

CHAPTER V

CONCLUSION AND RECOMMENDATION

V.1 CONCLUSION

There are still no clear international laws regarding satellite constellations' risk of liabilities, including space debris that might occur by the impact/collision between their own satellites. Achieving a satellite constellation requires a very large number of satellites in the same orbital position with a crisscrossing pattern with each other, resulting in congesting low earth orbit, as well as potentially creating lots of uncontrolled space debris that will be hazardous to other spacecraft. Even though there is technology to support the required risk mitigation measures, the risk is still there.

Currently, private companies like SpaceX which holds the majority of low earth orbit satellites face no apparent international legal issue in the operation of Starlink. The Liability Convention does not cover damages inflicted on their own, including the space debris that forms because of the collision. If a collision does occur between two Starlink satellites, the space debris should be included in fault liability (because it happened in outer space) but because there is no international element involved, the liability convention cannot be used. Also in the liability convention, it is interpreted that "damage" is only "direct damage", so that other countries that feel they have been harmed by the collision of the satellite constellation (indirect damage) cannot file a claim.

Apart from SpaceX's own voluntary responsibility to clean up space debris that has arisen, which is very difficult to achieve, there is no legal obligation that forces SpaceX to take responsibility. This space debris however can be interpreted by Article IX of the Outer Space Treaty as harmful interference towards another state that would like to use outer space, but yet again, there are no international laws to enforce this. There should be a clearer international agreement regarding Low Earth Orbit.

As such, states as well as private companies currently face no international legal consequences if damage occurs to their spacecraft by another spacecraft that is theirs. Different from the concept of space debris caused by an anti-satellite weapon (ASAT), which clearly violates the basic principles of the Outer Space Treaty regarding the peaceful uses of outer space, the collision of this satellite constellation does not violate any basic principles of the international space law but have a unique legal issue that must be addressed as well as enforced, to ensure the longevity of outer space exploration.

V.2 RECOMMENDATION

The technology in satellite systems is advancing fast, resulting in the number of satellites in orbit will grow exponentially in the upcoming years. As found in this writing, there are several legal vacuums in the space law regime. This includes claims toward space debris, liabilities towards space debris caused by a single launching state, and the risk mitigation of space debris on an international legal basis.

The international community consisting of lawmakers, politicians, diplomats, astronomers, physicists, and engineers that truly understand this matter must come together to fill this gap in law so our orbit won't be littered with space debris in the future. We cannot rely on space-faring entities whether it is governmental or private-owned to voluntarily prevent space debris from happening. Added to the equation is the deployment of satellite constellations filling our orbit, which made the chances of space debris forming grow higher. There must be cost-saving measures in the future as the technology becomes mainstream for the operation of satellites, and that may sacrifice the safety of the satellite's operation in orbit.

In that case, the only option for the international community to keep the risk of space debris from hindering our space exploration and activities in the future is to create an international law that will prevent it from happening in the first place. This can be in a form of a convention, treaty, or any other international agreement form that was supported and signed by as many countries as possible. The current space treaties in my opinion are obsolete and unable to fulfill keep up with the modern space activities complications, dating back to 1967 when at that time the current modern space technologies are simply unimaginable.

We need an update on international space law as soon as possible before any major incidents happened in space. Furthermore, we do not have the necessary international law to handle the case mentioned, because the Liability Convention doesn't have the necessary clauses to handle these new legal complications. UNCOPUOS with the help of ITU must initiate new international agreements relating to space debris. ITU has the data regarding satellite placements and space debris locations, and UNCOPUOS has the legal standing in cooperating new international agreement about space debris in Low Earth Orbit. As such, a new international agreement made by nations with the main interest in keeping space clean will result in the continuity of space exploration. In doing so, our future generations to come will have a clean space environment, specifically earth's orbit without space debris littering the orbit, ensuring safe space activity. The advocacy awareness of space law to the general public is also necessary to be done, because this topic is relatively unheard of to many people, and with that governments do not have the urge to develop a legal basis on this matter.

BIBLIOGRAPHY

Books

- Haley, A.G. (2012) *Space law and government*. Literary Licensing, LLC.
- Ito, A, (2011). *Legal Aspects of Satellite Remote Sensing*. 5th vol. Martinus Nijhoff Publishers.
- Verschoor, D. and Kopal, V., (2008). *An Introduction to Space Law*. 3rd ed. Alphen aan den Rijn: Kluwer Law International.

