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**POTENTIAL LIABILITIES OF SPACE DEBRIS FROM SATELLITE
CONSTELLATION**

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ABSTRAK

Konstelasi satelit adalah terobosan terbaru dalam teknologi telekomunikasi. Pemain terbesar di segmen baru ini adalah proyek Starlink yang dilakukan oleh perusahaan swasta Amerika Serikat, SpaceX. Starlink, dengan proyek konstelasi satelit kecil lainnya bertujuan untuk menyediakan koneksi internet yang andal kepada orang-orang di seluruh dunia di mana pun mereka berada. Konstelasi satelit beroperasi pada Low Earth Orbit (LEO) yang dilengkapi dengan ribuan satelit kecil yang mampu berkomunikasi satu sama lain untuk melayani kebutuhan internet secara global.

Namun, konstelasi satelit memiliki masalahnya sendiri, terutama masalah berpotensi menciptakan puing-puing luar angkasa yang tidak dapat dikendalikan jika terjadi tabrakan antara satelit tersebut. Dalam hal ini, hukum antariksa internasional tidak dapat menangani masalah ini, karena adanya kekosongan hukum. Biasanya, permasalahan hukum mengenai kegiatan keantariksaan yang mengandung liabilitas akan diselesaikan dengan Liability Convention tahun 1972, yang merupakan perpanjangan dari Outer Space Treaty tahun 1967.

Liability Convention hanya mencakup liabilitas yang terjadi antar negara yang berbeda. Dalam kasus konstelasi satelit, ada kemungkinan liabilitas yang terjadi pada negara/perusahaan swasta yang sama. Ini menciptakan masalah baru di mana tidak ada pihak yang dapat dimintai pertanggungjawaban atas puing-puing luar angkasa yang terakumulasi setelahnya yang akan berbahaya bagi aktivitas luar angkasa di masa depan. Liability Convention hanya mencakup klaim kerusakan akibat kegiatan antariksa sebagai akibat dari kerusakan langsung, dimana puing ruang angkasa dapat dikategorikan sebagai kerusakan tidak langsung.

Masalah tidak adanya dasar hukum internasional terhadap mitigasi risiko sampah antariksa juga menjadi masalah, karena hanya mengandalkan tanggung jawab sukarela untuk menghindari akumulasi sampah antariksa oleh entitas penjelajah antariksa itu sendiri baik milik pemerintah maupun swasta. Harus ada kesepakatan internasional untuk membakukan langkah-langkah mitigasi sampah antariksa yang diperlukan untuk memastikan konservasi dan kelangsungan ruang angkasa, khususnya orbit bumi. Termasuk menyikapi persoalan kekosongan hukum yang terdapat dalam Liability Convention.

Kata Kunci: *Konstelasi Satelit, Liabilitas, Puing-puing Antariksa, Perjanjian Luar Angkasa*

ABSTRACT

Satellite Constellation is the newest breakthrough in telecommunication technology. The biggest player in this new segment is the Starlink project conducted by the United State's private company SpaceX. Starlink, with other minor satellite constellation projects, aims to provide people all over the world with a reliable internet connection wherever they are. Satellite constellations operate on Low Earth Orbit (LEO) equipped with thousands of small satellites that are able to communicate with each other to serve the internet demands globally.

However, satellite constellations come with their own issue, mainly the issue of potentially creating uncontrollable space debris if a collision between said satellites occurs. In this case, international space law couldn't handle this issue, because there is a legal vacuum in the legal regime. Normally, legal issues regarding space activities that contain liabilities will be solved by the Liability Convention of 1972, which acts as the extension of the Outer Space Treaty of 1967.

The Liability Convention only covers liabilities that happen between different countries. In the case of satellite constellations, there is a possibility of liabilities that happen to the same country / private company. This creates a new issue where no one can be held responsible for the space debris that accumulates afterward that would be harmful to future space activities. The Liability Convention only covers claims of damage by space activities as a result of direct damage, which space debris is arguably categorized as indirect damage.

