SPACE, THE FINAL *LEGAL* FRONTIER: A LOOK AT LEGAL IMPEDIMENTS TO THE INCREASING COMMERCIALISATION OF OUTER SPACE

A dissertation submitted in fulfilment of the requirements of the degree Master of Laws (LLM by Dissertation - LAWS8002) in the Faculty of Commerce, Law and Management at the University of the Witwatersrand, Johannesburg, South Africa.

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DECLARATION

I, **Tristan Bevan Marot** (Student Number 804731), under the auspices of my supervisor (Dr Muriel Mushariwa) hereby declare that this dissertation is my own independent and unaided work. The dissertation is re-submitted in fulfilment of the requirement for the degree of Master of Laws (LLM) in the Faculty of Commerce, Law and Management at the University of the Witwatersrand, Johannesburg, South Africa. This dissertation - either in part or in completion - has not previously been submitted for any degree at The University of The Witwatersrand or any other university or institution.

Date

28-06-2021

Place

SANDTON

Signature

(Tristan Bevan Marot)

ACKNOWLEDMEGMENTS

“Man must rise above the Earth – to the top of the atmosphere and beyond – for only thus will he fully understand the world in which he lives “

- *Socrates*

This dissertation represents a significant milestone in my academic career and is the culmination of many years of hard work. I was fortunate to be able to undertake research at the intersection of two of my core interests – law and outer space. Despite the research and writing process being challenging, it was ultimately a rewarding experience that has taught me the value of patience, tenacity and, of course, coffee. I would like to extend acknowledgements to several people without whom this project would not have been a success.

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I hope one day all the pondering I did during this dissertation of what it might one day be like for humanity to operate in outer space, will be answered as I watch humanity begin to operate as a space fairing civilization. I hope to be able to ponder about passenger liability not from behind my very much terrestrial desk, but instead upon a spacecraft as I rise through the atmosphere. I hope to see the Earth from above and visit the wonders of our solar system and beyond. Perhaps I will never get the opportunity, but I have faith that humanity will prevail over the issues outlaid in this dissertation. To paraphrase Elon Musk. My hope is to one day have the ability to die on a planet that is not the one upon which I was born, just preferably not on impact!

ABSTRACT

Interest in outer space has seen a recent revitalisation and now more than ever is a controversial and popular topic. This dissertation explores the law of outer space in relation to current and future outer space commercial operations - focusing particularly on the legal impediments thereto. In depth analysis of the development and status of current Outer Space Law will be undertaken considering the contextual history which resulted in the state-based approach currently observed. This analysis will consider broader treaties (UN) as well as country specific legislation. Current commercial operations being undertaken in space will be explored along with any interactions the industry has with the law of outer space, considering where concerns and frictions are occurring. The nature of commercial operations in space is rapidly changing. Increasingly the emergence of private entities dominating the space sector is being observed. Moreover, the type of activities being undertaken are changing. These likely developments will be presented and analysed relating to the developing science and technologies as well as the developing commercial needs which may dictate changes and emergences. Specific likely emerging commercial activities – such as space tourism and resource extraction – will then be contrasted with current law to see if they are currently catered for and if any friction could possibly occur in their development. The manner in which arising issues could be worked around within the scope of current law as well as opportunities, solutions and suggestions for amendments will be discussed. Furthermore, the potential for developments in the law that could ease/hinder these commercial developments will be examined.

TABLE OF CONTENTS

DECLARATION ..... **i**

ACKNOWLEDMEGMENTS ..... **ii**

ABSTRACT ..... **iv**

TABLE OF CONTENTS ..... **v**

LIST OF ABBREVIATIONS AND ACRONYMS ..... **vii**

LIST OF FIGURES ..... **ix**

PREAMBLE **1**

Rationale 4

Research Objectives and Research Questions 5

Research Methodology 6

Scope and Limitations 7

Chapter Outline 8

CHAPTER 1 – INTRODUCTION AND BACKGROUND **12**

1.1. History of Space Law 12

1.2. Fundamentals of Space Law 14

1.3. Contemporary Space Law 17

1.4. Comparisons between Maritime and Aviation Law to Space Law 21

1.5. South African Space Law 26

1.6. Conclusion 31

CHAPTER 2 – UNMANNED COMMERCIAL OPERATIONS IN SPACE **32**

2.1. Unmanned Commercial Operations in Space 32

2.2. Space Liability Convention – Definition of “Space Object” and “Damage” 33

2.3. Space Liability Convention - Causation 38

2.4. Space Liability Convention - Fault 42

2.5. Space Liability Convention – Canada Claim 47

2.6. Kessler Syndrome 51

2.7. Space Debris Guidelines 54

2.8. Space Traffic Management 61

2.9. Conclusion 70

CHAPTER 3 – MANNED COMMERCIAL OPERATIONS IN SPACE **71**

3.1. Space Tourism 71

3.2. Definition and Delimitation of Outer Space 74
3.3. State-Centred Liability 84
3.4. Legal Status of Space Tourists 94
3.5. Conclusion 102
CHAPTER 4 – FUTURE COMMERCIAL OPERATIONS IN SPACE: RESOURCE HARVESTING 103
4.1. Resource Harvesting in Space 103
4.2. OST, Moon Treaty and Private Ownership 109
4.3. Moon Treaty 117
4.4. Title IV of the US Commercial Space Launch Competitiveness Act of 2015 123
4.5. Luxembourg's Exploitation and Use of Space Resource Law 128
4.6. Potential Solutions 133
4.7. Conclusion 139
CONCLUSION 141
Summary 141
Aims and Objective Fulfilment 142
Recommendations 142
BIBLIOGRAPHY ..... a
ANNEXURES ..... s

LIST OF ABBREVIATIONS AND ACRONYMS

18 SPCS – 18th Space Control Squadron of the United States Air Force

ASTEROIDS Act - American Space Technology for Exploring Resource Opportunities in Deep Space Act

ATM – Airspace Traffic Management

CDM – Conjunction Data Messages

DTI – Department of Trade and Industry (RSA)

EML1 – Earth Lunar Lagrange Point 1

EEZ – Exclusive Economic Zone

ESA – European Space Agency

FAA – United States Federal Aviation Authority

IA – Industry Associations

IAA – International Academy of Astronautics

IATA – International Air Transportation Authority

ICAO – International Civil Aviation Organization

ICJ – International Court of Justice

IGO – Intergovernmental Organisations

IMO – International Maritime Organisation

ISA – Indian Space Agency

ISFO - International Space Flight Organisation

ISS – The International Space Station

ITU – International Telecommunication Union

JAXA – Japan Aerospace Exploration Agency

LED – Light-Emitting Diode

LEO – Low Earth Orbit

MHI – Mitsubishi Heavy Industries

MRI – Magnetic Resonance Imaging

NASA – National Aeronautics and Space Administration (Independent Space Agency of the United States Federal Government)

NEA – Near-Earth Asteroids

NEO – Near Earth Orbit

NGO – Non-Governmental Organisation

NORAD – North American Aerospace Defence Command

OPEC – Organisation for Petroleum Exporting Countries

OSA – outer space Act of 1986 (United Kingdom)

OST – outer space Treaty

PCA – Permeant Court of Arbitration

RFI – Radio Frequency Interference

RFMO – Regional Fisheries Management Organisation

Roscosmos – Roscosmos State Corporation for Space Activities (Space Agency of the Russian Federation)

SACSA – South African Council on Space Affairs

SANSA – South African National Space Agency

SES – Société Européenne des Satellites

SSA – Space Situational Awareness

STM – Space Traffic Management

ULA – United Launch Alliance

UN – United Nations

UNCED – United Nations Conference on Environment and Development (Rio Earth Summit)

UNFSA – United Nations Fish Stocks Agreement

UNCITRAL - United Nations Commission on International Trade Law

UNCLOS – United Nations Convention on the Law of Sea

UNCOPUOS – United Nations Committee on the Peaceful Uses of Outer Space

UNGA – United Nations General Assembly

UNISA – United Nations International Space Agency

UNOOSA – United Nations Office of outer space Affairs

US – United States of America

USDS – United States Department of State

USGS – United States Geological Survey

USSR – Union of Soviet Socialist Republics (Soviet Union)

LIST OF FIGURES

Figure 1 - Flow Diagram Demonstrating Methodological Approach of Thesis. 6
Figure 2 - Flow Diagram Highlighting Chapter Outline of Thesis. 8
Figure 3 - Estimated Number of Objects in Orbit of Earth 53
Figure 4 - Diagram Showing Applicable Zones as created by the UNCLOS 83

PREAMBLE

A decade ago, the future of space exploration looked rather bleak. On 8 July 2011, the Space Shuttle Atlantis took off for the last time, ending the Shuttle Program and America's human launch capabilities. Since the end of Apollo in 1975, the furthest humans have ventured off our planet is to the International Space Station (ISS), a mere 400 or so kilometres above earth - nothing compared to the 384 400km to the moon or 54.6 million km to Mars. After the final launch of the Shuttle Program, Roscosmos, the Russian space agency, was the only organisation which still had human launch capabilities, but even its program was dated with the Soyuz-U, the launch vehicle being used, being a 37-year-old design at the time. In the week of the final Space Shuttle launch, The Economist ran an edition with a cover which proclaimed, "The end of the Space Age". The article inside read:

> "The vision being sold in the 1950s and 1960s, when the early space rockets were flying, was of adventure and exploration… Other planets may or may not have been inhabited by aliens, but they, and even other stars, were there for the taking. That the taking would begin in the lifetimes of people then alive was widely assumed to be true. No longer. It is quite conceivable that 36,000km [the distance at which geostationary satellites orbit Earth] will prove the limit of human ambition. It is equally conceivable that the fantasy-made-reality of human space flight will return to fantasy. It is likely that the Space Age is over."[1]

Thankfully, it appears The Economist was wrong. The romance of human exploration of outer space, of space ports floating above the Earth, of an abundance of resources harvested from asteroids, or of human settlements on other orbital bodies such as the Moon or Mars, has re-entered the public consciousness. Not since the time of the Moon Landing and the Space Race, has human space exploration been so prevalent in public discourse and the imagination of the average person. However, unlike in the 60s and 70s, it is no longer pioneered by big governments, and purely state actors, but rather increasingly by private corporations. Elon Musk's Space Exploration Technologies Corp (SpaceX), Jeff Bezos's Blue Origin, Richard Branson's Virgin Galactic - are all firms looking at getting normal everyday people into space in the next

[1] The Economist 'The end of the Space Age' available at *https://www.economist.com/leaders/2011/06/30/the-end-of-the-space-age* accessed on 12 October 2019.

decade for as affordable a cost as possible[2]. Planetary Resources Inc, Deep Space Industries and a few others all looking at resource collection in space, mainly through the mining of near-earth asteroids[3]. SpaceX[4], the Mars Society[5] and NASA[6] have all released plans to have Lunar or Martian human settlements (permanent or temporary) in the next 2 – 3 decades. Except for NASA, all the above-mentioned entities are private companies, operating in a market formerly dominated by government agencies.

We are going to outer space. The question is no longer if or when - we already are. We are entering a second golden age of space exploration, one that will hopefully not lose its steam as the last did, and one where the charge is led by business interests rather than those of the state; by economic feasibility as well as by public imagination. This rapid bounce back in a matter of a few years, and the switch from state dominated operations, to private industry dominated endeavours has left the legal framework governing Space Exploration far behind.

The frank assessment of the Law of outer space is that it is outdated and setup for a time when it was only governments which were going to space. The budgets and engineering needed to exit the atmosphere and enter a stable orbit around Earth and beyond where simply unfathomable for the private sector. The development of Space Law during the Cold War has had a substantial effect on its legal foundations and is often pointed to as the reason for its State Centred approach.

> "The Soviets' successful launch of Sputnik in October 1957 shifted outer space from the realm of science fiction and speculation to the realm of real international concerns. Governments were faced with the problem of determining not only what they wanted to do in space but also what sorts of rules for unilateral activity and mutual interaction should prevail there. When Sputnik ushered in the space age, the world was divided into two great

[2] Stefanie Waldek 'How to become a space tourist: 8 companies (almost) ready to launch' available at *https://www.popsci.com/how-to-become-a-space-tourist* accessed on 12 October 2018.
[3] Chloe Cornish 'Interplanetary players: a who's who of space mining' available at *https://www.ft.com/content/fb420788-72d1-11e7-93ff-99f383b09ff9* accessed on 12 October 2018.
[4] SpaceX 'Making Life Multiplanetary' available at *https://www.spacex.com/mars* accessed on 12 October 2018.
[5] The Mars Society 'Founding Declaration' available at *http://nextgen5.marssociety.org/home/about/founding-declaration/* accessed on 12 October 2018.
[6] Cheryl Warner 'Expands Plans for Moon Exploration: More Missions, More Science' available at *https://www.nasa.gov/feature/nasa-outlines-new-lunar-science-human-exploration-missions* accessed on 12 October 2018.

> power blocs, each consisting of one superpower plus allies, associates, and clients, and a scattering of European neutral and Third World nonaligned states. The distribution of space capability was even more starkly bipolar than the distribution of overall capability: until 1972 only the superpowers possessed the ability to launch large objects into space, place satellites into geostationary orbit, and send humans into earth orbit or beyond"[7]

However, this is no longer the reality of space exploration. Whilst there are still major state funded actors like the US's National Aeronautical and Space Administration (NASA), Russia's space agency Roscosmos, the Indian Space Agency (ISA), European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and China National Space Administration - there are a number of private entities which are beginning to dominate space exploration. Since the end of the Cold War about of half of all Space Launches have been conducted by private launch providers, mostly Arianespace, United Launch Alliance (ULA) and SpaceX.[8]

This parity is not likely to last. Only 4 states conducted their own launches in 2018 namely China, Russia, India and Japan in order of number of launches conducted. With China having recently legalised private space launches and a few Chinese space start-ups now appearing, the largest state launch provider is likely to be sending less vehicles up in the years to come.[9] Roscosmos only had so many launches because it had the sole capability to send up Astronauts to the ISS however with SpaceX having now demonstrated its ability to safely launch people and ULA potentially following suit later in 2021 it is likely a large swath of those launches will move over to private providers.[10] Even Japan with a total of 3 launches in 2018, is more a hybrid than purely

[7] MJ Peterson 'The Use of Analogies in Developing Outer Space Law' (1997) 51 *International Organization* 245.
[8] Ed Kyle 'Space Launch Reports' available at https://www.spacelaunchreport.com/log2018.html accessed on 23 March 2019; The Economist 'The space race is dominated by new contenders' available at https://www.economist.com/graphic-detail/2018/10/18/the-space-race-is-dominated-by-new-contenders accessed on 23 March 2018.
[9] Trefor Moss 'In China's New Space Odyssey, 80 Startups Race to Get Into Orbit' available at https://www.wsj.com/articles/chinese-startups-push-into-space-business-1541851211 accessed on 24 March 2018.
[10] Joseph Navin & Lee Kanayama 'ULA, Boeing, and NASA prepare for uncrewed and crewed Starliner flight tests' available https://www.nasaspaceflight.com/2021/06/starliner-oft2-perparations/ accessed on 28 June 2021; Amanda Kooser 'NASA, SpaceX aim for Halloween launch for Crew-3 to the ISS' available at https://www.cnet.com/news/nasa-spacex-aim-for-halloween-launch-for-crew-3-to-the-iss/ accessed on 28 June 2021; Mike Wall 'SpaceX to fly 3 more private astronaut missions to space station for Axiom Space' available at https://www.space.com/spacex-axiom-deal-more-private-astronaut-missions accessed on on 28 June 2021.

state launcher, with its rockets being not only built but operated by Mitsubishi Heavy Industries (MHI).[11]

Rationale

This research is motivated by the urgency presented by the status quo in which the commercialisation of space and the activities therein is occurring rapidly and projected to continue to develop. The changes occurring are hypothesised to not be catered for entirely and in some cases at all under existing Outer Space Law. In order to understand this concern better, the aim of this master's dissertation will be to investigate existing Outer Space Law and compare it to the realities of current and future space exploration. In so doing we will identify the gaps in the legal framework and discuss potential solutions to those issues.

Notable gaps in the literature exist as although research has been undertaken on some commercial space activities in relation to law – such as space tourism or asteroid mining – a comprehensive overarching legal review and analysis of all critical commercial space matters is absent. This perpetuates the silo thinking observed in the Space Law field and is potentially impeding development of the industry.

The premising purpose underlying this research is to be able to examine an emerging and dramatically changing commercial market and identify gaps and conflicts within legislation - with the aim of resolving those conflicts and addressing the gaps - using the commercialisation of space as the case study for this investigation.

[11] Moss op cit note 9; Mitsubishi Heavy Industries 'Space' available at https://www.mhi.com/products/space/ accessed on 23 March 2019.

Research Objectives and Research Questions

The overall purpose and aim of this dissertation will be to explore the Law of Outer space and contrast its framework with the contemporary realities of commercial operations in outer space as well as the anticipated development path of commercial operations. In terms of novel research contributions there will be 2 main areas of inquiry which will combine to provide the content on the specific chapter topics.

1. **Analysis of the Law of Outer Space within contemporary Commercial Operations in Outer Space.**
    a) What current commercial operations are there which interact with Outer Space?
    b) How - if at all - do these operations interact with the Law of Outer Space?
    c) What frictions are present between the commercial operations and the Law?
    d) How are these frictions being addressed, if at all?
    e) What regime governs the interactions of commercial operations in outer space within the Law of Outer Space?

2. **Analysis of the Law of Outer Space in relation to future developments in Commercial Operations in Outer Space.**
    a) What developments are there likely to be in the types of commercial operations which occur in Outer Space?
    b) Are these likely developments catered for under the current law?
    c) What frictions could potentially occur?
    d) How could these issues be worked around within current law?
    e) How could the law be amended to addresses these frictions?
    f) What developments in the law could help ease/hinder these commercial developments?

Research Methodology

The research methodology employed in this study is qualitative in nature – comprising of evaluation and analysis of existing law in each context.[12] The dissertation is interdisciplinary and combines both scientific explanations and legal analysis. Evaluation of primary sources of law in the form of treaties and domestic laws is undertaken through predictive impact identification research as well as evolutionary tracing of the law's history and development[13]. Comprehensive, integrative exploration of secondary sources (academic literature and commentary) is considered and discussed in relation to existing and likely future contexts and scenarios. These approaches and methodologies allow for a comprehensive gap analysis which assesses the difference between a current state of legal performance in relation to an ideal or future outcome. This approach is demonstrated below in fulfilment of the projects 2 main aims.

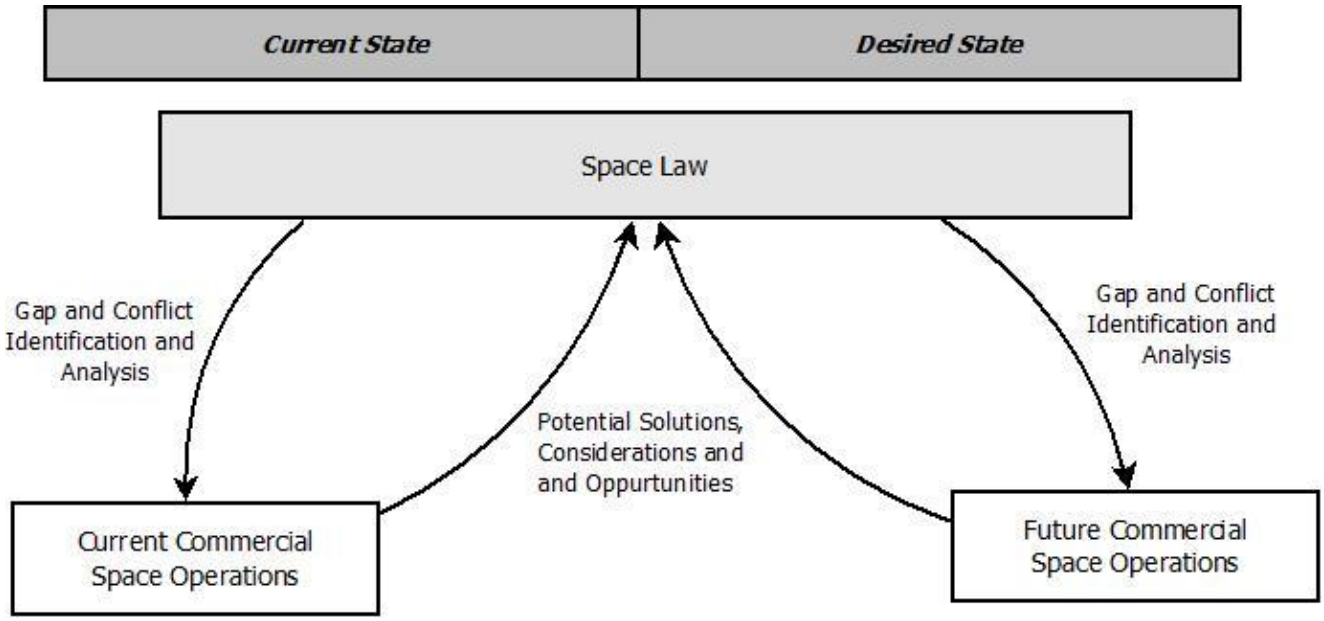

Figure 1 - Flow Diagram Demonstrating Methodological Approach of Thesis.

[12] McConville and Wing Hong Chui (eds.). Research Methods for Law - Qualitative Legal Research and Law in Context. 2nd Edition. (2017) Ch 2 and 6.

[13] Steven M. Barkan, Barbara A. Bintliff and Mary Whisner. (eds). Fundamentals of Legal Research. (10th ed.) (2015). 1-23.

Scope and Limitations

This research was undertaken considering the most likely scenarios for the commercialisation of Outer Space. It is worth noting however that the nature of the space activities discussed in this dissertation are dynamic and continually evolving and adapting, therefore although every effort was made to ensure that content presented was true at the time of initial submission, the possibility that variables such as key stakeholders or activities being undertaken may vary slightly in the future. There are also many unforeseen variables and uncertainties regarding the future of commercialisation of space that cannot be predicated and taken into consideration during analysis.

Given the nature of this legal analysis, complex scientific explanations have at times been oversimplified to allow readers enough knowledge to understand the legal implications in discussion.

Chapter Outline

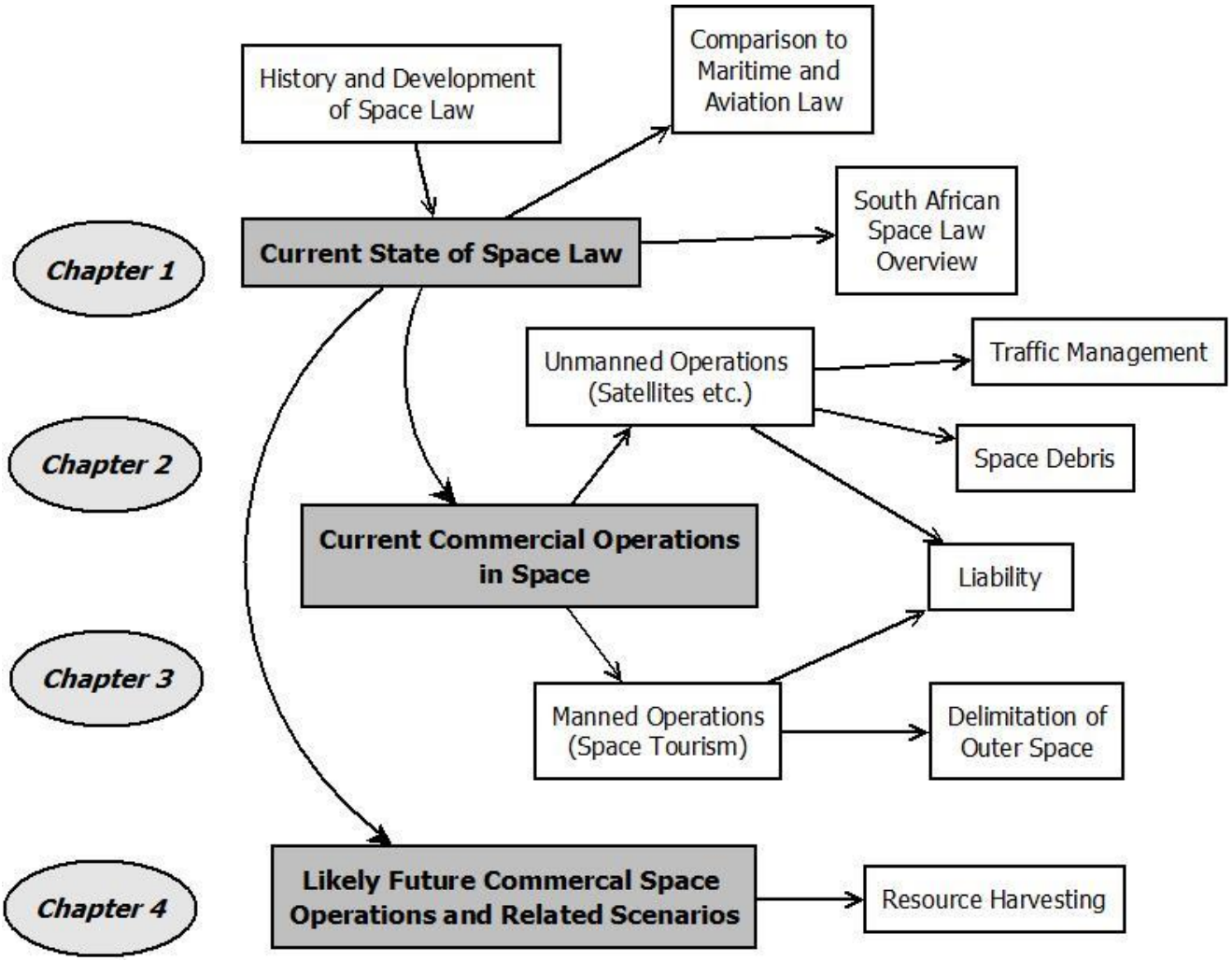

Figure 2 - Flow Diagram Highlighting Chapter Outline of Thesis.

Chapter 1: Introduction and Background

This chapter serves two purposes. The first is to look through the development of the Law of Outer Space, commenting on its foundational principles and discussing the context within which the Law of Outer Space was created as the historical context within which the Law of Outer Space developed had a massive effect on its foundational principles and the effects these principles have on modern development of the Law. This includes the pre-Cold War origins of the Law of Outer Space, with a brief introduction on the academic fundamentals which were considered before space flight was possible as well as the development of Space Law during the Cold War. This will focus on the 5 treaties passed through the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and its origins.

The second purpose is to provide a grounding in what the contemporary Law of Outer Space is comprised of and to use this is the foundation for the discussions going forward into later chapters. This includes some general critiques of the Law such as the enforceability of Public International Law and the potential for rogue actors. This includes looking at the way in which the Law of Outer Space is applied, as well as comparing the Law of Outer Space, Maritime Law and Aviation Law.

The chapters hereafter look at the foundations of the Law of Outer space which will need to be clarified, adapted or amended to allow an environment within which commercial operations are more certain. The occur in logical progression - starting with issues which need to be addressed immediately (before commercial operations scale up), operations in Near Earth Orbit (NEO) and finally progressing outwards into the solar system.

Chapter 2: Unmanned Commercial Operations in Space

This chapter looks at how the law could encourage the responsible use of outer space. Without regulation of the debris in orbit around earth, we could potentially face an issue where we cannot even use space for any purpose commercial or otherwise because of the hazards presented by debris in space.

This begins with an explanation of the technical aspect of the problem and the science behind phenomenon such as the Kessler Syndrome and other potentially disastrous

environmental effects of Space Exploration. Potential issues explored include the use of hypergolic fuels in rocket launches and debris left in space from launches and the hazards they could present to future missions (including the doomsday scenario of a Kessler Syndrome event, wherein the amount and density of space debris triggers a chain reaction that exponentially increases the level of space debris creating a debris cloud around the Earth which could make launches off Earth near impossible). Finally, the cross contamination of other worlds is looked at, where foreign bodies are taken off Earth either intentionally or unintentionally, and the potential issues this could present.

Hereafter the chapter explores the sparse existing law, as well as current efforts by different bodies (such as the European Space Agency) to address these issues. This includes commentary on how many of the measures being taken are merely at the behest of scientists within these organisations and not due to any regulatory requirement of enforcement. The measures the Law could take to try and prevent any of these environmental concerns from becoming large scale concerns is then examined.

Chapter 3: Manned Commercial Operations in Space

This chapter is dedicated to understanding liability in relation to commercial endeavours in Outer Space given the goal of minimising risks and maximising profits/benefits. This will be done through the lens of initial commercial operations in Near-Earth Orbit (NEO). This will start with a discussion around the question “Where does outer space start?”. We will look at the science which informs the legal answer thereto before progressing into what the contemporary answers are from a legal standpoint (of which there are no concreate answers).

This chapter will then progress to explore the likely development of space tourism as the first widespread commercialisation of space, first with sub orbital hops, progressing to having orbiting hotels for tourists to stay in. This will look at the efforts of companies to decrease the cost and accessibility to space for average civilians and discuss the issues around passenger liability. The current state centred liability regime is discussed including the possibility of private individuals trying to claim under this, and the consequential burdens imposed on states.

Finally, this chapter will then explore some potential solutions to the above identified issues. This will first occur through an analysis of the development of passenger liability on aircrafts and drawing parallels in its development to potential paths of development within passenger liability aboard spacecraft. There will also be an analysis of the different approaches to classification of the liability regime applicable, looking at the spatialist and functional approaches as described earlier and contrasting their approaches.

Chapter 4: Future Commercial Operations in Space – Resource Harvesting

While the previous chapter deals with commercial concerns in the short-term, this chapter will deal with an issue which is likely to only occur in the long-term, when commercial operations are based in space, as opposed to being based on earth but with activities centred on going into space. Here the activities are occurring in space, not because of the attraction of space, but merely because that is where the operations need to occur. The main concern here will be Property Rights in space, however the conduit through which this discussion will take place will be through the example of Asteroid Mining as it is an activity within which the issues are particularly relevant.

We will begin by discussing the likely development path of the technology so as to properly frame the discussion on the law in the later parts of the chapter.

The chapter then goes through how the law as it stands will present challenges to commercial operations namely due to the uncertainty it creates in commercial operations ability to claim areas/objects in space.

Some potential solutions to these issues will then be considered. It compares and contrasts potential amendments to the law, such as allowing for the claiming of space, the granting of exclusive economic zones to companies or inaction.

CHAPTER 1 – INTRODUCTION AND BACKGROUND

1.1. History of Space Law

> "As new areas of the world and outer space have been discovered and explored, man has had to develop regulations to govern the use of these new areas. However, it was not until man possessed the technological means of extracting or using the resources of these new areas that there was an urgent need to develop regulations for the oceans and space."[14]

Human space exploration can be seen as going back millennia, to times when the Ancient Civilizations used the stars for navigation, or to when Galileo created his first telescope. Many however would disagree and state that human Space Exploration began in earnest in 1957 with the launch of Sputnik-1, thus enabling us to, for the first time, touch space. A mere 4 years later, Yuri Gagarin, the son of Russian farmers, became the first person to enter Space when the Vostok-1 craft he was in completed an orbit of the Earth. The origins of Space Law however start before our first forays off Earth.

Stephen Doyle notes that the first mention of Space Law occurs almost 50 years earlier, appearing in a journal Article written by Belgian jurist Emile Laude, published in a Parisian publication with proper development of the concept starting in the 1930s.[15]

> "In 1932 the first comprehensive monograph appeared [written by Vladimir Mandl], presenting important, fundamental concepts of Space Law. Brief commentaries appeared in the 1930s and 1940s. The first doctoral dissertation dealing with Space Law appeared in 1953. By 1954 expanding international exchanges were occurring among jurists and commentators concerned about the need for clarification and definition of law anticipating human activity in outer space."

The development of Space Law has always remained rather niche with "the outer space legal framework [being] very fragmented –consisting of treaties, UN principles

[14] Robin Elizabeth Lewis *An Analysis of the Law of the Sea and Outerspace Law: Claims Over the Natural Resources of the "Commons"* (unpublished M.A. thesis, University of Richmond, (1987).
[15] Stephen E. Doyle 'A Concise History of Space Law' available at http://www.iislweb.org/website/docs/2010keynote.pdf accessed on 02 February 2019.

and guidelines, regional regulations and intergovernmental agreements, as well as national guidelines and legislation."[16] It can be both very detailed in some respects, and full of holes in others. For example, the fundamental definition of Space Law being "all the law that may govern or apply to outer space and activities in and relating to outer space" [17], itself is contested as legal academics have struggled to define Outer Space. Although the growing consensus points to somewhere around 100 km above sea level being the start[18], a point known as the Von Karman Line which is the theorised lowest possible stable orbit around earth.[19] This has recently been disputed however, with new models putting the line closer to 80 km above mean sea level, thus showing the problem.[20] The ramifications of this problem will be discussed later on in this chapter.

The UN General Assembly established an adhoc committee in 1958 to discuss policy around space activities and establish an adequate legal framework to govern activities in space. This became a permanent committee in 1959 with the establishment of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) with the establishment of a dedicated legal sub-committee in 1962.[21]

Space Law as an international legal regime, has its foundation in five UN treaties, namely:

- The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty).
- The 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into outer space (Rescue Agreement).

[16] A Ferreira-Snyman 'Legal Challenges Relating to the Commercial Use of Outer Space, with Specific Reference to Space Tourism' (2014) 17 *Pochefstroomse Elektroniese Regsblad* 01/612.
[17] Henery R. Hertzfeld (ed) *A Guide to Space Law Terms* (2012) 120.
[18] Ibid at 82; Francis Lyall & Paul B. Larsen *Space Law: A Treatise* (2009) 163; Glenn H. Reynolds & Robert P. Merges 'Outer Space: Problems of Law and Policy' (1990) 3 *Havard Journal of Law and Technology* 275 - 278
[19] John Spacey 'What is the Karman Line?' available at *https://simplicable.com/new/karman-line* accessed on 15 October 2018.
[20] Jonathan C. McDowell 'The edge of space: Revisiting the Karman Line' (2018) 151 *Acta Astronautica* 668-677.
[21] United Nations Office for outer space Affairs 'COPUOS History' available at http://www.unoosa.org/oosa/en/ourwork/copuos/history.html accessed on 03 March 2019.

- The 1972 Convention on International Liability for Damage Caused by Space Objects (Liability Convention).
- The 1975 Convention on Registration of Objects Launched into outer space (Registration Convention).
- The 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty).

In addition to these, as a branch of Public International Law, the fundamental rules of International Law particularly those incapsulated in the UN Charter, are also applicable to any activities in Space.

Although law in general is often characterised by incorporating principles going back in some cases millennia, the reality is that in Space Exploration as shown above, even a few years can differentiate drastically different paradigms. These treaties for the most part do not cover the issues encountered by modern commercial space ventures. Take for example Asteroid Mining, which is "the exploitation of raw materials from asteroids and other minor planets, including near-Earth objects. These raw materials include precious metals, such as gold and silver."[22] A commercial venture wishing to exploit asteroids for their natural resources are faced with a number of legal issues due to this regime of treaties.

1.2. Fundamentals of Space Law

> "In order to avoid any misunderstanding, let it be said at the very outset that Space Law, as it now exists, is not an independent legal system. It is merely a functional classification of those rules of international law and of municipal law relating to outer space, natural or man-made objects in outer space, spacemen, and man's activities in outer space."[23]

The above is crucial to understand as a starting point for a discussion on the effects of Space Law. It is not a functional body of legislation in the same way most other

[22] Erin Bennett 'To Infinity and Beyond: The Future Legal Regime Governing Near-Earth Asteroid Mining' available at *https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2935403* accessed on 16 October 2018.
[23] Bin Cheng *Studies in International Space Law* (1997) 383.

transportation methods are governed. Fabio Tronchetti summates my sentiment quite eloquently in his book on the *Fundamentals of Space Law and Policy* stating:

> "…Space Law offers a rather variegate picture. Despite including a vast number of applicable rules, it cannot claim to be a comprehensive and integral legal system. In particular, its main limit consists of not addressing all issues that would be desirable for completeness. Its further advancement relies on the willingness of states to cooperate towards this goal. However, as the number of countries capable of accessing and using outer space increases, the challenges to the formation of effective Space Law parallelly augment."[24]

Space Law's relative uniqueness as a mode of transport, both in that it is not as frequented as other forms of travel but perhaps more importantly in that it is still a very new form of transportation on the scale of international law, means that the body of legislation which does exist is at best persuasive but more realistically, toothless.

To explain my sentiment here, we need to take a step back to examine International law itself. For the purposes of this discussion, international law can fall into one of two categories. General International Law (or Customary International Law) comprises the first body of international law, which is binding upon all actors and has its foundations in generally accepted practices which are accepted as law.[25] The second category, Treaties, is where the body of Space Law is comprised, which are binding only on those parties which consent to be a part of the treaty.

> "Notwithstanding frequent assertions or assumptions to the contrary, a treaty, however numerous its contracting parties, cannot as such create rights or duties for non-parties without their consent, a point now happily re-affirmed in Article 34 of the 1969 Vienna Convention on the Law of Treaties, although as Article 38 of the same Convention says nothing precludes a rule established in a treaty from becoming binding on third parties as a rule of general international law. But, as the North Sea Continental Shelf Cases (1969) have shown, whether a treaty rule has become a rule of general international law is an issue which must be established in respect of each individual rule by reference to general State practice and not by reference merely to the number of States parties to the treaty in question."[26]

[24] Fabio Tronchetti *Fundamentals of Space Law and Policy* (2013) 3-4.
[25] Article 38(1)(b) *Statute of the International Court of Justice.*
[26] Bennett op cit note 22.

A foundation of law is enforcement, a method to compel those who are subject to a law, to comply. Both General International Law and Treaties suffer from the issue of often not having any enforcement mechanism. Without this, it is to the whims of those subject to the law to comply, and in an inherently self-interested world, that can be difficult to achieve - resulting in law in that situation merely being an articulate expression on an ultimately feeble paper. No matter the context, and regardless of the need for international compliance, time and time again international law has served to reinforce that when it comes to Law, the ultimate authority is the State. Within the territory of a State, it is only State which can ensure compliance. Conversely this has another implication, the State can only enforce within its territory. This, although often breached, has been a foundational principal of territorial sovereignty dating back to the Treaty of Westphalia. Speaking in 1928, Judge Max Huber in the Palmas Arbitration between the United States and the Netherlands explained this principle, albeit in an overly verbose nature as was the character of jurists of that time:

> "The development of the national organisation of States during the last few centuries and, as a corollary, the development of international law, have established this principle of the exclusive competence of the State in regard to its own territory in such a way as to make it the point of departure in settling most questions that concern international relations…[T]erritorial sovereignty belongs always to one, or in exceptional circumstances to several States, to the exclusion of all others. The fact that the functions of a State can be performed by any State within a given zone is, on the other hand, precisely the characteristic feature of the legal situation pertaining in those parts of the globe which, like the high seas or lands without a master, cannot or do not yet form the territory of a State.
>
> Territorial sovereignty is, in general, a situation recognised and delimited in space, either by so-called natural frontiers as recognised by international law or by outward signs of delimitation that are undisputed, or else by legal engagements entered into between interested neighbours, such as frontier conventions, or by acts of recognition of States within fixed boundaries…
>
> …[I]t serves to divide between nations the space upon which human activities are employed, in order to assure them at all points the minimum of protection of which international law is the guardian."[27]

[27] Max huber 'Island of Palmas Case' (1928) II *Reports of International Arbitral Awards* 839.

Under this formulation of territorial sovereignty, International Law operated under three categories of territory. National Territory, the area over which a state had control and exclusive jurisdiction (*nationales territorium*), territories which could not be claimed or controlled, and upon which no state had jurisdiction such as the oceans or Antarctica (*territorium extra commercium*) and finally territories which could be claimed, and could have state jurisdiction, but which at that point did not (*territorium nullis*).

Thus, the question, is Outer Space territory which cannot be claimed, or is it territory which has yet to be claimed, and consequentially can there be state enforcement in Outer Space?