Journal

- Amalia, R., (2020). State Obligations Related To The Launch of Objects Into Outer Space Under International Law. *Universitas Lampung*, 2(2).
- Benkö, M. and Schrogl, K.-U. (1997) "History and impact of the 1996 UN Declaration on 'Space Benefits,'" *Space Policy*, 13(2), pp. 139–143. Available at: [https://doi.org/10.1016/s0265-9646\(97\)00004-0](https://doi.org/10.1016/s0265-9646(97)00004-0).
- Bin, C. (1997) "Part IV outer space, astronauts, and Space Objects, 13 outer space: The International Legal Framework—the International Legal Status of Outer Space, space objects, and Spacemen," *Studies in International Space Law* [Preprint]. Available at: <https://doi.org/10.1093/law/9780198257301.003.0014>.
- Burke, J., (1984). Convention on International Liability for Damage Caused by Space Objects: Definition and Determination of Damages After the Cosmos 954 Incident. *Fordham International Law Journal*, 8(2).
- Citaristi, I. (2022) "United Nations Office for outer space affairs—UNOOSA," *The Europa Directory of International Organizations 2022*, pp. 247–248. Available at: <https://doi.org/10.4324/9781003292548-53>.
- Dennerley, J.A. (2018) "State Liability for Space Object Collisions: The proper interpretation of 'fault' for the purposes of International Space Law," *European Journal of International Law*, 29(1), pp. 281–301. Available at: <https://doi.org/10.1093/ejil/chy003>.
- Inter-Agency Space Debris Coordination Committee (2021) "IADC Statement on Large Constellations of Satellites in Low Earth Orbit," IADC [Preprint].
- Japan Aerospace Exploration Agency (2022) Settlement of Claim between Canada and the Union of Soviet Socialist Republics for Damage Caused by "Cosmos 954" (Released on April 2, 1981, Settlement of claim between Canada and the Union of Soviet Socialist Republics for damage caused by "cosmos 954" (released on April 2, 1981). Available at:

https://www.jaxa.jp/library/space_law/chapter_3/3-2-2-1_e.html (Accessed: December 16, 2022).

- Kadarisman, M., (2012). *Pendaftaran Orbit Satelit Oleh Negara Berdasarkan Konvensi International Telecommunication Union (ITU) 1998*. Makassar: Universitas Hasanuddin.
- Kovacic, W. E. (2020). Competition policy retrospective: the formation of the united launch alliance and the ascent of spacex. *George Mason Law Review*, 27(3).
- Larsen, P. B. (2017). Small satellite legal issues. *Journal of Air Law and Commerce*, 82(2).
- Reis, H. (1978). Some reflections on the liability convention for outer space. *Journal of Space Law*, 6(2).
- Mayence, J.-F. (2017) "The role of Uncopuos in the international regulation of non-governmental space activities," *Commercial Uses of Space and Space Tourism*, pp. 254–265. Available at: <https://doi.org/10.4337/9781785361074.00019>.
- Pečujlić, A.N. (2020) "Registration convention," *Oxford Research Encyclopedia of Planetary Science* [Preprint]. Available at: <https://doi.org/10.1093/acrefore/9780190647926.013.132>.
- Roy, A.E. (1988) "Satellite orbits in an atmosphere: Theory and applications," *Planetary and Space Science*, 36(2), p. 231. Available at: [https://doi.org/10.1016/0032-0633\(88\)90060-8](https://doi.org/10.1016/0032-0633(88)90060-8).
- Space liability convention (2008) *International Documents on Environmental Liability*, pp. 345–351. Available at: https://doi.org/10.1007/978-1-4020-8367-9_25.
- United Nations Office at Vienna (2017) "United Nations treaties," *International Space Law* [Preprint]. Available at: <https://doi.org/10.18356/72574d6c-en>.
- von der Dunk, F. (2003) "The Registration Convention : Background and Historical Context," *International Institute of Air and Space Law, Leiden* [Preprint].
- Williams (2006) "The Registration Convention Thirty years on," *57th International Astronautical Congress* [Preprint]. Available at: <https://doi.org/10.2514/6.iac-06-e6.3.09>.
- Zwart, M. and Lisk, J. (2022) "Low Earth Orbit, Satellite Constellations and Regulation," *Flinders University*, pp. 4–53.