The issue of no international legal basis for space debris risk mitigation also is an issue, because we only rely on the voluntary responsibility of avoiding space debris accumulation by the space-faring entities themselves whether it's governmental or privately owned. There should be an international agreement to standardize the necessary space debris mitigation measures to ensure the conservation and continuity of outer space, especially earth's orbit. Including addressing the issue of the legal vacuum found in the Liability Convention.

Keywords: Satellite Constellation, Liabilities, Space Debris, Outer Space Treaty

FOREWORD

It is with great pleasure that I present this legal thesis, which delves into the intricacies of international Space Law, specifically the complications regarding space debris that potentially may be caused by satellite constellations. The research conducted in this thesis highlights the current state of the law in this area and offers valuable insights and recommendations for future developments. The author has shown a deep understanding of the subject matter and has made a significant contribution to the legal field. I hope that this thesis will serve as a valuable resource for legal practitioners, scholars, and policymakers, and will spark further dialogue and research in this important area of the law.

I would like to extend my heartfelt thanks to all of the individuals and organizations who have contributed to the creation of this legal thesis. Firstly, I would like to express my gratitude towards my thesis advisor, who provided invaluable guidance and support throughout the research and writing process. I would also like to thank the members of the thesis committee for their insightful feedback and for helping to shape the final product.

I would also like to thank the legal professionals, scholars, and experts who generously shared their time and expertise, providing valuable insights and perspectives that have greatly enriched this thesis, either whom I met personally or through online publications. Additionally, I would like to express my appreciation to the libraries, archives, and other research facilities that provided easy access to the necessary resources needed for this thesis.

Finally, I would like to thank all of my family and friends who have supported and encouraged me throughout this journey. Their unwavering support has been a source of inspiration and motivation. I hope that this thesis will make a meaningful contribution to the legal field, and I am deeply grateful to everyone who has helped make it possible.

Bandung, 27th of January 2023

Author

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CHAPTER I

INTRODUCTION

I. BACKGROUND

Today's communication tools are no longer what they used to be, which rely on analog systems such as telegraphs and pagers. Telephone connections through GSM (Global System for Mobile) and CDMA (Code Division Multiple Access) systems have also been abandoned, because they are deemed insufficient for today's communication needs.¹ Starting from the existence of 3G technology, advanced communication has become possible because this technology provides a relatively fast internet connection. The increasing speed of the internet opens up many new possibilities in human life, especially concerning modern communication.

As of 2022, the available mobile internet broadband is in the 3G, 4G, and 5G signal ranges² that come from a BTS (Base Transmitter Receiver) tower established by internet / cellular operators. So for areas that have not built the BTS tower, they will not get an internet signal. This problem becomes increasingly difficult because increasing internet speed will have an inverse impact on the signal coverage distance. This is because high-speed internet signals require high signal waves as well, while high signal waves will be difficult to transmit over long distances. For example, a 3G signal can be reached from a BTS tower from a radius of 70 km.³ The 4G signal has a radius of 16 km from the nearest BTS tower and the signal from 5G is only a maximum of 500 meters from the BTS transmitter (no longer in the form of a tower, but a small device that will usually be installed on a power pole or wall of a building).⁴

These obstacles cause the development of internet infrastructure to require large investments for internet operators, coupled with competition between internet operators who want their internet services to be spread as widely as possible. However, there are still many remote areas that do not get an internet signal because their geographical location is difficult to reach, so it is no longer economical for internet service providers to install internet network

¹Verizon.com. (2022). CDMA Network Retirement | Verizon. Available at: <[https://www.verizon.com/support/knowledge-base-218813/#:~:text=After%20December%2031%2C%20\(2022\)%2C%20if,911%2C%20on%20the%20Verizon%20network.](https://www.verizon.com/support/knowledge-base-218813/#:~:text=After%20December%2031%2C%20(2022)%2C%20if,911%2C%20on%20the%20Verizon%20network.)> [Accessed 21 March 2022].

²3G, 4G, and 5G are generational terms on telecommunications, meaning that 3G is the third generation, 4G are fourth generation, and so on, look: <https://teknologi.bisnis.com/read/20220107/280/1486583/apa-perbedaan-jaringan-3g-4g-dan-5g-simak-ulasannya>

³Rantcell.com. (2022). Comparison of 2G 3G 4G 5G | 2G vs 3G vs 4G vs 5G | Rantcell. Available at: <<https://rantcell.com/comparison-of-2g-3g-4g-5g.html>> [Accessed 21 March 2022].