In 1979, an attempt is made at an answer with the Moon Treaty: neither. Instead a fourth category is created, territories which are the heritage of mankind (*territorium commune humanitatis*). This attempts to put all celestial objects and the paths of their orbits within the jurisdiction of the international community, thus making it subject to international law and legal principles. This however has yet to take substantial effect. Although the Moon Treaty as of 2019 has 20 parties to the treaty, no nation with the capability for orbital launch is a party.[28] The legal value of this Treaty is thus brought into doubt.

1.3. Contemporary Space Law

> "The core of the whole space legal system is constituted by the instruments negotiated within the framework of the United Nations (U. N.), particularly within the U. N. Committee on the Peaceful Uses of outer space (UNCOPUOS). These instruments are: (a) the five U. N. space treaties; (b) a set of U. N. General Assembly principles. In addition to the U. N. space instruments, other norms have been concluded by states on a bilateral and multilateral basis outside of the UNCOPUOS framework. The relevant parts of the statutes of international inter-governmental organizations, such as the International Telecommunication Union (ITU) and the European Space Agency (ESA), can be mentioned as examples of this kind. Furthermore, a growing number of countries have adopted national laws and/or internal regulations governing national space activities. National laws are meant to implement international Space Law norms

[28]UNTC 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' available at https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXIV-2&chapter=24&clang=_en accessed on 12 February 2019.

> and to make sure that private space activities do not undermine international obligations and security interests. Finally, it should be kept in mind that international Outer Space Law is a branch of public international law. Consequently, the fundamental rules of international law, particularly those included in the U. N. Charter, are applicable to activities in outer space."[29]

"The outer space Treaty is the cardinal instrument regulating activities in outer space"[30] and as such most founding principles of the Law of outer space can be found in its articles. The first and most important of these is Article I which enshrines the rights of parties to explore, investigate and use for peaceful purposes, Outer Space. It specifically references how outer space should be ''for the benefit and in the interest of all countries, irrespective of their degree of economic and scientific development, and shall be the province of all mankind.''[31] It is this philosophy which forms the foundational principle of the Law of Outer Space.[32]

This with Article III, which requires that parties conduct their activities in space with due consideration of International Law and within accordance to the Charter of the United Nations[33], lays out a clear idea of what law makers then wanted to stress about the usage of outer space by states. This is that in all instances the usage of space should be "in the interest of maintaining international peace and security and promoting international co-operation and understanding."[34]

This follows on from the concern of the time that the rapidly developing technology between the two superpowers (USA and USSR) would turn space into another battleground of the Cold War. Article IV of the treaties establishes a partial demilitarization of space, forbidding parties placing nuclear weapons or other weapons of mass destruction in outer space and completely demilitarising the moon and other celestial bodies.[35]

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[29] Fabio Tronchetti *Fundamentals of Space Law and Policy* (2013) 3-4.
[30] Ibid.
[31] United Nations Office for outer space Affairs 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies' available at http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf accessed on 17 April 2019.
[32] Cheng op cit note 23; Welly ND "Enlightened state interest - A legal framework for protecting the common heritage of mankind from Hardinian tragedy" (2010) Journal of Space Law 273-313.
[33] UNOOSA op cit note 31.
[34] Ibid.
[35] Tronchetti op cit note 29; UNOOSA op cit note 31.

Peterson highlights the disagreement between two space fairing superpowers:

> "a realist would not have been able to predict whether outer space would be treated as a common area or as something to be "conquered" and parceled out among space- faring states. Both conceptions of space were advanced in the early 1950s; some commentators compared space to the high seas, while others compared it to national airspace… the superpowers initially disagreed, with the U.S. government preferring the high seas conception and the Soviet government the national airspace conception."[36]

Consistently the Treaty refers or presumes that the activity will be state run, and only once does it mention Non-Governmental Organisations in space, and that is in Article VI. "Article VI establishes the principle of international responsibility of states for national space activities, whether such activities are carried out by governmental agencies or by non-governmental entities. Accordingly, states must authorize and continuously supervise the space activities of their non-governmental entities."[37]

Again, this avoidance of the law addressing actors in space who are not states themselves is heavily founded in the beliefs of the time. Firstly, there are the issues highlighted earlier around the sheer costs and technological advancements needed for a private entity to be space fairing being so great that it was inconceivable at the time of drafting of these treaties. However, beyond this, there seems to have just been an underestimation or perhaps complete ignorance to the sheer commercial potential in outer space and this failing is compounded as we move forward as the sheer number of actors involved grows continually.[38]

There are arguments that this was a deliberate and strategic position on the sides of the drafting states.

> "The launch of Sputnik-1 introduced the Cold War space era, where space activities were intrinsically linked to the political objectives and priorities as well as to the national security or military concerns of the two superpowers, the USA and the then Soviet Union. Due to the strategic and political importance of space, the space powers were reluctant to allow

[36] Peterson op cit note 7.
[37] Tronchetti op cit note 29.
[38] Walter E "The Privatisation and Commercialisation of Outer Space" in Brünner C and Soucek A (eds) outer space in Society, Politics and Law (2011) 494

> any nongovernmental actors to explore outer space. In addition, the high cost and technological risks involved hampered private investment in outer space projects."[39]

It is unlikely that such omittances from existing Space Law will preclude or prohibit modern day private space exploration. As Ferreira-Snyman points out, in its contemporary implementation private space flight does not violate or fall outside the outer space Treaty.

> "Article I of the outer space Treaty requires that the exploration and use of outer space shall be carried out for the benefit and in the interest of all countries… space tourism may have certain (long-term) social and economic advantages: Space tourism will most probably eventually lead to more affordable access to space, which could be seen as beneficial for all mankind. In addition, private human spaceflight may have certain social and economic advantages such as the development of new technologies in the area of human space travel and the boosting of private investment, which could alleviate pressure on the use of public funds for near-earth space exploration."[40]

However, the concern going forward is that as the commercial use of space increases so do the number of actors and the disincentive of actors to agree on limitations to their exploitation of space.

> "Outer space was soon found to be a place with abundant opportunities for commercialization. Telecommunications services proved to be the first successful space commercial application, to be followed by remote sensing and global navigation services. In the last decade, the rapid development of space technologies has brought space tourism and space mining to the forefront of space commercialization. With more and more commercial activities taking place on a daily basis from the 1980s, the existing Space Law faces severe challenges. The five conventions, enacted in a time when space was monopolized by two superpowers, failed to take into account the commercial aspect of space activities. While there is an urgent need for new rules to deal with the ongoing trend of space commercialization, international society faces difficulties in adopting new rules due to diversified concerns over national interests and adjusts the legislative strategies by enacting soft laws."[41]

[39] Lewis op cit note 14.
[40] Ibid.
[41] Yun Zhao 'Space Commercialization and the Development of Space Law' (2018) *Oxford Research Encyclopaedia of Planetary Science* 1.

1.4. Comparisons between Maritime and Aviation Law to Space Law

The relative novelty of Space Law means that its principles do not find widespread adoption or certainty. Uncertainty in a legal regime is a large impediment to commercial ventures. We can see this best when we compare the area of Space Law to two other areas of international law which deal with transport, and from which Space Law draws a lot of its principles. Maritime Law (or the Law of the Seas) and Aviation Law. The comparability of these two branches of law to space law is an academically contested topic but nonetheless provides an important reference to later contentions in this research project – particularly where a determining the applicable legal regime to an object or person is concerned.

> "Maritime law, also known as admiralty law, is a body of laws, conventions, and treaties that govern private maritime business and other nautical matters, such as shipping or offenses occurring on open water. International rules, governing the use of the oceans and seas, are known as the Law of the Sea"[42]

Maritime Law has a centuries long history, and indeed is one of the key points of origin of the broader work of International Law. Because of this, it in many aspects predates our modern concept of treaties and modern states. This however serves to strengthen rather than weaken it, as many aspects of Maritime Law, and even more so in the Law of the Seas, are Customary International Law making them binding upon all states regardless of their consent.[43]

Although a lot of this Law has since been codified in numerous treaties, these do not detract from the enforceability of the concepts, but rather serve to clarify the law. This is comparable to the purpose legislation serves on a national level when codifying existing common law concepts.[44] Enforcement can still be a somewhat questionable process, however under the supervision of the International Maritime Organisation, the United Nations Convention on the Law of Sea (UNCLOS) hands over enforcement to state parties when issues are within their territorial waters. When it concerns activities in international waters this will be more fully covered when looking at potential

[42] Julia Kagan 'Maritime Law' available at https://www.investopedia.com/terms/m/maritime-law.asp accessed on 15 February 2019.
[43] J. Ashley Roach 'Today's Customary International Law of the Sea' (2014) 45 *Ocean Development & International Law* 243.
[44] Ibid.

enforcement mechanisms for Space Law later in this dissertation, but briefly Alfred H.A. Soons summates stating:

> "These rules are complex, because distinctions have to be made between the various jurisdictional zones at sea and between the positions of the flag state, the coastal state and the port state. Traditionally, ships in the high seas (all sea areas beyond a narrow band of territorial sea) were under the exclusive jurisdiction of the flag state. In an increasing number of situations, the coastal state now has law enforcement authority over foreign ships in expanded areas up to 200 nautical miles offshore. But apart from these situations, flag state jurisdiction still prevails beyond the territorial sea. This makes effective law enforcement difficult" [45]

Of noticeable interest in a comparison with the Law of the Seas is the change in development of the Maritime Law, reflecting the changing political situation influencing it as it is comparable to fluctuations in Space Law currently occurring.

> "Throughout its long history, a theme has continually recurred and dominated the law of the sea. This central and persistent theme is the contradiction between government authority over the sea and the freedom of the seas. This dichotomy has been reflected in the political, strategic and economic circumstances of each particular age. For example, when two great powers together dominated, the main thrust of practice favoured freedom of navigation; in these periods the seas seemingly became more strategically than economically important. On the other hand, when power was distributed equally between a multiplicity of states, protection and preservation of maritime resources and the affirmation of local authority over the sea was favoured."[46]

We can see this reflected in Space Law. Its origins occurred in a situation of two great powers, namely the USA and USSR who were more concerned with potential limitations on their exploration and usage of Space. Thus, the treaties and conventions focus on a freedom of Space and the peaceful utilisation of it. However, we are now in the transitionary period where there is a growing plurality of actors within the arena. And so, the focus needs to, and is, shifting to resource protection and authority.

A number of fundamental concepts are shared across the two bodies of law. For example, the "Common Heritage of Mankind Doctrine" has its origins in academic

[45] Alfred H.A. Soons 'Law Enforcement in the Ocean' (2004) 3 *WMU Journal of Maritime Affairs* 8.
[46] UNOOSA op cit note 31.

jurisprudence around the Law of the Seas before being incorporated into the Moon Treaty.[47] The duty upon states able to rescue Sailors in distress[48] is also closely mirrored in the Rescue Agreement.

When it comes to Aviation Law, Space Law is perhaps more different than one would assume. Both do share their origins in Marine Law and the Law of the Seas, and Space Law does incorporate some concepts from Aviation Law, however there are differences as well. "The essential difference between air law and Space Law stems from the legal status of airspace and of outer space. Whereas airspace, except over the high seas and Antarctica, is under the sovereignty of subjacent states, outer space is governed by the regime of freedom."[49] Aviation Law thus has a lot more reliance on national sovereignty and national legislation, although the International Civil Aviation Organization does have oversight in an attempt to ensure similar compliance levels and organise safe and efficient international travel.[50]

It is a common misnomer that Aviation and Space Law are the same or similar body of law, often termed Aerospace Law. While a potential space craft may be subject to Aviation Law, at the beginning and perhaps end of its journey, there is a finite boarder between the two and they are not the same body of law. Cross jurisdiction does not exist between the two bodies of law, the Chicago Agreement is only applicable within parties' Sovereign Airspace, perhaps even in Airspace over the High Seas.[51] However once passed through our atmosphere, at whatever point that is eventually agreed upon being, it ceases to have enforcement and instead we give way to the Outer space Agreement and others. [52]

An interesting question presented is to which body of Law Space Craft are applicable. Is it as I describe above, dependant which region they are in? There is no consensus

[47] Walter op cit note 38.
[48] Irini Papanicolopulu 'The Duty to rescue at sea, in peacetime and in war: A General Overview' (2016) 98 *International Review of the Red Cross.*
[49] Ivan A. Vlasic 'Air Law and Space Law' available at https://www.thecanadianencyclopedia.ca/en/article/air-law-and-space-law accessed on 13 February 2019.
[50] Article 44 of the Convention on International Civil Aviation (Chicago Convention).
[51] This would rely on an argument that the widespread acceptance of the agreement, with over 190 countries as party makes certain elements of the agreement Customary International Law and thus applicable even in Airspace over international waters.
[52] Tanja Masson-Zwaan 'Regulation of Sub-orbital Space Tourism in Europe: A Role for EU/EASA?' (2010) 264.

yet, however there are two general schools of thought which come through from the interaction between marine and aviation law, the functional and spatialist approaches.

Imagine an Aircraft crashes into the ocean, not due to pilot error but due to a bird strike. A passenger, who survives the accident, wishes to explore their options for compensation through delict. If the accident occurs in international waters, their remedies are governed by the Warsaw Convention on Claims, Damages and Choice of Law.

> "The Warsaw Convention, as modified by the Montreal Protocol No. 4, provides the exclusive basis for filing personal injury suits against air carrers in international air transportation between High Contracting parties. Airlines that are signatories to the International Air Transportation Authority ("IATA") Intercarrier Agreement on Passenger Liability assume liability for an injury caused by an accident within the meaning of the Warsaw Convention unless the airline can prove that it took all necessary measures to avoid the injury or accident."[53]

Thus, the Warsaw Convention confirms all liability upon carriers, even if crashing into the oceans, and in so doing excludes any applicable Marine Law, leaving the aircraft in the exclusive jurisdiction of Aviation Law as far as liability is concerned. However, should the same accident occur, however instead of crashing into International Waters, it instead crashes into Lake Michigan or into the Hudson River as famously happened to US Airways Flight 1549 (the plot point for the movie "Sully"), US national law has a very different answer.

> "Commercial airline flights may be subject to maritime jurisdiction, depending on whether there is a significant relationship to maritime activity. The Supreme Court assessed what must occur to invoke federal admiralty jurisdiction in Executive Jet Aviation, Inc. v. City of Cleveland, 409 U.S. 249 (1972). In this case a plane was flying from Cleveland, OH to a U.S. domestic location, and crashed into Lake Erie after a flock of seagulls flew into the plane. The aircraft sank in the lake, and the owners sued the city for property damage [they argued the City had failed at its obligation to keep

[53] Ladd Sanger & Vicki S. Brandt 'Flying-and Crashing-on the Wings of Fortuosity: The Case for Applying Admiralty Jurisdiction to Aviation Accidents Over Navigable Waters' available at https://www.slackdavis.com/wp-content/uploads/2018/10/Ladd-Sanger-Paper-Flying-And-Crashing-On-The-Wings-Of-Fortuosity-Applying-Admiralty-Jurisdiction-To-Aviation-Accidents-Over-Navigable-Waters.pdf accessed on 18 February 2019.

the airport free of birds[54]], arguing that maritime law applied since the plane sank in the navigable waters of the lake.

> The Supreme Court … looked at instances in the history of maritime law where those injured on land were permitted recovery. Maintenance and cure, or living and medical expenses, can be recovered by those injured in the course of employment for a boat, regardless of whether it was on sea or on land. Likewise, if a vessel is deemed unseaworthy, and the unseaworthiness causes an injury on land, recovery is available under maritime law. The Supreme Court also pointed out that Congress extended the Admiralty Jurisdiction Act to include all property and personal damage caused by a vessel on navigable waters on land and on sea. Ultimately, the court looked at these legislative and judicial examples as a model to view the relationship of the injury-causing wrong to traditional maritime activity." [55]

Critics of this approach are many, including that the rationalisation of the US Supreme Court that injuries occurring on a boat on land extend Marine Law, logically would then extend Aviation Law to injuries occurring on an Aircraft on water, however in subsequent cases the US Supreme Court cemented its spatialist approach.[56]

When it comes to the approach likely taken in Space Law, the conversation is still ongoing amongst academics and jurists, however, there appears to be a sway towards a functional approach similar to the approach taken by international law with regards to Air and Marine Law. Speaking about suborbital space tourism as an exploration of grater international Space Law, Tanja Masson Zwaan contends:

> "… it must be decided whether the initial sub-orbital variety of space tourism will be regarded as aviation or as space activity under international or national law. Here, a 'functional' approach is chosen, that is, air law is applied if sub-orbital space tourism is regarded as aviation, and Space Law is applied if it is treated as a space activity. The 'spatialist' approach, where air law would be applied to the portion of the flight taking place in the airspace, and Space Law to the part of the flight taking place in outer

[54] Ibid.
[55] John Merriam & Gordon Web 'When Air Meets the Sea: Applying Maritime and Admiralty Law to Commercial Aviation Accidents' available at https://www.cruiselawusa.com/when-air-meets-the-sea-applying-maritime-and-admiralty-law-to-co.html accessed on 18 February 2019.
[56] See the discussion had by Sanger and Brandt.

space, is not practical – not in the least because there is still no internationally agreed delimitation between air space and outer space."[57]

1.5. South African Space Law

When it comes to domestic Space Law, South Africa has two important acts which relate to space activities: The *Space Affairs Act*[58] and the *South African National Space Agency Act.*[59] These two acts work to promote and regulate the space industry in South Africa as well as ensure that South Africa upholds its commitments in international law. Before discussing the legislation as it stands it is useful to understand the context of space industry in South Africa.

South Africa's national space program started in the 80's as a classified military operation in conjunction with Israel.

> "As South Africa's political and economic isolation increased during the 1980's, the military became increasingly concerned about the growing Warsaw Pact and Cuban military presence on the subcontinent. With the strengthening of the air defences in the neighbouring countries, the South African Air Force could no longer carry out aerial photoreconnaissance missions with impunity over those countries. The government therefore decided to develop a reconnaissance satellite programme. This required creating the capacity to build, test, launch, operate and replace a series of reconnaissance satellites. The launch capability also served another purpose, namely as a medium-range ballistic missile system, which coupled with the country's nuclear weapons programme, gave it regional nuclear deterrent capability. The launcher and satellite development was carried out in collaboration with Israel. Facilities were established in the southern Cape for the testing and integration of the satellites and launch vehicles, and three suborbital test flights were conducted from the Overberg launch site, near Cape Town."[60]

However, with the dissolution of the USSR in the early 90s, the ending of the Cold War and the government shifting focus away from holding power to transitioning into a

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[57] Op cit note 52
[58] Act 84 of 1993, as amended by the *Space Affairs Amendment Act* 64 of 1995.
[59] Act 36 of 2008.
[60] Peter Martinez 'The Development of Space Law in South Africa' (2015) 64 *Zeitschrift fur Luftund Weltraumrecht - German Journal of Air and Space Law* 353-354.

democratic dispensation, the need for a military space program diminished. This as well as mounting international pressure to dismantle its nuclear and launch capabilities as a precondition to reintroduction into the international community, resulted in the closure of the military space programme in the early 90's.[61]

> "As part of the general change of political posture, from being isolated on the world stage, to being more open and transparent and playing an active role on the world stage, South Africa joined the United Nations Committee on the Peaceful Uses of outer space (UN COPUOS) in 1994. It was at this time and against this backdrop that the Non-Proliferation of Weapons of Mass Destruction Act (Act 87 of 1993) and the Space Affairs Act (Act No 84 of 1993) were both passed. Thus, the adoption of space legislation was a part of South Africa's disarmament process, and for a long time after 1993 space affairs were in the shadow of disarmament and were not developed separately from a policy perspective. Attempts were made to commercialise the satellite programme under the name Greensat, but those attempts ultimately failed and the Greensat programme was cancelled in 1994 as the Government of National Unity reprioritized national programmes."[62]

Despite having the legislation and bodies to implement the legislation, it laid dormant until 1998/1999 when a group of academics built Sunsat, the first South African satellite to be built and licensed as such under the *Space Affairs Act*.[63] It was launched aboard an American rocket in February of 1999 and would operate for 2 years making scientific observations of the sun.[64] However this mission was a scientific one led by researchers from a public university, not a government led mission. It would only be in 2003 when government would begin to acknowledge the value of having a publicly funded and directed space program, with it eventually releasing a space policy document in 2009.[65] This followed on from the *South African National Space Agency Act* which established the South African National Space Agency (SANSA) to co-ordinate the countries space activities.

> "The Space Agency Act therefore focuses on the *implementation* of space related activities, rather than on their *regulation*, which falls under the Space Affairs Act. The

[61] Ibid.
[62] Ibid.
[63] Ibid.
[64] The Satellite Encyclopedia 'Sunsat' available at *https://www.tbs-satellite.com/tse/online/sat_sunsat.html,* accessed on 26 November 2019.
[65] Martinez op cit note 60 at 358.

> South African National Space Agency was established as an operational entity in 2010 through the amalgamation of several space-related entities. So by 2010, the country had in place the key pillars of a new civil space programme."

To date, including Sunsat, there are only 3 registered space craft on the National Registry of Objects Launched into Outer Space.[66]

The *Space Affairs Act*[67] contains the bulk of legislation which regulates commercial space operations in South Africa, with it holding as its purpose:

> "To provide for the establishment of a Council to manage and control certain space affairs in the Republic; to determine its objects and functions; to prescribe the manner in which it is to be managed and controlled; and to provide for matters connected therewith."[68]

This council - South African Council on Space Affairs (SACSA) – is comprised of members appointed by the Minister of Trade and Industry in terms of section 6 of the Act[69], and as set out in the act includes in its mandate:

- "Take care of the interests, responsibilities and obligations of the Republic regarding its space and space-related activities in compliance with Conventions, Treaties and Agreements
- Authorises space activities: Issue licenses and amend, suspend or revoke such licenses
- Regulates space activities
- Advise the Minister on matters that have an influence on space affairs"[70]

While this legislation has been adequate for South Africa's limited commercial activities thus far, the Department of Trade and Industry (DTI) is currently drafting a replacement titled the *South African Outer Space Bill*. This was a decision taken by the department after two consultation workshops at the University of Pretoria with numerous academics and industry players, which came to the conclusion that the short comings of the act could not be dealt with by another amendment act, but that

[66]SACSA 'National Registry of Objects Launched into Outer Space' available at *http://www.sacsa.gov.za/registry/index.php*, accessed on 26 November 2019.
[67] Act 84 of 1993 op cit note 58.
[68] Act 84 of 1993 op cit note 58.
[69] Act 84 of 1993 op cit note 58.
[70] Nomfuneko Majaja 'Space Related Issues" available at *https://www.thedti.gov.za/parliament/2018/Space_Issues.pdf*, accessed on 15 November 2019.

an entirely new act should be drafted.[71] Anton Alberts lists these shortcomings as including:

- **"Definitions:** There is a need to define or redefine various terms such as "Launching", "Licence", "Outer space", "Space activities", "Spacecraft", "Space industry" etc.;
- **Scope and Application:** No actual provision that outlines the scope and application of the *Space Affairs Act* resulting in the reliance on Section 11 that deals with licencing to deduce what it is;
- **Authorisation and Licensing:** A new licencing regime is necessary given the new types of space activities by new role players;
- **Continuing Supervision of Space Activities:** This is necessitated by the international obligations placed on the country by international conventions, treaties and agreements to which the country is a party;
- **Safety and Environmental Considerations:** The current sections in the *Space Affairs Act* are not sufficiently clear and need to be revised;
- **Liability and Insurance:** There is no mention of third-party liability expressed as a requirement. Limits on liability is also needed to encourage industrial development;
- **Registration:** There is no provision for the registration of space objects in the *Space Affairs Act.* This must, therefore, be included in line with the *Registration Convention:*
- **In-Orbit Transfer of Ownership:** No such provision in the *Space Affairs Act* deals with this matter. The *Bill* will have to address this in accordance with a national registry as prescribed, inter alia, by the *Registration Convention.*"[72]

I was graciously provided with a copy of the new bill by the DTI, and while I was asked not to reproduce or distribute the bill due to it not yet being gazetted and promulgated, I have been allowed to make comment on the draft bill as it currently stands. It must however be stated that this commentary is made on the draft of the bill as it currently stands[73] and that the bill is likely to change before it is gazetted - however it is in a very advanced stage of drafting.

In terms of definitions, the bill makes no further attempt to define "outer space" than what is already in Southern African Law, namely that:

[71] Anton Alberts 'South Africa' in Annette Froehlich (ed) *Integrated Space for African Society: Legal and Policy Implementation of Space in African Countries* (2019) 68 – 69.
[72] Ibid.
[73] This is version 11 of the draft bill, valid as of 21 August 2019.

> "'outer space' means the space above the surface of the earth from a height at which it is in practice possible to operate an object in an orbit around the earth;"[74]

This unsurprising considering South Africa's relatively neutral position in the international debate taking place around the definition and delimitation of outer space (which will be discussed further in the next chapter).

Of interest are some of the definition included in the bill which are not in the current act. The first of which is a definition of "damage", taken from the Liability Convention and the definition of the "National Space Registry". These definitions and the accompanying provisions they then form a part of are in accordance with ratification of the Liability Convention and Registration Convention respectively. However, by pulling the definition of damage verbatim from the Liability Convention, the bill also inherits the concerns around this definition (which is discussed in the next chapter).

The above is a recurring concern with the bill as it makes little attempt to develop the body of Space Law, instead copying verbatim from more "established" legal sources, often inheriting with them the concerns or critiques of these other bodies of Space Law. Overall, the bill takes a somewhat conservative approach, sticking to what is internationally already accepted and doing no more and no less than what is required from South Africa to still be present on the international stage, albeit in the shadows.

A good example of this is the way in which the bill deals with the concerns of state liability created by the Liability Convention. Here the bill follows the exact model found in British legislation (see discussion in Chapter 3). This model sees the legislation first requiring that space activities first be licensed by the competent authority before occurring, then making a provision of the license that the entity have insurance sufficient to reimburse the state the costs of any liability it is found to have due to the activities of the private entity. This then dramatically increases operational costs to the private entity, often forcing them to register in other countries, due to the costs of the insurance which must be sufficient to cover claims which could be multiple times the market cap of the private entity. This completely stifled commercial space activities in the UK, even with them recently introducing a liability cap something the bill does hint

[74] Act 84 of 1993 op cit note 58.

at but not state explicitly. Thus, with the bill merely copying this model, the bill does not encourage private enterprise to come to our shores and exploit “flags of convenience” (see discussion in Chapter 3) but instead actively discourages enterprise.

The bill is also noticeably silent on the new developments in Outer Space Law. It has no mention of the rights of citizens to exploit resources in Outer Space, as has occurred in US and Luxembourg legislation. It makes only a few passing references to human spaceflight, and the rights of passengers or obligations upon launching entities.

The bill could have been an opportunity to shape our legislation as being on the forefront of the boom in commercial space operations, encouraging entities which could operate from anywhere in the world, to bring their enterprise and thus tax here. Instead, it is merely an update required to keep South Africa in line with UN treaties, but one which will see our space industry remain relatively non-existent. A concern acknowledged by the drafters in our discussions was that politicians, which will be required to move this bill through the political process, will see it as irrelevant to their constituents and thus ignore it in favour of more politically appealing bills. Considering this bill has been in the drafting stage for numerous years now, it seems this concern is more than valid.

1.6. Conclusion

This chapter has established a foundational understanding for the reader of the history and development of the Law of Outer Space as well as the context which has produced currently observed issues within the law such as state-centred approaches and lack of enforceability of laws. Contemporary International Space Law was explored, with reference to the contrasting concepts of Maritime and Aviation Law. This juxtaposition highlighted key flaws and gaps in the law. South African Space Law and the author’s contributions thereto during the research process was considered.

CHAPTER 2 – UNMANNED COMMERCIAL OPERATIONS IN SPACE

Humans are notoriously wasteful and messy. No technological leap forward has come without an environmental consequence and toll. Space Exploration is no exception. While it may allow us to escape some of the environmental impact we have had on Earth during our previous technological advances, space exploration is also impacting upon our environment both on Earth and above.

This chapter will investigate a number of the more immediate concerns for a commercial venture moving forward into Low-Earth Orbit (LEO) with unpiloted space objects. The first part of this chapter will look at the *Convention on the International Liability for Damage Caused by Space Objects*[75] (Space Liability Convention), analysing the important elements of the convention such as what a "Space Object" is, what constitutes "Damage", how causation is conceptualised and importantly "Fault" in the context of the convention. Once this foundational understanding is established, The next part of this chapter will proceed to examine how the Liability Convention may be interpreted by looking at the only claim made under the convention (Canada against the USSR). The final part of this chapter will then explore the issue of Space Debris though the lens of Kessler Syndrome, as well as attempts to prevent such a hypothetical scenario occurring, using the case study of the Iridium 33/Kosmos 2251 incident. The chapter will conclude with a discussion on how to prevent in-orbit collisions, which threaten to be major contributors to space debris, and a massive commercial risk for private operators. This will focus on a discussion around space traffic management, viewed through the lens of the recent SpaceX Starlink and European Space Agency (ESA) Aeolus' close miss.

2.1. Unmanned Commercial Operations in Space

Who does this? What exactly do they do? What are satellites and what are they used for? Why does this exist? How is it done?

[75] United Nations Office for outer space Affairs '*Convention on the International Liability for Damage Caused by Space Objects*' available at http://www.unoosa.org/pdf/gares/ARES_26_2777E.pdf accessed on 23 July 2019.

2.2. Space Liability Convention – Definition of "Space Object" and "Damage"

Of the 5 UN Conventions on Space, the Space Liability Convention would be the originator of the academic discourse on Space Debris. It sets out the fundamental rules of liability in the event of damage occurring due to Space Debris. Two important definitions which must be understood from the formal name of the Convention for this discussion, are "Damage" and "Space Object".

"Damage" is defined by Article I of the Liability Convention, as "loss of life, personal injury or other impairment of health; or loss of or damage to property".[76] It further stipulates that the property can be owned by states, private entities, or international organisations. It is clear from the text that cases of damage caused directly by contact with a space object are included in this definition. What is unclear is whether more general or indirect damages are included in this definition, with Nandasiri Jasentuliyana & Roy S.K. Lee noting in *Manual on Space Law* that "at the seventh session of the Legal Subcommittee, the majority opinion on the issue of indirect damage was merely an issue of causality that was not necessary to state in the Convention".[77]

There are diverging views held by academics on the scope of damages covered by the convention. Opinions generally fall into one of two camps: a conservative interpretation, or a more progressive interpretation.

Proponents of the conservative interpretation hold that the phrasing "caused by" creates a limitation in language to only that damage which the space object creates upon physical impact. Stephen Gorove supports this stating that under the convention damage be "interpreted to mean that consequential damage where the damage does not flow directly and immediately from the act, but only from the consequences of such act, under normal circumstances would not be covered by the Convention."[78]

In contrast, the more progressive interpretation follows the natural language interpretation of "caused by" to include those elements of damage which occur

[76] Ibid.
[77] Nandasiri Jasentuliyana & Roy S.K. Lee (eds) *Manual on Space Law* (1979) 115.
[78] Stephen Gorove 'Cosmos 954: Issues of Law and Policy' (1978) 6 *Journal of Space Law* at 141.

because of the event occurring as a whole and not just the specific impact.[79] Carl Christol in support, holds that "caused by" should allow for the "recovery of damages both for a direct hit and for the indirect or consequential aspects of an accident . . . resulting from the malfunctioning of a space object and its component parts."[80]

Elena Carpanelli and Brendan Cohen compiled a comprehensive analysis of the meaning of damage within the Space Liability Convention, which was subsequently published. Noting the diverging views of academics and even the views of the drafters, they undertook to seek clarity holding:

> "Understanding the exact meaning and scope of the Liability Convention's vague clause "damage caused by space objects," as well as its application to specific circumstances not clearly provided for in the text, requires an interpretation of the treaty. Consequently, we will look to the *Vienna Convention on the Law of Treaties*, which is generally regarded as the authoritative guide to the customary international law norms governing this type of analysis. Article 31 is the primary rule of interpretation, requiring consideration of the ordinary meaning of terms in light of their context, plus any subsequent agreement, practice, or relevant rules of international law, and where applicable, any special meaning agreed on by the Parties. Article 32 is a supplemental means of interpretation that may take into account the preparatory work of the treaty to confirm the meaning under article 31 or to provide further guidance when the primary methods leave the meaning ambiguous or absurd."[81]

However even after their extensive analysis and application of the *Vienna Convention*, they determined that the results were inconclusive as different approaches yielded conflicting results. In their conclusion they note:

> "While we clearly do not yet have large permanent colonies on the moon, space is certainly more populated today than ever before by humans on the International Space Station, satellites in many types of orbits, and uncountable pieces of space debris. Additionally, the ideas and activities of private space entrepreneurs are exciting, but they push at the edges of our conception of traditional liability in outer space. Although the current uncertainty has apparently not frozen exploration and commercial activity

[79] Lalin Kovudhikulrungsri & Duangden Nakseeharach 'Liability Regime of International Space Law: Some Lessons from International Nuclear Law' (2011) 4 *Journal of East Asia and International Law* at 291 & 306.
[80] Carl Christol 'International Liability for Damage Caused by Space Objects' (1980) 74 *American Journal of International Law* at 346.
[81] Elena Carpanelli & Brendan Cohen 'Interpreting "Damage Caused by Space Objects" under the 1972 Liability Convention' 2013 *International Institute of Space Law* at 3&4.

> in space, the lack of clarity can nonetheless have a chilling effect on development. Therefore, the time has come to start thinking about amending the Liability Convention, taking into account the last forty years" developments in law and technology." [82]

"Space Object" is just as obscure within the law, if perhaps not more obscure. "Space Object" is defined in Article I as "include[ing] component parts of a space object as well as its launch vehicle and parts thereof". This however leads to inevitable confusion as it violates the principal rule taught by every primary school teacher to never define a term using the term itself.

The ambiguity of this term's definition has been the subject of much academic debate. Scott Kerr discussing the definition holds that:

> "[T]he definition in essence states that a space object is defined as a space object, its launch vehicle, and their parts. However, the modifier "its" in "its launch vehicle" clearly references the term "space object," and as such we may presume that a space object must be an object that utilizes a launch vehicle."[83]

However, this itself is not sufficient in a modern context due to the development of technologies which mean that it is possible to have space objects which do not fall within this definition, but logically should still be protected against in the event of damage.

Consider two scenarios which could easily occur with current technology and which would fall outside this definition of a space object. Carpanelli and Cohen discuss the activities of a company called *Made in Space.*

> "Made in Space is trying to launch 3-D printers into orbit to create parts where they are needed. The pieces were never "component parts of a space object," nor were they "launch vehicle[s] and parts thereof," yet if a space station support strut that was constructed entirely in outer space instead of being launched first from the surface were to tumble to earth and damage property, it would only be fair to compensate the victim for the harm suffered."[84]

In-orbit fabrication and assembly are both technologies which are being developed, with a number of companies dedicating vast amounts of resources into the

[82] Ibid at 11.
[83] Scott Kerr 'Liability for space debris collisions and the Kessler Syndrome (Part 1)' available at *http://www.thespacereview.com/article/3387/1,* accessed on 10 August 2019.
[84] Carpanelli & Cohen op cit note 81.

technology.[85] This technology is required if we are to progress in our colonisation and utilisation of the rest of the solar system and beyond. [86] However, as it develops, if a mishap were to occur it is unclear where liability would fall, if at all as it is unclear if it would be considered a space object under the convention.

The second scenario concerns a technology which will be explored in more depth in Chapter 4. Consider a scenario where the manipulation of an existing extra-terrestrial object causes damage, this would seem to be outside the definition of "Space Object" as worded in the Liability Convention.

Planetary Resources, a US based company backed by Alphabet (Google's holding company), is developing the technology to extract resources from near-Earth asteroids.[87] The most likely implementation of the technology will involve moving an asteroid into orbit around the earth before extracting resources from it.[88] If during or after this process, the asteroid either in its entirety or fragments thereof which have broken off - a likely consequence when trying to extract resources from the core of the asteroid - were to impact and damage spacecraft or deorbit and cause damage on Earth, it would seem logical and fair that the Liability Convention should apply. However, again under the current phrasing this scenario may not be covered.[89] Analysing the issues with the definition of "Space Object", Laura Skopowska concludes in her master's dissertation:

> "[A]n evolutive interpretation of the Convention, which follows its victim-oriented purpose, finds the notion of 'launching' as including all the possible ways of 'conveying' an object in the outer space. The act of placing, installing or even producing an object in the outer space or on a celestial body would be considered as 'launching' ('launching' in a broad sense). From the moment an object created through additive manufacturing will be 'launched' (in a broader sense), it will fulfil the definition of a 'space object'. The composition of an object, whether it is made from terrestrial or extra-terrestrial material, is of minor importance from the point of view of the Liability

[85] Ruslan S. Skomorohova, Andreas M. Hein and Chris Welch 'In-orbit Spacecraft Manufacturing: Near-term Business Cases' (2016) *67th International Astronautical Congress*.
[86] Ibid.
[87] Mike Wall 'Asteroid Mining Venture Backed by Google Execs, James Cameron Unveiled' available at *http://www.space.com/15395-asteroid-mining-planetary-resources.html*, accessed on 10 August 2019.
[88] Puneet Bhalla 'Mining Asteroids and Exploring Resources in Space' (2015) *Centre for Land Warfare Studies Journal* at 145.
[89] Carpanelli & Cohen op cit note 81.

> Convention. Therefore, the evolutive interpretation, that is the only one consistent with the Convention's victim-oriented purpose, should be regarded as the proper one. It necessitates the inclusion of objects directly constructed or manufactured in the outer space having movable or immovable character into the legal category of 'space objects'. Such an interpretation will give legal certainty to space actors and potential victims of space activities involving the use of objects manufactured in the outer space."[90]

It is this conclusion which makes most sense to support until such a time as the definition is amended to include the technologies which were unforeseen at the time of drafting the Liability Convention. However, this still only covers objects which are purposefully "launched" into outer space. What is unclear is if this broader definition of "launch" would then include Space Debris.

As of yet, there is no definition for "Space Debris" in the *corpus iuris spatialis in iuri gentium*.[91] There are "high level qualitative guidelines" which were published in 2007 by the Science and Technology Subcommittee of United Nations Committee on the Peaceful Uses of outer space (UNCOPUOS)[92] which were subsequently endorsed by the United Nations General Assembly (UNGA).[93] These define "Space Debris" as "All man-made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional."[94] While not legally binding themselves upon states, the adoption of these guidelines by the UNGA may suggest a crystallisation of these guidelines into customary international law.[95] This is discussed in more detail later in this chapter.

It can therefore be argued that when combining this definition with the analysis by Skopowska of the "victim-oriented purpose" of the Liability Convention, that it is only logical to conclude that an object in space, regardless of its status as functional or not, should be considered a "space object" for the purposes of the Liability Convention. I would expand on this with the argument that "man-made" as required in the definition

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[90] Laura Rut Skopowska *Is an object built in the outer space a 'space object' under the Liability Convention?* (unpublished LLM thesis, Université Du Luxembourg, 2017) 53.
[91] body of Space Law in international law; UNOOSA op cit note 31.
[92] United Nations Office for outer space Affairs 'Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space' available at *http://www.unoosa.org/pdf/publications/st_space_49E.pdf* accessed on 10 August 2019.
[93] United Nations General Assembly, Resolution 62/217.
[94] UNOOSA op cit note 92.
[95] Kerr op cit note 83.

for Space Debris, does not merely refer to the origin of the component materials, but also to the preceding process the objects were subjected to. Thus, if an object such as an Asteroid were to be manipulated by man-made forces, its new path would consequently ascribe to being man-made, and thus the object itself (the asteroid or any of its fragments) should now also be considered man-made for the purposes of the Liability Convention.

This is however all merely academic conjecture, as until a situation arises putting the definition of “Space Object” to a legal test before the relevant authorities, it is unclear what path if any will be taken to clarify the definition.

2.3. Space Liability Convention - Causation

The Liability Convention never clearly defines causation, instead using the phrasing “Caused By”. The phrase clearly references causation[96], with the previously mentioned session notes clearly showing that the drafters had intended that a test for causation be an integral inquiry in a claim under the Liability Convention.[97] What is less clear is what the applicable test for causation ought to be, an issue which is amplified when considering the earlier discussion on how indirect damage could be approached. If indirect damage were to be measured as an issue of causality but there is no specific test for causation, this then makes the determination of liability in the event of indirect damage even more unclear.