Internet

- Abbany, Z. (2020) Modern spy satellites in an age of space wars – DW – 08/25/2020, dw.com. Deutsche Welle. Available at: <https://www.dw.com/en/modern-spy-satellites-in-an-age-of-space-wars/a-54691887> (Accessed: December 16, 2022).
- Aerospace Corporation. (2021). *Novel Satellite Deorbiting Method Can Help Mitigate Space Debris Crisis | The Aerospace Corporation*. Available at: <https://aerospace.org/Article/novel-satellite-deorbiting-method-can-help-mitigate-space-debris-crisis> [Accessed 4 April 2022].
- Alamalhodaie, A. (2022) Third Time's the charm? NASA will attempt to launch its Mega Moon Rocket early tomorrow morning, TechCrunch. Available at: <https://techcrunch.com/2022/11/15/third-times-a-charm-nasa-will-attempt-to-launch-its-mega-moon-rocket-early-tomorrow-morning/> (Accessed: December 16, 2022).
- Aloia, V. (2019) "The sustainability of large satellite constellations: Challenges for space law," *Legal Aspects Around Satellite Constellations*, pp. 79–94. Available at: https://doi.org/10.1007/978-3-030-06028-2_6.
- Australian Space Academy (1987) Satellite Orbital Lifetimes, Orbital lifetimes. Available at: <https://www.spaceacademy.net.au/watch/debris/orblife.htm> (Accessed: December 15, 2022).
- Atkinson, N. (2021) How long will space junk take to burn up? here's a Handy Chart, Universe Today. Available at: <https://www.universetoday.com/150233/how-long-will-spacejunk-take-to-burn-up-heres-a-handy-chart/> (Accessed: December 16, 2022).
- Betz, E. (2021) How do spacex's Starlink Satellites actually work?, Astronomy.com. Available at: <https://astronomy.com/news/2021/06/how-do-starlink-satellites-actually-work> (Accessed: December 15, 2022).
- Boyle, A. (2019) Elon Musk reveals how to stuff 60 Starlink satellites on SpaceX's Falcon Rocket, GeekWire. Available at: <https://www.geekwire.com/2019/elon-musk-reveals-60-starlink-satellites-stuffed-spacexs-falcon-rocket/> (Accessed: December 15, 2022).
- CenturyLink (2022) What is Fiber Internet?, CenturyLink. Available at: <https://www.centurylink.com/home/help/internet/fiber/what-is-fiber-internet.html#:~:text=Fiber%2Doptic%20internet%2C%20commonly%20called,70%25%20the%20speed%20of%20light.> (Accessed: December 15, 2022).

- Chai, W. and Lazar, I. (2021) What is Telecommunications (Telecom)? definition from searchnetworking?, Networking. TechTarget. Available at: <https://www.techtarget.com/searchnetworking/definition/telecommunications-telecom> (Accessed: December 15, 2022).
- Chen, A. (2021) Starlink and the rise of a new space internet, The Green Arch. Available at: <https://archmeregreenarch.org/1456/news/starlink-and-the-rise-of-a-new-space-internet/> (Accessed: December 15, 2022).
- Christol, C.Q. (1980) "International liability for damage caused by Space Objects," American Journal of International Law, 74(2), pp. 346-371. Available at: <https://doi.org/10.2307/2201505>.
- Cloudflare.com. (2022). *What is latency?*. Available at: <https://www.cloudflare.com/learning/performance/glossary/what-is-latency/> [Accessed 23 March 2022].
- Cooke, K. (2022) How to speed up your satellite internet, SatelliteInternet.com. Available at: <https://www.satelliteinternet.com/resources/how-to-improve-satellite-internet-speed/#:~:text=The%20most%20common%20cause%20for,GB%20of%20data%20per%20hour>. (Accessed: December 15, 2022).
- Cooke, K. (2022) How to speed up your satellite internet, SatelliteInternet.com. Available at: <https://www.satelliteinternet.com/resources/how-to-improve-satellite-internet-speed/#:~:text=The%20most%20common%20cause%20for,GB%20of%20data%20per%20hour>. (Accessed: December 15, 2022).
- Contributor, T.T. (2008) What is geostationary satellite?: Definition from TechTarget, Mobile Computing. TechTarget. Available at: <https://www.techtarget.com/searchmobilecomputing/definition/geostationary-satellite> (Accessed: December 15, 2022).
- Council of Europe (2022) The internet, a public service accessible by everyone - portal - publi.coe.int, Portal. Available at: <https://www.coe.int/en/web/portal/public-service-accessible-by-everyone> (Accessed: December 15, 2022).
- Crist, R. and Leavitt, L. (2022) Hughesnet, viasat and... elon musk? satellite internet explained, CNET. CNET. Available at: <https://www.cnet.com/home/internet/satellite-internet-explained/#:~:text=S%20atellite%20internet%20works%20similarly%20to,that%20picks%20up%20the%20signal>. (Accessed: January 4, 2023).