⁴Viavisolutions.com. (2022). 5G Technology | How Fast is 5G? What Is Its Range? - VIAVI. Available at: <<https://www.viavisolutions.com/en-us/5g-technology#:~:text=5G%20Range,for%20pure%20standalone%205G%20deployment.>> [Accessed 21 March 2022].

devices. The lack of internet infrastructure has resulted in underdeveloped regions not being able to access the internet, in this all-digital world.⁵ This problem is a challenge that is often ignored by internet operators because imposing internet infrastructure development on disadvantaged areas, will certainly sacrifice the company's economic calculations.

One idea to solve this problem has been around for a long time, namely the use of satellites as a means of communication.⁶ We know that the Sputnik 1 satellite was the world's first communications satellite, launched by the Soviet Union in 1957.⁷ Since the launch of the first satellite, more and more other satellites have been launched for communication and military purposes, especially by the Soviet Union and the United States. But unfortunately, communication via satellite is not widely used in general, because satellites at that time were only able to transmit relatively small data packets so satellites could only be used for basic communication purposes, often only for certain circles/state needs.

With the development of technology, the launched satellites began to accommodate sophisticated communication needs, such as television, telephone, and internet. For example, for television needs via satellite, satellites that are in the GSO orbit are used, because the location of the satellite relative to the earth does not change, so the connection between the receiver on the ground and the satellite can always be connected. Indonesia also has satellites of this kind, namely the Palapa satellite, Indostar, Telkom, INASAT (Indonesia Nano Satellite), LAPAN-TUBSAT (National Institute of Aeronautics and Space and Technische Universität Berlin), Nusantara Satu, as well as other satellites operated by banking.⁸

These satellites have the potential for fast signal and data transmission, but it is impossible to serve the entire community in certain areas which are very large in number with these satellites in the GSO because we are blocked by the laws of physics. The signal that we use for telecommunications is an electromagnetic wave signal. These waves are in a vacuum, traveling at the speed of light, which is about 300 million meters per second.⁹ Therefore it can be calculated that the signal takes time to move from one place to another, not instantaneously.

⁵KOMINFO, P., (2022). Belum Tersentuh Meski Tak Terpencil. Available at: <https://kominform.go.id/content/detail/13518/belum-tersentuh-meskitakterpencil/0/sorotan_media> [Accessed 21 March 2022].

⁶Verschuur, D. and Kopal, V., (2008). *An Introduction to Space Law*. 3rd ed. Alphen aan den Rijn: Kluwer Law International, p.55.

⁷NASA. (2022). Sputnik 1. Available at: <https://www.nasa.gov/multimedia/imagegallery/image_feature_924.html> [Accessed 21 March 2022].

⁸katadata. (2022). Indonesia miliki 9 satelit pada 2019. Available at: <<https://databoks.katadata.co.id/datapublish/2021/07/10/indonesia-miliki-9-satelit-pada-2019>> [Accessed 21 March 2022].

⁹Fritzsche, H., (2022). *electromagnetic radiation | Spectrum, Examples, & Types*. Encyclopedia Britannica. Available at: <<https://www.britannica.com/science/electromagnetic-radiation>> [Accessed 23 March 2022].

Even though the signal travels at the speed of light, theoretically the fastest latency¹⁰ of satellites that in GSO maxed at 700ms.¹¹ This latency is not sufficient for our current internet needs, for example for video calls, playing online games, and streaming, it becomes uncomfortable and even unusable if there is a large latency on the internet that we use. Internet via satellites located on the GSO will also have poor data download speeds, due to the limited number of satellites that can be placed on the GSO. Based on these data, it appears that it is difficult to realize good internet services that come entirely from GSO satellites.