Gorove, holding that “caused by” must be interpreted in the context of causality, stated that there “must be proximate causation between the damage and the activity from which the damage resulted.”[98] Christol comments on Gorove’s position stating:

> “[I]n the light of the positions put forward during the negotiation of the Liability Convention, since no conclusion was reached as to "direct" versus "indirect" cause, clearly the term "cause" should only require a causal connection between the accident and the damage. As noted by Foster, it will be difficult, if not impossible, to foresee all the circumstances that may result in damage.”

[96] Kerr op cit note 83.
[97] Jasentuliyana and Lee op cit note 77.
[98] Gorove op cit note 78.

It does appear from both session notes on the drafting of the Liability Convention[99] as well as working papers drafted by delegations during the drafting, that the test was to be one of proximate causation[100]. Why this was not expressly included in the final draft of the paper is unclear.

Worthy of consideration in the context of causation is the difficulties of identification. Of great importance in any inquiry into causation is the identification of ownership of a space object to whom causation, and thus liability, would be attributed.

In order to better understand the legal implications, it is necessary to first acquaint the reader with the necessary orbital mechanics. I should however proviso here that due to this being a legal discussion and not a dissertation in Astrophysics, I will be greatly simplifying the complex concepts and using the language of a layperson. This is to assist the reader in grasping the fundamentals and thus better be able to understand the application of the law.

An object is considered to be in orbit when its momentum (although scientifically incorrect, one could think of this as the velocity of the object in a straight line) is in equilibrium with force of gravity pulling the object down to Earth. To quote NASA's page explaining the topic:

> "An object's momentum and the force of gravity have to be balanced for an orbit to happen. If the forward momentum of one object is too great, it will speed past and not enter into orbit. If momentum is too small, the object will be pulled down and crash. When these forces are balanced, the object is always falling toward the planet, but because it's moving sideways fast enough, it never hits the planet. Orbital velocity is the speed needed to stay in orbit. At an altitude of [242 kilometers] above Earth, orbital velocity is about [28100 km/h or about 7800 m/s]. Satellites that have higher orbits have slower orbital velocities. [At geostationary orbit, approx. 42164 km above Earth, orbital velocity would be about 11km/s or 3070m/s]"[101]

Following Newton's First Law of Motion[102], one would assume that an object in orbit would be devoid of external forces and would thus stay in the same predictable orbit

[99] Carpanelli & Cohen op cit note 81.
[100] Carpanelli & Cohen op cit note 81.
[101] Flint Wild 'What Is an Orbit?' available at *https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbit-58.html*, accessed on 23 August 2019.
[102] Every object in a state of uniform motion will remain in that state of motion unless an external force acts on it.

around the Earth. This would mean that if one knows an objects position and velocity, one could predict its path around the Earth and thus "track" the object. This, however, is not the full story due to atmospheric drag.

Discussed in Chapter 1, the Karman Line is a point at about 100km above sea-level that most scientists agree to be the edge of the atmosphere and the beginning of space. It was explained that this point is not necessarily accurate. Although the atmosphere is extremely thin, it still does extend past the Karman Line. This is best illustrated by Aurorae which occur due to the interaction of highly charged particles in the Solar Wind being redirected by our Magnetosphere and interacting with high-altitude gas molecules. These gases include Oxygen and occasionally Nitrogen and cause Aurora to occur between 90 and 130 km, but occasionally as high as 650km above sea level. [103]

The Thermosphere is a layer of the Earth's atmosphere between 85km and 600km[104] . Objects orbiting within this band of the Earth's atmosphere and up to 2000km above sea level are considered to be in Low-Earth Orbits (LEO's)[105]. Whilst atmospheric pressure is relatively low, with it being less than 1/2200000th the pressure at sea level when at 110km above sea level and getting exponentially less as altitude increases[106], it does still exist. Thus, with objects moving at up to 7800m/s when in orbit, the effects thereof are still noticeable. This is less of a concern with heavier space objects as then the momentum of the space object attenuates the minimal drag presented.[107]

The way we track Space Objects is thus a combination of the principals explained above, in combination with ground-based Radar and Lidar which periodically confirm position and velocity.[108] This system allows US Department of Defence who are the main trackers of objects in orbit around space to accurately maintain records of objects as small as 5cm in diameter.[109] Whilst objects as small as 1cm can be tracked

[103] Truls Lynne Hansen 'The northern lights-what are they?' available at *http://geo.phys.uit.no/articl/theaurora.html*, accessed on 23 August 2019; Northern Lights Centre 'Northern Lights' available at *https://www.northernlightscentre.ca/northernlights.html*, accessed on 23 August 2019.
[104] Gerd W. Prölss 'Physics of the Earth's Space Environment: An Introduction' (2010) Ch 1.
[105] NASA Office of Safety and Mission Assurance, 'NASA Safety Standard 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris' (1995) 37-38.
[106] Prölsso p cit note 102.
[107] D. Mehrhol et al, 'Detecting, Tracking and Imaging Space Debris' 2002 *European Space Agency Bulletin*
[108] Ibid.
[109] Mark Carcia, 'Space Debris and Human Spacecraft' available at https://www.nasa.gov/mission_pages/station/news/orbital_debris.html, accessed on 23 August 2019.

periodically, due to the increased effect of atmospheric drag on objects this small, their orbital stability is greatly reduced, and thus it is more difficult to predict their exact path.[110]

In 1974 the UNGA adopted the *Convention on Registration of Objects Launched into outer space* (known as the Registration Convention), which has since been ratified by most space fairing nations. The only noticeable exception to this being New Zealand, which due to the work of Rocket Lab, a US company based in New Zealand, has only recently become a space fairing nation. Of importance in this Convention are Articles II(1) and IV(1), reproduced in full here:

> "Article II
>
> 1. When a space object is launched into earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain. Each launching State shall inform the Secretary-General of the United Nations of the establishment of such a registry.
>
> …
>
> Article IV
>
> 1. Each State of registry shall furnish to the Secretary-General of the United Nations, as soon as practicable, the following information concerning each space object carried on its registry:
>
> (a) name of launching State or States;
> (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."[111]

[110] Ben Greene 'Laser Tracking of Space Debris' (unpublished research report, Electro Optic Systems, 2003).
[111] United Nations Office for outer space Affairs 'Convention on Registration of Objects Launched into Outer Space' available at http://www.unoosa.org/pdf/gares/ ARES_29_3235E.pdf accessed on 26 August 2019.

The convention thus sets-up a system by which states must be aware of space objects launched within their borders. The space objects purpose and its orbital information must be reported to the UN so that a record of them may be kept. This means that in the case of an incident occurring, it is theoretically simple case of backtracking the objects prior path and matching that with the registry. This allows for a supposedly easy path to identification of objects which as stated is a crucial step in any test for causation.[112]

The above operates as intended if it is a space object which is in its planned orbit without any malfunction or deviation. The reality is that in this ideal scenario the occurrence of an issue which would attract liability is relatively low.[113] It is when things go wrong that this system starts to exhibit its weaknesses, and the problem of identification becomes even larger. When an object which is ancillary to a launch or comes off an existing space object due to a collusion or other cause and this space debris causes damage, identifying it can be near impossible.

> "The most practical problem in establishing liability for damage caused by a collision with space debris is proving who is responsible for the debris. Currently there exists no internationally accepted system of monitoring or tracking space objects. Even domestic systems, like the North American Aerospace Defense Command (NORAD), would need a very advanced technology to provide unequivocal reliability in identifying the precise source of debris - the type of reliability necessary for assertions of liability"[114]

2.4. Space Liability Convention - Fault

The Liability Convention establishes both fault-based liability and absolute liability[115] which can be found in Articles II through IV, reproduced in full below.

> "Article II

[112] James P. Lampertius, 'The Need for an Effective Liability Régime for Damage Caused by Debris in Outer Space' 13 (1992) *Michigan Journal of International Law* 454 – 455.
[113] Mehrhol et al. op cit note 107.
[114] Lampertius op cit note 112.
[115] Kerr op cit note 83.

A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight.

Article III

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.

Article IV

1. 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, to the extent indicated by the following:
    a. If the damage has been caused to the third State on the surface of the earth or to aircraft in flight, their liability to the third State shall be absolute;
    b. 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 persons for whom either is responsible.
2. In all cases of joint and several liability referred to in paragraph 1 of this article, the burden of compensation for the damage shall be apportioned between the first two States in accordance with the extent to which they were at fault; if the extent of the fault of each of these States cannot be established, the burden of compensation shall be apportioned equally between them. Such apportionment shall be without prejudice to the right of the third State to seek the entire compensation due under this Convention from any or all of the launching States which are jointly and severally liable."[116]

From the above the Liability Convention creates two different standards of liability. If the damage occurs due to a Space Object deorbiting and subsequently causing damage on its path through the lower atmosphere (below the Karman Line) or upon impacting the ground/once on the ground, then there is no requirement for fault

[116] UNOOSA op cit note 75.

(Articles II and IV (1)(a)). If the damage is caused while still in Outer Space, then there is a requirement to prove fault. (Articles III and IV)

As a departure point, while some may use the terms absolute liability and strict liability interchangeably, it is of importance to note that in the fields of international law, especially that of the Law of outer space the terms are separate and distinct.[117]

Strict Liability has come to mean "liability attaching upon proof of only a causal connection between the object put in motion by the party against whom a claim is made and the injury suffered by the claimant. The term as used herein also implies the availability of certain exonerations from liability."[118]

Absolute Liability by contrast is a much more rigorous form of liability and is arguably warranted due to the nature of the danger posed. McDougal, Lasswell and Vlasic express this origin in law writing:

> "A liability approaching absolute for ultra-hazardous activities is not a new concept and is now widely accepted in many mature systems of law. Its most authoritative base in Anglo- Saxon law is commonly associated with the famous English case *Rylands v. Fletcher*, and ordinarily generalised as holding that one who engages in an activity, or maintains a condition, involving an extraordinary degree of risk of harm to others is absolutely liable for the loss it causes."[119]

This more rigorous form of Liability thus recognises not only the intense danger that the technology can pose, but also the inability of the average public to take any actions which may limit their risk to the dangers posed.

This form of liability finds its development in international law during the drafting of the various treaties on the uses of nuclear energy. "These agreements incorporate the concept of 'channelling,' which traces liability back to the nuclear operator, no matter how long the chain of causation, nor how novel the intervening factors."[120] This form of liability has fewer exonerations than strict liability, with the 1960 *Paris Convention*

[117] British Institute of International and Comparative Law *Current Problems in Space Law: A Symposium* (1966) 55; Edward F. Hennessey 'Liability for Damage Caused by the Accidental Operation of a Strategic Defense Initiative System' 21 (1988) *Cornell International Law Journal* 320.
[118] Stanley Mazarof, "Exonerations from Liability for Damage Caused by Space Activities" 54 (1968) *Cornell Law Review* 74.
[119] Myres S. McDougal, Harold D. Lasswell, and Ivan A. Vlasic *Law and Public Order in Space* (1963).
[120] L. F. E. Goldie, 'Liability for Damage and the Progressive Development of International Law' 14 (1965) British *Institute of International and Comparative Law* 1216.

on Third Party Liability in the Field of Nuclear Energy, holding that liability can only be exonerated with a intervening act which is:

> "... directly due to ... disturbances of an international character such as armed conflict and invasion, of a political nature such as civil war and insurrection, or grave natural disasters of an exceptional character, which are catastrophic and completely unforeseeable, on the grounds that all such matters are the responsibility of the nation as a whole."[121]

Its explanatory note goes on to clarify that this form of liability is "not subject to the classic exonerations for tortious acts, force majeure, acts of God or intervening acts of third person."[122] All this culminates in a very rigorous form of liability, perhaps best articulated by Goldie:

> "The concept of absolute liability developed in the nuclear liability treaties (i.e., the combination of channelling with the imposition of liability upon the operator in all cases except where the society as a whole may be viewed as responsible), more effectively than any other concept met so far, prevents the creator of a risk from passing that risk onto the public and thus expropriating other people."[123]

With this understanding of absolute liability, it becomes easy to understand why there is an establishment of a dual-liability system within the Liability Convention. It appears the intention of the drafters is to provide protection to private citizens, who through no involvement in the dangerous activities of space, find themselves on the receiving end of a deorbiting space object.[124] This is in contrast to damage which occurs in space, where it could be argued that there is a passive acceptance of the inherent dangers of operations in space, thus allowing for a liability system based on fault.[125]

> "It is generally held, at least in common law countries, that [absolute] liability applies to certain abnormally dangerous conditions and activities. Since, at present, most space activities might be regarded as 'abnormally dangerous'. one might argue that 'fault' should play a diminished role in space. On the other hand, one could also argue that

[121] Nuclear Energy Agency 'Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960, as amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982' available at *https://www.oecd-nea.org/law/nlparis_conv.html*, accessed on 01 September 2019.
[122] Ibid.
[123] Goldie op cit note 120.
[124] Kerr op cit note 83.
[125] Hamilton DeSaussure, P.P.C. Haanappel, 'A Unified Multinational Approach to the Application of Tort and Contract Principles to Outer Space,' 6 (1978) *Syracuse Journal of International Law and Commerce.*

> all persons on the space station are to some degree engaged in an 'abnormally dangerous' activity and that this is quite different from the situation on Earth where the injured party might not be a participant in the activity in question."[126]

However, if one considers that the justification for imposing absolute liability is the protections of private citizens then the argument for extending absolute liability is made stronger by the fact that space exploration is increasingly going to be conducted by individuals in their private capacity. This will be discussed further in Chapter 3.

No contrasting the fault-based liability regime set up by the Liability Convention, it is important to first consider what "Fault" means.

In international law, fault can mean either "Objective" or "Subjective" Fault.[127]

> "'Objective fault' means the mere breach of a pre-existing legal duty, whereas 'subjective fault' is about the wilful misconduct of a state. The difference is that 'subjective fault' takes into account the mental state of the actor, the actual intent, while assessing the breach of the legal duty."[128]

The Liability Convention never defines what it means by fault, and so the question appears to be left open as to which definition of fault is applicable. However, Howard Baker proposes as a solution "that subjective fault is applicable to the Liability Convention, since objective fault is no more than a restatement of a basic principle of State liability under international law."[129] Lampertius supports this holding that "if 'fault' means only objective breach of a pre-existing legal rule, a State is free to do whatever it wishes unless it can be demonstrated that there is a limiting rule of international law."[130]

The issue of fault-based liability will be returned to later in the chapter when examining space debris and space traffic management.

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[126] U.S. Congress, Office of Technology Assessment *Space Stations and the Law: Selected Legal Issues -- Background Paper* (1986).
[127] Pierre-Marie Dupuy & Jorge E. Viñuales *International Environmental Law* (2015) 262.
[128] Laura Verëll *The Effectiveness of the Liability Regime in the 1972 Liability Convention on Damage Caused by Space Debris to the Space Object of a State in outer space* (unpublished LLM thesis, Universiteit van Amsterdam, 2017) 17.
[129] Howard A. Baker, 'Space Debris: Legal and Policy Implications' 6 (1989) *Utrecht Studies in Air and Space Law* 84 .
[130] Lampertius op cit note 112 at 456.

2.5. Space Liability Convention – Canada Claim

As a final look at the Liability Convention, let us look at the only known claim to be brought under it; the claim by Canada against the USSR for Kosmos 954.

On September 18th, 1977 the USSR launched Kosmos 954 - a Naval Surveillance satellite - which using active radar was supposed to track the movement of maritime vessels for reconnaissance purposes.[131] It was reported to the UN Secretary General, in line with the Registration Convention, on 22 November 1977[132] and importantly contained a Nuclear Reactor as part of its power source - which contained 50kgs of Uranium 235.[133]

Although the satellite was intended for long term operation, in Mid-December of 1977, NORAD (which had been tracking the satellite as part of the tracking programs mentioned above) observed the satellite making erratic manoeuvres including altitude adjustments of up to 70km.[134] After engagement, the USSR admitted that they had lost control of the satellite and that the system which was meant to eject the Nuclear Reactor and place it into a stable orbit, thus stopping it from re-entering the Earths atmosphere with the rest of the craft, had failed.[135]

> "On January 24, 1978, the satellite entered the earth's atmosphere intruding into Canadian air space at about 11:53 A.M. Greenwich Mean Time to the north of the Queen Charlotte Islands on the west coast of Canada. On re-entry and disintegration, debris from the satellite was deposited on Canadian territory, including portions of the Northwest Territories, Alberta and Saskatchewan."[136]

The Government of Canada, along with assistance from the USA, proceeded to initiate a search and clean-up operation which involved canvasing an area of around 124 000 km^2, before determining that radioactive debris had been spread over an area of

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[131] NASA Space Science Data Coordinated Archive 'Cosomos 954' available at *https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1977-090A* , accessed on 01 September 2019.
[132] 'Settlement of Claim between Canada and the Union of Soviet Socialist Republics for Damage Caused by "Cosmos 954"' available *http://www.jaxa.jp/library/space_law/chapter_3/3-2-2-1_e.html*, accessed on 01 September 2019.
[133] Harland, David M & Lorenz, Ralph D *Space Systems Failures – Disasters and rescues of satellites, rockets, and space probes* (2005) 236.
[134] Leo Heaps *Operation Morning Light : Terror in our Skies : The True Story of Cosmos 954* (1978) 14
[135] Ibid.
[136] Settlement op cit note 132.

approximately 600 km^2.[137] Ultimately 12 large fragments, 10 of which were radioactive, were recovered. One piece was so radioactive that it would have been fatal to humans after only a few hours of exposure.[138]

Canada then initiated a claim under the Liability Convention for C$6 041 174.70 (approximately C$20,3 Million today, which with an exchange rate of R11.14 - the exchange rate as of 01 September 2019 - would be approximately R226.3 Million.) The claim was "for actual and future unpredicted expenses associated with the search and recovery mission and radioactive material."[139]

This claim was made under Article II of the Liability Convention which holds that: "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight."[140] However no formal proceedings ever occurred. The two parties instead reached an agreement with the USSR paying out C$3 000 000, (adjusted C$ 10 Million, R112.4 Million).[141]

This final settlement is significant, as Article 31.3(a) of the *Vienna Convention on the Law of Treaties* holds that agreements entered into by state parties to a treaty, subsequent to the treaty and for the purposes of that treaty, are relevant to "the interpretation of the treaty or the application of its provisions."[142]

The first issue of note is the reinforcement of the concept of absolute liability. Both states put forth conflicting submissions on the cause of the satellite deorbiting, with the USSR claiming a *novus actus interveniens.*

> "On Jan. 6, 1978, for reasons that as yet remain unclear, sudden depressurization of the satellite took place outside the visibility zone of our facilities for tracking space objects. Judging from the fact that the depressurization process was very rapid, it can be assumed that the satellite collided in flight with some other body of natural or

[137] Kerr op cit note 83.
[138] Marientta Benkö *Space law in the United Nations* (1985) 46.
[139] Kerr op cit note 83.
[140] UNOOSA op cit note 75.
[141] Settlement op cit note 132
[142] International Law Commission, 'Vienna Convention on the law of treaties (with annex). Concluded at Vienna on 23 May 1969' available at *https://treaties.un.org/doc/Publication/UNTS/Volume%201155/volume-1155-I-18232-English.pdf*, accessed on 01 September 2019.

> artificial origin. As a result the satellite's onboard systems went out of commission, it lost orientation, and began an uncontrollable descent."[143]

This however appears to have been immaterial with the doctrine of absolute liability holding out. Of greater interest is the differentiation between the claim submitted and the pay-out eventually agreed to between the two parties. As Kerr contends:

> "The discrepancy between damages claimed and damages paid likely flows from the definition of damages under the Space Liability Convention… the discrepancy between damages claimed and damages paid suggests there were additional legal considerations. One or more of the following three considerations may have played a role:
>
> 1. The discrepancy may reflect the parties' belief that the definition of damages in the Space Liability Convention does not include 'unpredicted future damages';
> 2. The discrepancy may reflect the parties' belief that the test for causation required for liability was not met for the 'unpredicted future damages'; and
> 3. The discrepancy may simply reflect a compromise on the part of both parties resulting from negotiations meant to avoid legal proceedings."[144]

Canada did in the annexures of its claim submit detailed costings for clean-up of all the hazardous material, down to car rental and photocopying.[145] Despite this inclusion, Canada only claimed for costs associated with the clean-up of the hazardous material seeming to concede that it was only damage for which there was a quantifiable cost which needed to be incurred (injury). The USSR further argued that it was only incidental costs which it was liable to pay and not any fixed costs which would still have been incurred had the accident not occurred, such as the salaries of the members of Canadian Armed Forces who participated in the clean-up operation.[146]

Ultimately however, the Settlement of Claim, does not address why there was a discrepancy, and indeed does not address any of the assertions put forth in the Statement of Claim. It dismisses the entire matter stating that payment shall be made

[143] Alexander F. Cohen 'Cosmos 954 and the International Law of Satellite Accidents' 10 (1984) *Yale Journal of International Law* 80-81.
[144] Kerr op cit note 83.
[145] Cohen op cit note 143 at 85.
[146] Cohen op cit note 143 at 86.

"in full and final settlement of all matters connected with the disintegration of the Soviet satellite Cosmos 954 in January 1978."[147]

This leaves open many unanswered questions. Cohen points out that this settlement may not even be relevant with it instead being an *ex gratia* payment by the USSR and "hence, devoid of normative content".[148] Ultimately though, with this being the only claim even made under the Liability Convention in almost 5 decades of its operation, its relevance has never been tested, and until such a time it is difficult to ponder with any certainty what its relevance, if any, will be.

To date there are few examples of satellites which posed, let alone caused damage terrestrially, with the majority simply burning up on re-entry, or being directed to land in the ocean.[149] Two instances where this either didn't occur or was not possible, were the deorbits of Skylab and USA-193. In the case of Skylab, the first US manned space station, when it deorbited it entered Australian airspace and it caused windows to rattle and dropped small pieces of debris on the town of Esperance in Western Australia. Ultimately though no substantial damage was caused. The US government was fined US$ 400 for littering by the town council, which was ignored.[150]

In the case of USA-193, a US reconnaissance satellite, the US lost control of the satellite and there were concerns of it having a radioactive power source which were never confirmed. The US did confirm that it had about 400 kg of Hydrazine aboard - a highly toxic propellent. The US eventually used an Anti-Sat Missile to cause the satellite to disintegrate into small enough pieces while in a very low orbit thus causing it to all burn up before damage could be caused.[151]

[147] Settlement op cit note 132 at Article 1.
[148] Cohen op cit note 143 at 89.
[149] Sara Chodosh 'You'd be surprised how often space junk falls out of the sky' available at *https://www.popsci.com/space-junk-debris-falls/*, accessed on 01 September 2019.
[150] Emma Wynne 'When Skylab fell to earth' available at *https://www.abc.net.au/local/photos/2009/07/09/2621733.htm*, accessed on 01 September 2019.
[151] Michael C. Mineiro 'FY-1C and USA-193 ASAT Intercepts: An Assessment of Legal Obligations under Article IX of the outer space Treaty' 34 (2008) *Journal of Space Law*.

2.6. Kessler Syndrome

Once again it is necessary to pause our discussion on the law and ensure an adequate understanding of the science, to allow a more robust discussion on the subsequent legal issues. Of key concern is Kessler Syndrome, which will build upon our earlier discussion of orbital mechanics.

> "Space is the most fragile environment that exists because it has the least ability to repair itself. Only the Earth's atmosphere can remove satellites from orbit. When the sun flares up in its eleven-year cycle, it heats the upper atmosphere and makes it expand so that debris and spacecraft in low orbits are subjected to increased drag. But the higher the original orbit, the less air there is to collide with."[152]

As discussed, orbital speeds are immense, with some orbital periods resulting in speeds of 28km/s and more. This can turn even the smallest particle, a chip of paint for example, into a projectile which could destroy satellites.[153] In 1978, Donald J. Kessler published a paper which hypothesized a scenario in which the density of space debris in orbit would result in "collisional cascading".[154] Writing in 2009, Kessler discusses his original paper, noting that the paper predicted that by the year 2000, if nothing was changed:

> "the population of catalogued debris in orbit around the Earth would become so dense that catalogued objects would begin breaking up as a result of random collisions with other catalogued objects and become an important source of future debris. These finding were important for three reasons:
>
> 1. At the time, it was generally assumed that there were very few objects in orbit that were too small to catalogue, although there was no definition as to what limiting size was in the catalogue. The paper illustrated that even if this assumption were correct, future collisions between catalogued objects would produce a large amount of small debris fragments. This small debris population would be more hazardous to other spacecraft than the natural meteoroid environment immediately after the first collision.

[152] Joel R. Primack 'Debris and Future Space Activities' available at http://physics.ucsc.edu/cosmo/Mountbat.PDF, accessed on 04 September 2019.
[153] Donald J. Kessler et al 'The Kessler Syndrome: Implications to Future Space operations' (2010) *American Astronautical Society* 1-3.
[154] Ibid.

2. Each collision would also produce several hundred objects large enough to catalogue, increasing the rate that future collision breakups would occur…. resulting in an exponential growth in the collision rate and debris population.
3. The only way to prevent this exponential growth was to reduce the number of rocket bodies and non-operational spacecraft left in orbit after their useful lifetime."[155]

Since then, more accurate measuring and attempts to reduce the amount of space debris produced, has meant that this is yet to occur, but there is still significant risk thereof, especially in the bands 800km – 1000km and 1300km – 1425km above earth.[156] The risks of this may be difficult for the layperson to grasp, but they are immense. Discussing this Primack and Abrams brilliantly convey this writing:

> "In the Star Wars movies and in hundreds of other popular science fiction films, we see things blow up in space and the fragments quickly dissipate, leaving space clear again. But in reality, space never clears after an explosion near our planet. The fragments continue circling the Earth, their orbits crossing those of other objects. Paint chips, lost bolts, pieces of exploded rockets—all have already become tiny satellites, traveling about 17,000 miles per hour, ten times faster than a high-powered rifle bullet. There is no bucket we could ever put up there to catch them. Anything they hit will be destroyed and only increase the debris. A marble traveling at that speed would hit with the energy of a one-ton safe dropped from a three-story building. With enough orbiting debris, pieces will begin to hit other pieces, fragmenting them into pieces, which will in turn hit more pieces, setting off a chain reaction of destruction that will leave a lethal halo around the Earth. To operate a satellite within this cloud of millions of tiny missiles would become impossible: no more Hubble Space Telescopes or International Space Stations. Even the higher communications and GPS satellites would be endangered."[157]

Sadly, this is not a hypothetical scenario. While a runaway cascade has yet to happen, we have had incidents occur which Kessler argued could be potential triggers for a runaway cascade.

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[155] Donald J. Kessler 'The Kessler Syndrome' available at *http://aquarid.physics.uwo.ca/kessler/KesSym.html*, accessed on 04 September 2019.
[156] Kessler et al. op cit note 153 at 11.
[157] Joel R. Primack and Nancy Ellen Abrams 'Star Wars Forever? — A Cosmic Perspective' available at *http://physics.ucsc.edu/cosmo/UNESCOr.pdf*, accessed on 04 September 2019.

> "On February 10, 2009 the Iridium 33 and Cosmos 2251 satellites collided with a velocity of 11.6 km/sec, at an altitude of 790 km. The collision was catastrophic, likely producing hundreds of fragments large enough to catastrophically breakup other satellites, and tens of thousands of fragments large enough to damage other satellites. This is the first clear example of what was predicted in 1978. Although there have been three other random collisions between catalogued objects since 1991, none of those were catastrophic."[158]

To call this event a catastrophe is not a hyperbole, with 2296 pieces of debris having been catalogued as created just from this collision and 1505 of these still in orbit as of 2016[159]. This resulted in a substantial increase in space debris, and rates as the second[160] largest single incident creator of space debris. This can easily be seen in the increase in the size of the green bar in 2009 on the following graph from the European Space Agency.[161]

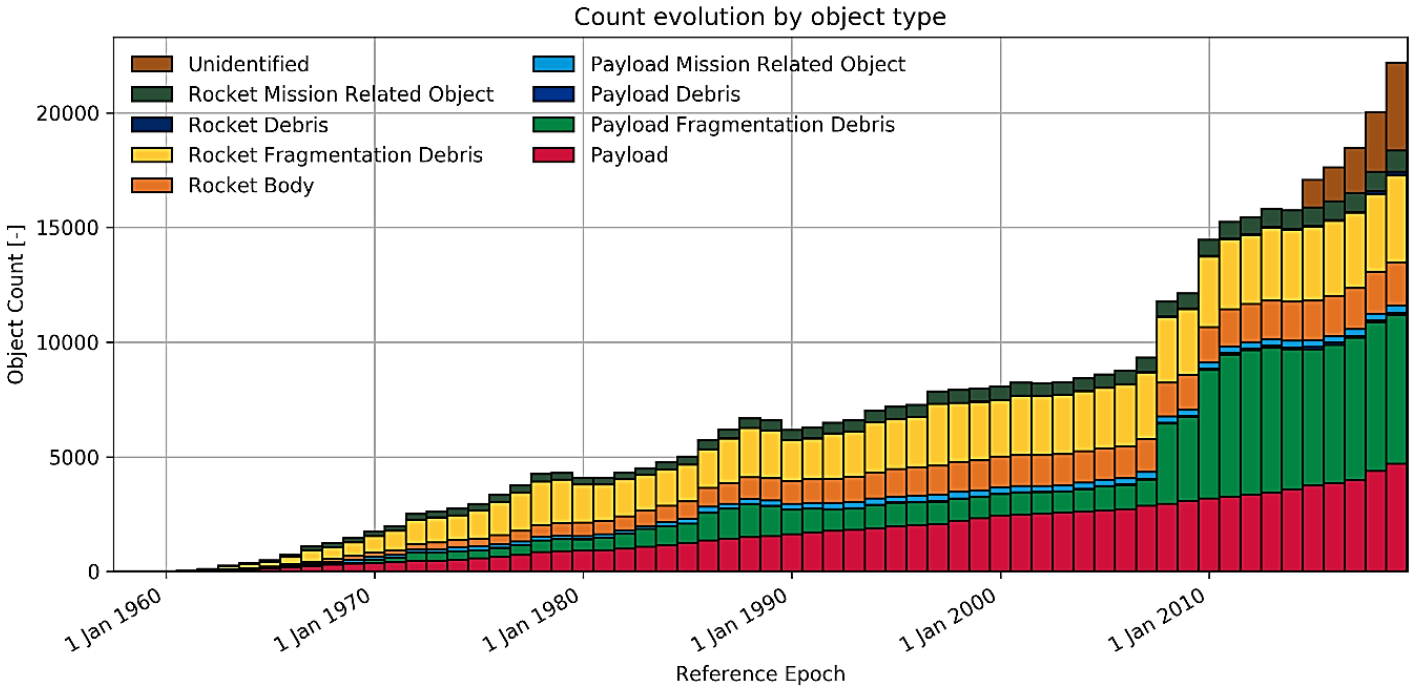

Figure 3 - Estimated Number of Objects in Orbit of Earth

[158] Kessler op cit note 155.
[159] P. Anz-Maedor 'Top Ten Satellite Breakups' 20 (2016) *Orbital Debris Quarterly News* 6.
[160] The largest is the destruction of FY-1C by China in 2007 as part of their Anti-Satellite Missile Test program.
[161] European Space Agency 'About Space Debris' available at *https://www.esa.int/Our_Activities/Space_Safety/Space_Debris/About_space_debris*, accessed on 01 September 2019.

2.7. Space Debris Guidelines

Returning to the issue of fault, a key element of any fault-based analysis is the violation of a legal duty. This then requires the establishment of a standard of care by which "one can judge [the] reasonableness and the legality of the actions of a state."[162]

Until recently there was no real standard of care established which pointed to the expected burdens upon a state with regards to Space Debris.[163] The UN treaties on Space Law are mum of the topic, with Tan commenting:

> "The specificity of damage, the requirement of fault, and the difficulty of identification all contribute to the impotence of the Liability Convention and the Registration Convention in the protection of the outer-space environment from debris pollution."[164]

No customary law deals with space debris either.[165] Arguably this is no different today, however while there may not be any hard law on the topic, the amount of soft law on space debris is increasing.[166]

Recognising the imminent dangers presented by space debris:

> "At its fiftieth session, in 2007, [COPUOS] endorsed the space debris mitigation guidelines and agreed that its approval of those voluntary guidelines would increase mutual understanding on acceptable activities in space and thus enhance stability in space-related matters and decrease the likelihood of friction and conflict."[167]

These guidelines were later endorsed by the UNGA in Resolution 62/217 with it holding that:

> "the voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number of national and international organizations, and invited Member States to implement those guidelines through relevant national mechanisms."[168]

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[162] Verëll op cit note 128 at 18.
[163] Lampertius op cit note 112 at 456.
[164] David Tan 'Towards a New Regime for the Protection of outer space as the "Province of All Mankind" 25 (2000) *Yale Journal of International Law* 168.
[165] Lampertius op cit note 112 at 456 – 457.
[166] Verëll op cit note 128 at 18.
[167] UNOOSA op cit note 92 at iv.
[168] UNOOSA op cit note 92 at iv.

These Guidelines propose 7 measures to limit the creation of more space debris. This includes systems being "designed not to release debris during normal operations"[169], operators aiming to "limit the probability of accidental collision in orbit"[170] and satellites being designed to remove themselves from LEO at the end of their missions, amongst other guidelines.[171]

These guidelines are, however, specifically expressed as being voluntary and non-binding. COPOUS themselves contend that these guidelines have "not yet achieved the status of a legal obligation."[172] However, as Popova and Schaus note:

> "Nevertheless, these non-binding instruments do not fully lack relevance as they can serve as a model for the development of national Space Laws which impose concrete obligations for implementing mitigation measures on private space actors."[173]

This is already occurring, with the European Space Agency basing its guidelines off the COPOUS Guidelines, and several other states either confirming through legislation or policy, their adherence to the Guidelines.[174] An interesting argument by Popova and Schaus, further highlights that it may be an obligation on states to ensure compliance with these guidelines by operators within their borders, even if the guidelines may not be binding upon the state.

This argument stems from Article IX of the outer space Treaty, which reads:

> "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 conduct exploration of them so as to avoid their harmful contamination…"[175]

[169] UNOOSA op cit note 92 at Guideline 1.
[170] UNOOSA op cit note 92 at Guideline 3.
[171] UNOOSA op cit note 92 at Guideline 6.
[172] Lampertius op cit note 112 at 457.
[173] Rada Popova & Volker Schaus 'The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space' (2018) *Aerospace* 11.
[174] Ibid at 12.
[175] UNOOSA op cit note 31.

Popova and Schaus thus argue that under this provision, there is a requirement on states to ensure that their activities do not harm the activities of other states, which arguably any increase in space debris may do.

> "Thus, certain conditions can be prescribed to operators in space legislation: the legal basis for prescribing such conditions is Art VI of the OST which gives a "mandate" to states to authorize activities while, according to Art. IX of the OST, taking into account the activities of other states in outer space…"[176]

This argument is, however, tentative at best and is unlikely to withstand an inquiry utilising it to prove fault.

The Iridium 33 and Cosmos 2251 collision discussed earlier, provides an interesting case study involving space debris for any commercial entity with operations in space. Soon after the incident occurred, commentators were quick to point out that this could perhaps lead to the first time Article III of the Liability convention could be invoked.[177] This could for the first time test the fault based liability regime set up by the Convention, and indeed be only the second time in its history that the convention has even been invoked.

Discussing soon after the accident occurred, Frans von der Dunk hypothesised how fault may be interpreted in a way which would result in Iridium being held liable.

> "…a 'fault' presumes a choice for the person at fault, a choice between at least two options of "conduct", where that person whether by "intention' or 'negligence' has chosen an option (that is by flawed "judgment") leading to the harm concerned, where choosing another option would not have led to such harm. Applying this generic definition of 'fault' to the case at hand, however, would lead to the counter-intuitive conclusion that, if any entity, Iridium would be the liable one. As was confirmed by Iridium spokesperson Elizabeth Mailander, the company indeed could have moved the satellite out of the way if given a precise warning. By contrast, ever since Cosmos 2251 had run out of control some 13 years earlier, there was nothing the Russians could have done to make Cosmos 2251 avoid a collision with Iridium 33."[178]

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[176] Popova & Schaus 0p cit note 171 at 12.

[177] Michael Listner 'Iridium 33 and Cosmos 2251 three years later: where are we now?' available at *http://www.thespacereview.com/article/2023/1*, accessed on 12 September 2019.

[178] Frans G. von der Dunk 'Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?' (2010) *Space, Cyber, and Telecommunications Law Program Faculty Publications* 203.

The Russians' official responses on the incident did seem to indicate that this was their stance on the matter and that since there was physically no action they could take, they could not be found to be at fault.[179] They also pointed out that they had no obligation in international law to dispose of the satellite.[180] For its part, Iridium first highlighted that it, correctly, had no obligation in law to prevent a collision even if it knew about the collision. (A concept which will be revisited below).[181] Its main contention in the public was that it did not receive any warning of a potential collision. As Ting Wang notes:

> "In the Iridium-Cosmos case, one may argue that the United States did not warn Iridium operators of the possible collisions, therefore it is at fault in this case. However, even if the United States provided a warning, the operators would have received an estimate of a probability of a collision, which could be less than 1/10,000. It is still possible that Iridium would not have performed a collision avoidance manoeuvre because the collision probability could be too low to trigger it. According to the JSpOC (US Joint Space Operations Centre) orbital data, the minimum distance between Iridium-33 and Cosmos-2251 was estimated to be about 800 m around the collision moment. In the past, Iridium-33 passed within similar distance of a large number of other satellites. Indeed, if each conjunction with less than 1 km distance were to trigger a manoeuvre, Iridium 33 would have required 29 manoeuvres in 2008."[182]

If either argument is accepted, the logical conclusion is that Russia is the injured party and thus deserving of compensation by the US, who could then potentially recover these damages from Iridium. This does however pose an interesting question: "could Russia really hold the United States… liable for 'damage' done to a lifeless piece of metal in outer space?"[183]

Article VIII of the outer space Treaty provides for indefinite ownership and control by states over the objects they launch or commission for to be launched.[184] "While lifeless, it might still serve some practical purposes and/or represent some real value to the owner; in the absence of applicability of any concepts such as 'abandonment'

[179] Listner op cit note 177.
[180] Listner op cit note 177.
[181] Listner op cit note 177.
[182] Ting Wang 'A Liability and Insurance Regime for Space Debris Mitigation' 24 (2016*) Science & Global Security* 26.
[183] von der Dunk op cit note 178.
[184] UNOOSA op cit note 31.

and ‘salvage’ in Outer Space Law generally speaking it is still for the operator to make a determination of worthlessness.”[185]

This leads into a larger conversation about how compensation should be calculated for what is ultimately in Russia’s case, something they no longer generate value from. There was no calculatable income from the satellite, or even a cost of replacement as it was disused. According to Article XII of the Liability Convention, compensation should be determined “in order to provide such reparation in respect of the damage as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which would have existed if the damage had not occurred.”[186]

Even trying to work out the value of a functional satellite once in orbit is difficult. “… [T]he “market value” of a satellite could also be quite different from the cost to replace the satellite. For example, it took roughly 7 billion dollars to build the Iridium system. However, the system was sold at a price of 35 million dollars several years later.”[187]

This all once again highlighted the incredible deficiencies within the Liability Convention, as there were very few answers within the Convention as to what should occur in this situation. All this speculation was for naught though as no claim was ever lodged by either Russia or the US. “[T]he conflicting information leading up to the crash, coupled with the lack of tracking data for that region of Earth orbit, gave neither party sufficient evidence to meet the fault standard set by the second scenario.”[188]

While there was a case in this incident to say that Russia was the victim, it cannot be ignored that ultimately it was Iridium which lost commercial value from debris left in space by Russia. At the time of Kosmos 2251’s design and launch, there were no guidelines which required it perform a re-entry burn upon completion of its mission but suppose that there were. Envisage a scenario in which Kosmos 2251 was designed and launched after the adoption of the Debris Mitigation Guidelines by the UN, could this change where fault lies?

