Outer Space Regime Evolution: The Sustainable Governance of Low Earth Orbit for Future Generations

Jennifer Lauren Napier

PhD

2023

Outer Space Regime Evolution: The Sustainable Governance of Low Earth Orbit for Future Generations

Jennifer Lauren Napier

A thesis submitted in partial fulfilment of the requirements of the University of Northumbria at Newcastle for the degree of Doctor of Philosophy

Research undertaken in the Faculty of Business and Law within the Northumbria Law School

March 2023

Abstract

With the increasing number of actors, space objects, and debris utilizing Low Earth Orbit (LEO), it is time to reconsider what this increase in activity means for the future of the Outer Space Regime and the Low Earth Orbit governance framework with consideration for safety, security, and sustainability of the activities on-orbit and the orbital environment itself. The Outer Space Regime is the legal and political regime that governs human activity in space. The LEO governance framework sits within the regime and is the political and legal framework for activities in LEO and for the LEO environment. The beginnings of the Outer Space Regime included the creation and adoption of outer space treaties. However, since the mid-1980s there has been a legal shift towards non-binding international law. Therefore, this research will consider how the Outer Space Regime is evolving by examining the influence of politics and law as well as other socio-legal factors and ambient developments in technology. Understanding how the Outer Space Regime is evolving is crucial to understanding the LEO governance framework. This research sets out four research questions which will guide in addressing the main argument which is if the Outer Space Regime is evolving, what does that mean for the sustainable governance of Low Earth Orbit now and for future generations. To answer the research questions, this research will use a qualitative, dual international law – international relations methodological approach.

The research will first look at the Outer Space Regime and how it is evolving using international relations academics under the theme of regime theory. This will aid to inform on how the LEO governance framework is part of the regime and how the holistic evolution creates a need for an updated framework for LEO. This research will also critically evaluate the current international binding and non-binding law applicable to the regime and the LEO governance framework. It is through this dual approach of examining international relations and international law considerations that the research questions can be answered and form the basis for original contribution to knowledge in the field. As governance is applied by State and non-State actors, where a national perspective is needed, the UK will provide as the central State case study. Another original contribution to the research is pairing this international law and international relations academic analysis with practical approaches from State and non-State actors. This academic and practical approach will be applied to another original contribution of analyzing 21

governance theories to consider which of these might be best suited to the evolving regime and the need for an updated LEO governance framework. At the end of the research when the preferred governance framework is put forth, recommendations will be given on how to evolve the governance framework for Low Earth Orbit and how this recommendation has been found based on the challenges in LEO as well as the overarching evolutionary developments of the regime itself. As will be seen, the risk governance model will be argued as the preferred model for the LEO governance framework paired with tools such as Space Situational Awareness and Space Traffic Management as well as legal and political elements from the broader Outer Space Regime. Risk governance includes a clear process for managing varying degrees of risk and is understood by decision-makers and operators. Risk governance is not only a governance theory but is also supported by operational standards on risk management. A risk governance model can be applied top-down and bottom-up and at various levels such as internationally or nationally.

List of Contents

Acknowledgements

I would like to thank Northumbria University for offering me this RDF funded PhD position. It has been a rewarding experience and I am grateful to have had the opportunity to research on a space law topic in such a supportive Law School.

I would like to thank Professor Chris Newman for taking me on as his PhD student. Chris has been an inspiration! Chris was incredibly supportive and patient with me since I was doing my PhD alone in the UK during COVID. I am truly grateful for his guidance and direction on this incredible PhD journey.

Author's Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas, and contributions from the work of others.

Any ethical clearance for the research presented in this commentary has been approved. Approval has been sought and granted through the Researcher's submission to Northumbria University's Ethics Online System.

I declare that the Word Count of this Thesis is 88,543 words.

Name: Jennifer Lauren Napier

Date: 28 February 2023

List of Acronyms & Initialisms

ADR – Active Debris Removal

AI – Artificial Intelligence

ALAN – Artificial Light At Night

AMOS – Advanced Maui Optical and Space Surveillance Technologies Conference

ASAT – Anti-Satellite Weapon

C2 – Command and Control

CAA – Civil Aviation Authority (UK)

CBMs – Confidence-Building Measures

CD – Conference on Disarmament

CIL – Customary International Law

CONFERS – Consortium for Execution of Rendezvous and Servicing Operations

COTS – Commercial-Off-the-Shelf Parts

CPO – Close-Proximity Operations

CPR – Common-Pool Resources

CRP – Conference Room Paper

CSIS – the Centre for Strategic and International Studies

CSR – Corporate Social Responsibility

DARPA – Defense Advanced Research Projects Agency (USA)

DoD – Department of Defense (USA)

EDI – Equality, Diversity, and Inclusivity

EO – Earth Observation

EoL – End of Life

ESA – European Space Agency

FAA – Federal Aviation Administration (USA)

FCC – Federal Communications Commission (USA)

FCDO – United Kingdom Foreign, Commonwealth, and Development Office

GGE – Group of Governmental Experts

GPS – Global Positioning System

GSO – Geostationary Orbit

IAA – International Academy of Astronautics

IAC – International Astronautical Congress

IADC – Inter-Agency Space Debris Coordination Committee

IATA – International Air Transport Association

IAU – International Astronomical Union

ICJ – International Court of Justice

ICT – Information and Communications Technology

ILC – International Law Commission

INGOs – International Non-Governmental Organisations

IoT – Internet of Things

ISS – International Space Station

ITU – International Telecommunications Union

ITU-R – International Telecommunications Union Radiocommunication

JSpOC – Joint Space Operations Center (USA)

LEO – Low Earth Orbit

LSC – United Nations Committee on the Peaceful Use of Outer Space Legal Subcommittee

LTS – Long-Term Sustainability

LTSG – Long-Term Sustainability Guidelines

MEO – Medium Earth Orbit

MIFR – Master International Frequency Register (ITU)

NASA – National Aeronautics and Space Administration (USA)

NATO – North Atlantic Treaty Organization

NEOs – Near-Earth Objects

NGOs – Non-Governmental Organisations

NOAA – National Oceanic and Atmospheric Administration (USA)

NBIL – Non-Binding International Law (aka 'soft law')

OEWG – Open-Ended Working Group

Ofcom – United Kingdom Office of Communications

OOS – On-Orbit Servicing

OSR – Outer Space Regime

OST – Outer Space Treaty or Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies

PAROS – Prevention of an Arms Race in Outer Space

R&D – Research and Design

RF – Radiofrequency

RPO – Rendezvous and Proximity Operations

SA – Situational Awareness

SDA – Space Data Association

SDA – Space Domain Awareness

SDGs – Sustainable Development Goals

SDMG – Space Debris Mitigation Guidelines

SI – International System of Units

SSA – Space Situational Awareness

SSC – Space Safety Coalition

SSI – Space Security Index

SSN – Space Surveillance Network (USA)

SSR – Space Sustainability Rating

SST – Space Surveillance and Tracking

STC – Space Traffic Coordination

STEM – Science, Technology, Engineering, and Math

STM – Space Traffic Management

STSC – United Nations Committee on the Peaceful Use of Outer Space Scientific and Technical Subcommittee

SWF – Secure World Foundation

TCBM – Transparency and Confidence-Building Measures

TLS – Traffic Light System (used in UK)

TM – Traffic Management

UK – United Kingdom

UKSA – United Kingdom Space Agency

UN – United Nations

UN COPUOS – United Nations Committee on the Peaceful Uses of Outer Space

UNESCAP – United Nations Economic and Social Commission for Asia and the Pacific

UNGA – United Nations General Assembly

UNIDIR – United Nations Institute for Disarmament Research

UN OCHA – United Nations Office for the Coordination of Humanitarian Affairs

UN ODA – United Nations Office for Disarmament Affairs

UN OOSA – United Nations Office of Outer Space Affairs

US/USA – United States of America

USSR – Union of Soviet Socialist Republics (Soviet Union)

USSTRATCOM – U.S. Strategic Command

WBGU -- German Advisory Council on Global Change/Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (Germany)

1 Introduction

1.1 Purpose

The Outer Space Regime is the legal and political regime that includes space law, as well as established international law and more generally the international system that governs human activity in space. The analysis in this thesis will focus on Low Earth Orbit (LEO) as an environment and one that is utilised by various actors. This research is significant in that it includes perspectives about these actors and their activities as well as just examining LEO as an environment. This is a crucial part of the Outer Space Regime and as such it is also important to understand the creation, evolution, and maintenance of the regime to better understand where the LEO governance framework sits within the international relations and international law underpinnings of said regime.

The research will consider how the Outer Space Regime is evolving by examining the influence of politics, law as well as socio-legal factor and ambient developments in technology. The analysis will encompass the current governance framework of Low Earth Orbit. An examination will be undertaken into the scope of governance and regime theories from International Relations as well as a critical look at binding and non-binding law applicable to outer space to better understand how to better govern this crucial area of space.

1.2 Background

With the increasing number of actors (State and non-State) utilizing the Earth's orbits and creating missions to other celestial bodies, it is time to reconsider what this increase in activity means for the future of the Outer Space Regime regarding safety, security, and sustainability. This is incredibly timely in LEO where most artificial satellites and debris are situated.[1] It has been argued for some years now that space is congested, contested, and competitive;[2] however, the international space community has been somewhat slow to respond in terms of international laws and national

[1] European Space Agency, 'The Current State of Space Debris' (*ESA*, October 2020) <https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris> accessed 09 February 2023

[2] Beth Duff-Brown, 'The Final Frontier Has Become Congested and Contested' (*Stanford Center for International Security and Cooperation,* 4 March 2015) <https://cisac.fsi.stanford.edu/news/security-space-0> accessed 16 February 2023 citing Air Force Lt. Gen. John "Jay" Raymond

regulations due to slow international bureaucracy and the need to have consensus on international law.[3] The 2007 anti-satellite test from China and the 2019 anti-satellite test from India created over 3,000 pieces of debris collectively and added to the growing space debris population in Earth's orbits. As of April 2021, over 34,000 tracked objects are greater than 10cm[4] while "objects smaller than this usually are too small to track for conjunction assessments and collision avoidance".[5] This has led to questions about what constitutes responsible behaviours in space,[6] coupled with growing concerns about how to leverage national interests against the safety, security, and sustainability of orbits. As the number of satellites continues to rise, Low Earth Orbit is dangerously close to becoming an orbit more prone to collisions which could limit access.

In addition to the responsible use of space, the evolution of the Outer Space Regime requires consideration of several issues that transcend traditional disciplinary boundaries. Legal questions regarding liability of actors for damage; concerns regarding the equitable use of space; notions that space security is understood to mean more than just traditional military and national security measures by some States. This requires an attitudinal shift from legislators, diplomats and policy makers, moving away from traditional Cold War narratives to solutions that are more befitting contemporary space activity.

The language used by all stakeholders is emblematic of the issue of attitudes and approaches to governing human activity in LEO. In some languages 'security' and 'safety' are the same word[7] which adds difficulty to defining, interpreting, or separating traditional security measures from those of safety.

---

[3] Sophie Goguichvili, Alan Linenberger, Amber Gillette, and other, 'The Global Legal Landscape of Space: Who Writes the Rules on the Final Frontier?' (*Wilson Center*, October 2021) <https://www.wilsoncenter.org/article/global-legal-landscape-space-who-writes-rules-final-frontier> accessed 09 February 2023

[4] European Space Agency, 'Space Debris By the Numbers' (*ESA*, 15 April 2021) <https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers> accessed 21 April 2021

[5] NASA, 'Space Debris and Human Spaceflight' (*NASA*, May 2021) <https://www.nasa.gov/mission_pages/station/news/orbital_debris.html> accessed 09 February 2023

[6] See Jessica West and Gilles Doucet, *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report*, (Project Ploughshares 2021); UNGA, Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours, A/Res/75/36, 7 December 2020.

[7] For example, in the German language *Sicherheit* means safety, security, and certainty. Safety and Security are also the same word in the Spanish and French languages. Therefore, language is important and not always interpreted the same as in English. This can become a political tool used at the international level to debate the wording of documents created in committee meetings.

Tan describes the importance of words in legal and political contexts:

> Words have the uncanny ability of assuming new and different meanings at different places and times; this is particularly true of legal concepts, which are shaped by contemporary politics and social conditions.[8]

As Tan suggests, it is not just differences in language but also that words change meaning over time. Flowing from this, it is suggested that the regime should not be posited as existing within the context of a 'space race' or as following a post-Cold War agenda. The Outer Space Regime is diverse and inclusive of a greater number of views from various types of State and non-State actors and the notion of a binary superpower contest is not helpful when conceptualising activities in LEO.

This can be best appreciated by looking at the number of Member States and Permanent Observers in the United Nations Committee on the Peaceful Use of Outer Space (UN COPUOS) and its legal and technical subcommittees.[9] As of 2022 there are 102 Member States and 49 Permanent Observers in UN COPUOS and its subcommittees which highlights the change from the onset in 1958 when there were 18 Member States and 0 Permanent Observers.[10] This change coincides with the changing international political landscape from a bipolar world during the Cold War, toward a multipolar world post-Cold War, to what is now a multistakeholder and more globalised world.

As the Outer Space Regime is growing and evolving, the time is ripe for research into how that evolution is occurring, why it is occurring, and what that means for LEO, which is growing to be the most used orbit, with a large diversity of actors. Therefore, the main arguments within this research will evaluate the current Low Earth Orbit governance framework, what is working and what needs to evolve, as well as what challenges actors are facing while utilising LEO and why all

[8] David Tan, 'Towards a New Regime for the Protection of Outer Space as the Province of All Mankind' (2000) 25 (1) Yale Journal of International Law 145-194, 163

[9] United Nations Office of Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space and its Subcommittees' (*UNOOSA*, 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html> accessed 09 February 2023

[10] United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Membership Evolution' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html> accessed 24 February 2023; United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Observer Organizations' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html> accessed 24 February 2023

this matters. From this assessment, recommendations will be given as to the way forward in LEO, politically and legally, to maintain a more sustainable, safe, secure, and up-to-date governance framework that supports the needs of all actors now and in the future.

Low Earth Orbit is part of the outer space environment and is the closest orbit to the Earth's surface. Therefore, this section will discuss the technical aspects of where LEO is situated within outer space as well as what types of space activities are found on-orbit. Additionally, this section will explain which actors are utilising LEO and why that matters. Finally, this section will discuss the importance of using LEO especially for socio-economic and environmental concerns on Earth.

Low Earth Orbit, arguably, is where space begins, though there is no legally defining delimitation between air space and outer space.[11] The upper limit to LEO is roughly 2,000 km.[12] There is a twofold reasoning for not legally defining the delimitation of outer space. First, States do not want to lose any sovereignty claims as high up in air space above their territory as possible because aerospace technology advances are allowing for higher air space to be utilised under the auspice of aviation and not space activity. Further, State sovereignty in air space above territory is supported by Article 1 of the *Convention on International Civil Aviation* which states that, "the contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory".[13] Second, as technology advances allowing for aviation machines to function at higher altitudes, as well as the reverse where technology is advancing to allow for space objects to function closer to the stratosphere, the delimitation could in fact constantly be in flux. However, most space objects in LEO travel between 230 to 1520 km.[14]

A space object in Low Earth Orbit takes about ninety minutes to circumnavigate Earth and creates a roughly circular path. LEO is mostly below the inner Van Allen radiation belt which gives it a

---

[11] See United Nations Office of Outer Space Affairs, 'Working Group on the Definition and Delimitation of Outer Space of the Legal Subcommittee' (*UNOOSA*, 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/lsc/ddos/index.html> accessed 09 February 2023

[12] NASA, 'LEO Economy FAQs' (*NASA*, February 2022) <https://www.nasa.gov/leo-economy/faqs> accessed 09 February 2023

[13] International Civil Aviation Organization (ICAO), Convention on International Civil Aviation (adopted 7 December 1944, entered into force 4 April 1947) Ninth Edition, Doc 7300/9. Also known as the Chicago Convention.

[14] Seradata, 'SpaceTrak' (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022

level of safety from space weather.[15] Low Earth Orbit is home to very small and small satellites as well as the International Space Station (ISS) and the Tiangong Space Station.[16]

It is often stated by many space experts that outer space is congested, contested and competitive.[17] This statement extremely accurate in Low Earth Orbit. With the addition and continuation of space debris this is a very grave and important statement. There are a multitude of stakeholders in space within the spheres of private and public sectors which means access to space is getting harder and the placement of objects in orbit is getting tighter. As of 2022, there are over 5,000[18] active satellites in LEO without calculating space debris. Add in over 25,000 pieces of tracked debris over 10cm (the majority in LEO)[19] and LEO becomes overrun with objects; without counting the millions of un-trackable debris under 10cm.[20]

Low Earth Orbit is the most accessible entry point to space because it is closest to Earth and can be utilised with small and very small satellites which are cheaper and easier to put into orbit than the larger satellites of higher orbits. With this accessibility comes a diverse group of State and non-State actors utilising LEO either for the first time as emerging actors or on a routine basis. Actors utilise LEO for military, civil, commercial, academic, or scientific purposes. Most of the satellite in LEO are for navigation, connectivity, or Earth Observation. Additionally, many satellites in LEO function as satellite constellations – or fleets of satellites working together on-orbit. The most well-known of these satellite constellations are the US SpaceX Starlink and the UK OneWeb systems.[21]

As of 2022, over 70 States[22] are responsible for satellites in LEO. This is pursuant to Article VI of the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer*

---

[15] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Routledge, 2018) 153
[16] As space stations have their own governance and pertain specifically to human spaceflight, this research will not consider space stations as in scope. The focus of the research will be on uncrewed space objects in Low Earth Orbit.
[17] Beth Duff-Brown, 'The Final Frontier Has Become Congested and Contested' (*Stanford Center for International Security and Cooperation*, 4 March 2015) <https://cisac.fsi.stanford.edu/news/security-space-0> accessed 16 February 2023 citing Air Force Lt. Gen. John "Jay" Raymond
[18] Seradata, 'SpaceTrak' (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022
[19] NASA, 'Astromaterials Research & Exploration Science NASA Orbital Debris Program Office Frequently Asked Questions' (*NASA*, 02 June 2022) <https://orbitaldebris.jsc.nasa.gov/faq/#> accessed 02 June 2022
[20] ESA, 'Space Debris by the Numbers' (*ESA*, 07 November 2022) <https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers> accessed 21 December 2022
[21] More will be discussed about these satellite constellations in Chapter Five.
[22] Seradata, 'SpaceTrak' (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022

Space, including the Moon and Other Celestial Bodies (herein known as the Outer Space Treaty or OST) which articulates that States:

> Shall bear international responsibility for national activities in outer space … whether such activities are carried on by governmental agencies or by non-governmental entities …[23]

Of those States, the United States is responsible for most space objects in LEO. This does not mean that LEO governance should be dictated by the United States, rather that the governance of LEO needs to take into consideration this growing commercial market and question how to keep LEO accessible to all, per the tenets of the Outer Space Treaty, and not allow US appropriation or complete congestion on-orbit by SpaceX.[24]

It is important to know why actors choose to utilise LEO and why it matters from the perspective of what is gained from having satellites in this orbit. Low Earth Orbit was the location in space where the very first space activities were conducted from the Soviet Union's Sputnik to the United States' Mercury and Gemini missions all the way through to the now orbiting space stations. At the forefront of space exploration and activity, LEO was used as a testing ground for long-duration flight to the Moon and was used for military and civil purposes with support from commercial actors. Over time, with the rise of the private sector creating their own space missions, came the New Space era when Low Earth Orbit became a beehive of activity for State and non-State actors alike. LEO has always been the first stop for emerging space States, emerging commercial space actors, or academic actors to reach outer space whether through test phases or for planned missions. This still holds true today as well. LEO is also continuously used for human spaceflight where astronauts can run experiments and learn how to operate in space.

Most of what LEO satellites are utilised for revolves around the use of space-enabled technologies and data which can be considered under the term Earth Observation (EO). Earth Observation includes remote sensing, satellite navigation with geospatial data, and satellite communications. According to the Group on Earth Observation, Earth Observation includes "… space-based or

[23] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[24] See Lauren Napier and Christopher J Newman, 'Regulation of Satellite Constellations' in Yanal Abul Failat and Anél Ferreira-Snyman (eds), *Outer Space Law: Legal Policy and Practice* (2nd edn, Global Law and Business 2022)

remotely sensed data, as well as ground-based or *in situ* data".[25] Additionally, according to the United Kingdom, Earth Observation is "the collection, analysis and presentation of data in order to better understand the planet Earth".[26] Therefore, throughout this research the term Earth Observation may be used and understood to include remote sensing and other forms of satellite data. However, as remote sensing is a term that was utilised before EO and is defined through a United Nations General Assembly (UNGA) Resolution. The UNGA Principles Relating to the Remote Sensing of the Earth from Outer Space defines remote sensing as:

> The sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment.[27]

As the remote sensing definition implies, all these technologies and data rely on the radiofrequency spectrum which is managed by the International Telecommunications Union (ITU), therefore, it is also important to recognize that the ITU regards 'space radiocommunication' as "any *radiocommunication* involving the use of one or more *space stations* of the use of one or more *reflecting satellites* or other objects in space".[28]

The use of the term space station here refers to an object intending to go beyond Earth's atmosphere[29] – which includes satellites in Low Earth Orbit. It is important to note that throughout this research more will be discussed relating to the ITU and the radio frequency spectrum as this research considers the ITU radio regime to be part of the regime complex connected to the Outer Space Regime.

The list of uses for Earth Observation satellite data is a rich and diverse list. Space-enabled data, data coming from satellites, can be utilised by spacefaring and non-spacefaring State and non-State

---

[25] Group on Earth Observations, 'GEO at a Glance' (*GEO* 2022) <https://earthobservations.org/geo_wwd.php> accessed 21 December 2022

[26] UK Space Agency, 'Earth Observation (EO)' (*UKSA* 18 December 2018) <https://www.gov.uk/government/collections/earth-observation-eo> accessed 21 December 2022

[27] UNGA, 'Principles Relating to Remote Sensing of the Earth from Outer Space' (1986) Res 41/65

[28] International Telecommunications Union, 'Radio Regulations' (Geneva, 1995, updated Sharm el-Sheik, 2019) Vol 1, 7

[29] International Telecommunications Union, 'Radio Regulations' (Geneva, 1995, updated Sharm el-Sheik, 2019) Vol 1, 13

actors and can support socio-economic and environmental challenges that are faced back on Earth. With the importance of the United Nations Sustainable Development Goals (SDGs),[30] space-enabled technologies and data can also support initiatives that foster meeting said goals. The United Nations Office of Outer Space Affairs (UNOOSA) has extensive information on how space can support the SDGs through satellite technology and data.[31] Coined 'Space4SDGs'[32] UNOOSA highlights how space can be a driver or ancillary part of reaching the goals set forth for sustainable development. The understanding of utilising LEO satellite activity to support the SDGs is crossing over into the fields of international development and inclusive development.

On top of using satellites in Low Earth Orbit for Earth Observation, many satellites are also utilised for capacity building, or learning, for emerging space actors as well as universities. With the inclusion of more payload options to launch into space as well as with the cheaper hardware, software, and commercial off-the-shelf parts (COTS) for satellites,[33] it is now easier and less of a resources risk to send satellites into orbit in LEO for educational and developmental purposes. The lower costs of launching and carrying out a satellite mission in LEO means more State and non-State actors can utilise space on more equal footing which is in-line with Article I of the Outer Space Treaty. These missions can include research and design testing, scientific experiments, as well as offer an emerging or developing spacefaring State the opportunity to join the group of spacefaring nations, which is growing increasingly important because of the EO benefits described above – especially for supporting the SDGs and the challenges the Global South face such food security or global health. Finally, States – especially through the military – do still utilise Low Earth Orbit for national and space security purposes as well.

As Low Earth Orbit has become increasingly congested due in part to space debris but also because of the rise of the diverse number of actors with satellites on-orbit, it is understood that with these

---

30 United Nations Department of Economic and Social Affairs, 'The 17 Goals' (*UN* 2023) <https://sdgs.un.org/goals> accessed 28 February 2023

31 United Nations Office for Outer Space Affairs, 'Space Supporting the Sustainable Development Goals' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/space4sdgs/index.html> accessed 28 February 2023

32 Ibid

33 COTS are usually discussed in a technical or economic-driven paper. However, there is an International Standards Organisation (ISO) standard relating to COTS in Low Earth Orbit. See ISO, 'ISO 21980:2020 Space Systems-Evaluation of Radiation Effects on Commercial-Off-The-Shelf (COTS) Parts for Use on Low-Orbit Satellites' (*ISO* 2020) <https://www.iso.org/standard/71848.html> accessed 28 February 2023. Note, only the abstract is available to view for free.

factors come challenges on how to continue to be able to utilise LEO safely, securely, and sustainability for current and future generations. Therefore, considerations must be taken on how best to find viable solutions to these challenges with the support of a governance framework that bolsters the equitable use of the orbit while also encouraging the 3S approach of safety, security, and sustainability.

The most highly publicized challenge in LEO is space debris, or the inactive and spent satellites, rocket boosters, and other flotsam still on-orbit but not controlled or active. Connected to the issue of space debris is the added challenge of tracking and monitoring not only debris but also active satellites in LEO. Currently there are a handful of actors[34] tracking and monitoring space objects and debris on-orbit, mostly through the United States military. Add to this there is a lack of coordination at the international level with limited sharing opportunities to better understand the situation of traffic – both active and inactive – in Low Earth Orbit. This means that while risk of collision is already high given the number of space objects and debris on-orbit, adding in the lack of communication and transparency means the current governance framework is severely lacking in truly understanding the LEO environment and how best to work together on these challenges. As space debris is a challenge that requires a certain level of local understanding, which can only be found through tracking as space objects are uncrewed, it is imperative that space situational awareness is part of the process. Further, as space debris poses a serious risk to space objects in LEO, one governance model under consideration will be a risk governance model.[35]

Another set of challenges within Low Earth Orbit are the equitable and appropriate use of the radio frequency spectrum, the protection of satellite data from cyber security issues, and other general security issues around the use of space. These three issues are grouped together as they are also part of other regimes: The International Telecommunications Union (ITU) regime, the cyber regime, and the security regime, respectively. Therefore, they will be discussed and analysed from the view of the regime complex, that which brings regimes together on common issues and challenges or have overlap in scope or application. Within this research this will be seen between the outers space regime and the ITU regime, the outer space regime, and the cyber regime, as well as the outer space regime and the security regime. Mostly the issues stemming from these regimes

[34] Space Security Index, 'Space Situational Awareness' (*SSI* 2020) <https://spacesecurityindex.org/2020/09/space-situational-awareness/> accessed 28 February 2023
[35] See Chapter Four and Recommendations in this research.

include the principles of harmful interference, protection of assets and data, as well as the transparency and confidence-building between States.

The satellites themselves are also a challenge in Low Earth Orbit. With more diversity in actors and with the sheer number of actors putting satellites into orbit there are concerns that satellites shall be registered through their national registration parameters as well as through the United Nations Office for Outer Space Affairs.[36] As satellites are more frequently being used in coordination with one another by satellite constellations or mega constellations there is the added concerns over these satellite systems and their further congestion of the orbit and radio frequencies.

What all these challenges mean holistically speaking is that the current Low Earth Orbit governance framework is not working to alleviate the stresses of utilising the orbit for safe, secure, and sustainable purposes. As will be alluded to in this research, the foundation of the governance framework will need to be analysed by looking at various governance models or theories to find if other options might be better suited to the task than the global governance, or global space governance, model currently in practice. All of this leads to the understanding that strengthening the space situational awareness of the LEO environment through a tailored space traffic management plan may be the answer to how to operate a stronger governance framework within LEO. This research and its research questions puts these hypotheses to the test via discussion, analysis, and evaluation of existing expert space literature, governance and regime discourse, and document analysis of international law instruments applicable to Low Earth Orbit and the Outer Space Regime.

1.3 Research Questions

The following research questions are proposed to guide this research toward finding the best way forward for a safe, secure, and sustainable long-term use of Low Earth Orbit:

1. How is the Outer Space Regime evolving and why is this important to Low Earth Orbit?
2. Why does the Low Earth Orbit governance framework need to evolve and what measures need to be in place to make this happen?

[36] See Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15

3. What is the optimal model of governance for Low Earth Orbit while still staying nested within the Outer Space Regime keeping in mind legal, political, socio-economic, and environmental considerations?
4. How would an updated governance model in Low Earth Orbit address the activities and issues in Low Earth Orbit from international relations and international law perspectives?

The first research question:

> RQ1: How is the Outer Space Regime evolving and why is this important to Low Earth Orbit?

This research question posits the importance of understanding the Outer Space Regime – why it was created, why it is still important, and how it is evolving. This more holistic understanding of the *lex specialis* of outer space and its underpinnings both legally and politically help to set the scene for a greater understanding of how the LEO governance framework functions as a nested sub-regime within the Outer Space Regime. For as the foundational regime evolves and is broadened by number and type of actor, so too is Low Earth Orbit. It will be seen that changes that are made within the Outer Space Regime have direct implications for the Low Earth Orbit governance framework.

The second research question:

> RQ2: Why does the Low Earth Orbit governance framework need to evolve and what measures need to be in place to make this happen?

This research question addresses Low Earth Orbit – and the heart of this research – specifically. For as stated above regarding RQ1, it is necessary to analyse the way a regime evolves and what that means for all sub-regime frameworks. This research focusing on the Low Earth Orbit sub-regime and its governance framework. As will be found in following sections hazards and challenges, such as the growing number of space debris and active satellites on orbit as well as the need for more use from radio frequencies, are turning Low Earth Orbit into an environmental resource that is dwindling over time. Therefore, the governance framework needs to be constantly updated, or evolved, to meet the demands of spacefaring actors as well as find solutions to the hazards found on orbit. RQ2 sets up the third and fourth research questions by allowing the research to first discuss the systemic underpinnings of accepting that the Outer Space Regime and

LEO are evolving legal and political systems that need to evolve to stay true to Article I of the Outer Space Treaty[37] which stipulates that outer space exploration and utilisation is for all and indiscriminatory in nature.

The third research question:

> RQ3: What is the optimal model of governance for Low Earth Orbit while still staying nested within the Outer Space Regime keeping in mind legal, political, socio-economic, and environmental considerations?

This research question dives into a look at current governance framework models and what advantages and disadvantages they might bring in being applied to the current Low Earth Orbit governance framework to make it a more robust framework for the future. Currently, it is not known which of the models (or hybridization of models) will be best suited for a more improved Low Earth Orbit governance framework. The nature of this research question is the foundation of the doctoral research as it is known that while LEO is functioning with various active State and non-State actors, the orbit is becoming increasingly congested, contested, and competitive making it an unstable, limited resource that needs a better governance framework in place to be utilised now and in the future. As this is an ongoing discussion within the international space community, it is highly relevant to consider what could be done – specifically legally and politically – to make LEO more secure, safe, and sustainable. Therefore, this research and the second research question will address this effort in more minute detail with the added academic theory and methodological dual approach taken from international relations and international law. This approach and the idea of looking outside the space community hints at originality as most research in space law and policy is derived from previous space law and policy research, or from time to time, environmental law.

[37] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

The fourth research question goes one step further.

> RQ4: How would an updated governance model in Low Earth Orbit address the activities and issues in Low Earth Orbit from international relations and international law perspectives?

After understanding which governance framework model is appropriate for Low Earth Orbit, this model will be applied and the aspects and challenges within the orbit – such as space debris – will be discussed to confirm that the model is indeed practical moving forward. LEO is a finite resource and is critical for life on Earth through Earth Observation satellite technology and data. Therefore, this research is important because the international space community needs to maintain a secure, safe, and sustainable orbit now and for future generations so to contribute to supporting the SDGs and initiatives that society needs for Earth's future as well.

These research questions will be analysed through the lens of international law and international relations as part of a qualitative socio-legal approach. It is critical that the Outer Space Regime and Low Earth Orbit governance framework be understood and built upon from a socio-legal perspective. This research will look holistically at the Outer Space Regime and the Low Earth Orbit governance framework as well as deep dive into the challenges facing the orbit legally as well as politically. The research questions will pave the way forward for a dually holistic and specific look at the current legal and political concerns that can create answers to address how better to maintain Low Earth Orbit.

1.4 Originality of Research

As most research in the space sector is more forward-looking and theoretical, there are gaps in the literature and room for originality. Low Earth Orbit is an established space environment with a plethora of actors and activity, there is literature on many of the challenges found on-orbit, space debris having the most extensive catalogue of expert literature ranging from law to technical publications. As LEO becomes more congested and diversified there is room for analysis and further discussion on how to keep the orbit safe, secure, and most recently discussed – sustainable. This research is using a socio-legal theory from the perspectives of law and international relations. There is room for a different style of analysis than from the purely legal, policy, or technical purviews. After having reviewed the leading publications and arguments regarding Low Earth Orbit and its governance framework as well as the challenges found on-orbit, it has been found that the following are original contributions to the international research that is on-going for said orbit and the outer space regime. This is because most literature used in this research is either IR scholars but not space experts or space law and policy experts but not IR experts. This research is truly novel as it marries both IR and space law expertise together.

Regarding the outer space regime collectively, as will be seen in a subsequent section, the evolution of the outer space regime is something that has not been addressed within the international relations discourse on outer space. Further, the evolution of a regime is a sub-section of regime theory analysis that is lacking robust discussion within the IR community. Therefore, extensively speaking about and analysing the evolution of the outer space regime is original work not only for the space community but for the general IR discourse as well. On top of this, there have been discussions on regime complexes – as will also be discussed further on in this research – however none on how the outer space regime works with other tech regimes such as the telecommunications regime or the cyber regime. This is mostly stemming from the fact that many IR space scholars are focused on space security or geopolitical issues and not specifically about regime theory or analysing the regime itself. These two angles, the evolution of the outer space regime and how it fits into a regime complex will be discussed as part of the larger framework within which the LEO governance framework sits and will also provide opportunity for this aspect of the research to be applied to journal articles within the IR academic community.

As regime theory has now broadened out to governance theory, another major aspect that will be discussed and analysed within this research, is also original in that the various governance theories, or models, will be analysed to find which are most suited to creating a sustainable LEO environment. Most space experts just accept global governance or what they term 'space governance' or 'global space governance' as the accepted model without consideration as to if this is the best approach moving forward. This research's originality forms the underpinning of the focus of this research and is closely tied to the research questions. These discussions and analyses of regime evolution, the regime complex, and the governance models are the main components of this research and justify the methods used and interpretation of the challenges faced within the Outer Space Regime and Low Earth Orbit. All of which is then underpinned by applicable law.

Speaking in terms of the challenges faced in LEO such as space debris or the tracking and monitoring of active satellites (to name two of many challenges), this research will take a more holistic approach to these challenges and how they affect one another and ways to find governance solutions that will attempt to support these challenges more holistically. Typically, literature is speaking about each challenge separately or from the perspective of space debris specifically. The originality here is to look at all together and find out how to make a stronger governance framework that can support while understanding the interconnectedness of the challenges. This is where it has been hypothesized that the use of space situational awareness (SSA) and space traffic management (STM) plus a better governance model may be the way forward on bringing these issues together. While the discourse on SSA and STM is not original nor especially new, it is original to think about how all these aspects work together and from the secure, safe, and sustainable (3S approach) paired with a governance model that would suit the challenges and needs of Low Earth Orbit.

1.5 Methodology

This research uses a qualitative, dual international relations – international law methodological approach as the underpinning methodology which means that analysis will be conducted from political and legal purviews. This perspective is critical as law does not exist in a vacuum and politics do shape legal documents.

As Holland and Webb argue;

> Although we often think of law and politics as necessarily distinct systems, the reality is more complex, as law performs an important part in preserving the political structure and processes, and politics plays an increasing role in shaping the law ...[38]

Therefore, the dual international relations – international law methodological approach will be used within this research as it is very difficult at the international level to separate the politics from the law and vice versa.

[38] James Holland and Julian Webb, *Learning Legal Rules* (11th edn, Oxford University Press 2022) 4

Further, at the international level, Holland and Webb suggest:

> International relations are governed primarily by a form of law called public international law. This creates rules, for example, for the recognition of states as legal entities, the setting of their territorial boundaries, and the conduct of diplomacy between them.[39]

Overall, what this means is that this research can also be understood as socio-legal research and as such most of this research will stem from a classical social science and legal literature review. Within this overarching dual analysis will also come various other methods to be used to offer a deeper and more robust analysis and answering of the research questions. Specifically, from international relations, this research will utilise regime theory and governance theory as the systemic baseline for analysis as the main point of the research is to deduce the most practicablegovernance framework for Low Earth Orbit. Therefore, analysing governance models and theories through a hybrid form of content-comparative analysis will be conducted.

Additionally, as there are many State and non-State actors occupy Low Earth Orbit with various types of satellites, where appropriate and necessary, this research will also take to analyse at the national level using case studies. As this research is being conducted within the United Kingdom, the main national case study will be the UK, though because the United States is one of the major spacefaring nations, where needed some US national aspects will be included as well. Furthermore, as much of what is discussed is done at the international level through the United Nations, heavy emphasis will be placed on legal (binding and non-binding) instruments created and maintained at the United Nations – specifically the United Nations Committee on the Peaceful Use of Outer Space (UN COPUOS) and its subcommittees.

Finally, at the end of the research when the preferred governance framework is put forth, recommendations will be given on how to evolve the governance framework for Low Earth Orbit and how this recommendation has been found based on the challenges in LEO as well as the overarching evolutionary developments of the regime itself. The research will specifically look at what can be extrapolated from relevant governance models to create recommendations for a bespoke Low Earth Orbit governance framework that fits within the evolving Outer Space Regime.

[39] Ibid, 5

All these aspects to the methodological approach come together to create a dynamic and well-rounded way in which to conduct the research and answer the research questions. Where there has not been any literature or past research will require original work to fill all gaps and justify the necessity of this body of work.

1.6 Summary of Chapters

This section will give a brief overview of the main chapters of the research. This will provide an understanding of the flow and structure of the research.

1.6.1 Regime Theory and Regime Complex

Chapter Two takes an international relations approach paired with discourse on international law as the law is part of the regime. The chapter will start by explaining and providing literature on what is meant by a regime using regime theory found in international relations. Within the discourse on regime theory there will be discussion on how regimes are created and why as well as what it takes to maintain a regime. Regime theory will also give insight into how regimes might evolve or change over time – which is incredibly important for this research as the outer space regime is constantly changing based on the scientific and technological advances in the industry. After an overview of regime theory is given, two regimes, the Trade Regime and the Climate Change Regime, will be discussed to give example to the theory at hand. These regimes are used because the literature available on regime theory and evolution always rely on these two regimes – the Trade Regime most often. From this discussion, regime theory will be applied to the Outer Space Regime. First, the research will discuss the creation of the Outer Space Regime and then discuss the evolving nature of the regime. Further, two additional concepts will be presented – a nested regime and a regime complex. The nested regime aspect will focus on the use of law within a regime while the regime complex will show how one regime is interconnected with other regimes – with a close look at the Outer Space Regime and regimes connected to it such as the Telecommunications Regime. Finally, this chapter will look at Low Earth Orbit and discuss how the governance framework for the orbit is part of the Outer Space Regime. This will tie the research together to give an understanding of why the Outer Space Regime was discussed first to make way to discuss the main point of the research which is the Low Earth Orbit governance framework.

Within this last section, governance theory will also be discussed as it a more modern take on regime theory and will also be applied to the research.

1.6.2 Binding and Non-Binding Lawof Outer Space

Chapter Three focuses on international law and space law. This chapter starts off with a discussion on binding international law within the Outer Space Regime which consists of various treaties and principles. Some of the outer space treaties will be closely analysed and discussed as they are all important space treaties for the use of Low Earth Orbit. This chapter will also analyse and discuss non-binding international law generally and then as pertains to outer space. This is because international law is becoming increasingly more non-binding in nature and reasoning for this will be analysed within the chapter. Finally, this chapter will also discuss a growing trend – normative behaviour and norms. Taken from political science and law normative behaviour and norms will be discussed generally and then discussed and analysed within the Outer Space Regime as this discourse is also being had within the diplomatic community regarding space security and is important to the Low Earth Orbit governance framework moving forward.

1.6.3 The 3S Approach

Chapter Four looks at security, safety, and sustainability – the 3S Approach – generally and then applied to space and LEO. First the term security is discussed in general terms and then discussed and analysed as space security. Then the term safety is discussed in general terms and then discussed and analysed as space safety. Then the terms sustainability and sustainable development are discussed in general terms and then discussed and analysed as space sustainability and space for sustainable development. The 3S Approach is critically analysed specific to LEO within the governance framework.

1.6.4 Governance Theory Analysis

Chapter Five focuses on governance theory which is a segue from regime theory. Governance theory is applied to this research through a critical analysis of twenty-one governance models. Each model is presented, discussing what the model entails as well as the strengths and weaknesses of the model. Then each model is analysed vis-a-vis the current Outer Space Regime and Low Earth Orbit governance framework to see how applicable the model could be for the evolution and future use within the regime and governance framework. After each model is assessed, the research gives an overview and critical analysis of the current governance of the Outer Space Regime and LEO. Finally, based on the analysis of the governance model and the current governance recommendations are given as to which governance models will be further considered in the recommendations chapter at the end of the research.

1.6.5 Current LEO Governance Framework

Chapter Six takes a deep dive into the current governance framework of Low Earth Orbit. It starts with an understanding of what small satellites are and how international law as well as national regulations are applied to these satellites in LEO. Next, satellite constellations are discussed. While they are still small satellites and law do apply the same, there is analysis on the legal challenges regarding satellite constellations given that some constellations consist of 1000s or more satellites and will do so in the future. Next, this chapter looks at some of the most critical challenges to the Low Earth Orbit governance framework and addresses the political and legal issues surrounding these challenges. The main challenge addressed is space debris. This chapter also discusses the components of the Low Earth Orbit governance framework which includes a look at situational awareness and how it is applied to space as space situational awareness. This ties to a look at traffic management and how it is being applied to space – LEO in particular – through the concept of space traffic management. Finally, this chapter will go over potential strategies for enhancing the Low Earth Orbit governance framework. These strategies include a Space Security Rating; Long-Term Sustainability 2.0; Space Traffic Management; and the use of norms in space.

1.6.6 Recommendations and Conclusion

The last chapter will focus on recommendations for the Low Earth Orbit governance framework moving forward and will also give concluding remarks for the entire research. The chapter will start with a discussion on the components needed within a governance framework and how those components make the governance framework function. This is then discussed and analysed as applied to LEO. Taken from Chapter Five, four governance models analysed will be applied to the

Low Earth Orbit governance framework based on their applicability to the orbit and how the governance model is set up generally. This chapter then gives concrete recommendations for the sustainable governance of Low Earth Orbit which calls upon the use of risk governance paired with other strategies such as long-term sustainability, situational awareness, and traffic management of the orbit.

2 Regime Theory and the Regime Complex of the Outer Space Regime

To answer the first research question regarding the Outer Space Regime, this chapter critically evaluates regime theory and applies it to the Outer Space Regime. Special consideration is given to the evolution of regimes and to the term 'regime complex', where two or more regimes share the same issues or themes. This consideration and analysis of the evolving regime and regime complex for outer space brings originality of knowledge[1] to the international relations and law academic community and facilitates the understanding of the extant governance structure.

This chapter will describe what regime theory is, why a regime is created, maintained, and evolves, and why regimes may become part of a larger complex of regimes within an international setting. Additionally, the Outer Space Regime is critically analysed, specifically why it was created, why it is maintained, how it is evolving, and how it is connects to other regimes (e.g., telecommunications, cyber, and security) to form a larger tech regime complex. Finally, the discussion on regime theory transitions to a more modern adaptation of governance theory and to the different governance models that make up regimes and their sub-regimes, such as the Outer Space Regime and Low Earth Orbit (LEO). This chapter contributes to answering Research Question 1: How is the Outer Space Regime evolving, and why is this important to Low Earth Orbit?

This more holistic discussion on the Outer Space Regime and answering Research Question 1 provides the foundational underpinning for the other research questions and deeper discussion and analysis of the governance framework of Low Earth Orbit. This is due, in part, because Low Earth Orbit is a sub-regime of the Outer Space Regime and, therefore, is held to the same political and legal considerations. Additionally, this holistic discussion provides a basis for better assessment of potential changes or developments to the Low Earth Orbit governance framework.

[1] To date there is not any literature on regime theory or the regime complex regarding the Outer Space Regime specifically. Most literature is about outer space and spacepower from an international relations academic purview. Literature generally concerns the related theories or discusses the Trade Regime.

2.1 Regime Theory

In 1983 Stephen Krasner offered the International Relations (IR) community his seminal definition of a regime:

> Regimes can be defined as sets of implicit and explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations. Principles are beliefs of fact, causation, and rectitude. Norms are standards of behaviour defined in terms of rights and obligations. Rules are specific prescriptions or proscriptions for action. Decision-making procedures are prevailing practices for making and implementing collective choice.[2]

From this concept arose the popularity of the international relations regime theory, which analyses the reasoning and ways in which sovereign States create and maintain international regimes. Krasner's work utilises regime theory as a classical IR theory. However, it has fundamental links to International Law (IL), making this a robust choice for this dual IR-IL methodological-based research. Regime theory involves not only behaviours, but also at legal tenants within a regime. Another founding regime theorist, Oran R. Young, considers:

> International regimes are those pertaining to activities of interest to members of the international system. For the most part, these are activities taking place entirely outside the jurisdictional boundaries of sovereign states, or cutting across international jurisdictional boundaries, or involving actions with a direct impact on the interests of two or more members of the international community.[3]

Young posits that in the current globalised world, actors work collectively across sovereign boundaries to consider activities pertaining to a collective group of actors. This is also why research on outer space from an IR-IL perspective falls under the purview of regime theory. This understanding from Young is connected to legal considerations, as Article I of the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (herein known as the Outer Space Treaty or

---

[2] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 2

[3] Oran R. Young, 'Regime Dynamics: The Rise and Fall of International Regimes' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 93

OST)[4] maintains that outer space, including celestial bodies, is to be explored and utilised by all.

It is important to note that regimes are fluid, living beings where endogenous and exogenous changes can alter the course of the regime.

> Regimes are thus approached as dependent variables that can vary in several ways: in the actors' adherence to rules, norms, and principles; in the coherence and pervasiveness of agreed procedures; and in the degree to which actors share convergent expectations.[5]

Regimes are sector–specific, with certain actors, legal aspects, and key variables pertaining to the sector's nuances and needs. Additionally, individual regimes can also be connected through regime complexes, as discussed later in this section. However, first it is important to discuss regime creation and the typology of regimes to gain a better practical understanding of why regimes are created in the first place. Then it is important to consider how regimes are maintained and evolve. Then, through regime theory evolution, the research transitions to the discourse on governance theory and models of governance. This is then applied to the Outer Space Regime with consideration for the gaps in the literature which allow for original contribution to the international relations discussion on regime evolution, using outer space as the prime example. This builds the backbone for the research on the Low Earth Orbit governance framework and aids in answering the research questions.

2.1.1 Regime Creation

From an international law perspective, regimes are legal regimes that predominately converge around a treaty or set of treaties and other international law that provide *lex specialis* for a particular sector or field on top of general international law. In international relations, regimes are influenced not solely by the law, but also the actors–predominately States–and their interests, actions, and involvement in creating and maintaining the political and legal agreements, as well as the fora used for diplomatic discourse such as the United Nations. This research relies on Krasner as the predominate international relations expert on regime creation.

[4] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[5] Charles Lipton, 'The Transformation of Trade: The Sources and Effects of Regime Change' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 233

To better understand how a regime is built, this section illuminates why regimes are created and what this implies for States.

Regimes are created for various reasons, but predominately, regimes are created to serve State interests, and therefore, tend to be built in a way that encourages States participation. Some examples of these interests include gaining political power, creating norms and principles, encouraging usage and custom, and generating knowledge (e.g., through advancement in technology and science).[6] Krasner stipulates five key terms for understanding regimes: interest (i.e., State self-interest), common interest, cost, benefits, and collective goods.[7] States may join a regime either as regime creators (Krasner's 'political entrepreneurs') or as regime joiners.

> Neither international agreements nor international regimes are created spontaneously. Political entrepreneurs must exist who see a potential profit in organizing collaboration.[8]

States that pursue regime creation tend to do so for the above reasons. Regime joiners may join for the same reasons, but they may also join for fear of being left out, and therefore lowering their status. Much like the way individuals join clubs and groups to feel included and have their voices heard, regime joiners do so for their self-interest, as they consider the costs of being left out higher than those of joining, regardless of any resulting legal obligations.

Krasner states "… the basic function of regimes is to coordinate state behaviour to achieve desired outcomes in particular issue-areas".[9] The caveat here is that regime theory sways toward realism in the sense that States rule supreme and without States there would be total chaos. Krasner also mentions common interests and collective goods as reasons for creating regimes, as well as the use of the United Nations system as a forum for political and legal discussion amongst States.

Another major aspect to regime creation is the legal and political commitments necessary for the regime to be maintained, as articulated below. It is not enough that a regime is created based on State interest or even common interests; it must also utilise both legally binding international law (general and *lex specialis)* and norms, principles, and other forms of non-binding

[6] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)

[7] Ibid

[8] Robert O. Keohane, 'The Demand For International Regimes' (1982) 36 (2) International Organization, 325-355, 339

[9] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 7

international law (NBIL) or political commitments. These aspects build the framework upon which the regime rests and these commitments play a critical role in the regime life cycle.

The Outer Space Regime was created during the Cold War as a security measure between the United States and the Soviet Union (USSR). With nuclear arsenals growing and weapons technologies rapidly advancing post-WWII, the US and USSR believed the space environment could be the next location of war. To create détente between the US and USSR, States came together to create the Outer Space Regime and the Outer Space Treaty, using the United Nations as a platform for deliberation. The treaty focused on the peaceful use and non-weaponization of outer space. State regime creators worked together from 1957 to 1967 with other regime creators, such as the United Kingdom (UK), to find common ground on how space should be explored and utilised. It was in the common interest of all regime creators that space remain peaceful–not become a place of war or hostility. The creation of the Outer Space Regime is discussed further below.

2.1.2 Maintaining a Regime

In terms of regime maintenance and utilisation, regimes:

> facilitate burden sharing, provide information to governments, and help great powers keep multiple and varied interests from getting in each other's diplomatic ways.[10]

More broadly put, "regimes are social institutions governing the actions of those interested in specifiable activities (or accepted sets of activities)".[11] Additionally, regimes are social institutions "… for managing conflict in a setting of interdependence …"[12] Regimes are maintained out of necessity. In an interconnected world where States are increasingly concerned with transboundary issues such as sustainable development and cyberspace, regimes now support not only national security, but also newer concerns of safety and sustainability.

A regime can be considered a wide-scale form of multilateralism in which all State actors within the regime are working toward a common goal or set of goals. However, there is a

[10] Robert O. Keohane and Joseph S. Nye Jr., "Two Cheers for Multilateralism" (1985) 60 Foreign Policy, 148-167

[11] Oran R. Young, 'Regime Dynamics: The Rise and Fall of International Regimes' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 93

[12] Ernst B. Haas, 'Words Can Hurt You; or, Who Said What About Regimes' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)

growing use of multistakeholderism as today's regimes also include many non-State actors at the transnational level. This use of multistakeholderism is varied, as many States, such as Russia and China, still believe that the State is the only actor necessary for international decision-making. Whether multilateral or multistakeholder, a regime holds the legal, social, and political considerations through a forum, such as the United Nations.

The United Nations (UN) was created and is maintained as an international forum of peacekeeping, allowing all States to have an equal platform upon which they may discuss issues and challenges faced by the global community. Regimes function in a similar manner, in that States may voice their interests, concerns, and solutions to global challenges whilst managing potential conflict over said challenges. Legal and political instruments are critical to regime maintenance. These instruments serve as the framework for how actors are encouraged and expected to behave on the international stage. This is why this research takes an IR-IL approach. Understanding why a regime and its governance framework is created, evolving, and maintained is based on political and legal commitments and understandings. Regimes are maintained to facilitate cooperation through behaviour and to provide a framework for national implementation that can also support regulating non-State actors within the regime. As a regime is maintained, over time it may also need to evolve to stay current and useful. The next section covers regime evolution.

2.1.3 Regime Evolution

Much literature details why regimes are created and may decay, but consideration is given to regime evolution. When discussing regime evolution, most scholars analyse the Trade Regime and the Climate Regime. These are two prime examples of evolving regimes and are useful for analysis on regime evolution. However, there is much room for original contribution in regime evolution analysis, and the Outer Space Regime presents an excellent opportunity. This section offers a better understanding of how international relations scholars perceive how and why regimes evolve. Krasner argues there are two forms of regime evolution.

> Change within a regime involves alterations of rules and decision-making procedures, but not of norms or principles; change of a regime involves alteration of norms and principles…[13]

This view posits that regimes can evolve in a way that retains the integrity of the original regime, or they may evolve into completely new regimes or sub-regimes. Additionally, "regimes can change based on shifts in technology/science and/or knowledge".[14] This is an important factor in the Outer Space Regime, as well as within the regime complex.

Haggard and Simmons suggest another approach with four ways in which regimes can evolve– strength, organizational form, scope, and allocational mode.[15]

According to Haggard and Simmons' framework, strength of a regime is measured by States' level of compliance[16] with the legalities of the regime, even where their self-interests are contradictory[17]. In other words, regime demonstrates strength if its legal tenets hold fast even when it is out of the States' interests. This can be seen in the Outer Space Regime where States' political self-interests do come into play, but they also uphold the tenets of the Outer Space Treaty and implement the principles into national regulations on space activity.

Organisational form includes the administrative system set in place to aid in dispute settlement, transparency, communication, and verification[18]. Actors in the Outer Space Regime are gaining interest in regime maintenance, especially international space law enforcement. The Legal Subcommittee of the UN Committee on the Peaceful Uses of Outer Space (UN COPUOS) facilitates discourse on the implementation of international space law into national legislation. Here, Member States can also call out other Member States for not having signed and ratified treaties or for irresponsible behaviour in space pursuant to international space law. Through the UN system, States can contribute to transparency and confidence-building measures, aiding in the organisational form of the regime.

---

[13] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 5

[14] Arthur A. Stein, 'Coordination and Collaboration: Regimes in an Anarchic World' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 138

[15] Stephan Haggard and Beth A. Simmons, "Theories of International Regimes" (1987) 41 (3) International Organizations, 491-517, 496

[16] Ibid, 496

[17] Ibid, 496

[18] Ibid, 496-497

Scope involves the content or issues discussed within the regime[19]. This is a reliable measure for regime evolution, as it shows how the regime adapts to changing needs and issues. A regime can add agenda items to its mandate over time to broaden or update its scope. The *Guidelines for the Long-Term Sustainability of Outer Space Activities* (herein known as the Long-Term Sustainability Guidelines or LTSG)[20] were created within UN COPUOS to ensure current and future generations have access to explore and use space as set out in Article I of the Outer Space Treaty.[21]

Allocational mode refers to the method of resource allocation,[22] whether this is by non-State actors at one extreme of the spectrum or solely by States at the other end. Within the Outer Space Regime, allocation of resources is managed through tenets of treaties. In the Outer Space Treaty under Article II,[23] space, the Moon, and celestial bodies are not to be nationally appropriated, because space as a resource should be for the benefit of all States. For satellites to use the radio frequency spectrum, the International Telecommunications Union (ITU) Radio Regulations set out the tenets for allocation and allotment of radio frequencies for satellite use, more of which will be discussed in further chapters.

The Pew Center on Global Climate Change issued a report on the evolution of multilateral regimes, which detailed other ways in which they could evolve.[24] The report considers four paths for regime evolution: political consensus, trial and error, flexibility, and confidence and trust. Political consensus concerns whether problems or challenges exist and, if so, how to address them. It usually takes considerable time and deliberation to, first, acknowledge and then find solutions to such challenges. For example, the Long-Term Sustainability Guidelines took ten years to complete within the UN COPUOS. Although they are non-binding, they still required Member State consensus. First, the issue of space sustainability was added to the UN

[19] Ibid, 497
[20] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69
[21] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[22] Stephan Haggard and Beth A. Simmons, "Theories of International Regimes" (1987) 41 (3) International Organizations, 491-517, 498
[23] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[24] Daneil Bodansky and Elliot Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 3-4

COPUOS mandate. Then deliberations took place regarding the method of regulation of space sustainability. The guidelines were then discussed, created, and agreed upon. Although a lengthy process, Political consensus is necessary for international law created through the UN system.

In terms of trial and error, States may discuss and attempt different approaches to addressing issues before deciding the best course of action. This may involve creating non-binding instruments before committing to a legally binding treaty or creating various types of working groups through the United Nations system to further deliberate. Within the Outer Space Regime, this method is observable in approaches to space sustainability and space security. In the case of space sustainability, as noted above, States took the non-binding international law approach with guidelines for national implementation and non-State actor consideration. In space security, States are currently considering norms and how a responsible actor in space might mitigate threats to space systems, most often through political commitments.

Flexibility is essential, especially considering the world's reliance on rapidly evolving scientific and technological advances. A regime must be capable of adapting its understanding of issues and approaches to solutions based on developments in science and technology. This applies heavily to the Outer Space Regime, as space activities change and develop as technologies advance. With the growing issue of space debris in Low Earth Orbit, States must consider space sustainability and address End of Life (EoL) procedures in their national regulations. The UK, for example, has a traffic light assessment[25] for satellite licencing, which requires operators to consider space debris and the sustainability of Low Earth Orbit.

States need confidence and trust in a regime, built through transparency and confidence-building measures (TCBMs) both within the regime and between actors. Confidence and trust can also stem from the legitimacy of the regime and the behaviour of its member States. In the Outer Space Regime, deliberating issues through the UN system and knowledge-sharing regarding activities in space and the implementation of international space law in national regulations are part of building trust and transparency. This helps States know when other actors are abiding by the tenets of space law. Committee meetings at the UN to address issues

[25] Civil Aviation Authority, 'Applying for a Licence: Pre-Application Engagement and How to Apply for a Licence' (*CAA* 2022) <https://www.caa.co.uk/space/orbital-satellite-operator/applying-for-a-licence/> accessed 24 November 2022

and share information are an important TCBM and communication strategy that help maintain the regime.

The Trade Regime and the Climate Change Regimes are considered in the next section, as they are two examples frequently academically analysed as evolving regimes under the framework of regime theory. These analyses are then applied to the Outer Space Regime and the Low Earth Orbit governance framework. The critical analysis of regime theory as applied to space to form an underpinning methodology is original as this application is not found in any prior legal or political academic space discourse.

2.1.3.1 Regime Evolution: The Trade Regime

The evolution of the Trade Regime from the General Agreement on Tariffs and Trade (GATT) into the World Trade Organization (WTO) is well-analysed. From an IR perspective, this regime is the most cited in discussions of regime theory and regime evolution. Three key points should be gleaned from this evolutionary process, all of which are now relevant to the Outer Space Regime. First,

> Perhaps the biggest single problem for trade today is that the domestic and international institutional mechanisms are no longer fully complementary: the range of domestic stakeholders has expanded, and the international issues have become more complex and demand more domestic institutional change.[26]

Within the Outer Space Regime there is also a changing dynamic nationally and internationally, especially with the rise of non-State actor participation in space activities of their own design, unrelated to government projects. What is expected at the international level by States must also apply to national-level regulations for non-State actors. Within Low Earth Orbit, there are many complex issues involving the organisational level of non-State actors that must be addressed at the international level. As LEO becomes increasingly congested with satellites (active and inactive) and space debris, there will need to be institutional change on how collision avoidance manoeuvres are conducted both between States and between State and non-State actors, as not all actors have the same rigour of monitoring or means of communication.

[26] John H. Barton, Judith L. Goldstein, Timothy E. Josling, and Richard H. Steinberg, *The Evolution of the Trade Regime: Politics, Law, and Economics of the GATT and the WTO* (Princeton University Press, 2006) 19

The second aspect of the evolutionary process is the matter of spill-over. According to Barton et. al, "spill-overs have increasingly generated trade topics that historically have been treated as internal regulatory measures".[27] This suggests that what once were national regulatory issues now cross over into international consideration. Topics that might typically reside within another regime can spill over into the trade regime due to interconnected challenges. Within the Trade Regime:

> In the 1980s and 1990s, demand emerged to address many "new" issues, such as trade in services, intellectual property protection, and internal investment measures. Since the Uruguay Round, the WTO has also begun addressing issues relating to environmental protection and competition policy.[28]

The Outer Space Regime faces a similar issue of "spill-over", for example, in space security. Considering potential threats to space systems from cyber or electronic warfare, discussion of regulatory solutions across regimes is crucial. Sustainable development is another area of cross over between the OSR and other regimes. Many State and non-State actors utilise space systems in support of Sustainable Development Goals (SDGs). Therefore, terrestrial environmental and socio-economic concerns are also on the agenda within the UN at the United Nations Committee on the Peaceful Use of Outer Space Scientific and Technical Subcommittee. This facilitates the sharing of information on how space systems can and do support SDGs and other development needs. Satellites can have autonomous features built in as well as advanced robotics, artificial intelligence (AI), machine learning, or Internet of Things (IoT) capabilities. These technological advancements are regulated outside of the Outer Space Regime; however, discussion on these technological trends now occurs within the space industry as well.