However, recently there have been breakthroughs due to the impact of very rapid technological developments. The satellite constellation is a technological breakthrough and a new idea from private companies engaged in the space sector, such as SpaceX and Blue Origin. This constellation is a technology that has been confirmed to be better than conventional satellite placement in GSO orbit because the satellite constellation operates at low orbital altitude / LEO. By operating in a low orbit, connections for telecommunications purposes can be faster because the physical position of the satellites is close to the earth, as well as the more number of satellites, of course, increasing the capacity of telecommunication lines.

However, with the launch of a satellite constellation whose number can reach tens to hundreds of thousands of units, it is conceivable that this satellite constellation will cause new problems, such as space pollution in the form of space junk. In addition, there is the potential for problems such as frequency interference between satellites, because there are so many of them in the LEO. If this obstacle occurs, then the operation of the satellite constellation will be disrupted.¹² This condition is exacerbated by the information that in the coming years there will be more space companies that will also use LEO orbits for placing satellite constellations.¹³ Consequently, legal issues over this satellite constellation become increasingly important to be discussed immediately.

US company SpaceX plans to launch 42,000 satellites that form a constellation of satellites called Starlink. Each of the tens of thousands of Starlink satellite units is small in size and will orbit at low earth orbit (LEO).¹⁴ Starlink itself will operate at an altitude of 550 kilometers above sea level, which is a much lower altitude than GSO. The launch of such a large number of satellites has a mission so that the whole world can enjoy fast internet,

¹⁰Latency is the amount of time needed for a packet of data to transfer from one place to another, look: <https://www.cloudflare.com/learning/performance/glossary/what-is-latency/>

¹¹Via Satellite. (2022). GEO, MEO, and LEO - Via Satellite. Available at: <<https://www.satellitetoday.com/content-collection/ses-hub-geo-meo-and-leo/>> [Accessed 21 March 2022].

¹²Larsen, P. B. (2017). Small satellite legal issues. *Journal of Air Law and Commerce*, 82(2), 283.

¹³Kovacic, W. E. (2020). Competition policy retrospective: the formation of the united launch alliance and the ascent of spacex. *George Mason Law Review*, 27(3), 863-904.

¹⁴Starlink. (2022). Starlink. Available at: <<https://www.starlink.com>> [Accessed 21 March 2022].

without the need to build BTS towers¹⁵ for the distribution of the internet connection.¹⁶ This is possible because the physical position of the Starlink satellite is in a low orbit so according to the laws of physics it is possible to have a very low latency, up to 5 milliseconds. The large number of satellites to be launched also increases the download speed of Starlink users, targeted to reach speeds up to 10 GB/s (Gigabit per second).¹⁷ Devices that support internet connection will be directly connected to the Starlink satellite, wherever we are in the world. With various innovations and conveniences offered, Starlink also does not escape criticism and potential problems that may arise.

Currently, SpaceX's Starlink project has been approved by the ITU (International Telecommunication Union), which serves as a special organization of the United Nations (United Nations) that regulates international communication and information technology.¹⁸ One of the areas regulated by the ITU is licensing of telecommunications satellites in earth orbit. Should Starlink not get ITU's approval, then this project will not be able to run. This permit is important because the ITU seeks to avoid signal interference/signal entanglement between satellite operators in earth orbit. The permit includes information on the frequency of the signal to be used, the planned orbital altitude, and the number of satellites to be launched. Furthermore, ITU has received registrations for 30,000 Starlink satellites that will orbit LEO.¹⁹

On the other hand, many parties do not agree with the launch of the satellite constellation in LEO. The arguments that are put forward are several potential problems that can occur, one of which is space pollution.²⁰ This pollution consists of the many wrecks of satellites that are no longer in operation and are just left orbiting the earth, without being able to be controlled by humans. Apart from satellite carcasses, because of the large number of satellites needed to create a satellite constellation, will also cause new problems because of

¹⁵Ee.itk.ac.id. (2022). Teknik Elektro | Berita. Available at: <<https://ee.itk.ac.id/berita/detail/pengetahuan-teknik-elektro-bts-tapi-pemancar>> [Accessed 21 March 2022].

¹⁶KOMINFO, P., (2022). Kominfo Bangun 4.200 BTS Demi Desa Teraliri Internet di 2021. Website Resmi Kementerian Komunikasi dan Informatika RI. Available at: <https://www.kominfo.go.id/content/detail/31756/kominfo-bangun-4200-bts-demi-desa-teraliri-internet-di-2021/0/sorotan_media> [Accessed 21 March 2022].

¹⁷Space.com. (2022). Starlink: SpaceX's satellite internet project. Available at: <<https://www.space.com/spacex-starlink-satellites.html>> [Accessed 21 March 2022].

¹⁸ITU. (2022). *About ITU*. Available at: <<https://www.itu.int/en/about/Pages/default.aspx>> [Accessed 23 March 2022].

¹⁹Henry, C., (2022). *SpaceX submits paperwork for 30,000 more Starlink satellites - SpaceNews*. SpaceNews. Available at: <<https://spacenews.com/spacex-submits-paperwork-for-30000-more-starlink-satellites/>> [Accessed 23 March 2022].

²⁰Nhm.ac.uk. (2022). What is space junk and why is it a problem?. Available at: <<https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html>> [Accessed 21 March 2022].

this very large number. Satellite constellations can potentially cause frequency interference problems between satellites in LEO orbit, because of the large number that we have never encountered before. The emergence of this space pollution is also feared to have the potential to crash and damage other satellites that are still operational or hit a rocket that is gliding, so that the possibility of these satellites falling back to earth and potentially causing property damage, etc. This space junk and space debris has the potential to cause a space mission to fail.²¹ The issue of liability if there is a loss due to the damage caused to this space junk and space debris, both on earth and in outer space also needs to be discussed. For this reason, further discussion and analysis are needed regarding the issue of satellite constellations, which will be reviewed from International Space Law.

1.2 RESEARCH QUESTIONS

Based on the aforementioned background, can lead to several questions that become the main problems in this research:

1. What is the arrangement for legal liability in the event of space debris from a satellite constellation?
2. What are the efforts to mitigate the potential risk of space debris due to the placement of the satellite constellation?

1.3 OBJECTIVES AND BENEFITS OF RESEARCH

This research are necessary because it has the following objectives and benefits:

a. Objectives:

1. Knowing the arrangement of satellite constellations in terms of International Space Law.
2. Knowing the potential risk mitigation efforts for the placement of satellite constellations.

b. Benefit:

1. Theoretical Benefits:

- Understand the steps of accountability for those who are harmed by the constellation of satellites.
- Knowing the regulations of International Space Law that apply to a constellation of satellites.

²¹Dujmovic, J., (2022). SpaceX will need to solve these two problems for Starlink to be successful. MarketWatch. Available at: <<https://www.marketwatch.com/story/spacex-will-need-to-solve-these-two-problems-for-starlink-to-be-successful-2020-01-29>> [Accessed 21 March 2022].

2. Practical Benefits:

- Knowing satellite constellation potential liabilities for the benefit of current or upcoming projects.
- Anticipating the responsibility that should be carried out by the agency or company in the event of a loss due to the operation of the satellite constellation.

I.4. RESEARCH METHODS

Because the nature of this legal writing is in the form of an undergraduate thesis, the writer conducts descriptive-analytical research. In relation to the satellite constellation and International Space Law, the author tries to analyze various sources of law that can help the author to describe the state of International Space Law with the operation of the satellite constellation.

The research method used by the author is a normative juridical research method. In this method, the author conducts research on data in the form of "Law In Books", such as document materials or legislation, especially sources of international law such as international agreements and international customs. The author also uses domestic and international journals because the field of space law is a legal field that is still developing and its nature is not yet fully developed. The use of this normative juridical research method is also expected to be able to dissect and find the intended truth in this research, by researching various literature to solve the problem formulation in order to get an answer.

Therefore, the author uses a deductive reasoning style with legal principles, legal norms/rules, and legal theories which are used as the Major Premise. Then the author uses the criterion of coherent truth with the tools of legal principles, legal norms/rules, and legal theory to assess and determine the truth of a thing. The truth found by the author must also be reliable, without going through empirical testing or verification. So that verification of the author's writing only needs to be done by peer groups.

Seeing the nature of this research is about outer space, the authors use data collection techniques in the literature, especially from journals, books, and the latest news via the internet regarding satellite constellations and International Space Law. Qualitative data analysis is also important as the basis of this paper.