- Daehnick, C. et al. (2022) Large leo satellite constellations: Will it be different this time?, McKinsey & Company. McKinsey & Company. Available at: <https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time> (Accessed: December 15, 2022).
- Dano, M. (2022) Demand strains SpaceX's Starlink Network, Light Reading. Available at: <https://www.lightreading.com/satellite/demand-strains-spacexs-starlink-network/d/d-id/782045> (Accessed: December 15, 2022).
- Dart, C. (2022) In 1978, a Soviet satellite exploded over traditional Dené land. its effects are still felt today | CBC Arts (2022) CBCnews. CBC/Radio Canada. Available at: <https://www.cbc.ca/arts/operation-morning-light-podcast-soviet-satellite-exploded-traditional-dene-land-1.6650994> (Accessed: December 16, 2022).
- Dent, S. (2022) Satellites must be deorbited within five years of completing missions, FCC rules, Engadget. Available at: <https://www.engadget.com/satellite-de-orbit-five-years-fcc-092538937.html> (Accessed: December 16, 2022).
- Digwatch (2022) *Telecommunications infrastructure - DW observatory, Digital Watch Observatory.* Available at: <https://dig.watch/topics/telecommunications-infrastructure> (Accessed: December 15, 2022).
- Dominguez, A. (2013) Optical telegraph (semaphore system), Omeka RSS. Available at: <https://kimon.hosting.nyu.edu/physical-electrical-digital/items/show/1353> (Accessed: January 4, 2023).
- Dujmovic, 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].
- Dunbar, B., (2022). *What Is an Orbit?*. NASA. Available at: <https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbit-58.html> [Accessed 27 March 2022].
- Dunbar, B. (2015) *What is a satellite?*, NASA. NASA. Available at: <https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-satellite-k4.html> (Accessed: December 15, 2022).

- Earth Science Data Systems, NASA (2022) Earthdata. Available at: <https://www.earthdata.nasa.gov/> (Accessed: December 15, 2022).
- Editor, P.M. (2021) How to get wi-fi on a plane (guide), PilotMall.com. PilotMall.com. Available at: <https://www.pilotmall.com/blogs/news/how-to-get-wi-fi-on-a-plane-guide> (Accessed: December 15, 2022).
- Ee.itk.ac.id. (2022). Teknik Elektro | Berita. Available at: <https://ee.itk.ac.id/berita/detail/pengetahuan-teknik-elektro-bts-tapi-peman-car> [Accessed 21 March 2022].
- Eldridge, A., (2022). *SpaceX | Spacecraft, Rockets, & Facts*. Encyclopedia Britannica. Available at: <https://www.britannica.com/topic/SpaceX> [Accessed 11 April 2022].
- Encyclopedia Britannica. (2015). *International Telecommunication Union | UN agency*. Available at: <https://www.britannica.com/topic/International-Telecommunication-Union> [Accessed 11 April 2022].
- ESA. (2022). Types of orbits. Available at: https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits#LEO [Accessed 21 March 2022].
- ESA. (2022) Low Earth orbit, LEO. Available at: https://www.esa.int/ESA_Multimedia/Images/2020/03/Low_Earth_orbit (Accessed: December 15, 2022).
- ESA. (2022) Low-earth orbits are getting crowded. Available at: https://www.esa.int/ESA_Multimedia/Images/2022/04/Low-Earth_orbits_are_getting_crowded (Accessed: December 15, 2022).
- Faradiba, N., (2021). *Apa Itu Satelit dan Fungsinya untuk Bumi*. KOMPAS.com. Available at: <https://www.kompas.com/sains/read/2021/06/04/100200123/apa-itu-satelit-dan-fungsinya-untuk-bumi> [Accessed 6 April 2022].
- Fintelics (2021) Medium. Available at: <https://fintelics.medium.com/starlink-vs-5g-will-it-be-a-better-home-internet-service-fb563754128c> (Accessed: December 15, 2022).
- Garcia, M. (2015) International Space Station, NASA. NASA. Available at: https://www.nasa.gov/mission_pages/station/main/index.html (Accessed: December 15, 2022).