The third matter to consider is that changes in geopolitics, macroeconomic conditions, technological developments, and institutional changes can lead to regime evolution.[29] The Outer Space Regime started in the geopolitical atmosphere of the Cold War and now exists in a multipolar and multistakeholder epoch, with over 100 States deliberating on issues in the UN COPUOS. From a geopolitical perspective Bowen suggests, "… what happens in Earth orbit

---

[27] John H. Barton, Judith L. Goldstein, Timothy E. Josling, and Richard H. Steinberg, *The Evolution of the Trade Regime: Politics, Law, and Economics of the GATT and the WTO* (Princeton University Press, 2006), 20
[28] Ibid, 20
[29] Ibid, 20

will reflect the politics of the international system on Earth".[30] Within the Outer Space Regime and Low Earth Orbit, geopolitical trends on Earth will translate to the political atmosphere of those that utilise and benefit from space. This connection also exists between the respective economic markets of space and Earth. The space economy is now firmly established, so more non-State actors can utilise space for business growth and prosperity, meaning the space market now ebbs and flows with the terrestrial economic market.

As previously noted, technological advances such as IoT, AI, and cyber warfare can be directly applied to space. Therefore, the legal decision-makers of the OSR must be prepared to consider whether any regulations might be needed within the regime in response to technological advances stemming from other regimes. Furthermore, the Outer Space Regime has encountered institutional changes throughout its history, resulting from the five treaties and various binding and non-binding legal instruments that have been developed. Additionally, shifts in political rhetoric in general–such as towards climate change; development issues; Equality, Diversity, and Inclusion (EDI); or considerations for developing States–tend to shape the regime. Examples of this within the Outer Space Regime involve the inclusion of discourse on SDGs, international cooperation, and knowledge-sharing, as well as the recent European Space Agency (ESA) parastronaut feasibility project.

Analysing the Trade Regime as an evolving regime and its similarities to the Outer Space Regime demonstrates the justification for the assertion of this research that the OSR is in fact an evolving regime. All three of the parameters for the Trade Regime's evolution are also prevalent within the Outer Space Regime and have direct application to Low Earth Orbit framework changes. The understanding that a regime evolves because of many exogenous and endogenous variables has been theoretically discussed within regime theory literature, usually citing the Trade Regime as the prime example. However, as demonstrated below, the Climate Change Regime, albeit 'younger', has also had to adapt due to the urgency of the issue.

2.1.3.2 Regime Evolution: The Climate Change Regime

Like the Trade Regime, the Climate Change Regime is often referred to as an evolving regime. Although the Climate Change Regime is a younger regime, there is a sense of urgency placed on its evolution as sustainability is a leading issue in world politics.

[30] Bleddyn Bowen, *War in Space* (Edinburgh University Press, 2020) 2

> …in environmental regimes, there is a particular need for flexibility and evolution, because our understanding of problems is likely to change as science and technology develop. Regimes need to be able to respond in a flexible manner.[31]

Building on the concepts introduced in the previous section on regime evolution, rhese concepts of flexibility and evolution are true of not just environmental regimes, but also for any regime that is highly influenced by science and technology – as is the Outer Space Regime. The sheer speed at which scientific and technological advancements develop means if a regime does not evolve it will soon become obsolete and unable to regulate effectively.

There are five dimensions upon which the regime can evolve, as found in the Climate Change Regime.

> Regimes can evolve along one or more dimensions. First, they can become deeper. Second, they can become broader. Third, they can become more integrated. Or fourth, they can evolve along multiple dimensions at once.[32]

Bodansky and Diringer additionally suggest that a regime may deepen through greater precision.

Considering the dimension of deepening, Bodansky and Diringer posit that it can occur "…through the development of stronger review, dispute settlement, and enforcement mechanisms".[33] While the Outer Space Regime does have a strong review mechanism in place through UN COPUOS and its subcommittee deliberations, the regime has not yet fully established any dispute settlement or enforcement mechanisms. UN COPUOS and its subcommittees regularly review the ways and means of implementation of legal instruments as well as how the instruments can work together to present legal solutions to outer space affairs. Member States can suggest items to add to the agenda as issues or challenges arise, as in the case of consideration of small satellites and satellite constellations.

Regarding dispute settlement, the Outer Space Regime has a thin mechanism in place which includes claiming compensation through diplomatic channels, international instruments, or

[31] Daneil Bodansky and Elliot Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 3
[32] Ibid, 5
[33] Ibid, 9

establishment of a Claims Commission. The latter has not yet been called upon or put into use. The *Convention on International Liability for Damage Caused by Space Objects* (hereafter referred to as the Liability Convention)[34] includes Articles IX-XIII on claiming compensation through diplomatic channels and Articles XIV-XX on establishing a Claims Commission. Further, Article XI of the Liability Convention sets forth that:

> Nothing in this Convention shall prevent a State, or natural or juridical persons it might represent, from pursuing a claim in the courts or administrative tribunals or agencies of a launching State.[35]

Article XI[36] also stipulates that a State must choose between pursuing a claim either via courts and tribunals or under the Liability Convention. Article XI also stipulates that a State must choose between pursuing a claim either via courts and tribunals or under the Liability Convention. A State may not pursue a claim through both channels, nor may it do so through another international agreement to which the concerned States are bound. In 2011, the Permanent Court of Arbitration created the Optional Rules for Arbitration of Disputes Relating to Outer Space Activities. However, as of 2023, no entity has called upon them. Within the Regime Complex, there are additional dispute mechanisms regarding radio frequency interference and the use of the radio frequency spectrum through the ITU. The ITU sets forth dispute clauses under Article 56 of the Constitution, Article 41 of the Convention, and Article 15 of the Radio Regulations.[37] These articles may apply to satellite radio utilization; however, they are handled through the ITU, not through the Outer Space Regime, strictly speaking.

Finally, on the matter of dispute mechanisms, State and non-State actors may also wish to settle matters outside of the international options. Typically, actors prefer to work out amicable settlement over going to court. Further, arbitration clauses are usually built into contracts to create clear understanding of what the process would be for claims settlements. The only example of international dispute settlement within the international outer space community took place in 1978 when a Soviet satellite, Kosmos 954, accidentally crashed into North-West Canada, spreading debris–including the satellite's nuclear reactor–across the State. Under the

[34] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[35] Ibid
[36] Ibid
[37] See Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330; International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn)

Liability Convention, Canada chose to claim compensation through diplomatic negotiations. By 1981, the Soviet Union agreed to pay Canada approximately 3 million Canadian dollars "… due to the damage caused, however [the Soviet Union] did not admit liability for the incident".[38] Additional analysis of the Liability Convention and liability issues in Low Earth Orbit will be addressed in Chapter Two.

Enforcement within the Outer Space Regime is weak at best. There are no strict or binding policing mechanisms to hold actors accountable. As it stands under the Outer Space Treaty Article VI,[39] States are responsible for non-State actors in space. Therefore, at the international level, States are solely responsible for their own activities and the activities of non-State actors under their jurisdiction. There do exist various treaties and binding and non-binding international legal instruments, but if a State were to be in breach of a legal tenant, they would likely face a mere calling-out or 'slap on the wrist' within the UN system. At most, a State might be sanctioned, but only if it had violated a treaty to which it was a signatory State, and the sanctions would have to be approved by the United Nations Security Council.

Bodansky and Diringer also explain that regimes can evolve in breadth:

> A regime can also evolve through the broadening of its membership or substantive scope, starting with a comparatively small number of like-minded states and then adding new members and new subject areas.[40]

This second dimension of evolution has already happened because of the Outer Space Treaty. As stated before, in 1958, at the beginning of the Outer Space Regime, there were only 18 Member States in UN COPUOS[41]. As of 2023, there are 102 Member States[42], which shows that there is a broadening of membership based on the utilisation, benefit from, and interest in outer space. Over the years, new issues have been put on the agenda, such as the long-term

---

38 Andrew Brearley, 'Reflections Upon the Notion of Liability: The Instances of Kosmos 954 and Space Debris' (2008) 34 Journal of Space Law, 291-319, 310

39 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

40 Daneil Bodansky and Elliot Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 9

41 United Nations Office of Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Membership Evolution' (*UNOOSA*, 2021) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html> accessed 20 November 2022

42 Ibid

sustainability of outer space, or more recently, small satellites and satellite constellation concerns.

The third dimension of evolution posited by Bodansky and Diringer is integration, particularly of fragmented legal instruments that become linked or merge. This integration has been found to enhance coordination across States. Essentially, this has happened within the OSR, as the Outer Space Treaty is the foundation upon which all other legal instruments – binding or non-binding – are tied. The LTSG take into consideration all five outer space treaties as well as the Space Debris Mitigation Guidelines and other space legal instruments. While they are not merged legal instruments, the legal framework within the Outer Space Regime allows for binding and non-binding tenets to be linked to each other, to the core Outer Space Treaty, and to general international law.

Regimes can also evolve along multiple dimensions at once. This variable can be taken to have two meanings. First, that all variables mention in this section are being used at the same time and second, that the OSR can evolve alongside the regimes within the regime complex as well as having the regimes consider the same issues at the same time. The Outer Space Regime is currently evolving in each dimension. The regime is considering further agenda items, new scientific and technological advances, as well as how these items are interconnected along the regime complex. With the growing number of Member State and Permanent Observers to the UN COPUOS, there is a growing number of interested parties and a more diverse knowledge base for deliberations. Legally speaking, the Outer Space Regime is also growing or evolving. For example, the LTSG will be further considered at UN COPUOS under working group LTS 2.0 to deliberate on ways and means of implementing the guidelines and debating additional guidelines for the future. Finally, the Outer Space Regime is now adding to considerations within the Security Regime under the UN 1st Committee by deliberating over responsible behaviours in space under the new *United Nations General Assembly Resolution (Res 75/36) on Reducing Space Threats through Norms, Rules, Principles of Responsible Behaviours*. Each of these is being worked on simultaneously and with the UN system. Other evolutionary changes are being made at the regional, national, industry levels as well.

The fifth variable of regime evolution, through greater precision, can be observed through a legal lens.

> Regimes often begin by articulating very general standards and the provide greater precision over time, either through decisions or the parties or through additional legal instruments such as protocols or annexes.[43]

Within the Outer Space Regime this has always been the case, as the first treaty was created in 1967 with the subsequent treaties being created between the 1967 and 1979. Though today there are not currently any deliberations on new space treaties, there are many non-binding instruments, political commitments, and State-to-State agreements being created that link to the Outer Space Treaty. Additionally, with the ITU, revisions to the Radio Regulations are completed at the World Radiocommunication Conference every four years. For example, the most recent conference in 2019 included additional information regarding radio spectrum utilisation for large satellite constellations as there is growing interest in the private sector in the use of these constellations for global internet coverage.

In practicality, the variables that lead to regime evolution are formulaic. The key difference is how actors deal with these variables with regards to the specificities of the regime itself. Three IR scholars–Koremenos, Lipson, and Snidal–came up with a similar set of variables to describe regimes in terms of dependent and independent variables. The dependent variables include membership, scope, centralization, control, and flexibility. The independent variables involve distribution problems, enforcement problems, number of actors, and uncertainty.[44] Trade Regime experts, Climate Change Regime experts, and IR regime evolution theorists alike argue that there are variables that must be identified to effectively analyse and understand the evolutionary process of regimes.

The evolution of the Outer Space Regime tends to share more parallels with that of the Climate Change Regime than the Trade Regime, as it is happening at the same time, in the same political climate.

> The international climate community does not face an either-or choice. Given its urgency and enormity, the only choice is to confront the climate

[43] Daneil Bodansky and Elliot Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 7
[44] Barbara Koremenos, Charles Lipson, and Duncan Snidal, "The Rational Design of International Institutions" (2001) 55 (4) International Organizations, 761-799

> challenge on all practical fronts. The real question, at any given moment, is which avenues offer the greatest promise of moving countries forward.[45]

This sentiment holds true for the Outer Space Regime as well. The outer space community is facing many issues, and the path of ‘or-or-or’ is no longer relevant–the outer space community must now think in terms of ‘and-and-and’ to find the most promising way forward for the regime, the environment, and its actors.

2.1.4 Concluding Thoughts on Regime Evolution

Most literature on evolutionary regime theory is broad and lacking extensive detail. There are gaps in the literature that call for more IR analysis of what a regime’s evolutionary process entails. Specifically, the actual process of regime evolution is little discussed beyond the mere notion that it can occur. This research argues that regime evolution–to a certain extent–is happening every day. A regime is always in flux, because it is a living element. Specific decision-makers representing States and non-State actors come and go; critical topics of interest move with the growth of scientific and technological knowledge; changes in States’ governments can affect its foreign affairs and interests, which are then reflected in their decision-making within regimes.

The existing literature does not say much about the importance of the Global South or developing and emerging States with regards to regime evolution. Regimes do not only affect the West or developed States, and there must be discussion of how different States may approach and work within a regime. As non-binding legal instruments gain prevalence, there must be a stronger discussion of what their use implies for a regime. This process itself could be considered a huge evolutionary process. With the rise of interest from non-State actors, such as private actors and international organizations, regimes have more than sovereign State interest and activity to consider, especially in the Outer Space Regime. The regime analysis of the Outer Space Regime below considers these gaps with regards to the more formal theoretical discussion provided by the IR regime theorists mentioned above.

[45] Daneil Bodansky and Elliot Diringer, ‘The Evolution of Multilateral Regimes: Implications for Climate Change’ (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 23

2.2 The Outer Space Regime: Creation and Evolution

To lay a foundation for the analysis of the Low Earth Orbit governance framework, first it is important to discuss why and how the Outer Space Regime was created. This demonstrates why this research considers the Outer Space Regime to be an evolutionary regime. Krasner suggests that,

> change within a regime involves alterations of rules and decision-making procedures, but not of norms or principles; change of a regime involves alteration of norms and principles.[46] [1]

It is natural for regimes to alter rules and decision-making procedures over time, especially as technology, science, and knowledge advances in the regime's domain. However, changing the regime also requires reconsidering norms and principles, thus potentially changing the behaviours of actors based on shifts in politics, interests, or advancing science, technology, and knowledge. The evolution of the Outer Space Regime began with the creation of the Outer Space Treaty and followed with additional treaties and other legal instruments and political commitments as the space environment became more frequented by a growing number of actors, activities, and space debris. In recent years, the Outer Space Regime has started to reconsider its norms and principles, especially with the growing non-State actor presence in space and the rapid advancement of space capabilities on-orbit and on celestial bodies. The creation of the regime is a reasonable starting point upon which to build a framework of governance, but in an ever-changing multipolar world faced with rapidly changing technology, some regimes are faced with incredible change.

In 1958, shortly after the launch of the Soviet Sputnik satellite–the first satellite to be launched into space–the United Nations General Assembly (UNGA) established an ad hoc Committee on the Peaceful Use of Outer Space with 18 members to consider outer space affairs and legal problems. One year later, in 1959, the UNGA established UN COPUOS as a permanent committee with 24 members, reaffirming the mandate to serve:

> … as a focal point for international cooperation in the peaceful exploration and use of outer space, maintain close contacts with governmental and non-governmental organizations concerned with outer space activities, providing for exchange of information relating to outer space activities and

[46] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 5

assisting in the study of measures for the promotion of international cooperation in those activities[47]

Also in 1958, the United Nations Office for Outer Space Affairs (UNOOSA) was created as a small expert group to support the ad hoc committee. By 1993, UNOOSA became what it is today in Vienna, Austria, providing secretariat services to UN COPUOS and its two subcommittees, the Scientific and Technical Subcommittee and the Legal Subcommittee. In 1979, the Conference on Disarmament was established in Geneva, Switzerland, where space security–including the prevention of an arms race in outer space and the militarization of outer space–are under consideration. In terms of the legal instruments of the Outer Space Regime, the regime was built on a foundation of treaty law during the Cold War between 1963 and 1967. The early years were focused on security through détente between the United States and the Soviet Union and sovereign prestige over the race to the Moon. Many international relations academics have observed that space governance has been largely shaped by the Cold War[48]. Sheldon and Gray further analyse that while the Cold War is important for space governance, that does not mean it should be the only point of consideration.

The Outer Space Treaty was brought into force 10 October 1967[49]. At this time there were 28 Member States to the UN COPUOS. 59 States signed when the Outer Space Treaty was open for signature on 27 January 1967. As of February 2023, 23 States have signed and 112 have ratified the Outer Space Treaty.[50] While 27 January 1967[51] could be argued as the date on which the Outer Space Regime was solidified, it was created before this date through deliberations on drafting the treaty itself as well as the creation of the ad hoc committee in 1958.[52]

---

[47] United Nations Office of Outer Space Affairs, 'COPUOS History' (*UNOOSA*, 2022) <http://www.unoosa.org/oosa/en/ourwork/copuos/history.html> accessed 6 May 2021

[48] See: Peter L Hays and Charles D Lutes, 'Towards a Theory of Spacepower' (2007) 23 Space Policy 206-209; John B Sheldon and Colin S Gray, 'Chapter 1 Theory Ascendant? Spacepower and the Challenge of Strategic Theory' in Charles D Lutes and Peter L Hays, *Toward a Theory of Spacepower: Selected Essays* (National Defense University Press 2011); and James Clay Moltz, 'The Changing Dynamics of Twenty-First-Century Space Power' (2019) 13 (1) Strategic Studies Quarterly 66-94.

[49] Committee on the Peaceful Uses of Outer Space Legal Subcommittee, 'Status of International Agreements Relating to Activities in Outer Space as at 1 January 2022' (28 March 2022) A/AC.105/C.2/2022/CRP.10

[50] Ibid

[51] Ibid

[52] United Nations Office for Outer Space Affairs, 'Timeline' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/timeline/index.html> accessed 24 February 2023. See 'First General Assembly Resolution on Outer Space Adopted December 13, 1958' on Timeline.

The ‘space treaty’ epoch ran between 1958 and 1984 until the last treaty, the Moon Agreement, came into force on 11 July 1984. This was an era of treatylaw, security measures and the bringing into force of five interconnected space treaties known as the Outer Space Treaty; the *Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space* (henceforth referred to as the Rescue Agreement); the Liability Convention; the *Convention on Registration of Objects Launched into Outer Space* (henceforth referred to as the Registration Convention); and the *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* (henceforth referred to as the Moon Agreement).

From a regime theory perspective, the creation of the Outer Space Regime and the first epoch could be defined as hierarchical, hegemonic, and based on negotiation A hierarchical governance structure allows States to dominate the regime while non-State actors take a more “subservient role”[53]. The Cold War era ushered in a bipolar hegemonic world, pitting the United States against the Soviet Union with an emphasis on the use and advancements of science and technology. With the rising tensions of a potential nuclear war, the two super-powers came together to negotiate the Outer Space Treaty in hopes of preventing a war in space. Moltz suggests this was an era of Cold War ‘spacepower’ he terms a technocracy which included a State-centric and military-led approach to space governance.[54] This type of regime creation is what Oran Young classifies as a constitutional, negotiated order in which the development of the regime involves those States which would be considered subject to the regime and are thus “directly involved in the relevant negotiations”.[55]

From 1982 until 1999, principles were being developed which eventually ushered in the ‘principles’ epoch. It was from this period onward that Non-Binding International Law (NBIL) started to become the predominate mechanism at the international level. There was a rise in the number of State Parties to the treaties as well as focus away from militaristic uses of space into more economic ventures, which would later lead to the rise of the private sector in the ‘new space’ era. Here Moltz would say the shift is from a technocracy to a netocracy where there is

[53] Rikke Arnouts, Marielle van der Zouwen, and Bas Arts, ‘Analysing Governance Modes and Shifts – Governance Arrangements in Dutch Nature Policy’ (2012) 16 Forest Policy and Economics, 43-50, 44
[54] James Clay Moltz, ‘The Changing Dynamics of Twenty-First-Century Space Power’ (2019) 13 (1) Strategic Studies Quarterly 66-94
[55] Oran Young, ‘Regime Dynamics: The Rise and Fall of International Regimes’ (1982) 36 (2) International Organizations, 277-297, 283

a more commercial-led form of space governance.[56] It was then, during the deliberations over the principles, that the concept of a more pluralistic regime, with a nested and complex format including non-State actors came into play. These principles, such as the *Principles Relating to Remote Sensing of the Earth from Outer Space,* are nested under the Outer Space Treaty and the four subsequent treaties.

From 2000 onward, the Outer Space Regime was firmly in an epoch of political commitments and non-binding international law. Starting with the Space Debris Mitigation Guidelines first developed by the Inter-Agency Space Debris Coordination Committee (IADC) and then brought to UN COPUOS for endorsement in 2007, the era of non-binding legal instruments continued the work started by the previous epoch focusing on principles and shifting legally to Non-Binding International Law or 'soft law'. The latest non-binding mechanisms at the international level are the 2019 Long-Term Sustainability Guidelines, created and reaching consensus over a 10-year work-plan within UN COPUOS. As the size of membership to UN COPUOS has reached over 100 as of 2023, it is understandable that with more diversity in membership, the size of membership, and the addition of further challenges and concerns in space that finding consensus for a new space treaty would be lengthy and perhaps even outdated by the time it would be open for signature. Therefore, unless consensus can be found on certain topics in the coming decades, it is unlikely that the non-binding legal epoch is to be replaced soon. While the regime may evolve in other dimensions, it seems that the evolution to NBIL is here to stay for the time being. This `non-binding approach can be further seen in the UN Conference on Disarmament where space security is discussed. On space security, States have taken the approach of considering political commitments and responsible behaviours in space, which now are non-binding tenets reinforced by national acceptance.

2.2.1 The Outer Space Regime as a Nested Regime: A Dual Approach

The interpretation of a 'nested' regime in international relations is two-fold: one meaning is that international law is comprised of nested sources of law relevant to the regime; while the second is that the actors themselves are nested within various multilateral/multistakeholder frameworks. The first approach, considered by Keohane within his regime theory analysis suggests:

[56] James Clay Moltz, 'The Changing Dynamics of Twenty-First-Century Space Power' (2019) 13 (1) Strategic Studies Quarterly 66-94

> Investigation of the sources of specific agreements reveals that they are not, in general, made on an *ad hoc* basis, nor do they follow a random pattern. Instead, they are "nested" within more comprehensive agreements, covering more issues.[57]

What this means is that the treaties stand as the foundation to the regime upon which all else is nested within.

This multi-layered system allows for continuity stemming from the treaties onward, which then means that the treaties do not need to be re-opened for discussion, but rather built upon using additional principles, resolutions, other forms of international law–including non-binding international law and implementation of international space law at the national level. The Outer Space Regime nest includes binding and non-binding international law, national policies and regulations, and various standards and best practices of a more operational purview.

The second approach, taken by Alter and Meunier, considers actors as the nested variables under consideration.

> Nesting refers to a situation where regional or issue-specific international institutions are themselves part of multilateral frameworks that involve more states or multiple issues. Institutions are imbricated one within another in concentric circles, like Russian dolls.[58]

In this iteration, Alter and Meunier provide the example of European States, as some are part of the European Union and various regimes but also act as individual Member States. This example can be applied to the Outer Space Regime because just as some European States are Member States and Members of the European Union, they can also be actors within the Outer Space Regime, the European Space Agency, and have space agencies of their own. Alter and Meunier argue that this entanglement at the international level created by nesting "… of international institutions creates a problem of overlapping jurisdictions with no hierarchy to resolve conflicts across regimes".[59]

[57] Robert O. Keohane, 'The Demand for International Regimes' (1982) 36 (2) International Organization, 325-355, 334
[58] Karen J. Alter and Sophie Meunier, 'Nested and Overlapping Regimes in the Transatlantic Banana Trade Dispute' (2006) 13 (3) Journal of European Public Policy, 362-382
[59] Ibid

Because the Outer Space Regime is the overarching regime for space activity based on the tenets of the outer space treaties and because LEO is also based on the tenets of the outer space treaties, it can be argued that the sub-regimes in space, such as LEO, are also nested within the larger, more holistic Outer Space Regime. One caveat could be if the outer space treaties were no longer relevant, for example to space settlements or a continuous human presence on Mars. However, this discussion is beyond the scope of this research and, as such, it will be assumed that the Outer Space Regime and the core outer space treaties are the foundation and holistic regime for all other space sub-regimes, such as Low Earth Orbit.

2.2.2 The Outer Space Regime and the Regime Complex

While the Outer Space Regime nest showcases the international law perspective, the Outer Space Regime complex showcases the international relations perspective with regards to the various actors and institutions working within the regime. The concept of the regime complex has been discussed by many key experts in international relations. A regime complex is:

> … an array of partially and non-hierarchical institutions governing a particular issue-area. Regime complexes are marked by the existence of several legal agreements that are created and maintained in distinct fora with participation of different sets of actors. The rules in these elemental regimes functionally overlap, yet there is no agreed upon hierarchy for resolving conflicts between rules.[60]

This understanding suggests a horizontal overlapping of issue areas with commonalities. Another interpretation by Nye is that a regime complex "… is a loosely coupled set of regimes".[61] Nye further suggests that a regime complex lies somewhere between a single regime and a fragmented arrangement.[62] While most of the institutions fall within the Outer Space Regime, there are some, such as the International Telecommunications Union (ITU) and the United Nations Institute for Disarmament Research (UNIDIR), which fall within their own

[60] Kal Raustiala and David G. Victor, 'The Regime Complex for Plant Genetic Resources' (2004) 58 International Organization, 277-309, 279
[61] Joseph S. Nye Jr., 'The Regime Complex for Managing Global Cyber Activities' Global Commission on Internet Governance (Centre for International Governance Innovation, the Royal Institute for International Affairs, and Chatham House) Paper Series No.1, May 2014, 7
[62] Ibid, 7

regimes and other regime complexes, such as the Telecommunications Regime or Security Regime, respectively, as well as the growing Cyber Regime.

Since the ‘non-binding international law’ epoch emerged in 2000, it has been maintained with support from seminal works such as the Space Debris Mitigation Guidelines, the *Transparency and Confidence-Building Measures (TCBMs) in Outer Space Activities*, and the newest LTSG being added to the list of instruments being implemented at the State and non-State levels. NBIL is further discussed in Chapter Two. The NBIL epoch is blended with discourse on normative behaviour and what actions and attitudes indicate responsible behaviour in space, specifically for State actors. However, as the private sector is ever growing in the Outer Space Regime, the use of industry standards and best practices is also under consideration in the current epoch of space governance.

2.3 The Outer Space Regime

The remainder of this section will go into detail on the Outer Space Regime and analyse the evolution of the regime. Additionally, the Outer Space Regime will then be connected to the Low Earth Orbit sub-regime with an explanation of how LEO is nested within the regime and an analysis of the current framework for LEO. Moving forward, it should be noted that the terms ‘regime’ and ‘governance’ are used synonymously in this analysis.

In the first epoch of the Outer Space Regime, the model of governance was considered a hierarchy formed from a Cold War Order.[63] A hierarchy mode of governance is based on authority, regulation, and States being considered the only actors within the regime. State actors create the laws, rules, norms, principles, and other instruments that form the basis of the regime. During this epoch, the OST and the subsequent space treaties were deliberated upon, created, and then signed and ratified to a certain extent. Comparatively, the current epoch employs a network mode of governance. In a network mode of governance, there is an emphasis on collaboration, encouragement of voluntary behaviour using non-binding international law, and inclusion of other forms of actors, such as the non-State actor. In a network governance mode,

[63] See: John B Sheldon and Colin S Gray, ‘Chapter 1 Theory Ascendant? Spacepower and the Challenge of Strategic Theory’ in Charles D Lutes and Peter L Hays, *Toward a Theory of Spacepower: Selected Essays* (National Defense University Press 2011); James Clay Moltz, ‘The Changing Dynamics of Twenty-First-Century Space Power’ (2019) 13 (1) Strategic Studies Quarterly 66-94; Joan Johnson-Freese and Brian Weeden, ‘Application of Ostrom’s Principles for Sustainable Governance of Common-Pool Resources to Near-Earth Orbit’ (2012) 3 (1) Global Policy 72-81; and Peter L Hays and Charles D Lutes, ‘Towards a Theory of Spacepower’ (2007) 23 Space Policy 206-209

"… stakeholders work together to achieve common goals".[64] This shift is a large factor in why this research considers the Outer Space Regime as an evolutionary regime.

From Krasner's[65] perspective, as mentioned above, there can be change *within* a regime, such as rules or decision-making procedures, or change *of* a regime, meaning changes to the norms and principles. The Outer Space Regime has experienced both change within the regime as well as change of the regime. For example, the rules have been shifted from mainly treaties to mainly, and decision-making procedures now include non-State actors. The change of the regime itself has occurred through international law, norms and principles, space treaties, UNGA resolutions, and other NBIL within the OST legal framework. These changes have facilitated a better understanding of the use and exploration of outer space for both State actors and non-State actors. Hays and Lutes suggest this change to the regime is because space governance is still in its infancy.[66] Pfaltzgraff argues that "the world is constantly being constructed …"[67] and "people are constantly changing and redefining their relationships based on the practices and rules that they create"[68]. Which understood within regime theory means that actors in space "… have the ability to create, or construct, the types of arrangements…"[69] they want for space governance. Hays, Lutes, and Pfaltzgraff's perspectives align with Kranser's understanding of regimes changing and help to better understand why the space regime is changing as well.

Using Stein's[70] above-mentioned interpretation that regime change is based on science, technology, and knowledge, it could be argued these are the fundamental changes happening within the Outer Space Regime as outer space exploration and use is inherently highly technical and scientific. The regime will always be changing as the space community learns how to utilise space in different ways through advancements of rockets, robotics, satellites, and even machine learning and artificial intelligence. Knowledge is a critical point for the regime. Advanced knowledge in Science, Technology, Engineering, and Math (STEM) not only innovate and

---

[64] P.J. Evans, *Environmental Governance* (Routledge, 2012) 35
[65] Stephen D. Krasner, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 5
[66] Peter L Hays and Charles D Lutes, 'Towards a Theory of Spacepower' (2007) 23 Space Policy 206-209, 209
[67] Robert L Pfaltzgraff Jr, 'Chapter 3 International Relations Theory and Spacepower' in Charles D Lutes and Peter L Hays, *Toward a Theory of Spacepower: Selected Essays* (National Defense University Press 2011), 53
[68] Ibid, 53
[69] Ibid, 54
[70] Arthur A. Stein, 'Coordination and Collaboration: Regimes in an Anarchic World' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 125

support robust Research and Design (R&D) but also broaden the exploration and use of space. However, this is not the only way in which knowledge can evolve the regime.

For emerging and developing States, whether already spacefaring or not, knowledge (including technology transfer and data sharing) is critical for their involvement in the space sector. This type of knowledge, now widely known as 'capacity building', is a tenant in which States or individual actors can learn from other actors as well as from the past. The Outer Space Regime is also growing through technology transfer and spin-off technology, where developments for space utilisation and exploration can also have impacts back on Earth for socio-economic development which is mirrored by Moltz's analysis of the regime shifting towards a netocracy which is primarily commercial-led[71]. Within the Outer Space Regime, there is also consideration for the Sustainable Development Goals as space applications support them through the 'Space4SDGs' programme. Knowledge and its uses through data, science, technology, and other sources, is a huge component of the regime.

These advances facilitate the growth, expansion, and adaptability of the Outer Space Regime, leading to its evolution. As the Outer Space Regime evolves, it continues to build its regime complex through more concrete links to other regimes and sub-regimes within the global strata.

Haggard and Simmons'[72] believe regime change originates from strength, form, scope, and allocational mode. These variables can be considered with regards to the Outer Space Treaty. With strength comes a level of compliance, both with treaties and with non-binding international law. Levels of compliance are discussed in Chapter Three. However, this is a growing challenge for the Outer Space Regime as it moves away from treaty law into NBIL. Due to the voluntary nature of NBIL and the trickle-down approach to embedding it into national regulation, compliance is harder to track, verify, and adhere to.

There is an administration apparatus within the Outer Space Regime which includes the UNOOSA, UN COPUOS, the Conference on Disarmament (CD) and the ITU. The administrative mandate of UNOOSA is that it catalogues the registration of space objects– in line with the Registration Convention, provides a forum for deliberations and discussions through UN COPUOS and its subcommittees, and maintains a digital database of all space-related United Nations documents, such as UNGA resolutions, the outer space treaties, and

[71] James Clay Moltz, 'The Changing Dynamics of Twenty-First-Century Space Power' (2019) 13 (1) Strategic Studies Quarterly 66-94
[72] Stephan Haggard and Beth A. Simmons, 'Theories of International Regimes' (1987) 41 (3) International Organizations, 491-517, 496

reports from committee sessions. Additionally, UNOOSA supports capacity building, international collaboration, and initiatives such as Space4SDGs or Space4Health. At the national level, administration can be dispersed among various departments of state and, where applicable, national space agencies. For example, within the UK, the Foreign, Commonwealth, and Development Office (FCDO); the Office of Communications (known as Ofcom); the United Kingdom Space Agency (UKSA); and the Civil Aviation Authority (CAA), all work on outer space affairs, such as licensing, space object registration, radio spectrum allotments, the peaceful use of outer space, and space security.

The 'scope' of the Outer Space Regime refers to the content or issues are under deliberation within. Most of the content is based on space treaties, principles, and resolutions, as found in the *International Space Law: United Nations Instruments* book. Content includes non-binding international laws such as the LTSG and the Space Debris Mitigation Guidelines. Issues can differ based on the activity in outer space; however, some of the issues that currently fall within the scope of the Outer Space Regime include space debris, radio frequency allotment, harmful interference, weaponization of space, use of planetary and space resources Lastly, Haggard and Simmons[73], look at mode, the preferences on resource allocation. This is not discussed in detail within the OST and should be developed specifically for LEO and the issue on space debris. This is discussed in more detail in Chapter Six on space debris, where the research discusses and analyses the LEO as a resource and how it should be allocated and managed by space traffic management (STM) and space situational awareness (SSA). However, mode does not concern only the LEO sub-regime, as resource allocation is expected to become a huge challenge for the Moon and other celestial bodies with consideration for utilisation of resources such as minerals and water deposits for the long-term presence of astronauts on the Moon or other celestial bodies.

The evolutions of the Trade Regime and the Climate Change Regime offer lessons for the Outer Space Regime. The Trade Regime[74] saw three factors that led to the shift from a General Agreement on Tariffs and Trade (GATT)-focused regime to a more robust World Trade Organization (WTO) regime, thus changing the Trade Regime overall. The first was the expansion of actors. This trend has also occurred in the OSR. In the beginnings of the Outer Space Regime, there were predominately two major State actors–The United States and the

[73] Ibid, 496
[74] John H. Barton, Judith L. Goldstein, Timothy E. Josling, and Richard H. Steinberg, *The Evolution of the Trade Regime: Politics, Law, and Economics of the GATT and the WTO* (Princeton University Press, 2006) 19

USSR–deliberating the need for peaceful use of outer space to create détente. However, today there is a more diverse number of State actors deliberating on the Outer Space Regime.

The second issue leading to the Trade Regime's evolution was topic spill-over from other regimes that became interconnected with the Trade Regime. The Outer Space Regime has the same interconnectedness with other regimes, which is why this research uses the concept of the regime complex. Topics that connect regimes can include cyber security, machine learning and artificial intelligence, disarmament issues, and big data issues. These issues combined with the inclusion of specific outer space-related challenges comprise the scope of the regime complex. Though this list is not exhaustive and may continue to grow, the core of the regime remains focused within space-specific topics and law. The regime complex model allows the regime to include peripheral scope that may be applicable, support, or be connected to challenges and activity within the Outer Space Regime.

The last factors to mention in the Trade Regime's evolution are the political, technical, institutional, and economic changes that occurred. As demonstrated in the previous examples, this is not unique to either the Trade Regime or the Outer Space Regime. It should be reiterated that global considerations affect regimes and can push evolution as well. For example, the SDGs have a huge impact globally on multiple regimes, outer space being no exception. Large movements, like that of climate change, propel regimes to consider other facets that may not have originally been deliberated on within their scope or core of understanding.

In its evolution, the Climate Change Regime[75] gained a deeper, broader, integrated, multidimensional, and more precise scope. These changes have occurred within the Outer Space Regime. A regime complex incorporates growing concerns on a global level, leading regimes to deepen, broaden and integrate their scope on a multidimensional field. This is exactly what is in progress due to challenges, such as big data and cyber security, that can cross regimes while still composing core regimes of their own. Although there is great expansion of the scope of these regimes, there is also greater precision. Consider Stein's model, which considers science, technology, and knowledge as drivers of regime evolution. It is with greater precision of scientific and technological advancements, as well as the greater knowledge of actors, that the regime can continue to grow, and its activities can become more abundant and more specific with greater outputs and greater return. The growth of the private sector is also

[75] Daneil Bodansky and Elliot Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022, 9

driving the regime to evolve. Therefore, all variables discussed in this section can be applied to both State actors and non-State actors.

Koremenos, Lipson, and Snidal state the variables of membership, scope, centralization, control, flexibility, disruption problems, enforcement problems, number of actors, and uncertainties are those that evolve regimes.[76] While most variable have been discussed by the other experts above and have already been given examples from the Outer Space Regime, the variables to address from Koremenos, Lipson, and Snidal are control, flexibility, distribution problems, uncertainties, and enforcement problems. While membership, scope, and number of actors have already been addressed, centralization and control of the regime is one facet that is still under discussion. Some questions to consider are: Does control lie within the UN COPUOS? Or is control shifting to the national level due to greater private sector involvement, which does not have access to the UN COPUOS? Would this mean that the Outer Space Regime is decentralised? As non-State actors, under international law, are subject to State responsibility, there could arguably be a need for a centralised model of control, whereby States work through the UN COPUOS and then apply the international perspectives to national space policy that applies to non-State actors. Flexibility is key, as the focus of space law has shifted from treaty law to NBIL. The voluntary nature of NBIL gives way to flexibility within the legal tenants of the regime. This means that as science, technology, and knowledge continue to expand and grow, so too can law. It takes a long time for treaties to be discussed, drafted, and agreed upon, whereas non-binding international law which has the flexibility adapt at a much quicker pace. With the growing number of actors within the OSR, flexibility is beneficial as it is easier to get consensus on voluntary NBIL agreements than on treaties. This flexibility is why a NBIL approach is such an important area of discussion for both IR and IL scholars.

Problems of enforcement and distribution as well as uncertainties within the regime are critical variables the regime faces today. Recommendations of topics for further discussion within the regime are provided, as not much has been discussed within the OSR that can support this research. These issues are largely connected to the growing concerns involving security interests the issues of STM and SSA, specifically within Low Earth Orbit. Therefore, this research delves into these challenges and identifies possible solutions that could be carried out by the Outer Space Regime and the LEO sub-regime.

[76] Barbara Koremenos, Charles Lipson, and Duncan Snidal, 'The Rational Design of International Institutions' (2001) 55 (4) International Organizations, 761-799

As outer space is a risky place for exploration and activity, it is understood there will always exist uncertainties on return of investment, mission success, space debris, space weather, and other hazards. Additionally, as missions venture further away from Earth's orbit, moving into cislunar and beyond, more can go wrong, with little to no ability to correct from mission control.

Environmental experts[77] discuss dependencies, as mentioned above, such as path dependency, goal dependency, and interdependency. The dependency of interest for the regime is goal dependency. This research analyses goal dependency as something that can be obtained and that actors try to move towards. This calls to mind the Long-Term Sustainability Guidelines (LTSG), which include 21 guidelines achieved consensus as of 2019. The LTSG look to incorporate capacity building, operational standards, space debris mitigation efforts and the use of space to support the SDGs. The development of LTSG demonstrates the forethought of States to provide a long-term perspective on the safe, secure, and sustainable use of outer space, even if only within a voluntary set of guidelines. The LTSG are goals States and non-State actors can consider incorporating in space activity and regulation.

Young[78] describes exogenous aspects of evolutionary regime change as being though science, technology, and politics, in contrast to endogenous aspects, which take place through the performance of actors. As exogenous factors have already been discussed, this section focuses on the endogenous aspects. Performance of actors includes both actor activity in space (including the number of space objects, the number of launches, or the types of space objects) as well as the legal and political choices that actors make. Whether States choose to uphold voluntary guidelines is a kind of performance. Abstention or silence on an issue is another type of performance. Working together collaboratively in bilateral and multilateral agreements is another form of performance. Actor performances such as these contribute to regime shifts based on the decisions and rational choices made. Therefore, the performance, or actions, of the actors within the regime guides the evolution of the regime itself.

There are a few aspects that are not covered within evolutionary regime theory literature. These include the change non-State actors bring to the regime, the importance of the inclusion of the

[77] Kristof Van Assche, Anna-Kartharina Hornidge, Achim Schlüter, and Nataşa Vaidianu, 'Governance and the Coastal Condition: Towards New Modes of Observation, Adaptation and Integration' (2020) 112 Marine Policy, 1-10, 4

[78] Oran R. Young, 'Regime Dynamics: The Rise and Fall of International Regimes' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 93

global South, and representation of individuals at an institution. Non-State actors, especially private actors, are specifically altering the Outer Space Regime, as discussed in previous sections[79]. The Global South, including developing or emerging States–whether emerging economically or as space nations or –is a consideration not thoroughly investigated in literature. The Global South should have equitable access to and use of space, as set out in the Outer Space Treaty. Transfer of knowledge and technology through capacity building and data sharing at various levels of end users can develop a better understanding of how emerging nations can explore and utilise space equally with major space-faring States. Lastly, individual representation, such as at UN COPUOS, could also alter the regime. Some actors are career diplomats while other representatives that come to UN COPUOS are experts in space (astrophysics, law, etc.), which heightens the challenges of the regime at the international level. As these individual actors come and go through time, so too can the rhetoric of the State or the Permanent Observer within the committee. This alteration of individual actors can occur due to changes in government changes in funding to governmental space agencies, projects, and missions; changes in the individual's perspectives; or interaction with other States and their individual actors. There is much more that can be explored in terms of individual representation of actors as well as the global South, and this research attempts a start. Nevertheless, these issues present excellent opportunities for further research.

This analysis has demonstrated that the Outer Space Regime is indeed an evolutionary regime that sits within a regime complex with other regimes. The Outer Space Regime is growing and adapting to exogenous variables, such as the growing concern over the SDGs and cyber security. The Outer Space Regime also has nesting properties regarding international law and national regulations. To build upon this information, the current management of the Low Earth Orbit sub-regime and how the LEO governance framework should evolve with the regime is discussed in the following section. International law is a huge factor in that evolution and the framework of LEO; therefore, it is considered with international law in mind.

2.4 Low Earth Orbit as a Sub-Regime to the Outer Space Regime

The current framework of the Low Earth Orbit sub-regime utilises much of what is part of the Outer Space Regime overall. The LEO framework includes the use of the space treaties as well

[79] See: James Clay Moltz, 'The Changing Dynamics of Twenty-First-Century Space Power' (2019) 13 (1) Strategic Studies Quarterly 66-94

as non-binding international law. An example of such NBIL in LEO is the Space Debris Mitigation Guidelines and its 25-year rule on how long satellites should stay in orbit before End of Life operations are put in place for deorbiting into Earth's atmosphere.

Like the OSR, Low Earth Orbit is part of a nested regime. For example, the current International Telecommunications Union Radio Regulations for 'non-geostationary satellites' or amateur satellites are applicable to small satellites and mega constellations on orbit in LEO. These regulations are based in the Telecommunications Regime, which also handles regulations for maritime, aviation, and ground-based radio needs.

At the national level, each spacefaring nation has licensing requirements and procedures for non-State actors to procure a launch and send a satellite into orbit. This includes registration of space objects nationally and internationally, obtaining radio spectrum allotments and registration, as well as procuring the launch and right to conduct missions in space based on specific national criteria.

There are operational standards set by the International Standards Organization (ISO), as well as company standards that non-State actors use internally to make satellites and missions ready and in-line with national and international space laws, policies, and other applicable instruments of a binding or non-binding nature.

With the growing diversity of actors in LEO comes the worry that regulations, too, will become diverse. The space treaties give the foundational principles for what should be done in space. However, these principles are vague, and many do not directly apply to non-State actors. Therefore, it is critical that national licencing requirements and national space law is connected to international space law to assume a thread of continuity between States and their activities or their non-State actors' activities.

In terms of Space Situational Awareness (SSA)/Space Domain Awareness (SDA) and Space Traffic Management (STM) there is currently no international approach or legal foundation to guide how these should be implemented at the global level. There are facets of the OST that allude to the concepts of SSA and STM through the understanding that space actors should be collaborative and transparent for the equitable use of space. However, these specific terms are not mentioned in the space treaties directly. Currently, most tracking of space debris and satellites on orbit is conducted through the United States Strategic Command (USSTRATCOM). Regarding SDA, there is a multilateral initiative, Combined Space Operations (CSpO) between the United States, United Kingdom, Germany, France, Canada, New Zealand, and Australia focused on coordinating policy, operations, and addressing challenges in the space sector. SSA/SDA and STM are topics of growing discussion at the international level, as they must be better understood and implemented both nationally and internationally. This is likely to be a slow process, as it is highly political to discuss the "management" of space, given Article II in the Outer Space Treaty[80] declares space to be an environment of non-appropriation. There is also the issue, specifically on dual-use and military satellites, of national security regarding States tracking other States' assets, which could be construed as espionage or potential avenues for harmful interference. Therefore, there is much work to be done on what SSA and STM as complementary components should look like in the Outer Space Regime both holistically and in the LEO governance framework specifically.

Many challenges must be addressed more concretely to create an LEO framework that will be secure, safe, and sustainable (3S Approach) in the long-term. The crux of this research involves addressing these challenges from both IR and IL perspectives to find recommendations for the way forward for a LEO governance framework. Each challenge–space debris, radio frequency allotment, harmful interference, insurance, SSA and STM, cyber security, and the increasing use of mega constellations–is analysed separately in the coming chapters. This enables the discussion about these challenges holistically in the concluding recommendation remarks at the end of this research.

Like the Outer Space Regime, the Low Earth Orbit sub-regime is also evolving, in part due to the growing concern over space debris and the increasing volume of actors and satellites on orbit. Additionally, with the inclusion of the 21 LTSG, the increasing persistence to lower the 25-year rule on satellites on orbit, and the rising R&D for rendezvous proximity operations (RPO), on-orbit servicing (OOS), and active debris removal (ADR), the time is now to start shifting these challenges into manageable variables within an improved LEO governance framework that is tailored to the LEO environment, actors, and missions. It is only recently that the space community has started to address the long-term sustainability of space utilisation. LEO, with the growing space debris challenge, is arguably the most critical place in space where long-term sustainability must be addressed immediately. The 3S Approach to LEO is vital for a strong governance framework if States and non-State actors wish to continue to not only utilise LEO, but also pass through it to conduct successful missions to other celestial

[80] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

bodies and deeper into space. It should be remembered that "… the scope and complexity of new scientific and technological developments are outpacing the capacities of our systems of international organization to manage them".[81] This is a large contributing factor to the space community outpacing the space treaties. This research aims to support the inclusion of NBIL as this form of law is flexible, timely, and can be incorporated into actors' operations and policies. This argument will be discussed further in Chapter Two on international law.

The challenges involved in taking a strong 3S Approach to LEO governance are immense and not without political difficulties. However, it is important to consider what an effective LEO governance framework should look like. For example, which type of governance would best support–realistically–the interests of State and non-State actors while also encouraging solutions-focused decision making? Additionally, how should the LEO governance framework be managed and who should do so? In the case of the Outer Space Regime, the space treaties and other aspects of the regime are brokered by the UNOOSA while also being under deliberation within UN COPUOS and its Scientific and Technical Subcommittee and Legal Subcommittee.

2.5 From Regime Theory to Governance Theory

While the term 'regime' is used in the context of the Outer Space Regime within this research, the term 'governance' is also applied moving forward. This is large part due to LEO being a sub-regime of the Outer Space Regime and, as such, having a legally and politically similar governance framework. At the international level, both 'regime' and 'governance' are used when referring to Earth's orbits, deep space, celestial bodies, and the use of space overarchingly. The legal scholars within the space community use the term 'legal regime' when referring to the legal instruments within the framework. For the purposes of this dual IR-IL research, a regime or governance framework is understood to include both legal and political underpinnings as well as socio-economic and environmental concerns.

Though the term 'regime' will not be abandoned here, it is important to understand that 'regime' will refer to the holistic outer space framework while governance will be applied specifically to LEO. Much of what is said in governance theory is directly continued from

[81] John Gerard Ruggie, 'International Responses to Technology: Concepts and Trends' (1975) 29 (3) International Organization, 557-583, 557

regime theory; therefore, the next section continues with further considerations taken from this section on regime theory. Additional to regime theory, governance theory also considers specific models or modes of governance and how they can be utilised to create frameworks. This adds more nuance to the holistic regime discussion above. Both sections work together to develop an understanding of the systemic choices and needs, available to create bespoke options for international communities to better tackle challenges and issues within a regime or regime complex through concrete governance frameworks.

2.6 The Regime Complex of Outer Space: Cyberspace, Security, and Telecommunications

A regime complex is an international horizontal governance framework encapsulating issue-areas with commonalities. A regime complex involves the joining between multiple single regimes and allows for de-fragmented arrangements with no identifiable linkages.[82] Given the overlap of technical components and national interests, the Outer Space Regime Complex consists of the Security Regime, the Cyberspace Regime, and the Telecommunications Regime. Each one of these regimes is briefly discussed in this section with an analysis of how the regime connects to both the Outer Space Regime and Low Earth Orbit. Some key concepts are under consideration across regimes, such as responsible behaviours of actors; transparency and confidence-building measures (TCBMs); legal principles such as non-interference; challenges with interpretation of instruments, verification, compliance, and enforcement; and fragmentation.

2.6.1 Security Regime

The Security Regime is an international and holistic regime with a legal underpinning founded in the United Nations Charter, specifically Chapter I, Article I, which stipulates that the purpose of the UN is "to maintain international peace and security … in conformity with the principles of justice and international law …".[83] As such, the security regime can arguably be connected

[82] Joseph S. Nye Jr., 'The Regime Complex for Managing Global Cyber Activities' Global Commission on Internet Governance' (2014) (Centre for International Governance Innovation, the Royal Institute for International Affairs, and Chatham House Paper Series No.1) 7

[83] Charter of the United Nations and Statute of the International Court of Justice (adopted 26 June 1945, entered into force 24 October 1945)

to all international regimes, as the UN was founded on the tenets of peace and security for all humankind. The UNGA First Committee:

> … deals with disarmament, global challenges and threats to peace that affect the international community and seeks out solutions to the challenges in the international security regime.[84]

This work is done in cooperation with the United Nations Disarmament Commission and the Conference on Disarmament based in Geneva, Switzerland. Additionally, security research is conducted through the UNIDIR as autonomous work within the framework of the UN.

Outer space joined as a subject for debate within the CD in 1982 through Agenda Item 7 – Prevention of an Arms Race in Outer Space (PAROS). However, it was not until 1985 that agreement was reached on a mandate for the *Ad Hoc* PAROS Committee, which would be discussed under Agenda Item 5 within the CD.

> Since its inception, the *Ad Hoc* PAROS Committee has continuously examined three subject areas of its mandate: issues related to the prevention of an arms race in outer space; existing agreements governing space activities; existing proposals and future initiatives on the prevention of an Arms Race in Outer Space.[85]

While the subject areas of the mandate have stayed consistent, there has been considerable gridlock on forward movement for any type of treaty regarding PAROS due to opposition from the United States. This mandate is in line with the OST as Article IV proclaims:

> States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.[86]

---

[84] UNGA, 'Disarmament and International Security (First Committee)' (*UNGA*) <https://www.un.org/en/ga/first/index.shtml> accessed 13 July 2021

[85] Pericles Gasparini Alves, 'Prevention of an Arms Race in Outer Space: A Guide to the Discussions in the Conference on Disarmament' UNIDIR/91/79 (1991)

[86] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

The Outer Space Treaty was created through the UN Fourth Committee via UN COPUOS. Because it is the foundation of all international space law, the OST is applicable to PAROS as well.

One resulting challenge from having space security discourse in the CD separate from more general discourse on outer space within UN COPUOS is that international space affairs are splintered between the Outer Space Regime and the security regime. This siloed approach is short-sighted because, as this research suggests, security, sustainability, and safety in space are interconnected and concern all space actors–not only States. However, for the foreseeable future, it seems space security will be siloed within the UNGA First Committee via the CD while all other space affairs will continue to be discussed within the UNGA Fourth Committee via UN COPUOS with support from UNOOSA. This choice of forum splintering is of a political nature as States find self-serving ends to speak about space security in a UN context that is more State-centric, leaving other space issues under the peaceful uses of space discourse, which is more diverse in scope. This splintering of space affairs further articulates the growing relevance of the regime complex, not only for the Outer Space Regime, but also for the challenges within the Low Earth Orbit governance framework.

Turning back to the workings of the space security discourse, the UNGA First Committee "… voted in favour of adopting five resolutions on outer space security"[87] which included: prevention of an arms race in outer space; further practical measures for the prevention of an arms race in outer space; no first placement of weapons in outer space; transparency and confidence-building measures in outer space activities; and reducing space threats through norms, rules, and principles of responsible behaviours. The United States only voted in favour of the latter, perhaps because reducing space threats through norms, rules and principles of responsible behaviours is an initiative led by its ally, the UK. What is certain (also within the UN COPUOS) is that the US, UK, and other 'like-minded' States are in opposition to the legal way forward for space security, in contrast to Russia, China, and their 'like-minded' States. This is more likely a result of a clash between liberal and illiberal governments rather than a post-Cold War political field.

Security in outer space–and, more specifically, LEO–is a highly political discussion with two strong coalitions of States, namely liberal and illiberal governments. Some States, such as the

[87] Nuclear Threat Initiative, 'Proposed Prevention of an Arms Race in Space (PAROS) Treaty' (*NTI* 2021) <https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/> accessed 21 July 2021

UK, believe that space security should only be discussed within the UNGA First Committee, and therefore within the CD, whilst keeping discussion of space safety and sustainability within the UNGA Fourth Committee under the UN COPUOS. This siloed approach, however, could cause issues in the future. This is especially true for Low Earth Orbit, as it is the most contested, congested, and competitive orbit currently in use. Elements such as the various types of actors and dual-use satellites occupying LEO indicate that the line between security and safety/sustainability is increasingly blurred. “Space systems are integral to national security, development, and daily life”.[88] Therefore, threats to space systems (including ground, satellites, data, users) could deny use of these at the regional, national, or local levels. While there is no legally binding understanding of ‘space threats’ versus ‘space hazards’, the UK, for example, sees threats as a UNGA First Committee issue and hazards as falling under the purview of UN COPUOS within the UNGA Fourth Committee. This stems from a traditional, hierarchical approach that separates State military behaviours from other actors’ behaviours. However, there are reasons to dispute this reasoning. First, some threats, such as anti-satellite tests (ASAT tests) can generate hazards such as space debris. Secondly, with some commercial satellites being dual use, the lines are blurred between what is State and non-State activity. Therefore, it is not prudent to isolate one from the other given that these threats and hazards can be interconnected or causally linked.

Space security in Low Earth Orbit is of growing interest, as LEO is the most heavily trafficked orbit with the biggest diversity of actors and uses of satellites. Most LEO satellites have direct socio-economic, environmental, or militaristic applications on Earth. This connects to extensive research on space powers and the importance of Earth’s orbits for the security of societies today. Instead of perceiving Earth’s orbits as some faraway places, Bowen proposes: “Earth orbit is more like part of a proximate, crowded and contestable coastline and a littoral environment rather than a vast, remote, distant and expansive ocean”.[89] Hickman and Dolman also consider LEO to be “… a critical location point for the near and medium term development of space”[90]because of the number of actors on-orbit in LEO and the use of LEO as a thoroughfare to other orbits, celestial bodies, and deeper space[91].

[88] J. Lauren Napier, ‘Report: Responsible Behaviours in Space, National Submissions to the UN’ (Wilton Park 2021) 1
[89] Bleddyn Bowen, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press 2020) 2
[90] John Hickman and Everett Dolman, ‘Resurrecting the Space Age: A State-Centered Commentary on the Outer Space Regime’ (2002) 21 (1) Comparative Strategy 1-20, 15
[91] Ibid

This notion of a "cosmic coastline"[92] reinforces the increasing importance and reliance on Low Earth Orbit in daily life at every level, which is why it is so critical that the safety, security, and sustainability of the orbital environment be considered holistically through the LEO governance framework. Understanding that Low Earth Orbit (and other Earth orbits) are close to home underpins States' security concerns in space. As the use of space is essentially institutionalised,[93] it is imperative that an evolving LEO governance framework include security considerations for all types of actors especially considering the rise of cyber and electronic threats that could undermine space systems.

To conclude this section on the security regime and its implications for the Outer Space Regime and Low Earth Orbit, it follows that the security regime is just one part of the larger regime complex that must be considered holistically to provide effective solutions for evolving the LEO governance framework. Security issues such as potential threats to space systems and the growing use of cyber and electronic warfare indicate that a siloed approach to space security could be antiquated. This is especially true for LEO, as it is a littoral environment relied upon by individual users as well as State and non-State actors. The next section demonstrates that the Cyberspace Regime is also connected to both the Outer Space Regime and the Security Regime, further evidencing that the regime complex should be part of any governance discussion going forward.

2.6.2 Cyberspace Regime

The Cyberspace Regime is a relatively young regime, as the World Wide Web was created in 1989. From a legal perspective, the regime is a fledgling because it is currently without a foundational treaty. However, with the growing user base of the Internet and the wide use of the cyber realm by governments (and their militaries), the private sector, and other actors, efforts have been made to create non-binding international law and national regulations, creating at least a fragile governance framework. The Cyberspace Regime considers information and communications technology (ICT), the Internet, and cyber security, which includes cyber capabilities and threats. Like the Security Regime, the Cyberspace Regime is considered under the UNGA First Committee. However, in contrast to the security regime, the

[92] Ibid, 5
[93] Ibid, 10

Cyberspace Regime has a formidable non-State actor presence within the governance decision-making process.

In reviewing the literature on cyberspace governance, it was found that some authors also mention a regime complex pertaining to the Cyberspace Regime. For example, Nye found that "… much of cyber governance comes from actors and institutions that are not focused purely on cyber".[94] This statement suggests that actors consider many regimes at one time and may themselves find overlaps between regimes, suggesting a regime complex. Klimberg and Faesen follow Nye's understanding of the regime complex and interpret that "the various interlocking but separate governance processes that together define cyberspace …"[95] form a regime complex. This statement solidifies the understanding that governance, though it may be separated or siloed in some cases, can still function as a collective whole through a regime complex.

> … the Internet is regulated through an elaborate cyber regime complex that has pockets of dense regulation in some subject areas as well as patches that are largely unregulated.[96]

This statement is extremely impactful, as it summarises why regime complexes and regime evolution are so critical for governance issues. The idea that governance is not fully complete or equally distributed across the framework–or indeed the regime and regime complex–suggests the need for holistic approaches to try to catch all and find a balance of regulation.

Another important finding in the literature on cyberspace governance is that most authors suggest the governance framework model to be multistakeholderism, even though certain States, namely Russia, China, and other 'liked-minded' States, prefer a multilateral model. This debate over the more liberal approach to governance versus an illiberal one is no different to the discussions taking place in the Security Regime. What sets the Cyberspace Regime apart is that it is highly dependent on non-State actors and, as such, does function more as a multistakeholder governance model. However, this is because most of the West has a strong

---

[94] Joseph S. Nye Jr., 'The Regime Complex for Managing Global Cyber Activities' (2014) (Global Commission on Internet Governance, Paper Series No.1) 9

[95]Alexander Klimburg and Louk Faesen, 'Chapter 7 A Balance of Power in Cyberspace' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020) 151

[96] Dennis Broeders and Bibi van den Berg, 'Chapter 1 Governing Cyberspace: Behavior, Power, and Diplomacy' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020) 2

non-State actor presence in the cyber realm, and they are not as tightly-bound by regulations and cyber sovereignty as their non-State counterparts in, for example, China. This rising tension over multistakeholderism versus multilateralism is remarked upon by Shires. He found that this opposition also has direct connotations for attempting to create norms and responsible behaviours in cyberspace. Shires suggests:

> The difficulty of reaching global agreement on cyber norms is generally attributed to a bipolar division in cybersecurity governance, reflecting two opposing sets of values. On one hand, there is a group of what experts have called 'like-minded' states. This group generally includes the United States and European countries, and it believes in open and free Internet driven largely by global market competition with some government regulation and civil society observation, known as multistakeholderism. The second group includes Iran, Russia, and China, and prioritizes state control over national 'borders' in cyberspace with strict governmental limits on content, known as cyber sovereignty.[97]

Shires' findings further explain this geopolitical tension between 'like-minded' States over how best to govern the Cyberspace Regime. This same issue is found in the Security Regime and the Outer Space Regime, showcasing the importance of understanding geopolitics in relation to *lex specialis* regimes and why the law cannot be disconnected from political issues.

At the international level, there are some key lessons to be learned from the Cyberspace Regime that could be helpful for future deliberations over security matters in outer space and, specifically, Low Earth Orbit. The Cyberspace Regime has two high-level working groups at the UN, focusing on Developments in the Field of Information and Telecommunications in the Context of International Security. The UN Group of Governmental Experts (GGE) was created in 2004 to provide a platform for deliberations around the issues of cyber diplomacy and governance "… without going down the road of a treaty".[98] A GGE, as the name implies, consists of experts, representing States, that work to find consensus on non-binding tenets. The GGE is led by the West and 'like-minded' States; however, participation is of an international

---

[97] James Shires, 'Chapter 10 Ambiguity and Appropriation: Cybersecurity and Cybercrime in Egypt and the Gulf' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020) 206

[98] Dennis Broeders and Bibi van den Berg, 'Chapter 1 Governing Cyberspace: Behavior, Power, and Diplomacy' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020) 3

nature, with 25 States involved, plus consultations with regional institutions such as the African Union. Some argue that a GGE is more exclusive in nature, and its limitation to experts makes it more like a club than an international discussion forum. The GGE has produced three reports that have found consensus (2010, 2013, 2015) with significant suggestions. The first critical component that reached consensus is the notion that international law applies to cyberspace. Additionally, in 2015, the GGE found consensus on formulating non-binding norms for responsible State behaviour. However, after 2017, the GGE failed to reach consensus in a report again, with some arguing for the "death of the norms process".[99]

The other working group is the UN Open-Ended Working Group (OEWG), which discusses roughly the same issues and challenges as the GGE but more openly in terms of participation, as the name suggests. The UN Conference on Disarmament Affairs states:

> The OEWG process also provides the possibility of holding intersessional consultative meetings with industry, non-governmental organizations [NGOs] and academia.[100]

The OEWG, while open, is led by Russia and its 'like-minded' States, thus creating a juxtaposition between the two working groups in terms of ideology and diplomatic aims. In 2021, a report reached consensus with a focus taken on confidence-building measures (CBMs) rather than norms, a deliberate diplomatic choice to further separate the two working groups based on liberal versus illiberal ideologies.

These differences of opinion over CBMs and norms are not unique to the Cyberspace Regime. The Outer Space Regime is also having these deliberations within the CD regarding potential threats and challenges to space security. In December 2020, the UNGA published *Resolution 75/36 Reducing Space Threats Through Norms, Rules, and Principles of Responsible Behaviours*, suggesting a normative road be taken to space security, much like the GGE report in the Cyberspace Regime. Another similarity is that this resolution is backed by the West and has received push-back from China and Russia. The fact that the exact same process is happening within the Cyberspace Regime should be a factor when considering the ways and means forward on a new non-binding instrument for the Outer Space Regime. The OSR's

[99] Dennis Broeders and Bibi van den Berg, 'Chapter 1 Governing Cyberspace: Behavior, Power, and Diplomacy' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020) 3

[100] United Nations Office for Disarmament Affairs, 'Open-ended Working Group' (UN) <https://www.un.org/disarmament/open-ended-working-group/> accessed 03 August 2021

failure to learn from this further suggests the high-level political game being played within UN deliberations across the regime complex without the intention from either side to find camaraderie and consensus on a way forward.

One way in which the Cyber Regime connects to the regime complex is through non-binding international law. The *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (hereafter known as the Tallinn Manual 2.0) has chapters pertaining to the regime complex: cyber and security; cyber and telecommunications; and cyber and outer space. In the chapter discussing space law and cyber, it is understood that the rules "… address cyber activities in, from or through outer space".[101] There are three rules listed in this chapter pertaining to cyber and space law. 'Rule 59 – Respect for Space Activities' is connected to the Outer Space Treaty by emphasising that States "… must respect the right of States of registry to exercise jurisdiction and control over space objects appearing on their registries"[102] and that States must conduct their "… cyber operations involving outer space with due regard for the need to avoid interference with the peaceful space activities of other States".[103] 'Rule 60 – Supervision, Responsibility, and Liability' is aligned with the Outer Space Treaty as well as the Liability Convention. The experts acknowledge "… that space activities, including those involving cyber operations, are subject to the space law regime of responsibility and liability",[104] which includes State supervision for non-State actors. Though the Tallinn Manual 2.0 is not a legally-binding set of rules, it does further articulate the international expert opinion that the Cyber Regime comprises a regime complex, connecting to the Security, Telecommunications, and Outer Space Regimes. Furthermore, the manual demonstrates that general international law and international space law are applicable to cyber activity in space. These points justify the relevance of the regime complex and demonstrate why a holistic approach to Outer Space Regime issues should be the norm. The next regime under consideration is the Telecommunications Regime, a more established regime compared to Cyber and Outer Space.

[101] Michael N. Schmitt (ed), *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (Cambridge University Press 2017) 270
[102] Ibid, 277
[103] Ibid, 277
[104] Ibid, 281

2.6.3 The Telecommunications Regime and the International Telecommunications Union

All active satellites on-orbit utilise a part of the radio frequency spectrum to communicate, which is why radio frequency coordination and allocation is an important factor to consider for the Outer Space Regime and Low Earth Orbit governance. Additionally, this reliance on the radio frequency spectrum, not just in space, but also in other domains, is why this part of the regime complex is so robust and well-established. Of all the regimes connected to the Outer Space Regime, the Telecommunications Regime is the most closely connected, especially for regulations.

Radio frequency management comes from the Outer Space Regime complex by way of the International Telecommunications Union. The ITU is a specialised agency of the United Nations and is the oldest organisation within the UN system. The ITU has rights and obligations for its Member States under the Constitution and Convention as well as through the Radio Regulations. As of 2023, there are 193 States Parties to the Treaties,[105] many of which overlap with States Parties to the Outer Space Treaty. The Telecommunications Regime has been considered part of the Outer Space Regime since the early days of the OSR. According to the Secure World Foundation (SWF):

> Since the beginning of the space age, the ITU has aided the exploration and use of space through international coordination and frequency allocation. The ITU is tasked with ensuring the rational, equitable, efficient, and economical use of the radiofrequency spectrum.[106]

Originally the ITU regulations were focused on the Geostationary-Satellite Orbit (GSO) with reference to satellites both GSO and non-GSO. Since 2012, at the World Radiocommunication Conference (WRD-12), there has been recognition that small satellites need further regulatory consideration. At the first International Telecommunications Union Radio (ITU-R) Small Satellite Regulation and Communication Systems symposium in 2015, a *Prague Declaration on Small Satellite Regulation and Communication Systems* was created. This declaration noted the growing interest by various types of non-State actors to procure launches for small satellite missions to Low Earth Orbit. The Prague Declaration urges:

[105] International Telecommunications Union, 'Membership' (*ITU* 2023) <https://www.itu.int/hub/membership/our-members/> accessed 28 February 2023

[106] Secure World Foundation, *Handbook for New Actors in Space* (Christopher D. Johnson ed, Secure World Foundation 2017) 17

> ...the small satellite community to comply with the applicable international and national laws, regulations and procedures, indispensable to guarantee the long-term sustainability of small satellite projects, the avoidance of harmful interference and proper management of space debris.[107]

While there are additional reports and Radio Regulation Resolutions pertaining to small satellites, they are also applicable to satellite activity in general. These newer developments regarding the inclusion of small satellites in radio regulations can be updated every four years at the World Radiocommunications Conference or be further supplemented by reports, handbooks, and other guiding non-binding materials such as the 2021 working document on creating an ITU-R Small Satellite Handbook.

Before moving into the legal considerations of the ITU regulations, it is important to understand what it manages and regulates. First, the ITU divides the Earth into three administrative regions. Region One includes Europe, Africa, Russia, former Soviet Union States, and Mongolia. Region Two includes the Americas and Greenland. Region Three includes Asia, Australia, and the Pacific.

> Each administrative region has assigned particular frequencies to particular technologies and services. The ITU has allocated a number of frequencies for specific space activities, including frequencies for Earth exploration, meteorology, radio astronomy, emergency telecommunications, radio navigation, space operations, space research, and amateur satellites.[108]

These three regions and the further breakdown of how and why the frequencies are utilised suggests an organised, and perhaps even equitable, governance framework for radio.

The radio frequency spectrum is "… divided into bands that are either exclusively allocated or that share allocations for various applications".[109] This allocation depends on the needs of the radio bands based on the space activity.

> The regulated frequency band (9 kHz – 1000 GHz) is segmented into smaller bands and allocated to over forty defined radiocommunication

---

[107] The International Telecommunications Union, 'Prague Declaration on Small Satellite Regulation and Communication Systems' (2015) <https://www.itu.int/en/ITU-R/space/workshops/2015-prague-small-sat/Documents/Prague%20Declaration.pdf> accessed 09 August 2021

[108] Secure World Foundation, *Handbook for New Actors in Space* (Christopher D. Johnson ed, Secure World Foundation 2017) 18

[109] Ibid, 18

> services. The services are identified as PRIMARY or *secondary* (the latter shall cause no harmful interference to, or claim protection from, the former).[110]

This detailed regulation of the frequency bands was put into place to limit harmful interference between objects relying on the frequencies. To coincide with the detailed regulation of the radio frequency spectrum, the radio frequency allotment must be registered internationally and nationally, much like space objects. At the international level, this is done via the ITU and the Master International Frequency Register (MIFR), which is specified under Article 8 of the ITU Radio Regulations.[111] At the national level, it is done through the licensing procedure, usually with a department or ministry of communications, which then files directly to the ITU. For example, this is the case in the UK through Ofcom.

Taking a top-down assessment first, this research separates the elements of the ITU Constitution and Convention and the Radio Regulations that are applicable to LEO and small satellites. This is challenging, as the ITU's body of international law is extremely robust and encompasses marine, aviation, space, and telecommunications. Once narrowed down to the elements applicable to space, the articles are separated between ground-based astronomy and communications as well as those specific to the geostationary Orbit. Most references applicable to LEO come in the form of "non-GSO" rhetoric, which could also include Medium Earth Orbit (MEO) and is not clearly specific to LEO *per se*. However, the ITU has recently been working to resolve *lacunae* regarding radio regulations for non-GSO satellites by introducing additional considerations for small satellites, very small satellites (which includes femto-, nano-, and pico-satellites), satellite constellations, and mega constellations. Therefore, when piecing together the regulatory radio spectrum framework for LEO, it must be noted that some areas are vague, newly developed, or still under development. Additionally, these considerations are deliberated over through the ITU sessions in Geneva, Switzerland and are separate to the discussions at the UN COPUOS held in Vienna, Austria. However, the ITU is a Permanent Observer to the UN COPUOS and its subcommittees, and representatives of the ITU may speak or present on relevant information regarding radio frequency allotment and utilisation of satellites in outer space including their data.

[110] Attila Mattas, Yvon Henri, Chuen Chern Loo, 'Chapter 12: The ITU Radio Regulations Related to Small Satellites' in Irmgard Marboe (ed), *Small Satellites: Regulatory Challenges and Chances* (Brill Nijhoff 2016) 240

[111] International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn)

2.6.3.1 The ITU Constitution and Convention

Considering the Telecommunications Regime at its broadest, while still being applicable to LEO, the purposes of the International Telecommunications Union, as set out in Article 1 of the Constitution and Convention are:

> a) to maintain and extend international cooperation among all its Member States for the improvement and rational use of telecommunications of all kinds;
>
> a bis) to promote and enhance participation of entities and organizations in the activities of the Union and foster fruitful cooperation and partnership between them and Member States for the fulfilment of the overall objectives as embodied in the purposes of the Union;
>
> f) to harmonize the actions of Member States and promote fruitful and constructive cooperation and partnership between Member States and Sector Members in the attainment of those ends.[112]

What is important to note here is that unlike the UN COPUOS where there are only Member States and Permanent Observers from Non-Governmental Organisations (NGOs) or International Non-Governmental Organisations (INGOs), the ITU also includes Sector Members which are members of the private sector or public organisations. Therefore, consideration of this type of actor is considered more closely connected to the ITU governance framework.

Additionally, within Article 2 it is known that the ITU shall:

> a) effect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations and different countries;

[112] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 3-4

> b) coordinate efforts to eliminate harmful interference between radio stations of different countries and to improve the use made of the radio-frequency spectrum for radiocommunication services and of the geostationary-satellite and other satellite orbits.[113]

The purpose of the ITU and its governance framework regarding space services is inclusive of allocation, allotment, and registration with an understanding to avoid harmful interference and to coordinate efforts including "other satellite orbits" which includes LEO. Later in this section is discussion on allocation, allotment, and registration from both international and national perspectives. There is also discussion of the concepts of due regard and harmful interference, as these are key challenges across the LEO governance framework in that they are also under consideration across the regime complex.

Article 6, Paragraph 1 of the ITU Constitution and Convention articulates that Member States are "… bound to abide by the provisions of this Constitution, the Convention and the Administrative Regulations …"[114] Article 6, Paragraph 2 of the ITU Constitution and Convention[115] discusses the execution of instruments much in the same way that Article VI of the OST mentions that States Parties to the Treaty "… shall bear international responsibility for national activities in outer space …",[116] including activities of non-State actors. Similarly, Article 6, Paragraph 2 of the ITU Constitution and Convention states:

> The Member States are also bound to take the necessary steps to impose the observance of the provisions of this Constitution, the Convention and the Administrative Regulations upon operating agencies authorized by them to establish and operate telecommunications and which engage in international services, or which operate stations capable of causing harmful interference to the radio services of other countries.[117]

Within the Outer Space Regime Complex, both the OST and the ITU Constitution and Convention accord States Parties to the Treaties responsibility for their own actions as well as

[113] Ibid, 5
[114] Ibid, 11
[115] Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330
[116] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[117] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 11

the actions of other actors falling under their jurisdiction. This means that although States are the dominate actors at the international level, non-State actors and their activities are considered from the top-down through national level regulations and licensing procedures. Therefore, within the Outer Space Regime, international law is applicable to non-State actors through the management of States. This is primarily conducted via national licensing procedures. As mentioned above, in the UK, the regulating of radio frequency utilisation is done through the ITU via Ofcom. This is an additional step in the licensing of a space object done in conjunction with UKSA, which handles the licensing and registering of satellites to UNOOSA. Therefore, satellites are licensed and registered through both the ITU and UNOOSA for radio and general orbital use, respectively.

As space and satellite activities fall under the Radiocommunications Sector within the ITU (ITU-R), Article 12 of the ITU Constitution and Convention is applicable as it states in Paragraph 1:

> 1) The functions of the Radiocommunications Sector shall be, bearing in mind the particular concerns of developing countries, to fulfil the purposes of the Union, as stated in Article 1 of this Constitution, relating to radiocommunications: by ensuring the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including those using the geostationary-satellite or other satellite orbits …[118]

Article 12 is like part of the Outer Space Treaty Article I which also stipulates the importance of the exploration and use of outer space being "… for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development …"[119] and "… free for exploration and use by all States without discrimination of any kind, on a basis of equality …"[120]. Within the Outer Space Regime complex, Member States are obligated to consider their use of space, activities in space, and radio frequency spectrum utilisation with regards to developing countries and all other actors, because both outer space and the radio spectrum are bound by a shared non-appropriation and use through licensing and registration.

[118] Ibid, 19
[119] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[120] Ibid

It can be argued, however, that while a specific radio frequency is in use by a specific actor, it could be seen as temporary appropriation through use that was allotted, registered, and licensed to the actor for a specific activity and period of time. According to Herter:

> The electromagnetic spectrum has many of the attributes of a "common property" resource. It is freely accessible to all, although, … the first user of a radio frequency, provided he meets certain regulatory requirements, has a *de facto* lock on the frequency, and has virtually "appropriated" it.[121]

The radio spectrum, as part of the larger electromagnetic spectrum, "… has the same interrelated physical dimensions of space, time and frequency".[122] As such, a single radio frequency can be used either: "by more than one actor in different geographical areas at the same time; in the same area but at different times"[123] and different radio frequencies can be used: "in the same geographical area by different actors at the same time".[124]

From Articles 44 and 46 of the ITU Constitution and Convention,[125] the radio spectrum is a limited natural resource that is subject to harmful interference, which can constitute a major constraint on the use of radio frequencies and the spectrum.

Within the ITU Constitution and Convention, there are special provisions for radio as set out in Articles 44 through 48.[126] Applicable to LEO are Articles 44 and 45,[127] which include the use of the radio-frequency spectrum and the geostationary-satellite and other satellite orbits, and harmful interference, respectively. Article 44 expresses:

> 1) Member States shall endeavour to limit the number of frequencies and the spectrum used to the minimum essential to provide in a satisfactory manner the necessary services. To that end, they shall endeavour to apply the latest technical advances as soon as possible.
>
> 2) In using frequency bands for radio services, Member States shall bear in mind that radio frequencies and any associated orbits, including the

[121] Christian A. Herter Jr. 'The Electromagnetic Spectrum: A Critical Natural Resource' (1985) 25 (3) Natural Resources Journal, Symposium on International Resources Law, 651-663, 655
[122] Ibid, 655
[123] Ibid, 655
[124] Ibid, 655
[125] Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330
[126] Ibid
[127] Ibid

> geostationary-satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries.[128]

A critical element of Article 44 is the concept that "… radio frequencies *and* (emphasis added) any associated orbits … are limited natural resources …",[129] arguing the point that LEO and the radio frequency spectrum must be managed holistically, as they are already classified as limited natural resources by the ITU. Additionally, the growing number of space debris pieces without mitigation or remediation strategies is moving LEO towards being a non-renewable resource or limited natural resource if not managed, which adds to further justifies that LEO needs a more holistic and robust governance framework to investigate these challenges as linked and inter-dependent. This is another keystone in the argument for better understanding of the Outer Space Regime complex to support the needs of the Low Earth Orbit governance framework.

Taking a step back, it is important to understand what is meant by 'limited natural resource' and what that implicates for the radio frequency spectrum. Regarding the electromagnetic spectrum, of which the radio spectrum is a part, it is important to note that it is not depletable. Herter explains that the electromagnetic spectrum "… is always available in infinite abundance except for that portion which is being used. When that portion of the electromagnetic spectrum is not in use, it is instantly renewable".[130] The spectrum can be abused or polluted through overcrowding or harmful interference. Herter also suggests that "the spectrum has been called a "limited" natural resource because, given present technology, there is only a finite portion available for beneficial uses at any one time".[131]

The same could be said for LEO in that with overcrowding and no clear plan for clearing *all* space debris, the orbit itself is a limited natural resource which can be renewable if, and only if, space debris mitigation and remediation measures are applied across all space actors, which

[128] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 49
[129] Ibid, 49
[130] Christian A. Herter Jr. 'The Electromagnetic Spectrum: A Critical Natural Resource' (1985) 25 (3) Natural Resources Journal, Symposium on International Resources Law, 651-663, 653
[131] Ibid, 655

is part of national implementation strategies regarding the international Space Debris Mitigation Guidelines and the LTSG.

A major challenge across the regime complex is the potential threat of harmful interference. Within the Telecommunications Regime, Article 45 of the ITU Constitution and Convention includes three paragraphs on harmful interference as such:

> 1) All stations, whatever their purpose, must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Member States or of recognized operating agencies, or of other duly authorized operating agencies which carry on a radio service, and which operate in accordance with the provisions of the Radio Regulations.
>
> 2) Each Member States undertakes to require the operating agencies which it recognizes and the other operating agencies duly authorized for this purpose to observe the provisions … above.
>
> 3) Further, the Member States recognize the necessity of taking all practicable steps to prevent the operation of electrical apparatus and installations of all kinds from causing harmful interference to the radio services or communications mentioned … above.[132]

To clarify the term 'station', according to the Tallinn Manual 2.0 a 'station' refers to:

> … any radio transmitting station whether located on the Earth or space-based, that emits radio frequency signals over the electromagnetic spectrum and is capable of causing harmful interference …[133]

Article 45[134] thus dictates that neither States nor authorised non-State actors using radio services or communications should cause harmful interference on Earth or in Space. Furthermore, within the Annex to the ITU Constitution and Convention, the term 'harmful interference' is defined as:

---

[132] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 50

[133] Michael N. Schmitt (ed), *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (Cambridge University Press 2017) 295

[134] Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330

> Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations.[135]

Though this definition is specific to radio, it can be applied to the LEO governance framework and space systems utilising the radio frequency spectrum. The key concept of harmful interference is also touched upon in the Outer Space Treaty, Article IX, which stipulates that States Parties to the Treaty "… shall conduct all their activities in outer space … with due regard to the corresponding interests of all other States Parties to the Treaty"[136] and should undertake international consultations if a State Party to the Treaty believes an activity would cause harmful interference with another activity of other States Parties to the Treaty. Though the terms 'due regard' and 'harmful interference' are not defined within the Outer Space Treaty, they can be understood to fit under the auspice of general international law given Article III of the Outer Space Treaty agrees that "States Parties to the Treaty shall carry on activities in the exploration and use of outer space … in accordance with international law …"[137].

In the Cyberspace Regime, the Tallinn Manual 2.0 mentions harmful interference regarding Article 45 of the ITU Constitution and Convention and "wireless cyber communications and services"[138] taking place over radio waves. The experts of the Tallinn Manual 2.0 agree that harmful interference is:

> … caused by one State with another's use of frequencies that enable cyber communications or services, wherever those communications or services take place, including outer space.[139]

Harmful interference can be engaged through electronic warfare targeting the electromagnetic spectrum by way of jamming or spoofing. According to the Center for Strategic and International Studies (CSIS), "jamming devices interfere with the communications to and from

---

[135] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 63
[136] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[137] Ibid
[138] Michael N. Schmitt (ed), *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (Cambridge University Press 2017)
[139] Ibid, 297

satellites by generating noise in the same radio frequency band",[140] which can happen during uplink or downlink transmissions. Spoofing, as described by CSIS, "… is a form of electronic attack where the attacker tricks a receiver into believing a fake signal, produced by the attacker, is the real signal it is trying to receive".[141] This can include false information or commands. Within the context of space security, "States should consider threat capabilities such as lasing, jamming, or spoofing which can cripple and deny use of data"[142] within space systems. From the examples given within the Outer Space Regime complex, the obligation of due regard and avoidance of harmful interference is set in binding international law across the regime complex.

2.6.3.2 The ITU Radio Regulations

The International Telecommunications Radio Regulations comprise a four-volume, legally-binding, hefty tome that supplements the ITU Constitution and Convention. They are a completed text as updated by the World Radiocommunications Conference and were last updated in 2019 at WRC-19 in Sharm el-Sheik, Egypt. The ITU Radio Regulations, considered to be leading international law in the Telecommunications Regime, are based on two primary concepts:

> (1) the concept of block allocations of frequencies that are intended for use by defined radio services in accordance with the Table of Frequency Allocations ("the Table") as contained in Article 5 of the Radio Regulations; this concept generally provides common frequency allocations to mutually compatible services operating with similar technical characteristics in specific parts of the spectrum and establishes a stable planning environment for administrations, equipment manufacturers, and users; and
>
> (2) the concept of voluntary or mandatory regulatory procedures (for coordination, notification and recording) adapted to the allocation structure.[143]

[140] Todd Harrison, Kaitlyn Johnson, and Makena Young, 'Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons' (Center for Strategic and International Studies, February 2021) 8
[141] Ibid, 8
[142] J. Lauren Napier, 'Report: Responsible Behaviours in Space, National Submissions to the UN' (Wilton Park 2021) 2
[143] Attila Mattas, Yvon Henri, Chuen Chern Loo, 'Chapter 12: The ITU Radio Regulations Related to Small Satellites' in Irmgard Marboe (ed), *Small Satellites: Regulatory Challenges and Chances* (Brill Nijhoff 2016) 239-240

This insures the equitable access and rational use of the radio frequency spectrum and its associated orbits for availability and protection against harmful interference.

It is important to note that in the Preamble of the Radio Regulations, it was reiterated that radio frequencies and orbits are limited natural resources that:

> … must be used rationally, efficiently and economically, in conformity with the provisions of these Regulations, so that countries or groups of countries may have equitable access to both, taking into account the special needs of developing countries and the geographical situation of particular countries.[144]

This Preamble aligns with the Outer Space Treaty and other international space instruments such as the Long-Term Sustainability Guidelines, as it promotes the equitable use and consideration for developing countries.

Additionally, the Radio Regulations have five overarching objectives including:

> … to facilitate equitable access to and rational use of the natural resources of the radio-frequency spectrum and the geostationary-satellite orbit; to ensure the availability and protection from harmful interference of the frequencies provided for distress and safety purposes; to assist in the prevention and resolution of cases of harmful interference between the radio services of different administrations; to facilitate the efficient and effective operation of all radiocommunication services; to provide for and, where necessary, regulate new applications of radiocommunication technology.[145]

It is interesting to note that in the Radio Regulations Preamble there is only mention of the geostationary-satellite orbit, while in the ITU Constitution and Convention, other applicable orbits are under consideration as well as GSO. However, they share a goal to prevent harmful interference and use through efficient, effective, and equitable means, also supported by international space law rhetoric.

One feature more common within the Telecommunications Regime than in the Outer Space Regime is the inclusion of key term definitions within legal texts. While the Liability Convention and the Registration Convention in the Outer Space Regime do have a few key

[144] International Telecommunications Union, 'Radio Regulations: Articles' (2012 edn, ITU) 3
[145] Ibid, 3

terms defined, the Radio Regulations have a vast lexicon, catalogued under Articles 1-3, which apply to the Regulations specifically. Though there are many terms within the Radio Regulations relating to space activity, there are three key terms that are germane to this research, as they connect to the legal term 'space object' found within the Liability Convention and the Registration Convention collectively. These three terms are 'spacecraft', 'satellite', and 'active satellite'.

According to the ITU Radio Regulations, 'spacecraft' refers to "a [hu]man-made vehicle which is intended to go beyond the major portion of the Earth's atmosphere";[146] 'satellite' refers to "a body which revolves around another body of preponderant mass, and which has a motion primarily and permanently determined by the force of attraction of that other body";[147] and 'active satellite' refers to "a satellite carrying a station intended to transmit or retransmit radiocommunication signals".[148] As a reminder, within the Liability Convention and Registration Convention, 'space object' refers to an object in space that "includes component parts of a space object as well as its launch vehicle and parts thereof".[149]

It is important to consider these key terms holistically because the Outer Space Regime and the Telecommunications Regime form a regime complex, which creates overlap and coordinated efforts regarding activity in LEO. One observation to note, which is also found in guidelines and industry standards, is that industry and technical experts tend to use the term 'spacecraft', while legal experts tend to use the term 'space object'. As demonstrated by the different approaches in defining the terms; a spacecraft is defined in a technical capacity, more general in scope about how it is made and where its use is intended. A space object is defined with consideration of what it includes. Both definitions are widely accepted, utilised, and legal.

The ITU Radio Regulations are a compilation of articles, resolutions, and appendices, all grouped according to an overarching theme, such as aviation, maritime, or outer space. The Radio Regulations are very specific and technical tenets meant for an operator, or potential operator, of any activity which requires the use of the radio frequency spectrum. Furthermore,

---

[146] Ibid, 24

[147] Ibid, 24

[148] Ibid, 24. It is important to note here that a 'station' refers to a transmitter or receiver and the definition can be found in the Radio Regulations: Articles on page 13. Additionally, a 'radiocommunication' means communications via radio waves and various definitions can be found in the Radio Regulations: Articles on page 7.

[149] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187; Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15

there are various tenets within the ITU Radio Regulations applicable to non-GSO satellites and Low Earth Orbit. There are also various supporting documents from the ITU that further articulate the regulations of non-GSO satellites which could be incorporated into the Low Earth Orbit governance framework. One such regulation from WRC-19 is ITU-R Resolution 35, *A Milestone-Based Approach for the Implementation of Frequency Assignments to Space Stations in a Non-Geostationary-Satellite System in Specific Frequency Bands and Services*. This was the first ITU Radio Regulation to give guidance on satellite constellations, specifically 'mega' constellations, and the use of the radio frequency spectrum.

With a better understanding of the regime complex, it is also important to analyse the legal and political challenges across the regime complex, especially those that have direct implications for Low Earth Orbit. This is why this research considers the regime complex when discussing how to evolve the Outer Space Regime and enhance the LEO governance framework.

2.7 Concluding Remarks

This chapter provided an overview of the international relations regime theory. The discussion included discourse on what a regime is, why one is created, how it is maintained, and how it can evolve. Examples were given from the Trade Regime and the Climate Change Regime, which showcased the importance of a regime's ability to evolve and adapt to internal and external challenges and circumstances. Regime theory was then applied to the Outer Space Regime, including LEO as a sub-regime. The concept of a nested regime was then described, followed by an explanation of how the Outer Space Regime fits this model. Additional to regime theory, the concept of a regime complex was introduced and discussed. This chapter then transitioned to discourse on governance theory, the modern adaptation of regime theory. The overview of regimes and governance in this chapter are expanded upon in Chapter Two, which focuses on the legal aspects of governance, ranging from international law to non-binding law to norms. The discussion in Chapter One and the following chapters aids in answering the first research question: "How is the Outer Space Regime evolving and why is this important to Low Earth Orbit?", which is answered in the concluding chapter.

3 Binding and Non-Binding Law and the Outer Space Regime

This chapter sets out the binding and non-binding tenets of outer space law that make up the specialised laws of the Outer Space Regime. This does not, however, reside in a legal vacuum. As has been discussed above within the discourse on the regime itself, the Outer Space Regime is part of a larger regime complex connected to the telecommunications, cyberspace, and security regimes. From a legal theory perspective, each regime creates *lex specialis* which allows laws to govern specific subject matter that may need further legal tenets rather than only relying on the tenets of general international law. General international law forms the foundations of all legal discourse for States. *Lex specialis* forms the foundation for a specific regime but still falls under general international law. This chapter contributes to answering Research Question 1–How is the Outer Space Regime evolving and why is this important to Low Earth Orbit?–and Research Question 2–Why does the Low Earth Orbit governance framework need to evolve, and what measures need to be in place to make this happen? –by providing a critical analysis of the fundamental legal issues within the regime.

3.1 Binding Laws and the *Lex Specialis* of Outer Space

In international law there are binding and non-binding mechanisms. Non-binding international law is discussed later in this chapter. This section focuses on binding law and the *lex specialis* of laws in outer space. International law is sourced from four categories as supported by the International Court of Justice (ICJ) in the *Statue of the International Court of Justice* under Article 38 (1) (a-d).

> The Court, whose function is to decide in accordance with international law such disputes as are submitted to it, shall apply: a. international conventions, whether general or particular, establishing rules expressly recognized by the contesting states; b. international custom, as evidence, of a general practice accepted as law; c. the general principles of law recognized by civilized nations; d. subject to the provisions of Article 59, judicial decisions and the teachings

> of the most highly qualified publicists of the various nations, as subsidiary means for the determination of rules of law.[1]

In the Outer Space Regime, there are treaties and conventions as well as general principles. Treaties and conventions, as mentioned within the *Vienna Convention on the Law of Treaties* (VCLT) under Part III, Section 1, Article 26 '*Pacta sunt servanda*' stipulates: "Every treaty in force is binding upon the parties to it and must be performed by them in good faith".[2] The foundation of the Outer Space Regime is based in *lex specialis* international law under the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (also known as the Outer Space Treaty or OST)[3] and includes binding principles brought together under one treaty. The Outer Space Treaty is the foundation for the subsequent treaties such as the *Convention on International Liability for Damage Caused by Space Objects* (also known as the Liability Convention)[4] or the *Convention on Registration of Objects Launched into Outer Space* (also known as the Registration Convention)[5]. Both of which are pertinent to Low Earth Orbit governance alongside the Outer Space Treaty. This is not to say that general international law does not apply to the Outer Space Regime–it does. Pursuant to Article I, "outer space … shall be free for exploration and use by all States … in accordance with international law …"[6] Further, under Article III of the OST,

> States Parties to the Treaty shall carry on activities in the exploration and use of outer space … in accordance with international law, including the Charter of the United Nations …[7]

[1] Charter of the United Nations and Statute of the International Court of Justice (signed 26 June 1945, entered into force 24 October 1945)
[2] Vienna Convention on the Law of Treaties (adopted 23 May 1969, entered into force 27 January 1980) 1155 UNTS 331
[3] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[4] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[5] Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15
[6] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[7] Ibid

The Outer Space Treaty Articles I and III[8] solidify the understanding that the Outer Space Regime legal foundation is also founded on general international law. This notion of general international law applying to specialised international law is reiterated by the International Law Commission (ILC) which suggests that a regime inclusive of *lex specialis* is not exempt from general international law.[9] Carrying on the discussion about specialised international law, the next sections speak in greater detail about the Liability Convention and Registration Convention as they are also important binding international space law for Low Earth Orbit and the Outer Space Regime.

3.1.1 Liability in Space: The Outer Space Treaty and the Liability Convention

Liability in outer space is unique as it hinges on four key variables–whether damage occurred in space or on Earth from space; all fault is State responsibility at the international level; causation is difficult to pinpoint; and there is no legal precedent for liability in space. These variables are analysed in this section regarding the legal instruments of the Outer Space Regime relevant to liability in and from outer space. The issue of liability within the Outer Space Regime has legal tenets in the Outer Space Treaty under Article VII[10] as well as having a separate treaty specific to liability called *The Convention on International Liability for Damage Caused by Space Objects*[11] (henceforth known as the Liability Convention). Additionally, there is *de facto* liability that is prevalent under Article III of the Outer Space Treaty as it mentions the need to act "… in accordance with international law, including the Charter of the United Nations …"[12]

Article VII of the Outer Space Treaty is the first law on liability in or from outer space which states:

[8] Ibid
[9] International Law Commission, *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law* (13 April 2006) A/CN.4/L/682, 82
[10] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205
[11] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[12] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

> Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.[13]

Article VII indicates that States Parties to the Treaty bear international responsibility and liability for damages of a governmental or non-governmental nature, including those by non-State actors' activities under their jurisdiction and those which take place on Earth, in air space, or–as applicable to this research in outer space. Therefore, the responsibility and fault lie on States at the international level. This understanding of fault is discussed in more detail within this section under the tenets of the Liability Convention.

From Article VII of the Outer Space Treaty, United Nations Member States created *The Convention on International Liability for Damage Caused by Space Objects,*[14] which stands as the *lex specialis* for liability within the Outer Space Regime. The Liability Convention is the third treaty in the space treaty family and entered into force 1 September 1972. As of February 2023, the Liability Convention has 98 ratified Member States and 19 Signatory States.[15]

The Liability Convention is important both for its specifications on fault and liability regarding space objects and its definition of four key concepts: 'damage,' 'launching,' 'launching state,' and 'space object;' thus, making them legally binding. Defined terms are important because much of the terminology used within the Outer Space Regime does not have legally binding definitions. However, even legally binding definitions can be interpreted differently by States depending on diversity of knowledge and language.

[13] Ibid

[14] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187.

[15] Committee on the Peaceful Uses of Outer Space Legal Subcommittee, 'Status of International Agreements Relating to Activities in Outer Space as at 1 January 2022' (28 March 2022) A/AC.105/C.2/2022/CRP.10

Under Article I of the Liability Convention, the key terms for liability are defined as such:

> For the purpose of this Convention: (a) The term "damage" means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations; (b) The term "launching" includes attempted launching; (c) The term "launching State" means: (i) A State which launches or procures the launching of a space object; (ii) A State from whose territory or facility a space object is launched; (d) The term "space object" includes component parts of a space object as well its launch vehicle and parts thereof.[16]

These legal definitions help determine the understanding of fault and are specifically applied to the Liability Convention with application for Low Earth Orbit. The main flaw with these legal definitions is regarding 'damage' as it is not an exhaustive list of the types of damages that can occur, such as indirect damage, cyber damage, interference or temporary interference, or financial loss. Therefore, this creates grey areas when it comes to claiming damages and adds to the hurdle of establishing fault.

The next article of consideration applicable to LEO and within the Liability Convention is Article III, which states:

> In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.[17]

Article III can be interpreted to mean there must be fault-based damage in outer space caused by a space object of a launching State to persons or property on board another space object of another launching State. Fault is not limited to functioning space objects. Fault, in and of itself, is unusual in international law. In space it is even more so as it is harder to establish fault when there is no

[16] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[17] Ibid

one there to observe the fault in question. This lack of local understanding on-orbit can make establishing fault next to impossible. To establish fault, there must be proof of breach; proof of litigation; knowledge of whether the actor complied with standards and practiced due regard or duty of care; whether the actor attempted to avoid harmful interference; and understanding of whether the actor was conducting responsible behaviour. There are many sub-issues with these points on establishing fault. For example, there must be an understanding of what standards–apart from international space law–must be met, such as non-binding international law (guidelines, industry standards, best practices, norms). How is due regard or duty of care defined for space and how can a principle be measured? Did the operator attempt to avoid harmful interference? What qualifies as responsible behaviour versus irresponsible behaviour? Is the fault direct or indirect? What is the chain of causation, and how can it be proven?

Looking first at due regard and the intention to avoid harmful interference, the Outer Space Treaty, Article IX specifies:

> In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and shall conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the earth resulting from the introduction of extra-terrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by

> another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.[18]

The key points here regarding liability are that States Parties to the Treaty shall act with due regard and avoid harmful interference towards activities in space. Due regard is challenging in that actors may be unable to find causation if a collision or harmful interference does indeed occur.

As interpreted in the *Cologne Commentary on Space Law*:

> The State must prove beyond a reasonable doubt that everything possible was undertaken to prevent a harmful act from occurring. The 'due regard' principle is to be interpreted according to the particular facts and circumstances of the case.[19]

Due regard in the Outer Space Regime is connected to an understanding of the need to conduct space activity in a way that avoids harmful interference or contamination. Furthermore, the due regard principle from the OST is also aligned with the principle of non-harmful interference from the ITU Constitution and Convention which includes radio regulations for satellites. Under Article 45 Harmful Interference[20] within the ITU Constitution and Convention, Member States must not cause harmful interference to radio services, including those actions of their non-State actors.

Additional to the above issues on liability in and from space, the Liability Convention also covers joint and several liability under Articles IV and V.[21] Relevant to Low Earth Orbit under Article IV of the Liability Convention are paragraphs 1 (including 1b) and 2. Article IV, Para. 1, states:

---

[18] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[19] Sergio Marchisio, 'Article IX' in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017) 570

[20] Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330, Art 45

[21] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187

> In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, and of damage thereby being caused to a third State or to its natural or juridical persons, the first two States shall be jointly and severally liable to the third State …[22]

Article IV, Para. 1 allows for third-party damages to be covered by the first two States under the auspice of joint and several liability. Furthermore, Article IV, Para. 1b suggests:

> If the damage has been caused to a space object of the third State or to persons or property on board that space object elsewhere than on the surface of the earth, their liability to the third State shall be based on the fault of either of the first two States or on the fault of the persons for whom either is responsible.[23]

Article V, Paragraph 1 of the Liability Convention takes Article IV further by stipulating that "whenever two or more States jointly launch a space object they shall be jointly and severally liable for any damage caused".[24]

Finally, Articles IX–XX of the Liability Convention[25] deal specifically with claiming compensation for damages and the right to establish a Claims Commission if diplomatic negotiations fail. However, to establish a Claims Commission, a party must do so "… within one year from the date on which the claimant State notifies the launching State that it has submitted the documentation of its claim …"[26]

Liability in and from space is a difficult matter. Without local understanding of the orbit, it is almost impossible to find causation and, therefore, fault. Having the Liability Convention at hand does help Member States, however, as there is no precedent in space for fault liability, and the treaty has not been put into practice as of 2023. Given the number of satellites and debris and the

---

[22] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[23] Ibid
[24] Ibid
[25] Ibid
[26] Ibid

growing number of non-State actors and of satellites within satellite constellations, LEO may in fact be the first place where the Liability Convention could come into play in the near future.

3.1.2 International Space Law and the Registration of Space Objects

All human-made objects launched into space must be registered through a national register and the international register organised by UNOOSA. Additionally, all objects must also be registered for radio spectrum allotment through a national register and the international register organised by the ITU. Within the Outer Space Regime there is the OST which generally speaks on space object registration. This gave way for the Registration Convention on space objects. The tenets of what is expected of States within these two treaties regarding registration of space objects are discussed in this section. The registration of the radio frequency is discussed in a separate section, as this pertains to the Telecommunication Regime and is not mentioned within the core Outer Space Treaties.

Within the Outer Space Treaty, Article VIII specifically concerns the registration of space objects, and Article XI coincides with registration by way of asking for transparency of activities in space. Article VIII proclaims:

> A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data prior to their return.[27]

[27] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

Article VIII of the Outer Space Treaty[28] is the precursor to and starting off point for the Registration Convention which is discussed below after outlining the registration provisions of the OST. Based on esteemed analysis taken in the *Cologne Commentary on Space Law*:

> Registration creates, in a sovereignty-free area, a chain of attribution between the launching State, the space object, international responsibility for space activities and jurisdiction and control by the registering State.[29]

Registration supports a one State approach thus clarifying "… the identification of the relevant national law that is applicable for the space object in question"[30].

In the view of this research, Article XI of the Outer Space Treaty is a complementary article to Article VIII in terms of registration by focusing on State behaviour in space as a transparent practice for promotion of international cooperation. Article XI mentions,

> In order to promote international cooperation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the Moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.[31]

OST Article XI can extend past Article VIII by including non-State actors directly. It can also mean that while State and non-State actors may submit information on their activities to UNOOSA or through statements and presentations at UN COPUOS and its subcommittees, they may also do so for the public.[32] However, this is articulated on what State and non-state actors deem 'feasible

[28] Ibid

[29] Bernhard Schmidt-Tedd and Stephan Mick, 'Article VIII' in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017) 495

[30] Ibid, 495

[31] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[32] Jean-Francois Mayence and Thomas Reuter 'Article XI' in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017) 630

and practicable' which may exclude information that would harm national security or other strategic interests.

The Convention on Registration of Objects Launched into Outer Space[33] entered into force 15 September 1976, making it the fourth space treaty. The Registration Convention is the *lex specialis* from Article VIII of the Outer Space Treaty and is for recording space objects launched into space. As of February 2023, the Registration Convention has 72 ratified Member States and 3 Signatory States[34].

Article I of the Registration Convention reiterates the legal definitions for 'launching State' and 'space object' found in the Liability Convention. However, here another legal definition is added – 'State of registry'– which "… means a launching State on whose registry a space object is carried in accordance with Article II"[35]. The Registration Convention provides a brief explanation of why registration of space objects is important and what the process should entail. The key points to understand from this convention are that there can be only one State of registry per space object, and that State shall record certain information about the space object in question. This information shall be sent to the Secretary-General of the United Nations to be recorded in the international register. Article IV stipulates what information is needed, such as:

> …(a) Name of launching State or State(s); (b) An appropriate designator of the space object or its registration number; (c) Date and territory or location of launch; (d) Basic orbital parameters, including: (i) Nodal period; (ii) Inclination; (iii) Apogee; (iv) Perigee; (e) General function of the space object.[36]

UNOOSA offers support online by keeping an updated list of space objects registered or under application; providing the registration form; and showing national space object registries. For Low Earth Orbit, UNOOSA and the ITU have created a handbook, *Guidance on Space Object Registration and Frequency Management for Small and Very Small Satellites,*, in order to support

[33] Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15
[34] Committee on the Peaceful Uses of Outer Space Legal Subcommittee, 'Status of International Agreements Relating to Activities in Outer Space as of 1 January 2022' (28 March 2022) A/AC.105/C.2/2022/CRP.10
[35] Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15
[36] Ibid

the growing use of small and very small satellites for State and non-State actors. This handbook includes information on registration specifically applicable to Low Earth Orbit where these small and very small satellites operate.

The challenges emanating from the Registration Convention include the low number of States Parties to the Treaty and the fact that some registration applications are not made until the space objects are already on orbit or de-orbited, if registered at all. However, the fact that there is a treaty specifically designed for registration of space objects demonstrates the forethought on the need for space traffic management, which is touched upon later in this research. Another positive indication is the connection across the regime complex with the ITU on space object registration and radio frequency registration. While there is still a need for more States to be signed to the treaty and more timely registration procedures, it is useful that the legal framework exists and allows for an interconnected national and international approach through national licensing procedures, offering a one-stop-shop for operators for space object registration, radio registration, and complete licensing of satellites.

3.2 Non-Binding International Law

Soft law is any non-legally binding instrument of a voluntary nature that can take form for a plethora of reasons, as will be discussed below. Hard law consists of legally binding instruments, such as treaties, while soft law provisions:

> a) provide evidence of existing law; b) be formative of the *opinio juris* or state practice which generates new customary rules; c) be the first step of a process leading to the conclusion of a treaty; d) alter and lose their non-binding character as a result of state compliance with them.[37]

The terms 'hard' and 'soft' law are less accessible and do not facilitate concrete understanding. Therefore, in this research the terms 'legally binding' or 'binding' international law and 'non-binding' international law (NBIL) are utilised. The concept of NBIL is taken from Reinicke and

[37] Fabio Tronchetti, '4.5 Soft Law' in Christian Bruenner and Alexander Soucek (eds) *Outer Space in Society, Politics and Law* (Springer Vienna 2011) 621

Witte[38] as they consider non-binding international legal agreements, or NBILAs, however the choice of NBIL instead of NBILA allows for terms other than agreements to be considered (e.g., provisions, guidelines, etc.).

There is scholarly debate on the merits of binding versus non-binding law. However, they should be seen as two types of law that work together for a more robust legal framework for a given regime. Reinicke and Witte argue this very point by stating:

> NBILAs and traditional hard law therefore are not mutually exclusive, but instead represent two cornerstones of the possible range of obligations chosen by multiple public and private parties…[39]

NBIL can hold an important supporting role to legally binding international law, as it can fill gaps much more prudently than treaty amendment. Therefore, they are two important types of international law that can go together, or stand-alone as international decision-makers see fit. It is in this stand-alone manner that Thirlway suggests that NBIL can be, and is, created to be NBIL and nothing greater.

> If the choice is made to use non-binding language in a text which could of its nature embody a binding commitment, that is because those responsible for the text did not intend it to be binding – they knowingly created soft law.[40]

This is already seen in the Outer Space Regime with the creation of the Long-Term Sustainability Guidelines or the drafting of the Space2030 Agenda. NBIL can be a precursor to legally binding instruments, but it can also stand on its own like the LTSG, as argued by Abbott and Snidal:

> Soft law is valuable on its own, not just as a steppingstone to hard law. Soft law provides a basis for efficient international "contracts," and it helps create normative "covenants" and discourses that can reshape international politics.[41]

---

[38] Wolfgang H. Reinicke and Jan Martin Witte, 'Interdependence, Globalization, and Sovereignty: the Role of Non-binding International Legal Accords in Chapter 3 Challenges to the International Legal System, in Dinah Shelton (ed) *Commitment and Compliance: The Role of Non-Binding Norms in the International Legal System* (Oxford University Press 2003)

[39] Ibid, 95

[40] Hugh Thirlway, *The Sources of International Law* (2019, 2nd edition, Oxford University Press) 191

[41] Kenneth W. Abbott and Duncan Snidal, "Hard and Soft Law in International Governance" (2000) 54 (3) International Organization, 421-456

Additionally, NBIL can be inclusive of non-State actors in terms of creation and implementation, whereas legally binding international law is specifically created and implemented by States with application toward non-State actors imbedded into national policies and regulations. Non-State actors being part of the process could then go further to encourage implementation.

What makes NBIL useful–and increasingly prevalent–is its ability to adapt, which is important in the Outer Space Regime and the LEO governance framework because of how quickly scientific knowledge and technology can change. This, in turn, can render laws and policies obsolete or in need of amendment, as will be the case with the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines '25-year rule'. The time it takes to negotiate, create, and gain signatories to a treaty is often painstakingly slow. However, NBIL can be achieved in a shorter timeframe, thus allowing it to match shifting political, scientific, and technical climates.

The key caveat is that NBIL cannot be strictly enforced. However, in terms of compliance, NBIL can "… serve to assist States in coordinating their behavior".[42] This can contribute to international coordination, as it allows State and non-State actors to coordinate their behaviour voluntarily, which may encourage adherence because the consequences for non-adherence or stopping adherence are lesser than those of treaties or other legally binding instruments. Also, non-State actors cannot directly coordinate under legally binding international law, which means that States must have policies and regulations at the national level to support non-State actor adherence and determine what violations would apply with non-adherence. These can wildly differ from State to State, thus potentially breaking down coordination and potentially creating legal fragmentation. Because NBIL is created internationally and is, therefore, less fragmented, it could allow for greater global coordination across different types of actors. Rational actors ultimately want to avoid risk and loss. NBIL could be the politically favourable option in the long run. Regardless, States do not want to incur losses, whether economic or political, especially to reputation. The loss of political reputation, and subsequent loss of trust and confidence, could make it harder for a State

[42] Andrew T. Guzman and Timothy L. Meyer, 'International Soft Law' (2010) 2 (1) Journal of Legal Analysis, 171-225, 188

to work with other States in the future. Therefore, although non-legally binding, NBIL does have merit to encourage compliance among State and non-State actors.

3.2.1 Non-Binding International Law and the Outer Space Regime

This section describes what NBIL means for the Outer Space Regime and the LEO governance framework. There is already NBIL specific to space, and since 2000 (when the Non-Binding International Law Epoch began), the Outer Space Regime has moved toward building NBIL in place of legally binding international space law, as it currently stands in 2023. The two most successful examples of NBIL in space are the Space Debris Mitigation Guidelines (both the Inter-Agency Space Debris Coordination Committee and the UN COPUOS versions) and the LTSG. These examples of NBIL are more scientific and technical in nature and are prime examples of why NBIL works in the international space law arena. They support the idea that "…informalism may be the way forward in a time where technological, scientific and economic evolution tends to outstrip the pace at which law is formally being made".[43]

While the IADC SDMG, UN SDMG, and the LTSG are discussed in subsequent sections, it should be noted that they hold tenets for a safe, secure, and sustainable space environment and are applicable to Low Earth Orbit. There is another NBIL space agreement from the UNGA Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities. Created in 2013, the GGE report on TCBMs also aims for a space environment that is safe, secure, and sustainable for the long-term benefit of humankind. The GGE maintain that this report is a NBIL document and as such should work to

> … complement the existing international legal framework pertaining to space activities and should not undermine existing legal obligations or hamper the lawful use of outer space, particularly by emerging space actors.[44]

Therefore, it is understood that this report was created under the assumption that it would serve as complementary NBIL to the already-established legally binding international space law. The GGE

[43] Gérardine Meishan Goh, 'Softly, Softly Catchee Monkey: Informalism and the Quiet Development of International Space Law' (2009) 87 Nebraska Law Review, 725-746, 745

[44] UNGA Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities (29 July 2013) UN Doc A/68/189, 2

report on TCBMs is discussed later in this chapter, as these NBIL provisions in the Outer Space Regime are connected by their support of a safe, secure, and sustainable long-term use of the space environment. In this research, this triad is understood as the 3S Approach.

In the Outer Space Regime, NBIL has been predominately created to support existing legally binding international space law and fill gaps in outer space treaties as science, technology, exploration, and use of space have developed. There are several common themes, such as the long-term use of outer space, the consideration of developing States, and the use of space for peaceful purposes with non-appropriation.

3.3 Normative Behaviour

Normative behaviour is addressed in law, international relations, and sociology. Therefore, this research considers normative behaviour from a diplomatic perspective, as States are currently deliberating on 'responsible behaviours' in space within the UN Conference on Disarmament regarding space security matters. At the basic level, norms offer an understanding of what 'should' be done. They can start at the international level and trickle down, or societal movements can create norms through minority groups and non-State actors. Regardless of origin, the most important element to create normative behaviour is that the actors, specifically States, must feel that this behaviour is legally binding on them.

It is important to understand first how normative experts define and comprehend normative behaviour and what brings actors to these behaviours. Elsenbroich and Xenitidou articulate that a

> … decision is normative if there is social influence (pressure, invocation, threat of punishment, etc.) on the agent and if the agent makes the decision in favour of the social demand.[45]

Here they regard actors as 'agents' and assert that normative behaviours stem from normative decision-making and societal influences which correlate to the emergence of norms and the use of influences by norm entrepreneurs.

[45] Corinna Elsenbroich and Maria Xenitidou, 'Three Kinds of Normative Behaviour: Minimal Requirements for Feedback Models' (2012) 18 Computational and Mathematical Organizational Theory, 113-127, 115

Elsenbroich and Xenitidou further define a behaviour as normative "… if and only if it results from a normative decision"[46] which means that:

> (a) all behaviours resulting from normative decisions are normative behaviours and that (b) only behaviours resulting from normative decisions are normative behaviours.[47]

This further demonstrates that norm entrepreneurs carry weight when deciding what is to be considered normative behaviour. Their decisions can make or break norms moving through the normative life cycle, as articulated below.

Anomaly and Brennan offer a different perspective, arguing that norms are "… the informal rules that govern the behaviour of members of a group".[48] They further stipulate that:

> … since social rules or regularities change over time, and differ between groups, regularities do not need to make *everyone* (including dissenters, outsiders, and social scientists) feel obligated to follow them in order to count as norms[49]

and as such:

> for a rule to exist as a norm for a particular group, enough people within the group must believe they should follow it. Norms are, in this sense, normative: they are action-guiding rules or procedures that govern the behaviour of members of a group.[50]

This includes compliance through evaluation as well as silence. As discussed below, this is where norm influencers add weight to already-emerging norms suggested by norm entrepreneurs.

---

[46] Ibid, 115
[47] Ibid, 115
[48] Jonny Anomaly and Geoffrey Brennan, 'Social Norms, the Invisible Hand, and the Law' (2014) 33 (2) University of Queensland Law Journal, 263-283, 264
[49] Ibid, 264
[50] Ibid, 264

Finnemore and Sikkink suggest that norms "… are actively built by agents having strong notions about appropriate or desirable behavior in their community".[51] However, this 'appropriate' or 'desirable' behaviour may in fact be based on a stakeholder's best interests and may seem 'appropriate' or 'desirable' only to themselves. Yet, it is through norm entrepreneurs and norm promoters or leaders that the norm itself becomes normative behaviour within the community, which is the first step that sets the norm on its life cycle.

The discussion of the life cycle of norms includes the actors–norm entrepreneurs or norm leaders as well as norm influencers or norm promoters. The first stage of the life cycle of norms is 'norm emergence', in which a norm entrepreneur–an actor who aims to create a norm and normative behaviour–attempts to "… convince a critical mass of states (norm leaders) to embrace new norms…".[52] The second stage, 'norm acceptance' or 'norm cascade' "… is characterized more by a dynamic of imitation as the norm leaders attempt to socialize other states to become norm followers".[53] This then creates a norm cascade as it moves through the rest of the community via a "… combination of pressure for conformity, desire to enhance international legitimation, and the desire of state leaders to enhance their self-esteem…".[54] These first two stages act as the tipping point at which the norm must be adopted, or it cannot reach the third stage of internalization. At the third stage, internalization, "… norms acquire a taken-for-granted quality and are no longer a matter of broad public debate".[55] It is at this stage of internalization that many actors would take the norm as 'normative behaviour' and as such would consider the norm to be what they 'ought' to do.

As is also the case with regimes, eventually a norm may decay as "a norm may lose its appeal in a group and is hence either abandoned, replaced or modified by a competing one,"[56] restarting the life cycle. It is through this process that normative behaviour rises and falls – though whether the behaviour is good or not relies on other factors which are further discussed in this research. What then makes a norm successful? – Norm entrepreneurs. They are "critical for norm emergence

---

[51] Martha Finnemore and Kathryn Sikkink, 'International Norm Dynamics and Political Change' (1998) 52 (4) International Organization, 887-917, 896
[52] Ibid, 895
[53] Ibid, 895
[54]Ibid, 895
[55] Ibid, 895
[56] Christopher K. Frantz and Gabriella Pigozzi, 'Modeling Norm Dynamics in Multi-Agent Systems' (2018) 5 (2) Journal of Applied Logics – IFCoLog Journal of Logics and their Applications, 491-563, 503

because they call attention to issues or even “create” issues by using language that names, interprets, and dramatizes them”.[57]

Norm entrepreneurs also need a good platform (i.e., forum or international organization, as examples) from which they can speak and gain norm leaders for the norm to cascade throughout the community. Sometimes it is not the quantity of actors but the specificity of actors that makes the difference.

> Some states are critical to a norm’s adoption; others are less so. What constitutes a “critical state” will vary from issue to issue, but one criterion is that critical states are those without which the achievement of the substantive norm goal is compromised.[58]

At the international level, this could include hegemonic leaders or established States or actors within the community. Within the Outer Space Regime this could mean the United States, Russia, China, European States, Japan, or India. At the regional or national level this could also include major private stakeholders or organisations vested in making standards that reflect both state and non-state interests while upholding international space law. The best examples here are the Space Safety Coalition (SSC) and the Space Data Association (SDA), as they are a collection of industry and academia professionals focused on standards that adhere to international space law whilst also showcasing the interests and willingness of non-State actors to be on the same page as States when it comes to the long-term sustainability and use of outer space. This leads to the question of why State and non-State actors choose to comply or defect when it comes to norms and normative behaviour. The next section further discusses norms and their life cycle, perception, and application within the Outer Space Regime.

3.3.1 Norms and Outer Space

As the previous section argues, normative behaviour can be legal, political, or sociological in interpretation and analysis. Essentially, norms concern collective action and cooperation, which

[57] Martha Finnemore and Kathryn Sikkink, ‘International Norm Dynamics and Political Change’ (1998) 52 (4) International Organization, 887-917, 897
[58] Ibid, 901

are the driving catalysts within the Outer Space Regime and within Low Earth Orbit specifically (Higher orbits and celestial body utilisation do require the same but are beyond scope of this research.). According to Anomaly and Brennan,

> Norms can be understood as emerging within social groups to solve collective action problems in which there is a conflict between individual rationality and social welfare.[59]

This understanding of norms as solvers of collective action issues can be applied to the Outer Space Regime. The actors utilising outer space are part of an international space social group that is connected via organisations, international organisations, as well as the United Nations. States come together at UN COPUOS and its subcommittees to solve collective action problems, such as space debris. Non-State actors have similar discourse on collective action problems through organisations such as the Space Safety Coalition. The reason States must deliberate on collective action issues at UN COPUOS and the subcommittees is because States act as individual rational actors or within in coalitions with "like-minded" States, sometimes creating what Anomaly and Brennan[60] suggest as 'conflict', taken to mean difference of opinion, interpretation, or analysis of how best to solve collective action problems in order to create social welfare–or the long-term sustainability, safety, and security–of outer space, including the Earth's orbits and celestial bodies. Therefore, normative behaviour, otherwise referred to as political commitments are currently hailed as a solution to collective action problems where consensus may prove challenging for treaties or hard international law. This is not unique to the Outer Space Regime; he same can be said for other parts of the regime complex, such as the Cyberspace Regime or the Security Regime, where normative behaviour is finding traction where treaty progress is not.

Normative behaviour as maxims of cooperation connects to international relations and economic academic game theory. Elster suggests that there can be utilitarian, Kantian, or fair norms for cooperation. An actor considering norms as utilitarian "… would cooperate if and only if [their] contribution increases the average utility of the members in the group".[61] Whilst an actor considering norms as Kantian would "… cooperate if and only if it would be better for all if all

[59] Jonny Anomaly and Geoffrey Brennan, 'Social Norms, the Invisible Hand, and the Law' (2014) 33 (2) University of Queensland Law Journal, 263-283, 265
[60] Ibid
[61] Jon Elster, 'Social Norms and Economic Theory' (1989) 3 (4) Journal of Economic Perspectives, 99-117, 101

cooperated than if nobody did".[62] Norms of fairness allows an actor to "… cooperate if and only if most other people cooperate".[63] Regardless, actors, especially States, choose to adhere to a norm out of self-interest through fear of being left out or fear of sanctions or because they genuinely believe it is the best option. From Elster's understanding of norms for cooperation, within the Outer Space Regime, there are actors that could fit into any of the three types suggested. Elsenbroich and Xenitidou also suggest that there can be coordination norms through conformity, obedience, or compliance.[64]

The Outer Space Regime is a *lex specialis* regime and as such adheres to both general international law and law created specifically for the outer space environment. The regime includes legal, political, and social norms. As the Outer Space Regime is a tech regime reliant on scientific and technological advancement, it can be challenging for law to keep up.

Johnson suggests:

> It's widely accepted that the current state of norms of behavior governing space activities [are] struggling to keep pace with the increasingly rapid innovation and diversification of space activities. The space law treaties … contain basic principles, yet don't provide adequate guidance for many current and proposed activities. In recent years, the lack of government direction has resulted in the private sector taking the lead in developing standards for activities such as orbital data sharing and satellite servicing.[65]

The above excerpt suggests that a bottom-up and a top-down approach to governing outer space will stay constant as State and non-State actors find solutions to collective action problems through a mix of binding and non-binding instruments, including norms of behaviour. Non-binding instruments and norms may be the way forward to keep pace. However, as demonstrated by the decade-long deliberations to consensus on the 21 non-binding LTSG; even non-binding

---

[62] Ibid, 101
[63] Ibid, 101
[64] Corinna Elsenbroich and Maria Xenitidou, 'Three Kinds of Normative Behaviour: Minimal Requirements for Feedback Models' (2012) 18 Computational and Mathematical Organizational Theory, 113-127, 114
[65] Chris Johnson, 'Insight – Developing Norms of Behavior for Space' (*Secure World Foundation*, February 5, 2020) <https://swfound.org/news/all-news/2020/02/insight-developing-norms-of-behavior-for-space/> accessed 08 June 2021

instruments have a lengthy process from creation to consensus in addition to the next stage of implementation and adherence.

Three reports have been compiled on norms in outer space, including two through organisations and one from the United Nations General Assembly. UNIDIR published a 2015 report on *Regional Perspectives on Norms of Behaviour for Outer Space Activities*. Project Ploughshares held regional workshops and produced the 2021 report *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report*. Finally, the United Kingdom led an initiative resulting in *United Nations General Assembly Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours* to move forward through the UN PAROS agenda. These three reports are analysed here along with key challenges regarding norms: fragmentation, framing, consensus, interpretation, implementation, enforcement, monitoring, and verification. These challenges also apply to all binding and non-binding outer space instruments, which amplifies why the regime is evolving and in need of the governance framework to be moderated.

3.3.1.1 UNIDIR: Regional Perspectives on Norms of Behaviour for Outer Space Activities

Starting with an analysis of the UNIDIR 2015 report on *Regional Perspectives on Norms of Behaviour for Outer Space Activities* (hereafter known as the UNIDIR 2015 report), it must be understood that this report originates from an organisation that sits within the regime complex and is part of a broader security regime. Also, what is referred to as 'norms of behaviour' in the UNIDIR 2015report can be interpreted to mean NBIL. Whether this was by design or misunderstanding on the part of the authors is unclear. However, given the current *modis operandi* to discuss 'norms' and 'responsible behaviour' under the auspice of the United Nations by way of working groups and document creation of a non-binding nature, it can be argued that 'norms of behaviour' are being articulated through NBIL in the form of political commitments and not as legal norms via the customary international law (CIL) avenue. This is especially as States are making it clear that norms of behaviour are regarded as political commitments, as further demonstrated in the forthcoming analysis of the UNGA Resolution 75/36 within the space security context.

One rationale the report suggests (which particularly pertains to Low Earth Orbit) states that:

> with increasingly cheaper solutions for space-based needs, such as nano-satellites and hosted payloads, it is clear that there will be significantly more orbital traffic in coming years.[66]

This statement alludes to the understanding that the current Space Traffic Management (STM) framework–or lack thereof–will need further support, perhaps in the form of norms of behaviour. In fact, the UNIDIR 2015 report suggests the use of a norms of behaviour model, the advantage being

> … that they do not create binding obligations on States, permitting incremental movement towards solutions to issues that need to be addressed in a timely manner, especially those issues where political obstacles can make the negotiation of formal instruments a long and protracted process. Such small steps can be useful in the maintenance of political momentum on particular issues.[67]

This idea that non-binding instruments can be created in a timelier manner than binding commitments suggests there can be rules which can stay relevant and avoid being bogged down in politics. Of course, as has already been mentioned, norms and other non-binding instruments are not a panacea. However, they can offer another path that might be quicker and more flexible for actors to implement. In fact, flexibility is another key aspect of the usefulness of norms of behaviours as mentioned in the UNIDIR 2015 report. The report gives the example:

> As has been seen with norms of behaviour in other domains, such as aerospace and maritime activities, rules of the road can be amended with relative ease as circumstances and needs change. This allows different frameworks to be tested before more formal agreements are sought, giving the international community an opportunity to gauge the effectiveness of specific approaches, practices,

[66] United Nations Institute for Disarmament Research (UNIDIR), *Regional Perspectives on Norms of Behaviour for Outer Space Activities* (UN Publications, 2015) 2
[67] Ibid, 10

> giving States ample room to move towards adherence in accordance with their own economic and technological capacities.[68]

This understanding of flexibility is observable throughout the regime complex also being prevalent within the Security Regime and the Cyberspace Regime, where there, too, exist UN groups on normative behaviours through non-binding instruments.

The overarching understanding from the UNIDIR 2015 report is that "… norms of behaviour can be described as voluntary "rules of the road" that can set baseline standards of conduct intended to mitigate threats to safety, security, and stability in outer space".[69]

3.3.1.2 Project Ploughshares: From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report

The second report from an organisation is the Project Ploughshares *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report* from January 2021 (hereafter known as the Ploughshares report). This report is based on a series of regional workshops conducted to gain global space expert input into the topic of normative behaviour in outer space. The Ploughshares report defines norms as "… rules or behaviours rooted in shared values and social expectations of appropriate conduct …".[70] Taking this definition as the baseline, "the workshop discussions reinforced appreciation of norms as social and value-laden"[71] and "… served to distinguish norms from other types of rules and emphasized the importance of moral obligation in motivating behaviour".[72] The key take-aways from the workshops and report findings include that "… security-related norms of behaviour in outer space are directly linked to – and can build upon – established and emerging safety and sustainability practices"[73]. Again, like the UNIDIR 2015 report, the Ploughshares report emphasises the importance of a secure, safe, stable, and sustainable utilisation of outer space. Conversely, the UNGA Resolution 75/36 lacks emphasis

[68] Ibid, 11
[69] Ibid, 29
[70] Jessica West and Gilles Doucet, *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report*, (Project Ploughshares 2021) 7
[71] Ibid, v
[72] Ibid, v
[73] Ibid, v

of these concepts in favour of a space security focus for discussion specifically within the UN 1st Committee, not through the UN 4th Committee where the peaceful uses of outer space are deliberated.

Additional to the understanding that security is linked to safety and sustainability in space, the Ploughshares report also identifies the following key factors: shared values, inclusivity and fairness, threatening activities and operating environment, opportunities for good practice, missing mechanisms, and the importance of leadership. Bolstering the regard of norms as vehicles for collective action and cooperation, the Ploughshares report suggests that "any effort to develop new norms of behaviour in space must first reflect a shared understanding of collective values and purpose".[74] While this may seem simple in theory, in practice–especially at the international level with a large body of Member States–finding shared understandings can be quite challenging because of cultural and language differences, as well as various diverging political interests, particularly between liberal and more authoritarian minded States. However, the intended point is that effective norms must be made of shared values to survive the normative life cycle and be implemented by most actors. The report's suggestion of inclusivity and fairness is understood as:

> Identifying and building on shared values [in order to create] a foundation for promoting norms that are both inclusive and fair, but these values must be incorporated into the entire norm process, including the goals and benefits of normative development.[75]

Much like shared values, creating norms in an inclusive and fair way may seem simple, but it is challenging in reality for the same reasons. If normative behaviours in space are to be laid out within the Outer Space Regime, considering that Article I of the Outer Space Treaty suggests the equal and accessible use of space regardless of economic or technological power, then this shared, inclusive, and fair approach is already a guiding principle upon which all norms in outer space should be followed.

A large part of the current space security discourse on normative behaviour centres around potentially threatening activities in space and how they may impact the orbital environment as well

[74] Ibid, v
[75] Ibid, v

as the assets on-orbit. Threatening activities can range from those which are cyber or electronic in nature to anti-satellite (ASAT) testing and weaponry. Additionally, the report flags concerns such as "… non-cooperative rendezvous and proximity operations (RPOs) and other close-proximity operations (CPOs)…"[76] as priorities, especially in conjunction with space debris concerns. Earth's orbits, including Low Earth Orbit, are part of the operating environment. Much of what is conducted in Earth's orbit is done with a level of secrecy including an "… overall lack of transparency, trust, and dialogue [which] was seen to be a key contributor to the potential for conflict and conflict escalation"[77] between actors on-orbit. Although there is much posturing in the UN COPUOS and its subcommittees over the importance of TCBMs and the need to share information and cooperate in space, when talking about national military activities this is almost non-existent. The Ploughshares Report emphasises the need for good practice through TCBMs and communication. The report suggests this could be accomplished through notifications, registration of space objects, data sharing, consultations, and direct lines of communication between stakeholders.[78] The report further articulates that many of these mechanisms for good practices are missing, which can cause misunderstandings and escalation to conflicts. The final key understanding reported is that effective leadership is critical.

"Strong norms need effective leaders who can explain how certain necessary actions are clearly linked to accepted values and standards. Additionally, leadership must include consistent practice of the norms that are being espoused."[79]

This last finding relates to norm entrepreneurship (States as leaders in norm-building) and leading by example. Norms tend to die within the normative life cycle without norm entrepreneurship and encouragement from norm leaders to showcase why the norm in question should be chosen and implemented. Overall, the Ploughshares Report emphasizes that to operationalize norms there must be standards, behaviours, and best practices that reflect "…shared values, collectivity, common understandings, consensus, and expectations".[80] This way forward on norm

[76] Ibid, v
[77] Ibid, vi
[78] Ibid, vi
[79] Ibid, vi
[80] Ibid, 9

operationalism, in addition to lowering the threshold for potential threats, would create a sustainable orbital environment to conduct space activity.

3.3.1.3 UNGA: Resolution 75/36 Reducing Space Threats Through Norms, Rules, and Principles of Responsible Behaviours

The United Nations General Assembly adopted Resolution 75/36 on *Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours* (hereafter referred to as UNGA Resolution 75/36) in December 2020. This resolution was based on an initiative led by the United Kingdom "…encouraging States to consider existing and potential threats to space systems …"[81] This encouragement towards Member States is articulated in UNGA Resolution 75/36 Paragraph 5:

> Encourages Member States to study existing and potential threats and security risks to space systems, including those arising from actions, activities or systems in outer space or on Earth, characterize actions and activities that could be considered responsible, irresponsible or threatening and their potential impact on international security, and share their ideas on the future development and implementation of norms, rules and principles of responsible behaviours and on the reduction of the risks of misunderstanding and miscalculations with respect to outer space.[82]

From this encouragement, UNGA Resolution 75/36 Paragraph 6 further requests a UNGA report with submissions on the issue from Member States and other relevant organizations. What sets this initiative and UNGA resolution apart from the previous reports is that it advocates for a more siloed approach within the space security realm under the auspice of the UN 1st Committee, which deals with issues of security and disarmament. The report rests on the understanding that responsible behaviours and norms are about States and their national security interests, not about all actors in space nor how these issues may be tied to the larger understanding of the peaceful use

[81] J. Lauren Napier, *Report: Responsible Behaviours in Space, National Submissions to the UN* (UK Foreign, Commonwealth & Development Office with Wilton Park 2021) 1
[82] UNGA, Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours, A/Res/75/36, 7 December 2020, 3

of outer space, which includes safety and sustainability measures. While this does bring clarity and refinement to a complex discussion on what constitutes ‘responsible’ or ‘irresponsible’ behaviour in space, as well as what norms might apply, it does limit the more holistic scope of the Outer Space Regime and the 3S Approach (security, safety, sustainability) to governance which is crucial for Low Earth Orbit. There is no mention of non-State actors, especially private actors, which could prove short-sighted, as the commercial sector makes up 77%[83] of Low Earth Orbit activity, and there can be dual-use capabilities on top of that.

The UK ran two regional events in early 2021 to foster dialogue on UNGA Resolution 75/36 ahead of the national submissions. These events helped participants better understand the aims of the UK leadership on this issue and discuss key concepts about threats to space systems, legal instruments, appropriate steps forward, and mitigating threats through norms and behaviours. Participants suggested that behaviours "… could be categorised into a framework of prohibitive, prescriptive, or permissive as well as via a black, grey or white list"[84] which could help frame normative behaviours. Key aspects from the event such as TCBMs, pre-notification, communication, and lists of potential threatening activities such as jamming and spoofing were seen as paramount to creating a framework of normative behaviours in space.

However, some States, such as China, do not agree with this method of work. The idea of using non-binding norms of behaviour or political agreements instead of binding law is something that separates the UK and other liberal-leaning States from more authoritarian States such as Russia and China. This is not a new revelation. The same discussion on norms versus treaties as a way forward for governance is also under deliberation in the Cyberspace Regime with the US leading a GGE on norms while Russia is leading an OEWG taking a more legal path. It is important to recognise that both normative and legal discussions are required, as their separation can cause slow progress and inconsistent consensus, as found in cases in the Cyberspace Regime. In this multi-actor world, bespoke workplans to develop governance framework models that best support the actors, operations, and environment should consider a multi-tiered and multi-variable approach. In the classical, legal sense, norms may still lead to customary law or treaty, so using norms as a point of departure for discourse on highly political issues does seem sensible in a scientific and technical

[83] Seradata, ‘SpaceTrak’ (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022
[84] J. Lauren Napier, *Report: Responsible Behaviours in Space, National Submissions to the UN* (UK Foreign, Commonwealth & Development Office with Wilton Park 2021) 5

industry where law is struggling to keep pace. Therefore, this research continues to refer to norms and other non-binding international law as part of the process of updating the Low Earth Orbit governance framework to stay connected to current diplomatic and international discourse within the Outer Space Regime.

3.4 Concluding Remarks

This chapter discussed the legal aspects of governance. The chapter started with a description of the importance of the *lex specialis* of space law, which includes binding and non-binding law as well as normative behaviour and norms. There are treaties, principles, and other tenets of law that make up the legal components of space governance. For Low Earth Orbit, the importance lies in general international space law, liability, and registration as well as newer, non-binding elements. Finally, norms and normative behaviours are an important element of the legal discourse, especially regarding space security. This chapter highlighted the importance of different forms of law to support the governance of the Outer Space Regime and Low Earth Orbit. After having taken a more theoretical and legal approach in Chapters One and Two, Chapter Three takes a more practical approach, focusing on security, safety, and sustainability and what these tenets mean for the governance of the Outer Space Regime and Low Earth Orbit.

4 The Outer Space Regime, Low Earth Orbit and the 3S Approach: Security, Safety, and Sustainability

So far, this research has focused on the broad themes of Outer Space Regime theory and the underpinning legal framework for activity in space. These were evaluated through historical and theoretical lenses. This chapter will move the discussion on to contemporary space activity and seek to address the second, third and fourth research questions by examining an approach adopted by the international space community known as the 3S Approach[1].

Space security, space safety, and space sustainability (3S) represent three sides of a triangle and discussion under these broad banners are crucial to the Outer Space Regime as well as the Low Earth Orbit governance framework. Today, as well as for the long-term utilisation of space:

> The 3S are not just a concern of developed spacefaring nations, but really a global issue, where the irresponsible actions of a single actor could potentially negate the collective efforts of many nations – in an instant![2]

It is the wider recognition and consideration of the 3S Approach that is supporting the evolution of the Outer Space Regime. It is also why it is imperative that a more robust governance framework in LEO is necessary now. The terms 'security,' 'safety,' and 'sustainability' are ambiguous, often over-used – sometimes even misused – and arguably buzzword rhetoric to make it seem like policies are hitting the mark but are quite hollow in practicality. Within the Outer Space Regime, these terms do not have any legally binding force or definitions and they are usually discussed in a more siloed approach; but this separation is changing. This chapter will analyse each – security, safety, and sustainability -- theme individually more generally then apply them to space. What sets this research apart here is by taking an academic approach to the 3S Approach to enhance the critical understanding of these three elements as they are important to the Outer Space Regime and the LEO governance framework.

---

[1] Peter Martinez, Peter Jankowitsch, Kai-Uwe Schrogl, Simonetta Di Pippo, and Yukiko Okumura, 'Reflections on the 50th Anniversary of the Outer Space Treaty, UNISPACE+50, and Prospects for the Future of Global Space Governance' (2019) 47 Space Policy, 28-33

[2] Ibid, 29

4.1 Security

The concept of security is hard to pin down as it can encapsulate human, environmental, economic, national, and global security. Security interest and discourse has a long history because security is a fundamental concern for humanity; much as safety is and will be described below. The Oxford Dictionary defines security as, "the activities involved in protecting a country, building or person against attack, danger, etc."[3] This broader definition is useful because as will be seen below, much of the discourse on security is of the State or military persuasion predominately discussed by hegemonic powers. However, there are other forms of security, and all aspects of security are deeply intertwined. Indeed, according to the United Nations Trust Fund for Human Security,

> For many people, today's world is an insecure place, full of threats on many fronts. Protracted crises, violent conflicts, natural disasters, persistent poverty, epidemics and economic downturns impose hardships and undercut prospects for peace, stability, and sustainable development. Such crises are complex, entailing multiple forms of human insecurity.[4]

This understanding of human security touches upon this interconnected quality that security has across all facets of life. When issues overlap or grow, they can spill across States and impact societies as well as the environment.

From the legal purview of the United Nations, in the *Charter of the United Nations and Statue of the International Court of Justice*, peace and security are regarded internationally and are the backbone of international law and the United Nations. Chapter 1, Article 1 states:

> To maintain international peace and security, and to that end: to take effective collective measures for the prevention and removal of threats to the peace, and for the suppression of acts of aggression or other breaches of the peace, and to bring about by peaceful means, and in conformity with the principles of justice and international law, adjustment or settlement of

[3] Oxford Learner's Dictionaries, 'Security' (*Oxford Learner's Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/security?q=security> accessed 24 November 2022

[4] United Nations Trust Fund for Human Security, 'What is Human Security' (*UN Trust Fund for Human Security*) <https://www.un.org/humansecurity/what-is-human-security/> accessed 2 June 2021

> international disputes or situations which might lead to a breach of the peace.[5]

Again, there is this broader perspective interwoven with other key concepts of justice, international law, and peace. The interpretation of peace and security set forth in the UN Charter is important for space security because Article III of the OST[6] recalls the UN Charter should be held in accordance as well as other forms of international law for the exploration and use of outer space.

Arnold Wolfers, from a political science perspective, argued in 1952 that "… security, in an objective sense, measures the absence of threats to acquired values, in a subjective sense, the absence of fear that such values will be attacked".[7] However, in 1997 David Baldwin challenges Wolfers' definition by arguing that the 'absence of threats' is too ambiguous[8] and therefore, redefines security to mean,

> … security with respect to the actor whose values are to be secured, the values concerned, the degree of security, the kinds of threats, the means of coping with such threats, the costs of doing so, and the relevant time period.[9]

Baldwin went on to determine that not only did the concept of security need to be more solidified, but it also need to be understood through answering various questions such as how to address or define security; whom security is for; which values are connected to security; how much security is needed; from which threats, by what means and at what cost; and in what set period of time.[10] From a national security point of view, Wolfers addresses these questions by stating,

> If nations were not concerned with the protection of values other than their survival as independent states, most of them, most of the time, would not have had to be seriously worried about their security, despite what manipulators of public opinion engaged in mustering greater security efforts

---

[5] Charter of the United Nations and Statute of the International Court of Justice (signed 26 June 1945, entered into force 24 October 1945) 3

[6] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[7] Arnold Wolfers, '"National Security" as an Ambiguous Symbol' (1952) 67 (4) Political Science Quarterly, 481-502, 485

[8] David A. Baldwin, 'The Concept of Security' (1997) 23 Review of International Studies, 5-26, 13

[9] Ibid, 17

[10] Ibid, 13-17

> may have said to the contrary. What "compulsion" there is, then, is a function not merely of the will of others, real or imagined, to destroy the nation's independence but of national desires and ambitions to retain a wealth of other values such as rank, respect, material possessions and special privileges.[11]

It can be argued that security is not just about militaristic national security but also about protection of values which include international respect and prestige but can also mean economic value and national freedom. However, the caveat here is that this approach is a North and Western view as arguably the Global South and the Middle East have been combating water security, food security, and other societal security issues for centuries with more emphasis on welfare security rather than (or inclusive of) a more 'traditional' national military security. The same could also be said for a post-war Europe. Though this idea of a 'traditional' national military security is heavily emphasized by the United States and like-minded States which begs the question of whether this should indeed be considered the 'traditional' form of security. Which is why in this research it will be continuously articulated that security is broader and only one piece to the puzzle; safety and sustainability are the other pieces interlocked alongside security.

A point can be made on the distinction between national security and global security here. National security can vary depending on the needs of the State and its citizens. However, national security is essentially about protecting State jurisdiction and its citizenry. Global security on the other hand, speaks more to broader international security issues that no one State can manage alone and requires State cooperation. This understanding of global security is tied to the ever-increasing interconnectedness of States due in part to globalisation and other global issues such as the COVID-19 pandemic or the climate crises. The United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) goes beyond a purely militaristic approach to security more in line with this broader global security understanding. UN OCHA suggests a wide range of security areas such as: economic, food, health, environmental, personal, community, and political.[12]

---

[11] Arnold Wolfers, '"National Security" as an Ambiguous Symbol' (1952) 67 (4) Political Science Quarterly, 481-502, 488-489

[12] United Nations, 'National Security Versus Global Security' (*UN Chronicle*) <https://www.un.org/en/chronicle/article/national-security-versus-global-security> accessed 2 June 2021

More recent academic discourse on security is finding that "… security is perceived as a shared responsibility covering different levels and sectors in society"[13] and that it "… is no longer exclusively connected to the nation-state"[14]. This view supports the understanding that security can mean something different to individuals, organizations, States, societies, and internationally. Jore then defines security as:

> … perceived or actual ability to prepare for, adapt to, withstand, and recover from dangers and crises caused by people's deliberate, intentional, malicious acts, such as terrorism, sabotage, organized crime, or hacking.[15]

With a further understanding that security risk management "… includes assessing and reducing the likelihood and consequences of possible attacks by applying various types of risk-reducing measures. For example, by establishing critical infrastructure protection and by building organizational and societal resilience".[16] Though Jore's definition of security is more national or international specific without regard for the other forms of security such as environmental or welfare, the definition of security risk management is useful in the broadest of terms as it is important to understand not only what security is but also how to handle, or manage, it.

4.1.1 Space Security

Much like the holistic view of security, space security has also been predominately associated with the military and national security interests. It is established that,

> … a fundamental aspect of "space security" is the contribution that satellites make to the military security of states and the maintenance of international stability and balances of power, as well as the military threats to satellites and their ability to support international security.[17]

This understanding stems from the political rhetoric of the Cold War era and has lingered into the post-Cold War era as well. However, as was mentioned above with security discourse, this

---

[13] S.H. Jore, 'The Conceptual and Scientific Demarcation of Security in Contrast to Safety' (2019) 4 European Journal of Security Research, 157-174, 159
[14] Ibid, 159
[15] Ibid, 169
[16] Ibid, 169
[17] Michael Sheehan, 'Defining Space Security' in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015) 8

siloed understanding of space security only considers a handful of the spacefaring nations, namely the United States, Russia, China, and India. A more diverse working definition of space security is now needed when society is in an era of space exploration and utilisation that is divergent in stakeholders (different types of States, non-state actors including the private sector and academia) and their security needs. Concepts such as environmental, societal, or economic security concerns are now just as critical in the Outer Space Regime as are military and national security concerns.

For many of the developing States, including emerging space nations, access to and equitable use of space are massive security concerns. This is largely due to the nature of their space missions which focus on Earth Observation and remote sensing satellites aimed at supporting their sustainable development needs such as climate change and weather concerns; health and food security; disaster management and risk reduction; as well as urban development. The space community now considers Earth's orbits to be unique and important limited resources which need to be considered as environmental security concerns specifically given the vast amount of space debris present on-orbit, the congestion of the orbits, the potentials for radio frequency interference, and threats from space weather or Near-Earth Objects (NEOs), such as asteroids. Sheehan suggests:

> Space security involves a number of different aspects. It includes the security of satellites and spacecraft in orbit, the security of access to space, and the contribution to the security of people on Earth made by various types of satellites.[18]

This multi-approach to space security presents a better and more holistic view of all aspects under the umbrella of security concerns which are explicitly linked to safety and sustainability as well. Just another example of why a 3S Approach is the most robust when constructing a framework for LEO as well as for the future of the Outer Space Regime.

4.2 Safety

At the most basic level safety is "the state of being safe and protected from danger or harm".[19] In 1943 psychologist Abraham Maslow wrote *A Theory of Human Motivation*[20] prepositioning

[18] Ibid, 8

[19] Oxford Learner's Dictionaries, 'Safety' (*Oxford Learner's Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/safety?q=safety> accessed 24 November 2022

[20] Abraham Maslow, 'A Theory of Human Motivation' (1943) 50 (4) Psychological Review, 370-396

the human hierarchy of needs. Maslow stipulated that once physiological needs (air, water, shelter, food) were met, the next necessity was safety. Maslow posited that all organisms have traits that make them safety-seeking organisms. Humanity's need for safety is something built from within. It is a need that humanity shares with every living being. It is a basic for survival which is why discussion on safety is critical for the long-term sustainability of humanity and Earth. Safety typically implies human safety and is not understood to mean the safety of non-sentient beings, machines, or objects. As with Asimov's First Law of Robotics, "a robot may not injure a human being or, through inaction, allow a human being to come to harm"[21], the focus is on the safety of humans and not objects.

In international relations rhetoric, safety can be tied to security. However, while there is cross-over between safety and security, there are differences especially at the international level. For example, safety, in the context of outer space, is a matter taken under consideration through the 4th Committee of the UNGA with technical, scientific, and peaceful use of space connotations while security is a matter taken under consideration through the 1st Committee of the UNGA as a State concern with a strong political underpinning. This separation of safety means it is usually paired with sustainability rather than security because it is grouped under the agenda of peaceful uses of outer space.

4.2.1 Space Safety

Space safety is of a more technical nature and is typically associated with standards and best practices associated with space objects – including hardware and software – as well as astronautics and mission planning.

> Space safety refers to space mission hazards and relevant risk avoidance and mitigation measures. The space mission hazards include threats to human life, loss of space systems, and pollution of the Earth environment.[22]

Again, here, space safety refers to human safety but also adds the safety of the object and the environment. Space safety is heavily connected with the space debris issue as well as other hazards such as space weather and near-Earth objects (NEOs). Space safety is included in all

[21] Isaac Asimov, *I, Robot* (Harper Voyager 2013)
[22] Joe Pelton, Tommaso Sgobba, and Maite Trujillo, 'Space Safety' in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015) 204

phases of a mission from pre-mission, launch, on-orbit, to EoL procedures. In this research, launch, on-orbit, and EoL are the three phases that are most critical to Low Earth Orbit.

In terms of measuring safety, the Handbook of Space Security states:

> The definition of acceptable safety level is based not only on technical state-of-the-art considerations, but also on a number of nontechnical factors such as cultural, economic, market, or political assessments. The acceptable safety level of a system or an activity differs often from country to country and also evolves with time and public expectations.[23]

This 'acceptable safety level' is developed through safety standards and best practices and are "… considered to represent the minimal level of risk that society will accept and tolerate"[24]. However, this definition could cross over with space security because safety predominately means human safety, therefore this definition could be paired with the non-human elements of the space safety definition above could suggest security. Satellites can be programmed to avoid collisions and other potential vulnerabilities but can also become targets or have accidents resulting in collisions, debris creation, malfunctions, or the satellite ceasing to operate. These potential vulnerabilities and collision issues are security concerns – not safety. A satellite may have safety protocols, requirements, and standards to ensure it is a safe object however that is for the safety of humans. While maintaining the 'safety' of the space object from space debris, threats, or collisions is a security matter.

4.3 Sustainability and Sustainable Development

Sustainability is not a new concept, though it has been updated and rebranded due in large part to the SDGs; though there is a difference between sustainability and sustainable development even if they are commonly used interchangeably. In the 1st century BC Columella, as well as other ancient Egyptian, Mesopotamian, Greek, and Roman authors, understood a version of the need for sustainable practices because of environmental degradation. Columella understood it to mean the maintaining of 'everlasting youth' of the Earth.[25] Moving forward in history, at its most basic level, sustainability "… is derived from the Latin verb *sustinere* (*tenere*, "to hold";

---

[23] Ibid, 205-206
[24] Ibid, 206
[25] Jacobus A. Du Pisani, 'Sustainable Development – Historical Roots of the Concept' (2006) 3 (2) Environmental Sciences, 83-96, 85, quoting LJM Columella, 'Res Rustica' Vol. 1 (Books I-IV) Harrison Boyd Ash (English translation, Harvard University Press, 1948) 3, 5

sus, “up”) and is usually used in the context of being able to maintain an activity at a certain rate or level”[26]. The term ‘sustainable’ or ‘sustainability’ “…appeared for the first time in the *Oxford English Dictionary* during the second half of the 20th century”[27] though “the equivalent terms in French (*durabilité* and *durable*), German (*Nachhaltigkeit*, literally meaning ‘lastingness’, and *nachhaltig*) and Dutch (*duurzaamheid* and *duurzaam*) have been used for centuries.”[28] A good example of this first use was in German forestry in the early 1700s. Hans Carl von Carlowitz “suggested *nachhaltende Nutzung* (sustainable use) of forest resources, which implied maintaining a balance between harvesting old trees and ensuring that there were enough young trees to replace them”[29]. The Oxford definition of sustainable includes: “involving the use of natural products and energy in a way that does not harm the environment”[30] and “that can continue or be continued for a long time”[31].

Regarding the term sustainability, the Oxford English Dictionary says:

> the quality of being sustainable by argument; the capacity to be upheld or defended as valid, correct, or true”; “the quality of being sustainable at a certain rate or level”; “the property of being environmentally sustainable; the degree to which a process or enterprise is able to be maintained or continued while avoiding the long-term depletion of natural resources.[32]

Skipping forward to the 1970s and 1980s, the modern application is the now well-known concept of sustainable development. The concept of sustainable development changed the game in 1987 specifically when the World Commission on Environment and Development (WCED) issued *Our Common Future* also known as the *Brundtland Report* which advocated for ‘sustainable development’ as we know it today.

> The concept of sustainable development provides a framework for the integration of environmental policies and development strategies – the term ‘development’ being used here in its broadest sense. The word is often taken

[26] Peter Martinez, ‘Space Sustainability’ in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015) 259
[27] Jacobus A. Du Pisani, ‘Sustainable Development – Historical Roots of the Concept’ (2006) 3 (2) Environmental Sciences, 83-96, 85
[28] Ibid, 85
[29] Ibid, 85-86
[30] Oxford Learner’s Dictionaries, ‘Sustainable’ (*Oxford Learner’s Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/sustainable?q=sustainable> accessed 24 November 2022
[31] Ibid
[32] Oxford English Dictionary, ‘Sustainability’ (*OED*) <https://www.oed.com/> accessed 24 November 2022

> to refer to the processes of economic and social change in the Third World. But the integration of environment and development is required in all countries, rich and poor. The pursuit of sustainable development requires changes in the domestic and international policies of every nation.[33]

The paragraph was mentioned just above the paragraph with the now famous sustainable development definition: "Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future".[34]

Putting the two pieces back together it can be seen sustainable development is truly meant for *all* States and policy changes were, and still are, needed on various levels across the globe. This understanding of an environmental, societal, and economical approach was the creation of the triple bottom line. Gone were the excuses that the world could only be viewed from an anthropocentric view as the Brundtland Report as well as the United Nations Conference on the Human Environment in 1972 (along with Rachel Carson's *Silent Spring* in 1962 and Garrett Hardin's *Tragedy of the Commons* in 1968) showed the world that humanity desperately needed to have an eco-centric view as well – and quickly. The Oxford Dictionary backs this up by stating from an economic perspective that sustainable development is "economic development in which natural resources are used in ways compatible with the long-term maintenance of these resources, and with the conservation of the environment"[35].

Taking off the rose-coloured glasses, humanity came to find that, according to Du Pisani:

> the concept of sustainable development emerged as a compromise between the notions of development and conservation, which came to be seen as interdependent issues. The term 'sustainability', a noun used in ecology to refer to a state or condition that can be maintained over an indefinite period of time, was introduced on a more regular basis than before into development discourses.[36]

[33] World Commission on Environmental Development, 'Our Common Future, From One Earth to One World' (1987) 38

[34] Ibid, 39

[35] Oxford English Dictionary, 'Sustainable Development' (*OED*) <https://www.oed.com/> accessed 24 November 2022

[36] Jacobus A. Du Pisani, 'Sustainable Development – Historical Roots of the Concept' (2006) 3 (2) Environmental Sciences, 83-96, 91

This idea of thinking about sustainability issues as connected to ecological issues makes the argument that there can also exist discourse on conservation versus preservation and what these variables might mean for sustainability and sustainable development.

From a more current, environmental ethics perspective, there is an extended definition of what constitutes sustainable versus unsustainable. Curren defines the term 'sustainable' to mean "the totality of practices of some human collectivity is sustainable if, and only if, it is compatible with the preservation of the natural capital on which the practices fundamentally depend."[37] In reverse, he argues that the term 'unsustainable' means "the totality of practices of some human collectivity is unsustainable if, and only if, it is not compatible with the preservation of the natural capital on which the practices fundamentally depend."[38]

4.3.1 Sustainability, Sustainable Development, and Space

This research holds the concept of sustainability in high regard because LEO as a location and unique environment is already congested, contested, and competitive. Low Earth Orbit is a limited renewable resource saturated with satellites and space debris. Numbers which are rapidly growing each year especially considering the rise in the use of satellite constellations and anti-satellite testing respectively.

With the growing number of satellites and the growing number of debris, if sustainable changes are not made LEO will go from being an accessible orbit to a limited, non-renewable resource leaving developing States and emerging spacefaring States scrambling to get their fair and equitable use of LEO before it is gone. Koudelka supports this argument by stating that, "space can be considered a precious natural resource. In many aspects resource limitations exist".[39] Those that argue for safety and security in the Outer Space Regime and for LEO must realize that without a truly sustainable framework, there will not be a need to even worry about issues of safety or security because LEO will be closed for business which means access to higher orbits, the Moon, Mars, and deeper space could face the same limitations. There is no other way to get to deeper space without first passing through Low Earth Orbit. Newman and

[37] Randall Curren, "Sustainability: What It Is and How It Works Defining Sustainability Ethics" in Michael Boylan (ed), *Environmental Ethics* (Wiley and Sons 2014)
[38] Ibid
[39] Otto Koudelka, '2.2 Space – A Natural Resource' in Christian Bruenner and Alexander Soucek (eds) *Outer Space in Society, Politics and Law* (Springer Vienna 2011) 92

Williamson discuss the nuances between sustainability and sustainable development in the context of space exploration and utilisation:

> Sustainability and sustainable development are terms that tend to be used without any clear indication as to what sustainability means; all too often, they are catch-all terms devoid of specific goals beyond a vague reference to an ecological ideal. This inquiry has reaffirmed that, in a space context, sustainable development is a specific requirement to satisfy the needs of current space missions while ensuring the viability of future ventures. In concert with that, sustainability should mean that minimising harm to the environment becomes part of the mission objectives alongside other technical and scientific goals.[40]

The pressing matter will be how to integrate this way of thinking into a LEO governance framework that will be acceptable to all stakeholders operating, or planning to operate, in Low Earth Orbit – which is the core of this research and shall be reflected throughout the research analysis and recommendations to answer the research questions on how best to govern Low Earth Orbit. Former Chair of the Legal Subcommittee of UN COPUOS, Kai-Uwe Schrogl, made a similar call in 2011 arguing that "achieving sustainability in the uses of outer space will require a solid regulatory framework"[41]. Thus, showing that even now in the 2020s there is still a need for this "solid regulatory framework", especially for LEO – though headway is being made now that there are 21 Long-Term Sustainability Guidelines that have found consensus in UN COPUOS.

One looming issue stemming from international space law, which is a hurdle given the intention that the core space treaties are here to stay and are not looking to be open for amendment anytime soon (this research supports the treaties as they are), is the historical intention of the treaties. The space treaties are "… mired in the geopolitics of the Cold War and not reflective of the current multisectored space industry"[42] which directly relates to why "… sustainability has not embedded itself within mainstream space activity … because it was not embedded

[40] Christopher J. Newman and Mark Williamson, "Space Sustainability: Reframing the Debate" (2018) Space Policy 46, 30-37, 35
[41] Kai-Uwe Schrogl, '4.4 Space and its Sustainable Uses' Earth' in Christian Bruenner and Alexander Soucek (eds) *Outer Space in Society, Politics and Law* (Springer Vienna 2011) 608
[42] Christopher J. Newman and Mark Williamson, "Space Sustainability: Reframing the Debate" (2018) 46 Space Policy, 30-37, 34

within the normative behaviour promoted by the space treaties".[43] However, that has now changed with the inclusion of the UN COPUOS Working Group on the Long-Term Sustainability of Outer Space over a decade ago leading to the Long-Term Sustainability Guidelines. Additionally, with the creation of the SDGs there has been a bigger push on initiatives and discussion over 'Space4SDGs' which has also resulted in the creation of a Space2030 Agenda[44] through UN COPUOS.

4.3.2 Long-Term Sustainability of Outer Space

Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, also known as the Long-Term Sustainability Guidelines (LTSG), were presented as 21 guidelines, built on consensus through the UN COPUOS Long-Term Sustainability Working Group, at the 62nd UN COPUOS sessions in June of 2019. The LTSG are voluntary, holistic guidelines comprised of "… a compendium of internationally recognized measures for, and commitments to, ensuring the long-term sustainability of outer space activities and, in particular, enhancing the safety of space operations".[45] The Long-Term Sustainability Guidelines are a call to change perspective from a post-Cold War narrative toward a futuristic view for current and future generations to create systemic change in the Outer Space Regime that allows outer space to,

> … remain an operationally stable and safe environment that is maintained for peaceful purposes and open for exploration, use and international cooperation by current and future generations, in the interest of all countries, irrespective of their degree of economic or scientific development, without discrimination of any kind and with due regard for the principle of equity.[46]

This evolution of the regime toward a more sustainable use of space includes this connection between what is deemed space safety and space security. It is this triad of research and policy for space exploration and utilisation that will propel the Outer Space Regime into the next

[43] Ibid, 34
[44] UNGA Res 76/3 (28 October 2021) UN Doc A/RES/76/3
[45] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69, 50
[46] Ibid, 50

epoch. The LTSG reflect this 3S Approach through the purpose as well as objectives and scope of the guidelines. It is stated in the LTSG that the purpose of the guidelines:

> … is to assist States and international intergovernmental organizations, both individually and collectively, to mitigate the risks associated with the conduct of outer space activities so that present benefits can be sustained, and future opportunities realized.[47]

This purpose can extend toward other non-State actors as well as be highlighted within the more holistic purpose of the Outer Space Regime.

The purpose of the Long-Term Sustainability Guidelines is directly tied to Earth's orbits and will be applicable to a more robust LEO governance framework. The LTSG are directly applicable to LEO for the first paragraph of the LTSG document explains the background reasoning for building the 21 guidelines and the first sentence states that "the Earth's orbital space environment constitutes a finite resource that is being used by an increasing number of States, international intergovernmental organizations and non-governmental entities".[48] This 'finite resource' is the reality of LEO, and the Geostationary Orbit, if a more sustainable path is not followed now and in the future. This finite reality is where space is not unique. The same challenge is being deliberated on and tackled in the ocean regime as well. In Low Earth Orbit, this need to protect the finite resource is critically twofold. One, is that to access high Earth orbits, the Moon, Mars, and deeper into space, all space activities must first pass-through LEO and risk collision from the growing number of space debris and satellites in constellation formation. The second is that LEO is home to Earth Observation (EO) and remote sensing satellites which are "… essential tools for realizing the achievement of the Sustainable Development Goals [SDGs]"[49].

As was stated above, there have been many iterations of what is meant by sustainability and space sustainability. The Long-Term Sustainability Guidelines defines the long-term sustainability of outer space activities,

> as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in

[47] Ibid, 50
[48] Ibid, 50
[49] Ibid, 50

> order to meet the needs of the present generations while preserving the outer space environment for future generations.[50]

This definition, while not legally binding, is a strong working definition that will be considered as it was created under consensus by the UN COPUOS Member States.

With a toolkit of now established 21 guidelines, the work of State, and by extension non-State, actors are to realize implementation of the guidelines. Member States at UN COPUOS have already decided part of this will be through a LTS 2.0 framework, such as continuation of work within the LTS Working Group, to be discussed at UN COPUOS and its subcommittees. As the LTS 2.0 work plan has yet to be solidified[51], it is important at this stage to unpack the guidelines and see what is relevant for a more robust LEO governance framework because national implementation of the guidelines is now taking place with the UK leading this critical step in utilising the guidelines in cooperation with UNOOSA. Former UN COPUOS Chair Andre Rypl believes,

> The new mechanism [LTS guidelines] should promote the key concept of "sustainability as an enabler" i.e., the pursuit of sustainability will allow us to do more and do it better in space. It is intended to make sure that space remains accessible and usable by all. Sustainability is not about creating barriers or hurdles, but assisting all those involved in space activities, "to do things right", at a lower cost and with reduced risk. It is also about encouraging ownership – the promotion of the concept that we are all stewards of outer space and thus need to preserve it for future generations.[52]

This concept of sustainability as an enabler is prevalent in LEO and within the Outer Space Regime. For example, based on the discourse from the sixtieth session of the UN COPUOS Legal Subcommittee, some Member States are of the mind that the LTSG can support international space traffic management framework because the guidelines are already building traction from national implementation and the proposed LTS 2.0 Working Group at the UN. Using the LTSG as the driving force to find a way toward a space traffic management

---

[50] Ibid, 50

[51] At the time of writing this PhD the LTS 2.0 workplan started but was interrupted by COVID. The workplan may be further ahead as of Spring 2023, however, as the PhD is being submitted at the same time the LTS 2.0 will have to be considered more fully in follow-up research.

[52] United Nations Committee on the Peaceful Uses of Outer Space, 'COPUOS Chair's Non-paper: The Way Forward for LTS "Sustainability as an Enabler' (2019, Andre Rypl) 4

framework also supports this research analysis that the regime is evolving and toward a more non-binding legal method of work. It also suggests that the 3S Approach could be applied to a space traffic management framework as well.

Overall, the long-term sustainability of outer space – including LEO – is something that is at the forefront of discussion within the sessions of UN COPUOS and the subcommittees. Paired with the idea that the space environment should be safe, secure, and sustainable for current and future generations to utilise, is also the idea that space systems should continue to enable initiatives towards reaching the SDGs which is connected to the Space2030 Agenda. Therefore, this two-pronged approach to sustainability – sustainability in space as well as for Earth – will continue to be an underpinning of any direction the Outer Space Regime may evolve towards as well as the future of the governance framework for Low Earth Orbit.

4.4 Concluding Remarks

Through the discourse set out in this chapter, security, safety, and sustainability should be seen as a complete package for space objects as all three complement each other. This 3S Approach will be used throughout the research just as the methodology of the research looks at law and politics because none of these points reside in a vacuum and must be addressed as they overlap and interact with one another. Overall, this 3S Approach plus the regime complex are what build the Outer Space Regime as well as influences the governance framework of Low Earth Orbit. While this chapter gave a more practical approach to space governance, the next chapter – Chapter Five – will go back to theory with a deeper analysis of governance theory and critically analyse various governance models. The 3S Approach as well as the discussion on regimes and international law create the foundation for the research and helps to bring context to answering the research questions. The next chapter starts to take the foundation and uses the socio-legal method in application to another method which is governance model analysis. All of which can lead the research to answer the research questions and build recommendations for the Low Earth Orbit governance framework.

5 Governance Theory

The previous chapters talked about regime theory and the role international law plays in a regime. This was tied to the Outer Space Regime and the Low Earth Orbit governance framework. There was also discussion the importance of security, safety, and sustainability (the 3S Approach) to governing space, specifically LEO. These chapters gave insight into the importance of law and politics in the Outer Space Regime which will help to answer the research questions. This chapter is going to have a slightly different focus. This chapter will address governance theory which can be taken as a re-tooling of regime theory but is also "... one of the most frequently used social science concepts in the world".[1] Whilst regime theory became well established in the 1970s, primarily in the United States, governance theory took hold in the 1990s with experts coming from Europe.[2] Governance theory is particularly important for this socio-legal research as it is an interdisciplinary concept "... with roots in political science, public administration, sociology, economics, and law …"[3]. What this chapter will consider is that there is not one single 'theory' or 'model' of governance, rather there are many iterations and interpretations that must be considered.[4] This chapter will evaluate the various models (or theories)[5] of governance and apply them to the Outer Space Regime and the LEO governance framework. This chapter is an original contribution as there has been no attempt to do this kind of model analysis in previous space governance literature. The reason behind adopting this approach is because "governance takes into account a change in the actor constellation, both during the formation and the implementation of policies and in the method of political steering"[6] which works well with this research's socio-legal approach.

This chapter will start with an overview of what is meant by governance theory and introduce various models of governance. Then each model will be introduced, showing the strengths and weaknesses of each along with potential applicability to the Outer Space Regime and the LEO governance framework. Finally, a few top candidate models will be pushed forward to the concluding chapter where recommendations will be given, and the ideal model will be further

---

[1] Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 1

[2] Refer back to Chapter 1 for authors on regime theory. This chapter will be led by experts such as Christopher Ansell and Jacob Torfing, Kristof Van Ashe, Oliver Trieb, and others.

[3] Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 1

[4] Ibid, 1

[5] Moving forward the term 'model' or 'theory' can be understood to mean the same thing.

[6] Oliver Trieb, Holger Bahr, and Gerda Falkner, 'Modes of Governance: Towards a Conceptual Clarification' (2007) 14 (1) Journal of European Public Policy 1-20, 3

discussed. This model analysis will bring originality to the research and will guide in answering the research questions.

5.1 Governance Theory Explained

Discussion on governance relates to the systemic system itself as well as the parts thereof such as the actors, institutions, instruments, ideologies, and history as well as the interplay between these endogenous variables with themselves and with other exogenous variables such as with other regimes or governance systems through complex interaction. Modes of governance address politics, polity, and policy dimensions[7] which allows for steering and coordination of a governance framework.

According to Ansell and Torfing:

> Governance attempts to solve different types of dilemmas by creating institutional arrangements that redefine the payoffs from individual behavior and incentivize cooperation through top-down mandates or encourage bottom-up self-organizing. Governance is a multi-level process that creates monitoring mechanisms, punishes defection, rewards cooperation, provides information, fosters trust-based reciprocity, and otherwise attempts to create the conditions that make collective action likely to occur.[8]

Put another way, Van Assche, et al, define governance as:

> The coordination of collectively binding decisions by actors through means of institutions; which are understood as the coordination tools; policies, plans, laws and include also informal institutions.[9]

What both definitions suggest is that governance theory is about cooperation and coordination to create decisions that are part of a multi-level governance framework or system with processes in place utilising regulatory tools to solve collective issues.

---

[7] Ibid, 2

[8] Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 21

[9] Kristof Van Assche, Gert Verschraegen, and Monica Gruezmacher, Strategies for Collectives and Common Goods Coordinating Strategy, Long-Term Perspectives and Policy Domains in Governance (2021) Futures 128, 2

Much literature has been written on governance and its various theories or models. Therefore, it was imperative to this research to study and analyse as many models of governance as could be found to better understand which model, or models, applies to the status quo of the Outer Space Regime and to the LEO governance framework. This study and analysis helped to understand the path towards a more practicableset of governance frameworks for LEO and for the Outer Space Regime. Therefore, twenty-one governance models or theories were collectively researched, and the findings of the models under consideration will be discussed below.

It is important to review these governance models and theories to better understand and view their purposes, strengths, weaknesses, and potential applicability to LEO and the Outer Space Regime in general. Additionally, the status quo of space governance (in this case it is meant to encompass the Outer Space Regime as a whole) was assessed and will also be reviewed here to showcase the need for a deeper understanding and analytical perspective from a social science expertise and not just from a space law expertise – as is the case with the current global space governance literature.

5.2 Hierarchical Governance

Hierarchical governance is the traditional State-centric approach to governing. According to Arnouts, et.al:

> In an ideal-typical hierarchical governance arrangement, the governors mainly have governmental status and are superimposed above those governed, i.e., non-governmental actors. Non-governmental actors can be involved in governing, but they are mainly on the receiving end.[10]

What this implies is that hierarchical governance uses a top-down power structure that focuses on State decision-making and non-State decision-following. In hierarchical governance, governing is the "… domain of governments, with non-governmental actors in a subservient role".[11] Evans agrees by stating that hierarchical governance "… most resembles traditional

[10] Rikke Arnouts, Marielle van der Zouwen, and Bas Arts, Analysing Governance Modes and Shifts – Governance Arrangements in Dutch Nature Policy (2012) 16 Forest Policy and Economics, 43-50, 45
[11] Ibid

government, whereby there is a clear pyramid of control through which decisions taken at the top are subsequently passed down to those below".[12]

Currently, the Outer Space Regime follows a hierarchical governance framework. This can be seen by how discussion toward international space law and political commitments are made through the United Nations system both through UN COPUOS in Vienna and within the disarmament and security fora in Geneva and New York. Many States involved in the discourse of outer space affairs prefer for these discussions to stay international and State-to-State in a more traditional manner. With the rise of non-State actor activity in space, not only on behalf of States but also of their own accord, has brought some States to the conclusion that non-State actors should perhaps have a seat at the table.

The strength of using a hierarchical model comes from State autonomy and decision-making power. Because of this there can be a "… clear route to a desired outcome …"[13] in the sense that States know what they want and can make statements at the UN within committees or working groups to establish ways forward on issues typically leading to UNGA resolutions or other forms of political commitments and sometimes even treaties. States are committed to the UN as a forum for international debate and deliberation as it is a place where all States – whether emerging or established in space – can have a voice on crucial challenges and topics that may affect their space activity. Using the UN system also adds a level of legitimacy and durability in that States can trust the process and know what steps are likely to be taken to solve how to work through the agenda items in question.

The weakness of using a hierarchical model lies on the flipside of the strengths that States bring to this type of governance framework. Using traditional State-to-State discourse can lead to stagnation, lack of innovation, and an inflexibility based on rigid State self-interest and power politics. Especially in the space regime, the process within the UN can move sluggishly which means that science and technological advances quickly surpass the legal mechanisms up for discussion. This unbalanced pace between the legal and the technical can create frustration. With rigidity of State self-interest against the clock of technological advances, there is the fear of agenda items becoming stagnate or not reaching consensus which means going back to square one and falling even further behind. As Talesh points out, sometimes this hierarchical

[12] J.P. Evans, *Environmental Governance* (Routledge, 2012)
[13] Ibid

approach is "… too narrow and incomplete a policy framework to accomplish social goals"[14]. Perhaps this is indicative as to why it took ten years to find consensus on twenty-one long-term sustainability guidelines.

It is unlikely that a switch from a hierarchical governance model to another will happen any time soon at the international level for the Outer Space Regime because the UN process is integral to the how States deliberate issues on space activity and challenges. However, perhaps, as will be discussed below, there are models that could supplement this hierarchical process to bring in that much needed flexibility and timeliness that the UN process lacks. At the national level this hierarchical approach does work for licensing processes as well as the registration of space objects and the registration for radiofrequency spectrum allotment through the ITU. Having a top-down, command and control framework allows non-State actors the consistent processes and understanding that they must go through national bodies to be active in space. What will need discussion is the fragmentation between States, because not all national space law, regulation, and licensing procedures are built alike.

5.3 Global Governance

There are many interpretations of what is meant by global governance. According to Hira and Cohn, term global governance is an overarching framework which:

> Describes formal and informal arrangements developed to produce a degree of order and collective action above the nation-state level in the absence of an international government.[15]

However, Patrick opens the term to include:

> The collective efforts by sovereign states, international organizations, and other non-state actors to address common challenges and seize opportunities that transcend national frontiers.[16]

[14] Shauhin Talesh, 'Public Law and Regulatory Theory' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 104
[15] Anil Hira and Theodore H. Cohn, 'Toward a Theory of Global Regime Governance' (2003) 33 (4) International Journal of Political Economy, 4-27
[16] Stewart Patrick, "The Unruled World, The Case for Good Enough Global Governance" (2013) 93 (1) Foreign Affairs, 58-73

Global governance is also seen as the continuation of regime theory as it deals with similar issues and concerns.[17]

The strengths of the global governance model are that it includes State and non-State actors which come together to address common global challenges. As the UN is already established as a platform for global deliberations it can serve as a useable forum for challenges such as being seen with the SDGs. The weaknesses of the global governance model are, as is the case with all international endeavours, that large groups of actors find it difficult to come to consensus on ways forward for creating solutions to challenges. States are the predominate actors which means non-State actors may not have an equal say or have any control over ways forward as they may only be asked for expert input or considerations but not be made part of the final decision-making process. The Outer Space Regime and the Low Earth Orbit governance framework are considered global governance– global space governance – which will be discussed as its own model further in this chapter.

5.4 Evolutionary Governance

Evolutionary governance, much like adaptive governance, understands that nothing is stationary therefore a governance framework will need to evolve as well. Van Assche, et al, understands evolutionary governance as:

> … the making of and living by collectively binding decisions in any community, [which] is a processual amalgam of the continuous, ever changing, and thus evolutionary interplay of actors, institutions, knowledges and systems of sense-making (natural, technological, infrastructural) materialities and interest formations in any community, in any location and at any point in time.[18]

This understanding of evolutionary governance suggests that it is the regime or governance system as a whole – including all parts – that is constantly evolving and as such decisions should reflect these changes throughout the community, location, and over time.

---

[17] Anil Hira and Theodore H. Cohn, 'Toward a Theory of Global Regime Governance' (2003) 33 (4) International Journal of Political Economy, 4-27

[18] Kristof Van Assche, Anna-Kartharina Hornidge, Achim Schlüter, and Nataşa Vaidianu, 'Governance and the Coastal Condition: Towards New Modes of Observation, Adaptation and Integration (2020) 112 Marine Policy, 1-10, 3

Van Assche, et al, suggest that evolutionary governance is based on dependencies – path, goal, and interdependent. Path dependencies diverges into three sub-dependencies – cognitive, organisational, and material. Overarchingly path dependencies "… are legacies from the past which influence the current reproduction of governance"[19]. Cognitive path dependencies focus on concepts or ideologies:

> Inherited from previous states of the governance system, either through actors believing in them, or through embedding in policies, plans, laws, and in informal institutions.[20]

This suggests that a governance framework does not appear out of nowhere. There is a linear progression from inception onward – just as the regime life cycle suggests. Organisational path dependencies refer to the:

> Legacies imbued by inherited actors and institutions: the previous inclusion/exclusion of actors, the previous choice for this or that institution as a tool of coordination shapes what can happen next.[21]

This suggests that an evolutionary governance model is cognizant that actors change – both individual people and actors as a whole – which needs to be taken into consideration because the diversity of actors and changing of actors can impact coordination and shape future processes. Material path dependencies, simply, "… stem from natural, technological and cultural factors"[22]. What all these path dependency aspects suggest is that the past does affect the current and future way of a governance framework. No regime is stagnating but constantly evolving as this research advocates for under regime theory and governance theory.

Goal dependencies moves toward current and future underpinnings. According to Van Assche, et al, goal dependencies "… are impacts of visions for the future on the current reproduction of governance"[23]. This suggests that what processes and instruments are put in place at the current point in time should have a vision toward the future as the baseline of this model is that governance is always evolving. Therefore, looking ahead should be part of the process. A good example of this already exists in the Outer Space Regime with the creation of the international

[19] Ibid, 4
[20] Ibid, 4
[21] Ibid, 4
[22] Ibid, 4
[23] Ibid, 4

and non-legally binding LTSG which consist of 21 unique guidelines for the sustainability of space with the idea of utilisation for current and future generations.

Interdependencies focus on actors and institutions. Van Assche, et al, define interdependencies as "… dependencies in the present, between actors and institutions, between actors, and between institutions"[24]. This is incredibly important as the dynamics between various types of actors – whether State-to-State or State-to-non-State – absolutely impacts a governance framework. How actors interact with institutions such as the United Nations or other groupings like the Space Data Association shows how governance will progress. On top of this institutions interact with each other such is the case with UNOOSA and the ITU as both are pivotal to registration of satellites and registration of radio frequency spectrum allotments respectively.

All three types of dependencies – path and its subs, goal, and interdependence – are crucial to the evolution of a governance framework. Van Assche, et al, states:

> All three dependencies play out at the same time and influence each other. Interdependencies right now are shaped by a variety of path dependencies, while they create new path dependencies. Path dependencies and interdependencies shape goal dependencies, while goal dependencies can only be understood as properties of the whole governance system, including its path and interdependencies.[25]

This understanding of evolutionary governance feeds directly from regime evolution discourse in that there are many factors pushing regimes (or governance systems/frameworks) to constantly change and adapt because of exogenous and endogenous variables. This model of governance will be further discussed and analysed for both the Outer Space Regime and Low Earth Orbit as it is in-line with the research on outer space being an evolving regime that is constantly changing given the scientific and technological advancements as well as the growing diversity of actors utilising space for exploration, security, science, socio-economic and environmental concerns.

---

[24] Ibid, 4
[25] Ibid, 4

5.5 Risk Governance

Risk governance, as the name implies, "… aims to regulate, reduce or control risk problems"[26]. Risk governance includes assessment, management, as well as socio-cultural aspects of experiencing and coping with risk in a more interdisciplinary way.[27] In order to better understand risk with this multifaceted approach, a horizontal governance structure is used which includes State and non-State actors as part of the decision-making process. The strengths of risk governance are its inclusions of management, analysis, along with socio-cultural and techno-scientific considerations. Additionally, this model of governance takes its lead from International Standards Organization (ISO) standards and operators as well as being a model of governance from academics in the book *Handbook on Theories of Governance* referenced in this chapter. These aspects create a well-rounded risks-related decision-making structure which is beneficial for the entire risk cycle process.

The weaknesses of risk governance stem from risk management. According to Renn and Klinke, "risk management is confronted with three major challenges: complexity, uncertainty and ambiguity"[28]. Risks are complex and it is difficult to identify and quantify causal links. There is uncertainty because of the inability to "… provide accurate and precise quantitative assessments between a causing agent and an effect"[29]. Ambiguity, according to Renn and Klinke:

> Denotes either the variability of (legitimate) interpretations based on identical observations or data assessments of the variability of normative implications for risk evaluation (judgement on tolerability or acceptability of a given risk).[30]

All three of these challenges are also found in LEO regarding space debris and potential collisions. One of the biggest issues with potential collisions in space is in finding fault. If debris creates the collision event it is next to impossible to know which State is at fault. If a satellite collides with another satellite, it can be hard to find causation leading to uncertainty about fault. Given that the most robust SSA is through the US military, not all actors the ability to predict risks to space systems. Finally, with the rise of commercial SSA capabilities, there

[26] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 245
[27] Ibid, 245
[28] Ibid, 252
[29] Ibid, 252
[30] Ibid, 252

can be variability in interpretation of collision avoidance manoeuvring. Renn and Klinke find that "one key challenge to risk governance is the question of inclusion: which stakeholders and publics should be included in governance deliberations?"[31] This is also a challenge in LEO. While the US military does create bilateral agreements with certain States to share SSA data, because of security concerns not all information will be provided. This also leaves out States that are not in an agreement with the US. If SSA data is coming from a commercial entity, then it is only the customer that would be provided the information. Thus, it would be hard to say operationally which stakeholders would or should be involved in the process. However, from the governance level, it is most likely States – including Departments of Defence, military, space agencies or departments with space control, and Departments of State or Foreign Affairs – as well as maybe the few commercial actors with SSA capabilities that would lead the governance discourse.

Risk governance is niche and is heavily reliant on risk management and risk reduction strategies. This model of governance is typically framed under councils such as the International Risk Governance Council or nationally such as the German Advisory Council on Climate Change or through a framework such as the UK Treasury Department's Risk Classification Framework. Extrapolations from these councils and frameworks, as well as the overarching literature on risk governance could prove useful for SSA and space debris. However, the use of risk governance alone would not suffice the needs of LEO or the Outer Space Regime in entirety. Therefore, more on risk governance will be discussed in sections focussing on space debris and space situational awareness. However, risk governance does not offer a panacea for the governance framework of LEO nor the Outer Space Regime. This research will consider risk governance further as a contender for potential hybridization with other applicable models of governance.

5.6 Legal Governance

Legal governance is the model that looks through the lens of law. Legal governance looks at the different steering tools used by decision-makers through the legal distinction of 'soft' or non-binding law and 'hard' or binding law. Hard governing tools are binding such as treaties or national legislation while soft tools are political commitments based on voluntary compliance. Further discussion on hard and soft legal instruments will be discussed throughout

[31] Ibid, 254

this research as various forms of law are present in the Outer Space Regime and utilised in the current Low Earth Orbit governance framework.

The strength of soft and hard governance is that users of this model allow for binding and non-binding legal instruments to play a part in the governance framework. This is supported by Blomqvist's findings that:

> In recent decades it has often been argued that soft governing tools are becoming more important, as governments are replacing traditional, hard governing tools such as legislation with non-binding tools like recommendations or guidelines.[32]

This same trend is happening in the Outer Space Regime where non-binding international law or political commitments are being created instead of treaty. Reasons for this change stem from timeliness and flexibility. Details of the use of soft governing tools will be discussed further in this research. What is important to note here is that by including soft tools into a governance model it allows for flexibility of law as new knowledge or technology comes forth. Another strength of using the soft and hard governance model is that is allows for top-down and bottom-up steering. Binding law comes from the top down and is more authoritative whilst NBIL law can sometimes be driven by non-State actors based on operating best practices which creates law from the bottom-up. Used together, both forms of law create complimentary aspects which can make for a more robust governance framework.

The weakness of this model is compliance. Non-binding instruments allow actors to ask themselves why they should comply. The weight of consequences for non-compliance must outweigh the restrictions placed on the actor with compliance. Blomqvist suggests:

> As poor compliance is one of the most commonly cited drawbacks of soft policy tools, it becomes important to understand under what conditions this form of steering may still lead to desired outcomes.[33]

Non-binding tools are not the answer every time. If non-binding and binding legal tools are used in tandem in a complementary manner, then there is a chance of compliance and the framework leading to the outcomes desired.

[32] Paula Blomqvist, 'Soft and Hard Governing Tools' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 267

[33] Ibid, 275

The legalgovernance model is an important one as it focuses on the legal hurdles many governance frameworks do not discuss in detail. Throughout this research binding and non-binding legal instruments will be discussed, and emphasis will be given on the importance of non-binding tools in a rapidly changing world. Legal instruments are not the only considerations for building a governance framework. This governance model will be considered but most likely in connection with another model as legal instruments are not the only pieces needed to build a strong governance framework for Low Earth Orbit.

5.7 Inclusive Governance

Inclusive governance is a newer governance model focused on how global governance needs to be reimagined and evolved to meet the new challenges of today such as combating climate change, the Covid-19 pandemic, and the rising importance of meeting the SDGs targets. Chatham House launched an Inclusive Governance Initiative in 2020 with the understanding that today's challenges illustrate an "…urgent need for change in the structures and mechanisms of international cooperation"[34]. Inclusive governance supports a wider range of State and non-State actors getting involved in discourse and decision-making at the international level, much like multistakeholderism, with an understanding that equality, diversity, and inclusion are the cornerstones to an inclusive global governance model.

The advantages of an inclusive governance model are that power is transformed from only State hands to a wider variety of actors to garner more commitment to governance solutions. This model focuses on having multiple platforms for a variety of voices to advocate on issues and find solutions. This allows for marginalized actors to find they have a seat and a voice at the table. Transparency is a key priority within this model. Having access to data can support the overall governance but also support actors, especially those previously left in the margins. Inclusive governance still supports the use of international agreements – including non-binding instruments. This model allows for a wider variety of actors and resources to make the best choices for the challenges put to hand.

There are some disadvantages to inclusive governance. There are many States – such as China – that prefer States to be the only actors at the table. The understanding being that global challenges are best left to States. Inclusive governance could get pushback from States that

[34] Chatham House, 'Reflections on Building More Inclusive Global Governance: Ten Insights into Emerging Practice' (April 2021) 2

prefer a more hierarchical approach. Another drawback could be that the wider the group of participants the harder it will be to find consensus on achieving specific outcomes. Inclusive governance means implementing transparency and sharing which can be difficult for all actors to achieve either through want or ability. Perhaps a hybrid model where inclusive governance is part of the mix would allow for these disadvantages to be addressed.

The Outer Space Regime is only starting to think about issues pertaining to EDI as well as decolonizing space. While sustainability and sustainable development have been on the agenda in space a bit longer, these concepts are also only in their infancy regarding the space environment and space applications. In 2023 there are over 100 Member States at UN COPUOS, up from 18 at the start in 1958,[35] meaning there is growing interest in being part of the international discourse on space. It would be prudent to consider the inclusive governance model further in this research.

5.8 Summarizing Governance Models

The above governance models were analysed to better understand what options are available for consideration regarding the evolution of the Outer Space Regime and for recommendation of how to build a better bespoke governance framework for Low Earth Orbit. The global governance model plus the hierarchical governance model will be re-addressed as they function as the current Outer Space Regime governance system which are also in use for LEO governance as well. Within this section a re-cap of the preferred governance models will be summarized to better understand how they might complement one another and where the differences lie. Analysing which governance models could apply to the Outer Space Regime and the LEO governance framework help to address the research questions and brings originality to the research. The analysis and discourse from this chapter will provide support for the complete recommendations and final answers given at the end of this research in the last chapter.

Currently both the Outer Space Regime and the Low Earth Orbit governance framework rely on a hybrid global-hierarchical governance framework. While this may have been successful – and needed – during the Cold War and post-Cold War, with the introduction of a robust space economy driven by non-State actors having independent utilisation of space, there is now a call

[35] UNOOSA, 'Committee on the Peaceful Uses of Outer Space: Membership Evolution' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html> accessed 28 February 2023

to widen the scope of involvement and to include options from the bottom-up paired with top-down regulations. A closer look at legal, evolutionary, inclusive, and risk governance will be conducted to recommend ways to bring the Outer Space Regime into this updated diverse international playing field as well as to give LEO its own governance framework that can support the rising challenges and find solutions for a safe, secure, and sustainable future.

5.9 Governance for Outer Space Regime

Global space governance is the current mode of governance used within the Outer Space Regime and subsequently in Low Earth Orbit as well. It is the framework that has been established and built upon since the inception of the regime through international deliberations on the Outer Space Treaty in the 1950s. Most of the literature on global space governance is from the perspective of space law experts without the underpinnings of regime or governance theory discourse. That being said, understanding the status quo of the Outer Space Regime and its governance framework – as well as how it functions for Low Earth Orbit – is crucial for understanding why this research urges change and deeper analysis of the governance system for future application.

This section will create a small literature review on the status quo of the current global space governance model as well as analyse the works for strengths and weaknesses of the model as to how effective it is at governing the Outer Space Regime. This section will offer recommendations on what the future of the Outer Space Regime governance model should be, giving an IR-IL perspective typically lacking from previous space governance discourse. These recommendations will suggest a bespoke model that is in-line with the current and future needs of the regime and will aid in answering the research questions in the last chapter. This then will lead to the final part of the governance theory section which will do the same as this section but for the governance of Low Earth Orbit specifically.

5.9.1 Status Quo

The Outer Space Regime utilises a hybrid global-hierarchical governance framework built upon détente between the United States and then USSR during the Cold War. Legally speaking, the regime is also built upon the 1967 Outer Space Treaty as well as the four subsequent treaties and other international space law that filled the lacunae of general international law by creating *lex specialis* for space and the regime itself. Over the course of the seventy plus years since inception of the Outer Space Regime, there has been an influx of actors – State and non-State – as well as many technological and scientific advances for the exploration and use of space. Politically, and legally speaking, the Outer Space Regime is still State-centric with a more hierarchical, traditional, top-down approach used at international, regional, and national levels.

As most academic discourse on the Outer Space Regime is through the expertise of space lawyers, most of the discussion does tend to focus on the legal aspect of the regime. For example, space law experts Jakhu and Pelton describe global space governance as:

> The entirety of the agreements, laws, regulations and other mechanisms (mandatory or voluntary) in relation to outer space affairs or activities, and includes processes for their formulation, compliance monitoring, and/or enforcement by concerned international and/or national institutions.[36]

From their understanding of the global space governance framework for the Outer Space Regime, it is understood that the legal aspects are the central point in relation to the affairs or activities being regulated. From an international relations perspective the scope of the governance framework would also include actor relations, actions of actors, as well as the decision-making process, and which actors are at the table. All these factors influence what legal mechanisms end up being utilised whether of a voluntary or binding nature.

As was attested to in previous sections, the Outer Space Regime is indeed evolving – and not only because of scientific and technological advancements. The advancements being made in science and technology are allowing for more missions with various objectives which is also aiding in bringing costs down. Today the ability to use commercial off-the-shelf parts (COTS) and smaller computerware allows for more actors to access space because of this there can be a more diverse group of operators in LEO.

The regime is also evolving due to the increasing diversity and number of actors – both State and non-State. This clearly indicates that outer space affairs are important to a growing number of diverse actors. Increasingly more States are establishing space agencies and/or creating national space laws and policies. Further showcasing the importance space activity and exploration has on States' national interests.

[36] Ram S. Jakhu and Joseph N. Pelton (eds) *Global Space Governance: An International Study* (Springer 2017) 7

The regime is evolving in terms of legal instruments and items of consideration. While there an outer space treaty has not been created since the 1970s, there are plenty of UNGA resolutions, principles, and other instruments of international law that have been brought forth. There are increasing numbers of national space laws and policies including licensing requirements. Also, there are guidelines, standards, and best practices being created through UN COPUOS and outside of the UN system. The most recent and notable is the 2019 Long-Term Sustainability Guidelines[37] created over 10 years within UN COPUOS sessions and working group discussions. While much of what is created today is of a voluntary or non-binding nature, at the UN level many States are calling for implementation and knowledge-sharing on implementation of these legal instruments showing the interest in taking the tenets into national law and policy which then makes them binding.

The regime is evolving through more cross-over with regime complex issues and challenges. As the Cyberspace Regime is also continuing to evolve there are considerations that intersect with the Outer Space Regime, such as potential threats to space systems via cyberattacks. The Cyberspace Regime is also concerned over responsible behaviours of actors utilising cyber technologies. The same is currently underway for further discussion within the Outer Space Regime via the Security Regime under the UNGA 1st Committee. The ITU held the 2019 World Radio Conference[38] where amendments were made to the Radio Regulations regarding satellite constellations and radio spectrum utilization highlighting the importance of the new interest in mega constellations and the need to regulate them from the Telecommunications and Outer Space Regimes.

The status quo of the Outer Space Regime is that it is indeed evolving. It is prudent that the governance model of the regime be reconsidered to better meet the needs of the diverse and growing population of State and non-State actors as well as the growing list of agenda items and challenges faced concerning space systems and space exploration. The next section will take all that has been discussed thus far and prepare to answer Research Question 1 – How is the Outer Space Regime evolving and why is this important to Low Earth Orbit? as well as offer recommendations for the future of the regime governance framework while taking into

[37] UNOOSA, 'Long-Term Sustainability of Outer Space Activities' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html> accessed 28 February 2023

[38] ITU, 'World Radio Conference 2019 (WRC-19) Sharm el-Sheikh Egypt 28 October to 22 November 2019' (*ITU* 2023) <https://www.itu.int/en/ITU-R/conferences/wrc/2019/Pages/default.aspx> accessed 28 February 2023

consideration regime evolution and the growing connection within the regime complex. Important to note is that while this section does offer some concluding thoughts on the Outer Space Regime, the subsequent sections will look at LEO but also with the mind that any considerations and recommendations for LEO ultimately are tied to the Outer Space Regime itself as LEO is only a sub-regime governance framework working within the larger regime.

5.9.2 Governance Model Analysis

This section will look at the above governance models with more analysis given to help build recommendations in Chapter 7 and to answer the research questions. The models discussed include legal, evolutionary, inclusive, and risk.

Legal governance (also known as Soft and Hard governance), looks at the different legal instruments used in a governance framework. From treaties to national regulations, to operational standards, any hard or soft instrument that would apply to the governance of outer space and Low Earth Orbit. While this model of governance looks predominately at law, as this research has discussed, law is not the only aspect of governance that needs to be considered. On the flip side, governance is not just about the political aspect either. There does need to be a balance of political, legal, economic, societal, and environmental considerations which is why this legal governance model works best in a hybrid model with other types of governance. Therefore, this governance model has valuable aspects that can and will be utilised in the Outer Space Regime governance as well as the Low Earth Orbit governance framework. It is plausible because State actors already sign and ratify space treaties and are creating non-binding international law as well as political commitments that are supporting one another. For example, the LTSG supplement the Outer Space Treaty and as such provide more instruction for grey areas of regulation. Though these guidelines are voluntary and must be implemented by actors, they do offer a clear understanding of what should be done to support sustainability and further the governance of outer space – especially in Low Earth Orbit where these guidelines are so critical. Looking at what these legal instruments say as well as having discourse on implementation are important aspects of governance.

Evolutionary governance understands that regimes – including actors, laws, challenges, and interests – are constantly evolving and that a governance framework should reflect these changes over time. Evolutionary governance relies on dependencies of past influences, visions for the future, and interdependencies between various actors and institutions. As the Outer

Space Regime is a science- and technology-based regime where changes and updates occur on a frequent basis, the evolutionary governance model would be well-suited. As this model does not explicitly suggest one type of actor being more important to the decision-making process over another, it could be easy to shift to this form of governance. In fact, to a certain extent the Outer Space Regime is already using an evolutionary governance model because of the nature of changes to scientific and technological advances. However, more could be done to utilise the path, goal, and interdependent dependencies found in this model. For example, previous and current discourse on cyber security taken from the GGE and OEWG reports could influence how discourse on space security should be conducted. Take lessons learned from cyber and apply to space. This is a form of path dependency that would help to evolve the Outer Space Regime not only because there are similarities in high-level discussion but also because cyber security is extremely relevant to space – especially regarding space assets in Low Earth Orbit.

Inclusive governance stems from Chatham House and takes into consideration the current political climate as well as current global challenges like climate change and the SDGs. While inclusive governance is akin to multistakeholderism, there is also an element of supporting the Global South and underlying EDI issues. Inclusive governance is a model that would benefit and be appreciated by smaller spacefaring nations, especially those from the Global South, as well as non-State actors. There are aspects of inclusive governance already prevalent in the Outer Space Regime such as knowledge sharing, capacity building, cooperation, and considering the needs of developing countries. That means there is room for the inclusive governance model within space, but it would still be paired with another model because of the asymmetrical use of space. In LEO, which the most diverse in terms of actors, inclusive governance is critical. Every actor as the right to access space and to use LEO, which is why discourse akin to inclusivity and broader EDI tenets are in the Space2030 Agenda and even in the LTSG. This model is incredibly important for the future of space if humanity indeed wants an open and inclusive future in Earth's orbits and on celestial bodies.

Risk governance is meant to regulate, reduce, or control risks and includes assessment, management, as well as mitigation and remediation. Risk governance is taken from ISO standards and operators understanding of risk management as much as from the risk governance model in the *Handbook on the Theories of Governance* used in Chapter 5. Risks are difficult to govern as they are complex, uncertain, and ambiguous. It should be noted here that, in space, there are risks and potential threats. Risks are paired with safety while threats are paired with security. Much of what is mentioned about risk governance could apply to safety, security, and sustainability so there is no need to separate risk from threat within the model.As Renn and Klinke explain, "the characteristics of modern risks require new concepts which are able to deal with a situation in which risks are complex, interconnected and global"[39] which could apply to threats as well. Nowhere is this more applicable than Low Earth Orbit. Space debris, ASAT tests, cyber and electronic warfare, collision avoidance, and astronauts' safety are all critical challenges in LEO that are classed as risks and threats. Therefore, risk governance could very well play a large role in the LEO governance framework connected with the other models that would support the Outer Space Regime holistically as well as LEO specifically.

For the Outer Space Regime, a global hybrid governance model with aspects of legal governance, inclusive governance, and evolutionary governance should be considered. This hybrid approach would support all types of actors in space and would also consider the safety, security, and sustainability of space activities, astronauts, and the space environment (including celestial bodies). As this research is focused on LEO, it will be further spin-off research that can further unpack the needs for updating the Outer Space Regime governance model.

Answering RQ1: How is the Outer Space Regime evolving and why is it important to Low Earth Orbit? First, as has been discussed throughout the research, the Low Earth Orbit governance framework is nested within the more holistic Outer Space Regime governance framework. What changes within the overall governance of space will directly impact the LEO governance framework. As the regime is constantly evolving with new actors entering space, more voluntary legal instruments being created and implemented, and more challenges arising there are always ongoing discussions at the international, regional, and national levels about space governance. For example, the newest discussion on responsible behaviours in space does not specifically suggest this is only a LEO issue but as most activity at this time is in LEO it stands to reason that these discussions will affect the entire regime and LEO in terms of governance. The discussions at UN COPUOS on how to continue to update the LTSG and implement the 19 guidelines, is a whole of regime discussion with direct ramifications for activity in Low Earth Orbit. Anything that impacts the governance of the Outer Space Regime will be important to LEO because LEO is nested within the whole regime. The Outer Space

[39] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 245

Treaty applies to LEO just as much as it applies to the Moon – foundational outer space governance applies and is important in LEO as it is to other areas of space.

5.9.3 Recommendations

It should be no argument now that the Outer Space Regime is evolving. Discourse on a post-Cold War or new space agenda are already out-of-date as the regime is firmly established in a multipolar world with a diverse group of State and non-State actors. The recommendation is to move away from a traditional, hierarchical governance model into one that reflects the current geopolitical and legal world order would be better suited if the regime is to continue to move forward in a positive fashion.

Taking an Orwellian view that States are more equal than non-State actors is still upheld by the tenets of general international law as well as international space law, the recommendation is not to completely disrupt the power of States but rather to shift discourse and agendas to at least be in consideration of including the growing non-State actor presence in space affairs. As can be seen in the Cyberspace Regime and the Telecommunications Regime, non-State actors have a role to play in governance through consultations, events, national level discussions, and by being 'norm entrepreneurs' or standard setting themselves. Within the ITU there are also Sector Members which include industry, SMEs, academia, as well as regional and international organizations. While the Outer Space Regime does allow for non-State actors to take part in events and there are national level discussions and consultations; there is only a small presence of non-State actors at UN COPUOS sessions primarily on behalf of State delegations or as Permanent Observers. However, these individuals do not have voting power nor are they able to make decisions that affect census making or legal outcomes. While there are some States – such as China – that see international discourse to be conducted only via State-to-State interactions, there are other States that encourage the exchange of information and expertise from non-State actors. The driving force behind this recommendation is because within LEO alone the number of active commercial satellites is over 70%.[40] This percentage will only keep rising because of actors such as SpaceX creating mega constellations of satellites. Therefore, it behoves States to consider bringing non-State actors into the circle of discussion on outer

[40] Seradata, 'SpaceTrak' (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022

space governance, especially in LEO, based on the sheer number of actors and satellites they make up comparted to civil, military, or other endeavours.

As the world is now multipolar – even multistakeholder – other models of governance for the Outer Space Regime must be considered so as not to lag behind. Already, the Cyberspace Regime IR experts are suggesting that the regime is a multistakeholder model. This is because they take the approach that non-State actors make many of the resources, activity, and technology that make cyberspace function. However, there is divided acceptance of this model of governance between the West and other States such as China and Russia.[41]

Technological advances are happening so fast that quite frankly non-State actors do not want to wait on regulation and slow diplomatic consensus to understand what they may and may not be able to do in space. This is also why non-State actors – like the Microsoft example above – take initiative to create standards, guidelines, and best practices in parallel to international law and national regulations. For example, within the Outer Space Regime, CONFERS was created well before the topic on RPOs plus OOS was brought to UN COPUOS. CONFERS is a consortium of non-State actors and industry-led with the aim to researching, developing, and publishing non-binding instruments on RPOs and OOS. In fact, CONFERS has many publications on their website regarding principles, recommended practices, as well as technical and operational guidance available for download. Regarding UN COPUOS, to date (as of 2023) RPOs and OOS are not agenda items at UN COPUOS though Member States do refer to these operations in their deliberations. Two other industry-led organizations that are setting standards are the Space Data Association and the Space Safety Coalition. The SDA was created in 2009 and is focused on the sharing of operational data as well as promoting best practices across the industry. The SSC brings together various types of non-State actors with the aim to promote a safe use of space through their *Best Practices for the Sustainability of Space Operations*[42].

From these examples it can be argued that the non-State actor community has a vested interest in space governance and is keen to be part of the discussion. The caveat here is that most of the actors involved in these initiatives are Western which does not help with the already Western slanted approach to space governance. The takeaway here is that non-State actors are willing

[41] Dennis Broeders and Bibi van den Berg, 'Chapter 1 Governing Cyberspace: Behavior, Power, and Diplomacy' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020)
[42] Space Safety Coalition, 'Best Practices' (*SSC* 2023) <https://spacesafety.org/best-practices/> accessed 28 February 2023

to discuss governance and perhaps over time those actors will show more geographical diversity as the Outer Space Regime continues to evolve. While the idea of the multistakeholder governance model being applied to the Outer Space Regime seems unlikely in the near-future it is time to reconsider the traditional hierarchical and bi-polar approach from an era gone by. Sitting somewhere in the middle between hierarchical and multistakeholder would be the best course of action for the immediate to near future that way States are still happy with the structure but also a new model would allow for non-State and small State players to feel that their views are inclusive within the governance discourse.

It is here that Research Question 1 — How is the Outer Space Regime evolving and why is this important to Low Earth Orbit may be answered.

The Outer Space Regime is evolving along multiple dimensions in parallel. Technology and science advances, new actors are utilising space each year, and the challenges faced are becoming more complex and interconnected within the regime and through the regime complex. Space is increasingly tied to terrestrial considerations such as the climate crisis, national security, and connectivity – just to name a few. The recommendations in this section are critical to the future of the Outer Space Regime as well as to how the Low Earth Orbit Governance framework should advance.

This evolution of the Outer Space Regime will directly impact LEO because all of Earth's orbits are part of the Outer Space Regime and fall under the foundation of the Outer Space Treaty series (apart from the Moon Agreement). The Outer Space Regime encompasses the entirety of space exploration and utilisation perhaps until a time comes when there are permanent settlements on Mars. For the foreseeable future the regime with the Outer Space Treaty series is the foundation and core of the regime. Low Earth Orbit is a sub-regime of that system because some regulation – especially in terms of the ITU Radio Regulations – have general legal tenets that apply regime-wide and others that are specific to a certain orbit or celestial body (as is the case with the Moon Agreement being for the Moon and celestial bodies). Overarchingly, any changes or evolutions made to the Outer Space Regime, and by extension, the regime complex, directly impact governance considerations in Low Earth Orbit and other sub-regime governance frameworks accordingly. Therefore, the Outer Space Regime evolution is important to Low Earth Orbit and how the LEO governance framework must be addressed. For if the trunk is changing, so too are the branches.

5.10 Concluding Remarks

This chapter walked through the transition from regime theory to governance theory to build a frame for the next methodological approach which was to critically analyse various governance models and their potential applicability to the Outer Space Regime and the Low Earth Orbit governance framework. From this analysis, governance models were discussed and analysed to make recommendations in Chapter 7.. This chapter brought additional insight about governance models which will be important for answering the research questions. The analysis of governance models and critical consideration of them for the Outer Space Regime and the LEO governance framework is an original contribution that ties to the literature review and methodology of the research. Before recommendations can be made, the next chapter will look at the current LEO governance framework including the politics, law, and challenges to best understand the status quo and may need to evolve to fit the needs of the actors on orbit.

6 Current Governance Framework in Low Earth Orbit

The previous chapters on regime theory and the legal theory underpinning the Outer Space Regime and the Low Earth Orbit governance framework have been given the foundation for this research and allowed for support on answering the research questions proposed. These two chapters were paired with current diplomatic and stakeholder discourse on the security, safety, and sustainability of LEO – the 3S Approach – which gave insight into why an adaptive governance framework is so important for the future of Low Earth Orbit and the regime. The previous chapter gave an overview of governance models and how they could be applied to the regime and the LEO governance framework. While a few models have been tentatively selected to move forward for analysis, before they can be further analysed for the governance of Low Earth Orbit, first there must be discourse on the current governance framework. This chapter is the next stage in the research as it provides the extant situation in respect to the current governance framework in Low Earth Orbit. It is crucial to understanding what is happening currently alongside the theoretical work that has already been addressed in this research. This chapter connects the previous chapters to the last chapter which will offer recommendations, answer the research questions, and create conclusions for the research. Discussing how the current LEO governance framework is set up and maintained is crucial to finding answers to conclude this research.

The current governance framework in Low Earth Orbit is fragmented across issues and legal tenets. This chapter will give an overview of the main issues in Low Earth Orbit with analysis of the issue from the perspectives of international relations and international law. These issues include regulating small and very small satellites as well as the growing use of satellite constellations and mega constellations. Another issue under consideration is perhaps the most researched issue in space – space debris. To try to tackle these issues, there will also be analysis and discussion on ways in which the framework could evolve and include strategies for regulating and maintaining the orbit. Such strategies discussed include space situational awareness and space traffic management. These are broader strategies that have underpinnings in aviation. This chapter will also look at space-specific potential strategies being developed and discussed such as the Space Sustainability Rating, the Long-Term Sustainability of Space, using normative behaviours, and a further look at Space Traffic Management.

6.1 Small Satellites and Very Small Satellites

To date, the term 'small satellite' does not have a legal definition. The term 'small satellite' envelopes additional subcategories such as minisatellite, microsatellite, nanosatellite, picosatellite, femtosatellite, and CubeSat which all have different mass (kg), costs, orbital altitude, and mission durations in years.[1] Small satellites can be described as 'very small satellites', 'lean satellites',[2] or 'small spacecraft'[3] however legally under the five United Nations Outer Space Treaties they are all classified as 'space objects'[4] based on the definition of 'space object' first introduced in the Liability Convention under Article I (d): which "includes component parts of a space object as well as its launch vehicle and parts thereof"[5]. Therefore, small satellites are subject to international space laws by way of national space regulations and licensing procedures as well as the ITU Radio Regulations via national telecommunications procedures. They are typically placed in LEO and have an orbital life of about a couple of months to years, or even decades. The purpose of small satellites is varied and can includes military, commercial, or civil operators using applications such as Earth Observation via remote sensing, communications, science, technology, navigation, or other diverse applications.

Small satellites are unique in that they can be built with COTS microelectronics and can have a rapid turn-out rate.[6] According to UNOOSA and the ITU:

> Typical characteristics of small satellite missions include a) reasonably short development times; b) relatively small development teams; c) modest development and testing infrastructure requirements; and d) affordable development and operation costs for the developers, in other terms "faster, cheaper and smaller.[7]

---

[1] International Telecommunications Union Characteristics, Definitions and Spectrum Requirements of Nanosatellites and Picosatellites, as well as Systems Composed of Such Satellites (09/2014) Report ITU-R SA.2312-0

[2] International Academy of Astronautics Definition and Requirements of Small Satellites Seeking Low-Cost and Fast-Delivery (2017) Final Report of IAA Study Group 4.18

[3] International Organization for Standardization Space Systems – Requirements for Small Spacecraft (07/2018) ISCO/TS 20991:2018

[4] United Nations Office for Outer Space Affairs International Space Law: United Nations Instruments (2017)

[5] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187, Article I (d)

[6] For more details on the 'modern small satellite' read Martin N. Sweeting Modern Small Satellites – Changing the Economics of Space (Vol. 106, No. 3, March 2018) Proceedings of the IEEE

[7] United Nations Committee on the Peaceful Uses of Outer Space, 'Guidance on Space Object Registration and Frequency Management for Small and Very Small Satellites' (13 April 2015) A/AC.105/C.2/2015/CRP.17

This suggests that small satellites are more likely to be used by new, emerging, or smaller actors (which can include academic institutions and other non-State actors) but also suggests that small satellites make for a lower risk and cheaper option to access the use of space. Particularly, space-emerging States such as Costa Rica, Nigeria, or Indonesia see small satellites as opportunities to benefit from space applications. These space-emerging States consider Earth Observation data as important for socio-economic, environmental, or as supportive to the SDGs in their countries. Launching a small satellite allows for capacity building, the growth of a space industry within their State, and a chance to build technical knowledge and infrastructure. In these same ways, small satellites can be beneficial to private actors such as companies or to academia.

UNOOSA and ITU see some characteristics that might pose challenges:

> For various reasons, very often due to inexperience or unfamiliarity with the national and international regulatory framework, they are not always conducted in full compliance with international obligations, regulations and relevant voluntary guidelines (authorization, supervision, registration, ITU radio regulations, space debris mitigation guidelines etc.); and they have raised concerns to worsening the space debris situation.[8]

It is important for States to conduct knowledge-sharing at the international level to better inform those States that are new or emerging of the processes and procedures typically used for small satellite missions. Having strong national licensing procedures and national points of contact for non-State actors can support them in avoiding errors to licensing applications and procedures. Having free and accessible information such as the SWF *Handbook for New Actors in Space* or documents on small and very small satellites written together by UNOOSA and ITU can aid newcomers on how to operate satellites in LEO in a safe, secure, and sustainable manner.

Another important issue regarding very small satellites is their lack of propellant. As such these satellites cannot be manoeuvred which can pose a critical threat to other objects in the same orbit which can then lead to serious liability issues. Palkovitz suggests:

[8] Ibid

> While currently propellant systems are being developed to be compatible with the CubeSat standard, the reality is that most of these satellites cannot be further manoeuvred after their deployment.[9]

While this issue is important, most small satellites do have manoeuvrable capabilities. Also, with the rise in the technological precision of space object tracking, more collision avoidance manoeuvres are being conducted where applicable.

Currently small satellites are usually considered tag-alongs as secondary payloads,[10] however, with the rising interest in space and small satellites being a great way to access space in terms of cost and usability, they may become primary payloads in the form of satellite constellations. Satellite constellations, or mega constellations, are groups of small satellites that work together, much like a fleet of ships, to collect data pertaining to their mission. These satellites are identical and often have back-ups in the constellation in case of failure. More on satellite constellations will be discussed further in this chapter as they are a growing challenge in LEO.

6.1.1 Small Satellites and International Law

It is important to stress that all small satellites, including those in satellite constellations, are considered 'space objects' under international space law and as such are subject to international space laws just as the larger satellites are in higher orbits. These international space laws pertaining to satellites include the OST, the Registration Convention, and the Liability Convention. Further, as small satellites can be owned and operated by State and non-State actors alike and given the nature of international law to be applicable to States, there are two ways of approaching small satellites and their adherence to international space law. State owned and operated small satellites, because they are belonging to States, are bound by the space treaties directly as States are parties to the treaties. Whereas non-State owned, and operated small satellites are bound by the space treaties through States. Under the Outer Space Treaty, States conducting activities in space with space objects are bound by Articles VII and VIII on liability and control over registered objects respectively. Article VII stipulates:

---

[9] Neta Palkovitz, 'Small Satellites: Innovative Activities, Traditional Laws, and the Industry Perspective' in Irmgard Marboe (ed), *Small Satellites Regulatory Challenges and Chances* (Brill Nijhoff 2016)

[10] A secondary payload or piggyback payload is a small and lower-cost space object (such as a small satellite) that is also to be launched and deployed into space. This secondary payload can be bought from launch providers if the rocket or launch vehicle has enough room/weight available after the primary payload is accounted for. A primary payload is the main reason for the launch.

> Each State Party to the Treaty that launches or procures the launching of an object into outer space … and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty…[11]

What Article VII means is that States, whether launching or procuring a launch, are in fact internationally held accountable and are liable for damages to other space objects. What constitutes a 'launching State' versus 'procuring a launch' can become tricky as not all States have launching capabilities and not all States are acting on their own behalf but can also be acting internationally on the behalf of their non-State actors who are launching small satellites as well. Further, this article sets the tone for the Liability Convention which dives a bit deeper into what States are required to do regarding issues of liability in and from space. However, only the term 'launching State' is considered in the Liability Convention which applies to both launching and procurement of launches. What is important is that at least one State must act as the responsible party at the international level – whether that is as a launching State or procurer of the launch depends on national licensing procedures, the arrangements and agreements for launch, and national regulations. In terms of issue of liability and fault, small satellites are treated no differently than other larger satellites and space objects because the Outer Space Treaty and the Liability Convention make no distinction. According to Article III of the Liability Convention:

> In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.[12]

Article III provides that liability in space is fault-based liability and is not absolute. Fault liability can be incredibly difficult to prove, especially when dealing with a very small satellite that is non-manoeuvrable and space debris or two non-manoeuvrable very small satellites. Therefore, insurance is becoming increasingly important in Low Earth Orbit, however, the

[11] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[12] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187

price of insurance versus the overall price of the mission can sometimes be problematic as insurance can cost more than the cost of the satellite and the mission combined. More on liability and insurance will be discussed further in this chapter when speaking on national licensing procedures and satellite regulations.

Another important piece of the puzzle is the registration of space objects. Article VIII of the Outer Space Treaty speaks to the registration and control of space objects. Article VIII stipulates:

> "A State Party to the Treaty on whose registry an object is launched into outer space is carried shall retain jurisdiction and control over such object … while in outer space …"[13]

This again suggests that a State must take responsibility of said space object at the international level and have it registered on their national registry as well as record the space object to UNOOSA international registry as well as on the ITU Master International Frequency Register (MIFR). Article VIII is further extrapolated upon within the Registration Convention. Looking to satellite registration first, the Registration Convention provides details on how the launching State (which also includes procurement) should go about registering satellites, the timeline, and what to include in registration. This is usually done first at the national level and then the same information is applied to the international registry. For example, if the registration is for a non-State actor, they must comply with national registration procedures and then the State registers the satellite on their behalf at the international level. The same process is conducted for registration of radio frequency utilisation with a national and then international registry being applied to the satellite and with the State registering internationally on behalf of the non-State actor.

Most of what is written in the space treaties and suggested by the ITU for radio frequency utilisation is also part of national regulations and licensing procedures. However, for space-emerging States who may not have space laws and policies, this is where UNOOSA can support the building of space law frameworks through consulting and where State-to-State knowledge-sharing on space laws and policies at the UN COPUOS Legal Subcommittee can prove beneficial. It also helps to cut down on fragmentation and room for 'flags of convenience' if

[13] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

most States do have national space licensing procedures and space regulations in place. As this research is being conducted within the UK, the next section will walk through what a small satellite owner and operator must do to procure a launch and deploy a satellite into space all the way until EoL procedures. This launch to End of Life process is best described at the national level because the treaties are only starting points to what is required of States. National laws and procedures then add in non-binding international law, such as the Space Debris Mitigation Guidelines, and other non-binding tenets as they see fit which gives the non-State actor the tools to apply for a license, register an object, and register for radio frequency allotment. This use of non-binding international space law to supplement binding international space law is useful for State and non-State actors operating in LEO because these non-binding tenets enhance the governance framework. This use of binding and non-binding law within the LEO governance framework into the research and Research Question 4 by suggesting that a combination of laws added with national regulations and licensing procedures does in fact keep the framework evolving and addresses challenges in a cognisant way.

6.1.2 National Space Law and Licensing Procedures for Satellites in Low Earth Orbit

To launch a small satellite into Low Earth Orbit, the owner and operator of the satellite (or constellation) must first go through a national licensing process. This licensing process includes "… spectrum access, national security oversight, compliance with insurance and safety requirements, and space debris mitigation guidelines"[14] as well as the long-term sustainability guidelines and any other compliance aspects required by the State under which the license is being granted. Licensing is one part of what is known as pre-launch. However, before even considering licensing small satellite owners and operators go through a design and building of the space object or objects and the mission. It is never too early to start considering and preparing the licensing aspects of pre-launch as some of the processes take considerable time and/or must be completed at a certain stage in the mission timeline ahead of launch. The next step is launch, followed by on-orbit, and finally concluding with EoL considerations. This section will walk through all the regulations involved concerning the entire mission timeline from pre-launch to EoL as understood for small and very small satellites going to LEO.

The pre-launch phase is the most critical for a satellite mission to proceed. It is in this phase that all designing and building of the satellite is performed. It is also the time when licensing,

[14] Christopher D. Johnson (ed), *Handbook for New Actors in Space* (Secure World Foundation 2017 edition) 90

safety regulations, and other legal concerns are considered. Regarding the governance of Low Earth Orbit, following licensing and safety regulations are critical for the safety, security, and sustainability of the orbit. As has already been mentioned, licensing happens at the national level. Licensing includes launching, registering, radio frequency utilisation, and possibly remote sensing. Licensing is critical for States to have as part of their space regulations as it ensures the international community that what non-State actors are on-orbit are there because they have adhered to specific requirements for a safe, secure, and sustainable operation in space.

Licensing serves many purposes[15] not only applicable to ensure compliance with international space law but also to ensure compliance with international telecommunications law. First, licensing is used to control entry to the market. This is not meant to prohibit the use of space, for that would go against Article I of the Outer Space Treaty, rather, it is to safeguard the space environment and radio frequency spectrum against inappropriate utilisation and non-compliance of safety standards. Second, licensing imposes requirements for eligibility. According to Flanagan in telecommunications law, licensing can "… ensure that potential providers are solvent, able to deliver the services, complete the network they apply to provide, or use well the scarce resource they seek…"[16] This argues that the licensee is prepared and able to conduct a space activity whilst being mindful of the limitations of radio and orbital resources. Third, licensing imposes special rules and/or operating controls. For example, a license registers radio spectrum allocation and may require satellites to adhere to the Space Debris Mitigation Guidelines. Fourth, licensing is a means of enforcement. Without a license a non-State actor will not be able to launch a satellite into space nor utilise the radio frequency spectrum. Additionally, licensing establishes that the licensee is compliant with all national and international laws applicable to satellites. Fifth, licensing comes with fees. The fees cover the overall license as well as the registration of the satellite and the radio frequency spectrum allotment. Sixth, licensing supports monitoring. Because all satellites are registered on the UNOOSA International Registry and on the ITU MIFR, satellites are then known when, where, and for how long they should be on-orbit and what radio frequency they are utilising. This can help with SSA and the overall STM of an orbit. Lastly, licensing is a binding agreement between the government and the licensee.

[15] Anne Flanagan, 'Authorization and Licensing' in Ian Walden (ed), *Telecommunications Law and Regulation* (3rd edn, Oxford University Press 2009) 304-315
[16] Ibid, 307

The next section will use the United Kingdom as a case study for explaining space object licensing and how it conducted for safe and compliant use of the space environment as well as the radio frequency spectrum.

6.1.2.1 Case Study: UK

The UK government website has a useful Spaceflight Legislation and Guidance[17] webpage which gives some basic information for actors wishing to license their space activities through the UK. Stated up-front is the importance of international space law and how the UK follows the space treaties to create national legislation and regulations which then determines "… the requirements a licensee has to meet and to set out the obligations of each licensee".[18] This licensing procedure is in place to protect the State from its international obligations founded in the treaties, but it also protects the licensee from the State. If all licensing procedures are followed, then the space object will be allowed to launch and perform on-orbit. Within the UK there are two pieces of legislation that regulate space activities. The Outer Space Act 1986[19] (here forward referred to as OSA 1986) and the Space Industry Act 2018[20] (here forward referred to as SIA 2018). OSA 1986, under Section 1, applies to space activities carried out by UK entities with an overseas launch and/or operations from an overseas facility.[21] The SIA 2018 regulates space activities carried out from the UK including launching from the UK.[22] However, to date no launches have been carried out from the UK, this research will assume the OSA 1986 would be the UK legislation utilised for current space activities of UK actors. The OSA 1986 prohibits unlicensed activities under Section 3 and follows with Article 4 on why a license may be granted.[23] To be granted a license for space activities under the OSA 1986 the activity must be approved by the Secretary of State.

---

[17] UK government, 'Spaceflight Legislation and Guidance' (*UK government*, published 16 April 2014, updated 29 July 2021) <https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986> accessed 06 October 2021

[18] Ibid

[19] Outer Space Act 1986 (UK)

[20] Space Industry Act 2018 (UK)

[21] Outer Space Act 1986 (UK)

[22] Space Industry Act 2018 (UK)

[23] Outer Space Act 1986 (UK) s3, Art 4

A license shall be granted under OSA 1986 Section 4 if the Secretary is satisfied that the space activity:

> Will not jeopardise public health or the safety of persons or property and will be consistent with the international obligations of the United Kingdom and will not impair the national security of the United Kingdom.[24]

These points of necessity are important as under international space law the State is responsible for all non-State activity, therefore, it is prudent for national legislation to reflect that is done here in OSA 1986. The UKSA charges a licensing fee of £6,500 for a single orbital licence application under the OSA 1986.[25] Section 5 of OSA 1986[26] spells out the terms of the license. These terms include inspection of facilities and equipment; information such as date and location of launch as well as basic orbital parameters; inspection of documents relating to information required; give maximum liability amounts; End of Life disposal operations; and termination date of license. Regarding the information under review, the licensee is required to conduct operations in such a way as to:

> Prevent the contamination of outer space or adverse changes in the environment of earth, avoid interference with the activities of other in the peaceful exploration and use of outer space, and preserve the national security of the United Kingdom.[27]

Currently under OSA 1986, a license requires third-party liability as part of the terms of the license.[28] Orbital operations require €60m for insurance and indemnity but this could be higher for higher risk missions or waived for low-risk missions (though a waiver only applies to insurance and not €60m on indemnity).[29] The UK government website has a useful Spaceflight Legislation and Guidance[30] webpage has tables for understanding third-party liabilities and insurance requirements. Under Section 7 of OSA 1986 space objects must be registered through

---

[24] Ibid, s4

[25] UKSA, 'Guidance on Satellite Licence Fees for Constellation Operators' (*UKSA* 1 June 2022) <https://www.gov.uk/government/publications/guidance-on-satellite-licence-fees/guidance-on-satellite-licence-fees-for-constellation-operators> accessed 28 February 2023

[26] Outer Space Act 1986 (UK) s5

[27] Ibid

[28] Ibid, s5

[29] UK government, 'Spaceflight Legislation and Guidance' (*UK government*, published 16 April 2014, updated 29 July 2021) <https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986> accessed 06 October 2021

[30] Ibid

the United Kingdom and will then also be registered with UNOOSA as per the international obligations of the UK under the Registration Convention.[31] These are the main articles of OSA 1986 for acquiring a license for conducting space operations through the UK but launched from foreign soil. However, there is a parallel licensing process through Ofcom regarding the utilisation of the radio frequency spectrum.

Ofcom works with the ITU regarding actors wishing to file for radio frequency spectrum utilisation for satellites. Both the ITU and Ofcom suggest that "spectrum and orbital positions are valuable and limited resources"[32] and as such filings for radio utilisation support the management and coordination of the spectrum to avoid interference and allow for the appropriate use of the spectrum. The *Ofcom Procedures for the Management of Satellite Filings*[33] adheres to the ITU Radio Regulations particularly Article 5 on frequency allocations, Article 9 on coordination, and Article 11 on notification and recording of frequency assignments.[34] Ofcom allocates and coordinates radio frequency spectrum utilisation for UK actors by registering satellite frequency assignments to the ITU MIFR; adhering to Radio Regulations Article 49 on due diligence;[35] and by complying with related international law such as the Outer Space Treaties and the Radio Regulations as well as the OSA 1986 nationally speaking.

Submitting an application to Ofcom must be done in electronic format and in accordance with the ITU. According to the Ofcom *Procedures for the Management of Satellite Filings*:

> Ofcom will only file a satellite network application to the ITU on behalf of an applicant whose satellite network(s) meets the criteria contained in this document and which is consistent with the ITU Radio Regulations.[36]

This criteria Ofcom mentions are heavily reliant on due diligence requirements as well as establishing:

[31] Outer Space Act 1986 (UK) s7
[32] Ofcom, 'Procedures for the Management of Satellite Filings' (*Ofcom* 14 March 2019) 1
[33] Ibid
[34] International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn)
[35] Ibid
[36] Ofcom, 'Procedures for the Management of Satellite Filings' (*Ofcom* 14 March 2019) 19

> To the satisfaction of Ofcom, that their satellite project can be realised within the relevant regulatory time limits and the relevant technical and operational parameters[37]

as well as the management of the satellite and should be consistent with radio frequency allocations and allotments made by the ITU and the UK. Overall, Ofcom has a duty to ensure that all applications submitted to them and then on to the ITU are consistent with the ITU Constitution, Convention, and Radio Regulations.

Due diligence is part of Ofcom's requirements for radio frequency utilisation as it adheres to Resolution 49 of the ITU Radio Regulations.[38] The main consideration is stated under Resolution 49 c which considers "… that administrative due diligence should be adopted as a means of addressing the problem of reservation of orbit and spectrum capacity without actual use"[39]. These filings without actual use are called 'paper satellites' which limit the equitable use of the radio frequency spectrum by hoarding the frequency before it is needed. Ofcom works with the ITU to establish due diligence by licensees by ensuring:

> That filings are only submitted to the ITU where there is a reasonable prospect that the proposed network will be brought into operation within the relevant time period. It also serves to address the problem of reservation of orbit and spectrum capacity without actual use …[40]

Ofcom has four stages of milestones for that are due diligence requirements which must be provided to Ofcom for the application to be evaluated and potentially granted.[41] Once a license for radio frequency utilisation is given, it can be cancelled temporarily or permanently, by way of authority from the Radio Regulations, if the licensee causes harmful interference to other satellites.

Once a license has been provided for both the space object and the radio frequency utilisation, there is also the need to procure a launch which would require a contract with the satellite owner/operator and the launch provider. At this point in time there are no legal requirements for end-of-life procedures once the satellite ceases to operate or the mission is complete. It is encouraged to adhere to the Space Debris Mitigation Guidelines and consider the 25-Year Rule

[37] Ibid, 19
[38] International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn)
[39] International Telecommunications Union, Radio Regulations Volume III, Resolution 49 (Rev. WRC-12) 57
[40] Ofcom, 'Procedures for the Management of Satellite Filings' (*Ocfom* 14 March 2019) 21
[41] Ibid

where satellites should de-orbit within 25-years after ceasing operations. For some small and very small satellites the 25-Year Rule is too long and for others it is either applicable or too short.

National regulations regarding licensing and launching are critical steps to performing safely, securely, and sustainably on-orbit. Owning and operating one satellite can be quite a success for start-ups, academia, and emerging space States. Continuously launching satellites suggests that the actor is routinely compliant with national space law and licensing requirements. Where the biggest challenge lies today is with the operating of satellite constellations and 'mega' constellations. This next section will speak more specifically on these satellite constellations. While they also adhere to the same laws, regulations, and licensing procedure as all satellites, there are some additional considerations and challenges that need to be addressed. Specifically, if actors would like to see LEO sustainably used for current and future generations. The topic of satellite constellations is an important one for the space community as of time of writing this research (2019-2023) because LEO is already a congested orbit. Looking at the uses and challenges of satellite constellations in the next section, adds to understanding what is needed moving forward for a LEO governance framework that considers all activities and challenges on-orbit. This in turn, also helps answer the research questions proposed in this research.

6.2 Satellite Constellations and Mega Constellations

Satellite constellations (and mega constellations) are the tool of choice for contemporary space activity as can be seen by Starlink, OneWeb, and others.[42] With more actors in space having interest in using satellite constellations in Low Earth Orbit[43], and with LEO already congested with activity and space debris, constellations will be a challenge for the LEO governance framework. This section will discuss the origins of constellations, what they are, why they are useful in LEO, and the challenges they might create in terms of the 3S as well as legally. It is important to discuss satellite constellations as they are a big part of LEO activity and as such

[42] Lauren Napier and Christopher J Newman, 'Regulation of Satellite Constellations' in Yanal Abul Failat and Anél Ferreira-Snyman (eds), *Outer Space Law: Legal Policy and Practice* (2nd edn, Global Law and Business 2022)

[43] Lauren Napier, 'Thousands more satellites will soon orbit Earth – we need better rules to prevent space crashes' (The Conversation 28 January 2021) <https://theconversation.com/thousands-more-satellites-will-soon-orbit-earth-we-need-better-rules-to-prevent-space-crashes-154014> accessed 20 February 2023. See also: Lauren Napier and Christopher J Newman, 'Regulation of Satellite Constellations' in Yanal Abul Failat and Anél Ferreira-Snyman (eds), *Outer Space Law: Legal Policy and Practice* (2nd edn, Global Law and Business 2022)

regulatory considerations pose a challenge for the framework, which links to this overall research and answering the research questions.

6.2.1 Origins of Constellations

The concept of satellites working together in synchronization thus creating a 'satellite constellation' is not a new utilisation of satellites, nor is it restricted to use by commercial (non-State) operators. One of the first satellite constellations, Transit, was operated by the United States through the Defense Advanced Research Projects Agency (DARPA) and then later through the US Navy. The first Transit satellite entered orbit in 1960 and "… by 1968, a fully operational constellation of 36 satellites was in place…"[44] and operated until 1996 when the system was replaced by the current Global Positioning System (GPS). Transit is just one of several examples of early satellite constellations. In fact, there are satellite constellations operated by State and non-State actors in the United States, Russia, China, and Europe. A boom occurred in the 1990s when companies decided to provide connectivity on a global scale.

According to McKinsey:

> Globalstar, Iridium, Odyssey, and Teledesic had impressive plans. In the end, however, all but Iridium scaled back or cancelled their intended constellations because of high costs and limited demand. All suffered financial problems.[45]

Today there are many actors operating satellite constellations and forming constellations.[46] The most well-known is SpaceX's Starlink satellite constellation which aims to provide global broadband Internet. Another satellite constellation getting attention is the UK OneWeb communications constellation. Amazon has proposed a satellite constellation called Kuiper but as of late 2021 no satellites have been deployed into LEO. While most of the media and industry attention is fixated on the battle of the commercial sector and their satellite constellations in LEO, specifically US companies SpaceX and Amazon, there are also civil and military satellite

---

[44] Defense Advanced Research Projects Agency, 'Transit Satellite: Space-based Navigation' (2020) <https://www.darpa.mil/about-us/timeline/transit-satellite> accessed 31 August 2020

[45] Chris Daehnick, Isabelle Klinghoffer, Ben Maritz, Bill Wiseman, 'Large LEO Satellite Constellations: Will it be Different this Time?' (4 May 2020) <https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time> accessed 2 September 2020

[46] This information discussed in this paragraph was made possible by having access to the SpaceTrak database hosted by Seradata. See Seradata, 'Welcome to Seradata' (*Seradata*, 2021) <https://www.seradata.com/> accessed 11 November 2021

constellations in use. In fact, one of the largest military satellite constellations on-orbit in LEO is from China with almost 60 satellites. While it is fair to say that there are about 75 satellite constellations on-orbit in LEO as of late 2021, it is not easy to classify which ones should be considered 'mega' constellations. Therefore, the next section will touch upon defining constellations.

6.2.2 Definitions

There is currently no legally binding definition for satellite constellation nor for the newer term 'mega constellation'. However, a few working definitions are available that can give some insight into the meaning of said satellite constellations – mega or otherwise. A satellite constellation is "… a number of similar satellites, of a similar type and function, designed to be in similar, complementary, orbits for a shared purpose, under shared control".[47] Yet, the term mega constellation can be interpreted as a larger system than a satellite constellation. In fact, "… the question arises whether there should be a certain minimum number of satellites in order to call a group of satellites a constellation".[48] Do two plus satellites make a satellite constellation? Would 100 satellites then create a mega constellation? According to the International System of Units (SI), 'mega' is a prefix denoting a factor of one million (10^6 or 1000000). The Oxford Dictionary defines 'mega' as "very large"[49]. Therefore, interpretations of how to correctly use 'mega' could vary. The term 'mega constellation' has become a buzzword in the media and has become a colloquial term meaning large satellite constellation. The ITU uses the terminology of 'large' constellations or 'non-geostationary (non-GSO) satellite systems' and does not make use of the prefix 'mega' within the Constitution and Convention. Under Radio Regulations Resolution 35, as was updated at the World Radiocommunication Conference 2019 (WRC-19)[50]. The term 'mega constellation' was used in the Key Outcomes of the WRC-19 where the new resolution was highlighted as establishing "… regulatory procedures for the deployment of NGSOs, including mega constellations …"[51]

[47] Lloyd Wood, 'Satellite Constellation Networks' in Yongguang Zhang (ed) *Internetworking and Computing Over Satellite Networks* (Springer 2003) 13
[48] Damian M. Bielicki, 'Legal Aspects of Satellite Constellations' (2020) 45 (3) Air and Space Law, 245-264, 246
[49] Oxford English Dictionary, 'Mega' (*OED*) <https://www.oed.com/> accessed 24 November 2022
[50] International Telecommunications Union, World Radiocommunication Conference 2019, Res 35, 222
[51] International Telecommunications Union, 'Key Outcomes of the WRC-19' (2020) PG

in Low Earth Orbit. This utilisation of the term ‘mega constellation’ is most likely colloquial as, in fact, the newly adopted Resolution 35, at WRC-19, stipulates:

> a) that filings for frequency assignments to non-geostationary-satellite (non-GSO) systems composed of hundreds to thousands of non-GSO satellites have been received by ITU since 2011, in particular in frequency bands allocated to the fixed-satellite service (FSS) or the mobile-satellite service (MSS).[52]

Radio Regulations Resolution 35, in relation to defining mega constellations, suggests that these satellite systems are “composed of hundreds to thousands” of satellites and has done so since 2011. While the ITU is a regime of itself, because it is part of the outer space regime complex as mentioned before, this does grant consideration for how the ITU defines satellite constellations of all sizes. Especially given that the ITU is tasked with granting radio frequency spectrum utilisation to all future constellations.

Conducting a web search of the largest satellite constellations currently on-orbit in LEO (which includes Starlink, OneWeb, Planet, Spire, and Swarm – all US companies apart from OneWeb which is UK) the terms ‘network’ (OneWeb, Swarm), ‘internet system’ (Starlink) and ‘constellation’ (Planet, Spire). None of the companies used the term ‘mega’. Only Planet used a term of measurement referring to their flock of Doves satellite constellation. Planet says, “Our Doves, … make up the world’s largest constellation of Earth-imaging satellites …”[53]. It is true that Planet does have the largest Earth Observation satellite constellation at over 180 satellites so perhaps the use of the term ‘largest’ has more to do with showing how broad the coverage is when someone pays for the use of Planet’s products rather than trying to define the constellation as a ‘large’ or ‘mega’ constellation.

For the purpose of this research, a satellite constellation will be understood as two to one hundred satellites working together (including active and inactive – hibernation/stand-by) while a mega constellation will be defined as one hundred and one to thousands of satellites working together (including active and inactive – hibernation/stand-by). The latter matches up with the ITU understanding of mega constellations and as the ITU is part of the Outer Space Regime complex it seems fitting to defer to this understanding.

---

[52] International Telecommunications Union, World Radiocommunication Conference 2019, Res. 35, 222

[53] Planet, ‘Our Approach’ (*Planet,* 2021) <https://www.planet.com/company/approach/> accessed 11 November 2021

6.2.3 Advantages to Satellite and Mega Constellations

Overall, constellations[54] are used for a variety of purposes such as navigation, telecommunications, Earth Observation, or for military purposes. For example, according to the ITU:

> More recently, companies are planning large scale constellations in low- and mid-Earth orbits to provide global satellite internet, or Internet of Things [IoT] to connect machines and systems together directly.[55]

The most prominent example being SpaceX's Starlink constellation system which provides high-speed, low latency broadband Internet with near-global coverage. Currently, the first-generation batch of satellites has reached over 1,700 on-orbit since SpaceX started launching the constellation system in late 2019. It has been suggested that the second generation will have almost 30,000 satellites in the constellation. According to updated information in late 2021, "… the preferred configuration for Gen2 would feature 29,998 Starlink satellites in orbit, deployed at nine altitudes, ranging from 340km to 614km".[56] What this suggests is that Starlink may not be a mega constellation yet but if the 29,998 satellites proposed are put on-orbit this would classify as a mega constellation system.

As will be seen, there are many benefits to utilising satellite and mega constellations, however, there are also many challenges and drawbacks as well as unknowns that will be explored as well. Most of the advantages are of socio-economic, environmental, or security interests while many of the challenges and drawbacks are from legal, political, and scientific design.

Looking first at the benefits to utilising satellite constellations and mega constellations, essentially, constellations in LEO are small or very small satellites which are cheaper and quicker to bring on-orbit thanks in part to COTS parts and consist of shorter missions – all of which means loss of one or a few satellites in the constellation will not jeopardize the mission or cost the operator too much money or risk in the long-term. According to Volynskaya and Kasyanov, constellations have the advantages of reliability, timeliness, and low latency. For them, reliability is "when a number of satellites operate within the framework of a coordinated

---

[54] Herein the term 'constellation' can be understood to mean satellite constellations and mega constellations collectively unless stated otherwise.

[55] International Astronomical Union, 'Satellite Constellations' (12 February 2020) <https://www.iau.org/public/themes/satellite-constellations/> accessed 31 August 2020

[56] Michael Sheetz, 'SpaceX Adding Capabilities to Starlink Internet Satellites, Plans to Launch Them with Starship' (*CNBC,* 19 August 2021) <https://www.cnbc.com/2021/08/19/spacex-starlink-satellite-internet-new-capabilities-starship-launch.html> accessed 01 November 2021

programme [where] probable loss of one object will not result in disruption of the whole mission …"[57] This reliability suggests continual coverage, supporting the interests of the owner. Timeliness is meant through the implementation of new technology. Volynskaya and Kasyanov suggest:

> Orbital constellations are enlarged gradually, each launch places into orbit spacecraft created with the use of the latest technical and technological achievements. Such a scheme ensures timely decommissioning and replacement of earlier launched satellites upon their over aging…[58]

The gradual progression of sending up batches of satellites means newer satellites can improve on older models which in turn should lower risks on-orbit and create better performance in the long-run. Low latency is essentially the "… rapidity of data transmission (especially for Earth remote sensing satellites)"[59] and is needed "… to obtain rapid and detailed information"[60] especially regarding socio-economic or environmental concerns such as weather and natural disasters. In essence, satellite constellations can support "… non-stop global coverage of the Earth".[61] Meaning State and non-State actors will have a plethora of data at their disposal from space enabled services via these satellite and mega constellations. Some constellations will potentially give customers global broadband Internet coverage such as advertised by SpaceX's Starlink.

6.2.4 Challenges with Satellite and Mega Constellations

The challenges satellite constellations and mega constellations bring to the Low Earth Orbit governance framework are plentiful. From a strictly legal perspective, registration, liability, licensing, and the threat of appropriation of LEO are the target challenges both nationally and internationally. However, there are socio-legal issues such as the congestion and sustainable use of LEO given it is a quasi-finite resource which does pose some legal and ethical questions. Politically speaking, the above-mentioned concern over the appropriation of LEO would be a considerable deliberation over State power and control as well as State security issues. Strictly

[57] Olga A. Volynskaya and Rustam A. Kasyanov, 'Chapter 5: Launching Numerous Small Satellites – A Flourishing Business? The Case of the Russian Federation' in Irmgard Marboe (ed) *Small Satellites: Regulatory Challenges and Chances* (Brill 2016) 91
[58] Ibid, 91
[59] Ibid, 91
[60] Ibid, 91
[61] Ibid, 91

from an economic view, the fact that many of these constellations (mega or not) are competing in the commercial sector could create non-State actor competition or lack thereof such as is being played out between SpaceX, Amazon, and to a lesser extent, OneWeb. There are also issues that can be unpacked from a multidisciplinary view is that of how these constellations will change how the governance framework will need to address space situational awareness, space traffic management and the potential for more collisions and space debris. In terms of the radio frequency spectrum, these satellite systems bring a set of unique issues such as the finite resource of the spectrum, radio registration, and warehousing of the spectrum, that cross over from the ITU regime into consideration for the outer space regime. With more satellites comes greater possibility for cyber and radio attacks, such as through command and control (C2) or with ransomware – which crosses space security issues over to the ITU and cyber regimes. Lastly, ground-based astronomers are extremely frustrated by the incredible volume of satellites in LEO obscuring their views of outer space. All these challenges will be addressed, and at times interconnected, within this section.

6.2.5 Legal and Political Challenges in the Current LEO Governance Framework

As was mentioned above, legally, and socio-legally, there are many challenges created with the more popular use of satellite constellations and mega constellations. These challenges are connected to the wider Outer Space Regime by way of the outer space treaties, national space law and policy through licensing. The use of satellite constellations is also a challenge for the 3S as LEO needs to continue to be a secure, safe, and sustainable orbit for current and future use. This section will first unpack the issues relating to the Outer Space Treaties as well as international and regime-based challenges. Then discourse will be given on the challenges at the national level through regulations and licensing of these various-sized constellations. Finally, socio-legal, and ethical considerations will be given regarding the use of LEO as a sustainable and finite resource given the inclusion of space debris and the overall congestion on orbit.

Within the Outer Space Regime, the outer space treaties hold the core principles on the use of outer space – including Low Earth Orbit. Regarding satellite constellations and mega constellations there is no discrepancy that the Outer Space Treaty, the Liability Convention, and the Registration Convention apply. Article I of the Outer Space Treaty recalls that outer space is to be used by all States "without discrimination of any kind, on a basis of equality

…"[62] what could come into contestation here with respect to constellations – especially mega constellations – would be the equal use as currently over 64%[63] of all satellites (constellations and non-constellations) in LEO are considered under the jurisdiction of the United States which could lead some States to argue for a non-equal use of LEO. This then leads to Article II of the Outer Space Treaty which states that outer space "… is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means".[64] Though appropriation of LEO has, at this time, not been called into contention at the United Nations by any State, with the rise in utilisation of mega constellations, especially with 1000s+ satellites on orbit at a given time, there could be cause to call forth claims against appropriation of LEO. This argument has also been discussed by one space law expert who weighed pro and contra on the appropriation argument. While the expert did not give their learned opinion, they did offer compelling arguments for both sides of the story. Essentially issues over appropriation also connect to issues of equal use, due regard, harmful contamination, and coordination.[65] This section will take these initial observations and move toward a more detailed analysis leading to a finding on the issue of appropriation and mega constellations.

As was mentioned above, it is prohibited within the Outer Space Treaty to appropriate outer space – by any means. The grey area is that it is unknown whether one space actor – and by jurisdiction one State – launching 1000s+ satellites to form a larger constellation would be considered an act of appropriation. This would come down to whether other space actors and especially States Parties to the Treaty consider mega constellations to be appropriation because while these satellites are on orbit at a given altitude and on a specific plane no other satellite may occupy that point in LEO. Even though all satellites in LEO are "… moving through space and are not stationary…"[66] effectively making it harder to see constellation use as "… occupation, much less appropriation …"[67] While appropriation of LEO may not be clear

[62] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[63] This percentage is based on satellite on-orbit in LEO as of 10 November 2021. The percentage was created using data from the Seradata SpacTrak database. See Seradata, 'Welcome to Seradata' (*Seradata*, 2021) <https://www.seradata.com/> accessed 11 November 2021

[64] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

[65] Chris Johnson, 'The Legal Status of MegaLEO Constellations and Concerns about Appropriation of Large Swaths of Earth Orbit' in Joe Pelton (ed) *Handbook on Small Satellites* (Springer Nature Switzerland AG 2020) 17-24

[66] Ibid

[67] Ibid

regarding constellations and the dominance of the US on-orbit, there is one aspect of constellations that is a growing regulatory concern, and this is over the use of the limited resource known as the radio frequency spectrum. The next section will discuss the radio frequency spectrum as it pertains to satellite constellations and the rise of the mega constellations.

6.2.6 Radio Frequency Spectrum Utilisation and Constellations

In terms of the radio frequency spectrum, satellite constellations and mega constellations bring a set of unique issues to international and national regulators such as managing the limited resource itself as well as managing the equal use of the spectrum while avoiding harmful interference. The Telecommunications Regime, internationally supported by the UN specialised agency the ITU, crosses regimes by regulating satellite utilisation of the radio frequency spectrum. Therefore, this section details out how the ITU and national communications regulators, such as Ofcom in the UK, are part of the larger Outer Space Regime complex and what this means for the management of the spectrum for constellations and mega constellations.

In 2019 the World Radiocommunication Conference (WRC-19) saw ITU Member States adopting "… an innovative new milestone-based approach for the deployment of non-geostationary satellites (NGSO[68]) systems in specific radio-frequency bands and services".[69] The agreement established regulatory procedures for satellites being deployed in LEO – including mega constellations. Under the new procedures, operators of mega constellations:

> Will have to deploy 10% of their constellation within 2 years after the end of the current regulatory period for bringing into use, 50% within 5 years and complete the deployment within 7 years.[70]

This 'milestone approach' provides a regulated mechanism that aims to support that the Master International Frequency Register "… reasonably reflect the actual deployment of such NGSO

[68] Non-Geostationary Orbit (NGSO) refers to any orbit other than NGSO such as Low Earth Orbit (LEO). This terminology and categorization is used within the ITU for radio-frequency regulations.
[69] International Telecommunications Union, 'ITU Members Agree to New Milestones for Non-Geostationary Satellite Deployment' (20 November 2019) My ITU News <https://www.itu.int/en/myitu/News/2020/01/30/14/47/ITU-Members-agree-to-new-milestones-for-non-geostationary-satellite-deployment> accessed 06 September 2020
[70] Ibid

satellite systems in specific radio-frequency bands and services".[71] The approach adds to the already sophisticated coordination mechanism of the ITU in GSO by fine-tuning the coordination in LEO (or NGSO in ITU).

6.2.7 Ground-based Astronomy and Mega Constellations

One of the biggest challenges with constellations is the impact they are having on ground-based astronomy. According to the International Astronomical Union (IAU):

> We do not yet understand the impact thousands of these visible satellites scattered across the night sky and despite their good intentions, these satellite constellations may threaten …[72] [the dark and radio-quiet sky].

The principal complaint made by the IAU is that the metal used in the construction of the satellites is highly reflective and that reflections from constellations can make satellites appear as slow-moving dots in the hours after sunset and before sunrise. This can be detrimental to ground-based astronomy and the sensitivities of the telescopes. This is not a novel problem as ground-based astronomy already suffers from bright satellite trails in long exposure images. It is the sheer number of satellites that are proposed in these mega constellations – such as SpaceX's Starlink – that will make a piece of untainted, dark, and radio-quiet sky significantly harder to find.

As of April 2021, Chile, Ethiopia, Jordan, Slovakia, Spain, and the International Astronomical Union submitted a Conference Room Paper (CRP) to the 58th session of the United Nations Committee on the Peaceful Use of Outer Space Scientific and Technical Subcommittee (STSC) on Recommendations to Keep Dark and Quiet Skies for Science and Society (hereafter referred to as CRP Dark Skies). This CRP highlights three classes of interference to ground-based astronomy such as artificial light at night (ALAN); the growing number of LEO satellite trails; and radio-wavelength emissions.[73]

While the hype of the rise of the mega constellations and the growing presence of commercial actors in space are challenges within the current (and probably future) LEO governance

[71] Ibid
[72] International Astronomical Union, 'IAU Statement on Satellite Constellations' (3 June 2019) <https://www.iau.org/news/announcements/detail/ann19035/> accessed 06 September 2020
[73] UN Committee on the Peaceful Use of Outer Space, Scientific and Technical Subcommittee, 58th session, Recommendations to Keep Dark and Quiet Skies for Science and Society, A/AC.105/C.1/2021/CRP.17 (19 April 2021)

framework, another 'wicked problem' that persists in LEO is that of space debris. The next section will shift over to talk about the challenges of space debris regarding the sustainable use of LEO (as part of the 3S Approach). Space debris is the biggest concern in LEO because of the congestion of the orbit. This discussion on space debris will link to the 3S Approach as well as to the research questions because debris is something that must be addressed within the framework and will need to keep being addressed as the number of debris increases, or decreases, over time.

6.3 Space Debris

Without a doubt, the biggest challenge to the governance of LEO is space debris. Space debris is going to be the 'point of failure' of the governance framework, along with the congestion posed by satellite constellations, which is why it is critical that any model of governance used for LEO must address not only the 3S Approach, but also the congestion of the orbit. This section will look at what space debris is and how it is currently regulated as well as the political implications within the LEO governance framework.

Also known as 'orbital debris' or 'space junk', space debris is a hazard that poses considerable risk to the orbital environment, to the space objects, and to the astronauts aboard the International Space Station (ISS) and other human spaceflight activity in LEO such as the Chinese space station. As of June 2022, there are currently 25,000 pieces of trackable debris over 10cm and an estimated 500,000 between 1cm and 10cm.[74] Comparing this to the over 5000[75] active space objects in LEO, this data amplifies the fact that LEO is contested, congested and competitive and as such, is moving toward a non-renewable resource if not managed adequately. For the size of the debris, even down to the millimetre, is dangerous.

As an example, Aliberti, Napier, and Beischl suggest:

> Debris larger than 1 mm can cause perforations; debris larger than 2 cm can cause lethal collisions, resulting in the loss of a satellite; debris larger than

[74] NASA, 'Astromaterials Research & Exploration Science NASA Orbital Debris Program Frequently Asked Questions' (*NASA*, 2022) <https://orbitaldebris.jsc.nasa.gov/faq/#> accessed 02 June 2022
[75] This number was taken from using the SpaceTrak database on 02 June 2022. See Seradata, 'Welcome to Seradata' (*Seradata*, 2021) <https://www.seradata.com/> accessed 02 June 2022

10 cm can generate catastrophic collisions, having far reaching consequences.[76]

It is the size and speed at which the debris is orbiting together which makes the debris such a risk. At present there is no legally binding definition of space debris, however, according to the IADC, "space debris, also known as orbital debris, are all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional"[77]. This definition is taken as the de facto definition of space debris even though it is not legally binding. This definition was created by the IADC for their Space Debris Mitigation Guidelines (IADC SDMG) which was then applied to the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (UN SDMG) and is quoted with the same verbiage in the first paragraph on the background of space debris. The UN SDMG is a non-binding international law document endorsed by the UNGA in 2007 and since then has been implemented into many States' space law and policies.

Space debris can stay in orbit from days to decades as it depends on the altitude of the debris and the effects of atmospheric drag as it is being pulled back toward Earth's atmosphere where it will eventually burn up upon re-entry. For example:

> At 400 km, an object would not stay in space longer than one year," says Krag. "At 600 km, it would probably not remain there longer than 25 years. At 800 km, because the atmospheric drag is much weaker, it would stay for 200 years. And at 1000 km, it would stay forever.[78]

As most satellites in LEO are at between 300-1000 km (which ranges from debris staying on-orbit from under 25 years to over 1000 years[79]), it is imperative that space debris mitigation and remediation measures be considered for the long-term sustainability of the orbit. It is also important to understand that space debris does not appear out of nowhere. According to Aliberti, Napier, and Beischl sources of space debris may include:

---

[76] Marco Aliberti, J. Lauren Napier, and Christoph Beischl, "Orbital Congestion: Assessing the Prospects for Effective Governance Structure through Regime Theory" (2016, International Astronautical Federation) 67th International Astronautical Congress, IAC-16, E3.IP.3, 2

[77] Inter-Agency Space Debris Coordination Committee, *Key Definitions* (IADC, 2013)

[78] Holger Krag as quoted in Tereza Pultarova, 'Keeping Space Tidy: Industry Steps Up Junk Management Efforts' *Via Space* (August 2019) 18-22, 21

[79] United Nations Office of Outer Space Affairs, 'UNOOSA and ESA Space Debris Infographics and Podcasts' (UNOOSA, 10 February 2021) <https://www.unoosa.org/oosa/en/informationfor/media/unoosa-and-esa-release-infographics-and-podcasts-about-space-debris.html> accessed 11 November 2021. See Infographic 2: Falling to Earth Takes a Long Time

> In-orbit explosions, decommissioned or failed objects, intentional destruction of a space object, collision of space objects, solid rocket motor firing, ejection of reactor cores, intentional object release, or spacecraft surface erosion.[80]

Space debris can be taken as a hazard, or a threat with security implications. Further, according to the UN Space Debris Mitigation Guidelines:

> Historically, the primary sources of space debris in Earth orbits have been (a) accidental and intentional break-ups which produce long-lived debris and (b) debris released intentionally during the operation of launch vehicle orbital stages and spacecraft. In the future, fragments generated by collisions are expected to be a significant source of space debris.[81]

Debris released intentionally during operations such as spent rocket boosters makes up most of the 'legacy' debris from the then Soviet Union and US during the beginning of space travel.

As of 2021, most space debris in LEO is primarily made up of spent rocket stages (roughly 1,950[82] pieces), notably from the Russian Federation and the United States. It has been argued that the "most dangerous pieces of space debris that are up in the orbit right now are spent rocket bodies"[83]. This idea of future space debris being generated by collisions, or intentionally because of ASAT testing, is already a reality, which will be discussed in brief further on in this section.

From a mathematical point of view, space debris has also been defined by what is known as the 'Kessler Syndrome' which hypothesizes that "… debris populations can reach a certain magnitude where chain reactions of collisions will continue to produce debris even if no new objects are placed in that orbital region"[84]. What this means for LEO is that if the current

---

[80] Marco Aliberti, J. Lauren Napier, and Christoph Beischl, "Orbital Congestion: Assessing the Prospects for Effective Governance Structure through Regime Theory" (2016, International Astronautical Federation) 67th International Astronautical Congress, IAC-16, E3.IP.3, 1

[81] United Nations General Assembly Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) A/62/20 Annex or Resolution 62/217

[82] United Nations Office of Outer Space Affairs, 'UNOOSA and ESA Space Debris Infographics and Podcasts' (UNOOSA, 10 February 2021) <https://www.unoosa.org/oosa/en/informationfor/media/unoosa-and-esa-release-infographics-and-podcasts-about-space-debris.html> accessed 11 November 2021. See Infographic 1: Satellites Versus Debris

[83] Mike Safyan as quoted in Tereza Pultarova, 'Keeping Space Tidy: Industry Steps Up Junk Management Efforts' *Via Space* (August 2019) 18-22, 22

[84] Thomas K. Percy and D. Brian Landrum, "Investigation of National Policy Shifts to Impact Orbital Debris Environments" (2014) 30 Space Policy 23-33, 25

governance framework continues as it is with no remediation, the orbit could become an increasingly limited, or even, non-renewable resource. According to the Organisation for Economic Co-operation and Development (OECD):

> From an economic perspective, Earth's orbits and electromagnetic spectrum are "common pool resources", in the sense that they are characterised by [a] low level of excludability [meaning] no single actor can establish control over the good [and a] high subtractability of use [meaning] use by one agent detracts from the amount available to others.[85]

As it stands Low Earth Orbit is a common pool, limited, renewable resource and with the rise of the use of mega constellations and the potential increase for collisions causing more debris, this renewable resource will be even more congested and competitive than it is already. Perhaps even driving LEO toward a non-renewable resource environment. Therefore, solutions need to be put into place through the LEO governance framework that would incorporate mitigation, remediation, space situational awareness (SSA) and space traffic management (STM) in a practical manner. Space debris mitigation "… consists of all efforts to reduce the generation of space debris through measures associated with the design, manufacture, operation, and disposal phases of a space mission"[86]. While space debris remediation "… consists of efforts to manage the existing space debris population through active space debris removal with emphasis on densely populated orbit regions"[87]. Therefore, having monitoring and management as well as mitigation and remediation of space debris as part of the Low Earth Orbit governance framework is critical for the long-term sustainability of the orbital environment.

Along with the IADC and UN COPUOS and the Space Debris Mitigation Guidelines which will be discussed in the next section on space debris and international space law, there is another organisation, CONFERS as well as various companies, such as Astroscale (Japan, UK) that are involved in finding solutions to space debris in the long-term.

In sum, this issue of debris, or pollution, to use an environmental term, is not a new concept. In fact, the RAND Corporation identified comparable problems such as acid rain, hazardous

---

[85] Organisation for Economic and Co-operation Development (OECD), Space Sustainability: The Economics of Space Debris in Perspective, OECD Science, Technology and Industry Policy Papers (April 2020) No. 87, 15
[86] Inter-Agency Space Debris Coordination Committee, *Key Definitions* (IADC, 2013)
[87] Ibid

waste, and oil spills to share similarities with space debris because they all share the following characteristics:

> Behavioral norms (past and/or present) do not address the problem in a satisfactory manner. If the problem is ignored, the risk of the collateral damage will be significant. There will always be an endless supply of "rule-breakers". The problem will likely never be considered solved because the root cause is difficult to eliminate.[88]

It is this idea that the behaviour of actors regarding satellite missions and end of life procedures is linked to space debris is in fact why the governance framework of LEO must include strategies for keeping the orbit sustainable for current and future utilisation. These challenging characteristics of space debris (technically, legally, and politically) can be analysed from both the international law and international relations perspectives, as they should be, based on the gravity of the situation.

6.3.1 Space Debris and International Space Law

Looking at the legal framework of the Outer Space Regime, there are elements of treaty law that can be applied to space debris from the OST and the Liability Convention. There are also many NBIL agreements that are more directly applied to space debris based on the criteria that space debris is explicitly mentioned. Additionally, some national space law and policy does include mention of space debris as is the case in the UK.

As always, taking the OST as the foundation and starting point for international space law, it is to be reminded under Article I and Article II that outer space – which includes LEO – shall be explored and used by all and shall not be "… subject to national appropriation …"[89] This can be argued then that as space debris increases in quantity it could limit the exploration and utilisation of LEO and make it harder for other State and non-State actors to fulfil their right to access the orbit. This then would go in direct violation of the second paragraph of Article I which stipulates that outer space, again including LEO, "… shall be free for exploration and

[88] Dave Baiocchi and William Welser IV, *Confronting Space Debris: Strategies and Warnings from Comparable Examples including Deepwater Horizon* (Rand Corporation, 2010) xiv-xv

[89] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

use by all States without discrimination of any kind, on a basis of equality…"[90]. Therefore, according to the Outer Space Treaty, it is in the best interest of all States Parties to the Treaty to consider how to reduce space debris now and in the future so as not to blatantly violate Article I or Article II.

Article VIII of the OST stipulates that States Parties to the Treaty "… on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object …"[91] While Article VIII does not explicitly mention space debris, it also does not specify that the object must be a functioning or active object; only that it must be on the States' registry which in turn makes that State responsible for jurisdiction and control. Therefore, it can be argued that space debris – as has been confirmed with the definition above – is still a space object ergo, it shall also be controlled by the registered State. The problem here being that most debris is not attributable to an actor because of the size of the pieces. Causation of debris is tricky because operators do not have local understanding of the LEO environment and cannot always know who is to blame. It is hard to prove fault meaning actors may not be able to, or want to, claim responsibility. OST Article VIII can support this issue because States retain control over space objects meaning they have a due regard towards not creating debris in the first place.

Speaking of due regard, Article IX of the OST requires States Parties to the Treaty that they "… shall conduct all their activities in outer space … with due regard to the corresponding interests of all other States Parties to the Treaty".[92] The due regard principle – found also in international law – encourages actors to think of the needs of the many over the needs of the one or few. From this it can be argued that space debris could be a form of negligence that is in breach of the due regard principle. Causation and fault can be difficult to find on-orbit.

What does this mean for non-State actors? Article VI of the OST mentions that:

> States Parties to the Treaty shall bear international responsibility for national activity in outer space … whether such activities are carried out by governmental agencies or by non-governmental entities …[93]

[90] Ibid
[91] Ibid
[92] Ibid
[93] Ibid

As States are held accountable for non-governmental entities and the exploration, use, and activity in space they may endeavour to create will fall to the State for international accountability as well. Meaning it is in the best interest of States Parties to the Treaty to have non-governmental or non-State actors following international space law as well, which is primarily done through national space law and policy as well through national regulations and licensing procedures. Ergo, it is up to the registering State to hold their non-State actors accountable.

Speaking more on liability regarding space debris, the Liability Convention states in Article III that:

> In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State … by another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.[94]

In LEO there must be damages due to fault to become an issue of liability. Article IV denotes that there shall be joint and several liability when damage is caused to a third State or under Article V "whenever two or more States jointly launch a space object …"[95]. As has been analysed in this research, it is incredibly hard to prove fault in outer space as no one can directly see the incident and, regarding space debris, it is hard to determine to which State (or non-state) actor the debris belongs to, based on the small size of the fragments under consideration. However, if there is the ability to find causation and proof of fault then the Liability Convention does have specific articles applicable to LEO and space debris situations. Article X allows for a claim of compensation for damage within one year of occurrence or when unknown, within one year of learning about the event. To date, the Liability Convention, a Claims Commission, or the international courts have yet to be utilised for damages resulting from space debris in LEO.

Turning to NBIL specifically applicable to space debris are the Space Debris Mitigation Guidelines (there are two sets: IADC SDMG and UN SDMG), the Long-Term Sustainability Guidelines, the Space Safety Coalition Standards, and some ISO standards. As has been

[94] Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187
[95] Ibid

mentioned before, NBIL are, as the name implies, non-legally binding documents, that may be upheld by State and non-State actors at their own discretion.

The Space Debris Mitigation Guidelines of the UN Committee on the Peaceful Uses of Outer Space (UN SDMG) were originally developed by the Inter-Agency Space Debris Coordination Committee (IADC):

> Reflecting the fundamental mitigation elements of a series of existing practices, standards, codes and handbooks developed by a number of national and international organizations.[96]

To first give a little background on the IADC, it is an "… international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space"[97]. Comprised of space agencies from Canada, China, France, Germany, India, Italy, Japan, Korea, Russia, Ukraine, the United Kingdom, the United States, and the European Space Agency (ESA); the IADC aims to:

> Exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options.[98]

The IADC cooperative forum took the Space Debris Mitigation Guidelines to the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) which then created a Working Group on Space Debris within the Scientific and Technical Subcommittee of UN COPUOS to develop the Space Debris Mitigation Guidelines used today in tandem with the original IADC Space Debris Mitigation Guidelines (IADC SDMG).

The biggest differences between the UN SDMG and the IADC SDMG are that the IADC SDMG includes definitions, orbital regions, a bit more technical detail, and the '25-Year Rule'. The IADC SDMG states that LEO as a region is a "spherical region that extends from the Earth's surface up to an altitude (Z) of 2,000 km"[99] and is seen as a protected region that should

---

[96] United Nations General Assembly Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) A/62/20 Annex or Resolution 62/217

[97] Inter-Agency Space Debris Coordination Committee, 'What's IADC' <https://www.iadc-home.org/what_iadc> accessed 7 July 2020

[98] Ibid

[99] Inter-Agency Space Debris Coordination Committee, 'IADC Space Debris Mitigation Guidelines' (IADC 2007) 6

be ensured of its safe and sustainable use now and in the future especially regarding space debris.[100] This forward-thinking tenet about LEO being a protected region to ensure the long-term sustainability of the orbit is built upon in the LTSG. For example, LTSG Guideline B.3 promotes the sharing of space debris monitoring information and Guideline D.2 asks for consideration on managing the debris population in the long-term.[101]

Another tenet of the IADC SDMG is the so-called ‘25-Year Rule’ is found in the IADC SDMG section 5.3.2 Objects Passing Through the LEO Region regarding de-orbiting or EoL activity during the post-mission phase. Accordingly, section 5.3.2 states:

> A spacecraft or orbital stage should be left in an orbit in which, using an accepted nominal projection for solar activity, atmospheric drag will limit the orbital lifetime after completion of operations. A study on the effect of the post-mission orbital lifetime limitation on collision rate and debris population growth has been performed by the IADC. This IADC and some other studies and a number of existing national guidelines have found 25 years to be a reasonable and appropriate lifetime limit.[102]

It is argued that a satellite in, or passing through, LEO should not be found to be on-orbit longer than 25 years after operations have been completed. This point was omitted from the UN SDMG and is not followed by all States. In fact, some non-State actors believe the ‘25-Year Rule’ is too long when applied to very small satellites which usually do not have a mission timeline on-orbit past 25 years or for satellites orbiting below 500km. The 25-Year-Rule is not always implemented either because EoL procedures are reflected less in licensing regulations and because not all satellites in LEO stay on-orbit this long.

Turning toward the UN SDMG, though only seven guidelines, the guidelines are overarching in that they “… should be considered for the mission planning, design, manufacture and operational (launch, mission and disposal) phases of spacecraft and launch vehicle orbital stages”.[103] These seven guidelines include:

---

[100] Ibid, 6

[101] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69

[102] Inter-Agency Space Debris Coordination Committee, ‘IADC Space Debris Mitigation Guidelines’ (IADC 2007) 9-10

[103] United Nations General Assembly Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) A/62/20 Annex or Resolution 62/217

> Guideline 1: Limit debris released during normal operations; Guideline 2: Minimize the potential for break-ups during operational phases; Guideline 3: Limit the probability of accidental collision in orbit; Guideline 4: Avoid intentional destruction and other harmful activities; Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy; Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission; and Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.[104]

While Guideline 7 does not apply to LEO, Guideline 6 is specific to LEO and guidelines 1-5 are applicable to all orbits. Each guideline then includes two paragraphs with more in-depth understanding of what that guideline entails. However, the UN SDMG does not give guidance on space debris remediation, issues pertaining to responsibilities and liabilities, or risk and insurance concerns.[105] The UN SDMG are meant for new and future missions and does not apply retroactively to missions already on-orbit.

In terms of space security measures, the UN SDMG does not directly refer to ASAT testing, however, under Guideline 4 it is understood that intentional destruction should be avoided. Additionally, there are no legal instruments that discuss the political challenges with debris removal. As most debris is so fragmented it is not possible to know the owner, any debris removal plan would have significant political weight to it because States would worry over the debris removal system perhaps making unauthorised removals or removing the wrong pieces – either accidentally or on purpose. It is also the worry of 'how close is too close' concerning debris removal and servicing near functioning satellites that makes debris fall under national security concerns. The discourse of space debris removal, as well as on-orbit servicing, become international and political in scope.

The UN SDMG and the IADC SDMG are not considered a panacea of space debris non-binding law and as such are not comprehensive thus neither set of guidelines are "… a cure to the space debris issue which is interwoven with safety, security, environmental, economic and equity

[104] Ibid

[105] Stephen Hobe and Jan Helge Mey, 'UN Space Debris Mitigation Guidelines' (2009) 58 German Journal of Air and Space Law, 388-403, 394

concerns"[106]. A caveat being that even though the guidelines (both iterations) are considered NBIL there are legally binding tenets of due diligence in general international law as well as within the Outer Space Treaty Article IX as due regard which could support the argument to mitigate space debris.

As for application, these guidelines should be voluntarily taken as measures toward space debris mitigation through national mechanisms or, in the case of non-State actors, any applicable mechanisms in order "… to ensure that these guidelines are implemented, the greatest extent feasible, through space debris mitigation practices and procedures".[107] Tracking implementation can be difficult as it means looking at all State and non-State actors' legal mechanisms and operational standards, respectively speaking, to see if the UN SDMG have been applied (both theoretically and practically). However, as of 2015, a Compendium of Space Debris Mitigation Standards was adopted by UN COPUOS which showcases all relevant international and national mechanisms – legally binding and non-legally binding – which can attempt to give an understanding of which States consider space debris mitigation to be important to their national space law and policy as well as implementation in national licensing procedures.

This Compendium of Space Debris Mitigation Standards has been implemented as a living mechanism on UNOOSA website as part of their capacity building activities in space law.[108] As of April 2021, 42 States have submitted documentation on their national mechanism(s) which may apply to space debris mitigation, which includes the major space-faring States such as Russia, the United States, Japan, France, Italy, and Germany but does not include China, Iran, or the UAE. Additionally, the United Kingdom has submitted that they have space debris mitigation requirements as relevant under the Outer Space Act 1986[109] which relates to all UK space activity with launches and operations taking place outside of the UK.

The LTSG specifically mentions space debris in several of the guidelines. Under Guideline A.2, 2 (b):

[106] Ibid, 395
[107] United Nations General Assembly Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) A/62/20 Annex or Resolution 62/217
[108] United Nations Office of Outer Space Affairs, 'Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations' <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html> accessed 7 July 2020
[109] Outer Space Act 1986 (UK)

> In developing, revising or amending, as necessary, national regulatory frameworks, States and international intergovernmental organizations should: Implement space debris mitigation measures, such as the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, through applicable mechanisms.[110]

Further, under Guideline A.2, 2 (f), actors should:

> Consider the potential benefits of using existing international technical standards, including those published by the International Organization for Standardization (ISO), the Consultative Committee for Space Data Systems and national standardization bodies. In addition, States should consider the utilization of recommended practices and voluntary guidelines proposed by the Inter-Agency Space Debris Coordination Committee on Space Research.[111]

Guideline B.3 which is titled "Promote the collection, sharing and dissemination of space debris monitoring information"[112] is specifically dedicated to space debris and mentions:

> States and international intergovernmental organizations should encourage the development and use of relevant technologies for the measurement, monitoring, and characterization of the orbital and physical properties of space debris. States and international intergovernmental organizations should also promote the sharing and dissemination of derived data products and methodologies in support of research and international scientific cooperation on the evolution of the orbital debris population.[113]

Finally, Guidelines D.2 entitled "Investigate and consider new measures to manage the space debris population in the long term" gives five sub-guidelines for space debris management for

---

[110] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69, 50

[111] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69, 50

[112] Ibid, 50

[113] Ibid, 50

the long-term sustainability of space. These five sub-guidelines include that States and international intergovernmental organizations should:

> … investigate the necessity and feasibility of possible new measures, including technological solutions, and consider implementation thereof, in order to address the evolution of and manage the space debris population in the long term. These new measures, together with existing ones, should be envisaged so as not to impose undue costs on the space programmes of emerging spacefaring nations.[114]

States and international intergovernmental organizations should also:

> … take measures at the national and international levels, including international cooperation and capacity-building, to increase compliance with the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.[115]

Guideline D.2 mentions that investigation of new measures could include various ways and means in which to extend the operational lifetime of a space object; prevent collisions with objects and debris that are non-operational or without propulsion systems; post-mission disposal measures; and designs to enhance safety during uncontrolled re-entry to Earth's atmosphere[116]. Additionally, regarding law and policy, States and international intergovernmental organizations should ensure that any new measures in managing space debris are "… compliant with the provisions of the Charter of the United Nations and applicable international law …"[117].

The mention of non-State actors (such as private actors) is not explicitly addressed in the above mentioned LTSG guidelines. Guideline A.3 covers this by mentioning how States should supervise non-governmental entities and their activities, especially regarding the long-term sustainability of outer space – which as can be seen would include space debris mitigation.

ISO, an independent, non-governmental organization with a membership of 163 States, includes space debris mitigation standards and are another set of NBILs. The most important ISO standard for space debris mitigation is ISO 24113 the Space Systems – Space Debris

[114] Ibid, 50
[115] Ibid, 50
[116] Ibid, 50
[117] Ibid, 50

Mitigation Requirements. All other ISO standards for space debris are nested under ISO 24113 and "… describe detailed requirements and implementation measures to comply with ISO 24113"[118]. Considered the most important document in the ISO space debris standards family, ISO 24113, amended in 2019, defines:

> The primary space debris mitigation requirements applicable to all elements of unmanned systems launched into or passing through near-Earth space, including launch vehicle orbital stages, operating spacecraft and any objects released as part of normal operations or disposal actions.[119]

Clauses have been included requiring space object collision risks to be managed and where possible collision avoidance manoeuvres should be performed as well as the inclusion of a design level impact risk assessment against debris and meteoroid impacts to space objects.[120] The ISO standards are technical in nature and apply to the space object operators directly to guide them through the mission design, operational, and EoL phases of the space object's life.

Nested under ISO 24113, are ISO 23312 entitled Space Systems – Detailed Space Debris Mitigation Requirements for Spacecraft, which is an amalgamation of previous ISO standards 16127, 16164, 23339, and 26872.[121] It is anticipated that the next amendment to ISO 24113 will include details regarding mega constellations.[122]

As can be seen from this section, there are many international instruments (predominately non-binding) that support actors in their understanding of how to conduct secure, safe, and sustainable actions in space with regards to space debris. The next section will look at national space law regarding space debris with a case study on the UK.

6.3.2 National Space Law and Space Debris: a UK Case Study

Looking at States, many have national space law and policies with components directly applicable to space debris mitigation. Within the UK there is the Outer Space Act 1986[123] which serves as the legal basis for regulation of space activity carried out in connection with the UK.

[118] H. Stokes, Y. Akahoshi, C. Bonnal, R. Destefanis, Y. Gu, A. Kato, A. Kutomanov, A. LaCroix, S. Lemmens, A. Lohvynenko, D. Oltrogge, P. Omaly, J. Opiela, H. Quan, K. Sato, M. Sorge, and M. Tang, 'Evolution of ISO's Space Debris Mitigation Standards', First International Orbital Debris Conference, 2019, 1
[119] Ibid, 3
[120] Ibid, 5
[121] Ibid, 5
[122] Ibid, 9
[123] Outer Space Act 1986 (UK)

Under the legislation of the OSA 1986, operators can apply, and be granted, a license to operate in space if certain criteria are satisfactorily met as per the understanding of the Secretary of State. Criteria applicable to space debris includes the fact that the UK will not grant a license unless the activities:

> Will not jeopardise public health or the safety of persons or property, will be consistent with the international obligations of the United Kingdom, and will not impair the national security of the United Kingdom.[124]

Furthermore, regarding the space environment and other actors, the UK requires the licensee:

> To conduct operations in such a way as to prevent the contamination of outer space … and to avoid interference with activities of others in the peaceful exploration and use of outer space.[125]

As part of the licensing procedure, the UK requires qualitative and quantitative technical analyses for the potential licensee to be granted a license. These technical analyses include safety and reliability functionality as well as an understanding of the hazards associated with and the risks the hazards pose "… to satellites and other on-orbit spacecraft".[126]

Additionally, according to the UK:

> during the safety review, applicants will be obliged to demonstrate compliance/conformance with existing norms/best practices in relation to measures such as the IADC Space Debris Mitigation Guidelines, Space Debris Mitigation Guidelines of the Committee, and the growing body of international standards relating to debris.[127]

The OSA 1986 is applicable to UK nationals and is a mandatory space law instrument. However additional compliance with the above mentioned NBIL as well as ITU recommendations and ISO standards is a determining factor for the issue of a license in the UK to conduct space activities.

---

[124] United Kingdom of Great Britain and Northern Ireland, 'Space Debris Mitigation Standards' in UNOOSA Space Debris Mitigation Compendium, <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html> accessed 9 July 2020

[125] United Kingdom of Great Britain and Northern Ireland, 'Space Debris Mitigation Standards' in UNOOSA Space Debris Mitigation Compendium, <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html> accessed 9 July 2020

[126] Ibid

[127] Ibid

Regarding the UK implementation of the Long-Term Sustainability Guidelines, they have produced a UN Conference Room Paper (A/AC.105/C.1/2021/CRP.16)[128] as of April 2021, reporting on the UK voluntary implementation of the LTSG. The document covers how the UK OSA 1986 as well as the Space Industry Act 2018 adhere to aspects of the LTSG, much like they do for the Space Debris Mitigation Guidelines.

6.3.3 Non-State Actors and Space Debris Regulations

Non-State actors are also creating NBIL which considers issues relating to space debris such as the Space Safety Coalition which is an:

> Ad hoc coalition of companies, organizations, and other government and industry stakeholders that actively promotes responsible space safety through the adoption of relevant international standards, guidelines and practices, and the development of more effective space safety guidelines and best practices.[129]

The Space Safety Coalition has published a living document on *Best Practices for the Sustainability of Space Operations*, which as of November 2021 is endorsed by 52[130] diverse types of non-State actors. Something that the SSC does well in these best practices is that they respect and recall the IADC SDMG, the UN COPUOS SDMG, and ISO 24113 and urge space industry non-State actors to implement said guidelines and standards alongside the LTSG and the SSC best practices. This forward thinking urging to implement NBIL on the part of non-State actors is important in showcasing that these actors do believe there is merit in a coordinated legal effort to keep space safe and sustainable.

Within the best practices themselves the SSC urges that all spacecraft owners, operators, and stakeholders should exchange information specifically regarding safety and collision avoidance as well as urging these actors to consider how their activities can keep space safe and sustainable through prioritising the space environment and it is needs in the long-term.

---

[128] See UN Committee on the Peaceful Uses of Outer Space, 'United Kingdom: Update on Our Reporting Approach for the Voluntary Implementation of the Guidelines for the Long-Term Sustainability of Outer Space Activities' (19 April 2021) A/AC.105/C.1/2021/CRP.16 <https://www.unoosa.org/res/oosadoc/data/documents/2021/aac_105c_12021crp/aac_105c_12021crp_16_0_html/AC105_C1_2021_CRP16E.pdf> accessed 11 November 2021

[129] Space Safety Coalition, 'Home Page' (*SSC*, 2020) <https://spacesafety.org/> accessed 9 July 2020

[130] Space Safety Coalition 'Endorsees' (*SSC*, 2021) <https://spacesafety.org/endorsees/> accessed 11 November 2021

These best practices stress the importance of spacecraft designed in the best ways feasible to encourage the safe and sustainable use of outer space.

What this means is that the Outer Space Regime and the Low Earth Orbit governance framework have an international law and non-binding international law foundation to further build upon in terms of space debris. This means that the wheel does not need to be reinvented; rather it is proof again that the Outer Space Regime is an evolving regime where NBIL is being built to align with the core space treaties but is also considering changes in science and technology regarding mitigating space debris, not only by States but by non-State actors as well.

The current Low Earth Orbit governance framework is rife with challenges, or 'wicked problems' as this section has demonstrated. From how to understand regulating very small and small satellites as well as satellite constellations and 'mega' constellations to dealing with the increasing amount of space debris. While there are political discussions at the international, regional, and national levels as well as international binding and non-binding instruments supported by national regulations and licensing, the LEO governance framework as it currently stands needs to find more concrete solutions to these challenges. One way to do this is to fully understand what components are needed for a LEO governance framework and how these components can fit together to create a safe, secure, and sustainable orbit for current and future generations. The next section will highlight what the current LEO governance framework components are and how they are functioning which will lead into the further sections discussing potential strategies for the governance framework as well as recommendations given by this research.

6.4 Components of Low Earth Orbit Governance Framework

6.4.1 Space System Segments

Though the majority of what is talked about regarding the governance of Low Earth Orbit is the satellites, these space objects are only one segment of a larger space system. Space systems are said to be comprised of three segments: satellites, data, and the ground infrastructure. There could also be a fourth component: the user or end user. Understanding that satellites are part of a bigger system is important to the governing of satellites, Low Earth Orbit, and the Outer Space Regime. Space systems are integrated into daily life which means threats – intentional or unintentional – could disrupt national security to daily use. It is this security element that leads decision-makers to consider how best to govern space systems to protect their assets and all levels of end-users. Thus, when considering the governance of Low Earth Orbit, it must be understood that the aim is not just to govern the LEO environment nor just the satellites, but the environment as well as the whole of the space system segments.

6.4.2 Actors

Just as space system segments must be considered for the governance of Low Earth Orbit, so should consideration be given for the diversity of actors utilizing the orbital environment. Currently there are State and non-State actors with assets in LEO, with variety from major States to emerging space States and companies to academic institutions. For example, as of November 2021, there were 73 States responsible for activities in Low Earth Orbit, the majority of which were activities of non-State actors. The dominate States in LEO are the United States and China. Most of the United States' satellites are commercial activities. This is largely thanks to the satellite constellations mentioned in the previous section with SpaceX's Starlink the biggest contributor to activity on-orbit. Even with the United States dominating the market, the fact that there are over 70 States responsible for activities in LEO suggests an expanding diversity of actors as it becomes increasingly cheaper, faster, and easier to access space.

6.4.3 Politics and Law

The fundamentals of governance rely on the current political and legal climate as well as how these impact the challenges within the sector. In space governance, the geo-political discourse on Earth has direct connotations for outer space. As was seen when the Outer Space Treaty was written, which heavily replied on the geo-political challenges of the Cold War between the then Soviet Union and the United States. Today is no different. The considerations of climate change and sustainability paired with the SDGs has made the space community more aware of the importance of a sustainable space environment – not just one that is safe and secure. With the broadening of interests in space in terms of why space is being utilized (not just for exploration and prestige) comes more agenda items at UN COPUOS on how satellites – and space systems more generally – can support the SDGs, disaster management, maritime activities, and other Earth-based concerns. This is particularly true in Low Earth Orbit. Most of the actors (specifically non-State, commercial actors) are focused on Earth Observation which means that activity in LEO is an extension of Earth. As is argued by Bowen, "Earth orbit is more like part of a proximate, crowded and contestable coastline and a littoral environment, rather than a vast, remote, distant and expansive ocean"[131]. This idea of Earth orbits being directly linked to Earth reflects the importance of geopolitical and political understanding which will have direct implications toward any adaptation to the LEO governance framework and the Outer Space Regime more generally.

As is stated in the OST under Article III,[132] activities in space are in accordance with international law. Any updates or global discussions relating to general international law could also affect international space law. With the growing interest in non-binding law, especially around norms of behaviour and being a responsible actor, there is much in terms of international instruments across the regime complex that require national implementation. This also can shape how the governance moves forward and how States wish to shape future governance frameworks given the flexibility of non-binding instruments and the rapidity of technology advancements.

6.4.4 Radio Frequency Spectrum

A critical component to the governance of LEO is situated in the telecommunications regime. The management and use of the radio frequency spectrum are still an integral part of the Low Earth Orbit governance framework. National offices of communications work with the International Telecommunications Union to manage and maintain the sustainable use of the limited resource. Any consideration of updating the governance framework in LEO and the overall evolution of the Outer Space Regime must include consideration of radio frequency management.

6.4.5 Situational Awareness

Situational Awareness (SA) is important for a wide variety of operations such as flying aircraft, driving vehicles, or – in the case of this research – satellite operations. Endsley, a leading expert in situational awareness, defines situational awareness as "… the perception of the elements in

---

[131] Bleddyn Bowen, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press, 2020) 2
[132] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future".[133] SA is about the environment where the activity is being held. Being able to understand the environment and objects in a specific timeframe. Endsley further articulates that situational awareness "… involves far more than merely being aware of numerous pieces of data"[134] as it is overarchingly about knowledge "… pertaining to the state of a dynamic environment"[135]. Both a minute and a holistic understanding is needed to have true situational awareness. Situational Awareness spans across spatial and time-sensitive parameters allowing operators to take a more holistic understanding of the state of the environment in which they are operating over time. Operators "… must understand the integrated meaning of what they are perceiving in light of their goals"[136]. This means operators such as those in charge of command-and-control operations of satellites must factor in multiple variables and data in short periods of time to make the best judgement on how to proceed in the operation. This becomes increasingly more demanding and difficult in dynamic environments, such as, for example, on-orbit in LEO because:

> In dynamic environments, many decisions are required across a fairly narrow space of time, and tasks are dependent on an ongoing, up-to-date analysis of the environment. Because the state of the environment is constantly changing, often in complex ways, a major portion of the operator's job becomes that of obtaining and maintaining good SA.[137]

Obtaining and maintain good SA is difficult and can be stressful, which is why having situational awareness as part of a larger governance framework could be helpful.

The added caveat of on-orbit SA is that operators are not actually in the environment nor operating the satellite in the same way pilots fly planes, citizens drive cars, or captains steer ships. Satellite operators are back at a ground station supporting satellites via uplink and downlink telemetry which relies on telecommunication and cyber activity. The operators do not have a visual on satellites and the on-orbit environment in the same sense as operators in the air, on the sea, or on the road. Satellite operators must monitor for space debris, satellites (including active, inactive, or non-manoeuvrable), as well as for potential collisions. This

[133] Mica R. Endsley, 'Toward a Theory of Situation Awareness in Dynamic Systems' (1995) 37 (1) Human Factors: The Journal of the Human Factors Society, 32-64, 36
[134] Ibid, 32
[135] Ibid, 36
[136] Ibid, 34
[137] Ibid, 33

inability to have a true human local understanding of the space environment is part of the challenge with creating and maintaining successful SA in space. Situational awareness, performance, and decision-making are all different aspects that work together to make the best solutions for the desired outcome.

Situational awareness is about knowing what is going on and Endsley states there are three levels to best complete SA. Level 1 is the perception of the elements in the environment which is essentially taking stock of what is currently in the environment to "… perceive the status, attributes, and dynamics of relevant elements in the environment".[138] Level 2 is understanding the status quo of the environment to include a more holistic understanding of the environment and the elements. Level 3 looks to the future and allows "the ability to project the future actions of the elements in the environment – at least in the very near term"[139]. Taking Endsley's elements of SA as a jumping off point, Space Situational Awareness "… can be divided into three different sequential tasks: 1. Data collection … 2. Data analysis … 3. Communication to stakeholders …"[140]. This sequential tasking paired with Endsley's levels of SA make a strong start toward understanding what is necessary for a practical application of Space Situational Awareness.

6.4.6 Space Situational Awareness

Taking situational awareness as a baseline, Space Situational Awareness has been defined in different ways and has also been referred to as Space Domain Awareness (SDA) or Space Surveillance and Tracking (SST) which are slightly different than SSA. Regardless of which terminology is used, there are no legal definitions therefore, it is important to assess what is the best working definition for this research. In 2019, the US Air Force Space Command introduced the term Space Domain Awareness in an October 2019 memo. The reason the US military has changed the terminology is because they now consider space to be a war domain like the air, sea, and land. According to Space News, Air Force Space Command Deputy Commander Major General Shaw says:

[138] Ibid, 36
[139] Ibid, 37
[140] Quentin Verspieren and Hideaki Shiroyama, 'From the Seas to Outer Space: The Reverse Dynamics of Civil-Military Situational Awareness Information and Responsibility Sharing' (November 2019) 50 Space Policy, 1-6, 2

> Ihe implication of space as a warfighting domain demands [the US] shift [the] focus beyond the SSA mindset of a benign environment to achieve a more effective SDA, much the way the Navy works to achieve maritime domain awareness in support of naval operations and the Air Force strives for maximum air domain awareness to achieve air superiority.[141]

Additionally, Space News says the US October 2019 memo defines SDA as:

> The identification, characterization and understanding of any factor, passive or active, associated with the space domain that could affect space operations and thereby impact the security, safety, economy or environment …"[142] [of the US].

Because SDA is, first, US military specific, and second, predominately space security in scope, this research suggests that SDA is too narrow and Western hegemonic in scope for an international acknowledgement especially for States such as Russia, China, or Iran. Further, SDA does not consider that not all actors in space, especially in LEO, are military or State actors. This SDA terminology only further aids in the short-sighted and self-serving ideals found in space security rhetoric and throughout the regime complex. Space Domain Awareness is not international in scope and does not encompass non-State actors.

Space Surveillance and Tracking (SST), on the other hand, is part of the SSA programme at the European Space Agency (ESA). According to ESA, "a space surveillance and tracking (SST) system detects space debris, catalogues debris objects, and determines and predicts their orbits".[143] This SST data catalogue "… can be used to predict hazards to operational spacecraft, such as a potential collision with a debris object …"[144] Much like SDA, SST is too narrow in scope. While SST is applicable to all actors utilising orbits, the focus of SST is only on space debris which is only one, albeit large, challenge regarding the traffic on-orbit – especially in LEO. Neither SDA nor Space Surveillance and Tracking will be considered as the working definition of Space Situational Awareness within this body of research. While they cannot be

---

[141] Sandra Erwin, 'Air Force: SSA is no more; it's Space Domain Awareness' (*Space News*, 14 November 2019) <https://spacenews.com/air-force-ssa-is-no-more-its-space-domain-awareness/> accessed 14 August 2021 quoting Air Force Space Command Deputy Commander Major General John Shaw from his 4 October memo.
[142] Ibid
[143] European Space Agency, 'Space Surveillance and Tracking – SST Segment' (*ESA*, no date) <https://www.esa.int/Safety_Security/Space_Surveillance_and_Tracking_-_SST_Segment> accessed 14 August 2021
[144] Ibid

ignored, they are not all-encompassing concepts enough to satisfy the requirements of all actors, threats, or hazards on-orbit which in turn makes SDA and SST less than ideal norms for general SSA within the LEO governance framework. Not to mention that both SDA and SST are Western defined and on two opposing sides of rhetoric – security challenges versus peaceful uses challenges, even though, as will be seen, debris can come from accidental or intentional means.

Considering Space Situational Awareness more generally, some experts specify that there are three components of SSA – space weather, space objects, and space debris. According to Kennewell and Vo, a definition of this design suggests that SSA is:

> A knowledge of the energy and particle fluxes in near-Earth space, natural and artificial objects passing through or orbiting within this space, including past, present and future states of these components.[145]

While this definition is more in-line with ESA's SST, the loose understanding of 'artificial objects' to mean spacecraft (or satellite, or space object) also suggests those with military or warfare capabilities.

The Secure World Foundation (SWF) describes Space Situational Awareness as:

> The ability to characterize the space environment and activities in space. A key component of SSA is using ground- or space-based sensors, such as radars or optical telescopes, to track space objects. The tracking data from multiple sensors is combined to estimate orbits for space objects and predictions of their trajectories in the future. Other key components include space weather, characterization of space objects, and pre-planned maneuvers …[146]

The SWF definition gives a more technical understanding of what SSA is and how it works. This prediction of space object movement could imply for military strategy but does not explicitly suggest this.

The Space Security Index (SSI) refers to SSA as:

---

[145] John Kennewell and Ba-Ngu Vo, 'An Overview of Space Situational Awareness' (2013) 16th International Conference on Information Fusion, 1029-1036, 1029

[146] Secure World Foundation, *Handbook for New Actors in Space* (2017 edition Secure World Foundation) 40

> The ability to detect, track, identify, and catalogue objects in outer space, such as space debris and active or defunct satellites, as well as to observe space weather and monitor spacecraft and payloads for maneuvers and other events.[147]

The SSI definition covers more ground and could suggest security issues such as the Space Domain Awareness definition and debris issues as in the Space Surveillance and Tracking definition. It also gives the technical understanding of what SSA does.

Space Situational Awareness is critical because it can provide necessary knowledge for the safety, security, and sustainability of the Low Earth Orbit (LEO) environment. According to the International Academy of Astronautics (IAA), from the safety perspective:

> SSA plays an important role for the safety of spacecraft operations in orbit, in particular with a view to allow for conjunction and collision warnings between space objects.[148]

Furthermore, the Space Security Index suggests, from the security perspective that, SSA:

> Enhances the ability to distinguish space negation attacks from technical failures or environmental disruptions and can thus contribute to stability in space by preventing misunderstandings and false accusations of hostile actions.[149]

From the sustainability perspective, SSA allows for LEO to be considered as an environment where it can be monitored to maintain or to better utilize the orbit. According to Schrogl, SSA "is not so much an element of sustainable uses of outer space as it is an instrument to assess, implement and verify sustainability".[150] All these variables are why SSA data needs to be increased and available to all State and non-State actors to increase transparency and

---

[147] Space Security Index, *2019 Space Security Index: Executive Summary* (2019, 16th edition, Waterloo Printing) xi

[148] International Academy of Astronautics, *Space Traffic Management: Towards a Roadmap for Implementation,* Kai-Uwe Schrogl (ed) 2018, 76

[149] Space Security Index, *2019 Space Security Index: Executive Summary* (2019, 16th edition, Waterloo Printing) xi

[150] Kai-Uwe Schrogl, '4.4 Space and its Sustainable Use' in Christian Bruenner and Alexander Soucek (eds) *Outer Space Society, Politics and Law* (Springer Vienna 2011) 607

confidence-building measures of space activities as well as to "… reinforce the overall stability of the outer space regime"[151].

SSA services are predominately run by the United States Department of Defense (U.S. DoD) through the U.S. Strategic Command (USSTRATCOM) and has a SSA Sharing Programme which allows for multilateral data sharing between the U.S. and the United Kingdom, the Republic of Korea, France, Canada, Italy, Japan, Israel, Spain, Germany, Australia, the United Arab Emirates, and Norway. The U.S. Combined Space Operations (CSpO) supports coordinated Space Domain Awareness efforts through an initiative that includes Australia, Canada, New Zealand, the United Kingdom, France, and Germany.

Having SSA as a predominately US-led system with bilateral agreements suggests an unspoken US control of SSA. While this might work for the United States, its allies, and 'like-minded' States, it alienates SSA information and knowledge-sharing from States such as Russia, China, or Iran. Currently, SSA is not truly international in scope and those that use US-driven data are subject to US norms on SSA – further adding to the Western hegemonic rhetoric supported by opposing States. As of 2019, USSTRATCOM has signed 100 bilateral agreements to "… foster openness, predictability of space operations, and transparency in space activities".[152] As of April 2019, 20 States, two intergovernmental organizations, and 78 commercial actors have signed SSA 'data-sharing' agreements with USSTRATCOM. With the US in the leadership position of SSA, and only with those actors it deems 'responsible' limits a truly international, transparent, and equitable understanding of SSA which creates fragmentation for the LEO governance framework and for the future of space traffic management.

This understanding that Space Situational Awareness is the concept of Space Traffic Management within the LEO governance framework will be discussed further on in this research. According to the Secure World Foundation, "space situational awareness (SSA) is an important element of STM"[153]. The International Academy of Astronautics (IAA) understands that this reliance of SA on management is not unique to the Outer Space Regime. The IAA

---

[151] Space Security Index, *2019 Space Security Index: Executive Summary* (2019, 16th edition, Waterloo Printing) xi

[152] Karen Singer, '100th Space Sharing Agreement Signed, Romania Space Agency Joins' (*US Strategic Command*, 26 April 2019) <https://www.stratcom.mil/Media/News/News-Article-View/Article/1825882/100th-space-sharing-agreement-signed-romania-space-agency-joins/> accessed 14 August 2021

[153] Secure World Foundation, *Handbook for New Actors in Space* (2017 edition Secure World Foundation) 40

states that "any traffic management system relies on common situational awareness, and STM is no exception"[154]. The IAA considers SSA to be a prerequisite to STM specifically because:

> The successful establishment of an STM relies strongly on the capacity to reliably detect, track, identify and catalogue space objects on a global level as well as on the ability to authoritatively apply rules and standards to space engineering and operations.[155]

This research also takes that view that well developed SSA is important to the establishment and running of a competent STM system within the LEO governance framework. Situational Awareness as part of a traffic management system is already established in regimes such as maritime and aviation. It is well established that "at the basis of any form of traffic management is the knowledge of the environment and its actors …"[156], however, because the space environment is unique, the understanding of traffic management and what a 'space traffic management' system would look like must be analysed. The next section will discuss what is meant by traffic management, the current understanding of space traffic management, and what this means for the future of the Low Earth Orbit governance framework.

6.4.7 Traffic Management

Traffic management is not a new concept. It has used for road, air, and maritime traffic for quite some time. As 'space traffic', especially in Low Earth Orbit, is congested with active satellites and space debris, it is important to understand what is classically meant by a traffic management system to further consider whether this style of management could be applicable to the Low Earth Orbit governance framework. According to Thomson, traffic management:

> Includes all physical measures designed to influence the movement of traffic on an existing network. It excludes substantial alterations to the network itself, such as the installation of roundabouts and flyovers; it also

[154] International Academy of Astronautics, *Space Traffic Management: Towards a Roadmap for Implementation*, Kai-Uwe Schrogl (ed) 2018, 76
[155] Ibid, 8
[156] Quentin Verspieren, Hideaki Shiroyama, 'From the Seas to Outer Space: The Reverse Dynamics of Civil-Military Situational Awareness Information and Responsibility Sharing' (2019) 50 Space Policy, 1-6, 1

> excludes measure like taxation and licensing, which directly affect the volume of traffic or the type of vehicles used.[157]

Obviously, this definition of traffic management was written with the roadway system in mind however, it does provide a basic understanding of what is and is not included in traffic management. Thomson further argues that if a traffic management plan was not in effect, drivers would find their own ways through the traffic network and "… would have freedom to use the network to their greatest advantage …",[158] however, there could be boundaries to this freedom posed by other drivers. To have some structure, traffic management puts some restrictions on these freedoms of movement. Thomson suggests there are four categories of restrictions: route restrictions, right of way restrictions, parking restrictions, and speed limits.[159] While the definition of traffic management proposed here and the restrictions fit with land – and most likely air and sea – traffic, much of this does not apply to the physics of the orbital environment. For example, there is 'traffic' in Low Earth Orbit, however much of the traffic is space debris – non-manoeuvrable and non-functioning – and all the objects in LEO apart from the space stations are uncrewed. Which means the very nature of the traffic itself is vastly different that the traffic back on Earth. The four categories of restrictions posed by Thomson are not applicable to orbit with only a loose interpretation of right of way with the understanding that active satellites, where permissible, should attempt collision avoidance manoeuvres as often as possible, especially regarding the space stations. This begs the question of whether traffic management is indeed the correct terminology for space. The next section outlines the current understanding of space traffic management and give more insight into this question of whether the strategy is applicable to the Low Earth Orbit governance framework.

6.4.8 Space Traffic Management

The 1980s already saw the use of the term 'space traffic' with a more detailed discussion of the term occurring in the late 1990s which was then put into a study in 2006 by the IAA.[160] Now the discussion is about the importance of creating and maintaining a Space Traffic Management governance system which would have to include technical components such as

[157] J M Thomson, 'The Value of Traffic Management' (1968) 2 (1) Journal of Transport Economics and Policy, 3-32, 3
[158] Ibid, 4
[159] Ibid, 4
[160] Kai-Uwe Schrogl, '4.4 Space and its Sustainable Use' in Christian Bruenner and Alexander Soucek (eds) *Outer Space Society, Politics and Law* (Springer Vienna 2011) 609

SSA. According to the International Academy of Astronautics, Space Traffic Management is defined as:

> The set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.[161]

Taking this understanding of STM, it means STM as part of a governance framework could also be part of the regime itself as it applies to more than just Low Earth Orbit. However, STM can also be applied to LEO specifically within the governance framework.

The IAA then defines the purpose of STM as it provides:

> Appropriate means for conducting space activities without harmful interference. It supports the universal freedom to use outer space as laid down in the Outer Space Treaty of 1967. It should also be clear that for the purpose of achieving a common good, actors have to follow specific rules, which are also in their self-interest.[162]

This purpose of STM suggests that any Space Traffic Management plan must include consideration of international space law.

Space Traffic Management is analysed and applied to three phases of space operations: launch, on-orbit, and re-entry.[163] STM is highly critical, especially for emerging and new space actors, as it brings to the attention of all spacefaring actors the importance of the safety, security, sustainability, and stability of getting to, being in, and leaving space.

According to the U.S. Space Policy Directive 3 on a national space traffic management policy, the U.S. defines SSA, STM, orbital debris and an STM framework as follows:

> (a) Space Situational Awareness shall mean the knowledge and characterization of space objects and their operational environment to support safe, stable, and sustainable space activities. (b) Space Traffic Management shall mean the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and

[161] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Corinne Contant-Jorgenson, Petr Lala, and Kai-Uwe Schrogl eds, IAA 2006) 16.
[162] Ibid
[163] Ibid

> sustainability of operations in the space environment. (c) Orbital debris, or space debris, shall mean any human-made space object orbiting Earth that no longer serves any useful purpose. (d) A STM framework consisting of best practices, technical guidelines, safety standards, behavioral norms, pre-launch risk assessments, and on-orbit collision avoidance services is essential to preserve the space operational environment.[164]

As the United States is at the forefront of SSA capabilities and, as mentioned above, working multilaterally and bilaterally with other spacefaring State and non-State actors regarding SSA data sharing, it is important to mention the terms and definitions relating to SSA and STM as the U.S. is a norm entrepreneur and norm leader as well as a major spacefaring State in the Outer Space Regime. However, the US SPD-3 is a national approach and while the US is a leading space actor with many like-minded States in agreement it is not for national legislation to be followed by any or all other States – especially those that stand opposite of a Western hegemonic rhetoric such as China.

This is setting the scene for the future as STM is not fully developed either nationally or internationally at this moment in time. Daniel Oltrogge of the Space Safety Coalition (SSC) argues:

> In truth, it is a stretch to assert that anyone provides STM services today, as no one manages, controls or directs operators' spacecraft. But SSA and Space Traffic Coordination (STC) are available today through U.S. domestic and foreign entities as well as the global commercial marketplace.[165]

This term space traffic coordination has come into use predominately because some States are uneasy with the use of 'management' in what is supposed to be considered an international effort where no one State or non-State actor is 'managing' other actors' use of space. It can also be understood that at this stage there is only coordination and not yet management as States have not yet found a way forward on a true STM system that would be met with approval at the international level. It could be argued that STC is the starting point toward STM – if a true management system is what the Outer Space Regime actors are looking to create. As seen from

---

[164] United States, 'Space Policy Directive 3: National Space Traffic Management' (18 June 2018) <https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/> accessed 02 September 2020

[165] Daniel Oltrogge, 'Space Situational Awareness: Key Issues in an Evolving Landscape' (2020) Hearing of the Committee on Science, Space, and Technology, U.S. House of Representatives, Tuesday, 11 February, 5

the general discussion on traffic management, space does not quite fit the typical definition. For the Low Earth Orbit governance framework, some kind of traffic strategy will become critical given the congestion, debris, and diversity of types of players on-orbit. What a traffic strategy looks like has yet to be realised. In the next chapter, there will be further consideration of what might be possible for the governance framework of Low Earth Orbit. If the international space community prefers the term space traffic coordination or even space traffic management, one thing must be clear, in space, traffic management is something new and unique with perhaps some semblance to the Earth-based traffic management strategies.

6.4.9 Systemic Logistics

The current systemic logistics used in the governance framework of LEO are every evolving as the international discussion has turned to the 3S Approach of considering the safety, security, and sustainability of outer space. Much of what is logistically necessary for the governance framework relies heavily on diplomatic discourse and political commitments. Most of the logistics are applied across the Outer Space Regime as well as throughout the regime complex. These points include consideration of international law (binding and non-binding); transparency and confidence building measures; communication; monitoring and verification; normative behaviours; cooperation; and enforcement. Specific to outer space is also consideration of something called 'pre-launch' notification, as well as licensing and registration of space objects and their radio frequency utilization.

6.5 Potential Strategies for Low Earth Orbit Governance Framework Currently Under Consideration

As the Outer Space Regime is evolving along with the governance framework of Low Earth Orbit, there have been some potential strategies given by experts to further strengthen the governance. This section will discuss the potential strategies currently under consideration to evolve the LEO governance framework to include consideration for the safety, security, and sustainability of the orbit and the space objects. Currently there are four potential strategies that could impact the LEO governance framework. They are not exclusive to LEO, but they would have a direct impact on the activity in this orbit if used within the Outer Space Regime and applied to the governance framework of Low Earth Orbit. These strategies include the space sustainability rating; Long-Term Sustainability 2.0; normative behaviours in space; and space traffic management paired with space situational awareness.

6.5.1 Space Sustainability Rating

The Space Sustainability Rating is an initiative that was first discussed within the World Economic Forum Global Future Council on Space Technologies. It is now being created through collaboration by the World Economic Forum, the Space Enabled Research Group at the Massachusetts Institute of Technology Media Lab, the European Space Agency, the University of Texas at Austin, and Bryce Space and Technology. Using an international sustainability rating is not a new concept. Many industries, for example, fashion, use sustainability ratings to set performance targets and give recognition for those that meet said targets. A sustainability rating is a form of incentivizing actors to perform to a certain sustainability standard through voluntary implementation. Many elements are under consideration for a sustainability rating and "the design of the [Space Sustainability Rating] takes into account decisions a space operator can make during the design, operations and end of life phases of a space mission".[166] Some of these decisions can connect to supporting space situational awareness such as "features that make it easier to improve the accuracy of the estimation of satellite location …"[167]

Currently, the Space Sustainability Rating has seven 'modules' for compliance and verification which are the Mission Index to calculate a Space Traffic Footprint; Collision Avoidance; Data Sharing; Detectability, Identification, and Tracking; Application of Standards; External Services; and Verification.[168] What is missing from this version of a Space Sustainability Rating is any mention of consideration and inclusion of the Space Debris Mitigation Guidelines as well as the LTSG. There is not any consideration of the radio frequency spectrum which is a finite resource. At this stage, the sustainability rating is more technical in nature but at least it does have the ability to connect to space situational awareness. While this could serve as a promising tool alongside other considerations, it does not look to fulfil all the needs for a governance framework nor does it seem to be a finished and accepted strategy within the international space community, especially given it being a Western initiative. It also looks to only be utilized to hold non-State actors accountable, which while something that is needed, does not consider all actors using Low Earth Orbit.

---

[166] Minoo Rathnasabapathy, Danielle Wood, Francesca Letizia, Stijn Lemmens, Moriba Jah, Aschley Schiller, Carissa Christensen, Simon Potter, Nikolai Khlystov, Maksim Soshkin, Krisiti Acuff, Miles Lifson, and Riley Steindl, 'Space Sustainability Rating: Designing a Composite Indicator to Incentivise Satellite Operators to Pursue Long-Term Sustainability of the Space Environment" (71st International Astronautical Congress, CyberSpace Edition, October 2020) 3

[167] Ibid, 3

[168] Ibid, 4

6.5.2 Long-Term Sustainability 2.0

In 2019, Member States of the Committee on the Peaceful Uses of Outer Space reached consensus on the *Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space* after a decade of deliberations. The LTSG are a non-binding international instrument; however, the guidelines may become binding upon national implementation. These guidelines are important to the governance of Low Earth Orbit as is indicated in the guidelines themselves.

> The Earth's orbital space environment constitutes a finite resource that is being used by an increasing number of States, international intergovernmental organizations and non-governmental entities.[169]

As the orbital environment becomes more congested with an increasing number of actors and the amount of space debris it is important to think critically about how to govern Low Earth Orbit now and in the future. As LEO is used for space activities supporting socio-economic and environmental challenges including supporting the SDGs, it is imperative that the long-term sustainability of Earth's orbits be considered alongside safety and security concerns.

Though the Covid pandemic slowed progress within UN COPUOS and its subcommittees, especially in 2020 and early 2021, progress has been made regarding extending the work of the Long-Term Sustainability Working Group. In parallel, Member States, including the UK, have started submitting to the committee conference room papers on their voluntary national implementation of the guidelines. As of August 2021, the new Chair of the Working Group on the Long-Term Sustainability of Outer Space Activities prepared CRP 18 (A/AC.105/2021.CRP.18) which outlines the Chair's proposed terms of reference, methods of work, and workplan for the working group taking into consideration all inputs from Member States[170]. As this is only a proposal from the Chair, there will be further deliberations in 2022 to find an accepted way forward for the working group.

The proposed terms of reference include considering further challenges in space for possible new guidelines; sharing lessons learned based on national implementation of the guidelines;

[169] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69, 50

[170] Committee on the Peaceful Uses of Outer Space, Terms of Reference, Methods of Work and Workplan of the Working Group on the Long-Term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee, A/AC.105/2021/CRP.18 (2021)

and conducting capacity-building especially for emerging space States and developing States. As before, the proposed method of work will be during the Scientific and Technical Subcommittee as well as the plenary UN COPUOS sessions. The proposed multi-year workplan will range over five years from 2021-2025.

However, according to UNGA reports from UN COPUOS:

> the view was expressed that consideration of the legal aspects of the practical implementation of the [guidelines] should be included in the agenda of the Legal Subcommittee to ensure the involvement of legal experts of States.[171]

This view is important and should be given consideration because as the guidelines are voluntary and non-binding all current and future guidelines need implementation into national legislation which is a legal discussion.

While this proposed strategy for the governance of outer space, especially Earth's orbits, is critical to the long-term sustainability of the space environment and does consider safety elements, it is lacking the space security angle of the 3S Approach. If this strategy were to be paired with the normative behaviours in space strategy (to be discussed next) which is focused on space security, then all three perspectives would be covered. These two strategies are being discussed at the international level through the purview of the United Nations which gives them both legitimacy and political weight.

6.5.3 Normative Behaviours in Space

There is a new trend to look at what is classed as 'good' or 'bad' behaviour in space as well as what constitutes a 'responsible actor'. The front runner for normative behaviours as a potential strategy for the governance of the Outer Space Regime and Low Earth Orbit is the UNGA *Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours* being discussed within the Conference on Disarmament under space security issues. Current plans are to find consensus on developing either an open-ended

---

[171] United Nations General Assembly Report of the Legal Subcommittee on its Sixtieth Session, held in Vienna from 31 May to 11 June 2021, UN Doc A/AC.105/1243, VIII Future Role and Method of Work of the Committee, 19-20, 20

United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, 50-69, 50 working group or a group of governmental experts (or both) to further consider this resolution and create a report. Geopolitically speaking there is pushback from China and Russia specifically because they have proposed a treaty regarding space security issues – predominately about non-placement of weapons in space. As this is an era of non-binding international law and political commitments it stands to reason that the UNGA resolution will not go quietly into the night as it may prove easier to find consensus on an instrument that is voluntary over a treaty.

6.5.4 Space Traffic Management

Though the term 'space traffic management' (STM) is under consideration as not being applicable to what is meant by the coordination of objects on-orbit, as the potential strategy to be discussed uses the term, it will be used in this section. In 2021 at the United Nations Committee on the Peaceful Uses of Outer Space Legal Subcommittee, a single issue/item for discussion on the *General Exchange of Views on the Legal Aspects of Space Traffic Management* was considered under Agenda Item 12. Furthermore, the topic of space traffic management has been an on-going discussion at international space conferences, within international organizations, and through academic journal article discourse. There are many suggestions on what should be done considering space traffic management, however, what will be considered here is the IAA 2018 book *Space Traffic Management: Towards a Roadmap for Implementation* and the views from the UN COPUOS Legal Subcommittee.

Looking first at the 2018 strategy for a space traffic management plan from the IAA, they proposed two approaches, an incremental bottom-up approach, and a comprehensive top-down approach. According to the IAA, "the diverse yet unconnected STM elements existing today … may constitute the building-blocks of an STM system … constituting a classical bottom-up model".[172] This incremental bottom-up approach contains eight areas which can be framed within a space traffic management system. These include space situational awareness; space debris mitigation and remediation; standards for space safety; traffic rules; national space legislation; organizational aspects; private human spaceflight; and managing space resources. The latter two, private human spaceflight and managing space resources will be left aside in this research as they are out of scope. It is important to see that the IAA bottom-up approach is

[172] International Academy of Astronautics, *Space Traffic Management: Towards a Roadmap for Implementation* (Kai-Uwe Schrogl ed, IAA 2018) 104

meant for the larger Outer Space Regime and not only for Low Earth Orbit. For space situational awareness, the approach suggests that this element is a critical precondition to space traffic management. Further, space situational awareness "… will need to be brought together through suitable and reliable political or, preferably, legal instruments"[173] and this will need be done with cohesion from States, satellite operators, and private non-State actors. With space debris, the first step is mitigation with a second step being remediation such as active debris removal. The approach relies on the existing non-binding Space Debris Mitigation Guidelines as well as the ISO technical standards for space debris. In terms of space safety, this approach relies on the ISO technical standards and suggests that organizations lead in providing input for setting safety standards. Currently there are not any traffic rules per se, however, this approach suggests that the "core of STM will be norms for the actual regulation of traffic to, in and from outer space"[174] and the "development, coordination and implementation of specific traffic rules, or their confirmation and contextualisation (for rules that have already been established) will be a central task …"[175] Finding consensus on norms as well as finding ways to coordinate traffic rules with verification measures is a large task and is precisely why nothing has been internationally created to date. National space legislation is already used in space governance. Many spacefaring States have space legislation usually also paired with a space agency or department upon which space is under consideration. Ensuring knowledge sharing of national space laws and implementation of international instruments at the national level is a large part of maintaining balanced national space legislation globally and to avoid flags of convenience or fragmentation. This takes a top-down approach and may pose challenging with a bottom-up approach as suggested. The organizational aspect means establishing dialogues between United Nations offices and specialized agencies of the UN such as between UNOOSA and the International Civil Aviation Organization (ICAO) and between UNOOSA and the ITU. While the bottom-up approach does lend to flexibility and a more hands-on approach for all actors, it lends itself to fragmentation and chance for free-riding.

The IAA top-down approach of a comprehensive STM regime relies on four areas such as existing international law; diplomatic initiatives and work at the UN level; technical regulations; and future elements.[176] Additionally, with the top-down approach, it is argued that there is an institutional role that must be played which should be through the United Nations

[173] Ibid, 104
[174] Ibid, 105
[175] Ibid,105
[176] Ibid,107

Committee on the Peaceful Uses of Outer Space with interaction from ICAO and the ITU. The authors argue that for "… establishing a comprehensive STM regime, UNOOSA may be considered an adequate secretariat"[177] with State involvement through UN COPUOS and the UN more generally. The top-down approach relies on three elements to create a framework for space traffic management. First, it is argued that a unified, legally binding instrument such as an 'Outer Space Convention' be created.[178] This means to merge the five UN space treaties into a unified convention with fundamental principles and would act as a mechanism for administration of the space traffic management system. Second, that there should be a collection of provisions in an 'Outer Space Traffic Rules' instrument for regulating traffic in space which would be binding but open to review. Third, merging technical standards to create an 'Outer Space Traffic Technical Standards' which would be created by State and non-State actors. While the proposed Outer Space Convention does include salient points from the outer space treaties, especially the Outer Space Treaty itself, through principles; responsibility and liability considerations; and the establishment of an International Space Organisation, it would be a massive undertaking at UN COPUOS to reach consensus on such a treaty that includes the establishment of a coordinating organisation. Even discussing the idea of updating the OST or revamping the Moon Agreement leads to a slippery slope of walking away with treaties that become too tied down to yet another era of space exploration and utilisation or once opened are left and States are released from being bound to any international commitments at all. As it took a decade to produce and find consensus on the LTSG indicates how arduous a journey a new treaty and set up of an international organisation would take considering the divided views between democratic and autocratic powers. What this approach does not consider are the geopolitical challenges that are always looming over international law.

The second aspect of the top-down approach is the inclusion of a proposed set of Outer Space Traffic Rules which the IAA suggest being:

> Comparable to the ITU Administration Regulations, i.e., norms of technical content but with treaty status, complementing the [Outer Space Convention], being binding on all Parties to the [Outer Space Convention] and governing STM at a global level.[179]

[177] Ibid, 108
[178] Ibid, 108-113
[179] Ibid, 114

What does work about this concept is that the authors argue that much like the ITU, these traffic rules could be amended every three to four years at an international conference, such is done with the Radio Regulations via the World Radio Conference. However, again, to have a set of traffic rules created from the start, a Member State – or group of Member States – would have to put forth the proposal in the form of a CRP to UN COPUOS for consideration and deliberations. Then most likely a single agenda item or working group would need to be created for further considerations with allowance for Member State submissions on the topic. This is being seen in the Conference on Disarmament for the UNGA *Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours* which was put forward by the UK. This resolution had Member State submissions and is now being considered for a type of working group within the Conference on Disarmament. There are Member States such as China and Russia which would prefer a different route and pushed for a treaty by introducing the Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT) in the Conference of Disarmament in 2008.[180] This example showcases that set of traffic rules could be feasible if done through the United Nations, but it would take time and much deliberation to find a product with consensus. This set of traffic rules could be more obtainable that the proposed convention stated above.

The third aspect of the top-down approach is a proposed set of Outer Space Traffic Technical Standards which "… could incorporate and build on international standards already agreed upon …"[181] such as those from the ISO, the Space Debris Mitigation Guidelines, among others. Like the traffic rules the technical standards would be reviewed every three or four years through a coordinating and supervising body – the Outer Space Traffic Technical Standards Conference. Like the traffic rules, the idea of a comprehensive set of technical standards would be beneficial for space operators. It would be a good idea to conduct a feasibility study on other tech sectors to see how they coordinate ISO standards with other technical standards in their field. It would be interesting to know if any other tech sector has made a successful comprehensive set of tech standards and how it is received and implemented. Nonetheless,

---

[180] Russian Federation and China, 'Letter dated 2008/02/12 from the Permanent Representative of the Russian Federation and the Permanent Representative of China to the Conference on Disarmament addressed to the Secretary-General of the Conference transmitting the Russian and Chinese texts of the draft "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT)" introduced by the Russian Federation and China' (United Nations Digital Library 2008) <https://digitallibrary.un.org/record/633470?ln=en> accessed 06 June 2023

[181] Ibid, 115

much the like traffic rules, a set of tech standards would need to be proposed and go through consideration at the UN level with input from ISO and any other organisations that have existing technical standards for space.

The bottom-up approach to space traffic management proposed by IAA is too loose of a structure and leaves room for free-riding and other forms of fragmented regulation and adherence. On the other hand, the top-down approach would take at least a decade if not more to fully implement with all three instruments. While the top-down would allow for coordination and discourse at the international level, the worry, from this research perspective, is that consensus may never be found for so robust an option. Especially given the geopolitically divided interests of democratic (West and like-minded States) versus autocratic States such as Russia and China. The IAA does suggest a fifteen-year workplan using the UN COPUOS Legal Subcommittee as the platform for discussion and work[182], however, to consider and reach consensus on all three instruments would take potentially more than fifteen years to accomplish. In the end a middle ground needs to be found that would take into consideration geopolitical interests and a timeline that would benefit all actors in space – not only the major spacefaring States.

Since 2016 the UN Committee on the Peaceful Uses of Outer Space Legal Subcommittee has had an agenda item entitled General Exchange of Views on the Legal Aspects of Space Traffic Management under consideration. It was at this time:

> The Subcommittee noted that consideration of space traffic management was of growing importance for all nations. The space environment was becoming increasingly congested and complex owing to the growing number of objects in outer space, the diversification of actors and the increase in space activities, all of which made it more difficult to ensure safe and sustainable space operations, and space traffic management required a multilateral approach.[183]

From this articulation, space traffic management is heavily tied to the governance of the Outer Space Regime as well as the governance framework for Low Earth Orbit. In 2017 the subcommittee furthered this statement by adding that these "… factors increased the chances

[182] Ibid, 117
[183] United Nations General Assembly, 'Report of the Legal Subcommittee on its Fifty-Fifth Session, Held in Vienna from 4 to 15 April 2016' (A/AC.105/1113) XI. General Exchange of Views on the Legal Aspects of Space Traffic Management, 30

of potential collision in outer space…"[184] At this time the subcommittee also considered under this agenda item the IAA *Cosmic Study on Space Traffic Management* which is the precursor to the IAA space traffic management roadmap analysed above. In 2018 the subcommittee the *IAA Space Traffic Management: Towards a Roadmap for Implementation* was distributed to the delegations for consideration. From 2019 onward the IAA proposal was not mentioned, instead the LTSG were discussed in connection with space traffic management. In fact:

> The view was expressed that substantive elements of the guidelines for the long-term sustainability of outer space activities represented robust first building blocks for a space traffic management structure …[185]

This view was in line with another consideration that some delegations expressed considering:

> A multilateral comprehensive approach [which] would meet the needs of the growing global space economy in terms of safety, predictability and sustainability[186]

which are tenets of the LTSG. In 2021,[187] views were expressed that continue this line of thought on considering the guidelines as a first step towards space traffic management. Certain principles and norms of behaviour were presented such as transparency, cooperation, and capacity-building as key elements to be considered for space traffic management. This aligns with the UNGA Resolution 75/36 mentioned above.

No real consensus has been met on how to define space traffic management which makes it hard to exactly pinpoint what elements should be under consideration for a space traffic management plan. As the working group on the Long-Term Sustainability Guidelines starts up again in 2022 with a proposed workplan to accept, perhaps space traffic management will come under consideration here as well as under the UN COPUOS Legal Subcommittee agenda item as it seems there are Member State views to discuss these two initiatives in tandem. Like other challenges in space, there should also be consideration from emerging space States and non-

[184] United Nations General Assembly, 'Report of the Legal Subcommittee on its Fifty-Sixth Session, Held in Vienna from 27 March to 7 April 2017' (A/AC.105/1122) XI. General Exchange of Views on the Legal Aspects of Space Traffic Management, 26

[185] United Nations General Assembly, 'Report of the Legal Subcommittee on its Fifty-Eighth Session, Held in Vienna from 1 to 12 April 2019' (A/AC.105/1203) XI. General Exchange of Views on the Legal Aspects of Space Traffic Management, 30

[186] Ibid, 28

[187] Because of Covid there was not a typical subcommittee session in 2020 and therefore no final report is available. Thus, this research must skip to the 2021 proceedings for analysis.

State actors such as from the industry and academia to better find a solution that benefits all actors regardless of their level of expertise in the space community.

6.6 Concluding Remarks

As can be seen from this chapter, there are many potential strategies for the evolution of governance within the Outer Space Regime and for further consideration for the governance framework of Low Earth Orbit. Which means there is room to update the LEO governance framework as this research has suggested. Consideration of the 3S Approach is at the forefront of these initiatives and while each is unique and has something different to offer, they are all ambitious and fragmented ways to move forward. The next chapter will offer recommendations on ways forward for space governance and LEO governance taking into consideration these potential strategies, all previous chapter's elements, and challenges, as well as bring forward new and original ideas to supplement where needed. Taken from all these chapters, the next chapter will also answer the research questions brought forward and carried through the research.

7 Recommendations for Low Earth Orbit Governance Framework and Conclusion

This final chapter will set out the recommendations for the Low Earth Orbit governance framework and will give overarching concluding remarks to the research. The chapter will start with an overview of what a governance framework should include more generally and then discuss this regarding LEO. The final four governance models – inclusive, evolutionary, legal, and risk – will be further analysed regarding Low Earth Orbit governance. As risk governance is pulled out to be the main recommended governance model, a deeper discussion on risk governance will be given with critical analysis on its applicability to the LEO governance model. Finally, this chapter will spell out the recommended governance framework for a sustainable governance frame in Low Earth Orbit and give concluding remarks on the research.

7.1 Recommendations

This chapter will bring together all previous discussions to analyse and then submit suggestions for the future of the Low Earth Orbit governance framework. Throughout this research, a dual international law and international relations approach has been taken which will be continued within this section. It is prudent to take such a socio-legal approach to governance analysis given the importance of political will regarding international law. It is through the analysis of existing international law and space regulations as well as the mindset of State and non-State actors in how they create, interpret, and implement these laws that a governance framework can be identified.

This chapter will go through two parts of analysis. The first part will discuss what is necessary for a governance framework. There are many facets to building a governance framework that it is important to analyse which aspects are necessary versus good to have or would not work. There will be a discussion on these points regarding the Low Earth Orbit governance framework. The second part will consider the governance models picked as most relevant in section four of this research. Here a further analysis will be taken considering on the chosen models. Lastly, this section will give recommendations for an ideal Low Earth Orbit governance framework keeping in mind sustainability, safety, and security. This framework must also be practical, realistic, and possible where 102 UN COPUOS Member States would find consensus and chose to implement aspects into national regulations for non-State actors.

7.1.1 What's in a Framework?

If decision-makers and scholars knew how to create, implement, and maintain the perfect governance framework this research would not need to be conducted. Governance would not be the overly discussed issue that it is today with over 20 models to choose from. Alas, this is not the case. Ansell and Torfing suggest:

> There are no panacea governance arrangements that work at all times in all places. Instead, the challenge remains to policymakers, scholars, and practitioners to explore the relative costs of alternative pathways for collective goods provision and tailor governance arrangements to the characteristics specific to the dilemma[1].

This section will discuss what could and could not be in a governance framework. What is necessary, what is good to have, and what would not work. This will be applied to Low Earth Orbit.

If Low Earth Orbit is a limited renewable resource, not available to appropriation, then it needs governance that can support collective action through security, safety, and sustainability of the orbit and all actors and activities therein. Considering LEO and collective action, according to Ansell and Torfing:

> Governance attempts to solve different types of dilemmas by creating institutional arrangements that redefine the payoffs from individual behavior and incentivize cooperation through top-down mandates or encourage bottom-up self-organizing. Governance is a multi-level process that creates monitoring mechanisms, punishes defection, rewards cooperation, provides information, fosters trust-based reciprocity, and otherwise attempts to create the conditions that make collective action likely to occur[2].

A governance framework needs a multi-level process with many attributes. However, one governance framework does not live in a silo away from other frameworks, much like a regime is in a regime complex. The world is processing a climate crisis, ongoing wars and conflicts, and the ramifications of a pandemic. This is a world with wicked and super wicked problems.

---

[1] Christopher Ansell & Jacob Torfing (eds), *Handbook of Governance* (Edward Elgar Publishing 2016) 29
[2] Ibid, 21

With "knowns … unknowns … true lies and inconvenient truths".[3] In world that is volatile, uncertain, complex, and ambiguous.[4] Furthermore, the world today is polycentric, "… characterized by overlapping spheres of interest, competing value systems, different governance standards, and rising tensions".[5] With more actors comes harder and longer ways to reach consensus on the challenges of today. However, to make governance work and be applicable to all under its purview, "... the world cannot be divided any longer into 'the West and the Rest' and … civilizations need to coexist if they do not want to be absorbed by continuous conflicts".[6] It is no easy plight to evolve a regime and remodel governance. To have the courage to say and truly believe that the framework is not working and needs to be adapted to the needs of the many instead of the few. For current and future generations. Therefore, what is in a framework can vary depending on many extraneous factors as well as internal factors relating to the sector.

According to the United Nations Committee for Development Policy, governance is:

> The regulation of interdependent relations in the absence of overarching political authority, such as the international system. It encompasses the institutions, policies, norms, procedures and initiatives through which States and their citizens try to bring more predictability, stability, and order to their responses to transnational challenges[7].

This encapsulates global governance, which is only one model of governance, however, one that is relevant to Low Earth Orbit and of the model that will be further discussed in the next section. The UN Committee for Development Policy further suggests that "effective global governance cannot be achieved without effective international cooperation".[8] Therefore, international cooperation is a large aspect of any international governance framework. In fact, "it is also a legal obligation".[9] According to Article I, Paragraph 3 of the United Nations Charter, the purposes of the United Nations are:

---

[3] Matthew J Burrows & Oliver Gnad, 'Between 'Muddling Through' and 'Grand Design': Regaining Political Initiative – The Role of Strategic Foresight' (2018) 97 Futures 6-17, 6
[4] Ibid, 6-7
[5] Ibid, 7
[6] Ibid, 7
[7] United Nations Committee for Development Policy, 'Global Governance and Global Rules for Development in the Post-2015 Era' (2014) Sales No. E.14.II.A.1, 3
[8] Ibid, 3
[9] Ibid, 3

> To achieve international cooperation in solving international problems of economic, social, cultural, or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms for all without distinction as to race, sex, language, or religion.[10]

It is with the backing of the UN Charter that international cooperation is the primary necessity in any governance framework on an international scale. Further, this principle of international cooperation can also be backed by Article III of the Outer Space Treaty, which states that outer space exploration and activities are in accordance with international law including the UN Charter, as well as various articles of the Declaration on the Right to Development where the latter:

> Explicitly calls on States to act collectively, as well as individually, to create an enabling environment for development, particularly by removing obstacles and creating opportunities.[11]

With various instruments of international law supporting the principle of international cooperation, it is imperative that this principle be part of the LEO governance framework now and in future.

Governance on the international scale can have its organisational challenges. For example, many legal instruments and decision-making processes have been created with limited input from developing countries – though they should abide by them. This leads to an asymmetrical way of conducting governance, historically speaking. This means that one large aspect of governance today is the necessity to make sure all actors that want to have a say are at the table and making active contributions – having their voices heard and considered. This goes against that main principle of international cooperation which is expressed in international law – including international space law. International cooperation and inclusivity should both be pillars of governance and governance frameworks. In essence, "government on auto-pilot will not be sufficient any longer, nor muddling through or constant management".[12] Governance needs an overhaul, especially in Low Earth Orbit and outer space more generally. It is time to

[10] United Nations, 'Charter of the United Nations and Statute of the International Court of Justice' (1945) 1 UNTS XVI

[11] United Nations Committee for Development Policy, 'Global Governance and Global Rules for Development in the Post-2015 Era' (2014) Sales No. E.14.II.A.1, 3

[12] Matthew J Burrows & Oliver Gnad, 'Between 'Muddling Through' and 'Grand Design': Regaining Political Initiative – The Role of Strategic Foresight' (2018) 97 Futures 6-17, 9

understand what is necessary for a governance framework, what is good to have and should be included whenever possible. On the other hand, what is not working should be taken out of governance frameworks. Historically, States were the sole decision-makers of governance, and perhaps only a handful of States at that. While it may take time and some reconfiguring, non-State actors – especially how many are actors in space – should also be part of any governance framework discussion. Burrows and Gnad remark:

> 'The State' is no longer an omnipresent, omniscient, infallible Leviathan. But it is the only institution capable of establishing stability and order in a globalized world …[13]

While the State is very important to governance at the international level, and indeed stability is part of States' job descriptions, the State is not the only type of actor that should contribute to governance. For, with the wicked problems of today, classical governance is not the answer. "What seemed to be right in the past might not be valid any longer in the future."[14]

The UN Committee for Development Policy suggest key principles such as: common but differentiated responsibilities in accordance with respective capabilities; inclusiveness, transparency, and accountability; coherence; and responsible sovereignty.[15] While these key principles are a good start, there are other aspects to a framework that are necessary for a governance framework to have. Figure 1 below shows additional aspects for a framework with the UN key principles added in. As there are connecting and overlapping aspects, there are groupings which will then be discussed below.

[13] Ibid, 10
[14] Ibid, 12
[15] United Nations Committee for Development Policy, 'Global Governance and Global Rules for Development in the Post-2015 Era' (2014) Sales No. E.14.II.A.1, 14-16

FIGURE 1: Aspects of a Governance Framework

Common but Differentiated Responsibilities in accordance with capacities	Subsidiarity/ Multi-level	Inclusivity/ EDI/Multistakeholder	Transparency/ Confidence-Building/ Communication/Trust
Accountability/Monitoring	Coherence/Holistic Approach/ Reduced Fragmentation/ Regime Complex	Responsible Behaviours/Norms	Cooperation and Collaboration
Wise Laws (binding/non-binding/political commitments) and Implementation	Capacity-Building/Knowledge Sharing	Rewards and Punishments	Adapt/Evolve/ Flexibility

Common but Differentiated Responsibility (CBDR) is a principle that was crystalised in the climate change regime. According to the UN Committee for Development Policy, CBDR:

> Recognizes differences in the contribution and historical responsibilities in the generation of common problems as well as the divergences in financial and technical capacity across countries in order to equitably address shared challenges.[16]

This kind of CBDR discourse is prevalent under the UN COPUOS agenda item on space debris, especially regarding access to space versus legacy debris and ASAT debris. Many Member States do not believe it is fair that their access to space is at risk because of these debris issues that are because of a small number of States. Additionally, not all actors have the capacity to track, let alone, clean up debris. In a governance framework CBDR is critical because matching responsibility with capability ensures equity.[17]

[16] Ibid, 14
[17] Ibid, 14

The principle of subsidiarity – or a multi-level approach -- "suggests that issues ought to be addressed at the lowest level capable of addressing them".[18] Governance decision-makers should understand that some challenges within the governance framework could be addressed at the international, regional, national, or operational levels and should be considered. For example, States must take international law and implement the tenets into national law. It is the States that are responsible for non-State actors and as such must take the international tenets and create laws and licensing that holds non-State actors accountable. This must be done at the national level. Following the ISO standards, for example, is something that is conducted at the operational level. At the regional level, there are options for collaboration and coordination to support regional space activities. This is very important for Global South regions. The African Union is a great example here as they have a space strategy and space policy to help its members.[19] The African Union Space Policy Objective 4: Adopting Good Governance and Management supports coordinated efforts around governance by encouraging African Union non-State actors "to adopt good corporate governance and best practices for the coordinated management of continental space activities".[20]Inclusivity is another important aspect of a governance framework. As was mentioned in Chapter 5 and will be discussed again below, inclusive governance is a model worth considering for outer space and Low Earth Orbit specifically given the growing number of diverse actors using the orbit. Inclusivity is part of EDI. This idea of inclusivity is also like the multistakeholder approach where diversity amongst types of actors is encouraged for decision-making. With 102 Member States at UN COPUOS, and 71 States responsible for satellites in LEO – most of which are commercial – it is critical to have inclusivity as an aspect of the governance of the orbit. More will be discussed below on how to include inclusivity into the LEO governance framework.

In today's globalised world, governance should be holistic and have a level of coherence in order to reduce fragmentation of legislation across States and to promote stronger ties across the regime and regime complex. Coherence is "... needed between the international and national

[18] Ibid, 14
[19] For more information see: African Union, 'African Space Strategy: For Social, Political and Economic Integration' (2019) <https://au.int/sites/default/files/documents/37434-doc-au_space_strategy_isbn-electronic.pdf> accessed 06 June 2023; African Union, 'African Space Policy: Towards Social, Political and Economic Integration' (ND) <https://au.int/sites/default/files/documents/37433-doc-african_space_policy_isbn_electronic_.pdf> accessed 06 June 2023
[20] African Union, 'African Space Policy: Towards Social, Political and Economic Integration' (ND) <https://au.int/sites/default/files/documents/37433-doc-african_space_policy_isbn_electronic_.pdf> accessed 06 June 2023, 12.

spheres of policymaking"[21] but is also needed between States. This level of coherence "... requires improved coordination among various stakeholders and enhanced information sharing,"[22] both of which are also key elements of any governance framework. As the space community is inclusive of considerations regarding cyber and telecommunication – radio specifically – it is important to have this coherence across the regime complex. Also, as more non-State actors are accessing space there needs to be more coherence amongst national space law to avoid fragmentation and flags of convenience.

Cooperation and collaboration are foundations of governance, especially at the global level. Essentially all these other aspects of a governance framework are underpinned by levels of cooperation and collaboration. This can take shape in high level discourse, in adhering to international laws (binding or non-binding), or in actual cooperative and collaborative efforts on activities in the sector. The greatest example of collaboration in space is the International Space Station (ISS). The ISS has served as a symbol of how, even when geopolitics on Earth are tested, collaboration can still be maintained in space. More often than not, geopolitics do affect space activities – more reason to keep supporting governance inclusive of cooperation and collaboration.

Normative behaviours (norms or responsible behaviours) require a sense of oughtness, of how an actor should behave in each scenario. "Norms arise because they are needed to bring about cooperation in a mixed-motive setting…"[23] which is why they are crucial for any governance framework. It is through political commitments that actors solidify their pledge to act responsibly. In space this can be seen through discourse on what classifies as responsible behaviours in space and through implementation of norms once agreed to. As the space community is moving toward non-binding instruments it will be imperative that norms are also established to create responsible actors in space. This concept does not just apply to States as non-State actors are also supporting responsibility through best practices and standards.

Transparency and confidence-building measures and communication instil trust amongst actors. TCBMs "help to prevent conflict by providing States with practical tools to exchange information, build trust and reduce tensions at the bilateral, regional, or global level."[24] While

---

[21] Ibid, 15
[22] Ibid, 15
[23] Ann Florini, 'The Evolution of International Norms' (Sept 1996) International Studies Quarterly, Vol. 40, No. 3, Special Issue: Evolutionary Paradigms in Social Science, 363-389, 365
[24] United Nations Office for Disarmament Affairs, 'Transparency and Confidence Building' (*UNODA*, 2022) <https://www.un.org/disarmament/convarms/transparency-cbm/> accessed 14 June 2022

TCBMs tend to err on the side of security, communicating to instil trust can also support safety and sustainability as well. Having TCBMs in governance, especially given geopolitical stresses, can go a long way to diffuse or deescalate potential threats and risks. TCBMs are necessary to build trust and "... can contribute both to the development of mutual understanding and to the strengthening of friendly relations between States and peoples …"[25] In 2013 a Group of Governmental Experts on TCBMs in Outer Space Activities published an UNGA report (A/68/189) which was followed by an UNGA Resolution on TCBMs in Outer Space Activities (A/RES/68/50). The report set forth general characteristics and basic principles for TCBMs in outer space while the resolution encourages Member States to implement the proposed TCBMs.

Capacity-building and knowledge sharing are important for equity and inclusivity in governance. Not all actors are built the same and as such it is useful to share knowledge and support capacity-building to tackle global challenges and advancement in each sector. Capacity-building is connected to sustainable development, but it can also be important for advancement in scientific and technological aspects as well. Knowledge sharing can also come in the form of sharing how international laws (binding and non-binding) are being implemented at the national level. These aspects of governance can support States and other actors new to space.

A major aspect of governance is the law. It is not enough to just have laws but there is a need for 'wise laws' and for laws to be implemented by actors. In governance laws can include binding and non-binding as well as political commitments in the form of norms. Wise laws can be classified as laws that consider security, safety, sustainability of the space environment and the activities on orbit. These laws should be equitable and inclusive for all State and non-State actors. Wise laws at the international level will now be non-binding such as the LTSG or political commitments such as the UNGA resolution on responsible actors in space. Wise laws find consensus with a more diverse group of decision makers and are implemented at the national level. Wise laws at the national level take into consideration international law (binding and non-binding) and support licensing procedures. Wise laws are adaptive to science and technology and consider the wicked problems of space such as space debris.

[25] UNGA, 'Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities' (29 July 203) UNGA 68th session, A/68/189, 13

Probably the most difficult aspects of governance are monitoring and accountability. Monitoring takes resources that not all actors have and can imply that one actor is policing others. Therefore, monitoring must be done with a level of openness and communication. It is up to all States to hold others accountable by monitoring compliance.. In space, monitoring is primarily conducted by the US government – military – in the form of Space Situational Awareness. SSA is mainly tracking of space objects, including debris and natural Near-Earth Objects (NEOs) such as meteorites. While there are other actors, including non-State, that are tracking natural and human-made space objects, this form of monitoring does not directly imply they are policing or holding anyone accountable. While monitoring is important for governance, in space, given the lack of local understanding and the asymmetrical technological ability to track, it is one of the most under-represented and less understood aspect. Add in the geopolitical and security implications of monitoring and the hesitancy to have 'space police' and monitoring because a murky grey area of space governance at best. Understanding accountability is at least a bit less murky. Accountability, according to Papadopoulos, is:

> A relation in which an actor can be held to account by another actor and face consequences. In such a relation the first actor provides information on, and justification for, her action or inaction. These are evaluated by the second actor; a debate may ensue (the accountability relationship has a dialogical component that may be more or less emphasized) and at the end of this (stylized) "time-line" of accountability the first actor is rewarded or sanctioned depending on the judgement of the second actor.[26]

This understanding of accountability connects to the next step, which will be discussed next, which are whether an actor receives rewards or punishments for their actions. Currently, amongst Member States at UN COPUOS, accountability comes in the form of general exchange of views and activities, knowledge sharing, and other communicative efforts. It also means States holding non-State actors accountable through national space laws and licensing processes. The part that is weak is the rewards and punishments.

Rewards and punishments are part and parcel of accountability. At the international level, rewards include the acknowledgement that States are 'part of the club' and are welcome based

[26] Yannis Papadopoulos, 'Accountability' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 205

on their responsible behaviour and adherence to international laws. While punishments at the international level can result in economic sanctions. At the national level, non-State actors could be rewarded by acquiring further licensing for more space activities while they could be punished by being denied licensing.

Governance – especially governance for science and technology – needs to be flexible. Governance needs to adapt or evolve as the regime also evolves. Governance is a living system and cannot stay stagnate or it runs the risk of becoming obsolete. This aspect of governance is the core of this research. Space is a unique environment. More actors are entering space every year. Activities are diverse and many. Science and technology keep advancing. Wicked problems such as space debris need new solutions and wise laws. The best example of how space governance is adapting, and evolving is the shift to non-binding international law and political commitments. The LTSG and the work of the LTS working group show the need to look at LEO as an environment work preserving through sustainability, safety, and security. The deliberations include a more diverse group of Member States, and the guidelines are digestible for national space laws and non-State actor compliance. This is a good start to understanding how to better govern LEO and space more holistically.

For the Outer Space Regime to function now it must include all these framework aspects to bring space governance into the 2030s. Low Earth Orbit is the most critical place where space activity takes place and is the environment with the most diversity of actors and activities. It is imperative that these framework aspects be applied to the governance framework of Low Earth Orbit specifically. It is almost more important for them to be part of the LEO governance framework even if they are not considered more holistically for the Outer Space Regime. For these aspects to be implemented the overall governance model in space must evolve. The next section will discuss what models are potential for the Outer Space Regime and LEO. It must be understood that no matter what governance model – or hybrid of models – may be used, these framework aspects need to be applied.

The last part of this chapter will discuss recommendations for a LEO governance framework, keeping in mind the more holistic needs of the Outer Space Regime governance framework. It is in this section that overarching aspects of what are needed in a framework, as were mentioned above, will be paired with LEO specific aspects that are critical for the future safety, security, and sustainability of LEO and activities there. It is also in this section that the last three research questions will be answered.

7.2 Recommendations for an Ideal Low Earth Orbit Governance Framework

Low Earth Orbit is 'congested, contested and competitive'. Low Earth Orbit has the most diversity of actors and activities in space with over 70 States responsible for over 5000 satellites on orbit.[27] The above sections found that the Outer Space Regime is evolving and that a hybrid governance model is needed. These findings have direct application to LEO. However, as LEO is its own environment, different in astrophysics and utilisation than Geostationary Orbit, lunar orbit or Mars, there should also be a distinct LEO governance framework that is nested within the Outer Space Regime which is then nested within the Outer Space Regime Complex. To recap, LEO has wicked problems in the form of potential risks and threats: debris; ASAT testing; potential for cyber and electronic attacks; potential for interference (accidental or malicious in nature); potential for collisions; active and non-active or non-responsive satellites; all creating congestion, contestation, and competitiveness. This research has shown that Low Earth Orbit needs STM paired with SSA. LEO also needs a 3S Approach which combines considerations of security, safety, and sustainability instead of through siloed approaches. This research has found that a combined binding and non-binding legal approach to space law is the best way to legally approach governance. This means also having national implementation of international instruments as well as having national space laws and licensing procedures. To create inclusivity and equity knowledge sharing on implementation of international instruments and national space laws and procedures is critical to avoid fragmentation across State space law and to avoid flags of convenience. Space governance needs to abandon State-centric thinking especially in Low Earth Orbit where most satellites are non-State activities. Accountability is necessary through licensing. Space debris – legacy ASAT testing or otherwise – means monitoring and sharing monitoring is imperative to avoid collisions and to avoid harm to astronauts on orbit. When considering all the governance framework aspects mentioned above and considering the Outer Space Regime governance, the Low Earth Orbit governance framework can be condensed into tackling wicked problems (risks and threats) which should be done through legal considerations, monitoring, accountability, and knowledge exchange under the auspice of risk governance. As operators (State and non-State) must

[27] Seradata, 'SpaceTrak' (S*eradata*, 2022)<https://www.seradata.com/spacetrak3/> accessed 02 June 2022

conduct risk assessments and adhere to risk management ISOs (ISO 3100 and ISO 17666) plus take into consideration the Space Debris Mitigation Guidelines and the LTSG, among other international laws run through national regulations, risk governance speaks to decision-makers and operators alike. This can be useful in LEO where most actors are non-State. The idea that governance could be understood by engineers, scientists, as well as decision-makers could arguably mean better adherence to the governance framework. This section will explain the proposed LEO governance framework, risk governance.

7.2.1 Risk Governance

As has been discussed in this research, risk governance is a model which uses "... risk-related decision-making…"[28] This idea of risk governance or risk management is taken from ISO standards, operators, as well as from academia as has been mentioned previously. However, it is worth noting here that for the purpose of Low Earth Orbit risk governance would encompass risks and threats. Risk governance is defined by Renn and Klinke as:

> A complex of coordinating, steering and regulatory actions performed by institutions and facilitated processes that lead to collective decision-making under the conditions of uncertainty, ambiguity, [and complexity].[29]

From this definition risks fall into three categories complexity, uncertainty, and ambiguity but there can be simple risks as well. These categories will be explained in detail below, however, first, a few words more about risk governance more generally.

Risk governance works in a cycle. To begin with, actors must anticipate risks (and again here threats are assumed to be included in risks) through the first stage of risk governance known as pre-estimation. The caveat being, in pre-estimation, as considered by Renn and Klinke, that "what counts as a risk [or threat] to someone may be regarded as destiny by someone else or in other instances as an opportunity".[30] This kind of discourse is current in the deliberations on UNGA *Resolution 75/36 on the Reducing Space Threats Through Norms, Rules, and Principles of Responsible Behaviours*. Member States want to find what constitutes a threat and to understand a threat versus a hazard or risk. Partly because some States, such as the United

[28] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 245
[29] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 245
[30] Ibid, 247

Kingdom, want to keep threats which are security challenges separate from hazards and risks which are safety and sustainability problems. However, this is siloed and short-sighted as an ASAT test generating debris is just as hazardous as debris generated from collision with a meteoroid. While the latter may have lesser geopolitical connotations, they are both still dangerous for space assets, astronauts, and the longevity of the LEO environment. This selection of what is considered a risk, or a threat is known as framing. Framing must include all relevant stakeholders to best analyse how to proceed. It is why having deliberations and working groups at the UN level are so critical for the 3S approach to work and for LEO to be an orbital environment available for use in the long-term.

The next step in the cycle of risk governance is interdisciplinary estimation. This step assesses the risk (or threat) itself as well as assesses the concerns actors have regarding said risk (or threat). The German Advisory Council on Global Change (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, WBGU) created a report in 1998 on managing global risks. According to Renn and Klinke, the WBGU report concluded with eight criteria for evaluating risks: extent of damage; probability of occurrence; incertitude; ubiquity; persistency; reversibility; delay effect; and potential for mobilization.[31] Overall, this step:

> Consists of a systematic assessment not only of the risks to human health and the environment but also of related concerns as well as social and economic implications. The interdisciplinary risk estimation process should be informed by scientific analyses; yet, in contrast to traditional risk regulation models, the scientific process includes both the natural sciences and the social sciences, including economics.[32]

This could be taken further to also consider legal and political aspects. This concept of estimating risk, especially space debris and EoL procedures for satellites – both affecting LEO and the atmosphere of Earth – has become in mode especially during discussions at the 4th Secure World Foundation Space Sustainability Summit in June 2022. Panel experts suggested that addressing risks and threats in space takes scientific data-driven estimations for the space environment but also economic and legal considerations as well.

[31] Ibid; taken from German Advisory Council on Global Change, *World in Transition: Strategies for Managing Global Environmental Risks* (Springer, 1998)

[32] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 248

Once the risks, and threats, have been estimated the following step looks at risk characterization and evaluation. How to evaluate risk is difficult. This stage requires risk-benefit trade-offs to be considered. Renn and Klinke remark, “drawing the lines between ‘acceptable,’ ‘tolerable,’ and ‘intolerable’ risks is one of the most controversial and challenging tasks in the risk governance process”.[33] This discussion of threshold tolerance for risks and threats is an interesting one because it is hard to calculate for space debris for example. The capacity of LEO is still not quite known. While not mitigating and remediating debris is not the answer, how much debris is acceptable? Would the current debris numbers be acceptable or only tolerable? Perhaps that also depends on the actors’ perspectives as well. Or their understanding about what is and is not responsible behaviour in space. Renn and Klinke also come to the same conclusions about this.

> Looming below all risks [and threats] is the question of what is safe enough, implying a normative or moral judgement about acceptability of risk [or threat] and the tolerable burden that risk [or threat] producers can impose on others.[34]

There definitely more room for discussion within the international space community on what the threshold should be for risks and threats. This is already starting to be addressed on the space security side regarding threats. A similar thread should be had regarding risks. A better option would be to discuss both on the same platform. Nonetheless, setting the scope of what is and is not acceptable behaviour in LEO should be about risks and threats and this governance model provides a nice framework under which to do just that.

Risk management is a core part of risk governance. It starts with a review of all previous stages to understand how to manage the determined risk or threat. Again, it should be noted that while saying risks here, this could also apply to threats. Renn and Klinke explain:

> If the risk is acceptable, no further management is needed. Tolerable risks are those where the benefits are judged to be worth the risk, but risk reduction measures are necessary. If risks are classified as tolerable, risk management needs to design and implement actions that either render these risks acceptable or sustain that tolerability in the longer run by introducing risk reduction strategies, mitigation strategies or strategies aimed at

[33] Ibid, 250
[34] Ibid, 250

> increasing societal resilience at the appropriate level. If the risk is considered intolerable, notwithstanding the benefits, risk management should be focused on banning or phasing out the activity creating the risk. If that is not possible, management should be devoted to mitigating or fighting the risk in other ways or to increasing societal resilience by enhancing the elasticity, robustness, redundancy, diversity, adaptability and so on of social systems. If the risk is contested, risk management can be aimed at finding ways to create consensus.[35]

ISO Standard 17666:2016 on Space Systems – Risk Management, takes this concept of acceptable, tolerable, and intolerable further. Risks can also be scored from negligible to catastrophic based on the severity of consequence or from minimum to maximum on a scale of likelihood. From these two scales they can then be combined to assess the severity and likelihood of the risk or threat. Figure 2[36] goes through this scoring index. Here A-E represents likelihood and 1-5 represents severity.

Figure 2: Risk and Threat Index Combination of Severity and Likelihood

E Maximum	Low	Medium	High	High	Very High
D High	Low	Low	Medium	High	Very High
C Medium	Very Low	Low	Low	Medium	High
B Low	Very Low	Very Low	Low	Low	Medium
A Minimum	Very Low	Very Low	Very Low	Very Low	Low
	1 Negligible	2 Significant	3 Major	4 Critical	5 Catastrophic

[35] Ibid, 251

[36] Figure 3 is adapted from figures in ISO Standard 17666:2016. International Standardization Organization, 'Space Systems – Risk Management' (ISO 17666, 2016) 7-8

To further understand, according to ISO 17666:2016, Very Low Risk and Low Risk would be seen as acceptable whereas Medium Risk, High Risk, and Very High Risk would all be classes as unacceptable. To compare to Renn and Klinke, Very Low Risk could be tolerable for them whereas Low Risk would be acceptable and Medium to Very High Risk would be intolerable. In the end, most risks and threats should go through risk management which is, again, why the risk governance model seems appropriate for Low Earth Orbit, not only at the international level but also at the operational level as well.

As was mentioned above, risks can fall into four categories: simple, complex, uncertain, or ambiguous. A simple risk can be managed at the operational level where the actor would "find the most cost-effective way to make the risk acceptable or tolerable"[37]. This could be risk management for satellites in the design phase all the way to End of Life procedures. At this level of risk governance, the onus is on the operator to abide by standards and best practices; national space laws; and licensing regulations and procedures. To ensure the safety, sustainability, and security of their space asset and the LEO environment.

Complex risks "use experts to find valid, reliable and relevant knowledge about the risk"[38]. Renn and Klinke explain:

> Although the technology is highly complex, and many interacting parts can lead to multiple accident scenarios, most possible pathways to a major accident can be modelled well in advance[39]

This level of risk management would still focus on operators however there can be room for further stakeholder involvement. This could be missions such as rendezvous and proximity operations (RPO) or on orbit servicing (OOS) where the operator is the main risk manager however other stakeholders would need to be involved, such as the operator of the defunct satellite or operators in the vicinity to the RPO or OOS mission for coordination and transparency.

[37] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 252
[38] Ibid, 252
[39] Ibid, 252

Uncertainty in risk "denotes the inability to provide accurate and precise quantitative assessments between a causing agent and an effect"[40] which means having access to more knowledge on the risk or threat could reduce uncertainties over time. This level of risk management includes a slightly larger array of actors compared to complex risk. With uncertain risk operators, civil society, and other relevant experts such as scientists play key roles in collectively deciding a way forward. In LEO, uncertain risk could be collision avoidance – from debris or other satellites. Space Situational Awareness would have a critical role here to help with the broadening of knowledge. Which is why open access and knowledge sharing of SSA data is vital for all stakeholders operating in Low Earth Orbit.

The last challenge within risk management includes risks (or threats) that are ambiguous. Renn and Klinke denote ambiguity as:

> Either the variability of (legitimate) interpretations based on identical observations or data assessments or the variability of normative implications for risk evaluation (judgement on tolerability or acceptability of a given risk).[41]

This level of risk management includes all stakeholders from operators to scientific and technical experts, affected stakeholders, and decision-makers. The inclusion of a large body of actors is important as this level of risk management is 'discourse-based management'[42] through participatory processes.

> The aim of such a process is to produce a collective understanding among all stakeholders and the affected public about how to interpret the situation and how to design procedures for collectively justifying binding decisions on acceptability and tolerability that are considered legitimate.[43]

For an ambiguous risk or threat process, risk management creates conditions:

> Where those who believe that the risk is worth taking and those who believe otherwise are willing to respect each other's views and to construct and create strategies acceptable for various stakeholders and interests.[44]

[40] Ibid, 252
[41] Ibid, 252
[42] Ibid, 253
[43] Ibid, 253
[44] Ibid, 253

Ambiguous risk management would be well-suited for confronting space capabilities such as ASAT testing or electronic and cyber-attacks to space systems in Low Earth Orbit and their Earth-based counterparts. Renn and Klinke suggest at this level of risk or threat it is important to structure "... an effective and efficient process of inclusion (whom to include) and closure (what counts as evidence and the adopted decision-making rules).[45]

The last part of the risk governance cycle, which is instrumental across all stages and processes, is communication and participation. Lack of communication and participation across risk governance can impede the effectiveness of the process.[46] Within the concept of communication and participation there should also be a level of trust because "communication breakdowns can easily damage trust".[47] Another part of communication and participation is inclusion. This means risk governance needs the participation of operators, stakeholders, and decision-makers through inclusive fora such as deliberations via the United Nations, conferences, and other various open, expert, or high-level platforms. As the aspects of space security are highly geopolitical and unequal in balance (some States have more capabilities than others), it is important to communicate to build trust and to have inclusive participation to find ways forward on how to act responsibly in space.

As has been discussed here, risk governance – and risk management as part of that model – would serve as a smart jumping off point for evolving the LEO governance framework. Risk management speaks the language of all types of stakeholders – engineer, operator, State decision-maker – and is supported by ISO standards 31000:2018 Risk Management Guidelines and 17666:2016 Space Systems – Risk Management. Many of the elements of risk governance include crucial aspects of governance that were mentioned at the start of this chapter. The next section will take all these aspects plus the risk governance model and apply them to a proposed way forward for the sustainable governance of Low Earth Orbit and will answer the last two research questions.

[45] Ibid, 253
[46] Ibid, 253
[47] Ibid, 254

7.2.2 The Sustainable Governance of Low Earth Orbit

This section will finally pull together everything this research has presented and offer a proposed governance framework for Low Earth Orbit which considers the 3S Approach to the activities on-orbit and for the LEO environment.

As was mentioned above, the risk governance model offers a solid framework for Low Earth Orbit, however, it needs to be connected to other important elements to strengthen the governance framework. Risk governance will relate to SSA and STM as well as the broader Outer Space Regime and regime complex. This will be broken down in this section to better form a picture of what the framework would entail and how it might work in practice. Knowing the nature of States, this governance shift would be minute and gradual – adaptive and evolving – as it would be impossible to make grand changes and quickly given the geopolitical climate and the diversity of interests across the space community. Regime change and governance change does take time. In fact, while the Outer Space Regime and the governance of LEO seem stagnate, there are subtle shifts occurring such as this new drive for responsible behaviours through norms and the continued efforts toward an LTS 2.0. What needs a push is the importance of why the governance needs to change – the urgency for a safe, sustainable, and secure space environment – and to encourage space actors to implement non-binding laws as well as ramp up communication.

This section sets out to show how risk governance can be tied to SSA and STM to include these elements into the framework. It will also walk through the legal aspects needed for the LEO governance framework. A large part of governance is communication and knowledge sharing which means there will also be discussion on how this can be accomplished within the framework. This section will also touch on how actors can monitor space activities which links back to SSA and STM and will tie monitoring to accountability options. This section will look at how the LEO governance framework is linked to the grander Outer Space Regime and regime complex especially regarding the ITU and what elements from the larger regime and complex might be suited for LEO specifically as well.

As was discussed above, risk governance (in this research also includes threats), includes a clear process for managing varying degrees of risk and is understood by decision-makers and operators. Risk governance is not only a governance theory but is also supported by ISO standards on risk management and, for the purpose of this research, ISO standards on risk management for space systems. This further solidifies the argument that this can be a governance model applied top-down and bottom-up. Another consideration to be mindful of is that for the governance framework to work in LEO it must be applied at the international, national, and operational levels. The next section will go through how the LEO governance framework – with the risk governance model – would be applied at the international, national, and operational levels. Keeping in mind that this is also an adaptive or evolving governance framework as technologies and the diversification of actors and activities continues to change. It also must be addressed that all levels must consider pre-launch, launch, on-orbit, and EoL parts of the space systems life cycle.

Starting at the international level, the LEO governance framework should include all aspects of the risk governance model cycle including pre-estimation; interdisciplinary estimation; risk characterisation and evaluation; risk management; and communication and participation. There should also be inclusion of all levels of SSA including data collection; data analysis; and communication to relevant stakeholders. Of course, there are always legal considerations and ways for knowledge sharing and continued communication and discourse through the United Nations.

Under the current LEO governance framework, the international community is not fully engaged in SSA at any stage (data collection, data analysis, and communication) as only a handful of States have capacity as well as a few commercial actors. The former share access via bilateral agreements while the later share access for a fee which does not make for equitable or international SSA practices. Currently, there is not any international organisation set up to conduct SSA nor openly share the data. Member States of UN COPUOS Legal Subcommittee have expressed concerns over "... the lack of information and interpretation of space situational awareness…"[48] which has "... resulted in an increased risk of collisions and interference…"[49] While creating an international SSA component seems unlikely now it is perhaps something that must be addressed in future. In much the same way as the International Air Transport Association (IATA) supports air traffic management, in future there could be an association or organisation dedicated to space situational awareness and space traffic management – but this industry has a long way to go on establishing something like this. The idea of having a centralised STM or SSA body would seem ideal however, a one-to-one analogy like IATA cannot be used in space because there are commercial, military, civil, and academic space

[48] UNGA 'Report of the Legal Subcommittee on its Sixty-First Session, Held in Vienna from 28 March to 8 April 2022' (19 April 2022) 61st Session (2022) UN Doc A/AC.105/1260, 23
[49] Ibid, 23

objects in LEO and some satellites are dual use. IATA only addresses commercial air activity. One big reason for this lack of international body is that at the international level there is also no form of Space Traffic Management. As was mentioned previously in this research[50], STM is not really provided now because no one State, or actor, manages or controls all operations in Low Earth Orbit. It can be further argued that management is not even practiced at all at the international level. Perhaps the better term would be coordination as is mentioned here by Oltrogge:

> Rather than direct traffic, the potentially more relevant word is ‘coordination’ -- that is, helping coordinate between operators what the risk is and allowing each pair of operators to determine whom best to perform an avoidance maneuver if/when necessary.[51]

At the international level there are deliberations about SSA and STM through the UN COPUOS committee meetings but in practice SSA and STM (or STC) are conducted at the national (or regional – especially regarding Europe) and operational levels. If there is not to be SSA or STM at the international level, what then, would be part of the LEO governance framework at this level? The focus would have to be on risk governance, legal aspects, and knowledge sharing and communication aspects.

In terms of risk governance, the international space community is all over the board on the risk cycle depending on the risk – or threat – in question. There is currently also a fixed siloed approach where risks are handled within the UN COPUOS ‘peaceful’ side of deliberations and threats are handled within the UNODA CD ‘security’ side of deliberations. For long-term risk governance this would not be ideal but the chance of having risks and threats under one UN body seems impossible given the mandate of UN COPUOS. However, stronger cross-body discussions and knowledge sharing plus cross-cutting considerations could be strengthened. One side should always keep in mind what the other side is discussing and why (and vice versa).

Take space debris as a first example. Space debris is predominately discussed at UN COPUOS unless the debris was generated by ASATs then it is also discussed at UNODA CD. Space debris also has its own non-binding international law in the form of the Space Debris Mitigation

[50] Daniel Oltrogge, ‘Space Situational Awareness: Key Issues in an Evolving Landscape’ (2020) Hearing of the Committee on Science, Space, and Technology, U.S. House of Representatives, Tuesday, 11 February, 5
[51] Ibid, 3

Guidelines and has specific guidelines under the Long-Term Sustainability Guidelines. Further there are ISO standards specific to space debris. This would suggest that space debris has been framed (there are human-made and natural debris as well as various activities that can trigger or cause debris creation – like ASATs) which means that the Pre-Estimation part of risk governance has been successful regarding space debris. There has also been Interdisciplinary Estimation on space debris regarding the criteria of what is space debris. There are many classes of debris not just by natural or human-made but also based on size and trackability. With the SDMG, LTSG, and ISO standards there is also Risk Management on mitigation efforts. Further there are communications at the UN level where space debris is a continued agenda item especially at UN COPUOS (both from the scientific and technical perspective and legal perspective). Stepping back to the Characterization and Evaluation part of the cycle – there are not any legally-binding rules or norms on what is acceptable, tolerable, or intolerable for debris. Of course, it is argued that debris is intolerable, but accidents can happen. Further, natural impact from meteoroids may not be in human capacity to avoid. Data to track and trace debris is largely in the hands of the United States government which means not all actors have access to true numbers regarding debris on-orbit in LEO. As tracking is almost impossible for debris under 1cm there is an argument that the threshold for how much debris is tolerable on-orbit at one given time can only be an estimate at best. This Characterization and Evaluation part of the risk cycle may not be complete regarding space debris which could then make it difficult to fully manage the risk in the next part of the cycle. As of September 2022, the US (via the Federal Communications Commission or FCC) has taken the approach that the '25-year rule' from the Space Debris Mitigation Guidelines for deorbiting inactive satellites in LEO should be down to 5 years.[52] This could set an international precedent if other States look to the US as a norm entrepreneur and decide to follow suit. This is currently strictly within the US licensing framework which only impacts satellite operators with a satellite license from the US. With the US liable for most of the satellites in LEO, this could prove ground-breaking in tackling the space debris problem moving forward. The US drafting such regulation moves the discussion of space debris into the risk management part of the risk governance cycle. It remains to be seen if this discussion is picked up at the international level. The IADC Space Debris Mitigation Guidelines were presented to UN COPUOS in 2003 meaning that in 2027 the '25-year rule' would be up from when the guidelines were presented internationally, even though

[52] FCC, 'FCC Fact Sheet: Space Innovation; Mitigation of Orbital Debris in the New Space Age' (Second Report and Order, IB Docket Nos. 22-271 and 18-313, 8 September 2022)

the UN version omits the rule. With the UN adopted rules omitting the guideline on deorbit lifetime, and with the deadline not yet approaching since the guidelines were first introduced, it remains to be seen what will happen. The US push for a shorter 5-year rule domestically could open the debate. In time space debris, with the addition of on-orbit servicing, and other EoL procedures, could move into a firm risk management stage of the governance cycle.

Another example at the international level is the growing consideration of satellite constellations and mega constellations. It is interesting to note that most of the rhetoric about constellations is only regarding the so-called mega constellations, SpaceX Starlink specifically, though there are many constellations of varying sizes in Low Earth Orbit and not all are commercial. Unfortunately, satellite constellations are only at the first point – Pre-Estimation -- of the cycle within risk governance. Going back to Renn and Klinke, as was mentioned above, "what counts as a risk [or threat] to someone may be regarded as destiny by someone else or in other instances as an opportunity".[53] With the case of satellite constellations, astronomers see the larger, or mega, constellations as a threat to their research because of the visual disturbance in the night sky. The operators, especially commercial operators with satellite constellations consisting of 100 plus satellites, see these constellations as opportunities for Earth Observation and income for their businesses. A further factor is that at the international level both astronomers and commercial operators are largely not engaged in high-level discussions nor are decision-makers. Which also puts the discussion at a disadvantage of not having all relevant parties in the room. Member States at UN COPUOS are starting to deliberate over satellite constellations by way of framing the discussion – as the Pre-Estimation part of the risk governance cycle suggests. However, operators – and not only commercial – are requesting licensing and are already launching satellites for constellations regardless of the international discussion and framing of whether these objects are threats or risks to other stakeholders. The problem here is one of known unknowns. As was mentioned above, there is not enough data to suggest that the current active and inactive number of objects in LEO has reached the threshold of tolerance or intolerance for sustaining the use of orbit. Perhaps these constellations are only an eyesore only to astronomers and are not going to create massive amounts of collisions or need for collision avoidance manoeuvres. Until scientists can give a more detailed and accurate picture of the capacity of LEO, operators will continue to put up satellites as they are legally able to do so. Even if it is found that the threshold for sustainable

[53] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 247

use of LEO is already here, unless regulations are changed to be more selective on licensing – like GEO or how the ITU regulates the radio spectrum – there will still be operators acquiring licensing for launch of satellites. States will also keep launching their own satellites as well. It is important that satellite constellations be considered through the risk governance cycle to consider all possibilities as well as keep consideration for all stakeholders and their interests – which should be under consideration in this first stage now.

Next to space debris and satellite constellations, another risk to space activities is the more overarching discussion on space threats tied to security. This includes kinetic and non-kinetic capabilities such as ASAT tests or cyber and electronic attacks. What makes the issue of space threats slightly different to the two issues above is that this discussion is being had not through UN COPUOS but rather through the UN Conference on Disarmament. In 2020, the UNGA adopted *Resolution 75/36 Reducing Space Threats through Norms, Rules, and Principles of Responsible Behaviours* (Resolution 75/36) championed by the UK. This resolution emphasizes "… the importance of maintaining outer space as a peaceful, safe, stable, secure, and sustainable environment for the benefit of all …"[54] which reinforces the same rhetoric of UN COPUOS. However, this resolution goes further by recalling that the UN CD has a primary role to prevent an arms race in outer space, "… including the weaponization of outer space and threats from capabilities on Earth …"[55] What does this mean from a risk governance perspective? Recall, earlier this research declared that risk governance would include consideration of threats as well. Kinetic and non-kinetic threats can be considered within the risk governance cycle. Kinetic and non-kinetic threats are at different stages of the risk management cycle.

Kinetic threats, such as ASATs are the most common kinetic threats to space, now. These are Earth-to-space weapons which have been tested by Russia, China, and India. With the most recent occurring in 2021 with a Russian ASAT test in Low Earth Orbit.[56] There can be other forms of kinetic threats such as space-to-space or space-to-Earth, however the most discussed diplomatically and academically are the ASAT tests. Discussing kinetic threats of all types, regarding risk governance, the phase of risk management is needed now. States have already

---

[54] UNGA Res 75/36 (16 December 2020) UN Doc A/RES/75/36, 1
[55] UNGA Res 75/36 (16 December 2020) UN Doc A/RES/75/36, 2
[56] CSIS, 'Counterspace Timeline 1959-2021' (*CSIS*, 31 March 2021) <https://aerospace.csis.org/counterspace-timeline/?startYear=1945&endYear=2022&country=all&showStories=false&categories=Kinetic+Physical&subcategories=Direct-ascent+ASATKinetic+Physical%2CCo-orbital+ASATKinetic+Physical%2CTechnology+DemonstrationKinetic+Physical%2CDirect-Ascent+ASATKinetic+Physical%2CGround+Station+Attack+Kinetic+Physical> accessed 30 September 2022

framed what kinetic threats are and have characterised and evaluated that they are 'intolerable' risks, especially within LEO. The stage of risk management is now because, as Renn and Klinke suggest, "if the risk is considered intolerable … risk management should be focused on banning or phasing out the activity creating the risk".[57] In April 2022, the US announced:

> Commits not to conduct destructive, direct-ascent anti-satellite (ASAT) missile testing, and that the United States seeks to establish this as a new international norm for responsible behavior in space. The [US] also called on other nations to make similar commitments and to work together in establishing this as a norm, making the case that such efforts benefit all nations.[58]

This announcement has spurred other States into agreement. In May and September 2022, the OEWG on Reducing Space Threats convened at the UN in Geneva where statements from Japan, Germany, and Canada were given in support of the US moratorium on ASAT tests and the drive toward norms of responsible behaviours in space security.[59] This announcement fits perfectly into the risk management stage of the risk governance cycle in that States are deciding that ASAT tests should be phased out. This discussion during the OEWG also covered other forms of kinetic threats, however, the ASAT testing from Earth-to-space is the area where the most progress is being made politically because it is the area with the most active capable actors (namely Russia and China). Perhaps from this encouragement on halting ASAT testing, there will also be norms of responsible behaviours on all kinetic threats which means that this type of threat can start moving into the next stage of risk governance regarding continuous communication and participation towards following and upholding the risk management aspect of the cycle.

Non-kinetic threats are on a similar path of discussion however, not to the extent of ASAT testing. While ASAT testing also gets community and media attention, non-kinetic does not. Non-kinetic threats are electronic and cyber in nature such as jamming, spoofing, or lasing, as has been mentioned in previous chapters. Non-kinetic threats are known, therefore, regarding

---

[57] Ortwin Renn and Andreas Klinke, 'Risk' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016) 251

[58] The White House, 'Fact Sheet: Vice President Harris Advances National Security Norms in Space' (*the White House*, 18 April 2022) <https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/18/fact-sheet-vice-president-harris-advances-national-security-norms-in-space/> accessed 30 September 2022

[59] UNODA, 'Open-Ended Working Group on Reducing Space Threats' (UNODA, 2022) <https://meetings.unoda.org/section/oewg-space-2022_general-statements_19856/> accessed 30 September 2022. See Statements (first session and second session) for US, Japan, Germany, and Canada statements.

risk governance, they have moved past pre-estimation. If non-kinetic threats are further broken down to non-kinetic physical, electronic, and cyber – there is understanding as to what constitutes each. For example, non-kinetic physical counterspace weapons, such as lasers, "... can be used to temporarily dazzle or permanently blind the sensors on satellites, and higher-powered lasers can cause components to over-heat".[60] Electronic counterspace weapons use the electromagnetic spectrum to interfere with satellites by jamming or spoofing. The ITU has clear articles within the ITU Constitution (Article 45)[61] as well as the Radio Regulations (Preamble 0.4 and Article 15)[62] not to create harmful interference and to prevent harmful interference. Within the UK, Ofcom, enforces these legal tenets and there are strict protocols for if a satellite operator has created interreference (intentionally or not, maliciously or accidentally) or if a satellite operator has been interfered with. Cyber counterspace weapons target data and systems through loss of data or seizing command and control systems. These kinds of attacks can target the whole satellite system – including ground stations. For all non-kinetic threats, the line can be drawn that these are intolerable therefore the risk characterization and evaluation are complete for the risk governance cycle. Non-kinetic threats, alongside kinetic threats, need risk management with continued communication, participation, and transparency. As there are two OEWG -- one for cybersecurity and one for space security -- there is room for discourse on kinetic and non-kinetic threats in both groups. Especially given that the cyber group would have expertise on dealing with non-kinetic cyber threats more generally. Cross-coordination should be considered within the OEWGs as they are also speaking on the same rhetoric of responsible behaviours with norms, principles, and guidelines.

Along with space debris, there are efforts to have rendezvous and proximity operations or on-orbit servicing for satellites at the end-of-life stage or that have gone down and need servicing before end-of-life. While not many stakeholders are involved with RPO or OOS activities, there are space agencies and private entities working on mission concepts with magnets, harpoons, nets, or robotic arms. While these technologies are not risks or threats, *per ce*, they could be construed as such if the missions are not communicative and transparent in nature. It is of the utmost importance that RPO and OOS activities be known in advance so that operators with satellites in the vicinity of the client satellite are aware what is going on not only so they

---

[60] Todd Harrison, Kaitlyn Johnson, and Makena Young, 'Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons' (Center for Strategic and International Studies, February 2021) 8

[61] Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330, Art 45

[62] International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn) Preamble, Art 15

do not perceive the mission as a risk or threat but so they can also stand ready for course corrections where needed. These technologies have already been framed and assessed as acceptable with the normal safety risk management aspects put in place. Therefore, for risk governance, RPOs and OOS should be heavy on the continued communication amongst stakeholders as well as continued risk management.

Moving to national level and operational level risk governance. At the national level, risk governance can be tied to the licensing process. In fact, within the UK the CAA has an "... optional and free-of-charge pre-application"[63] Traffic Light System (TLS) which helps determine readiness to apply for an operator licence. Operators conduct risk management for missions using ISO Standards such as ISO 31000:2018 Risk Management – Guidelines and ISO 17666:2016 Space Systems – Risk Management. As operators utilise many risk and safety guidelines and practices it is from the operational level that risk governance comes forth. It is easily applicable to the national level as any licensing framework should consider risks through the auspices of safety, security, and sustainability. Especially, if, like the UK, national space regulations have implemented international space treaties, principles, and guidelines. What is important at the national level is knowledge-sharing at the international level on implementation into national regulations and operational knowledge-sharing through various platforms such as conferences on risk management. The Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference or the International Astronautical Congress (IAC) are two places where operators could share how risk management can be an integral part of any space mission. Additionally, national, and operational level stakeholders can tie risk management to space situational awareness which in turn would mean risk management could be applied to a space traffic management plan at the international level.

The recommendation here being that risk governance be the operational way forward to combine space situational awareness with the 3S Approach to create a space traffic management plan which could be applied at the operational, national, and international levels. Especially as risk governance speaks the language of operators, policymakers, and diplomats alike. At UN COPUOS, there is already progress on LTS 2.0 and at UNODA CD there is progress on responsible behaviours in space, which are checking all the parts of the risk governance cycle. Additionally, Member States of UN COPUOS Scientific and Technical

---

[63] CAA, 'Applying for a Licence: Pre-application Engagement and How to Apply for a Licence' (CAA 27 October 2022) <https://www.caa.co.uk/space/orbital-satellite-operator/applying-for-a-licence/> accessed 27 October 2022

Subcommittee have expressed the need for improvements to SSA capabilities across governments and commercial endeavours[64] and there is talk of the development of a SSA road map from the Australian Space Agency. Such initiatives like the SSA road map or the Space Sustainability Index only enhance a potential STM plan and would work well under a risk governance framework. This of course would be heavily emphasised in Low Earth Orbit, but an STM risk governance framework could apply to other places in space as well such as the Moon or Medium Earth Orbit. Thinking broader, any risk governance framework needs to be adaptive or evolutionary to ensure that any legal requirements are up to date with scientific and technological progress as well as ensuring the framework meets the needs of the diversity amongst all stakeholders – both State and non-State. As was mentioned in previous chapters, the Outer Space Regime is evolving and must do so because of the nature of space activity. This evolutionary governance must underpin any framework put in place for the framework to adapt with the times.

7.3 Review of Chapters

This last section will include a review of Chapters One through Five as well as summarising the recommendations. There will be a brief review of the research questions and how they have been answered as well as some final concluding remarks on the research.

7.3.1 Regime Theory and the Regime Complex

Chapter Two took an international relations approach discussing the governance of the Outer Space Regime and the Low Earth Orbit governance framework. This was paired with discourse on international law – part of the regime and governance framework. The chapter started by examining the literature on regime theory taken from international relations experts. Within the discussion on regime theory there was discussion on how regimes are created as well as why and what it takes to maintain a regime over time. Which led to further analysis on how regimes might evolve with two regimes given as case examples: the Trade Regime and the Climate Change Regime. From these case examples, regime theory was then applied to the Outer Space Regime to discuss the evolutionary nature of space governance. First there was discussion on the creation of the Outer Space Regime which then led to the

[64] UNGA 'Report of the Scientific and Technical Subcommittee on its Fifty-Ninth Session, Held in Vienna from 7 to 18 February 2022' (23 February 2022) 59th Session (2022) UN Doc A/AC.105/1258, 28

analysis of the evolving nature of the regime. Two additional concepts were presented – a nested regime and a regime complex. The nested regime concept focused on the use of law within a regime as well as the hierarchy of law within a regime. The regime complex concept showed how the Outer Space Regime is interconnected with other regimes such as the Telecommunications Regime, the Security Regime, and the Cyber Regime. Finally, this chapter analysed how the Low Earth Orbit governance framework is part of the Outer Space Regime.

7.3.2 Binding and Non-Binding Law of Outer Space

Chapter Three focused on international law and space law. The chapter started with a literature review on binding international law within the Outer Space Regime. The focus was on the Outer Space Treaty, the Liability Convention, and the Registration Convention as these treaties are important for the LEO governance framework. The chapter then had a literature review of non-binding international law in general terms and then specific non-binding laws pertaining to outer space and Low Earth Orbit. Finally, this chapter analysed the growing trend toward discourse on normative behaviour and norms in space.

7.3.3 The 3S Approach

Chapter Four conducted a literature review and analysis of the 3S Approach – security, safety, and sustainability – more generally and then as applied to the Outer Space Regime and Low Earth Orbit. Each part of the 3S Approach was defined generally and then in the context of LEO and space to critically analyse the importance of security, safety, and sustainability within the Outer Space Regime and the LEO governance framework.

7.3.4 Governance Theory Analysis

Chapter Five gave a literature review of governance theory (a modern version of regime theory) and then analysed various governance models as they could potentially be applied to Outer Space Regime and the LEO governance framework. The analysis covered an overview of what the model entails along with the strengths and weaknesses to assess each model's potential for application to the Outer Space Regime and the LEO governance framework. In the end, a few models were selected for further analysis and consideration for the Outer

Space Regime and LEO governance framework which were brought to the recommendations section of this research.

7.3.5 Current LEO Governance Framework

Chapter Six critically analysed the current governance framework of Low Earth Orbit. It started with an understanding of small satellites and satellite constellations and how international law as well as national regulations are applied to these satellites in LEO. There was critical analysis of the legal and political challenges of regulating satellites in LEO. One of the main challenges addressed was space debris because debris is an issue that cuts across all three of the 3S Approach. The chapter also discussed the components of the current LEO governance framework which included analysis of space situational awareness and space traffic management as supporting options for the challenges faced in governing Low Earth Orbit. Finally, the chapter presented potential strategies for enhancing the LEO governance framework such as the Space Security Rating; the Long-Term Sustainability 2.0; Space Traffic Management; and the use of norms in space.

7.3.6 Recommendations and Conclusion

The recommendations section of this chapter focused on recommending ways to enhance the current LEO governance framework evidenced by literature; laws and regulations; politics and diplomacy; decision-making; and models of governance. The recommendations started with discourse on the components needed for a governance framework and how the components allow a governance framework to function. This was then analysed and applied to Low Earth Orbit. The final governance models preferred at the end of Chapter Five were then further analysed for the LEO governance framework. The recommendation was given that Low Earth Orbit needs a sustainable governance framework that can evolve as technology advances and the diversity of actors on-orbit expands. The use of risk governance which speaks to decision-makers and operators alike was the chosen governance model to apply to the LEO governance framework paired with LTS 2.0, SSA, and STM to help make the risk governance model function alongside law and regulations.

7.4 Answering the Research Questions

This research set out to address and answer four research questions pertaining to the Outer Space Regime and the Low Earth Orbit governance framework. This section will present the research questions again. This section will also present the findings of this research backed by the literature to respond to these questions.

7.4.1 How is the Outer Space Regime evolving and why is this important to Low Earth Orbit?

As was discussed in Chapter Two, knowledge[65] is a critical point when it comes to why the Outer Space Regime is evolving. Advanced knowledge in science and technology means advances in how to access and utilise space. Knowledge can also mean 'capacity building' for emerging space actors through collaboration and information sharing with other more established space actors. Regimes can also evolve systemically through strength, form, scope, and allocational mode[66] as was demonstrated in Chapter Two of this research. This means that regimes can evolve through processes and practice. How decisions are made, who makes them, and what challenges are being discussed. These inform how the legal tenets should be created and implemented. Regimes can also evolve through membership, enforcement, diversity, flexibility, and acknowledging uncertainties.[67]

The Outer Space Regime is evolving. As of February 2023, there are 102 Member States[68] and 49 Permanent Observer[69] organisations of UN COPUOS. There are even more stakeholders when the number of private actors is also taken into consideration. With more stakeholders comes time needed to deliberate on issues faced in Low Earth Orbit. With 102 Member States it is harder to reach consensus in a timely manner. Which introduces the other way in which the regime is evolving – by its legal tenets. Something that was discussed in Chapter Three.

---

[65] Arthur A. Stein, 'Coordination and Collaboration: Regimes in an Anarchic World' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995), 125

[66] Stephan Haggard and Beth A. Simmons, 'Theories of International Regimes' (1987) 41 (3) International Organizations, 491-517, 496

[67] Barbara Koremenos, Charles Lipson, and Duncan Snidal, 'The Rational Design of International Institutions' (2001) 55 (4) International Organizations, 761-799

[68] United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Membership Evolution' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html> accessed 24 February 2023

[69] United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Observer Organizations' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html> accessed 24 February 2023

There has not been a space treaty entering into force since 1984. While legally binding space documents are still applicable today, there is growing use of non-binding international law and normative behaviour to supplement the treaties and principles of space. With the use of non-binding international law comes the need for more national space regulations and licensing procedures to create binding tenets domestically for State and non-State activities in space. In Chapter Six UK space regulations and licencing were discussed to showcase how implementation of international space law (binding and non-binding) could be brought to the national level. The Outer Space Regime is evolving through legal approaches both internationally and nationally.

Chapter Four critically analysed the importance of the 3S Approach to the Outer Space Regime and Low Earth Orbit. Current diplomacy does factor in space security, space safety, and space sustainability which is evidenced by the *United Nations General Assembly Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours*[70] deliberated on at the UN Conference on Disarmament or the *Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space* or the *Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space*[71] created by UN COPUOS. Additional to this growing diplomatic and legal interest in the 3S Approach is the continued consideration of how the regime complex can work together. The ITU[72] continues to regulate and amend regulations pertaining to the use of the radio spectrum for satellites which aligns with safety and sustainability agenda items in UN COPUOS. An area where there is room for growth and interaction is with the Cyber Regime to protect space systems from cyber threats – something that would tie over to the space security discussion within the UN CD.

The Outer Space Regime is evolving which means the governance models used – hierarchical and global – should be questioned by diplomats and decision makers. This research takes the approach that the governance of the Outer Space Regime should be a hybrid model. One that can support all stakeholders and activities in space. One that is underpinned by the legal tenets of the regime and one that is guided by the 3S Approach. Perhaps there is room to add adaptive

[70] UNGA, Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours, A/Res/75/36, 7 December 2020

[71] United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69

[72] International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019) 5

governance or inclusive governance to the hybrid model. However, there should also be discussion on each sub-regime and the governance model needed for these: LEO, the Moon, Mars, and so on as each sub-regime is a unique environment with different types of activities, challenges, and limitations which is why this research focuses on Low Earth Orbit.

7.4.2 **Why does the Low Earth Orbit governance framework need to evolve and what measures need to be in place to make this happen**?

Low Earth Orbit is the most used part of space with over 5,000 active satellites on-orbit.[73] With over 25,000 pieces of space debris over 10cm and millions of pieces of debris under 10cm LEO is congested and becoming fiercely competitive[74]. This concern over congestion has led to the creation of the Space Debris Mitigation Guidelines and the Long-Term Sustainability Guidelines through UN COPUOS. The ITU has also recently created the milestone approach for the use of the radio frequency spectrum for non-GSO (i.e., Low Earth Orbit) satellites. While the latter will be binding, the guidelines are not and must be implemented at the national level for binding effectiveness. These legal tenets can support the safety and sustainability of LEO but there is still the concern of threats to LEO and on-orbit where space security legal tenets must also be addressed. The LEO governance framework needs to include the 3S Approach in political and legal discourse and outcomes as was discussed in Chapter Three and throughout this research.

Low Earth Orbit is a limited resource and environment. The congestion on-orbit could even lead to the orbit towards a non-renewable limited resource in future if the 3S Approach is not coordinated with governance efforts such as Space Traffic Management as was discussed in Chapter Five. The LEO governance framework must include mitigation and remediation of space debris paired with SSA to monitor active and non-active space objects on-orbit from launch until End of Life. Operators of satellites do not have local understanding of LEO as they are not piloting satellites in space meaning SSA and some form of STM must be considered globally for coordination efforts and to boost transparency amongst actors. Tied to this is a need for communication efforts to be amplified. The recommendations section above in this

---

[73] Seradata, 'SpaceTrak' (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022
[74] NASA, 'Astromaterials Research & Exploration Science NASA Orbital Debris Program Office Frequently Asked Questions' (*NASA*, 02 June 2022) <https://orbitaldebris.jsc.nasa.gov/faq/#> accessed 02 June 2022; ESA, 'Space Debris by the Numbers' (*ESA*, 07 November 2022) <https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers> accessed 21 December 2022

chapter remarked on what would be needed in a governance framework to support a secure, safe, and sustainable LEO environment.

No real consensus has been met on how to define space traffic management which makes it hard to exactly pinpoint what elements should be under consideration for a space traffic management plan. This point, paired with the others mentioned in this section and throughout the research are why the LEO governance framework must adapt. As the next research question will articulate, there is a practicable governance model that could apply to LEO which does consider all stakeholders as well as the 3S Approach.

7.4.3 What is the optimal model of governance for Low Earth Orbit while still staying nested within the Outer Space Regime keeping in mind legal, political, socio-economic, and environmental considerations?

As was mentioned above in the recommendations, the risk governance model[75] offers a solid framework for Low Earth Orbit, however, it needs to be connected to other important elements to strengthen the governance framework. Risk governance paired with SSA and STM as well as the broader Outer Space Regime and regime complex would provide the model of governance for LEO. Risk governance (in this research also includes threats), includes a clear process for managing varying degrees of risk and is understood by decision-makers and operators. Risk governance is not only a governance theory but is also supported by ISO standards on risk management. A risk governance model can be applied top-down and bottom-up and at various levels such as internationally or nationally. f

7.4.4 How would an updated governance model in Low Earth Orbit address the activities and issues in Low Earth Orbit from international relations and international law perspectives?

The recommendations section of this chapter has identified that risk governance would be the most practicable governance model for LEO. Paired with continued use of SSA and keeping consideration of the 3S Approach, the risk governance model would, in a sense, be a Space Traffic Management Plan for LEO. For the model to work, decision makers must continue to

[75] Ortwin Renn and Andreas Klinke, ‘Risk’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

deliberate and exchange knowledge on national implementation of space law. They must also continue to view LEO challenges from purviews of security, safety, and sustainability. They must draw insight from the regime complex especially cyber and telecommunications. States must implement space law into national regulations and licensing processes and continue to encourage non-State actors to also be responsible actors in space. There must be room for the risk governance model to adapt, evolve, and be flexible as the diversity of actors and activities continues to grow on-orbit.

7.5 Final Remarks

This research has sought to address why and how the Outer Space Regime is evolving and what this means for the Low Earth Orbit governance framework. The research also critically analysed different models of governance to find a more suitable option for Low Earth Orbit given the challenges faced on-orbit and the need for a 3S Approach[76] to the ever increasingly congested, contested, and competitive[77] nature of the orbit. The analysis and critique created in this research has highlighted the important fact that the Outer Space Regime is indeed evolving and has moved into an era of non-binding international law which must rely on national regulations and licensing. This in turn means that the LEO governance framework must also evolve to consider the increasing number of unique actors entering orbit and the vastly increasing number of active satellites and debris on-orbit. This led to the recommendation that the LEO governance framework should use a risk governance model with SSA and some form of STM paired with the 3S Approach.

The benefit of conducting this socio-legal research amplifies the importance of considering how governance is shaped and does shape activities in space. The detailed critique of international law, international relations, and the wicked problems of space and LEO governance discussed in this research can serve as a primer for one solution to the issues faced. LEO is an orbit where satellites conduct Earth Observation and support humanity daily. Satellites are "... intrinsic components…"[78] supporting the climate crisis, disaster management,

[76] Peter Martinez, Peter Jankowitsch, Kai-Uwe Schrogl, Simonetta Di Pippo, and Yukiko Okumura, 'Reflections on the 50th Anniversary of the Outer Space Treaty, UNISPACE+50, and Prospects for the Future of Global Space Governance' (2019) 47 Space Policy, 28-33

[77] Beth Duff-Brown, 'The Final Frontier Has Become Congested and Contested' (*Stanford Center for International Security and Cooperation*, 4 March 2015) <https://cisac.fsi.stanford.edu/news/security-space-0> accessed 16 February 2023 citing Air Force Lt. Gen. John "Jay" Raymond

[78] Simonetta Di Pippo and Niklas Hedman, 'Forward' in United Nations Office for Outer Space Affairs (eds) *United Nations Office for Outer Space Affairs Annual Report 2021* (United Nations 2022) iv

and other aspects of critical concern today. Low Earth Orbit will only continue to be a critical orbit for a variety of actors – State and non-State – in the coming years which is why governing Low Earth Orbit (and space more generally) is such an important topic. Ultimately, it will be up to decision makers and stakeholders to evolve the governance of the Outer Space Regime and Low Earth Orbit.

> Space stakeholders are enhancing evidence-based decisions and policymaking, putting satellites into action for sustainable development, and working together to understand specific needs and develop tailored solutions.[79]

It is through forums like UN COPUOS where governance can be discussed and enhanced. But it is now time to include non-State actors in that discussion. Governance is politics, polity, and policy. Governance is society, governments, and technology. Governance takes a village – a global village – to support the security, safety, and sustainability of Low Earth Orbit and space for use now and in future generations. The time is now to let space governance evolve. Our future depends on it.

[79] Ibid, iv

List of References

Abbott K W and Snidal D, "Hard and Soft Law in International Governance" (2000) 54 (3) International Organization, 421-456

African Union, 'African Space Strategy: For Social, Political and Economic Integration' (2019) <https://au.int/sites/default/files/documents/37434-doc-au_space_strategy_isbn-electronic.pdf> accessed 06 June 2023

African Union, 'African Space Policy: Towards Social, Political and Economic Integration' (ND) <https://au.int/sites/default/files/documents/37433-doc-african_space_policy_isbn_electronic_.pdf> accessed 06 June 2023

Aliberti M, Napier J L, and Beischl C, "Orbital Congestion: Assessing the Prospects for Effective Governance Structure through Regime Theory" (2016, International Astronautical Federation) 67th International Astronautical Congress, IAC-16, E3.IP.3

Alter K J and Meunier S, 'Nested and Overlapping Regimes in the Transatlantic Banana Trade Dispute' (2006) 13 (3) Journal of European Public Policy, 362-382

Baiocchi D and Welser IV W, *Confronting Space Debris: Strategies and Warnings from Comparable Examples including Deepwater Horizon* (Rand Corporation, 2010)

Baldwin D A, 'The Concept of Security' (1997) 23 Review of International Studies, 5-26

Barton J H, Goldstein J L, Josling T E, and. Steinberg R H, *The Evolution of the Trade Regime: Politics, Law, and Economics of the GATT and the WTO* (Princeton University Press, 2006)

Bielicki D M, 'Legal Aspects of Satellite Constellations' (2020) 45 (3) Air and Space Law, 245-264

Blomqvist P, 'Soft and Hard Governing Tools' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Bodansky D and Diringer E, 'The Evolution of Multilateral Regimes: Implications for Climate Change' (December 2010) Pew Center on Global Climate Change <https://www.c2es.org/document/the-evolution-of-multilateral-regimes-implications-for-climate-change/> accessed 04 May 2022

Bowen B, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press 2020)

Brearley A, 'Reflections Upon the Notion of Liability: The Instances of Kosmos 954 and Space Debris' (2008) 34 Journal of Space Law, 291-319

Broeders D and van den Berg B, 'Chapter 1 Governing Cyberspace: Behavior, Power, and Diplomacy' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020)

Burrows M J and Gnad O, 'Between 'Muddling Through' and 'Grand Design': Regaining Political Initiative – The Role of Strategic Foresight' (2018) 97 Futures 6-17

CAA, 'Applying for a Licence: Pre-application Engagement and How to Apply for a Licence' (CAA 27 October 2022) <https://www.caa.co.uk/space/orbital-satellite-operator/applying-for-a-licence/> accessed 27 October 2022

Charter of the United Nations and Statute of the International Court of Justice (signed 26 June 1945, entered into force 24 October 1945)

Chatham House, 'Reflections on Building More Inclusive Global Governance: Ten Insights into Emerging Practice' (April 2021)

Civil Aviation Authority, 'Applying for a Licence: Pre-Application Engagement and How to Apply for a Licence' (*CAA* 2022) <https://www.caa.co.uk/space/orbital-satellite-operator/applying-for-a-licence/> accessed 24 November 2022

Committee on the Peaceful Uses of Outer Space Legal Subcommittee, 'Status of International Agreements Relating to Activities in Outer Space as at 1 January 2022' (28 March 2022) A/AC.105/C.2/2022/CRP.10

Committee on the Peaceful Uses of Outer Space, Terms of Reference, Methods of Work and Workplan of the Working Group on the Long-Term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee, A/AC.105/2021/CRP.18 (2021)

Constitution and Convention of the International Telecommunications Union (opened for signature 22 December 1992, entered into force 1 October 1994) 1825 UNTS 330

Convention on International Liability for Damage Caused by Space Objects (open for signature 29 March 1972, entered into force 1 September 1972) 961 UNTS 187

Convention on Registration of Objects Launched into Outer Space (open for signature 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15

CSIS, 'Counterspace Timeline 1959-2021' (*CSIS*, 31 March 2021) <https://aerospace.csis.org/counterspace-timeline/?startYear=1945&endYear=2022&country=all&showStories=false&categories=Kinetic+Physical&subcategories=Direct-ascent+ASATKinetic+Physical%2CCo-orbital+ASATKinetic+Physical%2CTechnology+DemonstrationKinetic+Physical%2CDirect-Ascent+ASATKinetic+Physical%2CGround+Station+Attack+Kinetic+Physical> accessed 30 September 2022

Curren R, “Sustainability: What It Is and How It Works Defining Sustainability Ethics” in Michael Boylan (ed), *Environmental Ethics* (Wiley and Sons 2014)

Daehnick C, Isabelle Klinghoffer, Ben Maritz, Bill Wiseman, ‘Large LEO Satellite Constellations: Will it be Different this Time?’ (4 May 2020) <https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time> accessed 2 September 2020

de Búrca G, Keohane R O, and Sabel C, ‘New Modes of Pluralist Global Governance’ (2013) 45 NYU Journal of International Law and Policy, 723-786

Defense Advanced Research Projects Agency, ‘Transit Satellite: Space-based Navigation’ (2020)

Di Pippo S and Hedman N, ’Forward’ in United Nations Office for Outer Space Affairs (eds) *United Nations Office for Outer Space Affairs Annual Report 2021* (United Nations 2022)

Du Pisani J A, ‘Sustainable Development – Historical Roots of the Concept’ (2006)

Duff-Brown B, ‘The Final Frontier Has Become Congested and Contested’ (*Stanford Center for International Security and Cooperation*, 4 March 2015) <https://cisac.fsi.stanford.edu/news/security-space-0> accessed 16 February 2023 citing Air Force Lt. Gen. John “Jay” Raymond

Elsenbroich C and Xenitidou M, ‘Three Kinds of Normative Behaviour: Minimal Requirements for Feedback Models’ (2012) 18 Computational and Mathematical Organizational Theory, 113-127

Elster J, ‘Social Norms and Economic Theory’ (1989) 3 (4) Journal of Economic Perspectives, 99-117

Endsley M R, ‘Toward a Theory of Situation Awareness in Dynamic Systems’ (1995) 37 (1) Human Factors: The Journal of the Human Factors Society, 32-64, 36

Environmental Sciences, 83-96, 85, quoting LJM Columella, ‘Res Rustica’ Vol. 1 (Books I-IV) Harrison Boyd Ash (English translation, Harvard University Press, 1948)

Erwin S, ‘Air Force: SSA is no more; it’s Space Domain Awareness’ (*Space News*, 14 November 2019) <https://spacenews.com/air-force-ssa-is-no-more-its-space-domain-awareness/> accessed 14 August 2021 quoting Air Force Space Command Deputy Commander Major General John Shaw from his 4 October memo.

European Space Agency, ’Space Debris by the Numbers’ (*ESA*, 07 November 2022) <https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers> accessed 21 December 2022

European Space Agency, ‘Space Surveillance and Tracking – SST Segment’ (*ESA*, no date) <https://www.esa.int/Safety_Security/Space_Surveillance_and_Tracking_-_SST_Segment> accessed 14 August 2021

European Space Agency, ‘The Current State of Space Debris’ (*ESA*, October 2020) <https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris> accessed 09 February 2023

European Space Agency, ’Space Debris by the Numbers’ (*ESA*, 07 November 2022) <https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers> accessed 21 December 2022

Evans P J, *Environmental Governance* (Routledge, 2012)

FCC, ‘FCC Fact Sheet: Space Innovation; Mitigation of Orbital Debris in the New Space Age’ (Second Report and Order, IB Docket Nos. 22-271 and 18-313, 8 September 2022)

Finnemore M and Sikkink K, ‘International Norm Dynamics and Political Change’ (1998) 52 (4) International Organization, 887-917

Flanagan A, ‘Authorization and Licensing’ in Ian Walden (ed), *Telecommunications Law and Regulation* (3rd edn, Oxford University Press 2009) 304-315

Florini A, ‘The Evolution of International Norms’ (Sept 1996) International Studies Quarterly, Vol. 40, No. 3, Special Issue: Evolutionary Paradigms in Social Science, 363-389

Frantz C K and Pigozzi G, ‘Modeling Norm Dynamics in Multi-Agent Systems’ (2018) 5 (2) Journal of Applied Logics – IFCoLog Journal of Logics and their Applications, 491-563

Gasparini Alves P, ‘Prevention of an Arms Race in Outer Space: A Guide to the Discussions in the Conference on Disarmament’ UNIDIR/91/79 (1991)

German Advisory Council on Global Change, *World in Transition: Strategies for Managing Global Environmental Risks* (Springer, 1998)

Gleckman H, *Multistakeholder Governance and Democracy: A Global Challenge* (Routledge, 2018)

Goguichvili S, Linenberger A, Gillette A, and other, ‘The Global Legal Landscape of Space: Who Writes the Rules on the Final Frontier?’ (*Wilson Center,* October 2021)

Group on Earth Observations, ‘GEO at a Glance’ (*GEO* 2022) <https://earthobservations.org/geo_wwd.php> accessed 21 December 2022

Guzman A T and Meyer T L, ‘International Soft Law’ (2010) 2 (1) Journal of Legal Analysis, 171-225

Haas E B, ‘Words Can Hurt You; or, Who Said What About Regimes’ in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)

Haggard S and Simmons B A, ‘Theories of International Regimes’ (1987) 41 (3) International Organizations, 491-517

Harrison T, Johnson K, and Young M, ‘Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons’ (Center for Strategic and International Studies, February 2021)

Hartman T and Geertman S, ‘Planning Theory’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)
Hatfield-Dodds S, Nelson R, and Cook D C, ‘Adaptive Governance: An Introduction and Implications for Public Policy’ (2007] ANZSEE Conference, Noosa Australia, 4-5 July, 4

Hays P L and Lutes C D, ‘Towards a Theory of Spacepower’ (2007) 23 Space Policy 206-209

Herter Jr. C A, ‘The Electromagnetic Spectrum: A Critical Natural Resource’ (1985) 25 (3) Natural Resources Journal, Symposium on International Resources Law, 651-663

Hickman J and Dolman E, ‘Resurrecting the Space Age: A State-Centered Commentary on the Outer Space Regime’ (2002) 21 (1) Comparative Strategy 1-20

Hira A and Cohn T H, ‘Toward a Theory of Global Regime Governance’ (2003) 33 (4) International Journal of Political Economy, 4-27

Hobe S and Mey J H, ‘UN Space Debris Mitigation Guidelines’ (2009) 58 German Journal of Air and Space Law, 388-403

Holahan R and Lubell M, ‘Collective Action Theory’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Holland J and Webb J, *Learning Legal Rules* (11th edn, Oxford University Press 2022)
Inter-Agency Space Debris Coordination Committee, ‘IADC Space Debris Mitigation Guidelines’ (IADC 2007)

Inter-Agency Space Debris Coordination Committee, ‘What’s IADC’ <https://www.iadc-home.org/what_iadc> accessed 7 July 2020

Inter-Agency Space Debris Coordination Committee, *Key Definitions* (IADC, 2013)
International Academy of Astronautics Definition and Requirements of Small Satellites Seeking Low-Cost and Fast-Delivery (2017) Final Report of IAA Study Group 4.18

International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Corinne Contant-Jorgenson, Petr Lala, and Kai-Uwe Schrogl eds, IAA 2006)

International Academy of Astronautics, *Space Traffic Management: Towards a Roadmap for Implementation*, Kai-Uwe Schrogl (ed) 2018

International Astronomical Union, 'IAU Statement on Satellite Constellations' (3 June 2019) <https://www.iau.org/news/announcements/detail/ann19035/> accessed 06 September 2020

International Astronomical Union, 'Satellite Constellations' (12 February 2020) <https://www.iau.org/public/themes/satellite-constellations/> accessed 31 August 2020

International Civil Aviation Organization (ICAO), Convention on International Civil Aviation (adopted 7 December 1944, entered into force 4 April 1947) Ninth Edition, Doc 7300/9

International Law Commission, *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law* (13 April 2006) A/CN.4/L/682

International Organization for Standardization Space Systems – Requirements for Small Spacecraft (07/2018) ISCO/TS 20991:2018
International Standardization Organization, 'Space Systems – Risk Management' (ISO 17666, 2016)

International Standards Organization, 'ISO 21980:2020 Space Systems-Evaluation of Radiation Effects on Commercial-Off-The-Shelf (COTS) Parts for Use on Low-Orbit Satellites' (*ISO* 2020) <https://www.iso.org/standard/71848.html> accessed 28 February 2023

International Telecommunications Union Characteristics, Definitions and Spectrum Requirements of Nanosatellites and Picosatellites, as well as Systems Composed of Such Satellites (09/2014) Report ITU-R SA.2312-0

International Telecommunications Union, 'ITU Members Agree to New Milestones for Non-Geostationary Satellite Deployment' (20 November 2019) My ITU News <https://www.itu.int/en/myitu/News/2020/01/30/14/47/ITU-Members-agree-to-new-milestones-for-non-geostationary-satellite-deployment> accessed 06 September 2020

International Telecommunications Union, 'Key Outcomes of the WRC-19' (2020)

International Telecommunications Union, 'Prague Declaration on Small Satellite Regulation and Communication Systems' (2015) <https://www.itu.int/en/ITU-R/space/workshops/2015-prague-small-sat/Documents/Prague%20Declaration.pdf> accessed 09 August 2021

International Telecommunications Union, 'Radio Regulations: Articles' (2012 edn, ITU)

International Telecommunications Union, 'Membership' (*ITU* 2023) <https://www.itu.int/hub/membership/our-members/> accessed 28 February 2023

International Telecommunications Union, 'Radio Regulations'(Geneva, 1995, updated Sharm el-Sheik, 2019) Vol 1

International Telecommunications Union, 'World Radio Conference 2019 (WRC-19) Sharm el-Sheikh Egypt 28 October to 22 November 2019' (*ITU* 2023) <https://www.itu.int/en/ITU-R/conferences/wrc/2019/Pages/default.aspx> accessed 28 February 2023

International Telecommunications Union, *Collection of the Basic Texts Adopted by the Plenipotentiary Conference 2019*, (ITU Publications 2019)

International Telecommunications Union, Radio Regulations (Geneva 1995, WRC-95, 2020 edn)

International Telecommunications Union, Radio Regulations Volume III, Resolution 49 (Rev. WRC-12)

International Telecommunications Union, World Radiocommunication Conference 2019, Res 35, 222

Jakhu R S and Pelton J N (eds), *Global Space Governance: An International Study* (Springer 2017)

Johnson C D (ed), *Handbook for New Actors in Space* (Secure World Foundation 2017 edition)

Johnson C, 'Insight – Developing Norms of Behavior for Space' (*Secure World Foundation*, February 5, 2020) <https://swfound.org/news/all-news/2020/02/insight-developing-norms-of-behavior-for-space/> accessed 08 June 2021

Johnson C, 'The Legal Status of MegaLEO Constellations and Concerns about Appropriation of Large Swaths of Earth Orbit' in Joe Pelton (ed) *Handbook on Small Satellites* (Springer Nature Switzerland AG 2020) 17-24

Johnson-Freese J and Weeden B, 'Application of Ostrom's Principles for Sustainable Governance of Common-Pool Resources to Near-Earth Orbit' (2012) 3 (1) Global Policy 72-81

Jore S H, 'The Conceptual and Scientific Demarcation of Security in Contrast to Safety' (2019) 4 European Journal of Security Research, 157-174

Kennewell J and Vo B, 'An Overview of Space Situational Awareness' (2013) 16th International Conference on Information Fusion, 1029-1036

Keohane R O and Nye Jr. J S, "Two Cheers for Multilateralism" (1985) 60 Foreign Policy, 148-167

Keohane R O, 'The Demand For International Regimes' (1982) 36 (2) International Organization, 325-35

Klimburg A and Faesen L, 'Chapter 7 A Balance of Power in Cyberspace' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020)

Kooiman J, 'Social-Political Governance' (1999) 1 (1) Public Management an International Journal of Research and Theory, 67-92

Koremenos B, Charles Lipson, and Duncan Snidal, 'The Rational Design of International Institutions' (2001) 55 (4) International Organizations, 761-799

Koudelka O, '2.2 Space – A Natural Resource' in Christian Bruenner and Alexander Soucek (eds) *Outer Space in Society, Politics and Law* (Springer Vienna 2011)

Krag H as quoted in Tereza Pultarova, 'Keeping Space Tidy: Industry Steps Up Junk Management Efforts' *Via Space* (August 2019) 18-22

Krasner S D, 'Structural Causes and Regime Consequences: Regimes as Intervening Variables' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)

Lipton C, 'The Transformation of Trade: The Sources and Effects of Regime Change' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)
Lyall F and Larsen P B, *Space Law: A Treatise* (Routledge, 2018)

Marchisio S, 'Article IX' in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017)

Martinez P, 'Space Sustainability' in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015)

Martinez P, Jankowitsch P, Schrogl K, Di Pippo S, and Okumura Y, 'Reflections on the 50th Anniversary of the Outer Space Treaty, UNISPACE+50, and Prospects for the Future of Global Space Governance' (2019) 47 Space Policy, 28-33

Maslow A, 'A Theory of Human Motivation' (1943) 50 (4) Psychological Review, 370-396

Mattas A, Henri Y, Loo C C, 'Chapter 12: The ITU Radio Regulations Related to Small Satellites' in Irmgard Marboe (ed), *Small Satellites: Regulatory Challenges and Chances* (Brill Nijhoff 2016)

Mayence J and Reuter T, 'Article XI' in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017)

Meishan Goh G M, 'Softly, Softly Catchee Monkey: Informalism and the Quiet Development of International Space Law' (2009) 87 Nebraska Law Review, 725-746

Moltz J C, ‘The Changing Dynamics of Twenty-First Century Space Power’ (2019) 13 (1) Strategic Studies Quarterly 66-94

Napier J L, ‘Report: Responsible Behaviours in Space, National Submissions to the UN’ (Wilton Park 2021)

Napier L and Newman C J, ’Regulation of Satellite Constellations’ in Yanal Abul Failat and Anél Ferreira-Snyman (eds), *Outer Space Law: Legal Policy and Practice* (2nd edn, Global Law and Business 2022)

Napier L, ‘Thousands more satellites will soon orbit Earth – we need better rules to prevent space crashes’ (The Conversation 28 January 2021) <https://theconversation.com/thousands-more-satellites-will-soon-orbit-earth-we-need-better-rules-to-prevent-space-crashes-154014> accessed 20 February 2023

NASA, ‘Astromaterials Research & Exploration Science NASA Orbital Debris Program Office Frequently Asked Questions’ (*NASA*, 02 June 2022) <https://orbitaldebris.jsc.nasa.gov/faq/#> accessed 02 June 2022

NASA, ‘Space Debris and Human Spaceflight’ (*NASA*, May 2021) <https://www.nasa.gov/mission_pages/station/news/orbital_debris.html> accessed 09 February 2023

NASA, ’LEO Economy FAQs’ (*NASA*, February 2022) <https://www.nasa.gov/leo-economy/faqs> accessed 09 February 2023

Newman C J and Williamson M, “Space Sustainability: Reframing the Debate” (2018) Space Policy 46, 30-37

Nuclear Threat Initiative, ‘Proposed Prevention of an Arms Race in Space (PAROS) Treaty’ (*NTI* 2021) <https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/> accessed 21 July 2021

Nye Jr. J S, ‘The Regime Complex for Managing Global Cyber Activities’ Global Commission on Internet Governance (Centre for International Governance Innovation, the Royal Institute for International Affairs, and Chatham House) Paper Series No.1, May 2014

Ofcom, ‘Procedures for the Management of Satellite Filings’ (*Ofcom* 14 March 2019)

Ölber P, ‘Deliberation’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Oltrogge D, ‘Space Situational Awareness: Key Issues in an Evolving Landscape’ (2020) Hearing of the Committee on Science, Space, and Technology, U.S. House of Representatives, Tuesday, 11 February

Organisation for Economic and Co-operation Development (OECD), Space Sustainability: The Economics of Space Debris in Perspective, OECD Science, Technology and Industry Policy Papers (April 2020) No. 87

Outer Space Act 1986 (UK)

Oxford English Dictionary, ‘Sustainability’ (*OED*) <https://www.oed.com/> accessed 24 November 2022

Oxford English Dictionary, ‘Sustainable Development’ (*OED*) <https://www.oed.com/> accessed 24 November 2022

Oxford Learner’s Dictionaries, ‘Safety’ (*Oxford Learner’s Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/safety?q=safety> accessed 24 November 2022

Oxford Learner’s Dictionaries, ‘Security’ (*Oxford Learner’s Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/security?q=security> accessed 24 November 2022

Oxford Learner’s Dictionaries, ‘Sustainable’ (*Oxford Learner’s Dictionaries*) <https://www.oxfordlearnersdictionaries.com/definition/english/sustainable?q=sustainable> accessed 24 November 2022

Oxford English Dictionary, ‘Mega’ (*OED*) <https://www.oed.com/> accessed 24 November 2022

Palkovitz N, ‘Small Satellites: Innovative Activities, Traditional Laws, and the Industry Perspective’ in Irmgard Marboe (ed), *Small Satellites Regulatory Challenges and Chances* (Brill Nijhoff 2016)

Pastine I, Pastine T and Humberstone T, *Introducing Game Theory: A Graphic* Guide (Icon Books Ltd, 2017) e-reader edition

Patrick S, “The Unruled World, The Case for Good Enough Global Governance” (2013) 93 (1) Foreign Affairs, 58-73

Pelton J, Sgobba T, and Trujillo M, ‘Space Safety’ in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015)

Percy T K and Landrum D B, “Investigation of National Policy Shifts to Impact Orbital Debris Environments” (2014) 30 Space Policy 23-33

Peters B G, ‘Institutional Theory’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Pfaltzgraff R L, ‘Chapter 3 International Relations Theory and Spacepower’ in Charles D Lutes and Peter L Hays, *Toward a Theory of Spacepower: Selected Essays* (National Defense University Press 2011)

Planet, ‘Our Approach’ (*Planet*, 2021) <https://www.planet.com/company/approach/> accessed 11 November 2021

Rathnasabapathy M and others, ‘Space Sustainability Rating: Designing a Composite Indicator to Incentivise Satellite Operators to Pursue Long-Term Sustainability of the Space Environment” (71st International Astronautical Congress, CyberSpace Edition, October 2020)

Raustiala K and Victor D G, ‘The Regime Complex for Plant Genetic Resources’ (2004) 58 International Organization, 277-309

Reinicke W H and Witte J M, ‘Interdependence, Globalization, and Sovereignty: the Role of Non-binding International Legal Accords in Chapter 3 Challenges to the International Legal System, in Dinah Shelton (ed) *Commitment and Compliance: The Role of Non-Binding Norms in the International Legal System* (Oxford University Press 2003)

Ruggie J G, ‘International Responses to Technology: Concepts and Trends’ (1975) 29 (3) International Organization, 557-583
Russian Federation and China, ‘Letter dated 2008/02/12 from the Permanent Representative of the Russian Federation and the Permanent Representative of China to the Conference on Disarmament addressed to the Secretary-General of the Conference transmitting the Russian and Chinese texts of the draft "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT)" introduced by the Russian Federation and China’ (United Nations Digital Library 2008) <https://digitallibrary.un.org/record/633470?ln=en> accessed 06 June 2023

Safyan M as quoted in Tereza Pultarova, ‘Keeping Space Tidy: Industry Steps Up Junk Management Efforts’ *Via Space* (August 2019) 18-22

Schmidt-Tedd B and Mick S, ‘Article VIII’ in Stephen Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law Volume I* (Berliner Wissenschafts-Verlag, 2017)

Schmitt M N (ed), *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (Cambridge University Press 2017) 270

Schrogl K, ‘4.4 Space and its Sustainable Use’ in Christian Bruenner and Alexander Soucek (eds) *Outer Space Society, Politics and Law* (Springer Vienna 2011) 607

Secure World Foundation, *Handbook for New Actors in Space* (2017 edition Secure World Foundation)

Seradata, ‘SpaceTrak’ (S*eradata*, 2022) <https://www.seradata.com/spacetrak3/> accessed 02 June 2022

Seradata, ‘Welcome to Seradata’ (*Seradata*, 2021) <https://www.seradata.com/> accessed 11 November 2021

Sheehan M, 'Defining Space Security' in Kai-Uwe Schrogl et al. (eds.), *Handbook of Space Security* (Springer 2015)

Sheetz M, 'SpaceX Adding Capabilities to Starlink Internet Satellites, Plans to Launch Them with Starship' (*CNBC*, 19 August 2021) <https://www.cnbc.com/2021/08/19/spacex-starlink-satellite-internet-new-capabilities-starship-launch.html> accessed 01 November 2021

Sheldon J B and Gray C S, 'Chapter 1 Theory Ascendant? Spacepower and the Challenge of Strategic Theory' in Charles D Lutes and Peter L Hays, *Toward a Theory of Spacepower: Selected Essays* (National Defense University Press 2011)

Shires J, 'Chapter 10 Ambiguity and Appropriation: Cybersecurity and Cybercrime in Egypt and the Gulf' in Dennis Broeders and Bibi van den Berg (eds), *Governing Cyberspace: Behavior, Power, and Diplomacy* (Rowman & Littlefield 2020)

Singer K, '100th Space Sharing Agreement Signed, Romania Space Agency Joins' (*US Strategic Command*, 26 April 2019) <https://www.stratcom.mil/Media/News/News-Article-View/Article/1825882/100th-space-sharing-agreement-signed-romania-space-agency-joins/> accessed 14 August 2021

Slaughter A, 'The Power and Legitimacy of Government Networks' in Susan Stern and Elisabeth Seligmann (eds), *The Partnership Principle: New Forms of Governance in the 21st Century* (Archetype Publications, 2004)

Space Industry Act 2018 (UK)

Space Safety Coalition 'Endorsees' (*SSC*, 2021) <https://spacesafety.org/endorsees/> accessed 11 November 2021

Space Safety Coalition, 'Home Page' (*SSC*, 2020) <https://spacesafety.org/> accessed 9 July 2020

Space Safety Coalition, 'Best Practices' (*SSC* 2023) <https://spacesafety.org/best-practices/> accessed 28 February 2023

Space Security Index, 'Space Situational Awareness' (*SSI* 2020) <https://spacesecurityindex.org/2020/09/space-situational-awareness/> accessed 28 February 2023

Space Security Index, *2019 Space Security Index: Executive Summary* (2019, 16th edition, Waterloo Printing)

Steelman T, 'Adaptive Governance' in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Stein A A, 'Coordination and Collaboration: Regimes in an Anarchic World' in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)

Stern S and Seligmann E, ‘The Art of Governancing: Becoming Pragmatic Bedfellows’ in Susan Stern and Elisabeth Seligmann (eds), *The Partnership Principle: New Forms of Governance in the 21st Century* (Archetype Publications 2004) The Alfred Herrhausen Society for International Dialogue, A Deutsche Bank Forum

Stokes H, and others, ‘Evolution of ISO’s Space Debris Mitigation Standards’, First International Orbital Debris Conference, 2019

Sweeting M N, Modern Small Satellites – Changing the Economics of Space (Vol. 106, No. 3, March 2018) Proceedings of the IEEE

Talesh S, ‘Public Law and Regulatory Theory’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Tan D, ‘Towards a New Regime for the Protection of Outer Space as the Province of All Mankind’ (2000) 25 (1) Yale Journal of International Law 145-194

Thirlway H, *The Sources of International Law* (2019, 2nd edition, Oxford University Press)
Thomson J M, ‘The Value of Traffic Management’ (1968) 2 (1) Journal of Transport Economics and Policy, 3-32

Transnational Institute, ‘Multistakholderism: A Critical Look’ (2019) Workshop Report

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (open for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205

Trieb O, Bahr H, and Falkner G, ‘Modes of Governance: Towards a Conceptual Clarification’ (2007) 14 (1) Journal of European Public Policy 1-20

Tronchetti F, ‘4.5 Soft Law’ in Christian Bruenner and Alexander Soucek (eds*) Outer Space in Society, Politics and Law* (Springer Vienna 2011)

UK government, ‘Spaceflight Legislation and Guidance’ (*UK government*, published 16 April 2014, updated 29 July 2021) <https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986> accessed 06 October 2021
UKSA, ’Earth Observation (EO)’ (*UKSA* 18 December 2018) <https://www.gov.uk/government/collections/earth-observation-eo> accessed 21 December 2022

UKSA, ’Guidance on Satellite Licence Fees for Constellation Operators’ (*UKSA* 1 June 2022) <https://www.gov.uk/government/publications/guidance-on-satellite-licence-fees/guidance-on-satellite-licence-fees-for-constellation-operators> accessed 28 February 2023

UN Committee on the Peaceful Use of Outer Space, Scientific and Technical Subcommittee, 58th session, Recommendations to Keep Dark and Quiet Skies for Science and Society, A/AC.105/C.1/2021/CRP.17 (19 April 2021)

UN Committee on the Peaceful Uses of Outer Space, 'United Kingdom: Update on Our Reporting Approach for the Voluntary Implementation of the Guidelines for the Long-Term Sustainability of Outer Space Activities' (19 April 2021) A/AC.105/C.1/2021/CRP.16 <https://www.unoosa.org/res/oosadoc/data/documents/2021/aac_105c_12021crp/aac_105c_12021crp_16_0_html/AC105_C1_2021_CRP16E.pdf> accessed 11 November 2021

UNGA 'Report of the Legal Subcommittee on its Sixty-First Session, Held in Vienna from 28 March to 8 April 2022' (19 April 2022) 61st Session (2022) UN Doc A/AC.105/1260

UNGA 'Report of the Scientific and Technical Subcommittee on its Fifty-Ninth Session, Held in Vienna from 7 to 18 February 2022' (23 February 2022) 59th Session (2022) UN Doc A/AC.105/1258

UNGA Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities (29 July 2013) UN Doc A/68/189

UNGA Res 75/36 (16 December 2020) UN Doc A/RES/75/36

UNGA Res 76/3 (28 October 2021) UN Doc A/RES/76/3

UNGA, 'Disarmament and International Security (First Committee)' (*UNGA*) <https://www.un.org/en/ga/first/index.shtml> accessed 13 July 2021

UNGA, 'Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities' (29 July 203) UNGA 68th session, A/68/189

UNGA, 'Principles Relating to Remote Sensing of the Earth from Outer Space' (1986) Res 41/65

UNGA, Resolution 75/36 Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours, A/Res/75/36, 7 December 2020

United Kingdom of Great Britain and Northern Ireland, 'Space Debris Mitigation Standards' in UNOOSA Space Debris Mitigation Compendium, <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html> accessed 9 July 2020

United Nations Committee for Development Policy, 'Global Governance and Global Rules for Development in the Post-2015 Era' (2014) Sales No. E.14.II.A.1

United Nations Committee on the Peaceful Uses of Outer Space, 'COPUOS Chair's Non-paper: The Way Forward for LTS "Sustainability as an Enabler' (2019, Andre Rypl)

United Nations Committee on the Peaceful Uses of Outer Space, 'Guidance on Space Object Registration and Frequency Management for Small and Very Small Satellites' (13 April 2015) A/AC.105/C.2/2015/CRP.17

United Nations Department of Economic and Social Affairs, 'The 17 Goals' (*UN* 2023) <https://sdgs.un.org/goals> accessed 28 February 2023

United Nations Economic and Social Commission for Asia and the Pacific, 'What is Good Governance?' (*UNESCAP*, 2009) <https://www.unescap.org/resources/what-good-governance> accessed 04 May 2022

United Nations General Assembly Report of the Committee on the Peaceful Uses of Outer Space Sixty-second Session (12-21 June 2019) UN Doc A/74/20 Annex II Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space 50-69

United Nations General Assembly Report of the Legal Subcommittee on its Sixtieth Session, held in Vienna from 31 May to 11 June 2021, UN Doc A/AC.105/1243, VIII Future Role and Method of Work of the Committee, 19-20

United Nations General Assembly Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) A/62/20 Annex or Resolution 62/217

United Nations General Assembly, 'Report of the Legal Subcommittee on its Fifty-Fifth Session, Held in Vienna from 4 to 15 April 2016' (A/AC.105/1113) XI. General Exchange of Views on the Legal Aspects of Space Traffic Management

United Nations Institute for Disarmament Research (UNIDIR), *Regional Perspectives on Norms of Behaviour for Outer Space Activities* (UN Publications, 2015)

United Nations Office for Disarmament Affairs, 'Open-ended Working Group' (UN) <https://www.un.org/disarmament/open-ended-working-group/> accessed 03 August 2021

United Nations Office for Disarmament Affairs, 'Transparency and Confidence Building' (*UNODA*, 2022) <https://www.un.org/disarmament/convarms/transparency-cbm/> accessed 14 June 2022

United Nations Office for Outer Space Affairs International Space Law: United Nations Instruments (2017)

United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space and its Subcommittees' (*UNOOSA*, 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html> accessed 09 February 2023

United Nations Office for Outer Space Affairs, 'Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations' <https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html> accessed 7 July 2020

United Nations Office for Outer Space Affairs, 'COPUOS History' (*UNOOSA*, 2022) <http://www.unoosa.org/oosa/en/ourwork/copuos/history.html> accessed 6 May 2021

United Nations Office for Outer Space Affairs, 'UNOOSA and ESA Space Debris Infographics and Podcasts' (UNOOSA, 10 February 2021) <https://www.unoosa.org/oosa/en/informationfor/media/unoosa-and-esa-release-infographics-and-podcasts-about-space-debris.html> accessed 11 November 2021

United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Membership Evolution' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html> accessed 24 February 2023

United Nations Office for Outer Space Affairs, 'Committee on the Peaceful Uses of Outer Space: Observer Organizations' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html> accessed 24 February 2023

United Nations Office for Outer Space Affairs, 'Long-Term Sustainability of Outer Space Activities' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html> accessed 28 February 2023

United Nations Office for Outer Space Affairs, 'Space Supporting the Sustainable Development Goals' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/ourwork/space4sdgs/index.html> accessed 28 February 2023

United Nations Office for Outer Space Affairs, 'Timeline' (*UNOOSA* 2023) <https://www.unoosa.org/oosa/en/timeline/index.html> accessed 24 February 2023

United Nations Office of Outer Space Affairs, 'Working Group on the Definition and Delimitation of Outer Space of the Legal Subcommittee' (*UNOOSA*, 2023) <https://www.unoosa.org/oosa/en/ourwork/copuos/lsc/ddos/index.html> accessed 09 February 2023

United Nations Trust Fund for Human Security, 'What is Human Security' (*UN Trust Fund for Human Security*) <https://www.un.org/humansecurity/what-is-human-security/> accessed 2 June 2021

United Nations, 'Charter of the United Nations and Statute of the International Court of Justice' (1945) 1 UNTS XVI

United Nations, ‘National Security Versus Global Security’ (*UN Chronicle*) <https://www.un.org/en/chronicle/article/national-security-versus-global-security> accessed 2 June 2021

United States, ‘Space Policy Directive 3: National Space Traffic Management’ (18 June 2018) <https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/> accessed 02 September 2020

UNODA, ‘Open-Ended Working Group on Reducing Space Threats’ (UNODA, 2022) <https://meetings.unoda.org/section/oewg-space-2022_general-statements_19856/> accessed 30 September 2022

Van Assche K, Hornidge A, Schlüter A, and Vaidianu N, ‘Governance and the Coastal Condition: Towards New Modes of Observation, Adaptation and Integration (2020) 112 Marine Policy, 1-10

Verspieren Q and Shiroyama H, ‘From the Seas to Outer Space: The Reverse Dynamics of Civil-Military Situational Awareness Information and Responsibility Sharing’ (November 2019) 50 Space Policy, 1-6

Vienna Convention on the Law of Treaties (adopted 23 May 1969, entered into force 27 January 1980) 1155 UNTS 331

Volynskaya O A and Kasyanov R A, ‘Chapter 5: Launching Numerous Small Satellites – A Flourishing Business? The Case of the Russian Federation’ in Irmgard Marboe (ed) *Small Satellites: Regulatory Challenges and Chances* (Brill 2016)

West J and Doucet G, *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report*, (Project Ploughshares 2021)

White House, ‘Fact Sheet: Vice President Harris Advances National Security Norms in Space’ (*the White House*, 18 April 2022) <https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/18/fact-sheet-vice-president-harris-advances-national-security-norms-in-space/> accessed 30 September 2022

Wolfers A, ‘“National Security” as an Ambiguous Symbol’ (1952) 67 (4) Political Science Quarterly, 481-502

Wood L, ‘Satellite Constellation Networks’ in Yongguang Zhang (ed) *Internetworking and Computing Over Satellite Networks* (Springer 2003)

World Commission on Environmental Development, ‘Our Common Future, From One Earth to One World’ (1987)

Yannis Papadopoulos Y, ‘Accountability’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Yasuda J, ‘Regulatory Governance’ in Christopher Ansell and Jacob Torfing (eds), *Handbook on Theories of Governance* (Edward Elgar Publishing 2016)

Young O R, ‘Regime Dynamics: The Rise and Fall of International Regimes’ in Stephen D. Krasner (ed), *International Regimes* (first published 1983, Cornell University Press 1995)