The author uses data sources that can be obtained from the internet because the development of information from the topics discussed is rapidly growing. The author also uses

books that discuss space law as a whole. Journals that discuss the satellite constellation, ITU, and space law are also widely used by the authors.

Especially the author uses the sources of three primary legal sources in the form of international agreements, namely the 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), Convention on International Liability for Damage Caused by Space Objects, and Convention on Registration of Objects Launched into Outer Space.

Secondary legal sources are also used by authors in the form of books, journals, and Articles that can help the writer's understanding and insight into applicable international law. Moreover, because of the dynamic nature of international law, rapidly changing, and there are many international customs, it is not enough for the author to rely solely on primary legal sources, but of course, they are supported and enriched through these secondary legal sources.

I.5. SYSTEMATICS OF THE RESEARCH

This research is divided into 5 (five) chapters, each of which consists of:

CHAPTER I - INTRODUCTION

In this section, the author explains the background of this research writing, the formulation of the problem and legal questions that are formulated based on the background, research questions, objectives and benefits of research, research methods to be used on examining the problems in this research, and systematics of the research which contains the writing framework of each chapter. This section also briefly mentions International Space Law and satellite constellations information, so that those who read this thesis can understand the basics of the discussion that may sound quite foreign to some people. Furthermore in this chapter, the problems that may arise due to the operation of satellite constellations, in terms of International Space Law will be introduced.

CHAPTER II – SATELLITE CONSTELLATION AS THE FUTURE OF TELECOMMUNICATION

In this chapter, the author explains the reason behind the existence of satellite constellations, with the example extensively studied by the author, Starlink, which was developed by the SpaceX company. The development and technical details behind modern telecommunication technology are also being discussed, as the reason why it is very significant for mankind. This chapter talks about the technical details behind satellite constellation and the premise of why this innovation is beneficial and potentially the future of

communication that we all will be relying on. This chapter also discusses the orbital types that a human-made satellite can operate from, especially in regard to satellite constellations.

CHAPTER III – THE PROVISIONS OF SPACE LAW RELATING TO SATELLITE CONSTELLATION

This chapter will try to explain the legal instruments of space law. Specifically for the purpose of this thesis, the author uses the international space law, rather than the domestic space law that a state may have written. The usage of international law regarding space is aimed so that this thesis will be universally accepted, especially by United Nations member countries. In this chapter also the author introduces what are the laws of space as a whole, not the specifics about satellite constellations because it will be discussed in later chapters. The main legal instruments of international space law can be broken down into two main parts, which are space law treaties and international organizations relating to space activities. Each part of the legal instruments found will be discussed thoroughly in relevance to the main topic of this legal writing.

CHAPTER IV – SATELLITE CONSTELLATION LIABILITIES UNDER THE PREVAILING INTERNATIONAL SPACE LEGAL PROVISIONS

This chapter will explain the available international law in relation to satellite constellations' liabilities. The main source of satellite constellation's liability is the space debris that may form because of impacts, contributing to that is the big number of satellites being launched to reach a constellation. Because the nature of this specific legal study is currently limited, the writer will try to interpret and give comments about the available law that may be applicable to the topic. For example, the Outer Space Treaty is extensively discussed to determine the possible logical laws that can be implemented on satellite constellations. The writer will also mention the main principle of international space law, one of which is the common heritage of mankind, which may or may not interfere with the satellite constellation's possible liabilities, minding its unique characteristics and novel in space law. In this chapter also the writer discusses the satellite constellation's risk mitigation, in regard to the current prevention laws regarding space activities. Here the author examines the legal background and potential liabilities that can be imposed on the satellite constellation operator company, especially in this study of SpaceX, as well as the United States as the country where the launch took place.

CHAPTER V - CONCLUSION AND RECOMMENDATION

In this section, the author conveys the conclusions obtained, based on the description and analysis of the problems encountered, which are related to the potential liabilities of satellite constellations in terms of International Space Law. Later in this section, the author also writes suggestions containing recommendations so that International Law, especially those governing outer space, can be further developed in the future in order to accommodate technological developments that result in the rapid advancement of space technology.