- GCFGlobal (2022) Internet basics: What is the internet?, GCFGlobal.org. Available at: <https://edu.gcfglobal.org/en/internetbasics/what-is-the-internet/1/> (Accessed: December 15, 2022).
- Gillis, A.S. (2021) *What is a teleconference?*, *Unified Communications*. TechTarget. Available at: <https://www.techtarget.com/searchunifiedcommunications/definition/teleconference> (Accessed: December 15, 2022).
- Gizis, A. (2020) WIFI vs Mobile Data Speed: Which is faster?, Speedify. Available at: <https://speedify.com/blog/internet-speed/wifi-vs-mobile-data-speed-faster/#:~:text=WiFi%20Is%20Usually%20Faster%20than%204G%20LTE%20Mobile%20Data.&text=There%20are%20so%20many%20situations,smartphone%20sticks%20%E2%80%93%20a.k.a.%20sticky%20WiFi>. (Accessed: December 15, 2022).
- GlobalData (2022) *Space Exploration Technologies Corp company Profile - Space Exploration Technologies Corp Overview*, *GlobalData*. Available at: <https://www.globaldata.com/company-profile/space-exploration-technologies-corp/> (Accessed: December 16, 2022).
- Glonass-iac.ru. (2022). Available at : <https://www.glonass-iac.ru/en/about_glonass/> [Accessed 11 April 2022].
- Goguichvili, S., Linenberger, A. and Gillette, A. (2021) The Global Legal Landscape of Space: Who writes the rules on the final frontier?, Wilson Center. Available at: <https://www.wilsoncenter.org/article/global-legal-landscape-space-who-write-s-rules-final-frontier> (Accessed: December 16, 2022).
- Goh, D. et al. (2017) Indonesia's space policy as outlined in the National Space Law of 2013, SpaceTech Asia. Available at: <https://www.spacetechnasia.com/indonesias-space-policy-as-outlined-in-the-national-space-law-of-2013/> (Accessed: December 16, 2022).
- Gray, T. (2004) *Animals in Space*, NASA. Available at: <https://history.nasa.gov/animals.html> (Accessed: January 4, 2023).
- Hannula, L. (2022) Starlink internet vs. Fiber Internet | whistleout. Available at: <https://www.whistleout.com/Internet/Guides/fiber-internet-vs-starlink-satellite-internet> (Accessed: December 15, 2022).
- Heather (2022) Starlink - Complete Guide: History, products, founding, and more, History. Available at: <https://history-computer.com/starlink-history/#:~:text=SpaceX's%20Starlink>

%20project%20started%20in,satellites%20launched%20in%20May%202019.
(Accessed: December 15, 2022).

Henry, 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].

History.com Editors (2009) World War I, History.com. A&E Television Networks. Available at:
<https://www.history.com/topics/world-war-i/world-war-i-history> (Accessed:
January 4, 2023).

Hitchens, T. (2021) Indian asat debris threatens all leo sats: Update, Breaking Defense.
Available at:
<https://breakingdefense.com/2019/04/indian-asat-debris-threatens-all-leo-sats/> (Accessed: January 4, 2023).

Howell, E., (2022). *What is Space?*. Space.com. Available at:
<<https://www.space.com/24870-what-is-space.html>> [Accessed 4 April 2022].

iau.org. (2020). *International Astronomical Union / IAU*. [online] Available at:
<<https://www.iau.org/public/themes/satellite-constellations/>> [Accessed 24
May 2022]

ICAO (2023) Convention on International Civil Aviation - Doc 7300 // , Convention on
International Civil Aviation - Doc 7300. Available at:
<https://www.icao.int/publications/pages/doc7300.aspx> (Accessed: January 4,
2023).

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

ITU (2022) Harmful interference / infringement, ITU. Available at:
<https://www.itu.int/en/ITU-R/terrestrial/tpr/Pages/HarmfulInterference.aspx>
(Accessed: December 16, 2022).

Intelsat (2022) Meet Intelsat 1, Intelsat. Available at:
<https://www.intelsat.com/meet-intelsat-1/> (Accessed: January 4, 2023).

International Astronomical Union (2022) Satellite Constellations. Available at:
<https://www.iau.org/public/themes/satellite-constellations/> (Accessed:
December 15, 2022).

- International Organization for Standardization (2022) ISO - International Organization for Standardization, ISO 24113. Available at: <https://www.iso.org/obp/ui/#> (Accessed: December 16, 2022).
- International Organization for Standardization (2006) "Space sustainability - space debris mitigation requirements." Available at: <https://doi.org/10.3403/30377479>.
- JAPCC. (2022). Congested outer space - Joint Air Power Competence Centre - NATO's Advocate to Air and Space Power. Available at: <https://www.japcc.org/articles/congested-outer-space/> (Accessed: December 15, 2022).
- Jones, A. (2022) Breakup of China's yunhai-1 (02) satellite linked to space debris collision, SpaceNews. Available at: <https://spacenews.com/breakup-of-chinas-yunhai-1-02-satellite-linked-to-space-debris-collision/> (Accessed: December 16, 2022).
- Jwst.nasa.gov. (2022). Webb's Launch GSFC/NASA. Available at: <https://www.jwst.nasa.gov> [Accessed 21 March 2022].
- Kacific (2022) Kacific1: The advantages of geostationary orbit, Kacific. Available at: <https://kacific.com/id/news/kacific1-the-advantages-of-geostationary-orbit/> (Accessed: December 15, 2022).
- katadata. (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].
- Khan, R., (2020). *Internet | Description, History, Uses, & Facts*. Encyclopedia Britannica. Available at: <https://www.britannica.com/technology/Internet> [Accessed 4 April 2022].
- Kim, J. (2022) Fiber optic network construction: Process and build costs, Dgtl Infra. Available at: <https://dgtlinfra.com/fiber-optic-network-construction-process-costs/> (Accessed: December 15, 2022).
- KOMINFO, P., (2022). Belum Tersentuh Meski Tak Terpencil. Website Resmi Kementerian Komunikasi dan Informatika RI. Available at: https://kominfo.go.id/content/detail/13518/belum-tersentuh-meskitakterpencil/0/sorotan_media [Accessed 21 March 2022].
- KOMINFO, 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].

Kulu, E. (2022) Satellite constellations, NewSpace Index. Available at: <https://www.newspace.im/> (Accessed: December 15, 2022).

Labrador, V. (2015) Satellite Communication, Encyclopædia Britannica. Encyclopædia Britannica, inc. Available at: <https://www.britannica.com/technology/satellite-communication> (Accessed: December 15, 2022).

La Cruz, L. (2022) Starlink satellites can look like a plume or train of light, EarthSky. Available at: [https://earthsky.org/space/spacex-starlink-satellites-explained/#:~:text=Starlink%20satellites%20orbit%20at%20an,340%20miles%20\(550%20km\).](https://earthsky.org/space/spacex-starlink-satellites-explained/#:~:text=Starlink%20satellites%20orbit%20at%20an,340%20miles%20(550%20km).) (Accessed: December 15, 2022).

Leosweep (2018) The space debris problem, LEOSWEEP. Available at: <https://leosweep.upm.es/en/project/the-space-debris-problem> (Accessed: December 16, 2022).

Loff, S., (2022). *About NASA*. NASA. Available at: <<https://www.nasa.gov/about/index.html>> [Accessed 6 April 2022].

Loff, S., (2015) Apollo 11, NASA. NASA. Available at: https://www.nasa.gov/mission_pages/apollo/apollo-11.html (Accessed: January 4, 2023).

Lyons, B. and Crow, M. (2022) Do cruise ships have Wi-Fi? and 6 other things you need to know about internet at sea, Cruise Reviews, Cruise Deals and Cruises - Cruise Critic. Available at: <https://www.cruisecritic.com.au/articles.cfm?ID=1419&stay=1&posfrom=1> (Accessed: December 15, 2022).

McGill University (2022) Telecommunication. Available at: <https://www.cs.mcgill.ca/~rwest/wikispeedia/wpcd/wp/t/Telecommunication.htm#:~:text=Telecommunication%20is%20the%20transmission%20of,smoke%20signals%2C%20drums%20or%20semaphore.> (Accessed: December 15, 2022).

Medium. (2022). *How important is your smartphone in your life?*. Available at: <https://medium.com/@KeepCoding_/how-important-is-your-smartphone-in

your-life-28ec82fff721#:~:text=We%20use%20it%20to%20set,to%20take%20our%20daily%20selfies.> [Accessed 21 March 2022].

Miftachul, M., (2013). Repository.dinamika.ac.id. Available at: <<https://repository.dinamika.ac.id/id/eprint/213/5/BAB%20III.pdf>> [Accessed 4 April 2022].

Mohanta, N. (2022) How many satellites are orbiting around Earth in 2022?, Geospatial World. Available at: <https://www.geospatialworld.net/prime/how-many-satellites-orbiting-earth/#:~:text=According%20to%20UNOOSA%20records%2C%20there,record%20of%20the%20operational%20satellites.> (Accessed: December 15, 2022).

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

National Geographic (2022) Orbit, National Geographic Society. Available at: <https://education.nationalgeographic.org/resource/orbit> (Accessed: December 15, 2022).

Nhm.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].

Nice, K. and Harris, T. (2002) *How satellite TV works*, *HowStuffWorks*. HowStuffWorks. Available at: <https://electronics.howstuffworks.com/satellite-tv2.htm> (Accessed: December 15, 2022).

nzherald. (2022). Starlink satellites spotted in northland sky. Available at: <<https://www.nzherald.co.nz/nz/watch-elon-musks-spacex-starlink-satellites-spotted-in-northland-sky/CE34IAY5GGZJYJYIQF3JNDLVCY/>> [Accessed 21 March 2022].

O'Callaghan, J. (2018) *What is space junk and why is it a problem?*, *Natural History Museum*. Available at: <https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html> (Accessed: December 16, 2022).

Odimpact.org. (2022). *United States Opening GPS Data for Civilian Use*. Available at: <<https://odimpact.org/case-united-states-opening-gps-data-for-civilian-use.html>> [Accessed 11 April 2022].

- Odishaw, H. (2022) Man-made satellites, *The Atlantic*. Atlantic Media Company. Available at: <https://www.theatlantic.com/magazine/archive/1957/10/man-made-satellites/640569/> (Accessed: December 15, 2022).
- Olsen, J., (2022). Where does space begin? It's an argument that's still up for debate. *wfsp*. Available at: <https://www.wfsp.com/Article/tech/science/space/where-does-space-begin-astronaut-spaceflight/67-a8f857f0-7a94-4ef4-bf0a-44ed75034e72> [Accessed 21 March 2022].
- Physics Classroom (2022) *Circular motion principles for satellites*, *The Physics Classroom*. Available at: <https://www.physicsclassroom.com/class/circles/Lesson-4/Circular-Motion-Principles-for-Satellites> (Accessed: December 15, 2022).
- Physics World (2021) Dark-coated Starlink satellites are better but not perfect, say astronomers, *Physics World*. Available at: <https://physicsworld.com/a/dark-coated-starlink-satellites-are-better-but-not-perfect-say-astronomers/> (Accessed: December 15, 2022).
- Pillow, L. (2021) *Op-ed: Satellite bankruptcies circa 2000 vs. 2020: We've come a long way!*, *SpaceNews*. Available at: <https://spacenews.com/op-ed-satellite-bankruptcies-circa-2000-vs-2020-weve-come-a-long-way/> (Accessed: December 15, 2022).
- Rai, D. (2020) Pacta sunt servanda: All you need to know about it, *iPleaders*. Available at: <https://blog.iplayers.in/pacta-sunt-servanda/> (Accessed: December 16, 2022).
- Ralph, E. (2020) SpaceX rolls out starlink "Better than nothing beta" in the US and Canada, *TESLARATI*. Available at: https://www.teslarati.com/spacex-starlink-better-than-nothing-beta-rollout/amp/?utm_campaign=gs-2020-11-23&utm_source=google&utm_medium=smart_campaign&gclid=Cj0KCQiAqOucBhDrARIsAPCQL1YAtFran--bHTj2Vjcz1H-dFxm pOP2onccDB_P_eHLajQRmGts4-KkaAi1SEALw_wcB (Accessed: December 15, 2022).
- Rantcell.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].
- Reuters (2021) Musk ready to invest as much as \$30 billion in Starlink, *mint*. Available at: <https://www.livemint.com/technology/tech-news/musk-ready-to-invest-as-mu>

ch-as-30-billion-in-starlink-11624984603581.html (Accessed: December 15, 2022).

Ronalds, B.F. (2015) Sir Francis Ronalds: The first electrical engineer, Sir Francis Ronalds | The first electrical engineer. Available at: <http://www.sirfrancisronalds.co.uk/> (Accessed: January 4, 2023).

Roztocki, N. (2019) Full article: The role of information and communication technologies in socioeconomic development: towards a multi-dimensional framework. Available at: <https://www.tandfonline.com/doi/full/10.1080/02681102.2019.1596654> (Accessed: December 15, 2022).

Ruge, A. (2020) Satellite Communication: The technology behind the Banking Industry, axessnet. Available at: <https://axessnet.com/en/satellite-communication-the-technology-behind-the-banking-industry/> (Accessed: December 15, 2022).

Ryan (2020) Everything you need to know about orbital mechanics, Orbital EOS. Available at: <https://www.orbitaleos.com/orbital-mechanics-1/> (Accessed: December 15, 2022).

Schmidt-Tedd, B. and Soucek, A. (2020) Registration of space objects, Oxford Research Encyclopedia of Planetary Science. Available at: [https://oxfordre.com/planetaryscience/oso/viewentry/10.1093\\$002facrefore\\$002f9780190647926.001.0001\\$002facrefore-9780190647926-e-95;jsessionid=FD2212C5380F1208D991D1148DE04754](https://oxfordre.com/planetaryscience/oso/viewentry/10.1093$002facrefore$002f9780190647926.001.0001$002facrefore-9780190647926-e-95;jsessionid=FD2212C5380F1208D991D1148DE04754) (Accessed: December 16, 2022).

Science Learning Hub (2013) Artificial satellites. Available at: <https://www.sciencelearn.org.nz/resources/269-artificial-satellites> (Accessed: January 4, 2023).

Science Learning Hub (2022) *Natural satellites*, Science Learning Hub. Available at: <https://www.sciencelearn.org.nz/resources/271-natural-satellites> (Accessed: December 15, 2022).

Sesnic, T., (2022). *Starlink Group 4-5 | Falcon 9 Block 5*. Everyday Astronaut. Available at: <https://everydayastronaut.com/starlink-group-4-5-falcon-9-block-5-2/> [Accessed 25 March 2022].

Sgobba, T. and Levin, E. (2013) Space surveillance, Space Surveillance - an overview | ScienceDirect Topics. Available at: <https://www.sciencedirect.com/topics/engineering/space-surveillance> (Accessed: December 16, 2022).

- Singh, L.A. et al. (2020) Low cost satellite constellations for nearly continuous global coverage, Nature News. Nature Publishing Group. Available at: <https://www.nature.com/articles/s41467-019-13865-0> (Accessed: December 15, 2022).
- Smithsonian Magazine (2021) How Yuri Gagarin was picked to be first in space, Smithsonian.com. Smithsonian Institution. Available at: <https://www.smithsonianmag.com/air-space-magazine/how-yuri-gagarin-was-picked-be-first-space-180977447/> (Accessed: January 4, 2023).
- Snow, B. (2016) What would a world without internet look like?, The Atlantic. Atlantic Media Company. Available at: <https://www.theatlantic.com/technology/archive/2016/04/a-world-without-internet/476907/> (Accessed: December 15, 2022).
- Space.com. (2022). SpaceX's Starlink satellites will soon get glare-reducing 'sunshades,' Elon Musk says. Available at: <https://www.space.com/spacex-starlink-satellites-sunshades.html> [Accessed 21 March 2022].
- Space.com. (2022). Starlink: SpaceX's satellite internet project. Available at: <https://www.space.com/spacex-starlink-satellites.html> [Accessed 21 March 2022].
- Starlink. (2022). Starlink. Available at: <https://www.starlink.com> [Accessed 21 March 2022].
- Strout, N. (2022) Space command calls out another Russian anti-satellite weapon test, C4ISRNet. C4ISRNet. Available at: <https://www.c4isrnet.com/battlefield-tech/space/2020/12/16/space-command-calls-out-another-russian-anti-satellite-weapon-test/> (Accessed: January 4, 2023).
- Submarine Cable Map (2022) Submarine Cable Map. Available at: <https://www.submarinecablemap.com/> (Accessed: December 15, 2022).
- Supantha M. (2021) Musk says may need \$30 bln to keep Starlink in orbit, Reuters. Thomson Reuters. Available at: <https://www.reuters.com/business/aerospace-defense/musk-sees-starlink-winning-500000-customers-next-12-months-2021-06-29/> (Accessed: December 15, 2022).

- The Aerospace Corporation (2022) *How does space debris threaten the ISS?*, Medium. Medium. Available at: <https://aerospacecorp.medium.com/questions-about-how-space-debris-can-threaten-the-iss-c90c83f724cc> (Accessed: December 16, 2022).
- Travel China Guide (2014) *How was the Great Wall of China defended?* Available at: https://www.travelchinaguide.com/china_great_wall/construction/fortifications.htm (Accessed: January 4, 2023).
- Tresia, (2022). *Apa perbedaan Jaringan 3G, 4G, dan 5G? Simak ulasannya!* | *Teknologi - Bisnis.com*. