contrast, commercially-led missions must forge partnerships and agreements to achieve the full scale of required capabilities. Luxembourg, in essence, cannot lead an expedition with their space program in the same way that large space powers (such as the US, Russia, and China) have historically done, but instead they can foster a favorable environment for the growth of these necessary commercial partnerships to proceed with missions of their own.

Luxembourg has many examples of domestic support projects in support of these research and industry relationships in the space resource field. Several prominent ones include the national business incubator Technoport, cooperation with LIST, the development of the Luxembourg Space Cluster, and the establishment of the space resources master’s program at the University of Luxembourg (Calmes et al., 2021). Domestic funding instruments are a critical focus as well, including LuxIMPULSE funding and cooperation with the European Investment Bank (EIB) via the European Investment Advisory Hub (LSA, 2019c). According to EIB, Luxembourg utilizes an “agile and mission-oriented” strategy for investment options to fund strategic space resource projects (Luxembourg; EIB, 2017)

Internationally, most R&D efforts flow within a European sphere through ESRI, while commercial operations are coordinated through LSA and the government of Luxembourg directly. Since the launch of the SpaceResources.lu initiative, several US-based companies have signed Memorandums of Understanding (MOU) for commercial cooperation in the space resources sector. These include Planetary Resources (of which the government of Luxembourg is a minority shareholder) and Deep Space Industries (Luxembourg, 2016c). According to members of the advisory board, the arrival of these US companies demonstrates the relevance of Luxembourg in this field, which builds off a “triple legacy” of finance, mining, and space industries (ibid). The hope from the outset was for Luxembourg to become a “Silicon Valley for space resources,” and companies such as Kleos Space have praised Luxembourg for their commercially-focused strategy and their responsiveness to ventures through a “shallow

bureaucracy” (Luxembourg, 2016c and 2017c). One of the most active industry partners is ispace, a Japanese robotic exploration company that signed an MoU with Luxembourg in 2017 (Luxembourg, 2017b). After choosing Luxembourg as their base of European operations, they have been very active in their moon-focused operations. Globally, it seems almost a guarantee that any current commercial space resource-oriented operational mission involves companies that have ties to Luxembourg.

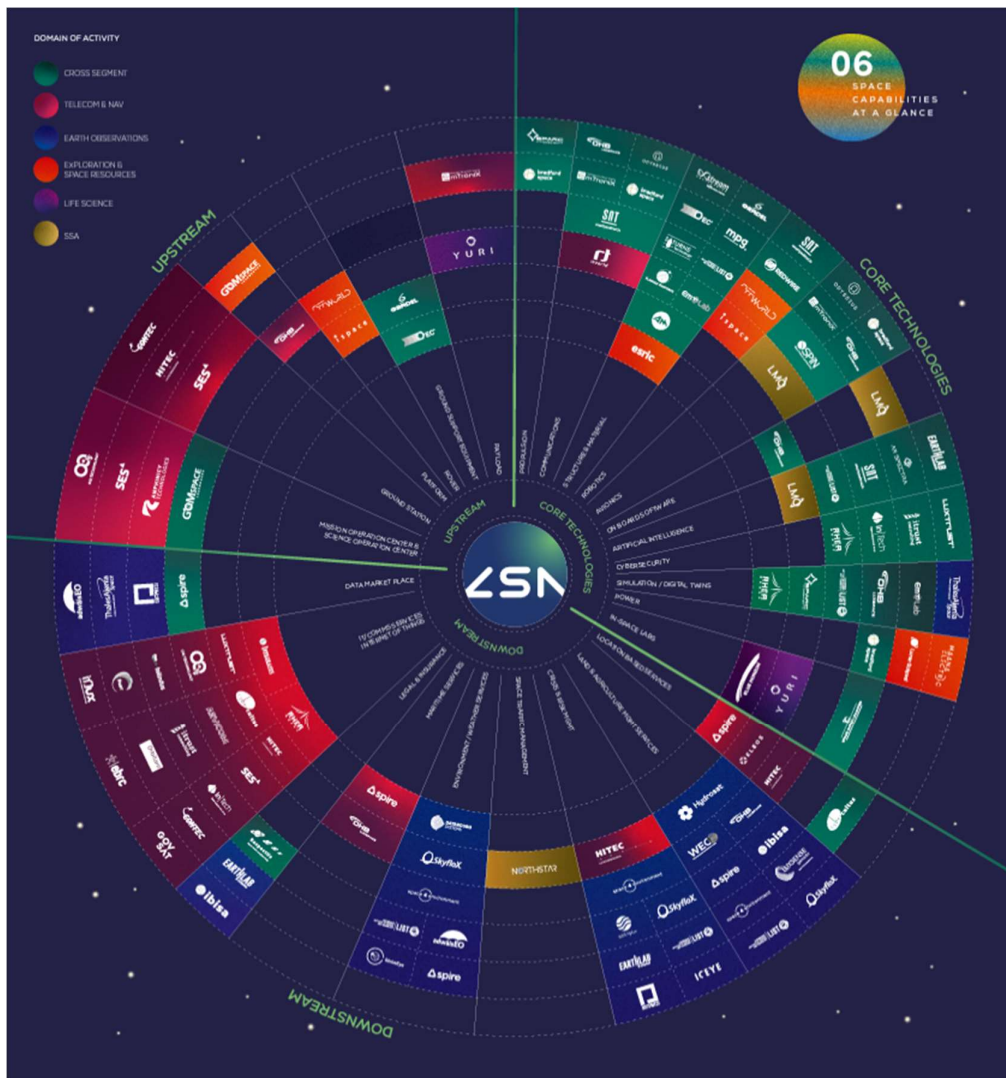


Figure 1. Luxembourg Commercial Space Capabilities (LSA, 2022b)

Chapter 3: Luxembourg Case Study – Analysis

3.1 Applied theoretical framework

The theoretical framework constructed in Chapter 1 will now be applied to analyze the data collected from the Luxembourg case. The country of Luxembourg has throughout its recent history realized the importance of international collaboration, and more specifically the European project. The small state and its people recognize that their existence and independence is fragile and has been challenged frequently. They justifiably feel that they must evolve their economy based on specific strengths that other nations may not be able to realize, or at least in an efficient manner. Although there was a period of benefit through the exploitation of natural resources, the physical industrial base is obviously very limited, and cannot hope to compete with the rest of Europe, much less the world. Even in joining economic forces with Europe, they recognize that to have influence and continue to enhance their own prosperity, they must have a competitive niche specialty.

From a realist perspective, it is notable that Luxembourg has assessed a potential area of specialization from which it can gain considerable economic benefits. Overall space technology development is already quite globally dispersed, and even within Europe under the auspices of national space programs harmonized through ESA, there has been tremendous progress. Although a leader in the satellite telecommunications fields for several decades through SES, they have been surpassed by a number of nations and transnational corporations in this area. It seems that Luxembourg made a realistic assessment of their strengths in the business, financial, legal, technology, and innovation realms, saw an opportunity with the US promotion of their space resource law in 2015, and decided to get out in front of the developing market by establishing themselves as the go-to center for all things related to space resource utilization. In the last seven years, it appears that they have at least accomplished this within the European scope.

A key topic that arose while at the SRW conference during interviews and as an active observer, and one that perhaps drives a more critical analysis, is the role of individual actors within Luxembourg in shaping their current space resource policy and enterprise. When assessing regimes from power-based approaches, the tendency is to consider the nation-state as the primary actor and decision-maker. This holds for interest-based approaches as well, but

the importance of commercial enterprises and international organizations is elevated. Only through the knowledge-based approaches, however, are the relative influences of individual actors raised to a similar level of consideration. From the Luxembourg case study, during the critical formative years of the SpaceResources.lu initiative, the space resource law, and the creation of the LSA, there were key figures that featured repeatedly through press releases. For example, the Minister of the Economy at the time, Etienne Schneider, is the focal point for policy formation and press statements, and current actors within LSA confirm that his vision and personality was a driving force in obtaining key milestone events (Luxembourg, 2016a, 2016b, and 2016c). Additionally, he continues to hold influence as a member of the multi-national Advisory Board on Space Resources (LSA, 2020).

Another element of consideration is trust. To have a functional policy that truly influences an international regime in any area, the element of trust carries significant weight. In this case, three forms of most importance are considered: the trust of Luxembourg's people towards its government, the trust of corporations (both domestic and international) towards Luxembourg policy, and the trust of the global society of nations towards the state of Luxembourg. For the first form, the trust of a nation's people in their government, specifically that the policy priorities of that government roughly line up with the majority view and that those policies will produce tangible benefits to the general population, is vital for the cohesion and continuity of long-term political endeavors. The population statistics mentioned previously creates an interesting political situation, where elected officials who presumably want to seek re-election would only have to cater to a fraction of the national population. At the same time, however, it is assumed that these officials recognize the vital importance of the foreign national population and commuters to a functioning workforce and growth of the economy, and therefore cater to them in the sense that they support attractive policies that promote foreign workforces, commercial bases, and investment (which, in turn, supports the national population). For political officials, therefore, public trust is a definite balancing act. In the realm of space resources, it is incumbent upon the decision-makers to gain the trust of this varied population that the required prioritization and investment in an unproven area will be worth the risk. The various public outreach programs headed by LSA mentioned previously are direct attempts to build this domestic trust.

The second form concerns the trust of corporations, both domestic and international, in the overall organization of Luxembourg – specifically, the trust that financial and legal support will remain consistent through a reasonable period of future operations, in order to justify initial

investment and assumption of risk. This confidence of support can come from several organizations, including government policies, official agencies, and funding instruments. Together, these represent the sphere of public-private partnerships (PPP) that are rapidly rising to prominence in the space resources field. At their core, this is what initiatives such as the SRW conference are targeting – the building of trust from global startup companies that Luxembourg, through its supportive government and associated organizations, will be at the forefront of the space resource utilization industry development. Here, the historical performance of Luxembourg in business and innovation-related fields is beneficial and sets a baseline level of confidence for commercial investment. Luxembourg advertises to private sector companies by offering “financial regulatory systems” that support investment and venture capital “within a wider European framework” (LSA, 2019c).

The final form regards the trust among the wider global community in the policy actions of Luxembourg. The importance of this element with regards to influencing the space resource utilization regime, and specifically the level of Luxembourg’s desire to enhance it, is much more debatable. At the outset, Luxembourg would seem to have to fight against historical international perception. The intents, motivations, and potential future actions of a country with such a high GDP per capita and previous investigations into banking and finance practices would naturally be questioned by the larger international community, particularly nations that make up the Global South. It is arguable that Luxembourg can still be a significant influence for controlling international space resource policy regardless, but to truly be recognized and gain a consensus of global recognition as a leader in this field, they must attempt to bridge this trust element. Within the SpaceResources.lu initiative, the LSA has created a board of advisors, currently consisting of nine international experts from five countries in fields of space science and technology, economic and government policy, and senior organizational management (LSA, 2020). Additionally, Luxembourg was one of the original signatories of the Artemis Accords spearheaded by the US (Calmes et al., 2021). This effort is slowly gaining traction within the international community, but is doubtful to gain certain major elements of support (particularly from China and Russia) because of the perception of US unilateral construction.

Perhaps most significantly in this regard, Luxembourg is a very active participant in the Working Group on the Legal Aspects of Space Resource Activity, which was created during the 2022 session of the LSC of the UNCOPUOS (UNOOSA, 2023). Upon its creation, the working group was given a five-year mandate to “assess the benefits of further development of such activities, including by way of additional international governance instruments” (ibid). It

is difficult to quantify the specific influence of Luxembourg on the actual creation of this committee, but it would be hard to argue that the timing of the national laws from the US and Luxembourg, in addition to projects pursued by the SpaceResources.lu initiative, did not press the general consensus that the current regime was insufficient. Additionally, Luxembourg's influence within the working group, displayed through its survey response and current proposals for actionable items, seems to be quite significant especially considering its size. From observations at the SRW conference, it is apparent that the demand for an international legal framework to operate under is paramount for companies looking to make significant investments in the space resource exploitation field – otherwise, their risk would be enormous. However, there exists a general pessimism for the typical timelines and potential ambiguity of results from such a working group, which is but one of several within the LSC of UNCOPUOS. Other nations simply might not place the same level of priority that Luxembourg does on this issue, or do not want to be pressured into conceding to terms based on an external timeline. Cognizant of this, it seems that Luxembourg is thus hedging its bets – visibly and definitively leading a UN-based solution, while continuing to pursue its own national legal framework to foster commercial enterprise and innovation that may eventually drive a de facto regime that sets behavioral norms for space resource utilization through informal consensus.

3.2 Comparisons to similar resource debates

To enhance the analysis of what influence Luxembourg has on shaping the space resource utilization regime, brief comparisons to other debates with similar characteristics can be made, with specific interest on how Luxembourg has approached controlling regimes in those areas. The most applicable comparisons are to deep seabed mining, Antarctica, and space-based telecommunications. Each of these has distinct characteristics, but the lessons pulled from evaluating their governing regimes and what views and influences Luxembourg has on them can broaden the understanding of the space resource investigation.

3.2.1 Seabed mining

An often-made comparison is in the area of deep seabed mining (DSM). Currently DSM resources are controlled by the International Seabed Authority (ISA), which was created through the 1982 UN Convention on the Law of the Sea (UNCLOS) and the 1994 Agreement

on Implementation (ISA, 2023). It is composed of the 167 state signatories of these agreements, plus the EU. Notably, the US is not a signatory (despite pushing for many changes made in the 1994 Agreement), but is an active observer. Part XI, section 2 of UNCLOS defines “The Area” of interest outside national jurisdiction, and states that the resources therein are “the common heritage of mankind” (UN, 1982). Moreover, the economic benefits are to be shared equitably, with special attention to developing states. Although the ISA has approved over a dozen exploratory contracts to date, it has yet to approve an operational commercial mining contract (Banet, 2020). Based on the types of materials found in explored areas, namely ones that are critical for battery production, there is mounting pressure from commercial organizations to authorize contracts utilizing green energy arguments. The main criticism against contract approval comes from various environmental groups, arguing that there exists an unquantified threat to the ocean environment. Additionally, there is criticism about the lack of transparency for decision-making within the organization and potential conflicts of interest (ibid).

In making a comparison to this area, the important questions are what lessons can be learned and applied to a potential space resource utilization regime, and what key differences exist between the deep seabed environment and that of outer space. One argument is to install a similar agreement and organizational body to govern space resources (Koch, 2018: 1). The criticisms against such an arrangement are vast, namely the lack of any approved mining contracts from ISA presupposes that there would also be a lack of commercial space resource exploitation contracts, thus stifling potential investment even further. Additionally, states who lead research and development for operations in space generally balk at the idea of equitable economic benefit sharing and technology transfer. With this in mind, why then would so many countries agree to such provisions in UNCLOS, but not for a potential space resource regime? It is likely this can be explained by looking at UNCLOS in context which is a rather large agreement (of which the mining aspect was simply a part) made during a time of transition towards the end of the Cold War. Or perhaps nations have assessed that the potential benefits gained from relatively unrestricted DSM do not outweigh those of having a stable controlling force in charge of approving operations. Space, on the other hand, presents an arena of more vast opportunities, prestige, and security concerns. It is hard to make an investment argument for DSM other than the direct materials benefit for manufacturing, whereas space resource utilization investment would be essential for supporting future exploration operations and developing the previously described sustainable space ecosystem. Additionally, space resources do not present the same level of criticism from environmental organizations as DSM

due to differences in proximity – in other words, an over-exploitation or a catastrophic accident in space does not, at the moment, present the same Earth-based environmental risks as DSM.

Since there is not a similar push for investment in a sustainable commercial deep-sea ecosystem, it appears likely that DSM will continue along its current path of unrealized potential and deficient investment. It is telling that Luxembourg is putting so much effort into the space resource industry, but nothing of note in the area of DSM. There are plenty of crossover technological and expertise areas between DSM and space resource utilization, but the key difference lies in the actual potential for operations and shaping of legal and regulatory frameworks. Luxembourg does not see itself as having meaningful influence in the DSM field, nor does it foresee a favorable benefit versus risk assessment to justify application of valuable effort. For the space resource field, however, the opposite is true – they have identified an area on which they can have outsized influence, and there is still regulatory flexibility through which they can shape a favorable outcome.

3.2.2 Antarctica

Another area of useful comparison is Antarctica. The current regime governing the use of the continent is the Antarctic Treaty System (ATS), which encompasses the main treaty signed in 1959 and several associated agreements (ATS, 2023). The most important provisions include only using Antarctica for peaceful and scientific purposes, the free exchange of scientific data, and the maintenance of the status quo for sovereignty claims. The character of the agreement is unique, in that some signatories have claims that are not recognized by any other party, yet these claims are not specifically refuted or affirmed in the treaty. Additionally, there are only 12 signatories (consisting of countries that had active scientific operations at the time of original treaty negotiation), and 56 total parties (ibid). Despite limited membership and the creation of the mechanism outside of the UN, the principles of military exclusion and barring of commercialization seem to hold broad international respect. In historical context, the main driving force for the original treaty were Cold War concerns between the US and the USSR, upholding the theory of preventing the other side from being able to utilize an element of power if they are unable to take advantage themselves.

Therefore, it is critical to identify if space territories could be treated in such a manner, or what key differences exist to prevent such an arrangement. The Protocol on Environmental

Protection (the Madrid Protocol) contains the specific ban on mining operations in Antarctica (ibid). The objectives codified demonstrate a commitment to avoiding adverse environmental effects, treating Antarctica along the common heritage of mankind principle. There exist known resources in the continent, but again, perhaps similar to DSM, countries have assessed that the benefits of pursuing these resources do not outweigh the costs and risks, both economic and political. Antarctica appears to be a very specific case with a defined set of motivating factors and limitations that would make a similar arrangement for space resources unlikely. For its part, Luxembourg is not yet a party to the treaty, but has recently submitted an application for associate membership in the Scientific Committee on Antarctic Research (SCAR), which could lead to potential future party membership in the treaty itself (SCAR, 2022). There are several interest areas for motivation, with the most notable one being for extreme environment testing for space resource utilization technology development (ibid). Here, Luxembourg is seen again realizing there is no room for shaping the Antarctic regime, but also taking advantage of the current organization for the purposes of development in other areas.

3.2.3 Space-based telecommunications

The field of telecommunications standards and regulations, specifically pertaining to satellite frequency allocation and orbit management, presents a worthwhile comparison to the space resource utilization debate. The International Telecommunication Union (ITU), as a specialized agency under the UN, performs many coordinating and standardizing functions for international telecommunications. Of applicable interest, they control the assignment of satellite orbits and their associated radio frequency (RF) spectrum allocation to prevent physical and RF interference (ITU, 2023). It holds immense international participation (essentially all the member states of the UN) and wields significant power and influence in the satellite communications domain.

Under a certain definition, specific orbits and locations within them can be considered a type of space resource – that is, an area that exists in outer space that can be occupied and implies some sort of ownership. As already described, for the purposes of this research the space resources of interest do not include such a definition. That does not reduce their importance by any means – as described in the theoretical framework chapter, such orbits and positions can be equated to strategic chokepoints of immense value in the outer space environment – and thus without sufficient management and consensus, they present an area of

international friction. Separating these resources through definition means that they should be treated differently and by separate governing regulations for the most effective management.

Although these significant differences exist, there are reasonable arguments that an ITU-style arrangement for a regime controlling space resource utilization would be the best available solution at present. Despite its large membership, it has become an agile agency with a commercial orientation and technology focus. Membership in the ITU not only consists of the member states, but also many businesses and academic institutions (ITU, 2023). Their objectives and mandates are forward-looking with the intent of facilitating global telecommunications. Their influence over satellite communications has not seemed to stifle the immense explosion in New Space enterprise in this field – arguably, it has enhanced it and made it possible. Such would be the hope of space resource utilization proponents in the shaping of an associated regime: to ensure coordination and that everyone is playing by the same rules so that a full, sustainable ecosystem can be realized. Of course, the legal and physical complexities are more immense for space resource governance, but the basic arguments for establishing an adaptive organization with widespread membership and a defined mandate could still hold.

Luxembourg fits into an interesting position when assessing this comparison. Their historic development in the telecommunications field has cemented their interest and support, however their current influence appears to be limited and overtaken by industry giants. They likely view the ITU as a stabilizing force in the industry, able to ensure access and facilitate development while not stifling commercial enterprise. By positioning themselves at the front of space resources development, they perhaps see the opportunity to enact a similar regime, but with more initial influence to shape the final outcome to best meet their objectives.

3.3 Comparisons to other space programs

While detailed comparison to other national strategies and actions in the space resource utilization field would be a worthwhile endeavor to fully understand and evaluate the questions of interest with respect to Luxembourg, it would simply be too large of an undertaking for the scope of this research. However, it is necessary to at least perform a quick sampling of relevant national space actors for comparison and to build a picture of Luxembourg's influence.

Examples of the US, China, Russia, the EU, the UAE, and Japan were chosen based on their relevance in the space resource utilization debate.

First, it is useful to connect the theoretical framework in the context of a national space program. Any country can have a space program (typically in the form of a space agency), regardless of its actual level of space operations or its relative spacepower status. Although there is a large public relations component (with expected controlled messaging), looking at how a particular nation's space program is structured, what operations that program is actively carrying out, and how the government enacts policy through that program is an essential starting point for a comparison. Following this, the legislative and policy actions of the respective government can be assessed with respect to its own geopolitical situation and then compared, however briefly, to the approaches Luxembourg has taken. These basic comparisons help to better illustrate the context of Luxembourg's influence in the area of international space resource utilization policy.

3.3.1 United States

Meaningful debate regarding any space-related field will likely contain at least some level of US examination for comparison. Their overall space strategy is formally captured in National Space Strategy documents, which are typically updated with each new presidential administration. There are strong ties with national security, the commercial sector, and international partnership.

Specific stances on space resource utilization policy have been well-voiced, as evidenced through the SPACE Act of 2015, current space strategy documents, the Artemis Accords, and inputs for the UN working group (US 2015, 2020b, and 2023; NASA, 2020). Although they continue to be a leading participant in discourse at the UN level, it is clear they believe the current pace of commercial operations will far outrun the ability of the UN to generate a working framework. Therefore, they desire to push for a de facto working arrangement in the meantime, not only to provide a suitable environment for operations, but also to drive the discussion and potentially create norms through customary action.

It is apparent through review of national laws, press releases, and interviews that the space resource utilization policy of Luxembourg aligns most closely with the US (Luxembourg 2019 and 2022; US 2023). However, the reasoning behind this policy, and the overall strategy

for implementation and long-term goals, are distinct in several ways. The US has the capacity, which it has demonstrated, to formulate unilateral policy (through the Artemis Accords) and generate its own operational missions through NASA and domestic commercial partnerships. The US recognizes the long-term value of space resource utilization to support a sustainable space ecosystem with lasting economic benefits, and places a premium on leadership in order to utilize its spacepower to establish norms. Their priority is on accelerating the required technologies and capabilities for the operational missions, with considerably less attention on the international discourse on establishing a legal framework for such activities. Establishing broad international acceptance of the Artemis Accords appears to be an attempt to bridge this divide, but it seems doubtful that the actual results of such efforts will change the manner in which they proceed.

3.3.2 China

There exists a great deal of external literature regarding China's likely space ambitions, but very limited internal primary sources when it comes to their stated position on space resource utilization policy. The face of China's policy can be found most recently in the China National Space Administration (CNSA) space perspectives white paper, which stress the peaceful nature of activities with a focus on achieving benefit for all mankind, as well as the primacy of international cooperation (CNSA, 2022). Their actions, as well as public statements by their President Xi Jinping, illustrate a more complete picture of their strategy, focused on national development in line with the Belt and Road Initiative, national security and military enhancement, and a re-balancing of traditional space power structure (Julienne, 2021). Although the CNSA is an attempted equivalent to national civilian space programs of other countries, most of the power and decision influence is held through the State Administration for Science, Technology and Industry for National Defense (SASTIND) and the People's Liberation Army (PLA) (Solomone, 2013: 20; Julienne, 2021). Commercial liberalization is very limited due to government Communist Party control over the aerospace sector, with state-owned organizations such as China Aerospace Science and Technology Corporation (CASC) having near total control compared to private companies (Solomone, 2013: 21; Julienne, 2021). Thus, the driving factors for Chinese space sector development are much more nationalistic with regards to realist power paradigms, with commercialization only a driver inasmuch as it directly benefits state development.

With specific regard to the utilization of space resources, it appears that China is intentionally quiet, as if pursuing a wait-and-see strategy (Julienne, 2021: 6). It is likely that their views mostly align with those of the US, but they are obviously not keen on the unilateral pursuits of the US through the Artemis Accords. For near-term space resource activities, China is focused primarily on lunar excursions. They joined with Russia for the International Lunar Research Station (ILRS), with open invitation for any international partners (CNSA, 2021). Recently, however, Russia's commitment has waned in favor of other priorities, with China taking the clear leading role. While offering an operational plan for their lunar exploits, China is mostly quiet on the actual legal stance on lunar resource status and utilization, other than being committed to finding a solution through UN methods. They have not brought forth their own legal framework, nor do they appear to be pressing the international community to adopt something specific, and they have not submitted a formal written input to the UNCOPUOS working group. They appear content to gauge the international reaction to the approaches of the US and Luxembourg, then either follow suit in their own way or criticize based on what best allows them to increase their relative spacepower. Because their national exploration program is lagging and there is not a pressured push from private enterprise, they do not feel rushed to lead the charge in directing international space resource policy. However, limited organizations, academics, and enterprises are working with Luxembourg with regards to their space resources initiatives (Luxembourg, 2018a).

3.3.3 Russia

Russia as a spacepower is in a period of transition and apparent decline. While still holding crucial influence in areas such as launcher production and satellite technology, it is struggling to cope with a changing dynamic of international competition from private enterprise (Vidal, 2021). Their influence in the European sphere, however, is still particularly substantial, especially in terms of orbital launcher services. Larger international dynamics, particularly Western sanctions and distrust following multiple phases of Ukrainian conflict, have put cooperation opportunities at risk and perhaps foreshadow a continued decline in the space sector.

Russia does not disguise its opposition to the US path regarding international space resource utilization policy. They have advocated strongly in favor of negotiating new rules and regulations within the UN framework, essentially producing an updated treaty, while

denouncing unilateral efforts such as those taken by the US through the Artemis Accords (Julienne, 2021: 35). Ideally, they would like to stop any efforts by either national or commercial organizations to exploit space resources until such a treaty is in place. This strategy makes sense considering their relative decline in the space sector – recognizing their lag in ability to exploit space resources operationally, it is more beneficial to stall other powers from taking advantage. Additionally, there is no evidence of cooperation with Luxembourg through space resources initiatives, as that might amount to working towards solutions outside of the UN framework and giving tacit approval to the chosen US path. Although cooperation with the US through Artemis may have been in their interests, it simply was not a realistic option to partner with the US in this regard in light of current national strategic conflicts and priorities. Strategic cooperation with China appears to have been the most logical next best option, specifically through the ILRS. In this current period of transition, however, it seems likely that their commitment to such a project will wane in favor of consolidating their strengths. Through their contribution to the UNCOPUOS space resources working group, it appears Russia is content to leave space resource utilization policy as a second-tier priority, while leveraging position and power through the UN to stall other power's competitive advantages (Russia, 2023). It remains to be seen if they will be an active contributor to creating a UN framework, or intentionally undermine efforts to enact a workable solution.

3.3.4 European Union

Although some useful comparisons could be made with individual European nations, it is of more value (at least within the scope of this research) to cover the European Union as a unit, especially considering the organization's ability to set policy. However, with regards to space policy, this becomes tricky due to the institutional relationship between the EU, ESA, and member states (and for security matters, NATO). Additionally, EU and ESA membership are not congruent, and certainly there are states outside of these organizations that are still considered part of the European sphere. For the purposes of this comparative analysis, the EU and ESA can be treated as separate entities that hold sufficient influence over the space resource utilization policies of their respective members, and thus a useful comparison can be performed between their stated positions and those of Luxembourg. It is of course important to note the Luxembourg is a member of both.

The EU does have an official Space Programme, focusing on missions of Earth observation, navigation, and secure communication (European Commission, 2022). It aims to channel investment and resources into projects that promote a competitive space ecosystem that meets the needs of its member states. Applied space technologies through specific components such as the Copernicus observation system, Galileo navigation system, and a network of space situational awareness tools are used as enablers to benefit the European population and enhance the EU as a global actor (ibid). Their missions generally align and promote the UN Sustainability Goals, with specific technology applications utilized to pursue various objectives. While generally supporting the overall EU space industry and the European “New Space” ecosystem, the EU is otherwise quiet regarding specific policy regarding space resource utilization. This is due to the limited mandate and competencies of what the Union can do, with the obvious difficulty of having multiple differing views between the various member states. In theory, the EU as a unit is in favor of promoting the commercialization of space in a manner that is sustainable and peaceful, in-line with international law and utilizing UN channels to debate and update that body of law as required. The EU seems to have a bit of a softening effect on any nationalistic tendencies of member states in the space realm, promoting the idea that the best way to enhance a competitive space industry in Europe is through coordinated effort. It seems likely that the EU Space Programme will eventually put forth a unified policy with regards to space resource utilization, but that it will happen after any action taken at the UN level as a resort of the working group in the LSC.

The ESA, on the other hand, does have published views on the space resource utilization debate. The ESA has similar functions and actions as a national space agency, but instead of replacing the agencies of individual member states, it tries to act as a harmonizer to coordinate efforts between them. This allows national governments to utilize their agencies in pursuit of their own objectives, while pooling resources and talents to facilitate more complex projects. The ESA Space Resources Strategy was released in 2019, which lays out details regarding the organizations vision for space resource exploitation technologies and missions through 2030 (ESA, 2019). As a more technical-based organization, this strategy focuses on outlining their specific assumptions about what resources will be of most value in this timeframe. The moon, with specific applications for propellant and life-support generation, are the priorities. They acknowledge at the end of their assumptions that “there is no international consensus regarding the legality of space resource utilization and exploitation under international law, nor are there international legal norms on the legal status of space resources

or their governance” (ESA, 2019). Luxembourg seems to recognize the intricacies of working within the framework of both of these organizations, aligning with their overarching views while also seizing initiative and leveraging its strengths to gather enhanced European support to enact more influence on a global scale.

3.3.5 United Arab Emirates

The UAE case is interesting in that their behavior seems to match that of Luxembourg in several respects. The main difference, however, is that they actually possess the ability and desire to execute national space exploration missions. They appear to be pursuing a similar line of effort with respect to clarifying space law at the national level, but for different end goals. Their space law of 2019 followed shortly behind that of Luxembourg and included provisions for defining ownership of space objects, making them only the third country to have such a law (UAE, 2019). However, this was only a small section of a much more expansive legislation covering their entire space program. In comparison, Luxembourg focused its initial legislative effort on clarifying the space resource issue, then followed up with a separate act codifying other issues. The UAE’s action to address multiple issues with the single act illustrated their desire to solidify their position as the predominant space actor in the Middle East and bring them recognition among the global space powers.

Of the main principles mentioned in their national space policy, the most apt are the support of national interests (namely security and stability) and the diversification of their economy (UAE, 2016). UAE’s wealth is based on a narrow industry with little room for flexibility that is very sensitive to global demands. Thus, a logical long-term strategic outlook would involve diversification options in growing fields that align with their potential strengths. It would appear that the UAE recognizes its ability to fill a regional spacepower vacuum, and also potentially serve as a viable option for international commercial enterprises in the space sector that are seeking alternatives to the US, China, and the EU. As opposed to Luxembourg, there is a significant influence of national pride, perceived need for strategic autonomy, and desire to take a seat at the international stage through the use of more traditional forms of spacepower.

3.3.6 Japan

The example of ispace illustrates Japan’s position on space resource utilization policy. In 2008, Japan enacted their Basic Space Law which led to the shaping of priorities in space, a creation of a space plan, and establishment of their Strategic Headquarters for Space Development (Japan, 2022). In 2021, they enacted the Space Resources Act, which clearly defined ownership of space resources for those that obtained the permit to exploit them, making them the fourth nation to have such a law behind the US, Luxembourg, and the UAE (Japan, 2021).

The key distinction, however, is then ispace immediately set about on an attempt to utilize this framework in operation. The Hakuto R Mission 1 had the objective of landing on the moon and returning a lunar sample to Earth – nothing that has not been performed previously by other nations, but this was to be the first time a commercial company (rather than a national agency) would carry out such a mission, and more importantly, the plan was to then sell this sample to NASA (ispace, 2023). This would have created the first commercial transaction of a natural space resource under such a legal framework – a major symbolic, if not technological, milestone. The ispace company has very close ties with LSA and was well-represented at the SRW conference. In fact, their landing attempt was to take place the following week, with many discussions held regarding the mission and its implications. Unfortunately, this attempt ended in failure, with the vehicle crashing during its lunar landing phase.³

3.4 Assessing influence

At the end of the analysis, the important determination is what level of influence does Luxembourg have on the shaping of the regime governing space resources. What appears clear is that, relative to its population size, Luxembourg wields an immense amount of power and influence in the international space resources utilization discussion. This characteristic holds across several other areas as well, such as GDP, European Union governance, international law, finance, and telecommunications sectors. Much of this can be explained through

³ Although unrelated but along a similar vein, during the SRW there was the first attempted orbital launch of SpaceX’s Starship spacecraft, which currently holds a contract as the landing vehicle for the Artemis III mission for the first return of humans to the moon. This mission also ended in “failure,” although achieved measurable success in the eyes of SpaceX, further illustrating the mindsets and risks of “New Space” commercial enterprises.

geopolitical characteristics of Luxembourg, how its government operates, and what their citizens value. As an agile organization with limited objectives, plus the ability to focus resources and effort due to a smaller set of relevant issues and challenges compared to larger countries, Luxembourg has managed to leverage its strengths particularly well in the field of space resource utilization. They are able to combine their expertise in the areas of business development, mining, and international law to seize an opportunity to be at least a European leader in this realm, if not a global one.

This of course begs the more important question of assessing their absolute influence. Luxembourg's relative power within the EU community has undoubtedly allowed them to take the reins as a European hub for space resource industry development, and thus become a de facto voice for Europe in shaping a controlling regime. Luxembourg seems to downplay their absolute global influence, instead mostly deferring to the US and claiming to follow their lead, but this (whether intentionally or not) somewhat disguises their true power. Although they have aligned with the US on most policies and agreements, their focused ability to forge commercial partnerships from anywhere and their open approach to international cooperation (mostly out of necessity) gives them an element of influence over the US. Additionally, although there is still much debate among the European community, Luxembourg seems to have mostly aligned voices towards a common viewpoint, thus giving the EU/ESA, and by extension Luxembourg directly, greater influence in shaping this regime. Their outreach to developing space programs, regardless of motivation, also suggests a forward-looking mindset to building and enhancing power in this area. Because changes to the regime are still actively in-progress, a decisive assessment of Luxembourg's absolute influence in shaping that change is difficult. However, based on the available evidence, in the last seven years they are only second behind the United States in driving the current course of action and debate regarding the legal framework for space resource utilization. Regardless of circumstance and implications, this is an unquestionably impressive endeavor.

In addressing the question of how Luxembourg influences the space resource utilization regime, a fundamentally different but related question has been intentionally avoided: simply put, is this a good thing? Of course, there are many elements to this, from aspects of ethics, global justice, and what is actually the "best" course for the future of human civilization. Those elements were illuminated through the theoretical framework to help explain causes and motivations in the Luxembourg case study, but so far this research has stopped short on offering

an opinionated view on its merits. The concluding section, however, will briefly cover this aspect in an attempt to highlight future prospects and suggest further areas of research.

Conclusion

The legal status of space resources is clearly still in debate, and likely will be for some time. The current regime for the utilization of these resources by the international community appears to be insufficient to meet the demands of national objectives and commercial expansion into space beyond Earth orbit. Different nations, organizations, and corporations have not only expressed a variety of views and arguments regarding the best way forward, but have taken legal and operational action for specific purposes. The body of this research sought to separate itself from determining the best or “correct” course of action, instead constructing a theoretical framework to examine a specific case of how one nation, Luxembourg, has approached this issue in an attempt to determine a relative level of influence. This conclusion will summarize these findings, but also briefly examine the potential future implications of such an approach. To bring greater relevance to this research, an attempt should be made to forecast the operational course of this issue for the next half-century to better inform decision-makers across multiple levels.

To summarize the analysis of the empirical case study, the starting question must first be reconsidered: how is the regime governing the utilization of space resources changing in response to current trends in outer space operations? Breaking apart this question, of primary concern are definitions of space resources, the current regime governing them, and the trends in space development driving the possible changes. The definition of space resources was drawn in the introduction, but of course could be broadened. The more limited definition of abiotic substances helped to focus the research and identify core issues. The current regime can be defined by the applicable clauses contained within the body of UN treaties regarding space. The treaty with the most applicability and widespread international acceptance is the OST, with additional support from the Registration Treaty. The Moon Treaty contained significant updates to the space resource utilization issue, but carries much less influence due to its very limited acceptance. Although details were scarce, the principles contained within these treaties were sufficient to govern actions in the space resource arena up until recently. The current trends in space operations and development are focused around commercialization, an influx of private investment, and the potential of generating wealth from space. It is apparent that these trends are putting pressure on the space resource utilization issue, and thus a significant driver for potential changes in the regime governing those resources. In other words, these

trends help explain why these shifts (or at least the apparent increase in pressure for changes) are happening now, rather than at any specific point in the past. Because an updated regime has not taken shape, it is of course difficult to quantify the degree of change that has occurred. This does not undermine the importance of researching this question, but it does limit the amount of empirical data that can be collected as well as the extent of specific conclusions that can be drawn from them.

In addition to these definitions, it is necessary to detail the “how” from the starting questions. This word is meant to imply several more detailed questions: what exactly is changing, how quickly is the change occurring, why is it happening (causes), and what does it mean? Although it is quite an expansive question, it is necessary to identify each of these parts in order to understand the issue. To approach these questions fully, however, would be an exhaustive project and was not the ultimate goal of this research. Additionally, although there would certainly be significant value in drawing out answers to these questions in a broad sense, the objective here was to construct a theoretical lens based on a wide array of literature to approach the issue, then utilize the lens through a specific case study to formulate and test a hypothesis in a more empirical manner.

To give more focus to this question, this research chose to take the case of Luxembourg, focusing on actions taken since 2016, to identify what influences they have had on bringing change to this regime. While this case is of course limited in scope, weighing heavily to the European regional sphere, it provides ample material for analysis on an issue that is currently in flux. Further research should be conducted by performing similar case studies for the major national actors in this field (namely the ones briefly examined in Chapter 3), as well as taking a closer look at non-state actors and performing a more detailed comparative analysis.

For the case study, there were several primary objectives. First, the government’s position on the issue of space resource utilization, specifically the status of the legal framework governing it and what their goals are for its future, needed to be defined. Next, the motivations for their position and goals needed to be understood. Following, specific actions and the actual mechanisms for how Luxembourg took those actions in support of these goals had to be examined. Finally, the ultimate goal was to trace the impact of these actions on influencing any changes in the regime controlling the utilization of space resources.

Since 2016, Luxembourg’s position on this issue has arguably been the most clear and consistent of any nation. Their message has remained strong and persistent since the start of

their SpaceResources.lu initiative, with a few semantic changes to better align objectives. They saw the importance of commercial enterprise in driving the nascent space resource industry, which itself was vital to develop a future sustainable ecosystem in space. They realized that private investment, however, is not possible at a sufficient scale without a stable legal framework in which to operate under – one that incentivizes taking risks and ensures the ability of an organization to utilize those resources. Their view and interpretation of the current governing regime is that it does not explicitly detail the legal questions of how to treat these resources, but also that appropriation in such a manner is implicit in the free use principle, so long as there is no attempt to establish national sovereignty over a celestial body (referencing a high seas metaphor). They recognize that a more robust set of international regulations would be essential to ensuring coordination, safety, and competitiveness, but that they will not simply wait and stifle operations in its absence. Thus, they determined that national laws establishing such a legal framework (while still adhering to currently established international law) combined with bilateral and multilateral agreements with like-minded nations was the best course in the meantime. While pursuing this path, they are still at the forefront of efforts to construct a more formal, detailed, and lasting regime through the UN.

The theoretical framework constructed in Chapter 1 can be used to help understand Luxembourg's motivations and how they see this issue. They understand the realist paradigm for general space matters as defined by the major space powers, as well as the significance of power balance to prevent the imposition of unilateral doctrine. Specifically with space resources, they can foresee the potential for inevitable competition, and thus the need for parameters to ensure this competition does not turn to violent conflict (as demonstrated through countless historical Earth-based examples). Elements of power-based and interest-based approaches to regimes help explain their measured approach to constructing meaningful action through the UN and multilateral cooperation while also forging ahead with national laws and initiatives to seize the opportunity to become a leader in the space resource industry and drive the favorable norms. Elements of knowledge-based approaches to constructing such a regime have only recently been manifested in Luxembourg's actions, but can help explain some slight shifts in messaging and outreach.

The specific actions of Luxembourg, and the mechanisms and actors used to carry them out, were of particular importance to this research. There is a long history of regulatory action that supports the space industry, including in particular the telecommunications act of 1997 and the founding of SES in 1985, but this research focused on the period beginning with the

commencement of the SpaceResources.lu initiative by the Ministry of the Economy in 2016. Following this came the space resources law of 2017 enacted by the Grand Duchy, and shortly thereafter the establishment of the LSA under the Ministry of the Economy. These initial actions were the most significant for the foundation of influence potential on the space resource regime. Following actions have included prominent participation in the Hague working group from 2017-2019, the establishment of ESRIC in 2020, numerous domestic funding initiatives for space resource industries, leading several annual conferences and symposiums (most notably the Space Resources Week), establishment of the Space Campus, and providing detailed input to the UN working group in 2023. Additionally, the space operations law of 2020 assists in fostering a workable environment for space operations with a primary objective other than space resource exploration and utilization, but whose development is still vital for the establishment of a thriving space ecosystem. The key actors within Luxembourg have been the leadership within the Ministry of the Economy since 2016, the managers of the SpaceResources.lu initiative and the space resources branch of the LSA (including its board of advisors), and the leadership of ESRIC. Because Luxembourg is such a small country, which has some operating characteristics akin to a corporation, and the relatively short recent timeframe of interest, it appears that specific individuals can have a large organizational influence, and by association, a potentially large influence on overall direction of at least shaping the conversation around the space resource governance regime.

Attempting to define the influence that Luxembourg has on changing the regime controlling the utilization of space resources was the ultimate goal of the empirical research. Regionally within Europe, Luxembourg appears to be well-established towards its objective to be a European hub for the space resource industry. As a regional conduit through which significant activity in this field passes through, they have been and will continue to be poised to steer the course of space resource utilization policy. Even if global recognition and validation is absent, simply having a considerable sway on European policy is significant within the international arena. From a global perspective, they derive a surprising amount of influence due to a combination of geopolitical and contextual factors. They clearly align with the US through their national laws and the Artemis Accords, but have the luxury of a more cooperative and focused approach. Although their stance has drawn plenty of criticism from states such as Russia for aggressive interpretations of current international space law and their history of wealth-focused policies, they have been able to assuage fears of many emerging space powers through UN coordination and development programs, public messaging, and the simple fact

that some of the more realism-based nationalist motivations do not seem to apply. For developed space powers that are perhaps on the fence about declaring a position on the issue, there appears to be at least some level of sufficient trust that Luxembourg is a benevolent actor who could serve as a suitable leader in driving suitable policy construction in the absence of UN-level action. It is this trust that can allow Luxembourg to take decisive and controversial actions while still building consensus and moving towards achievable international progress in developing an updated regime to control the utilization of space resources.

At the end, an assessment of what this influence actually means in the bigger picture can be made. Of course, this requires a significant amount of opinion and speculation, and thus was not a central focus of the research, but is still an important element that is open for debate. The specific benefits or disadvantages of such effects obviously depends on the eye of the beholder, so it is best to attempt to reference them with respect to the larger sphere of IR implications. On the positive side, Luxembourg's influence has brought the issue and relevant discussions into the light. It is still not a topic of the most immediate and highest importance (even within the space domain), but it is at least no longer a background issue left to its own devices.

On the negative side, there still must be an answer to the fundamental and bothersome question of why should national laws and initiatives dictate how elements beyond national boundaries are controlled and utilized. This point is especially stressed when considering the extremely small size of the nation taking those actions with far-reaching consequences for humanity, thus representing an insignificant fraction of the overall human population for actions on a global scale. Moreover, these actions and influences can essentially go unopposed, at least in any meaningful fashion, other than through denunciations and criticism. The same criticism can be levelled of course against any country taking similar action, most notably the US, but the fact that Luxembourg can have such quick, outsized influence in this specific area should at least pique interest. This of course raises the question of what would happen absent of US action and support – that is, would Luxembourg still have taken their same actions and have a similar level of influence? The supposition is almost certainly not. The initial US position and actions were a prerequisite for Luxembourg to assess the opportunity, calculate manageable risks, and leverage their strengths to gain influence. Without it, they could have certainly opted to take the same actions, but would likely have met disappointing results.

Another negative element already discussed is the potential for further global north-south divide. Although there certainly have been increases in the capacity of developing nations to participate in the general space industry, there are still wide swaths of the world that are merely consumers of the space economy, while a more limited set of powers can consider themselves providers of the benefits of that economy. This can already be seen playing out in near-earth orbital assets and seems destined to continue in the area of space resources. This is not to suggest that development should be stifled as a result, just that such considerations are important when constructing the rules governing these activities because of their lasting effects. Fortunately, there are a few key differences that potentially separate these developments from traditional historical comparisons. Although extraterrestrial territory seems destined for competition, its physical exploitation does not negatively affect any habitant population (at least for the foreseeable future). While not an excuse for permitting an “anything goes” mindset, it certainly allows breathing room for an adaptive governance solution.

Second, the driving organization forces pushing for development are commercial entities rather than states. They of course often involve state investment and PPP structures, but the central motivations are business-driven. These companies of course cannot operate without national support and in accordance with international frameworks, but at least the system appears to be heading down a different path than realist power competitions solely between state governments. Again, this is not meant to ignore this paradigm, but simply to suggest that the dynamic will be different and can allow for more global participation. Finally, there seems to be, at least for now, a definite feeling that the space “out there” is different and should be treated as such. The same cannot be said of near-earth orbital space, mostly because of its immediately proximity and immense strategic value. History will warn that this will inevitably change, but for now there is some genuine hope of a progressive future.

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Appendix A: Interviews

Name	Organization	Title	Type	Date
Bob Lamboray	Luxembourg Space Agency	Senior Project Manager - Exploration	Phone, semi-structured	03 February 2023
			In-person, informal	19 April 2023
Dr. Mathias Link	Luxembourg Space Agency	Deputy CEO	In-person, semi-structured	20 April 2023
Dovilė Matuleviciute	Luxembourg Space Agency	Senior Project Manager – Legal Affairs	In-person, semi-structured	21 April 2023
Dr. Kathryn Hadler	European Space Resources Innovation Center	Director	In-person, informal	20 April 2023
Franziska Zaunig	European Space Resources Innovation Center	Research Project Officer	In-person, informal	21 April 2023
Gerry Sanders	NASA In-situ Resources Utilization group	Member	In-person, informal	19-21 April 2023
Clive Neal	International Lunar Resource Evaluation	Member, Professor	In-person, informal	19-21 April 2023
Karl Hibbets	JHUAPL focus group	Member	In-person, informal	19-21 April 2023
Angel Abud-Madrid	Colorado School of Mines	Professor	In-person, informal	21 April 2023

All in-person interviews were conducted during the 2023 Space Resources Week conference at the Luxexpo center in Luxembourg.