[185] von der Dunk op cit note 178.
[186] UNOOSA o cit note 75.
[187] Wang op cit note 182.
[188] Listner op cit note 177.

In 2015, at the 54th session of the COPOUS Legal Subcommittee, the following question was posed by a member state:

> "Could the notion of "fault", as featured in articles III and IV of the Convention on International Liability for Damage Caused by Space Objects (Liability Convention), be used for sanctioning non-compliance by a State with the resolutions related to space activities adopted by the General Assembly or its subsidiary bodies, such as Assembly resolution 47/68 on the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, and the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space; in other words, could non-compliance with resolutions adopted by the General Assembly or with instruments adopted by its subsidiary bodies related to space activities be considered to constitute "fault" within the meaning of articles III and IV of the Liability Convention?"[189]

As a point of departure, it should be highlighted that this is not an inquiry into wrongfulness. Refusal to follow a non-binding resolution would not and should not attract state liability in so far as it being considered internationally wrongful conduct.[190] Instead here the inquiry is rather, "in the event of damage being caused" as is required by Article III and IV of the convention, could failure to uphold resolutions speak to the duty of care which should be taken, and therefore indicate a potential intentional act of omission as required by fault-based liability.

Consider the following senario:

A state launches a space object and does not design into the object a system which would reduce its altitude after its mission is complete so that it deorbits and burns up in the atmosphere, as is required by Guidelines 6 & 7 of the Space Debris Mitigation Guidelines.[191] The state subsequently completes its mission with the space object and abandons it, still in in orbit. If this space object were to then collide with another states satellite, could the launching state be held liable?

Well, it caused damage (the collision with another satellite), but was it at fault? While it may be difficult to argue that the guidelines themselves create some burden or *ergo omnes* obligation, they could speak to foreseeability. If we hold that it is through the

[189] UN COPOUS 'Report of the Legal Subcommittee on its fifty-fourth session, held in Vienna from 13 to 24 April 2015' available at h*ttp://www.unoosa.org/res/oosadoc/data/documents/2015/aac_105/aac_1051090_0_ html/AC105_1090E.pdf,* accessed on 14 September 2019

[190] Kerr op cit note 83.

[191] UNOOSA op cit note 92.

launching states omission to deorbit its space object that the collision occurred, then the harm could be held to be foreseeable because of the existence of guidelines being in place to prevent this exact type of harm from occurring.

To be clear, I do not contend that non-compliance with the guidelines could itself constitute fault, as the question placed before the Legal Subcommittee does. Rather I argue that the guidelines could indicate a potential Standard of Care a state should follow, failing which they could be said to have omitted an action to prevent a reasonably foreseeable harm. This harm being reasonably foreseeable because of the existence of guidelines to prevent it from taking place. As Dennerley puts it:

> "…the Mitigation Guidelines, along with all other soft law, do not define or, indeed, address the issue of fault under Article III, even impliedly. Rather, programmes and soft law, such as [Space Situational Awareness] and the Mitigation Guidelines, increase the regulation of space and, thus, create greater awareness in relation to the operation and control of space objects. In turn, this implies that a higher, rather than a lower standard of care, such as constructive knowledge, would be the relevant and applicable fault standard. Indeed, the more regulations and requirements incumbent upon launching states, coupled with an increasing awareness or knowledge of the space environment, means the more it will be presumed that states have, or ought to have, knowledge about how to safely operate their space objects."[192]

This could be framed as an extension of the concept of due diligence which is commonplace throughout international law. Consider the International Court of Justice (ICJ) in its *Corfu Channel* decision, in which it concluded that states have upon themselves an incumbent duty to not "allow knowingly their territory to be used for acts contrary to the rights of other States."[193] As an aspect of customary international law, this obligation of due diligence extends to operations in space.

> "It obliges states to observe certain conduct with respect to a particular activity and contains an element of 'good faith in [terms of] neighbourly relations', requiring states to control the acts of third parties where harm might occur between states."[194]

[192] Joel A Dennerley 'State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law' 29 (2018) *European Journal of International Law* 300.
[193] *Corfu Channel case (United Kingdom v. Albania*), Judgment, 9 April 1949, ICJ Reports (1949).
[194] Dennerley op cit note 192.

This Obligation for Due Diligence when combined Article IX of the outer space Treaty, as discussed above, could ensure that states have an obligation to conduct themselves - and ensure their citizens also conduct themselves - in a manner which mitigates harm to external parties as much as possible, arguably by the following of the Space Debris Mitigation Guidelines.

No matter how it is achieved, what is clear is that adherence with the Space Mitigation Guidelines is of utmost importance, if we wish to keep space a viable option for human use and exploration. The alternative, a space so congested with debris that any object placed there has a likely operational lifespan so short it will not reach commercial viability and human space flight would be suicidal, is one which is in the interest of no-one. The space mitigation guidelines are the best option to prevent such a catastrophist future. To quote Kessler et al:

> "Although new operational procedures have been developed over this period that have slowed the growth in orbital debris, these procedures have not been adequate to prevent growth in the debris population from random collisions. In order to prevent this growth, we are at a point where we must obtain near 100% compliance with guidelines established over 10 years ago and, in addition, we must retrieve a number of objects that are already in orbit. Fortunately, by selectively retrieving the most likely future debris sources, the rate of retrieval may be manageable, as long as at least 90% of future launches adhere to current debris mitigation guidelines….a percentage that has not been met in the past."[195]

2.8. Space Traffic Management

Article I of the outer space Treaty states quite clearly that "Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies."[196] While this as a governing principle is laudable, it does raise the issue of what occurs

[195] Kessler et al. op cit note 153 at 14.
[196] UNOOSA op cit note 31.

when two entities which both have the right to freely explore and utilize outer space, in so doing may inhibit the right of the other either intentionally or unintentionally.

Consider a scenario in which we have two operational satellites both with the capability to manoeuvre on a potential collision course. If both parties are aware of the potential collision who bears the onus to manoeuvre their satellite, utilising valuable fuel and potentially shortening the operational life span of the satellite, to avoid the potential collision?

A scenario like this is likely to become more common with private commercial ventures beginning to plan and indeed beginning to launch so called "mega constellations" – groups of satellites which number in the hundreds to thousands. SpaceX has their Starlink constellation, which is planned to have between 1500 and 2800 low earth satellites when completed and Amazon has its Kuiper constellation which is estimated to have around 3200 satellites in low earth orbit. These are just the 2 largest but 24 other companies plan to have active constellations in low earth orbit within the next couple of years.[197]

The increasing number of commercial satellites in low earth orbit will increase the probability of potential collisions occurring. The problem arises when considering that satellite operators have an active disincentive to perform avoidance manoeuvres thus taking no action to prevent these potential collisions. Performing these avoidance manoeuvres uses up the scarce fuel available on the satellite and with satellites currently not being able to be refuelled, the amount of fuel on board determines the operational lifespan of the satellite. Once the satellite reaches a critical level of fuel it must, in accordance with the Space Debris Mitigation Guidelines[198], utilise its remaining fuel to perform a deorbit manoeuvre, thus the more avoidance manoeuvres it must perform the sooner it will reach that critical level of fuel.[199]

A very similar scenario was faced by the ESA and SpaceX at the end of Aug 2019. First, it is of use to understand how organisations are made aware of potential collisions.

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[197] Theodore J. Muelhaupt *et al* 'Space traffic management in the new space era' 6 (2019) *Journal of Space Safety Engineering*.
[198] UNOOSA op cit note 92 at Guidelines 6 & 7.
[199] Eun-Hyouek Kim, Hae-Dong Kim and Hak-Jung Kim 'Optimal Solution of Collision Avoidance Maneuver with Multiple Space Debris' 9 (2012) *Journal of Space Operations* 20-21.

> "Typically, the United States Air Force [18th Space Control Squadron or 18 SPCS], which monitors space traffic, will issue warnings, or conjunction data messages (CDMs), if there is a high probability of a collision. The threshold for sending out a warning is when there is a probability of more than 1 in 10,000 of an impact… [Occasionally operators will] have an agreement with US Space Command that allows them to receive additional advanced warnings of these threats up to seven days beforehand (rather than the standard three days). [They then] submit their [data] to 18 SPCS on a regular basis so they receive additional CDMs that support possible maneuver planning,"[200]

Both ESA and SpaceX have such an agreement in place with 18 SPCS.[201] This system helped ESA become aware that its Aeolus satellite, an earth observation satellite launched in August 2018, had a 1 in 52 000 chance of colliding with one of SpaceX's trial[202] Starlink satellites.[203] According to the statement from SpaceX on the incident:

> "Our Starlink team last exchanged an email with the Aeolus operations team on August 28, when the probability of collision was only in the 2.2e-5 range (or 1 in 50k), well below the 1e-4 (or 1 in 10k) industry standard threshold and 75 times lower than the final estimate. At that point, both SpaceX and ESA determined a maneuver was not necessary. Then, the US Air Force's updates showed the probability increased to 1.69e-3 (or more than 1 in 10k) but a bug in our on-call paging system prevented the Starlink operator from seeing the follow-on correspondence on this probability increase—SpaceX is still investigating the issue and will implement corrective actions. However, had the Starlink operator seen the correspondence, we would have coordinated with ESA to determine the best approach with their continuing with their maneuver or our performing a maneuver."[204]

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[200] Loren Grush 'A bug in SpaceX's communication system kept the company in the dark about potential satellite collision' available *at https://www.theverge.com/2019/9/3/20847243/spacex-starlink-satellite-european-space-agency-aeolus-conjunction-space-debris*, accessed on 20 September 2019.
[201] Ibid.
[202] SpaceX launched 60 satellites on 23 May 2019 to begin testing its Starlink Constellation, which is intended to provide accesses to broadband internet anywhere on Earth. The majority of these satellites elevated their orbit to ~500km, however a few instead lowered there orbits to test re-entry procedures, including the one involved in this incident, Starlink 44. See, Caleb Henry 'SpaceX says more Starlink orbits will speed service, reduce launch needs' available *at https://spacenews.com/spacex-says-more-starlink-orbits-will-speed-service-reduce-launch-needs/*, accessed on 20 September 2019.
[203] Jon Brodkin 'SpaceX satellite was on "collision course" until ESA satellite was re-routed' available at *https://arstechnica.com/information-technology/2019/09/spacex-satellite-was-on-collision-course-until-esa-satellite-was-re-routed/*, accessed on 20 September 2019.
[204] Ibid.

When the probability of impact increased to 1 in 1000 and it still had not heard from SpaceX, ESA took the unilateral decision to fire the thrusters on the Aeolus and raise its orbit by about 350m.[205] Of note here, after the incident 18 SPCS confirmed that it had also sent 29 CDM's to SpaceX regarding this event.[206]

In the aftermath of this event the ESA, in a rather unprecedented move, was relatively vocal about their irritation at the conduct of SpaceX during the incident and called for greater co-operation in planning and executing avoidance manoeuvres.[207] According to Holger Krag, chief of the ESA Space Debris Office:

> "No one was at fault here, but this example does show the urgent need for proper space traffic management, with clear communication protocols and more automation… This is how air traffic control has worked for many decades, and now space operators need to get together to define automated manoeuvre coordination."[208]

While currently rare, with the planned increase in mega constellations it is likely that avoidance maneuvers like this are going to become more common and need to be coordinated more often.[209] Currently the coordination of these avoidance maneuvers is done voluntarily between satellite operators often just using email. Both ESA and SpaceX, as well as many other space operators, are investing in technology to automate these collision avoidance maneuvers, with the founder of SpaceX, Elon Musk, stating that the Starlink satellites already have the capability to "automatically manoeuvre around any orbital debris."[210] ESA wants to implement an autonomous system with it stating:

> "Collision avoidance manoeuvres take a lot of time to prepare – from determining the future orbital positions of functioning spacecraft, to calculating the risk of collision and the many possible outcomes of different actions… Under its Space Safety activities, ESA plans to invest in technologies required to automatically process collision warnings, coordinate manoeuvres with other operators and send the commands to

[205] Grush op cit note .200.
[206] Grush op cit note 200.
[207] European Space Agency 'ESA Spacecraft Dodges Large Constellation' available at *http://www.esa.int/Our_Activities/Space_Safety/ESA_spacecraft_dodges_large_constellation*, accessed on 20 September 2019.
[208] Ibid.
[209] Ibid.
[210] Brodkin op cit 203.

spacecraft entirely automatically, ensuring the benefits of space can continue to be enjoyed for generations to come."[211]

While it appears that the ESA will not be taking any further action in regard to this incident, it is unclear if they would have a claim from this incident. They did have to use fuel that might not have been used at that exact moment but in one of the ESA's statements on the incident they did state that they would have at some point had to raise the orbit of Aeolus anyway[212]. There are also some questions around whether this would fulfil the definition for damages as discussed earlier in this chapter.

Of greater interest is a scenario like the one above, however where instead of a communication breakdown, there was outright refusal by SpaceX to manoeuvre it satellite, would ESA have a claim for damages?

The short answer would likely be no. It would be difficult to classify the expenditure of fuel used to raise the orbit of the satellite as damage under the definition in the liability convention. However even if one did consider this to be damage, the next question becomes what value we place on this damage and thus what amount should be paid in reparations? It would be almost impossible to calculate the magnitude potential operational lifespan shortening that occurred because of this avoidance maneuver, especially since the satellite would have to perform multiple such maneuvers over its lifetime in the course of its normal operations. Even if one could figure out how much time it shortened its operational lifespan by, to then try and figure out the potential commercial value of this time would create a number based upon so many estimations, it would be difficult to convince any court of its certainty.[213]

This does set a rather concerning precedent. Considering the active disincentive operators have to maneuver their satellites, this could be the start of a strategy of playing in-orbit "chicken", hoping that the other operator blinks first and moves their satellite, thereby utilizing their fuel. It is obviously not in the interest of any operator to have an active satellite involved in a collision. However, the operator may do the weigh-up and conclude that the probabilities of inaction on their part leading to action

[211] ESA op cit note 207.
[212] Arthur Villasanta 'SpaceX Declined to Move Starlink 44 in Collision Course with ESA Satellite' available at *https://www.ibtimes.com/spacex-declined-move-starlink-44-collision-course-esa-satellite-2821827,* accessed on 28 September 2019.
[213] See discussion in Paul Larsen 'Commercial Operator Liability in The New Space Era' 113 (2019) *American Journal of International Law.*

on the part of the other operator (especially if it is a government operator which has research of national security concerns) are great enough to warrant the risk and thus is an effective strategy on their part.

> "Based on the perceived low risk and because of financial, anti-regulation, cultural or corporate image management reasons, satellite operators can be motivated to underestimate space safety and RFI [Radio Frequency Interference] risks and overstate the steps they take to address them. Like other tragedy-of-the-commons situations, it would be understandable if an operator's economic business model simply did not account for "worrying about the environment". One could also understand if the spacecraft operator selected a collision avoidance maneuver go/no-go threshold that protects their mission sufficiently, while not sufficiently protecting the long-term sustainability of space activities."[214]

Consider again the aforementioned scenario. SpaceX is aware of likely collision but employs the above strategy. ESA also follows this strategy and neither party moves their satellites. Should a collision occur, is either liable? The answer here is a little more complicated. Again, according to the specifics of the law, neither is required to maneuver their satellite - they are merely required to consult one another. They did do so however both refused to move. Considering they had knowledge of the potential, and thus must be held to have foreseen the possibility of a collision occurring, they are likely to be held jointly at fault for the collision. (Thus, any liability between the two is likely to be held to remain upon themselves.) What would be of note here is that should the debris from that collision go onto damage the satellite of a third party, they could, according to Article IV of the Liability Convention, be held jointly liable to that third party. There may be issues here with states having to claim on behalf of private entities, however for simplicities sake this has been ignored and will be addressed in Chapter 3.

Scenarios like this highlight the need for an increase in international co-operation and for states to come together and agree to some form of orbital traffic management system.

> "Reaching a global consensus won't be easy. Earth orbit has both civil and military uses, and the lines that divide them are often unclear and contentious. Nonetheless, a

[214] Daniel L Oltrogge & Salvatore Alfano 'The technical challenges of better Space Situational Awareness and Space Traffic Management' 6 (2019) *Journal of Space Safety Engineering* 72-79.

somewhat similar challenge was met in 1944, when 52 countries established the International Civil Aviation Organization, a UN body that sets global safety norms for civil aviation.

A global convention to regulate Earth orbit could have similar, industry-boosting benefits, by laying out protocols for satellite operators to communicate with each other, as well as binding standards for the creation, management and mitigation of space junk. New space powers, including India and Japan, would have a strong incentive to join such an organization, if only as a means to encourage nations such as the U.S. and Russia to clean up the messes they've already created. As the heavens become more crowded, leaders on earth are going to have to work together to keep them safe."[215]

The creation of a Space Traffic Management (STM) system, seems like a daunting task, but the reality is that multiple organizations are already working on the technology and policy required to make such a system a reality.[216] A big part of such a system begins with better Space Situational Awareness (SSA) systems.[217] While the technical details of how such a system operates is beyond the scope of this dissertation, it's sufficient to say it involves "higher accuracy sensor data", "enhanced tracking" and potentially outfitting satellites with transponders which will stay active past the lifespan of the satellite itself, as well as more detailed disclosure by operators of the orbital information of satellites.[218] While SSA systems themselves will not solve the issue, what they do is allow for more detailed information upon which decisions can be more accurately made. This is comparable to when air traffic control went from a green radar screen which just showed a blip every few seconds, to the detailed digitalized systems used today.

"The implications of the changing SSA and traffic congestion landscape are also spurring an industry response. New SSA companies are operating networks of telescopes (e.g., ExoAnalytics) and even radars (e.g., LeoLabs). Others are offering conjunction prediction and collision avoidance services (e.g., Analytical Graphics'

[215] Adam Minter 'Space-Faring Nations Need Regulations to Prevent Satellite Collisions: Opinion' available at *https://www.insurancejournal.com/news/international/2019/09/09/539191.htm*, accessed on 28 September 2019.
[216] Muelhaupt et al. op cit note 197.
[217] Oltrogge & Alfano op cit note 214.
[218] Muelhaupt et al. op cit note 197.

ComSpOC). The Space Data Association was created as a consortium to coordinate and deconflict its members' operational plans."[219]

With greater SSA, we could then move onto the creation of a STM system. How exactly this could occur is still up for much debate and discussion within both the international space industry, and amongst space fairing nations. However, the blueprint already exists. The establishment of the International Civil Aviation Organization (ICAO) dealt with similar issues: a market governed by states but interacted with by a mixture of state and private entities occurring in international territory.

The concept of STM is not a new one, with the International Academy of Astronautics (IAA), concluding a study in 2005 on the necessary principals which would need to be reviewed and/or established to begin making a global STM system a realty.[220] The system was based upon a similar approach which the *Chicago Convention* of 1944 took to Airspace Traffic Management (ATM), highlighting the need for a system which governed "The Launch Phase", "The In-Orbit Operation Phase" and "The Re-Entry Phase".[221]

Another commonly proposed approach is to create a specialized agency of the UN to deal with all matters related to Space, a UN International Space Agency (UNISA), similar to the International Civil Aviation Organization (ICAO) or the International Telecommunication Union (ITU). One argument for such an agency is the increased authority that such an agency would have, by the mere fact that it is a specialized agency, in contrast to the current regime of a permanent committee (UNCOPUOS) and office (UN Office of outer space Affairs, UNOOSA).[222] It could also help mitigate some of the deficiencies of COPUOS:

> "The key to understanding COPUOS is that, first and foremost, the forum is primarily a diplomatic one. Sitting at the country desks are representatives from permanent UN missions, not heads of space agencies. As a result, conversations tend towards high-

[219] Muelhaupt et al. op cit note 197.
[220] Corinne Contant-Jorgenson, Petr Lála & Kai-Uwe Schrogl (eds) *Cosmic Study on Space Traffic Management* (2005).
[221] Ibid.
[222] Kenneth S. Pedersen 'Is it time to create a World Space Agency?' 9 (1993) *Space Policy*; David Tan 'Towards a New Regime for the Protection of outer space as the "Province of All Mankind"' 25 (2000) *Yale Journal of International Law* 190.

level, diplomatic concerns, with a fraction of the time spent on technical presentations and considerations."[223]

What is clear is that soft law is insufficient, and steps need to be taken to ensure there is compliance with an international standard. The establishment of a dedicated specialised agency, and binding regulations which create a STM system would resolve many deficiencies and ambiguities in the current legal regime.

> "Although the guidelines have helped reduce some types of debris, such as fragments from rocket upstage breakup, there is no mechanism to enforce compliance with the guidelines, and some guidelines are frequently not followed, such as end-life disposal of satellites in LEO. The UNCOPUOS guidelines also do not address the issue of liability. If a fragment strikes a satellite, the owner of the satellite is unlikely to get compensation from the country or company that created the fragment. Solving the liability problem may offer a path to dealing with the debris problem. If satellite operators would be held liable for the debris they created, there would be a financial incentive for them to adopt debris mitigation guidelines."[224]

There is a definite recognition that more needs to be done, with UNCOPUOS recently (June 2019) approving its *Guidelines for the Long-term Sustainability of Outer Space Activities.*[225] This comprises of a comprehensive list of 21 guidelines which have the aim "of ensuring and enhancing the long-term sustainability of outer space activities, as understood at the international level and as set out in the guidelines".[226] These Guidelines themselves require that states and IGO's (Intergovernmental Organisations) increase co-operation with Guideline C1 stating:

> "States and international intergovernmental organizations should promote and facilitate international cooperation to enable all countries, in particular developing and emerging spacefaring countries, to implement these guidelines."[227]

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[223] Mehak Sarang 'Op'Ed: Thoughts on UN COPUOS' available at *https://spacegeneration.org/oped-thoughts-on-un-copuos*, accessed on 28 September 2019

[224] Henry op cit note 202 at 22-24.

[225] Untied Nations Office for outer space Affairs 'Long-term Sustainability of outer space Activities' available at *http://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html*, accessed on 30 September 2019.

[226] United Nations Committee on the Peaceful Uses of outer space 'Guidelines for the Long-term Sustainability of outer space Activities' available at *https://undocs.org/pdf?symbol=en/A/AC.105/C.1/L.366*, accessed on 30 September 2019.

[227] Ibid.

However again, these guidelines are voluntary, and while passing a body which requires the unanimous consent of its 93 member states, does speak to the international will for the guidelines to be implemented, there is no mechanism to ensure enforcement, or recourse in the event they are not followed.

2.9. Conclusion

This concludes the discussion on unmanned space objects and the potential issues with liability a commercial entity operating such an object may encounter as well some of the environmental concerns present in their operation.

CHAPTER 3 – MANNED COMMERCIAL OPERATIONS IN SPACE

The exploration and exploitation of space starts with probes and robotics but the goal of a vast portion of the space industry is to make going to space and to other celestial objects as easy as we can travel between continents today. Whether it be going up in short sub-orbital hops, staying for a couple of nights in an orbital hotel, or walking along the surface of the Moon, Mars or perhaps even a moon of Saturn or Jupiter, as our technology progresses, more and more humans will take to outer space.

When the UN treaties on outer space were drafted, the only humans which could feasibly be in outer space were highly trained professionals, specifically sent up by states as part of their state-run space programmes. With a couple notable exceptions this has held out over the decades, but it is unlikely to do so for much longer. This chapter will thus look at how the progression of the commercial space sector into civilian space flights will stretch the current law and highlight deficiencies in existing law which need to be addressed.

3.1. Space Tourism

For much of the *corpus iuris spatialis in iuri gentium*[228] the concept of humans in space, and thus the scope of humans it should cover, consisted of only those personnel sent by states for scientific and explorative purposes; it was Astronauts and Cosmonauts that would be in space, not civilians. However, going forward this is unlikely to be the case. The rise in for-profit companies offering the general public the opportunity to experience "space travel" in one form or another has created a legal vacuum in which we are unsure of the rights or obligations afforded to these private citizens venturing into one of our most dangerous frontiers.

> "Broadly speaking, 'space tourism' denotes any commercial activity that offers customers direct or indirect experience with space travel. Such activities have many different designs, ranging from long-term stays in orbital facilities to short-term orbital or suborbital flights…"[229]

[228] body of Space Law in international law.
[229] Stephan Hobe 'Legal Aspects of Space Tourism' 86 (2007) *Nebraska Law Review* 439.

Space Tourism, and indeed space tourists, are not defined or addressed in any of the 5 UN Treaties, and even in the growing body of soft law are addressed sparsely. It is however a sector which is growing significantly, with many current launch operators and several niche start-ups realising the large source of revenue private citizens wanting to go to space could present. Consider Dennis Tito, whom many consider to be the first "space tourist"[230].

> "Throughout the 1990s Tito negotiated with space agencies in Moscow before securing passage on a 2001 mission to the space station Mir at the cost of $20 million. He began training in 2000 at the Yury Gagarin Cosmonaut Training Centre in Star City, Russia, but the mission was canceled when Russia allowed the Mir station to crash to Earth. Instead, on April 28, 2001, Tito joined two Russian cosmonauts, commander Talgat Musabayev and flight engineer Yury Baturin, on a supply mission, Soyuz TM-32, to the International Space Station (ISS). The move caused some controversy at NASA, which felt that Tito needed several weeks of training at NASA facilities before going to the ISS. Tito stayed six days aboard the ISS before returning aboard Soyuz TM-31. Tito and the Soyuz crew parachuted to Earth on May 6, landing in the steppes of Kazakhstan."[231]

Since then 6 other multi-millionaires have paid around US$20 Million each to stay aboard the International Space Station (ISS), including South Africa's own Mark Shuttleworth and the Hungarian-American Charles Simonyi who has been twice.[232] These trips were all facilitated by Roscosmos and appear to have gone dormant with no new trips since 2009.[233] However in June 2019, NASA announced that it would begin conducting similar trips with travellers able to book trips aboard US Spacecraft[234] to stay a maximum of 30 days aboard the ISS at a cost of US$35 000 per night (excluding training and launch), with a maximum of two of these trips occurring per

[230] A more detailed discussion on whether he was indeed a tourist or not will follow later in this chapter.
[231] The Editors of Encyclopaedia Britannica 'Dennis Tito – American Businessman' available at *https://www.britannica.com/biography/Dennis-Tito*, accessed on 03 October 2019.
[232] Eva Yi-Wei Chang1 & Rock J S Chern 'A Study and Discussion on the Cost Issue of Suborbital and Orbital Space Tourism' 7 (2018) *Journal of Tourism and Hospitality* .
[233] Ibid.
[234] As of writing the US has no operational human launch capabilities, however two US companies, SpaceX and United Launch Alliance are scheduled to have their capabilities approved and operational sometime in 2020.

year.[235] This is in line with NASA's "Low-Earth Orbit Economy" policy, which is part of NASA's goal of "become[ing] one of many customers purchasing services from independent, commercial and free-flying habitable destinations in low-Earth orbit. A robust low-Earth orbit economy will need multiple commercial destinations…"[236]

However, opportunities for private citizens to experience space do not require multi-million-dollar expenditures. There are an increasing number of experiences available for (admittedly still wealthy) individuals who are prepared to spend in the region of US$200 000 to experience space on a suborbital space flight. With prices expected to drop in the near future by as much as 90%, this would make it comparable in cost to overseas trip for some families.[237] Consider the operations of Virgin Galactic, owned by UK billionaire Sir Richard Branson:

> "Tourism venture Virgin Galactic sent its spaceplane into space for the second time in February 2019, qualifying all three people on the flight for their commercial astronaut wings... Virgin Galactic's spaceplane, the *VSS Unity*, is designed to take passengers to the edge of space where they can experience a few minutes of weightlessness. But up until the end of last year, the vehicle had yet to breach Earth's atmosphere. That changed in December 2018 when Virgin Galactic made history by sending VSS Unity to a height of almost eighty-three kilometres, an altitude that many (but not all) consider to be the start of outer space. For those who adhere to that definition, it was the first time that people had launched to space from the U.S. since 2011. As a result, the two pilots of the December flight received astronaut wings from the *Federal Aviation Administration* in early February."[238]

SpaceX has also announced plans for a tourism mission to the Moon, called the #dearMoon project. This would be a crewed lunar flyby of their Starship rocket, financed by Japanese Billionaire Yasaku Maezawa.[239] SpaceX described the mission

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[235] Karen Northon (ed) 'NASA Opens International Space Station to New Commercial Opportunities, Private Astronauts' available at *https://www.nasa.gov/press-release/nasa-opens-international-space-station-to-new-commercial-opportunities-private*, accessed on 03 October 2019.
[236] Ibid.
[237] Yanal Abul Failat 'Space Tourism: A Synopsis on its Legal Challenges' 120 (2012) *Irish Law Journal* 121.
[238] Louis de Gouyon Matigon 'Space Tourism Legal Aspects' available at https://www.spacelegalissues.com/space-law-space-tourism-legal-aspects/, accessed on 03 October 2019.
[239] Kenneth Chang 'Meet SpaceX's First Moon Voyage Customer, Yusaku Maezawa' available at *https://www.nytimes.com/2018/09/17/science/spacex-moon-tourism-passenger.html*, accessed on 03 October 2019.

as the “first private lunar passenger flight, featuring a fly-by of the Moon as part of a week-long mission”.[240] The mission itself would take Mr Maezawa, several accomplished artists and some crew members on a fly-by of the moon so as to “be inspired in a way they have never been before”[241] with Mr Maezawa stating “If Pablo Picasso had been able to see the moon up-close, what kind of paintings would he have drawn? If John Lennon could have seen the curvature of the Earth, what kind of songs would he have written? If they had gone to space, how would the world have looked today?”[242] No matter the methods, more civilians will soon be occupying Outer Space, and with that comes multiple legal uncertainties which must be resolved.

3.2. Definition and Delimitation of Outer Space

Where does the Earth’s atmosphere end and outer space start? This fundamental question remains unanswered in international law and has done so for decades. The Legal Subcommittee of COPUOS has had distinct discussions on this topic going back to at least 1978[243], with one presentation at the ICAO/UNOOSA Symposium in 2016 claiming that it had been an agenda item for 50 years at that point, this would indicate that the discourse began in 1966.[244] A separate working group was established in 1984[245] which despite reconvening every year since, has yet to make much progress on the topic.[246]

As may be inferred from the above, there is no clear definition or delimitation of outer space in any of the *corpus iuris spatialis in iuri gentium*. Even in astrophysics, there is no agreed upon delimitation. As discussed in Chapter 1, there is no physical point at

[240] SpaceX ‘First Passenger on Lunar BFR Mission’ available at *https://www.spacex.com/news/2018/10/09/first-passenger-lunar-bfr-mission*, accessed on 03 October 2019
[241] DeerMoon Offcial Website, available at dearmoon.earth accessed on 03 October 2019.
[242] Ibid.
[243] UNCOPUOS ‘Report of the Legal Sub-Committee on the Work of its Seventeenth Session’ available at *http://www.unoosa.org/res/oosadoc/data/documents/1978/aac_105/aac_105218_0_html/AC105_218E.pdf*, accessed on 08 October 2019.
[244] José Monserrat Filho ‘Definition and Delimitation of outer space – a Deadlock Discussion?’ available at *https://www.icao.int/Meetings/SPACE2016/Presentations/2%20-%20J.%20Filho%20-%20Chair%20of%20COPUOUS%20LSC%20WG%20on%20DefDel%20of%20Outer%20Space.pdf*, accessed on 08 October 2019.
[245] Ibid.
[246] UNCOPUOS ‘Report of the Legal Sub-Committee on the Work of its Fifty-Eighth Session’ available at *https://cms.unov.org/dcpms2/api/finaldocuments?Language=en&Symbol=A/AC.105/1203,* accessed on 08 October 2019.

which the atmosphere ceases but rather there is a gradual diminishing of atmospheric pressure the farther away from the Earth's surface one progresses. This makes the process of delimiting to a specific point a challenging task.

States have generally avoided the topic in their national legislation with the notable exception of Australia whose *Space Activities Act 1998* delimited outer space as being above 100km, a delimitation which was retained in their *Space (Launches and Returns) Act 2018*. The US by contrast holds as policy "that defining or delimiting outer space is not necessary."[247] However, US Federal Aviation Authority (FAA) has been known to award Commercial Astronaut Wings to pilots who have flown craft above an altitude of 80km,[248] following a similar policy by the US Department of Defence and NASA.[249]

Over the decades various states have articulated their positions, even if they do not have legislation or policy on the topic. Since the days of the USSR, Russia has held that the delimitation should be between 100 – 110 km above sea level.[250] US allies, the UK and several other western powers, have held the view that no limitation is necessary.[251] China has held that a delimitation line should be decided and agreed upon, but has not made any suggestions as to the altitude that delimitation should occur.[252] The equatorial states of

> "Brazil, Columbia, Congo, Ecuador, Indonesia, Kenya, Uganda and Zaire claimed sovereignty up to the geostationary orbit above their territories, which is at a distance of 36,000km away from earth… However, equatorial states have slightly changed their standpoints in recent years, and have not adhered to claim their priority rights any more."[253]

[247] US Department of State '85. U.S. Statement, Definition and Delimitation of outer space and The Character and Utilization Of The Geostationary Orbit, Legal Subcommittee of the United Nations Committee on the Peaceful Uses of outer space at its 40th Session in Vienna from April' available at *https://2009-2017.state.gov/s/l/22718.htm*, accessed on 08 October 2019.
[248] de Gouyon Matigon op cit note 238.
[249] Paul Voosen 'outer space may have gotten a bit closer' available at *https://www.sciencemag.org/news/2018/07/outer-space-may-have-just-gotten-bit-closer*, accessed on 08 October 2019.
[250] Ni Li 'A study on the Delimitation of Outer Space' available at *https://www.academia.edu/8518439/A_Study_on_the_Delimitation_of_Outer_Space*, accessed on 08 October 2019.
[251] Ibid.
[252] Ibid.
[253] Ibid.

Many more states have articulated a position, but for the most part they can be synthesised down into one of two camps: the US, UK and a limited number of other states who believe that a delimitation is not necessary and the rest who believe a delimitation is necessary but differ on the exact height with a range of between 80km and 120 km above sea level.[254]

Arguments put forth by the former camp can be seen in the below extract from the statement on this issue by the Delegation of the United States made before the Legal Subcommittee of UNCOPUOS in 2001:

> "No legal or practical problems have arisen in the absence of such a definition. On the contrary, the differing legal regimes applicable in respect of airspace and outer space have operated well in their respective spheres. The lack of a definition or delimitation of outer space has not impeded the development of activities in either sphere... without a practical problem to address, undertaking such a definition would be a risky exercise… Whatever definition or delimitation were ultimately agreed upon would by its nature be arbitrary at worst, or, at best, be constrained by the current state of technology. For example, technological advances have increased the height at which aircraft can sustain flight, while they have decreased the height at which the orbital flight of space vehicles is possible. These technological advances will likely continue. It would be dangerous for the Legal Subcommittee to agree to an artificial line between air space and outer space, when it cannot predict the consequences of such a line."[255]

It is difficult to stand by an argument which at its core advocates for inaction because of an inability to precisely sequence the consequences of that action, especially in the case of law. The law by its very nature can be difficult to predict which is why historically societies have instead made sufficient attempts to consider the consequence of implementing a law but ultimately recognise that law will have unintended consequences and so can be subsequently amended.

The argument that delimitation is unwarranted (because an issue making it necessary has yet to occur) is a potentially unconscionable position when human lives may be involved. While it is correct to say that an issue has not yet arisen, concerns have been foreseen and will continue to arise as technology develops.

[254] Ibid.
[255] USDS op cit note 247.

Returning to the position that a delimitation is necessary, multiple arguments have been put forth as to the exact height at which such a delimitation should be placed, the majority of which have their origin in some or other scientific explanation.

> "Until now, most scientists have said that outer space is 100 kilometers away. At that point, it's been thought, the speed needed to achieve lift in the superthin atmosphere is equal to the speed needed to simply orbit the planet; once there, a spacecraft's horizontal pace would counteract the tug of Earth's gravity. It's an insight that has long been credited to aerodynamics pioneer Theodore von Kármán, though he credited the term to the world's first "Space Lawyer," Andrew Haley, in 1963."[256]

Advances in our understanding of the atmosphere and aerodynamics have since revised the height at which this phenomenon occurs to be potentially as low as 88km or even 66km above sea level.[257] This point however is not static, with the warming of the atmosphere by the sun during natural cycles of higher intensity solar output causing the atmosphere to expand and thus increasing the height at which the phenomenon would occur.[258] It is however unlikely that a satellite which has a perigee (the point in its orbit at which it is at its lowest height above sea level) below 80km will make another orbit around the Earth due to atmospheric drag.[259] Others have argued that the delimitation should be at the Mesopause, the coldest point in the Earth's atmosphere which is estimated to be around 85km above sea level.[260]

A further argument is that any point chosen is likely to be arbitrary and so rather than trying to find some scientific rationale, law makers should just choose height above sea level and declare that to be the delimitation point, as Australian law makers did with their legislation.

The importance of delimiting space is founded in determining the applicable legal regime to a vehicle. Should a vehicle have as its applicable regime Air Law or Space Law? In the past this has been determined by a spatialist approach, if the vessel was on/in the ocean than Maritime Law was applicable, if it was in the Air, then Air Law was applicable. (For a full explanation of this approach and its counter the functionalist

[256] Voosen op cit note 249.
[257] Voosen op cit note 249.
[258] Charles Q. Choi 'Tiny Solar Activity Changes Affect Earth's Climate' available at *https://www.space.com/19280-solar-activity-earth-climate.html*, accessed on 08 October 2019.
[259] Voosen op cit note 249.
[260] Voosen op cit note 249.

approach see Chapter 1.) This begs the question, if there is no definition of Outer Space then at what point do we determine if the vessel is now in outer space and that Air Law is no longer applicable?

In light of there being no definition or delimitation of Outer Space, as well as the lack of political will - especially by the main launching states like the US - theorists have proposed an alternative approach by looking at the function of the vehicle. The functional approach determines the applicable law by determining the operational purpose of the vehicle. If the vehicle's operational purpose is to propel persons or cargo through the atmosphere, then Air Law would be applicable. If its operational purpose is to propel persons or cargo out of the atmosphere or return them back into the atmosphere, then the Law of Outer Space would apply.[261]

The functional approach works well when looking at conventional technologies, for example an airplane moving through the atmosphere using atmospheric lift to stay in flight or a rocket powering/freefalling through the atmosphere. However, technology currently in testing already calls into question some of these assumptions and near-future technology is likely to stretch these limits even further. To illustrate this, we will look at the method Virgin Galactic's SpaceShipTwo (such as the aforementioned VSS Unity) and LauncherOne class vessels use to launch.

Virgin Galactic and Virgin Orbit (previously a division of Virgin Galactic which deals with satellite launches[262]) both use an "Air-Launched" system in which two vehicles are utilised.

> "When it begins commercial flights, SpaceShipTwo will carry six passengers and fly to 50,000 feet (15,240 meters) in altitude while attached to the bottom of WhiteKnightTwo. The craft will then separate for the trip into space by firing its engines for about 70 seconds and then shutting them off for the final coast up to 62 miles (100 km) above Earth. The passengers will feel weightless for about 5 minutes, Virgin Galactic representatives said. Next, SpaceShipTwo will turn back to Earth and "feather" its rudders, turning them up to 90 degrees to increase drag and control the movement of the spacecraft. At 70,000 feet (21,336 m), the spaceship will have

[261] For more detailed analysis on the functional approach and opposing spatial approach, see Ch1.
[262] Virgin Orbit available at *https://virginorbit.com/launch/,* accessed on 14 October 2019.

> enough air around it to move the rudders back to a configuration that allows for gliding during its descent. It will then land on Earth on a regular aviation runway."[263]

Which system of law should be applicable to a hybrid vehicle like this? It is first useful to have clarity on the definitions of an "aircraft" and of a "space object". For the latter, one can refer back to the previous chapter for a detailed analysis on the definition of a space object, but for the purposes of this discussion it is suffice to say it is an object which is launched into, and intended to operate in Outer Space. ICAO defines an aircraft as "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface."[264] It should be noted that this definition is derived from the Convention on International Civil Aviation[265] (Chicago Convention), which also gives mandate to the ICAO and explicitly excludes state or military aircraft from its jurisdiction [266] and so the discussion going forward would only be applicable to commercially owned and operated vehicles.

From these definitions it is clear that the mothership, WhiteKnightTwo, is an aircraft both before and after separation and so Air Law is applicable.[267] But what of SpaceShipTwo? SpaceShipTwo does generate lift from its aerofoils[268] and so "derives support in the atmosphere from the reactions of air" and so satisfies the definition of an aircraft. What is also clear from its name and marketing is that it is also intended to operate in Outer Space[269], and is launched into outer space by means of it detaching from the mothership and igniting its rocket, and so is also a Space Object. Trying to resolve this conflict, Stephen Hobe argues:

> "Until separation, the combined vehicle has the characteristics of an aircraft in terms of technical functions such as flight pattern and maneuverability: the space vehicle constitutes merely an additional cabin. Indeed, before separation, the space vehicle does not contribute to the propulsion and is fully dependent on the aircraft. Also, the dangers related to space missions are typically connected with the time of the launch,

[263] Elizabeth Howell 'SpaceShipTwo: On a Flight Path to Space Tourism' available at *https://www.space.com/19021-spaceshiptwo.html*, accessed on 14 October 2019.
[264] ICAO 'Glossary' available at *https://www.icao.int/cybersecurity/Lists/Glossary/AllItems.aspx*, accessed on 14 October 2019.
[265] ICAO 'Convention on International Civil Aviation' available at *https://www.icao.int/publications/Documents/7300_orig.pdf*, accessed on 30 October 2019.
[266] Ibid.
[267] Hobe op cit note 229 at 443.
[268] Howell op cit note 263.
[269] Virgin Galactic 'SpaceShipTwo' available at *https://www.virgingalactic.com/learn/*, accessed on 14 October 2019.

not with the transport by aircraft. Therefore, the aircraft and the attached space vehicle should be considered an 'aircraft' until separation and air law should apply both to the aircraft and the space vehicle before separation. After separation, however, the space vehicle does not 'derive support in the atmosphere from the reactions of the air' and should not be considered an aircraft. The vehicle may use the 'reactions of the air' in the landing process, but it may be argued that partial fulfillment of the definition is not sufficient to qualify the vehicle as an aircraft. The purpose of the vehicle at that point further supports the conclusion that the vehicle should not be regarded as an 'aircraft.'"[270]

Yanal Failat supports this stance, holding that:

> "air law applies to the space vehicle before detachment and to the mother ship after the separation, and Space Law applies to the object which operates on rocket-mode propulsion after separation."[271]

While mostly agreeing with the above authors, I would correct that the SpaceShipTwo design does also generate lift on its ascent through the lower atmosphere and does not solely rely on its rocket engine until much higher in its flight.[272] I would however, as Stephen Hobe does, argue that this partial fulfilment of the definition of aircraft does not outweigh the intended purpose of the spacecraft when going into orbit. When only performing a suborbital hop however, it may be argued that since space is only used 'in transit' between two or potentially even the same place on the Earth's surface, a broad interpretation of *de lege ferenda*[273] implies that Air Law be applicable.[274] This approach of looking at the destination of the vehicle may help in resolving issues of hybrid vehicles.

> "Is the vehicle's primary purpose to go into outer space in order to orbit, to conduct outer space activities (an Earth-Space mission), or to provide transportation from one point on Earth to another (an Earth-to-Earth mission)? In the former case, arguably it is a space object, while in the latter case, arguably it is not."[275]

[270] Hobe op cit note 229 at 443.
[271] Failat op cit note 237 at 148.
[272] Virgin Galactic op cit note 269.
[273] what the law should be.
[274] Jürgen Cloppenburg, 'Legal Aspects of Space Tourism' in Marietta Benkö & Kai-Uwe Schrogl (ed) *Space Law: Current Problems and Perspectives for Future Regulation* (2005) 196 – 197.
[275] Paul Stephen Dempsey and Maria Manol 'Suborbital flights and the delimitation of air space vis-à-vis outer space: functionalism, spatialism and state sovereignty' available at

Extend the applicability of Air Law into space creates a serious conflict of sovereignty.

> "The legal regimes that govern air space and outer space are distinct, and create a distinct conflict: while air space is an area to which State sovereignty can be attributed, outer space falls beyond sovereignty claims. Article 1 of the Chicago Convention explicitly recognizes the right of a State to extend 'complete and exclusive' sovereignty over the air space above its territory. In contrast, Article II of the outer space Treaty (OST) provides that outer space '[…] is not subject to national appropriation by claim of sovereignty […]'.[276]

It can thus be argued that to extend a sovereigns' Air Law into outer space may fundamentally violate this principle of the OST, however one may also be able to argue that this is already done without issue when applying the laws of a flag state to a vessel in Outer Space. All of these points are perhaps moot though as without a definition and delimitation of outer space we are unable to definitively determine at what point a vessel passes into Outer Space. Thus, if a vessel launches and returns to earth as a means of transport between the same or two places on earth, despite the natural language or marketing used, it could be argued that from a legal standpoint it never actually enters outer space and so it is only Air Law that is applicable.

This is the view of ICAO with it holding in its working paper on the issue that:

> "It might be argued from a functionalist viewpoint that air law would prevail since air space would be the main centre of activities for suborbital vehicles in the course of an earth-to-earth transportation, any crossing of outer space being brief and only incidental to the flight."[277]

No matter the approach taken, what is clear is that the resultant legal grey area of which legal regime is applicable is bad for business.

> "Commercial investment in space transportation systems is expensive, depends on as yet unproved technology, and is fraught with risk. Clear legal rules can help define the degree, or consequences, of risk, and reduce uncertainty, providing the predictability

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http://www.unoosa.org/res/oosadoc/data/documents/2018/aac_105c_22018crp/aac_105c_22018crp_9_0_html/AC105_C2_2018_CRP09E.pdf, accessed on 23 October 2019.

[276] Ibid.

[277] ICAO 'The Concept of Sub-Orbital Flights, Working Paper C-WP/12436 (30 May 2005)' available at *http://www.icao.int/ICDB/HTML/English/Representative%20Bodies/Council/Working%20Papers%20by%20Session/175/C.175.WP.12436.EN/C.175.WP.12436.EN.HTM*, accessed on 23 October 2019.

> necessary to support commercial investment. Conversely, legal uncertainty can increase risk and chill investment."[278]

In addressing the issues of the definition and delimitation of space a number of potentials have been proposed. The simplest would be for UNCOPUOS to agree on a delimitation, however considering the decades of discussion and the negligible progress being made, this is unlikely to occur any time soon.

Of major concern is the safety of passengers and craft in surrounding airspace during a launch or re-entry. If a vessel is determined to be spacecraft and thus Air Law is not applicable, it has no obligations to coordinate with ICAO during launch and re-entry. While in practice many launch providers coordinate with local air traffic control, there is no obligation to do this when in international airspace.[279] In light of this one suggestion has been to amend ICAO's definition of aircraft so as to include spacecraft passing through the atmosphere during launch and re-entry so that they have the same applicable safety and navigation rules.

> "ICAO could regulate aerospace vehicles by amending the definition of an 'aircraft' to include aerospace vehicles. It created the definition of aircraft, and amended it to clarify that air cushion vehicles were not within the Chicago Convention; ICAO could amend its Annexes again to clarify that sub-orbital vehicles fall within the definition of 'aircraft.' Annex 7 already includes gliders, balloons, helicopters, ornithopters, rotorcraft, and gyroplanes within the definition of 'aircraft.' Balloons have no wings. If a balloon can legally be deemed to be an 'aircraft', then an suborbital aerospace vehicle can be deemed to be an 'aircraft' as well, even if it is in the shape of a rocket."[280]

Another suggestion has been that since we have been unable to define Outer Space, we should instead attempt to define the limits of Air Space. This would thus inadvertently define outer space as everything beyond what we define as air space. This may be done through ICAO amending its Annexures, however "some may argue that such a change would require a new Protocol amending the Chicago Convention itself, or perhaps an entirely new multilateral convention."[281]

[278] Dempsey & Manol op cit note 275 at 33.
[279] Dempsey & Manol op cit note 275 at 35.
[280] Dempsey & Manol op cit note 275 at 35.
[281] Dempsey & Manol op cit note 275 at 35.

As mentioned in Chapter 2's discussion on Space Traffic Management, another popular suggestion is the creation of a new body to co-ordinate and manage space traffic, which could then implement its own navigational and safety rules. A suggested model for this is the Law of the Sea Convention of 1982 and its creation of the International Maritime Organisation (IMO).[282]

> "The United Nations Convention on the Law of the Sea of 1982 [UNCLOS] was concluded after almost a decade of negotiations during the third UN Conference on the Law of the Sea (UNCLOS III, 1973-1982); at this writing, it has been ratified by 168 States. It replaced a series of earlier relevant Conventions, including the 1958 Geneva Conventions on the Law of the Seas, which mostly focused on maritime matters, such as the navigation of merchant and military fleets, than on matters of exploration and exploitation of the Sea. The UNCLOS contains 320 articles and provides a thorough regime of rights and obligations of States over all parts of the Sea, by dividing them into several categories (e.g. Internal Waters, Territorial Waters, Archipelagic Waters, Contiguous Zone, Exclusive Economic Zone, Continental Shelf, and High Seas), with different sets of State rights and obligations over each of these categories."[283]

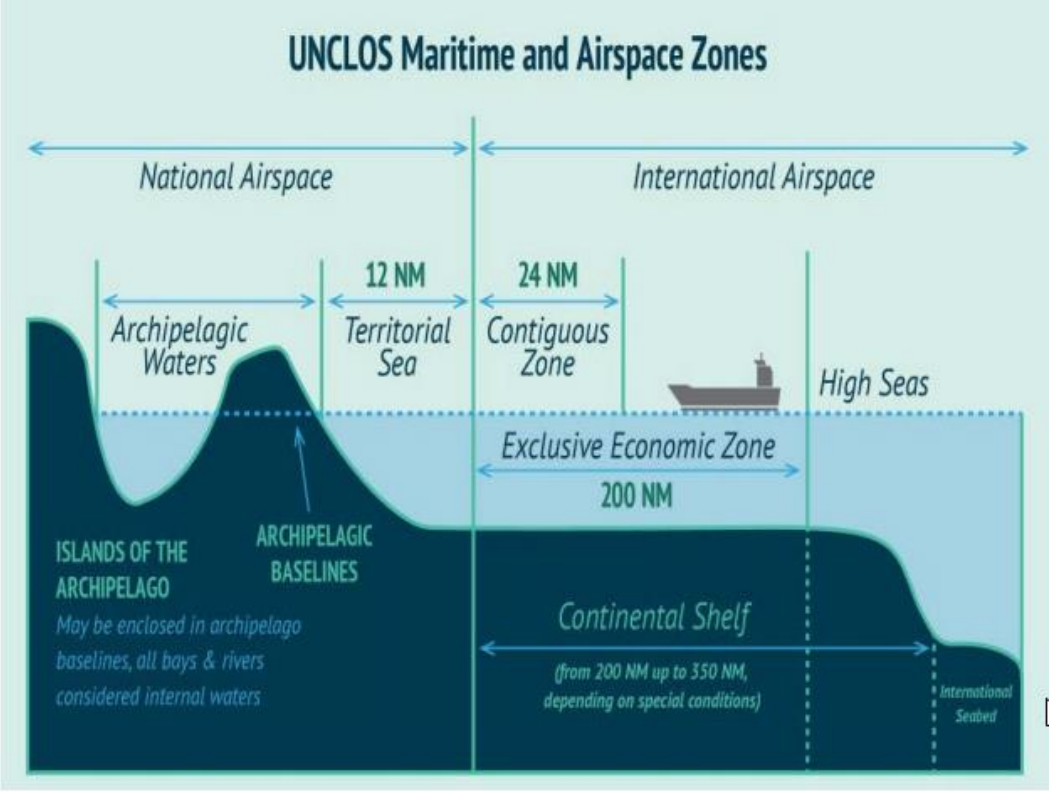

Figure 4 - Diagram Showing Applicable Zones as created by the UNCLOS

[282] Dempsey & Manol op cit note 275 at 36.
[283] Dempsey & Manol op cit note 275 at 37-38

A similar approach could be taken to the delimitation of space, in which a convention could:

> "(1) define what constitutes Air Space, where sovereign rights exist;
> (2) define Near Space, where limited rights of States exist; and
> (3) define Outer Space, where no sovereignty exists and is free for use by all."[284]

This would thus remove confusion as there would be Air Space and Outer Space as they are currently known, with an intermediate zone in-between known as Near Space. This would address both the concerns of states and the concerns created by hybrid vehicles. This Near Space could be:

> "like a mix of the UNCLOS Contiguous Zone and Exclusive Economic Zone, open to innocent passage by all, with aerial safety and navigation rules established (presumably by ICAO), enforced by States in Flight Information Regions, and whose aerospace and launch vehicles are subject to Air Law. It could also be restricted against overflights by foreign State aircraft absent permission of the underlying State."[285]

Again however, the difficulty would be in determining the exact heights above sea level at which these zones would be created with suggestions for the start of Near Space being from 18km to 50 km and ending at 120km to 160 km.[286]

3.3. State-Centred Liability

As discussed in the previous chapter, the bulk of liability in outer space is set up by the Convention on International Liability for Damage Caused by Space Objects (Liability Convention)[287]. This convention finds its origins in the outer space Treaty which at Article VI sets out the basis for Liability in space and importantly attributes

[284] Dempsey & Manol op cit note 275 at 42.
[285] Dempsey & Manol op cit note 275 at 44-45.
[286] Dempsey & Manol op cit note 275 at 44.
[287] United Nations Office for outer space Affairs '*Convention on the International Liability for Damage Caused by Space Objects*' available at http://www.unoosa.org/pdf/gares/ARES_26_2777E.pdf accessed on 23 July 2019.

the actions of any non-state actor in space to its state.[288] While the Liability Convention itself never addresses non-state actors in space, it does frame all claims through the lens of a "Launching State", with Article I containing the definition which reads:

> "(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;"[289]

What these treaties consequently do is create a state-centred approach to liability, in which states bear responsibility and liability for all actions conducted in space by their own space agencies and also any private enterprises based within their borders or utilising launch services within their borders.

> "States thus bear responsibility for their own space activities, as well as for the activities carried out by non-governmental entities that launch space objects from their territories. In addition, the activities of non-governmental entities must be authorised and continuously supervised by the relevant state. This broader form of accountability in Outer Space Law differs from the equivalent in international air law, where the state is responsible only for the regulation of the private entity, such as an airline, but not for damage caused by it. This provision in the outer space Treaty is significant, as space activities carried out by private entities are rapidly increasing."

The process set up by which supervision occurs changes according to domestic legislation. South Africa, by way of example, utilises a statuary licencing regime to authorise private space activities.[290] In contrast, France - which has its own launch services and a much more robust private space industry - has no licencing system.[291] However when it comes to making a claim through the Liability Convention the process from a private entity becomes rather convoluted and potentially prohibitive to any claim.

> "…in practice, it is a customary principle that governments are able to claim on behalf of their national corporations or individuals who are injured in space. Such claims must be brought forward through diplomatic channels within a year of the occurrence of the

[288] United Nations Office for outer space Affairs 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies' available at http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf accessed on 17 April 2019.
[289] UNOOSA op cit note 287.
[290] Snyman op cit note 16.
[291] Ibid.

> damage. In the event that a resolution is not achieved through diplomatic channels, the process will need to operate under Article XIV of the Liability Convention, which provides that the matter shall continue via a Claims Commission established at the request of either party related to the conflict. This Claims Commission has the power to decide on both the procedure and the amount of the reparation on a majoritarian basis. The Commission's decisions are reached and made public within a year of its establishment and are 'final and binding' in nature."[292]

There are two potential sources of concern that a private entity may encounter when trying to utilise the mechanism created by the Liability Convention. Namely the state against whom the claim is instituted against and potentially even more prohibitively the entities home state.

> "Article VIII of the Liability Convention requires that the state--not the injured person--present the claim to the "launching state"--not the person who caused the injury. Because nations and not individuals are involved, under article IX, claims for compensation must be presented "through diplomatic channels." If the two states in question do not have diplomatic relations then the claimant may present its claim through another state or through the Secretary General of the United Nations."[293]

As with the Rome Statute and most other international conventions which involve a dispute resolution mechanism, the Claims Commission created by the Liability Convention is only binding if both states consent to its jurisdiction. If they do not, then the finding of the commission is merely a recommendation.[294] Thus without good-faith cooperation between the states the entire process can be stonewalled with little recourse available to the state which brings the claim. Or as Kehrer put it:

> "In short, if the launching state is hostile to the victim state or if it determines that the liability regime is unfair as applied to launching states generally, it will simply not participate in dispute resolution. This undermines the very purpose of the Liability Convention."[295]

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[292] Failat op cit note 237 at 143.
[293] U.S. Congress, Office of Technology Assessment 'Space Stations and the Law: Selected Legal Issues -- Background Paper' available at *http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1011&context=spacelawdocs*, accessed on 25 October 2019.
[294] Trevor Kehrer 'Closing the Liability Loophole: The Liability Convention and the Future of Conflict in Space' (2019) 20 *Chicago Journal of International Law* 187.
[295] Ibid.

However, the claimants own state may refuse to even lodge the claim on their behalf.

> "The 1967 outer space Treaty and the Liability Convention establish no cause of action, no courts, no rules of procedure, and no method of enforcing even agreed resolutions. Lacking such mechanisms, claimants are forced to rely on the diplomatic procedures commonly used between nations."[296]

Tanja Masson-Zwaan, President of the International Institute of Space Law, draws the realistic conclusion from this in her Op-Ed on the Iridium 33 collision (discussed in the previous chapter) stating:

> "Despite all this, it must not be forgotten that, in the end, political circumstances and considerations might well prevent a government from presenting a claim to another government to obtain compensation for damage it, or one of its private entities, has suffered."[297]

Thus, if either state were to refuse to participate in the claims process there is little that a private entity which has suffered damage and loss can do within the Liability Convention to receive compensation for their loss. This has been a long-standing criticism of the Liability Convention as this makes it fail in fulfilling its fundamental purpose. If its purpose is to establish a liability regime the very nature of liability will result in disputes. If the operations of the liability regime created are predicated upon the good-faith cooperation of both states, then it operates as little more than agreed upon guidelines for states which would even in its absence likely have come together through diplomatic channels to resolve their dispute. If the states were unlikely to resolve their dispute in the absence of the Liability Convention, there is no provision within it which makes them any more likely to resolve that dispute. This makes it functionally useless for dispute resolution.

This reality means that a private entity seeking compensation is likely to avoid the Liability Convention in its entirety and seek other legal recourse, which will be discussed later in this chapter. However, there is real concern about the ramifications that a state-centred liability as created by the Liability Convention can have on private entities, this is due to the actions it can cause governments to take.

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[296] U.S. Congress op cit not 293.

[297] Tanja Masson-Zwaan 'Space Law and the Satellite Collision of 10 February 2009 (2009) *Space Research Today* 9.

Discussing the effects of the Liability Convention, Yanal Abul Failat writes:

> "…its overall effect obliges states to authorise and supervise private entities to ensure that their conduct does not render the state liable for their actions. This can be unfair since states, in certain scenarios, may not be directly involved in the offending activities and may not be benefiting from them. This is further hampered by the Convention's failure to cap the amount of compensation. The seemingly unlimited compensation can have a chilling effect on the development of private space programmes, as the state will likely seek reimbursement from private entities for any loss suffered."[298]

This can manifest itself in several potential concerns for a private entity.

Firstly, seeking to limit their exposure, certain countries may take legislative measures to severely limit or even outright prohibit private space enterprise. This is especially likely amongst those countries in the developing world who might already take the approach that space exploration and exploitation is not a valuable endeavour in comparison to their more immediate and terrestrial concerns.

In those states which do not prohibit, but rather implement oversight mechanisms and regulations, these measures are likely to increase the costs of operation for a private entity. A state would likely have to evaluate and regulate "the private operator's technical capabilities, stability, solidity, and financial capacity"[299] and this could manifest in higher costs either through licencing fees and other regulatory costs being passed on by governments or by the increased cost associated with adhering to higher and stricter standards.[300]

This is the exact circumstance in the United Kingdom. Any space activities undertaken by "United Kingdom nationals, Scottishfirms, and bodies incorporated under the law of any part of the United Kingdom"[301] are governed by its outer space Act of 1986 (OSA). The OSA, as with most domestic legislation on space activities, aims to ensure UK law complies with international treaties and enforces registration of objects as well as addressing liability for damage caused by space objects.[302] It addressed liability concerns in two major, prohibitive manners which thus far have been unique to the

[298] Failat op cit note 237 at 134.
[299] Failat op cit note 237 at 134.
[300] Scott Pace 'Regulating Outer Space: Making Space Commerce a Priority' (2016) 95 *Foreign Affairs*
[301] s2(1) outer space Act 1986.
[302] Failat op cit note 237 at 136.

UK.[303] First, it compels private citizens to indemnify Her Majesties' Government against any and all liability brought against the government because of that person's actions.[304] While this was initially an unlimited waiver, thus there was no cap to the liability, this has since been amended to require liability caps be stated on the licence issued.[305] Second, it allows the Secretary of State in issuing a license to require that the licensee be insured so as to ensure that Her Majesties' Government is able to recover any funds owed as a result of the indemnification.[306] These two requirements put any UK national or organisation at a competitive disadvantage when compared to competitors in a state without such requirements as it increases operation costs and liability concerns.

Compare this with the perhaps more commercially favourable approach, from a private entity's perspective, of the Russian Federation, a massive launch provider and at the time of writing the only launch state which has the capacity to put humans in orbit. Pulling here from the discussion by A. Kerrest de Rozavel and F. G. von der Dunk on the differing approaches of European countries to liability created by the Liability Convention:

> "The Russian Federation has a quite complex formulation to deal with the twin issues of liability reimbursement and insurance of the licensee for such events. Firstly, "[t]he types, forms, and terms of licenses, the conditions and procedures for their issue, withholding, suspension or termination, as well as other questions of licensing shall be regulated by legislation of the Russian Federation"—in other words, are deferred for the time being to further implementation. Secondly, however, the phrases "[t]he Russian Federation shall guarantee full compensation for direct damage inflicted as a result of accidents occurring while carrying out space activities in accordance with legislation of the Russian Federation" and "[c]ompensation for damage inflicted as a result of accidents occurring while carrying out space activities shall be paid by the organizations and citizens responsible for operation of the space technics involved" seems to suggest unlimited liability reimbursement would be the baseline rule.
>
> Thirdly, regarding the relationship between liability reimbursement and insurance it is provided that "the liability of organizations and citizens participating in the creation and

[303] Failat op cit note 237 at 136.
[304] s10(1) of the Act.
[305] s10(1A) of the Act.
[306] s13 of the Act.

use of space technics for damage inflicted as a result of accidents occurring while carrying out space activities shall be limited to the amount of the insured sum or insurance indemnity provided in contracts of insurance of space technics and risks involved in space activities"—but also: "if the insured sum or insurance indemnity is insufficient for compensation of the damage inflicted as a result of accidents occurring while carrying out space activities, recourse may be taken against the property of relevant organizations and citizens in the manner specified in legislation of the Russian Federation." This suggests, at least, a limitation to reimbursement in first instance whilst nevertheless allowing the Russian authorities a basis for claiming reimbursement of amounts above such limits if warranted by special circumstances.

Finally, on insurance itself the Law provides "[t]he organizations and citizens which exploit space technics or on whose order the creation and use of space technics for scientific and national-economy purposes is carried out, shall take compulsory insurance coverage in the amount set by legislation of the Russian Federation." Whereas it is not unequivocally clear that such insurance would cover the reimbursement obligation, that may at least be assumed.

Throwing in the competences of the licensing authority (that is Roskosmos, the Russian Space Agency) to determine the particular contents of any license,26 the result is that the requirements regarding liability and insurance can be tailored very much to specific instances at hand—but also a concurrent lack of legal certainty and transparency"[307]

Regulatory concerns are likely to be at the forefront for a private entity which is trying to remain competitive in the market and may push private entities to base and launch from states which are either incapable or unwilling to control and supervise the activities of private space operators within their borders.[308] This is already seen today in the international shipping industry with container ships and even cruise liners often flying a "flag of convenience" as opposed to what may be considered the legitimate flag of their home country. "Ultimately this may lead to victims of the same type of accident receiving different compensation and thus, forum-shopping."[309]

[307] A. Kerrest de Rozavel & F. G. von der Dunk 'Liability and Insurance in the Context of National Authorisation' in F.G. von der Dunk (ed) *National Space Legislation in Europe* vol 6 (2011) 128.
[308] Failat op cit note 237 at 134.
[309] Failat op cit note 237 at 134.

Adrian Taghdiri in his discussion on the concerns of flags of convenience in the space industry notes:

> "…as the space tourism industry grows in the next decade, several countries may establish loose regulatory regimes in an effort to attract private space groups. This "flags of convenience problem," prolific in the shipping industry, may lead to irreversible environmental damage, increased space debris, and safety hazards to space tourists." [310]

He goes on to note that due to the lack of enforcement mechanisms in international law, as discussed above, there are no real disincentives for a state to create regulatory frameworks which are intentionally slack so as to attract operators to become tax resident in their states.[311]

The state-centred approach to liability, as shaped by the Liability Convention, creates numerous complexities and challenges for a private entity seeking compensation. Seeing this, any private entity is likely to bypass the Liability Convention and associated liability regime and attempt to gain recourse through more traditional means such as the courts. Discussing this, the US Congress's Office of Technology Assessment notes:

> "Perhaps in anticipation of the problems [around state-centred liability], the drafters of the Liability Convention stated in article XI that: 'Nothing in this Convention shall prevent a State, or the natural or juridical persons it might represent, from pursuing a claim in the courts. ..of a launching state.' Indeed, given the vague nature of the Liability Convention as compared with the well-defined state of domestic law, it would be unlikely that any individual would ever use it to obtain compensation for injury."[312]

The applicable law in those courts depends on the respective state's approach but is likely to follow one of two approaches. Either *lex fori*, that is the law of the country in which the forum or court is situated, or alternatively the law of the state having the greatest interest. The later standard is one commonly used in the United States - a likely launch state for private entities.[313] The other common approach to determining

[310] Adrian Taghdiri 'Flags of Convenience and the Commercial Space Flight Industry: The Inadequacy of Current International Law to Address the Opportune Registration of Space Vehicles in Flag States' (2013) 19 *Journal of Science and Technology Law* 405.
[311] Ibid.
[312] U.S. Congress op cit note 293 at 47.
[313] U.S. Congress op cit note 293 at 48.

applicable law to a delictual matter, namely *lex loci delecti* or the law of the place where the delict occurred, is unlikely to be used due to there being no applicable national law to an incident which occurs in Outer Space. It is also likely that in instances where a contractual relationship exists (e.g. passengers or payloads aboard a tourist or transport vessel) that the contract will specify the applicable courts and law in the event of a dispute.

Determining which domestic court is used is similarly dependant on the rules of the court in question. If, for example, the incident occurred on one vessel or multiple vessels with the same flag state, then the flag state of that vessel would have jurisdiction.[314] If it occurred between two vessels with different flag states, then it would depend on the laws of those flag states. If one was South African for example, then one would apply the normal rules of establishing jurisdiction, such as *actor sequitur forum rei* or consent/submission. The citizenship of the specific individuals involved may also be considered, for example a French Citizen has a statutory right in French law to always have, as a means of recourse, the ability to approach the French courts, even if the dispute occurred in foreign territory or involved a foreign national.[315]

Utilising domestic courts, may have several short comings for any potential private entity. Any foreign government or intergovernmental organisation which may be involved in the dispute is "likely to raise the bar to jurisdiction of sovereign immunity" as even if the operations of a mostly commercial nature "there might be many aspects of a sovereignty-sensitive nature involved."[316] If one where to establish jurisdiction utilising *actor sequitur forum rei* this would involve an entity having to attempt to enforce its rights in a foreign jurisdiction against a native entity. Speaking on a hypothetical scenario of a foreign entity attempting to do this against a US based entity or even the US Government, Frans von der Dunk writes:

> "From a practical (and political) point of view, such claims would require the claimant to travel to the United States, introduce his claim in English to US courts, possibly hire a US lawyer, and suchlike. There would be no fundamental legal impediment for non-

[314] Taghdiri op cit note 310.
[315] See Article 14 of the French Civil Code; David W. Gruning 'Civil Code, as of 1st July 2013' available at *https://www.wipo.int/edocs/lexdocs/laws/en/fr/fr512en.pdf*, accessed on 29 October 2019.
[316] Frans G. von der Dunk 'About the New PCA Rules and Their Application to Satellite Communication Disputes' in Mahulena Hofmann (ed) 'Dispute Settlement in the Area of Space Communication: 2nd Luxembourg Workshop on Space and Satellite Communication Law' (2015) 102.

> US citizens to do so, but in practice it might turn out to be rather difficult to assert one's claims."[317]

This would become even more difficult in a jurisdiction with a legal system significantly different from the entities' native one, or in states which have less impartial or developing judicial systems. This latter point becomes more important when considering the flags of convenience argument made earlier.

Alternative dispute resolution mechanisms that a private entity may employ could include approaching the Permeant Court of Arbitration (PCA) in The Hauge. Such a method would however require the consent to arbitration of the parties involved but would allow for the appointment of adjudicators which are known to not only be impartial but may have the specific knowledge needed for the often niche disputes involved in disputes in the outer space industry.[318] The PCA has in recognition adopted specific rules for arbitration around disputes occurring in outer space industry.

> "The Permanent Court of Arbitration (PCA)[3] recognized a perceived need for specialized rules of arbitration for matters relating to the rapidly developing area of outer space activities. This led the PCA to initiate a project in 2009 to create a set of rules of arbitration that would meet the specific needs of disputes arising from outer space activities. This project led to the Optional Rules for Arbitration of Disputes Relating to outer space Activities (the Rules), which were adopted by the PCA on December 6, 2011. The Rules adopted by the PCA recognize that the scope of outer space activities involve not only the potential for dispute among nations in outer space activities, but disputes among private parties whose activities involve a component of or otherwise involve outer space activities… The Rules are based on the 2010 UNCITRAL Arbitration Rules[4] and have been modified to address the particular needs of disputes involving the use of outer space by nations, international organizations and private entities."[319]

These rules aim to create an arbitration process which:

> "takes into account terrestrial aspects versus space aspects, national law, and jurisdiction versus international law and the "global commons" character of outer space, the various categories of actors and stakeholders, public as well as private (and

[317] Ibid.
[318] Ibid.
[319] Michael Listner 'A new paradigm for arbitrating disputes in outer space' available at *http://www.thespacereview.com/article/2002/1,* accessed on 29 October 2019.

> including any contractual law issues), and finally the technological and operational complexities of the sector—each at least as well as, and often more efficiently and coherently than those other mechanisms."[320]

This may currently present the best approach for a private entity seeking to resolve a dispute, however as previously noted it requires the consent of both parties to the arbitration. In the case where one party is seeking to enforce its rights against a delinquent party, there are few appealing options which may be used, as is the nature of any operations which occur outside of any sovereign enforcement agency.

3.4. Legal Status of Space Tourists

Article V of the outer space Treaty starts:

> "States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle"[321]

The *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into outer space* (Rescue Agreement) refers throughout to "the personnel of a spacecraft."[322]

Could space tourists be considered astronauts under these agreements? There is no definition of an astronaut (interchangeable here with cosmonaut or spationaut) in the *corpus iuris spatialis in iuri gentium*.[323] Similarly, there is no definition or mention of space tourist, which is to be expected as the drafters would never have foreseen the possibility of space being utilised by civilians.[324] "International Space Law has not yet

[320] von der Dunk op cit note 316 at 109.
[321] UNOOSA op cit note 31.
[322] UNCOPUOS 'Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space' available at *http://www.unoosa.org/pdf/gares/ARES_22_2345E.pdf*, accessed on 30 October 2019.
[323] de Gouyon Matigon op cit note 238; Hobe op cit note 229 at 455.
[324] Failat op cit note 237 at 122.

reached a level where the legal status of commander, crew, and passengers are sufficiently defined."[325]

Under international law, interpretation when there is a lack of definitional clarity operates under both an analysis of the ordinary meaning of words and the intention of drafters at the time of preparation. Stephen Hobe in attempting to broach this topic notes that "…'astronaut' has a more explorative or scientific meaning, 'personnel' has a more functional meaning, and 'envoy of mankind' has a more humane meaning."[326] Speaking on the intention of the drafters to the meaning of 'envoy of mankind', he notes:

> "This seems to be of rather symbolic value though. The preparatory works in UN COPUOS suggest that states did not assume that any specific legal rights or duties would result from the status as "envoy of mankind."[327]

It seems unlikely that a space tourist would fulfil an explorative, scientific or functional role aboard a space vessel, and that they are more akin to passengers upon an aircraft. I would thus argue that under the ordinary meaning, space tourists would qualify as neither astronaut nor personnel. This would be reinforced by looking at their purpose aboard the space vessel. If they are aboard to ensure the safe operation of the vessel or the safety and comfort of those aboard, then I would argue they are personnel. If they are aboard from some explorative or scientific purpose, ie a research purpose, then I would argue they are astronauts. If they are aboard merely to experience being in space, then I would argue they fit neither definition and instead are space tourists/passengers.

As to the intention of the drafters, it is clear from the context of the treaties that civilians going to space was not considered to be possible within the lifetime of the treaty.[328] Further discussing the possibility of the privileges and immunities offered to astronauts being extended to space tourists, Smith and Hörl note that it was "not the intention of the treaty makers to cater for this group."[329]

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[325] Hobe op cit note 229 at 457.
[326] Hobe op cit note 229 at 455.
[327] Hobe op cit note 229 at 455.
[328] de Gouyon Matigon op cit note 238.
[329] Lesley Jane Smith & Kay-Uwe Hörl 'Legal Parameters of Space Tourism' available at *http://www.weber-steinhaus.com/bereiche_de/publikation_downloads/003LegalParameters.pdf*, accessed on 01 November 2019.

Pulling from the work of Francis Lyall and Paul B Larsen, Yanal Abul Failat argues that in attempting to define a space tourist as an astronaut one should have two main considerations, training and altitude.[330]

> "Firstly, various providers of space tourist services require and provide training for their customers. For instance, programmes such as the Atlas Aerospace Crew Training Program and Project Odyssey provide medical screening, centrifuge, and cosmonaut or astronaut training for prospective space tourists. Tourists undertaking this type of training are more likely than others to be considered astronauts. But, if training is considered to be an element of achieving the status of an astronaut, then an assessment of the longevity and the extent of the training may also be required. To illustrate, before a space tourist can visit the International Space Station, they are required to have at least six months of training. Further training is necessary if tourists decide to enjoy additional activities, such as space walks, which are offered by providers such as Space Adventures. By contrast, Virgin Galactic customers undertake only one week of training and, in some cases, as few as three days of training."[331]

They then go on to discuss the issues with the second criteria of altitude, which has already been noted earlier in this chapter. I would agree that looking at the training one has undergone is important in making the determination of their status, however I believe that looking at their purpose aboard the space vessel is a simpler and more robust method which would likely involve considering their training in any case.

Of interest to investigate is the example Failat gives of the International Space Station (ISS). Having had space tourists aboard and having an agreement amongst the member nations as to the definitions of people aboard and their rights and obligations, the operations of the ISS is perhaps as close as we can get to established practice and custom.

The *Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers* (2002 Agreement),

[330] Failat op cit note 237 at 124.
[331] Failat op cit note 237 at 124.

sets out who is allowed aboard the ISS and what designation they are assigned.[332] It provides for four definitions around people aboard the ISS, reproduced below:

> "Professional Astronaut/Cosmonaut
>
> A professional astronaut/cosmonaut is an individual who has completed the official selection and has been qualified as such at the space agency of one of the ISS partners and is employed on the staff of the crew office of that agency.
>
> Spaceflight Participant
>
> Spaceflight participants are individuals (e.g. commercial, scientific and other programs; crewmembers of non-partner space agencies, engineers, scientists, teachers, journalists, filmmakers or tourists) sponsored by one or more partner(s). Normally, this is a temporary assignment that is covered under a short-term contract.
>
> Expedition (Increment) Crewmembers
>
> Expedition crewmembers are the main crew of the ISS and are responsible for implementing the planned activities for an increment. The right of a partner to have its candidates serve as expedition crewmembers is allocated in accordance with Article 11.1 of the MOUs. As part of this allocation, it may be possible to have spaceflight participants as part of an expedition once the ISS has a crew complement of more than 3 persons.
>
> Visiting Crewmembers
>
> Based on experience to date with visiting vehicles to the ISS, visiting crewmembers travel to and from the ISS, but are not expedition crewmembers. Consequently, the visiting crewmembers do not count as a use of a sponsoring agency's allocation of flight opportunities or crew time on-orbit rights as defined in Article 11.1 and Article 8.3.c of the MOUs. They may be either professional astronauts/cosmonauts or spaceflight participants."[333]

This provides for a clear distinction between "Astronauts" and "Space Tourist" which the 2002 Agreement would term "Space Flight Participants". It further sets out clear criterion for when to consider an individual an astronaut. "Selection" and "Qualified" speak to both the individuals qualifications/training as well as having a specific

[332] ISS Multilateral Crew Operations Panel 'Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers' available at http://www.spaceref.com/news/viewsr.html?pid=4578, accessed on 30 October 2019.
[333] Ibid.

purpose within a recognised “Space Agency”. It also clearly states they need to be in the employ of a recognised space agency, again speaking to their specific purpose.

By contrast the 2002 Agreement gives a list of individuals who would specifically not be considered astronauts, including tourists. It must be noted that the board range of individuals listed under “Space Flight Participants” - which includes a number of professionals who might otherwise be considered astronauts under an approach looking at their purpose and training - seems to indicate that the most important qualifier in being a “professional astronaut” is the association with a recognised “partner space agency”. It should be noted that this does not seem, as the definition would suggest, to be limited to only those space agencies officially apart of the ISS programme, with other state space agency also having “astronauts” aboard the ISS on occasion. Discussing this, Sara Langston and Sarah Jane Pell write:

> “Astronauts sponsored by participating nations (but who are not States Parties to the intergovernmental ISS Agreement) have flown to the ISS under these crew selection criteria. Private individuals or space tourists, as they are colloquially called, fly under the definition and role of ‘spaceflight participants’.”[334]

From this, it appears the true definition of an Astronaut within the 2002 Agreement, is an individual in the employ of a state sponsored space agency, who is trained to operate aboard the ISS.

The proviso under “Expedition Crewmembers” that “it may be possible to have spaceflight participants as part of an expedition once the ISS has a crew complement of more than 3 persons”[335] seems to indicate that astronauts have as one of their mandates the safe functioning and operations of the ISS. This would again seem to indicate that an astronaut must have as one of their roles, flight operations.

There is one instance in which there is no ambiguity in law, a space tourist would be considered an astronaut if they set foot upon the moon. The *Agreement Governing the*

[334] Sara Langston & Sarah Jane Pell ‘What is in a name? Perceived identity, classification, philosophy, and implied duty of the ‘astronaut’ 115 (2015) *Acta Astronautica* 189.
[335] Ibid.

Activities of States on the Moon and Other Celestial Bodies (Moon Treaty) states at Article 10(1):

> "States Parties shall adopt all practicable measures to safeguard the life and health of persons on the Moon. For this purpose they shall regard any person on the Moon as an astronaut within the meaning of article V 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 and as part of the personnel of a spacecraft within the meaning of the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space."[336]

This in no uncertain terms indicates that any person upon the moon is an astronaut, regardless of purpose or training. Of course, there are questions around how applicable this provision may be within the *corpus iuris spatialis in iuri gentium*. As noted by Christopher Newman and Michael Listner:

> "The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the Moon Treaty) is considered to be a 'failed treaty' due to the low number of states agreeing to be bound by its provisions."[337]

Expanding on this Gennady Danilenko writes:

> "By 1984 the Moon Treaty had been ratified by five states and in accordance with its provisions had entered into force; however, although the treaty was negotiated by consensus it had not been ratified by the major space powers.6 It is beyond dispute that a treaty not ratified by states whose participation is crucial for the implementation of its provisions cannot be effective. The present signatories to the Moon Treaty who do not possess the necessary technical means to launch objects into outer space and to explore and exploit the resources of the Moon simply do not have the necessary effective power to bring this legislative project into operation."[338]

As of 2019, the list of states who have either acceded to or ratified the Moon Treaty has increased slightly to 18, however no major space fairing nation has ratified the

[336] UNCOPUOS 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' available at *http://www.unoosa.org/pdf/gares/ARES_34_68E.pdf*, accessed on 30 October 2019

[337] Christopher Newman & Michael Listner 'Failure to launch: the technical, ethical and legal case against Mars One.' available at https://sure.sunderland.ac.uk/id/eprint/5992/1/MarsOneTSR%20Final%20%28revised%7D.pdf accessed on 31 October 2019.

[338] Gennady M. Danilenko 'International law-making for outer space' 37 (2016) *Space Policy* 180.

treaty.[339] This does not make the Moon Treaty completely invalid however, as it only required 5 ratifications to enter force, which is has achieved and so is technically a valid instrument of international law.[340] Thus as Michael Lisner argues in another paper of his written in 2011:

> "Even with only six nations ratifying the Moon Treaty, the fact that eleven other nations, including Australia, France, and India, have acceded to or become signatories to the Moon Treaty creates a shadow of customary law that could grow such that non-parties could find themselves overshadowed by the penumbra of the Moon Treaty, especially if those non-parties take no action to refute its legitimacy."[341]

The status of the Moon Treaty will be discussed in more detail in the next Chapter.

The importance of clarity as to whether a space tourist could be defined as an astronaut comes from the increased rights and obligations afforded to astronauts within Space Law. As highlighted by Stephen Hobe:

> "Generally, the states exercising jurisdiction over a person have the authority to determine the rights and duties of passengers. However, international law contains a number of more specific regulations."[342]

He goes onto explain this importance stating:

> "This could have a considerable impact on passenger rights and obligations. For instance, the first sentence of Article V(1) of the outer space Treaty obliges states to render to astronauts 'all possible assistance in the event of accident, distress, or emergency landing on the territory of another State party or the High Seas.' Thus, the main implications of the status of an astronaut are obligations in case of emergency, which are further specified in the Rescue Agreement. According to the Rescue Agreement, such obligations apply more generally to 'personnel of a spacecraft.'"[343]

It could thus be stated that within the *corpus iuris spatialis in iuri gentium*, there is a dual value to being labelled as an astronaut. Firstly, the obligation it then places on

[339] According to the UN Treaty Collection site, available at *https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXIV-2&chapter=24&clang=_en*, accessed 31 October 2019.
[340] Michael Listner 'The Moon Treaty: failed international law or waiting in the shadows?' available at *http://www.thespacereview.com/article/1954/1*, accessed on 31 October 2019.
[341] Ibid.
[342] Hobe op cit note 229 at 454.
[343] Hobe op cit note 229 at 455.

states, and nearby astronauts, to “render all possible assistance” in the event of emergency and secondly, to be returned to one’s home state without delay when landing back on earth, regardless of landing spot.

As noted, the drafters of both the outer space Treaty and the Rescue Agreement only considered that the treaties be applied to astronauts, however the purpose and sentiment of such provisions was to protect those who ventured into the dangers of space.[344] In light of the view that the agreements where “prompted by the sentiments of humanity”[345] it has been argued that “it is inconceivable that in the case of an emergency only the astronauts would be rescued, without assisting the space tourists on board the space vehicle as well.”[346] Multiple potential justifications have been put forth to expand the scope of the obligation to assist to include all in space, not merely those deemed as astronauts.

Mark Sundahl argues that the bulk of the obligations to rescue and assist comes from the Rescue Agreement. Furthermore, since in the Rescue Agreement the term astronaut is replaced with personnel, with the exception of the title, and there is an omission of the an greater ascription such as “envoy of mankind” the obligation is broadened to include any persons aboard a space vessel, be it a commercial spaceflight or space tourists.[347] He goes onto to elaborate that if this status of the Rescue Agreement is accepted, it must then also trump the outer space Treaty’s narrower terminology, stating:

> “Under the *lex posteriori* rule in Article 30 of the Vienna Convention, the outer space treaty applies 'only to the extent that its provisions are compatible' with the Rescue Agreement. That the Rescue Agreement was intended to supersede the outer space Agreement with respect to the duty to rescue and return is clear. … Therefore, under the operation of the lex posteriori rule, the Rescue Agreement must trump the outer space Treaty where the terms are inconsistent.” [348]

[344] Ling Yan ‘Does the Rescue Agreement apply to space tourists’ (2011) *Proceedings of the International Institute of Space Law: 54th Colloquium on the Law of outer space* 197.
[345] Ibid.
[346] Snyman op cit note 16 at 028/612.
[347] Mark Sundahl ‘The duty to rescue space tourists and return private spacecraft’ (2009) *Journal of Space Law* 163-200.
[348] Ibid.

However as discussed earlier, I would posit that the term "personnel" would not and should not encompass a space tourist. I do however agree that the obligation to rescue should be extended to space tourists but that the complicated legal contortions Sundahl performs in an attempt to justify this are unnecessary. Instead, by looking at the teleological approach to treaty interpretation, space tourists can easily be covered by these obligations. Puling here from the work of Ferreira-Snyman:

> "In terms of this approach the treaty should be interpreted in the light of its object and purpose. As was pointed out earlier, the Rescue Agreement is based on a concern for human life. It is thus clear that the object and purpose of the treaty is to save the lives of people in distress while they are undertaking an outer space activity, irrespective of their status and their function on board the spacecraft. If space tourists were to be left in distress without any attempt by states to rescue them it would constitute a grave infringement of their rights to human dignity and life."[349]

Therefore, even though a space tourist would not qualify to be called an astronaut, the function behind the title, the obligation for states to do all they could to ensure their safety, would not fall away.

3.5. Conclusion

We are entering a period of space exploration which will be fascinating, pioneering and for most, inspirational. Humans spaceflight will become more accessible to persons who do not have the privilege of being born in a spacefaring nation and who have not dedicated their entire lives to the pursuit of space exploration. For the foreseeable future it will still be limited to those of significant wealth but progressively this barrier will lessen. What remains to be seen is how the law will develop to address this reality and whether this development will be as a result of parties being proactive or, as it so often is, as a result of tragedy.

[349] Snyman op cit note 16 at 030/612.

CHAPTER 4 – FUTURE COMMERCIAL OPERATIONS IN SPACE: RESOURCE HARVESTING

For all of modern space flight there has been a focus on two things: the ability to easily get into space and the information we can more easily gather and communicate by being in space. All satellites and people (with the exception of the previously mentioned 7 multi-millionaire space tourists) in space have had as their mission to either gather information – experiments on the ISS, earth observation or outwards observation of the rest of our solar system, galaxy and universe – or to transmit information. In space it is truly the age of information.

If we are to venture forth off our pale blue dot, to the Moon and Mars, then Ganymede and Titan, before eventually venturing off to the stars, we will likely need a greater incentive than information. Information is valuable but the enormity of costs to venture forth is unlikely to be covered by information alone. Instead, we are likely to be funded by the same reason we ventured forth during the age of discovery here on earth - raw materials; gold, platinum-group metals, rare-earth elements and perhaps most valuable of all, water.

What will push us to the stars is the vast wealth they hold, however as it is here on earth, when there is enormous wealth to be gained there is also enormous greed. With greed comes conflict and in order to prevent/resolve conflict we need law. This chapter will analyse the existing law we have around resource harvesting in space, how its attempt to mitigate conflict currently stifle commercial efforts, and how we might better formulate the law so it may better facilitate resource harvesting in space. In doing so we will first look at what resource harvesting in space will mean both from a technological standpoint and an economic one.

4.1. Resource Harvesting in Space

As we did earlier, before we can have a fruitful discussion on the legal issues relating to resource harvesting, we must establish a sufficiently detailed baseline understanding of the technological and economic considerations. This will allow for a well-rounded and truthful discussion on the consequential legal considerations.

Our global economic system – capitalism – requires goods. While services can be valuable, the core of the economic system is the movement and sale of goods.[350] To have goods we need industry and for industry to operate we require raw materials.[351] For the entirety of human history we have harvested those resources here on earth. For example, cutting down trees for wood, the harvesting of silk from cocoons and cotton from cotton plants or the extraction of minerals and crude oil from the earth's crust. These raw materials are the fuel that we use to keep our economic system running.

> "… the modern economy needs constant and indefinite growth in order to survive. If growth ever stops, the economy won't settle down to some cosy equilibrium; it will fall to pieces… An economy built on everlasting growth needs endless projects…" [352]

The pursuit of projects is something humanity has become quite adept at in the last century and has resulted in seemingly endless and rapid economic growth. Indeed, the colonisation of space is a continuation of our seeking for projects to fuel our economic growth and is likely to be one which will be very fruitful both economically and in terms of knowledge and scientific progress. However, endless projects require endless resources, endless goods, endless materials and it is here that we encounter a hard truth of physics … Earth's resources are finite.

For most of history, the resources of earth have been so plentiful that they were, if not in actuality, in effect limitless. We could always prospect and find more gold, oil or coal. Whatever we needed, through some effort we could find and harvest it within the confines of our planet This, however, might soon become fiction. It is estimated that we will deplete global coal reserves in the next 150 years or sooner, natural gas in the next 50 years and crude oil in the next 48 years.[353] While we may be able to develop renewable energy or nuclear energy solutions which see our energy needs taken care of, this requires materials - especially rare-earth elements/metals and platinum-group metals.

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[350] John Bosco Nkumunue *New Theory and Practice of Capitalism* (2014) ch 5.
[351] Ibid.
[352] Yuval Noah Harari *Homo Deus* (2016) 59.
[353] World Coal Association ´Where is coal found?' available at *https://www.worldcoal.org/coal/where-coal-found,* accessed on 11 November 2019.

We are increasingly becoming more dependent on minerals which are either rare in sizable deposits on earth (such as helium which is used in many medical and scientific applications[354] or lithium which is used in pretty much every consumer electronic device with a battery[355]) or difficult to harvest (such as the rare-earth metals used in everything from computer components and LED's to aerospace components and x-ray machines.)[356]

> "If you need to know one thing about rare earth metals, it's that they're crucial to modern technology, helping power everything from MRI machines and satellites to headphones and nuclear reactors… The name "rare earth" is a historical misnomer, stemming from the fact that when they first discovered they were difficult to extract from surrounding matter. The USGS (United States Geological Survey) describes rare earth elements as "moderately abundant," meaning that they're not as common as elements like oxygen, silicon, aluminum, and iron (which together make up 90 percent of the Earth's crust), but still well dispersed around the planet… unlike copper and similarly well-known elements, such as gold and silver, rare earths don't clump together in single-element lumps. Instead, because of their similar chemical composition they bond freely with one another in minerals and clays… To create rare earths from the ore that contains them the extracted material has to be dissolved in solutions of acids, over and over again, then filtered, and dissolved once more… Rare earth ore goes through these steps hundreds and hundreds of times, and for each new mining location, the concentration of the acids used has to be recalculated in order to target the specific impurities in the soil. To top it off, the whole process produces any number of nasty chemical byproducts and is radioactive to boot."[357]

The highly toxic nature of this extraction process has resulted in most countries being unwilling or unable to mine and process rare-earth metals within their own countries.

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[354] Ian Sample 'Huge helium gas find in east Africa averts medical shortage' available at *https://www.theguardian.com/science/2016/jun/28/huge-helium-gas-tanzania-east-africa-averts-medical-shortage*, accessed on 11 November 2019.

[355] Fei Meng *et al* 'Review of Lithium Production and Recovery from Minerals, Brines, and Lithium-Ion Batteries' (2019) *Mineral Processing and Extractive Metallurgy Review* 1-19.

[356] Jeremey Hsu 'Don't Panic about Rare Earth Elements' available at *https://www.scientificamerican.com/article/dont-panic-about-rare-earth-elements/*, accessed on 11 November 2019.

[357] James Vincent 'China can't control the market in rare earth elements because they aren't all that rare' available at *https://www.theverge.com/2018/4/17/17246444/rare-earth-metals-discovery-japan-china-monopoly*, accessed on 11 November 2019.

This has led to China dominating almost 90% of all production in these crucial elements.

Many of these elements which are rare or difficult to access on earth, as well as water-ice, are rather abundant in asteroids in our solar system.

> "All told, there are thought to be more than 150 million asteroids in the inner Solar System alone, and that's only the ones that measure 100 meters (330 ft) or more in diameter. These can be divided into three main groups: C-type, S-type, and M-type, which correspond to those that are largely composed of clay and silicates, silicates and nickel-iron, and metals. The majority - about 75% of asteroids - fall into the category of C-type; S-types make up another 17%; while M-type and other varieties make up the remainder. These latter two groups are thought to contain a huge amount of minerals, including gold, platinum, cobalt, zinc, tin, lead, indium, silver, copper, iron, and various rare-Earth metals. For millennia, these metals have been mined from the Earth's crust, and they have been essential to economic and technological progress."[358]

> "it has been estimated that the value of a single platinum-bearing asteroid could be between $25bn and $50bn. These metals are highly useful and valuable, both on Earth and in space. As a result of Earth's gravity, much of our planet's supply of these metals is found near Earth's core, making the relatively smaller amounts that are more readily accessible in the crust layer even more valuable. By contrast, on asteroids, the lower relative gravity makes these metals easier to access." [359]

These asteroids could provide humankind with an abundance of resources as it ventures forth to conquer the solar-system and in the case of rare-earth elements, moving extraction and refinement off world takes with it the toxicity and radioactivity risk. Furthermore, harvesting resources in space allows us to also undertake production in space. Harvesting water-ice to make rocket fuel, and materials to build spaceships could allow us to build vessels far larger than would be possible with earth bound construction. These spaceships could then go far farther since they wouldn't have to try escape earth's atmosphere first.[360] It is this which will allow us to take to

[358] Matthew S. Williams 'Asteroid Mining: What Will It Involve and Is This the Future of Wealth?' available at *https://interestingengineering.com/asteroid-mining-what-will-it-involve-and-is-this-the-future-of-wealth,* accessed on 12 November 2019.
[359] Scot W Anderson, Korey Christensen & Julia LaManna 'The development of natural resources in outer space' (2019) 37 *Journal of Energy & Natural Resources Law* 228-229.
[360] Ibid.

the stars and is likely to be the main thrust of resource harvesting in space as we go forward.

> "The moon also holds significant amounts of water contained in beds of ice found in 'permanently shadowed craters. Scientists estimate that within about 40 of these craters there are 1.3 trillion pounds or 600 million metric tonnes of water-ice. Translated to rocket fuel, this amount 'would be enough to launch one space shuttle per day for 2,200 years'. This makes the moon a very attractive option to house a space refuelling station, and indeed, there are multiple proposals to this effect."[361]

With clearly a strong value proposition for resource harvesting in space, the question turns to how it might be done. This is a lot less clear than why we might harvest resources in space. However, for the purposes of this discussion, an overview of the general approach, as opposed to the differing mechanics currently being argued within engineering and scientific circles, will be adequate.

Resource harvesting in space in the near future (<100 years) is likely to occur in 3 stages: near-earth asteroids (NEA), Luna and Mars, Asteroid Belt. However, regardless of the stage, there are 4 general steps to any mining venture in space (and indeed on earth); prospecting, extracting, processing and utilisation/manufacture. We will now explore these steps with the reference to NEA's.

Step one involves first identifying a suitable NEA to mine, usually using telescopes in orbit around earth to avoid atmospheric distortion.[362] Once we have found a suitable NEA, a prospecting probe then needs to be sent out to it to confirm what the telescopic observations have indicated and would likely attempt to mine a sample and return it to earth.[363]

The next step depends on the process utilised to mine the asteroid. We could tow the asteroid into an orbit of earth, or more likely place it in orbit of the moon or at the Earth-

[361] Ibid.
[362] Michael Belfiore 'How to Mine an Asteroid' available at *https://www.popularmechanics.com/space/a7942/how-to-mine-an-asteroid-11644811/*, accessed on 14 November 2019.
[363] Zenaida Gonzalez Kotala 'Steam-Powered Asteroid Hoppers Developed through UCF Collaboration' available at https://www.ucf.edu/news/steam-powered-asteroid-hoppers-developed-ucf-collaboration/, accessed on 14 November 2019.

Luna Lagrange Point 1 (EML1)[364] which lies in between earth and the moon.[365] However whether we tow the NEA or mine it where it is, we then need to extract resources from the NEA. This is likely to first be water and as our technology progresses will move onto metals and other minerals.[366] There are several methods that could be used to mine a NEA. Discussing this, Matthew Williams notes:

> "There are several possible techniques that can be used, ranging from the more basic to the highly futuristic. These include surface mining, where minerals could be removed by a spacecraft using scoops, nets, and augurs. Shaft mining is another possible means, where spacecraft equipped with drills bore into asteroids to extract the materials within… Applying heat to asteroids and then collecting the ores or ices as they melt away is another possible method, as is chemical disassociation. At the higher-end of the technology tree, there's the process of using self-replicating robots to harvest resources."[367]

Regardless of the method used, we would then need to process these raw materials, either on site or by transporting it to a refinery in orbit around the earth or moon. Once refined there are multiple ways these materials could be used. In situ utilisation of water could include using it for life support or by disassociating the molecules into their component parts and using the hydrogen and oxygen as rocket fuel or in hydrogen fuel cells. In the case of materials, we could use them for orbital construction, or perhaps return them back to earth.[368]

It should be noted that resource harvesting in space and returning the materials to earth is unlikely. Until such a time that the scarcity of materials increases to such a degree that their prices rise dramatically, it will simply not be economically feasible. NASA conducted a feasibility study into its own NEA mining project and its report on the topic noted:

> "There is no economically viable scenario we could identify that depends solely upon returning asteroid resources to LEO or the surface of the Earth. To be economically

[364] "A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun or Earth and the moon, equal the centrifugal force felt by a much smaller third body. The interaction of the forces creates a point of equilibrium where a spacecraft may be 'parked'."; Elizabeth Howell 'Lagrange Points: Parking Places in Space' available at *https://www.space.com/30302-lagrange-points.html*, accessed on 14 November 2019.
[365] Anderson et al. op cit note 359 at 233-235.
[366] Belfiore op cit note 362.
[367] Williams op cit note 358.
[368] Anderson et al. op cit note 359 at 236.

> feasible, asteroid mining will depend predominantly upon customers in-space who are part of the space industrial economy and infrastructure. It is possible that secondary markets on Earth may provide "icing on the cake" for platinum-group metals."[369]

However, it did find that within a "industrial space economy" there was a definite business case, holding:

> "A first order calculation of the cost of returning water from a Near Earth Asteroid to a staging base at EML1 yields a cost of $5,205 per kilogram, which compares quite favorably to the $12,295 cost of delivering water there from the Earth using a Falcon Heavy. Once all of the initial costs of establishing the asteroid mining enterprise have been retired and the cost of the returned water can be based solely on the operations cost of asteroid mining then that cost could fall to $1,733 per kilogram. Several techniques exist that could reduce these costs by a factor of two or more."[370]

All of the above may seem more science fiction than reality, however with NASA planning on establishing a permanently manned station around the moon in the next decade[371], and multiple private ventures planning to have orbiting space hotels, Luna bases and even Martian bases in the next decade or two, a viable "industrial space economy" may soon exist. With economists working on the business case, and scientists and engineers working on the technology, it is time for lawyers to work on the regulations and legal frameworks required for these activities.

4.2. OST, Moon Treaty and Private Ownership

There are two seminal articles within the OST which have ramifications for resource harvest in space; Article I and Article II which read as follows:

> "ARTICLE I
>
> The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of

[369] Marc M. Cohen *et al* 'Robotic Asteroid Prospector (RAP) Staged from L1: Start of the Deep Space Economy' available at *https://www.nasa.gov/sites/default/files/files/Cohen_2012_PhI_RAP.pdf,* accessed on 14 November 2019.
[370] Ibid.
[371] Erin Mahoney 'Q&A: NASA's New Spaceship' available at *https://www.nasa.gov/feature/questions-nasas-new-spaceship,* accessed on 14 November 2019.

their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

ARTICLE II

Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[372]

Let us start with Article II. The prohibition of sovereignty off earth has been cited by numerous academics as making resource harvesting in space illegal or to a lessor degree placing it in a legal grey area and potentially leading to a legal wild west of competing claims.[373] I will refute these claims, however it is first useful to understand the intention behind Article II.

It is difficult to truly know what the drafters thought the future of space would look like as one should remember that the drafting of the OST took place in a period when we had only just put man in space[374], before we sent man to the moon[375], and long before we would have a permanent human presence in space.[376] However, what we do know that was at the forefront of their concern was to prevent another scramble for territory

[372] UNOOSA op cite note 31.

[373] Tanja Masson-Zwaan & Bob Richards 'International Perspectives on Space Resource Rights' available at *https://spacenews.com/op-ed-international-perspectives-on-space-resource-rights/*, accessed on 20 November 2019.

[374] Yuri Gagarin completed an orbit of the earth on 12 April 1961.

[375] Apollo 10 would orbit the moon on 22 May 1969, with Apollo 11 landing on the moon on 20 July 1969, some 2 and a half years after the OST was first signed and some 8-9 years before the drafting for the OST began.

[376] The ISS has been permanently manned since 02 November 2000; MIR was permanently manned from 5 September 1989 to 28 August 1999 (Just short of 8 years).

as had occurred in Africa prior to the Berlin Conference[377] and to control the arms race which was occurring between the major superpowers.[378]

> "The 1967 outer space Treaty was the first treaty comprehensively addressing outer space and providing the main legal framework for space activities. Following the State-centred nature and focus of the space endeavour, the Treaty prohibited certain military uses of outer space in an effort to prevent the arms race from spreading to outer space and declared the realm free for exploration and use by all countries, subject to an—initially at least—rather limited set of loosely formulated conditions. These conditions centred around international cooperation, the need for ensuring that space activities would benefit all countries, and an obligation within reasonable bounds to avoid harmful interference in other States' legitimate space activities."[379]

I would argue that when looking at the mindset of the drafters at the time of drafting, it was never their intention to prevent resource harvesting in space.[380] Instead their intention was quite to the contrary - it was to enable any nation to be able to use space. The prohibition on sovereignty was to prevent a monopoly or duopoly over the treasures of space.[381] This position is supported by Article I which is clear in stating that "Outer space, including the moon and other celestial bodies, shall be free for exploration and *use* by all States [emphasis added]".[382] This would seem to indicate that while one country, and by extension an agent or enterprise of that country, may not claim any asteroid or celestial object, using it by harvesting its resources would be allowed. This however raises a potential conflict as noted here by Anderson, Christensen and LaManna:

> "…does the prohibition on national appropriation extend to a grant of private rights over extracted resources? Meaning, can private entities own resources extracted from the celestial body without any nation owning the body itself? The Treaty includes the

[377] Matthew Craven 'Between law and history: the Berlin Conference of 1884-1885 and the logic of free trade' (2015) 3 *London Review of International Law* 31-59.
[378] Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl 'Cologne Commentary on Space Law, Volume I: The outer space Treaty' (2011) 27 *Space Policy* 252.
[379] Frans G von der Dunk 'Billion-dollar questions? Legal aspects of commercial space activities' (2018) 23 *Uniform Law Review* 418-446.
[380] Joanne Irene Gabrynowicz 'Written Testimony of Joanne Irene Gabrynowicz Before the Committee on Science, Space and Technology United States House of Representatives' available at *https://science.house.gov/imo/media/doc/DraftGabrynowicz%20Testimony.pdf*, accessed on 22 November 2019.
[381] Ibid.
[382] UNOOSA op cit note 31.

> phrase ‘exploration and use’ twice in its terms. The word ‘use’ seems to indicate that leveraging space resources was within the contemplation of the drafters, and thus, not prohibited. Still, it is unclear how rights would be distributed where national appropriation is prohibited. The diplomatic history of the Treaty indicates that perhaps this point was left ambiguous deliberately in order to gain support across nations.”[383]

Another point of ambiguity they flag stems from Article I’s statement that the use and exploitation of outer space “shall be carried out for the benefit and in the interests of all countries”.[384] This raises further questions around the ownership of the extracted materials, with them noting that “some have argued that this clause mandates an international profit-sharing mechanism”.[385] However, as Tronchetti states:

> “The drafters of the outer space Treaty considered the space era as an opportunity for development for all humankind. It is, however, generally understood that Article 1 of the outer space Treaty does not set forth any mandatory requirement to share benefits resulting from space operations.”[386]

Leslie Tennen points out that there is no internationally accepted definition of “celestial body” and so while the commentary thus far has assumed applicability of the OST to asteroids, this may not be the case. She writes:

> “By its terms, article II applies to ‘outer space,’ the ‘Moon,’ and ‘other celestial bodies.’ A threshold inquiry is whether an NEO [Near-Earth Object] is a celestial body, and therefore subject to the non-appropriation principle. It can be asserted that if an NEO is not a celestial body, the NEO is outside of the prohibition of national appropriation… The scientific community, acting through the International Astronomical Union ("IAU"), has adopted its own definitions of various celestial bodies, with revisions last made in 2008. Currently, the various objects which can be found within the solar system and its environs include the Sun, the planets (including Earth), the Moon, the moons of other planets, NEOs, asteroids, comets, dwarf planets, transNeptunian objects (including plutoids), and Kuiper belt objects. The designation of an object as a dwarf planet, trans-Neptunian object, plutoid, or other category of body does not have legal significance insofar as the outer space Treaty is concerned. Should the IAU or other

[383] Anderson et al. op cit note 359 at 239.
[384] UNOOSA op cit note 31.
[385] Anderson et al. op cit note 359 at 239.
[386] Fabio Tronchetti ‘The Moon Agreement in the 21st Century: Addressing Its Potential Role in the Era of Commercial Exploitation of the Natural Resources of the Moon and Other Celestial Bodies’ (2010) 36 *Journal of Space Law* 499.

competent scientific body adopt a definition of "celestial body" which excludes one or more enumerated categories of objects, a question would be presented as to the legal significance and the applicability of the *corpus juris spatialis*, the body of Space Law, to the excluded objects. However, in the absence of such action by the international scientific community, the intent and purpose of the outer space Treaty would be better served and promoted by an expansive definition of "celestial body" to include all natural bodies within the solar system, excluding only the Earth."[387]

For the purposes of this discussion we will continue under the common assumption that all-natural bodies excluding the earth are "celestial bodies".

A comparison which can be made is to commercial fishing or to seabed mining in the high seas. As previously mentioned, UNCLOS addresses the issues of international waters, including the creation of EEZ's and the rights of entities to resource harvesting in the high seas. In its preamble it states that UNCLOS "will promote the economic and social advancement of all peoples of the world" - a similar clause to the OST's Article I.[388] It establishes a Freedom of the High-Seas at Article 87 which reads:

"1. The high seas are open to all States, whether coastal or land-locked. Freedom of the high seas is exercised under the conditions laid down by this Convention and by other rules of international law. It comprises, inter alia, both for coastal and land-locked States:
   (a) freedom of navigation;
   (b) freedom of overflight;
   (c) freedom to lay submarine cables and pipelines, subject to Part VI;
   (d) freedom to construct artificial islands and other installations permitted under international law, subject to Part VI;
   (e) freedom of fishing, subject to the conditions laid down in section 2;
   (f) freedom of scientific research, subject to Parts VI and XIII.
2. These freedoms shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas, and also with due regard for the rights under this Convention with respect to activities in the Area."[389]

[387] Leslie I. Tennen 'Towards a New Regime for Exploitation of outer space Mineral Resources' (2010) 88 *Nebraska Law Review* 796-797.
[388] UNCLOS 'United Nations Convention on the Law of the Sea' available at *https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf,* accessed on 25 November 2019.
[389] Ibid at Art.87.

Furthermore, just like Article II of the OST, Article 89 of UNCLOS restricts any claims of sovereignty over the high seas. The similarities between the two conventions continue with demilitarisation[390], freedom of navigation[391], the duties of flag ships[392] and the obligation to render assistance[393].

On paper this system is a politically acceptable solution which should ensure equitable opportunity and value creation for all nations in a manner which is balanced. However, in practice this system if far from perfect and presents many challenges. Looking into just the freedom of fishing we can see the conflicts in the system.

> "Limits on the ability of the UNCLOS regime to enforce obligations attached to the high seas right of open access were revealed by the high-profile depletion of high seas fish stocks in the Bering Strait Donut Hole (Alaskan pollock) and the Newfoundland Grand Banks (cod). Such management failures prompted a call at the 1992 Rio Summit (UNCED 1992) for a UN conference on the management of highly migratory and straddling stocks. This, in turn, led to the 1995 United Nations Fish Stocks Agreement (UNFSA 1995). UNFSA enhanced the UNCLOS legal framework by better defining the rights and responsibilities of coastal and distant water fishing nations, in particular the duty to cooperate either directly or through joining or establishing an RFMO [Regional Fisheries Management Organisation]. Under UNFSA, coastal states and states fishing on the high seas are required to give effect to their duty to cooperate by becoming members of relevant RFMOs. Other states with a 'real interest' in the fishery may become members… Despite the UNFSA enhancements, RFMOs still face difficulties in achieving sustainable fishing. Member states are often unwilling to make the tough decisions necessary to restore overexploited fisheries, and enforcement is given a low priority."[394]

Discussing the challenges that cause these issues and the manner in which UNCLOS is set out causes these issues, Stan Crothers and Lindie Nelson continue by stating:

> "[According to UNCLOS] High seas fisheries should be treated as global resources to be managed for the benefit of all peoples of the world. Despite this, rights are currently defined in a way that allow states to derive unilateral benefit from fishing and do not

[390] Ibid at Art.88.
[391] Ibid at Art.90.
[392] Ibid at Art.91-94.
[393] Ibid at Art.98.
[394] G.T. (Stan) Crothers & Lindie Nelson 'High Seas Fisheries Governance: A Framework for the Future?' (2006) 21 *Marine Resource Economics* 341 - 353.

> provide the means for accountability to be imposed on states for any fishing that does not accord with their responsibilities. While international law imposes a responsibility to cooperate in the management of high seas fisheries, economic models demonstrate that a cooperative solution is only possible when the cooperative outcome is better for all parties than the non-cooperative outcome, and when the agreement is binding in a manner that deters non-compliance."[395]

Admittedly comparing the freedom of fishing to asteroid mining is not a perfect comparison. For one, unlike with overfishing of a finite resource, asteroids are a lot more abundant and the existence of future asteroids is not predicated on the populations of asteroids today. However, from a systemic perspective, the legislative systems created are very similar and so the implementation of the system and reasons for their abuse are likely to be similar. In this regard, the fact that resource extraction is allowed under the framework of UNCLOS in international waters is sufficient to extrapolate a likely allowance at least in principle of resource harvesting in space – perhaps not perfectly though.

> "One scholar points out, however, that there may be substantive differences between fishing the high seas and mining asteroids, and thus equating the two oversimplifies the practical reality. Law professor Samuel Roth asks, 'If an asteroid-mining enterprise obtained control over a small asteroid in its entirety, with the intention of making use of all of its mineral content, would that be extraction of "asteroid resources" or assertion of exclusive rights over the territory?' At this stage, there is not a definitive answer to Roth's question, as a situation of that kind has yet to be tested. However, as noted above, proposals involving the retrieval, relocation and use of entire asteroids are under consideration and would implicate precisely the issue that Roth highlights."[396]

This concern is heightened when considering the likely initial technology which will be used to mine asteroids. Consider the following scenario:

Company A wishes to mine an asteroid which is high in Rhodium, a very rare (on earth) platinum group metal with numerous applications in industry. It expends the capital to identify a suitable asteroid and then to tow it either into earth orbit, lunar orbit or to an EML point – exactly which is immaterial. Once it has done this it begins mining the asteroid which measures 3 km across. Company B has been watching with interest

[395] Ibid.
[396] Anderson et al. op cit note 359 at 239.

and decides it also wants to mine Rhodium, however rather than expend the massive amount of capital on identifying and towing its own asteroid, it decides that the asteroid which is now very close is suitably large for both efforts to occur and that it will simply mine that asteroid. Since it costs Company B a fraction of the cost to setup and begin extracting, it is able to undercut Company A in price. (We will presume that the companies ran an economic model which took into account that drastically increasing supply as they would, would crash global prices for the element.)

Would Company A have any recourse? The short answer is that under current frameworks, no. As professor Samuel Ross highlights above, if the company attempts to exercise exclusive jurisdiction over the asteroid, and prohibit Company B from mining, that may be construed as imposing sovereignty. The OST is rather clear in its intent to allow open access and use of all celestial bodies, and so any prevention of this, even a perhaps justifiable prevention, would be in contradiction to the aims of the OST.

It should be noted here that Article IX of the OST does not give exclusive usage as some have argued.[397] Instead it merely states:

> "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."[398]

Consultations does not necessitate agreement, just that there are discussions.[399] Thus even if Company B were registered in a signatory to the OST, which would be unlikely

[397] See for example Cestmir Cepelka and Jamie Gilmour's argument:
"The inherent limitation on free access is its exercise. Like any other right in this sphere, it cannot be regarded as absolute and must be performed with reasonable regard to the interest of others exercising a like right. (sic utere tuo ut alienum non laedas) article IX of the Space Treaty makes an expressis verbis restatement of this principle in stipulating that activities have to be performed with due regard to the corresponding interests of all other states that are parties to the Treaty."
Cestmir Cepelka & Jamie Gilmour 'The Application of General International Law in Outer Space' (1970) 36 *Journal of Air Law and Commerce* 33

[398] UNOOSA op cit note 31.

[399] Jordi Sandalinas 'Art IX of the outer space Treaty and Peaceful Purposes: Issues and Implementation' 2010 *The 5th Eilene M. Galloway Symposium on Critical Issues in Space Law*; Laura Montgomery 'The "Non-Interference" Provision of Article IX of the outer space Treaty and Property Rights' available at

if the company wished to avoid any complications with their activities, then all that would be required is that its state of registry inform the state of registry of Company A. This would then leave any potential solution to the realm of diplomacy and politics.

One may argue that in moving the asteroid, its path is no longer natural, and thus for the purposes of the Liability Convention it would be now seen as a space object which was "launched", and thus under the OST it should no longer be a celestial body but rather a space object which is thus capable of being owned. Thus, the manipulation of the asteroid so as to place it somewhere else in space, allows it to be claimed.

This would in turn give Company A ownership rights over the asteroid and recourse both in international and domestic courts. However, this is a slippery slope. Allowing a loophole into the framework like this could in theory allow companies or states to start claiming celestial objects merely by influencing their position. The Hayabusa probe which JAXA landed on 25143 Itokawa in November of 2005 slightly altered the course of the asteroid.[400] Or the more recent Hayabusa2 mission which performed similarly but on a different asteroid named 162173 Ryugu.[401] Does this mean now that Japan can claim the asteroids as its own? It is doubtful that such a situation which is so obviously in violation of the intentions of the prohibition on territorial acquisition would be allowed.

4.3. Moon Treaty

What if instead of mining asteroids, we were attempting to mine on the moon? Helium is abundant on the moon and depleting on Earth due to its extensive use in the medical and manufacturing industries. It thus makes for a sensible case for resource harvesting on the moon at some point in the future.

The Moon Treaty is perhaps the only example in the *corpus iuris spatialis in iuri gentium* where the question of resource harvesting is specifically addressed.

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https://groundbasedspacematters.com/index.php/2017/03/31/the-non-interference-provision-of-article-ix-of-the-outer-space-treaty-and-property-rights/, accessed on 27 November 2019.

[400] Toru Yada *et al* 'Hayabusa-returned sample curation in the Planetary Material Sample Curation Facility of JAXA' 49 (2014) *Meteoritics and Planetary Science* 135 – 153.

[401] Kyoko Hasegawa 'The voyage home: Japan's Hayabusa-2 probe to head for Earth' available at *https://phys.org/news/2019-11-voyage-home-japan-hayabusa-probe.html*, accessed on 27 November 2019.

"According to its Preamble, one of the main reasons for the conclusion of the Moon Agreement was the possibility to exploit the natural resources of the Moon, which seemed a feasible option in the not-too-distant future. Therefore, the Agreement aims at creating conditions for the peaceful, orderly, and fair development of lunar activities, with particular attention to the interests of less developed States."[402]

The Moon Treaty thus states in Article 11 (reproduced in full here due to its importance):

"ARTICLE 11

1. The moon and its natural resources are the common heritage of mankind, which finds its expression in the provisions of this Agreement and in particular in paragraph 5 or this article.
2. The moon is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means.
3. Neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or nongovernmental organization, national organization or non-governmental entity or of any natural person. The placement of personnel, space vehicles, equipment, facilities, stations and installations on or below the surface of the moon, including structures connected with its surface or subsurface, shall not create a right of ownership over the surface or the subsurface of the moon or any areas thereof. The foregoing provisions are without prejudice to the international regime referred to in paragraph 5 of this article.
4. States Parties have the right to exploration and use of the moon without discrimination of any kind, on a basis of equality and in accordance with international law and the terms of this Agreement.
5. States Parties to this Agreement hereby undertake to establish an international regime, including appropriate procedures, to govern the exploitation of the natural resources of the moon as such exploitation is about to become feasible. This provision shall be implemented in accordance with article 18 of this Agreement.
6. In order to facilitate the establishment of the international regime referred to in paragraph 5 of this article, States Parties shall inform the Secretary-General of

[402] Tronchetti op cit note 386 at 501.

the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of any natural resources they may discover on the moon.

7. The main purposes of the international regime to be established shall include:
   (a) The orderly and safe development of the natural resources of the moon;
   (b) The rational management of those resources;
   (c) The expansion of opportunities in the use of those resources;
   (d) An equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the moon, shall be given special consideration.
8. All the activities with respect to the natural resources of the moon shall be carried out in a manner compatible with the purposes specified in paragraph 7 of this article and the provisions of article 6, paragraph 2, of this Agreement."

This article clarifies several key issues regarding space resource harvesting - at least when occurring on the moon - which makes this article "[t]he most innovative, as well as controversial"[403]. First of which is ownership. Nowhere else is the specific question of ownership of celestial bodies addressed. It is merely assumed that since sovereignty can never be exerted, any form of ownership could never occur either as the enforcement of ownership rights would require a sovereign power within which those rights could be protected.[404] While this is likely sufficient, having it explicitly stated is also valuable.

Perhaps most controversially in this Article is the assertion of the "common heritage of mankind" doctrine to resource exploitation, not to be confused with the "province of all mankind" which is found in the OST and reaffirmed every subsequent treaty. The latter is merely a recognition that the use of space should be done with the idea of developing the entirety of mankind as well as not restricting access to any party.[405] However the common heritage of mankind doctrine is a lot more onerous.

[403] Tronchetti op cit note 386 at 503.
[404] Virgiliu Pop 'Appropriation in outer space: the relationship between land ownership and sovereignty on the celestial bodies' (2000) 16 *Space Policy* 275-282.
[405] Tronchetti op cit note 386 at 498-499.

The common heritage of mankind doctrine has its roots in the *res communis ominium* theory, which allows for the general exploration and use of the area while barring any claims of sovereignty or territorial acquisition of/within the area.[406] Common heritage of mankind takes this a step further holding that all humankind should be given an equal opportunity to develop their standard of living and economic status and thus in the management of an area which is for all mankind, the benefits of it should go to all mankind regardless of their involvement in generating wealth from that area.[407] Further any activities occurring in these areas should only occur under the management or oversight of some international regime who will ensure the orderly and appropriate exploitation of the resources and ensure that it is done so in an equitable manner.[408]

It is paragraphs 5 to 8 which provide the framework to address the possibility of resource exploitation on the moon requiring the establishment of "an international regime, including appropriate procedures, to govern the exploitation of the natural resources of the moon". This clearly signifies the intention of the drafters to allow for resource extraction to occur and it is likely that this approach, as opposed to setting up the regime directly, was chosen so as to defer the issue to a later date and ensure consensus for the treaty to pass through COPUOS. Thus, these paragraphs can be seen being akin to a *pactum de negotiando*. The states which sign the treaty agree to negotiate in good faith to create the international regime but are not bound by the treaty to create one at all costs.[409]

This approach has however proven unpopular and lead to the Moon Treaty being widely ignored by states.

> "The problem with the common heritage of mankind concept is that developing and developed States hold opposite views about its interpretation and application. The former group advances a 'common property' interpretation of the common heritage of mankind concept for areas beyond national jurisdiction. This common property approach requires common management of such areas and common sharing by all States of the mined resources and the benefits generated therein, regardless of the

[406] Louis de Gouyon Matignon 'The Res Communis Concept in Space Law' available at *https://www.spacelegalissues.com/space-law-the-res-communis-concept-in-space-law/,* accessed on 28 November 2019.
[407] Christopher C. Joyer 'Legal Implications of the concept of the Common Heritage of Mankind' (1986) 35 *International & Comparative Law Quarterly* 190.
[408] Ibid.
[409] And indeed, no evidence for these negotiations having taken place or been successful could be found.

> level of participation in the exploitative activities. The latter group, and in particular the United States, refuse the interpretation of the common heritage of mankind concept proposed by the developing countries. In their view, the concept should be interpreted in such a way as to exclude changes in the existing conditions for access to international resources. In particular, the concept should not lead to a modification of the traditional freedom of the high sea, which provides States with freedom of exploration and use. Accordingly, developed States only recognize that the common heritage of mankind may contribute to certain improvement in the distribution of financial and other benefits derived from the exploitation of the resources located in the common heritage of mankind area. In this respect, the special needs of developing States should be taken into consideration. However, only the States exploiting the resources are entitled to decide how to share them and what is equitable."[410]

However, this division was never intended to be created, in fact the original inclusion of the common heritage of mankind doctrine did not intend to be interpreted as common property. Instead the Argentinian delegation which initially proposed the clause that would ultimately become Article 11(1) intended it to rather clarify the vagueness of "the province of mankind". The common heritage was intended to make more explicit that it should be a "beneficial domain which includes enjoyment, profit and receipt of fruits."[411] As Timothy Nelson states in his analysis of the article, "It did not matter that the phrase itself was relatively benign, if not meaningless; politics abhors a vacuum and it was soon given a meaning."[412] He goes on to clarify and note:

> "To be sure, the Moon Treaty does not prohibit (and thus implicitly permits) private lunar exploration. Moreover, it does not expressly ban the use of lunar minerals for profit, and it allows private actors 'to keep title to any private property which they might bring to the moon'"[413]

While this is true, it must be noted (as Nelson does go on to do) that any such operation would be subject to paragraph 5 through 8 of Article 11 which requires the establishment of an international regime under which such activities would be

[410] Tronchetti op cit note 386 at 505.
[411] Maureen Williams 'The Common Heritage of Mankind and the Moon Agreement: Economic Implications and Institutional Arrangement' (1981) *International Institute of Space Law* 87.
[412] Timothy G. Nelson 'The Moon Agreement and Private Enterprise: Lessons from Investment Law' (2011) 17 *ILSA Journal of International and Comparative Law* 397.
[413] Ibid at 398 quoting: Brian M Hoffstadt 'Moving the Heavens: Lunar Mining & the "Common Heritage of Mankind, " in the Moon Treaty' (1994) 42 *UCLA Law Review* 575 – 586.

regulated. It is here that the fears sown through paragraph 1 are amplified greatly. Writing on these fears, David Marko argues:

> "The agreement requires states to join before they can participate in the creation of a resource regime. This creates a couple of problems for developed countries and their corporate constituencies. Initially, to participate in the regime negotiations, the investment community will have to accept the common heritage principle. This they will not do. Additionally, the treaty requires that any regime embrace the notion of 'equitable sharing by all States in the benefits derived…' This is unacceptable to the powerful corporations because it is too open to subjective interpretation and the danger exists that the 'concept of equitable sharing is inconsistent with the concept of profit, and without profit motive private enterprise cannot be expected to risk capital on space investments.'"[414]

These concerns are only amplified again when considering the likely formation of the international regime. It is likely that such a body would be comprised of many developing nations which don't actually have the capabilities to exploit resources on the moon, but which will nonetheless want to also gain from the exploitation of lunar resources. This would put developed nations and their commercial entities at the mercy of these developing nations as was the case with the International Seabed Authority which was created by the 1982 Law of the Seas Convention, which also advocates for a common heritage of mankind.

> "… the regime creates a 'one-nation-one-vote' decision-making process for most major decisions. Many decisions require two-thirds to three-quarters of the votes. With probably less than eight of the treaty's parties likely to engage in deep seabed mining, they would be at the mercy of the third world."[415]

Again however, the criticism does not stop here. Nelson highlights the issues created by the timing of the creation of the international regime created by Article 11.

> "Compounding this all was that the 'regime' was only to emerge after it had been determined that exploitation of lunar resources was proven to be 'feasible'. This awkward timing meant that an international authority would impose its rules 'in the

[414] David Everett Marko 'A Kinder, Gentler Moon Treaty: A Critical Review of the Current Moon Treaty and a Proposed Alternative' (1992) 9 *Journal of Natural Resources & Environmental Law* 316 quoting from: Nancy L. Griffin 'Comment, Americans and the Moon Treaty' (1981) 46 *Journal of Air Law and Commerce* 762 and Nicolas Mateesco Matte 'The Common Heritage of Mankind and Outer Space: Toward a New International Order for Survival' (1987) 12 *Annals of Air and Space Law* 323.
[415] Ibid at 318.

> middle of the figurative game,' i.e., after potentially expensive feasibility studies had been conducted. Combined with the politically ambiguous nature of the 'regime', this created the specter of a private actor, having spent millions (or billions) on research on exploration and prospecting, suffering ''ex post facto' appropriation of their investments by a nebulous future international regime' with power to tax or veto any future exploitation of the very resources the private actor had just located."[416]

All these issues and concerns result in the Moon Treaty being a widely criticised and thus unsupported piece of international legislation. According to Professor Daniel Goedhuis, this is all the result of the Moon Treaty being "rushed through the United Nations in a great hurry before a consensus on the exact meaning and content of the concept of the moon and its natural resources being the common heritage of mankind had been achieved."[417]

As noted in the previous chapter however, this does not make the Moon Treaty a dead treaty with there perhaps being an argument that the moon treaty has entered into international common law. For more on this see the discussion in Chapter 3. Increasingly countries are adopting legislation which directly counters clauses in the Moon Treaty and reaffirms the country's position on resource harvesting, and the rights of their citizens in respect of this, perhaps in attempt to prevent the Moon Treaty ascribing as common law.

4.4. Title IV of the US Commercial Space Launch Competitiveness Act of 2015

In November of 2015, President Barak Obama signed into law the *US Commercial Space Launch Competitiveness Act*[418] (often simply called the Space Act, and henceforth here referred to as the US Space Act). While this Act mostly dealt with updating US legislation so as to address the massive commercial space industry within the US, it perhaps controversially also included Title IV which established rights with regards to US citizens participating in space-based mining operations.

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[416] Nelson op cit note 412 at 399 quoting: Benjamin D. Hatch 'Dividing the Pie in the Sky: The Need for a New Lunar Resources Regime' (2010) 24 *Emory Internation Law Review* 229.
[417] Daniel Goedhuis 'Some Recent Trends in the Interpretation and the Implementation of the Rules of International Space Law' (1981) 19 *Columbia Journal of Transnational Law* 233.
[418] U.S. Congress Available at *https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf.*

Title IX began life as a proposed separate act, titled the ASTEROIDS Act (American Space Technology for Exploring Resource Opportunities in Deep Space Act). This bill controversially held at §51302 that:

> "Any resources obtained in outer space from an asteroid are the property of the entity that obtained such resources, which shall be entitled to all property rights thereto, consistent with applicable provisions of Federal law."[419]

While there are numerous points one could critique within this original bill, the main contention was that it potentially violated the principles of the outer space Treaty, specifically those articles speaking to non-appropriation of celestial objects by states and a ban on exertions of sovereignty over them. This is a concern already raised in this chapter, with Tronchetti providing a well-articulated version of the concern directly against the Asteroid Act when he states:

> "Under international law property rights derive from States. In fact, in order to exist, property rights require a superior authority, a State, entitled to attribute and enforce them. This, of course, means that States need to have property rights themselves first before being able to recognize them to other subjects. Thus, any US attempt to confer property rights over asteroid resources to its private companies would indirectly signify that the United States attribute to itself ownership over those resources. Such an arbitrary attribution would collide with the non-appropriation clause, also because, as previously pointed out, no consensus on whether space resources can be removed and exploited exists. Furthermore, while the bill is not intended to extend US ownership over asteroids broadly considered (not only over their resources), arguably this could be its legal effect. Basically, through the ASTEROIDS Act, the United States would confer mining rights on asteroids. Under terrestrial mining law a State allocates to public and private companies the right to exploit the natural resources within its territorial jurisdiction. Such a State has, indeed, the title to do so because the resources are located inside its territory. By attributing to a private company the right to mine an asteroid and to acquire property rights over the extracted resources, the United States could be accused of considering that asteroid as part of its territory, thus violating the non-appropriation principle."[420]

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[419] Bill Posey & Derek Kilmer 'HR5063: American Space Technology for Exploring Resource Opportunities in Deep Space Act' available at *http://www.spacepolitics.com/wp-content/uploads/2014/07/AsteroidsActHR5063.pdf,* accessed on 03 December 2019.

[420] Fabio Tronchetti 'Private property rights on asteroid resources: Assessing the legality of the ASTEROIDS Act' (2014) 30 *Space Policy* 194.

Due to these concerns amongst others, the bill would go through various amendments before eventually becoming Title IX of the US Space Act, whose relevant parts for this discussion have been reproduced below.

> "**§ 51301. Definitions**
>
> In this chapter:
>
> (1) ASTEROID RESOURCE.—The term 'asteroid resource' means a space resource found on or within a single asteroid.
>
> (2) SPACE RESOURCE.—
>
> (A) IN GENERAL.—The term 'space resource' means an abiotic resource in situ in outer space.
>
> (B) INCLUSIONS.—The term 'space resource' includes water and minerals.
>
> …
>
> '**§ 51303. Asteroid resource and space resource rights**
>
> 'A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.
>
> …
>
> **SEC. 403. DISCLAIMER OF EXTRATERRITORIAL SOVEREIGNTY.**
>
> It is the sense of Congress that by the enactment of this Act, the United States does not thereby assert sovereignty or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body."[421]

From this one can see that there was an attempt to address concerns around a potential violation of the OST, with the specific references to property rights being removed, and the disclaimer of extraterritorial sovereignty being removed. Blount and Robison highlight that:

> "This change in language is quite important. Instead of granting the ambiguous 'property rights,' Title IV enumerates certain rights from the traditional bundle of rights that a commercial entity might have over chattel property… Simply put, this particular

[421] U.S. Congress op cit note 418.

> language does a better job in ensuring that private entities only have property rights to resources extracted from asteroids or other celestial bodies."[422]

It is clear that American legislators avoided any language which may insinuate or convey that a private entity would have exclusive use or control over a celestial object, save for that which may be afforded to the private entity under non-interference.[423]

The passing of the US Space Act is fully within the rights of the US, in fact one could argue that it is almost required by the OST. One should remember that the OST is not a self-executing contract as it is reliant on the state parties to pass legislation giving effect to its articles. As the state within which companies which are the most likely to soon be using in situ resource harvesting technology are registered, giving effect to Articles I and II of the OST in their domestic legislation is arguably required. Article VI of the OST requires that state parties authorize and continuously supervise the activities of their NGO's which are operating in space, thus if US NGO's are likely to soon be utilising in situ resource harvesting, they would need legislation which describes the mechanisms such activity would need to operate under.

> "The Act per se does not establish the authorization and supervision procedure for private space mining; it is, however, significant that its provisions specifically point out that the commercial exploration and recovery of space resources shall be subject to authorization and continuing supervision by the Federal government."[424]

Ultimately, as Tronchetti notes:

> "This [passing legislation giving effect to international treaties] is particularly true in connection with Articles I and II whose exact scope and correct implementation remain a matter of debate. One may certainly criticize the method used by the US to enact the Space Act, especially its Title IV, but this does not make the act of enactment per se illegal."[425]

It should be highlighted that Article II of the OST does not prohibit the appropriation of Space Resources, and the language of Article I(2) seems to almost encourage the

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[422] P. J. Blount & Christian J. Robison 'One Small Step: The Impact of the U.S. Commercial Space Launch Competitiveness Act of 2015 on the Exploitation of Resources in Outer Space' (2016) 18 *North Carolina Journal of Law and Technology* 175.
[423] Ibid at 176.
[424] Fabio Tronchetti 'Title IV – Space Resource Exploration and Utilization of the US Commercial Space Launch Competitiveness Act: A Legal and Political Assessment' (2016) 41 *Air and Space Law 151.*
[425] Ibid at 149.

"use" of space - which must surely include its resources. Thus, there is room within which a state may argue that resource utilisation and exploitation is permissible under the OST, and hence there is nothing of issue with legislation which merely clarifies that is citizens are entitled to do so under national as well as international law.

A potential area of concern can be found in §51302 of Title IX which obligates the President of the United States to "promote the right of United States citizens to engage in commercial exploration for and commercial recovery of space resources free from harmful interference [emphasis added]".[426] The Act never defines what "harmful interference" constitutes and thus what it would mean for an activity to be "free from harmful interference". This likely comes from Article IX of the OST which holds:

> "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."[427]

However, the US Space Act takes what is an obligation to consult and turns it into a right to be free from. This has vastly different consequences. As noted earlier in this chapter, the obligation to consult does not require consensus or indeed any further action than mere consultations, it does not prohibit the interference. A right to be free from harmful interference would prohibit any such conduct.

> "As the concept of "harmful interference" is not defined under the Act one might envision that, if implemented, this provision could result in the unilateral establishment of exclusion/safety zones on the surface of an asteroid so as to protect the activities of US mining companies. In a similar scenario, how would the setting forth of such zones not undermine the right of other States Parties to freely access, explore and use outer space provided in Article I of the Treaty and be consistent with the prohibition to appropriate outer space by other means? Furthermore, in the absence of any internationally agreed parameter on the length of space mining operations, the extensive presence of a private company on a celestial body surface, especially if

[426] U.S. Congress op cit note 418.
[427] UNOOSA op cit note 31.

> accompanied by the establishment of non-access zones therein, could be viewed by some as an attempt to acquire ownership over that area."[428]

Beyond this, nowhere in Title IX is it even acknowledged that it is possible that some non-US entities may also be involved in resource harvesting in outer space. It does not address what should occur should a non-US entity come into conflict with a US entity, or what should happen if they independently decide to mine the same asteroid. Is that harmful interference, and if so then what should occur?

While the US Space Act, specifically Title IV, is far from perfect it still serves a valuable role by taking that first step into the legal unknown and forcing the conversation on an area which will soon need legislation. As Tronchetti stated:

> "…despite its unilateral background, the Act may be the starting point of an international dialogue, possibly leading to the development of international rules to coordinate the exploration and use of outer space, including the extraction and use of resources."[429]

4.5. Luxembourg's Exploitation and Use of Space Resource Law

On the 20th of July 2017, the Grand Duchy of Luxembourg became the second country to adopt laws which directly address resource harvesting in space. It's *Law of 20 July 2017 on the Exploration and Use of Space Resources*[430] (henceforth Luxembourg Space Resources Act) was signed into law by the Grand Duke and shows an approach taken by the Grand Duchy which may prove very profitable in the coming decades.

However, before exploring the Luxembourg Space Resources Act some context is useful. When the ITU was tasked with managing and co-ordinating geostationary orbital slots and the radio frequencies of satellites, it set aside a fixed number of slots

[428] Tronchetti op cit note 424 at 153.
[429] Tronchetti op cit note 424 at 155.
[430] Officially *Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace.* Available at *http://data.legilux.public.lu/file/eli-etat-leg-loi-2017-07-20-a674-jo-fr-pdf.pdf,* with an English translation available at *https://space-agency.public.lu/en/agency/legal-framework/law_space_resources_english_translation.html.*

and frequencies for all member states. These could then be assigned by the relevant authorities within the state to its entities.[431]

> "If there are no entities capable of using the orbital positions and frequencies allocated to a particular ITU member state, those positions and frequencies remain available for the use of entities based outside the jurisdiction on a 'first come, first served' basis, subject to the oversight of the ITU."[432]

In the mid-80s, when this was occurring, the only real need for geostationary slots was for radio and TV broadcasters, all of whom in Europe were state-owned, and which Luxembourg did not have, nor did it have the capabilities to start one.[433] It thus found itself in a position of having these valuable slots – due to being located quite centrally in western Europe – but with it likely to lose them.[434] Rather than risk losing the slots, the Luxembourg government decided to instead provide seed capital to establish a private company which would then utilise the slots. It partnered with Clay T. Whitehead, an American with a record in the industry, and together created Société Européenne des Satellites (SES).[435] This proved to be a very profitable move, with SES becoming the world leader in satellite communication technologies, operating some 50 geostationary satellites, with the Government of Luxembourg still owning a stake in the company[436].

It is this success which the Grand Duchy hopes to repeat, this time with space resource harvesting. The Luxembourg Space Resources Act is one part of this, with the Government of Luxembourg also introducing more attractive tax regulations for these entities and establishing a €200 Million fund to invest in the start-ups developing the required technology.[437]

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[431] Rafal Kopec 'Geostationary Belt – State's Territory or Province of Mankind?' (2018) 8 *Review of Nationalities* 167 – 178.
[432] Charles Bjork 'The Luxembourg Space Resources Act and International Law' available at *https://fcilsis.wordpress.com/2018/12/12/the-luxembourg-space-resources-act-and-international-law/*, accessed on 05 December 2019.
[433] Ibid.
[434] Ibid.
[435] Ibid.
[436] Marc Feider & Jaques Graas 'Luxembourg Space Resources Act: Paving the legal road to space' available at *https://www.allenovery.com/en-gb/global/news-and-insights/publications/luxembourg-space-resources-act-paving-the-legal-road-to-space*, accessed on 05 December 2019.
[437] Louis Brennan 'How Luxembourg is positioning itself to be the centre of space business' available at *http://theconversation.com/how-luxembourg-is-positioning-itself-to-be-the-centre-of-space-business-120436*, accessed on 05 December 2019.

Returning to the Luxembourg Space Resources Act, in Article I it states, “Space resources are capable of being owned.”[438] It never clarifies what “Space Resources” are, nor what it means to “own” them. It should be noted that while the English translation of the law available from the Luxembourg Space Agency states the above, the original French states “Les ressources de l’espace sont susceptibles d’appropriation” which would more directly translate to “Space Resources are susceptible to appropriation”. Regardless of the interpretation, this is the totality of what the Luxembourg Space Resources Act has to say on ownership, with the rest of the Act focussing on the mechanism by which entities can use space resources. The law firm Ogier, summarises the requirements that an entity would need comply with under the Act to be able to use space resources as listed below:

“

1. the Operator must either be a public company limited by shares (*société anonyme* (SA)), a corporate partnership limited by shares (*société en commandite par actions* (SCA)), a private limited liability company (*société à responsabilité limitée* (SARL)) or a European Company (*société européenne* (SE));
2. the Operator must seek a written authorisation from the appropriate minister(s) in Luxembourg;
3. the Operator's place of central administration and registered office must be located in Luxembourg, and satisfactory evidence shall be given with respect to, notably (i) the administrative and accounting structures of the Operator to be authorised, (ii) the required financial, technical and statutory procedures and arrangements through which the exploration and utilization mission (including the commercialisation of space resources) are planned and implemented and (iii) the internal governance scheme of the operator;
4. the Operator shall demonstrate a sound and prudent operation;
5. the application for the authorisation must be accompanied by a risk assessment of the mission, and is conditional upon the existence of financial resources appropriate to the risks associated with the mission; and

[438] LSPA op cit note 430.

6. the annual accounts of the Operator shall be audited by one or more independent auditors (réviseurs d'entreprises agréés)."[439]

While the US Space Act is a lot shorter and gives more clarity as to the rights that one might have over space resources. The Luxembourg Space Resources Act by comparison is more vague around what it means to appropriate/own space resources, but gives a lot more clarity into the process which would authorise such an appropriation and thus fills a lot of the gaps left by the US Space Act.

Unlike the more nationalistic and unilateral approach of the US Government, the Government of Luxembourg also recognises that the act operates within a greater global community, which it addresses through engagements outside of the act.

> "In that regard, Luxembourg has already signed several memoranda of understanding with other countries on the legal aspects of space mining and participates in numerous other international initiatives, such as The Hague Space Resources Governance Working Group."[440]

There is some criticism of the Luxembourg Space Resources Act, levied mostly at Article I and stemming from amendments done between drafting and passing the Act. The Act does specify at Article 2(3) that:

> "The authorised operator may only carry out the activity referred to in paragraph 1 [explore or use space resources] in accordance with the conditions of the authorisation and the international obligations of Luxembourg."[441]

This, however, has been criticised by some as not being sufficient as it is the only place in the Act that references the international obligations of Luxembourg, or indeed the entirety of the international framework of Space Law. Whilst Luxembourg functionally appears to be taking a more internationally collaborative approach, this is not a requirement of its law. This as opposed to the US law which makes greater effort to emphasise that the ownership/appropriation only occurs in such a way as allowed by international law and not due to an imposition of US sovereignty. The Luxembourg law makes no effort to provide such assurances.

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[439] Laurent Thailly & Fiona Schneider 'Luxembourg set to become Europe's commercial space exploration hub with new Space Law' available at *https://www.ogier.com/news/the-luxembourg-space-law#,* accessed on 05 December 2019.
[440] Feider & Graas op cit note 436.
[441] LSPA op cit note 430.

During drafting this was not the case, with the original drafting of Article 1 holding that "Space resources are capable of being appropriated in accordance with international law"[442], a statement which while still vague leaves open the Luxembourg Space Resources Act to changes in the positions of International Law. Instead the act as it stands makes a unilateral declaration on behalf of the Grand Duchy.

> "The above amendments render the similarities between the Luxembourg Law and its American inspiration all the more apparent. Their legislative pedigree also reveals that such isolated references to the compliance of private operators with the 'international obligations' of States having adopted legislation on an issue of disputed legality at the international plane, is highly contentious and of dubious effectiveness. Indeed, the objective of legal certainty does not seem to be met but rather actively harmed by deleting the one reference to international law in the provision that addresses the legality of property rights over space resources."[443]

Continuing his critique, Philip De Man, the author of the above, also points out that the Grand Duchy has in essence unilaterally declared that Space Resources are capable of being appropriated (Article 1), and then shifted the burden of its international obligations onto its private entities (Article 2).[444]

I will attempt to deny that the Act does do this, however I would argue that this is a necessity created by the murky and divergent positions of the international law position. In the absence of a clear position by international law, the burden is on states to provide clarity for its citizens whilst simultaneously allowing room for a potential shift in the perspectives of international law. I would applaud both the US and especially Luxembourg for providing a clear position in the law for their citizens and in the case of Luxembourg also providing a mechanism which provides stability in what would otherwise be a very uncertain and unstable legal area for private entities. I suspect that they will profit greatly off being the first to do so when the technology eventually catches up.

[442] Les ressources de l'espace sont susceptibles d'appropriation en conformité avec le droit international.
[443] Philip De Man 'Luxembourg Law on Space Resources Rests on Contentious Relationship with International Framework' available at *https://ghum.kuleuven.be/ggs/publications/working_papers/2017/189deman*, accessed on 07 December 2019.
[444] Ibid at 13

4.6. Potential Solutions

Having taken a deep analysis into the current legal framework and its issues, as well as the steps domestic legislators are taking, one must ask if there is not a potential solution at an international level. To this end there have been several proposals which can be classified as solutions within the UN, and solutions outside the UN.

As the "guardian of international law"[445] the UN is often touted as being the competent body to oversee asteroid mining activities. Whilst a number of suggestions have been made as to the potential paths that the UN could take in this regard, the most common is one which we have mentioned before: the establishment of a specialised agency within the UN, similar to ICAO, which would regulate the entire space industry.

> "The idea of an international organisation for space modelled along the lines of ICAO is not a new one. It was put forward several years ago by FAA-AST [US Federal Aviation Authority, Office of Commercial Space Transportation] officials under the name of International Space Flight Organisation (ISFO). At the time, it was envisaged that the organisation would focus on futuristic international traffic of commercial hypersonic space planes, and on the launch of space vehicles from one country which, on its return to Earth, would land in a forgiven country. Clearly, potential interest in such operations, and therefor in the ISFO concept, was limited to a handful of countries."[446]

Whilst the proposal has not gained traction amongst member states of the UN, it has within the academic community, with it often being advocated as a potential solution provider to legal and regulatory issues faced by the commercial space industry.[447]

Though not quite as distinct as a specialised agency of the UN, the Moon Agreement did intend to establish a body whose responsibility it would be to regulate specifically resource extraction from the moon.[448] This would be similar to how the International

[445] Kamil Muzyka 'The problems with an international legal framework for asteroid mining' available at *https://www.academia.edu/32453498/The_problems_with_an_international_legal_framework_for_asteroid_mining_by_Kamil_Muzyka*, accessed on 14 December 2019.
[446] Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey *The Need for an Integrated Regulatory Regime for Aviation and Space* (2011) 119.
[447] Ibid.
[448] UNOOSA op cit note 31 at article 11.

Seabed Authority operates under UNCLOS, which as previously noted could be considered an almost sister convention to the Moon Treaty.

Whether it operates as either a specialised agency, a separate authority established in terms of a UN Convention, or via the mother UN body likely through either UNOOSA or UNCOPUOS, a number of potential approaches to regulation by the UN have also been proposed over time. The difference in approach mostly stems from how one interprets the obligations created by the UN Treaties, specifically around the "common heritage of mankind" principle.

Under a strict interpretation, in which the proceeds/resources must be used to the collective benefit of all humankind - with an emphasis on developing nations - a suggested model has been to have a UN Miner Contract.[449] This model has its origins in terrestrial mining in which a state or landowner, contracts a specialised miner to retrieve the minerals/ore but retains ownership and control throughout the process. Thus, in this context the UN (or the body tasked with regulation and oversight) would enter into a contract with the miner to retrieve the minerals and pay them their operational costs, but would then itself be tasked with the utilisation, distribution or sale of these minerals. The profits could then be shared amongst member nations via several different means. As Muzyka notes, this model:

> "gives mining companies the incentive and authorization by the UN space resource governance body, while at the same time forbids any form of appropriation or hoarding/stockpiling potential asteroid resources. Asteroid miners in this model are only the operators. This model however has it's drawback, not in the sense of international law, but in the sense of possible politicization of such body, where certain superpowers might manipulate the international space resource fund to reap profits rather than to equally or evenly distribute the benefits of asteroid mining."[450]

Under a more laissez-faire interpretation of the relevant provisions of Space Law, a licensing/assignment method has been proposed. This method draws its inspiration from the current method the ITU uses to assign geostationary orbital slots. Under this method there are two potential approaches: assignment or licensing.

[449] Muzyka op cit note 445 at 5.
[450] Muzyka op cit note 445 at 5.

The assignment approach would mean the UN, or some competent body created, would put to tender potential resources, which a company could then apply for the rights to mine. This has as its advantage a system in which a fairer market could be achieved as those entities from developing countries could be prioritised (although this itself may raise issues with flags of convenience) and allocations could also be more easily spread across the industry. However, as its downside, this requires the UN to exert the resources to identify potential harvestable opportunities.[451]

A licensing approach by contrast, would allow entities which have identified suitable asteroid to approach the UN for permission to harvest those resources. This approach would be rather similar to the approach used by the ITU to grant geostationary orbit slots.[452] This approach would mean that the UN would not need to search itself for suitable opportunities, and instead merely assesses the paperwork provided to it to ensure compliance with relevant standards. However, this method has two potential downsides. The first of which is that the method itself does nothing to foster the spreading of benefit, with instead those companies with the resources (likely due to their location in a developed part of the world) potentially establishing control over the industry. The second is an issue currently encountered by the ITU, which is the creation of paper-satellites, or in this case paper-miners.[453] This is an issue where an entity is awarded the rights and then instead of exercising the rights, uses this as an asset itself on speculative markets, or subcontracts the mining potentially acting as a front to be more attractive to regulators.[454]

Another proposed method, which could work under either interpretation is a method utilising salvage claims. In this method, a private entity would have to first identify a suitable claim and then move it to either a EML point, or some artificial orbit at which point it would file a salvage claim, just as would occur under maritime law.[455] The depending on the approach taken, they could either be entitled to the resources they

[451] Muzyka op cit note 445 at 6.
[452] Muzyka op cit note 445 at 6.
[453] Audrey L. Allison *The ITU and Managing Satellite Orbital and Spectrum Resources in the 21st Century* (2014) 55 – 71.
[454] Ibid.
[455] F. Lansakara 'Maritime Law of Salvage and Adequacy of Laws Protecting the Salvors' Interest' *International Journal on Marine Navigation and Safety of Sea Transportation* (2012)6 431 – 435.

recover or would be entitled to a salvage reward and the resources would go to the UN.[456]

All of these methods, along with having their respective pros and cons, also rely on the ability of the UN to get a mandate from its member states to perform any such actions. However, considering the issues in universal buy-in the UN currently suffers from within UNCOPOUS, it is unlikely that such buy-in could be achieved - especially considering that any of these approaches would require a resolution to the disagreements over the "common heritage of mankind" principles. Thus, several proposed solutions have been presented which would occur externally to the UN.

Solutions external to the UN generally fall into one of two categories. Intergovernmental Organisations (IGOs) or Industry Associations (IA) (i.e. organisations where states are the members, and organisations where the private entities are the members). In all likelihood, we may see the emergence of both as they are not mutually exclusive. Both of these approaches do nothing to address the legal issues present, but instead provide for a collective approach and accepted dispute resolution mechanism which may assist in negating the present legal issues.

IGO's could take several different forms, depending on the approach member states wish to take. Common examples of the models which could be explored are models based on either the operations of European Space Agency (ESA), Organisation for Petroleum Exporting Countries (OPEC) or the ISS Agreement.

A model based on ESA would see member states developing the technologies collectively (likely utilising public-private partnerships), and then managing the operations themselves via the agency. This model need not be external to the UN – there have been some calls for a UN Space Agency and may be similar to the approach discussed above the International Seabed Authority takes[457] – however it also need not necessarily be under the UN.

An OPEC model would see the actual operations externalised from the IGO itself, with the IGO instead focussing on regulating processes and importantly in the case of earth-return mining also the attempted regulation or at least co-ordination of supply.

[456] Muzyka op cit note 445 at 6.
[457] Lewis Pinault 'Towards a World Space Agency' in Cockell C. (ed) Human Governance Beyond Earth (2015) 173 – 196.

Considering the potential affects that earth-returning mining could have on the value of precious metals, such a co-ordination would likely be sought by the member states.[458]

An ISS Agreement model instead of having a specifically established IGO which has daily operations, would operate by having multi-lateral conferences and agreements, perhaps on a recurring basis, which would formulate agreement amongst those states with capabilities. Whilst again this could occur within the UN system, it could also occur externally to the UN.

Regardless of the specific model by which the IGO operates, there are some mutual benefits that an IGO approach could have. Discussing the major benefits of an IGO, Frans Von Der Dunk writes:

> "Firstly, IGOs present an often-used platform for the member states to conclude further substantive treaties on the subject matter the IGO is established for, which then of course as treaty law squarely form part of public international law. This may and indeed does also happen in the context of outer space and Space Law. A special subcategory here concerns treaties to which IGOs effectively become parties.
>
> Secondly, whilst competences to impose binding law regarding substantive issues on member states against their individual opposition are usually absent with IGUs, most of them have extended competences to adopt guidelines, recommendations, rules of the road and other non-formally binding texts. Many of those documents after their adoption turn out to gradually transform into customary international law, as the member states start to appreciate their legal relevance and authority more and more, specifically in the context of IGO-based cooperation.
>
> Thirdly, whilst internal binding regulations adopted within a particular IGO usually remain confined to procedural and organizational rather than substantive matters, the boundaries between the two cannot always be easily drawn and such regulations may sometimes develop their own momentum and impact, which may occasionally have an effect upon the creation of binding international law (whether treaty or customary) even beyond the member states themselves.

[458] There are of course arguments around how effective this could be, especially when OPEC has largely failed in resent years to control the crude oil market. See Övunç Kutlu 'ANALYSIS - OPEC losing control, share in global oil market' available at *https://www.aa.com.tr/en/energy/international-organization/analysis-opec-losing-control-share-in-global-oil-market/27117*, accessed on 17 December 2019.

> Finally, most of the major regulatory IGOs possess some dispute settlement system comprising mixed forms of judicial and non-judicial mechanisms, often prominently involving arbitration. Those dispute settlement mechanisms may not only use general public international law in the context of solution of particular disputes but in doing so may also contribute to further interpretation and understanding of these rules."[459]

The obvious downside of such an approach is that it allows for effective monopolisation of space resource harvesting regulation by the IGO, and its member states would likely consist of only the few developed states which have the resources to invest in these operations, thus meaning that control of the IGO and space resources would potentially only be in the limited hands of those developed nations. This would likely see the developing world excluded from the benefits of these resources.

An alternative approach would be to utilise Industrial Associations. These associations would be made up of the private entities which form the industry and would similarly be able to operate as a body to standardise regulations and operational procedures. However, again, these would in effect be non-binding or unenforceable as an entity could either opt out of the regulations or the association altogether. Such an association could however, if opted into, also provide a valuable dispute resolution mechanism for participating entities. Discussing how this occurs in the contemporary merchant industry, Salter and Leeson write:

> "In the absence of a supranational sovereign to enforce and sustain property rights between contemporary international traders, modern international trade is similarly governed privately—by a modern law merchant. Given the difficulties, and for many years the impossibility, of using national sovereigns to enforce international commercial disputes, contemporary international traders rely on private international arbitration associations instead. Indeed, at least 90 percent of modern international commercial contracts contain clauses stipulating the resolution of contractual disputes via private arbitration."[460]

They then go onto to discuss how the utilisation of Industrial Associations, and the alternative dispute resolution mechanisms which the association, (or another body

[459] Frans Von der Dunk 'International organizations in Space Law' in Frans Von der Dunk & Fabbio Tronchetti (eds) *Handbook on Space Law* (2015) 271 – 272.
[460] Alexander W. Salter & Peter T. Leeson 'Celestial Anarchy: A Threat to outer space Commerce?' (2014) 34 *Cato Journal* 590.

such as the International Chamber of Commerce or the Permeant Court of Arbitration) offers, as well as what they term “celestial anarchy” - which is the lawless situation created by legal ambiguities within the space treaties and the general international anarchical system - which could all combine to create “self-enforcing property rights”.[461] It is an interesting academic argument, which I would argue will likely occur in the pioneer days of space resource harvesting. I would, however, argue that such a system will not be politically acceptable for long when considering the vast power and wealth these mining companies would soon come to hold. Thus, while this may occur in initial stages, it is likely that states will eventually come to create some inter-governmental based regulatory system.

4.7. Conclusion

If we are to go to the stars, we will have to harvest the resources to build our spaceships and space stations as well as fuel them from our surrounds in space as it is simply not feasible to launch all the materials from Earth. In this regard, if that becomes the goal of humanity, I have no doubt we will develop the associated technologies to harvest resources in space. Of more ambiguity is whether or not we will harvest resources to return them to earth. However, the technology is being developed regardless and the legal ambiguities will need to be addressed at some point, which for the entities that are currently being established with these aims would be a concern in the near future.

For states, this emerging industry may be the most important to encourage and facilitate, as the long-term viability of such an industry may become the biggest income generator for states since the commercialisation of oil and global shipping. Entire economies could be catapulted if they position themselves correctly. The emergence of domestic legislation in this regard will also be the key indicator for entities regarding the likely approach that the international community will take. As Von der Dunk writes:

> “In short, the global environment for space activities presents a far from harmonized picture to the private sector, in spite of the, by definition, global nature of their activities. While there may be profound reasons for this (ranging from the security concerns that

[461] Ibid at 592-594.

> are always around the corner when it comes to space operations and space technologies to ideological differences concerning the appropriate role of private enterprise in a global commons such as outer space), at least a similarity of interpretation of key provisions of the space treaties by way of national implementation should be aspired to in order to minimize any legal uncertainty for private operators in either direction. Presumably, much progress could still be made in this realm, and much work consequently still needs to be done."[462]

Until the clarity is provided, the potential rewards will mean that private entities will still be enticed to develop the technology and begin operations - it will just be up to them to decide whose interpretation they will abide by, which will likely be the most beneficial to them under a capitalist model. The sooner we collectively decide on how to regulate and manage, the sooner we can decide as a society who benefits. The later we decide the more likely we are to repeat history and allow space resources to become another oil industry.

[462] Op cit note 379.

CONCLUSION

Summary

This dissertation discussed the development of Outer Space Law by exploring the history and fundamentals of contemporary space law – including the major Treaties which currently govern activities in Outer Space. A comparative discussion between Maritime, Aviation and Space Law was undertaken to reinforce this. South African Space Law was then explored.

Analysis of commercial activities in space and the legal and scientific ramifications thereof was done. This included in depth analysis of The Space Liability Convention in relation to the definitions of “Space Object” and “Damage” along with consideration of fault and causation. The Canada Claim was explored as a case study. Environmental concerns relating to space debris and space traffic management were considered.

This research then went on to analyse liability more closely in the context of commercial activities such as space tourism. The legal and scientific delimitation of Outer Space was explored as well as the legal status of space tourists. The major concern of a state-centred approach to current law was evaluated.

Finally, a discussion on industrial commercial activities in Outer Space was had. This included explanation and consideration of the potential for resource harvesting in Space. The Outer Space Treaty and Moon Treaty were explored in relation to implications for ownership whilst country specific legal concerns that either encourage, regulate, or discourage such activities were explored. Potential solutions to the above issues were then presented.

Aims and Objective Fulfilment

The main aims and objectives of this dissertation were successfully achieved. The principle aims of analysing the Law of Outer Space in contrast to the contemporary realities of commercial operations in space and well as future likely commercial developments was done.

This was achieved through the answering of the core research questions listed in the Dissertation Preamble. An understanding of existing laws and the history thereof was attained. The context was considered which resulted in the state-centred approach currently observed. The types of and nature of current commercial activities in space as well as those likely to exist in the foreseeable future and their interactions with law was achieved. Frictions and gaps were identified and solutions and mitigating approaches were identified.

Recommendations

This study concludes that - as hypothesised - that there is indeed a need to urgently consider updating and amending existing Outer Space Law in order to better facilitate as well as regulate Outer Space commercial activities. This will require the collaboration of multiple parties of both state and corporate backgrounds to work towards a common interest and the future of humankind. Importantly, there are several unnecessary hurdles hindering progress.

As hypothesised, with perhaps a few exceptions within soft law, technological abilities and scientific progression have left the law in a place where it regulates in a manner which is no longer relevant or worse actively hindering. It further does so on the understanding of a political reality which no longer exists.

There is some concern by the writer as to the political will to undertake these reforms as they are often counter to national self-interest or are seen as unneeded due to the specific applications thereof not yet being technologically feasible. However reactionary law as opposed to law which anticipates the coming realities, in the opinion of the author, is not one which is acceptable in a field which could quite literally affect our very ability to operate in that field, or in which human lives are already at considerable risk.

A correction of these laws, or potential entire redo of the regulatory framework is, again in the opinion of the author, crucial to encourage and foster the commercial sector in outer space and safeguard the lives of all who wish to venture forth into our final frontier.

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BIBLIOGRAPHY

Books and Book Chapters

Anton Alberts ‘South Africa’ in Annette Froehlich (ed) Integrated Space for African Society: Legal and Policy Implementation of Space in African Countries (2019) 68 - 69

Audrey L. Allison The ITU and Managing Satellite Orbital and Spectrum Resources in the 21st Century (2014) 55 – 71

Bin Cheng Studies in International Space Law (1997) 383

Corinne Contant-Jorgenson, Petr Lála & Kai-Uwe Schrogl (eds) Cosmic Study on Space Traffic Management (2005)

Fabio Tronchetti Fundamentals of Space Law and Policy (2013) 3-4

Frans G. von der Dunk ‘About the New PCA Rules and Their Application to Satellite Communication Disputes’ in Mahulena Hofmann (ed) ‘Dispute Settlement in the Area of Space Communication: 2nd Luxembourg Workshop on Space and Satellite Communication Law’ (2015) 102

Frans Von der Dunk ‘International organizations in space law’ in Frans Von der Dunk & Fabbio Tronchetti (eds) Handbook on Space Law (2015) 271 - 272

Gerd W. Prölss ‘Physics of the Earth's Space Environment: An Introduction’ (2010) Ch 1

Harland, David M &Lorenz, Ralph D. Space Systems Failures – Disasters and rescues of satellites, rockets, and space probes (2005) 236

Henery R. Hertzfeld (ed) A Guide to Space Law Terms (2012) 120

John Bosco Nkumunue New Theory and Practice of Capitalism (2014) ch 5

Leo Heaps Operation Morning Light : Terror in our Skies : The True Story of Cosmos 954 (1978) 14

Lewis Pinault ‘Towards a World Space Agency’ in Cockell C. (ed) Human Governance Beyond Earth (2015) 173 - 196

Marientta Benkö Space law in the United Nations (1985) 46

McConville and Wing Hong Chui (eds.). Research Methods for Law - Qualitative Legal Research and Law in Context. 2nd Edition. (2017) Ch 2 and 6.

Myres S. McDougal, Harold D. Lasswell, and Ivan A. Vlasic Law and Public Order in Space (1963)

Nandasiri Jasentuliyana & Roy S.K. Lee (eds) Manual on Space Law (1979) 115

Peter P. C. Haanappel The Law and Policy of Air Space and Outer Space: A Comparative Approach (2003)

Pierre-Marie Dupuy & Jorge E. Viñuales International Environmental Law (2015) 262

Steven M. Barkan, Barbara A. Bintliff and Mary Whisner. (eds). Fundamentals of Legal Research. (10th ed.) (2015). 1-23.

Walter E "The Privatisation and Commercialisation of Outer Space" in Brünner C and Soucek A (eds) Outer Space in Society, Politics and Law (2011) 494

Yuval Noah Harari Homo Deus (2016) 59

Case Law

Corfu Channel case (United Kingdom v. Albania), Judgment, 9 April 1949, ICJ Reports (1949)

Max huber 'Island of Palmas Case' (1928) II Reports of International Arbitral Awards 839

'Settlement of Claim between Canada and the Union of Soviet Socialist Republics for Damage Caused by "Cosmos 954"' available http://www.jaxa.jp/library/space_law/chapter_3/3-2-2-1_e.html, accessed on 01 September 2019

Journal Articles and Reports

A Ferreira-Snyman 'Legal Challenges Relating to the Commercial Use of Outer Space, with Specific Reference to Space Tourism' (2014) 17 *Pochefstroomse Elektroniese Regsblad* 01/612

A. Kerrest de Rozavel & F. G. von der Dunk 'Liability and Insurance in the Context of National Authorisation' in F.G. von der Dunk (ed) *National Space Legislation in Europe* vol 6 (2011) 128

Adrian Taghdiri 'Flags of Convenience and the Commercial Space Flight Industry: The Inadequacy of Current International Law to Address the Opportune Registration of Space Vehicles in Flag States' (2013) 19 *Journal of Science and Technology Law* 405

Alexander F. Cohen 'Cosmos 954 and the International Law of Satellite Accidents' 10 (1984) *Yale Journal of International Law* 80-81

Alexander W. Salter & Peter T. Leeson 'Celestial Anarchy: A Threat to Outer Space Commerce?' (2014) 34 *Cato Journal* 590

Alfred H.A. Soons 'Law Enforcement in the Ocean' (2004) 3 WMU *Journal of Maritime Affairs* 8

Ben Greene 'Laser Tracking of Space Debris' (unpublished research report, *Electro Optic Systems*, 2003)

Benjamin D. Hatch 'Dividing the Pie in the Sky: The Need for a New Lunar Resources Regime' (2010) 24 *Emory Internation Law Review* 229

Bin Cheng Studies in *International Space Law* (1997) 383

Brian M Hoffstadt ‘Moving the Heavens: Lunar Mining & the "Common Heritage of Mankind, " in the Moon Treaty’ (1994) 42 *UCLA Law Review* 575 - 586

British Institute of International and Comparative Law Current Problems in Space Law: A Symposium (1966) 55; Edward F. Hennessey ‘Liability for Damage Caused by the Accidental Operation of a Strategic Defense Initiative System’ 21 (1988) *Cornell International Law Journal* 320

Carl Christol ‘International Liability for Damage Caused by Space Objects’ (1980) 74 *American Journal of International Law* at 346

Cestmir Cepelka & Jamie Gilmour ‘The Application of General International Law in Outer Space’ (1970) 36 *Journal of Air Law and Commerce* 33

Christopher C. Joyer ‘Legal Implications of the concept of the Common Heritage of Mankind’ (1986) 35 *International & Comparative Law Quarterly* 190

D. Mehrhol et al, ‘Detecting, Tracking and Imaging Space Debris’ (2002) *European Space Agency Bulletin*

Daniel Goedhuis ‘Some Recent Trends in the Interpretation and the Implementation of the Rules of International Space Law’ (1981) 19 *Columbia Journal of Transnational Law* 233

Daniel L Oltrogge & Salvatore Alfano ‘The technical challenges of better Space Situational Awareness and Space Traffic Management’ 6 (2019) *Journal of Space Safety Engineering* 72-79

David Everett Marko ‘A Kinder, Gentler Moon Treaty: A Critical Review of the Current Moon Treaty and a Proposed Alternative’ (1992) 9 *Journal of Natural Resources & Environmental Law* 316 quoting from: Nancy L. Griffin ‘Comment, Americans and the Moon Treaty’ (1981) 46 *Journal of Air Law and Commerce* 762 and Nicolas Mateesco Matte ‘The Common Heritage of Mankind and Outer Space: Toward a New International Order for Survival’ (1987) 12 *Annals of Air and Space Law* 323

David Tan ‘Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind" 25 (2000) *Yale Journal of International Law* 168

Donald J. Kessler et al ‘The Kessler Syndrome: Implications to Future Space operations’ (2010) *American Astronautical Society* 1-3

Elena Carpanelli & Brendan Cohen ‘Interpreting “Damage Caused by Space Objects” under the 1972 Liability Convention’ (2013*) International Institute of Space Law* at 3&4

Erin Bennett ‘To Infinity and Beyond: The Future Legal Regime Governing Near-Earth Asteroid Mining’ available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2935403 accessed on 16 October 2018

Eun-Hyouek Kim, Hae-Dong Kim and Hak-Jung Kim ‘Optimal Solution of Collision Avoidance Maneuver with Multiple Space Debris’ 9 (2012) *Journal of Space Operations* 20-21

Eva Yi-Wei Chang1 & Rock J S Chern ‘A Study and Discussion on the Cost Issue of Suborbital and Orbital Space Tourism’ 7 (2018) *Journal of Tourism and Hospitality*

F. Lansakara ‘Maritime Law of Salvage and Adequacy of Laws Protecting the Salvors’ Interest’ *International Journal on Marine Navigation and Safety of Sea Transportation* (2012)6 431 – 435

Fabio Tronchetti ‘Private property rights on asteroid resources: Assessing the legality of the ASTEROIDS Act’ (2014) 30 *Space Policy* 194

Fabio Tronchetti ‘The Moon Agreement in the 21st Century: Addressing Its Potential Role in the Era of Commercial Exploitation of the Natural Resources of the Moon and Other Celestial Bodies’ (2010) 36 *Journal of Space Law* 499

Fabio Tronchetti ‘Title IV – Space Resource Exploration and Utilization of the US Commercial Space Launch Competitiveness Act: A Legal and Political Assessment’ (2016) 41 *Air and Space Law* 151

Fei Meng et al ‘Review of Lithium Production and Recovery from Minerals, Brines, and Lithium-Ion Batteries’ (2019) *Mineral Processing and Extractive Metallurgy Review* 1-19

Francis Lyall & Paul B. Larsen Space Law: A Treatise (2009) 163; Glenn H. Reynolds & Robert P. Merges ‘Outer Space: Problems of Law and Policy’ (1990) 3 *Harvard Journal of Law and Technology* 275 - 278

Frans G von der Dunk ‘Billion-dollar questions? Legal aspects of commercial space activities’ (2018) 23 *Uniform Law Review* 418-446

Frans G. von der Dunk ‘Space Tourism, Private Spaceflight and the Law: Key Aspects’ (2011) *Space Policy* 149

Frans G. von der Dunk ‘Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?’ (2010) *Space, Cyber, and Telecommunications Law Program Faculty Publications* 203

G.T. (Stan) Crothers & Lindie Nelson ‘High Seas Fisheries Governance: A Framework for the Future?’ (2006) 21 *Marine Resource Economics* 341 - 353

Gennady M. Danilenko ‘International law-making for outer space’ 37 (2016) *Space Policy* 180

Hamilton DeSaussure, P.P.C. Haanappel, ‘A Unified Multinational Approach to the Application of Tort and Contract Principles to Outer Space,’ 6 (1978) *Syracuse Journal of International Law and Commerce*

Howard A. Baker, ‘Space Debris: Legal and Policy Implications’ 6 (1989) *Utrecht Studies in Air and Space Law* 84

International Space Law: Some Lessons from International Nuclear Law' (2011) 4 *Journal of East Asia and International Law* at 291 & 306

Irini Papanicolopulu 'The Duty to rescue at sea, in peacetime and in war: A General Overview' (2016) 98 *International Review of the Red Cross*

J. Ashley Roach 'Today's Customary International Law of the Sea' (2014) 45 *Ocean Development & International Law* 243

James P. Lampertius, 'The Need for an Effective Liability Régime for Damage Caused by Debris in Outer Space' 13 (1992) *Michigan Journal of International Law* 454 - 455

Joel A Dennerley 'State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law' 29 (2018) *European Journal of International Law* 300

Jonathan C. McDowell 'The edge of space: Revisiting the Karman Line' (2018) 151 *Acta Astronautica* 668-677

Jürgen Cloppenburg, 'Legal Aspects of Space Tourism' in Marietta Benkö & Kai-Uwe Schrogl (ed) *Space Law: Current Problems and Perspectives for Future Regulation* (2005) 196 - 197

Kamil Muzyka 'The problems with an international legal framework for asteroid mining' available at https://www.academia.edu/32453498/The_problems_with_an_international_legal_framework_for_asteroid_mining_by_Kamil_Muzyka, accessed on 14 December 2019

Kenneth S. Pedersen 'Is it time to create a World Space Agency?' 9 (1993) Space Policy; David Tan 'Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind"' 25 (2000) *Yale Journal of International Law* 190

L. F. E. Goldie, 'Liability for Damage and the Progressive Development of International Law' 14 (1965) *British Institute of International and Comparative Law* 1216

Ladd Sanger & Vicki S. Brandt 'Flying-and Crashing-on the Wings of Fortuosity: The Case for Applying Admiralty Jurisdiction to Aviation Accidents Over Navigable Waters' available at https://www.slackdavis.com/wp-content/uploads/2018/10/Ladd-Sanger-Paper-Flying-And-Crashing-On-The-Wings-Of-Fortuosity-Applying-Admiralty-Jurisdiction-To-Aviation-Accidents-Over-Navigable-Waters.pdf accessed on 18 February 2019

Lalin Kovudhikulrungsri & Duangden Nakseeharach 'Liability Regime of International Space Law: Some Lessons from International Nuclear Law' (2011) 4 *Journal of East Asia and International Law*

Laura Rut Skopowska Is an object built in the outer space a 'space object' under the Liability Convention? (unpublished LLM thesis, Université Du Luxembourg, 2017) 53

Laura Verëll The Effectiveness of the Liability Regime in the 1972 Liability Convention on Damage Caused by Space Debris to the Space Object of a State in Outer Space (unpublished LLM thesis, Universiteit van Amsterdam, 2017) 17

Leslie I. Tennen 'Towards a New Regime for Exploitation of Outer Space Mineral Resources' (2010) 88 *Nebraska Law Review* 796-797

Ling Yan 'Does the Rescue Agreement apply to space tourists' (2011) Proceedings of the International Institute of Space Law: 54th *Colloquium on the Law of Outer Space* 197

Mark Sundahl 'The duty to rescue space tourists and return private spacecraft' (2009*) Journal of Space Law* 163-200

Matthew Craven 'Between law and history: the Berlin Conference of 1884-1885 and the logic of free trade' (2015) 3 *London Review of International Law* 31-59

Maureen Williams 'The Common Heritage of Mankind and the Moon Agreement: Economic Implications and Institutional Arrangement' (1981) *International Institute of Space Law* 87

Michael C. Mineiro 'FY-1C and USA-193 ASAT Intercepts: An Assessment of Legal Obligations under Article IX of the Outer Space Treaty' 34 (2008) *Journal of Space Law*

MJ Peterson 'The Use of Analogies in Developing Outer Space Law' (1997) 51 *International Organization* 245

NASA Office of Safety and Mission Assurance, 'NASA Safety Standard 1740.14, *Guidelines and Assessment Procedures for Limiting Orbital Debris'* (1995) 37-38

Ni Li 'A study on the Delimitation of Outer Space' available at https://www.academia.edu/8518439/A_Study_on_the_Delimitation_of_Outer_Space, accessed on 08 October 19

P. J. Blount & Christian J. Robison 'One Small Step: The Impact of the U.S. Commercial Space Launch Competitiveness Act of 2015 on the Exploitation of Resources in Outer Space' (2016) 18 *North Carolina Journal of Law and Technology* 175

Paul Larsen 'Commercial Operator Liability in The New Space Era' 113 (2019) *American Journal of International Law*

Peter Martinez 'The Development of Space Law in South Africa' (2015) 64 Zeitschrift fur Luftund Weltraumrecht - *German Journal of Air and Space Law* 353-354

Puneet Bhalla 'Mining Asteroids and Exploring Resources in Space' (2015) *Centre for Land Warfare Studies Journal* at 145

Rada Popova & Volker Schaus 'The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space' (2018) *Aerospace* 11

Rafal Kopec ‘Geostationary Belt – State’s Territory or Province of Mankind?’ (2018) 8 *Review of Nationalities* 167 - 178

Ram S Jakhu, Tommaso Sgobba & Paul Stephen Dempsey The Need for an Integrated Regulatory Regime for Aviation and Space (2011) 119

Robin Elizabeth Lewis An Analysis of the Law of the Sea and Outerspace Law: Claims Over the Natural Resources of the “Commons” (unpublished M.A. thesis, University of Richmond, 1987) ii

Ruslan S. Skomorohova, Andreas M. Hein and Chris Welch ‘In-orbit Spacecraft Manufacturing: Near-term Business Cases’ (2016) 67th *International Astronautical Congress*

Sara Langston & Sarah Jane Pell ‘What is in a name? Perceived identity, classification, philosophy, and implied duty of the ‘astronaut’ 115 (2015) *Acta Astronautica* 189

Scot W Anderson, Korey Christensen & Julia LaManna ‘The development of natural resources in outer space’ (2019) 37 *Journal of Energy & Natural Resources Law* 228-229

Scott Pace ‘Regulating Outer Space: Making Space Commerce a Priority’ (2016) 95 *Foreign Affairs*

Stanley Mazarof, “Exonerations from Liability for Damage Caused by Space Activities” 54 (1968) *Cornell Law Review* 74

Stephan Hobe ‘Legal Aspects of Space Tourism’ 86 (2007) *Nebraska Law Review* 439

Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl‘Cologne Commentary on Space Law, Volume I: The Outer Space Treaty’ (2011) 27 *Space Policy* 252

Stephen Gorove ‘Cosmos 954: Issues of Law and Policy’ (1978) 6 *Journal of Space Law* at 141

Tanja Masson-Zwaan ‘Regulation of Sub-orbital Space Tourism in Europe: A Role for EU/EASA?’ (2010) 35 *Air and Space Law* 264

Tanja Masson-Zwaan ‘Space Law and the Satellite Collision of 10 February 2009’ (2009) *Space Research Today* 9

Theodore J. Muelhaupt et al ‘Space traffic management in the new space era’ 6 (2019) *Journal of Space Safety Engineering*

Timothy G. Nelson ‘The Moon Agreement and Private Enterprise: Lessons from Investment Law’ (2011) 17 ILSA *Journal of International and Comparative Law* 397

Ting Wang ‘A Liability and Insurance Regime for Space Debris Mitigation’ 24 (2016) *Science & Global Security* 26

Toru Yada et al ‘Hayabusa-returned sample curation in the Planetary Material Sample Curation Facility of JAXA’ 49 (2014) *Meteoritics and Planetary Science* 135 - 153

Trevor Kehrer ‘Closing the Liability Loophole: The Liability Convention and the Future of Conflict in Space’ (2019) 20 *Chicago Journal of International Law* 187

U.S. Congress, Office of Technology Assessment Space Stations and the Law: Selected Legal Issues -- Background Paper (1986) available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1011&context=spacelawdocs, accessed on 25 October 2019

UN COPOUS ‘Report of the Legal Subcommittee on its fifty-fourth session, held in Vienna from 13 to 24 April 2015’ available at http://www.unoosa.org/res/oosadoc/data/documents/2015/aac_105/aac_1051090_0_ html/AC105_1090E.pdf, accessed on 14 September 2019

UNCOPUOS ‘Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space’ available at http://www.unoosa.org/pdf/gares/ARES_22_2345E.pdf, accessed on 30 October 2019

UNCOPUOS ‘Report of the Legal Sub-Committee on the Work of its Fifty-Eighth Session’ available at https://cms.unov.org/dcpms2/api/finaldocuments?Language=en&Symbol=A/AC.105/1203, accessed on 08 October 2019

UNCOPUOS ‘Report of the Legal Sub-Committee on the Work of its Seventeenth Session’ available at http://www.unoosa.org/res/oosadoc/data/documents/1978/aac_105/aac_105218_0_html/AC105_218E.pdf, accessed on 08 October 2019

US Department of State ‘85. U.S. Statement, Definition and Delimitation of Outer Space and The Character and Utilization Of The Geostationary Orbit, Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space at its 40th Session in Vienna from April’ available at https://2009-2017.state.gov/s/l/22718.htm, accessed on 08 October 2019

Virgiliu Pop ‘Appropriation in outer space: the relationship between land ownership and sovereignty on the celestial bodies’ (2000) 16 *Space Policy* 275-282

Walter Edith "The Privatisation and Commercialisation of Outer Space" in Brünner C and Soucek A (eds) *Outer Space in Society, Politics and Law* (2011) 494

Welly ND "Enlightened state interest - A legal framework for protecting the common heritage of mankind from Hardinian tragedy" (2010) *Journal of Space Law* 273-313

Yanal Abul Failat ‘Space Tourism: A Synopsis on its Legal Challenges’ 120 (2012) *Irish Law Journal* 121

Yun Zhao ‘A Legal Regime for Space Tourism: Creating Legal Certainty in Outer Space’ (2009) 74 *Journal of Air Law and Commerce* 962-963

Yun Zhao ‘Space Commercialization and the Development of Space Law’ (2018) *Oxford Research Encyclopaedia of Planetary Science* 1

Legislation and Treaties

According to the UN Treaty Collection site, available at https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXIV-2&chapter=24&clang=_en, accessed 31 October 2019

Act 36 of 2008

Act 84 of 1993, as amended by the Space Affairs Amendment Act 64 of 1995

Article 38(1)(b) Statute of the International Court of Justice

Article 44 of the Convention on International Civil Aviation (Chicago Convention)

Bill Posey & Derek Kilmer ‘HR5063: American Space Technology for Exploring Resource Opportunities in Deep Space Act’ available at http://www.spacepolitics.com/wp-content/uploads/2014/07/AsteroidsActHR5063.pdf, accessed on 03 December 2019

Charles Bjork ‘The Luxembourg Space Resources Act and International Law’ available at https://fcilsis.wordpress.com/2018/12/12/the-luxembourg-space-resources-act-and-international-law/, accessed on 05 December 2019

David W. Gruning ‘Article 14 of the French Civil Code, as of 1st July 2013’ available at https://www.wipo.int/edocs/lexdocs/laws/en/fr/fr512en.pdf, accessed on 29 October 2019

ICAO ‘Convention on International Civil Aviation’ available at https://www.icao.int/publications/Documents/7300_orig.pdf, accessed on 30 October 2019

International Law Commission, ‘Vienna Convention on the law of treaties (with annex). Concluded at Vienna on 23 May 1969’ available at https://treaties.un.org/doc/Publication/UNTS/Volume%201155/volume-1155-I-18232-English.pdf, accessed on 01 September 2019.

Montreal Convention 1999

Nuclear Energy Agency ‘Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960, as amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982’ available at https://www.oecd-nea.org/law/nlparis_conv.html, accessed on 01 September 2019

Officially Loi du 20 juillet 2017 sur l’exploration et l’utilisation des ressources de l’espace. Available at http://data.legilux.public.lu/file/eli-etat-leg-loi-2017-07-20-a674-jo-fr-pdf.pdf, with an English translation available at https://space-agency.public.lu/en/agency/legal-framework/law_space_resources_english_translation.html

Outer Space Act 1986

Space Affairs Act 84 of 1993

UNCLOS 'United Nations Convention on the Law of the Sea' available at https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf, accessed on 25 November 2019

UNCOPUOS 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' available at http://www.unoosa.org/pdf/gares/ARES_34_68E.pdf, accessed on 30 October 2019

United Nations General Assembly, Resolution 62/217

United Nations Office for Disarmament Affairs 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' available at http://disarmament.un.org/treaties/t/moon accessed on 19 October 2018

United Nations Office for Outer Space Affairs 'Convention on Registration of Objects Launched into Outer Space' available at http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf accessed on 26 August 2019

United Nations Office for Outer Space Affairs 'Convention on the International Liability for Damage Caused by Space Objects' available at http://www.unoosa.org/pdf/gares/ARES_26_2777E.pdf accessed on 23 July 2019

United Nations Office for Outer Space Affairs 'Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space' available at http://www.unoosa.org/pdf/publications/st_space_49E.pdf accessed on 10 August 2019

United Nations Office for Outer Space Affairs 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies' available at http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf accessed on 17 April 2019

United Nations Office for Outer Space Affairs 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies' available at http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf accessed on 17 April 2019

UNTC 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' available at https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXIV-2&chapter=24&clang=_en accessed on 12 February 2019

Websites and Internet Sources

"A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun or Earth and the moon, equal the centrifugal force felt by a much smaller third body. The interaction of the forces creates a point of equilibrium where a spacecraft may be 'parked'."; Elizabeth Howell 'Lagrange Points: Parking Places in Space' available at

https://www.space.com/30302-lagrange-points.html, accessed on 14 November 2019

Adam Minter ‘Space-Faring Nations Need Regulations to Prevent Satellite Collisions: Opinion’ available at https://www.insurancejournal.com/news/international/2019/09/09/539191.htm, accessed on 28 September 2019

Arthur Villasanta ‘SpaceX Declined to Move Starlink 44 in Collision Course with ESA Satellite’ available at https://www.ibtimes.com/spacex-declined-move-starlink-44-collision-course-esa-satellite-2821827, accessed on 28 September 2019

Caleb Henry ‘SpaceX says more Starlink orbits will speed service, reduce launch needs’ available at https://spacenews.com/spacex-says-more-starlink-orbits-will-speed-service-reduce-launch-needs/, accessed on 20 September 2019

Charles Q. Choi ‘Tiny Solar Activity Changes Affect Earth's Climate’ available at https://www.space.com/19280-solar-activity-earth-climate.html, accessed on 08 October 2019

Cheryl Warner ‘Expands Plans for Moon Exploration: More Missions, More Science’ available at https://www.nasa.gov/feature/nasa-outlines-new-lunar-science-human-exploration-missions accessed on 12 October 2018

Chloe Cornish ‘Interplanetary players: a who’s who of space mining’ available at https://www.ft.com/content/fb420788-72d1-11e7-93ff-99f383b09ff9 accessed on 12 October 2018

Christopher Newman & Michael Listner ‘Failure to launch: the technical, ethical and legal case against Mars One.’ available at https://sure.sunderland.ac.uk/id/eprint/5992/1/MarsOneTSR%20Final%20%28revised%7D.pdf accessed on 31 October 2019

DeerMoon Offcial Website, available at dearmoon.earth accessed on 03 October 2019

Donald J. Kessler ‘The Kessler Syndrome’ available at http://aquarid.physics.uwo.ca/kessler/KesSym.html, accessed on 04 September 2019

Ed Kyle ‘Space Launch Reports’ available at https://www.spacelaunchreport.com/log2018.html accessed on 23 March 2019

Elizabeth Howell ‘SpaceShipTwo: On a Flight Path to Space Tourism’ available at https://www.space.com/19021-spaceshiptwo.html, accessed on 14 October 2019

Emma Wynne ‘When Skylab fell to earth’ available at https://www.abc.net.au/local/photos/2009/07/09/2621733.htm, accessed on 01 September 2019

Erin Mahoney ‘Q&A: NASA’s New Spaceship’ available at https://www.nasa.gov/feature/questions-nasas-new-spaceship, accessed on 14 November 2019

European Space Agency ‘About Space Debris’ available at https://www.esa.int/Our_Activities/Space_Safety/Space_Debris/About_space_debris, accessed on 01 September 2019

European Space Agency ‘ESA Spacecraft Dodges Large Constellation’ available at http://www.esa.int/Our_Activities/Space_Safety/ESA_spacecraft_dodges_large_constellation, accessed on 20 September 2019

Flint Wild ‘What Is an Orbit?’ available at https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbit-58.html, accessed on 23 August 2019

Ian Sample ‘Huge helium gas find in east Africa averts medical shortage’ available at https://www.theguardian.com/science/2016/jun/28/huge-helium-gas-tanzania-east-africa-averts-medical-shortage, accessed on 11 November 2019

ICAO ‘Glossary’ available at https://www.icao.int/cybersecurity/Lists/Glossary/AllItems.aspx, accessed on 14 October 2019

ICAO ‘The Concept of Sub-Orbital Flights, Working Paper C-WP/12436 (30 May 2005)’ available at http://www.icao.int/ICDB/HTML/English/Representative%20Bodies/Council/Working%20Papers%20by%20Session/175/C.175.WP.12436.EN/C.175.WP.12436.EN.HTM, accessed on 23 October 2019

ISS Multilateral Crew Operations Panel ‘Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers’ available at http://www.spaceref.com/news/viewsr.html?pid=4578, accessed on 30 October 2019

Ivan A. Vlasic ‘Air Law and Space Law’ available at https://www.thecanadianencyclopedia.ca/en/article/air-law-and-space-law accessed on 13 February 2019

James Vincent ‘China can’t control the market in rare earth elements because they aren’t all that rare’ available at https://www.theverge.com/2018/4/17/17246444/rare-earth-metals-discovery-japan-china-monopoly, accessed on 11 November 2019

Jeremey Hsu ‘Don’t Panic about Rare Earth Elements’ available at https://www.scientificamerican.com/article/dont-panic-about-rare-earth-elements/, accessed on 11 November 2019

Joanne Irene Gabrynowicz ‘Written Testimony of Joanne Irene Gabrynowicz Before the Committee on Science, Space and Technology United States House of Representatives’ available at https://science.house.gov/imo/media/doc/DraftGabrynowicz%20Testimony.pdf, accessed on 22 November 2019

Joel R. Primack ‘Debris and Future Space Activities’ available at http://physics.ucsc.edu/cosmo/Mountbat.PDF, accessed on 04 September 2019

Joel R. Primack and Nancy Ellen Abrams ‘Star Wars Forever? — A Cosmic Perspective’ available at http://physics.ucsc.edu/cosmo/UNESCOr.pdf, accessed on 04 September 2019

John Merriam & Gordon Web ‘When Air Meets the Sea: Applying Maritime and Admiralty Law to Commercial Aviation Accidents’ available at https://www.cruiselawusa.com/when-air-meets-the-sea-applying-maritime-and-admiralty-law-to-co.html accessed on 18 February 2019

John Spacey ‘What is the Karman Line?’ available at https://simplicable.com/new/karman-line accessed on 15 October 2018

Jon Brodkin ‘SpaceX satellite was on “collision course” until ESA satellite was re-routed’ available at https://arstechnica.com/information-technology/2019/09/spacex-satellite-was-on-collision-course-until-esa-satellite-was-re-routed/, accessed on 20 September 2019

Jonothan O’Callaghan ‘SpaceX Prepares To Make History With First-Ever Human Spacecraft Launch Tomorrow’ available at https://www.forbes.com/sites/jonathanocallaghan/2019/03/01/spacex-prepares-to-make-history-with-first-ever-human-spacecraft-launch-tomorrow/#129ba61c43f3 accessed on 23 March 2019

Jordi Sandalinas ‘Art IX of the Outer Space Treaty and Peaceful Purposes: Issues and Implementation’ 2010

Eilene M. Galloway Symposium on Critical Issues in Space Law;

Laura Montgomery ‘The “Non-Interference” Provision of Article IX of the Outer Space Treaty and Property Rights’ available at https://groundbasedspacematters.com/index.php/2017/03/31/the-non-interference-provision-of-article-ix-of-the-outer-space-treaty-and-property-rights/, accessed on 27 November 2019

José Monserrat Filho ‘Definition and Delimitation of Outer Space – a Deadlock Discussion?’ available at https://www.icao.int/Meetings/SPACE2016/Presentations/2%20-%20J.%20Filho%20-%20Chair%20of%20COPUOUS%20LSC%20WG%20on%20DefDel%20of%20Outer%20Space.pdf, accessed on 08 October 2019

Julia Kagan ‘Maritime Law’ available at https://www.investopedia.com/terms/m/maritime-law.asp accessed on 15 February 2019

Karen Northon (ed) ‘NASA Opens International Space Station to New Commercial Opportunities, Private Astronauts’ available at https://www.nasa.gov/press-release/nasa-opens-international-space-station-to-new-commercial-opportunities-private, accessed on 03 October 2019

Kenneth Chang ‘Meet SpaceX’s First Moon Voyage Customer, Yusaku Maezawa’ available at https://www.nytimes.com/2018/09/17/science/spacex-moon-tourism-passenger.html, accessed on 03 October 2019

Kyle Maxey ‘Asteroid Mining – Who Wants to be a Trillionaire?’ available at https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/15308/Asteroid-Mining-Who-Wants-to-be-a-Trillionaire.aspx accessed on 19 October 2018

Kyoko Hasegawa ‘The voyage home: Japan's Hayabusa-2 probe to head for Earth’ available at https://phys.org/news/2019-11-voyage-home-japan-hayabusa-probe.html, accessed on 27 November 2019

Laurent Thailly & Fiona Schneider ‘Luxembourg set to become Europe's commercial space exploration hub with new Space Law’ available at https://www.ogier.com/news/the-luxembourg-space-law#, accessed on 05 December 2019

Lesley Jane Smith & Kay-Uwe Hörl ‘Legal Parameters of Space Tourism’ available at http://www.weber-steinhaus.com/bereiche_de/publikation_downloads/003LegalParameters.pdf, accessed on 01 November 2019

Loren Grush ‘A bug in SpaceX’s communication system kept the company in the dark about potential satellite collision’ available at https://www.theverge.com/2019/9/3/20847243/spacex-starlink-satellite-european-space-agency-aeolus-conjunction-space-debris, accessed on 20 September 2019

Louis Brennan ‘How Luxembourg is positioning itself to be the centre of space business’ available at http://theconversation.com/how-luxembourg-is-positioning-itself-to-be-the-centre-of-space-business-120436, accessed on 05 December 2019

Louis de Gouyon Matignon ‘The Res Communis Concept in Space Law’ available at https://www.spacelegalissues.com/space-law-the-res-communis-concept-in-space-law/, accessed on 28 November 2019

Louis de Gouyon Matigon ‘Space Tourism Legal Aspects’ available at https://www.spacelegalissues.com/space-law-space-tourism-legal-aspects/, accessed on 03 October 2019

Marc Feider & Jaques Graas ‘Luxembourg Space Resources Act: Paving the legal road to space’ available at https://www.allenovery.com/en-gb/global/news-and-insights/publications/luxembourg-space-resources-act-paving-the-legal-road-to-space, accessed on 05 December 2019

Marc M. Cohen et al ‘Robotic Asteroid Prospector (RAP) Staged from L1: Start of the Deep Space Economy’ available at https://www.nasa.gov/sites/default/files/files/Cohen_2012_PhI_RAP.pdf, accessed on 14 November 2019

Mark Carcia, ‘Space Debris and Human Spacecraft’ available at https://www.nasa.gov/mission_pages/station/news/orbital_debris.html, accessed on 23 August 2019

Matthew S. Williams ‘Asteroid Mining: What Will It Involve and Is This the Future of Wealth?’ available at https://interestingengineering.com/asteroid-mining-what-will-it-involve-and-is-this-the-future-of-wealth, accessed on 12 November 2019

Mehak Sarang ‘Op’Ed: Thoughts on UN COPUOS’ available at https://spacegeneration.org/oped-thoughts-on-un-copuos, accessed on 28 September 2019

Michael Belfiore ‘How to Mine an Asteroid’ available at https://www.popularmechanics.com/space/a7942/how-to-mine-an-asteroid-11644811/, accessed on 14 November 2019

Michael Listner ‘A new paradigm for arbitrating disputes in outer space’ available at http://www.thespacereview.com/article/2002/1, accessed on 29 October 2019

Michael Listner ‘Iridium 33 and Cosmos 2251 three years later: where are we now?’ available at http://www.thespacereview.com/article/2023/1, accessed on 12 September 2019

Michael Listner ‘The Moon Treaty: failed international law or waiting in the shadows?’ available at http://www.thespacereview.com/article/1954/1, accessed on 31 October 2019

Mike Wall ‘Asteroid Mining Venture Backed by Google Execs, James Cameron Unveiled’ available at http://www.space.com/15395-asteroid-mining-planetary-resources.html, accessed on 10 August 2019

Mike Wall ‘Boeing Preps for Upcoming Starliner Test Flight to Space Station’ available at https://www.space.com/boeing-starliner-flight-launch-test-prep.html accessed on 23 March 2019

Mitsubishi Heavy Industries ‘Space’ available at https://www.mhi.com/products/space/ accessed on 23 March 2019

NASA Space Science Data Coordinated Archive ‘Cosomos 954’ available at https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1977-090A , accessed on 01 September 2019

Nomfuneko Majaja ‘Space Related Issues” available at https://www.thedti.gov.za/parliament/2018/Space_Issues.pdf, accessed on 15 November 2019

Övunç Kutlu ‘ANALYSIS - OPEC losing control, share in global oil market’ available at https://www.aa.com.tr/en/energy/international-organization/analysis-opec-losing-control-share-in-global-oil-market/27117, accessed on 17 December 2019

P. Anz-Maedor ‘Top Ten Satellite Breakups’ 20 (2016) Orbital Debris Quarterly News 6

Paul Stephen Dempsey and Maria Manol ‘Suborbital flights and the delimitation of air space vis-à-vis outer space: functionalism, spatialism and state sovereignty’ available at

http://www.unoosa.org/res/oosadoc/data/documents/2018/aac_105c_22018crp/aac_105c_22018crp_9_0_html/AC105_C2_2018_CRP09E.pdf, accessed on 23 october 2019

Paul Voosen ‘Outer Space may have gotten a bit closer’ available at https://www.sciencemag.org/news/2018/07/outer-space-may-have-just-gotten-bit-closer, accessed on 08 October 2019

Philip De Man ‘Luxembourg Law on Space Resources Rests on Contentious Relationship with International Framework’ available at https://ghum.kuleuven.be/ggs/publications/working_papers/2017/189deman, accessed on 07 December 2019

SACSA ‘National Registry of Objects Launched into Outer Space’ available at http://www.sacsa.gov.za/registry/index.php, accessed on 26 November 2019

Sam Blum ‘SpaceX's First Manned Mission to The ISS Could Come as Quickly as July’ available at https://www.popularmechanics.com/space/rockets/a26625114/spacex-manned-mission-iss/ accessed on 23 March 2019;

Sara Chodosh ‘You'd be surprised how often space junk falls out of the sky’ available at https://www.popsci.com/space-junk-debris-falls/, accessed on 01 September 2019

Scott Kerr ‘Liability for space debris collisions and the Kessler Syndrome (Part 1)’ available at http://www.thespacereview.com/article/3387/1, accessed on 10 August 2019

SpaceX ‘First Passenger on Lunar BFR Mission’ available at https://www.spacex.com/news/2018/10/09/first-passenger-lunar-bfr-mission, accessed on 03 October 2019

SpaceX ‘Making Life Multiplanetary’ available at https://www.spacex.com/mars accessed on 12 October 2018

Stefanie Waldek ‘How to become a space tourist: 8 companies (almost) ready to launch’ available at https://www.popsci.com/how-to-become-a-space-tourist accessed on 12 October 2018

Stephen E. Doyle ‘A Concise History of Space Law’ available at http://www.iislweb.org/website/docs/2010keynote.pdf accessed on 02 February 2019

Tanja Masson-Zwaan & Bob Richards ‘International Perspectives on Space Resource Rights’ available at https://spacenews.com/op-ed-international-perspectives-on-space-resource-rights/, accessed on 20 November 2019

The Economist ‘The end of the Space Age’ available at https://www.economist.com/leaders/2011/06/30/the-end-of-the-space-age accessed on 12 October 2014

The Economist ‘The space race is dominated by new contenders’ available at https://www.economist.com/graphic-detail/2018/10/18/the-space-race-is-dominated-by-new-contenders accessed on 23 March 2018

The Editors of Encyclopaedia Britannica ‘Dennis Tito – American Businessman’ available at https://www.britannica.com/biography/Dennis-Tito, accessed on 03 October 2019

The Mars Society ‘Founding Declaration’ available at http://nextgen5.marssociety.org/home/about/founding-declaration/ accessed on 12 October 2018

The Satellite Encyclopedia ‘Sunsat’ available at https://www.tbs-satellite.com/tse/online/sat_sunsat.html, accessed on 26 November 2019

Tim Fernholz ‘SpaceX and Boeing are running out of time to fly astronauts into space’ available at https://qz.com/1328927/spacex-and-boeing-are-running-out-of-time-to-fly-nasa-astronauts-to-iss-warns-the-government-accountability-office/ accessed on 23 March 2019;

Tim Fernholz ‘SpaceX takes its biggest step toward flying people into space’ available at https://qz.com/1562886/elon-musks-spacex-is-near-ready-to-launch-humans-into-space/ accessed on 23 March 2019;

Trefor Moss ‘In China’s New Space Odyssey, 80 Startups Race to Get Into Orbit’ available at https://www.wsj.com/articles/chinese-startups-push-into-space-business-1541851211 accessed on 24 March 2018

Truls Lynne Hansen ‘The northern lights-what are they?’ available at http://geo.phys.uit.no/articl/theaurora.html, accessed on 23 August 2019; Northern Lights Centre ‘Northern Lights’ available at https://www.northernlightscentre.ca/northernlights.html, accessed on 23 August 2019

United Nations Committee on the Peaceful Uses of Outer Space ‘Guidelines for the Long-term Sustainability of Outer Space Activities’ available at https://undocs.org/pdf?symbol=en/A/AC.105/C.1/L.366, accessed on 30 September 2019

United Nations Office for Outer Space Affairs ‘COPUOS History’ available at http://www.unoosa.org/oosa/en/ourwork/copuos/history.html accessed on 03 March 2019

Untied Nations Office for Outer Space Affairs ‘Long-term Sustainability of Outer Space Activities’ available at http://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html, accessed on 30 September 2019

Virgin Galactic ‘SpaceShipTwo’ available at https://www.virgingalactic.com/learn/, accessed on 14 October 2019

Virgin Orbit available at https://virginorbit.com/launch/, accessed on 14 October 2019

World Coal Association ´Where is coal found?' available at https://www.worldcoal.org/coal/where-coal-found, accessed on 11 November 2019

Zenaida Gonzalez Kotala 'Steam-Powered Asteroid Hoppers Developed through UCF Collaboration' available at https://www.ucf.edu/news/steam-powered-asteroid-hoppers-developed-ucf-collaboration/, accessed on 14 November 2019

ANNEXURES

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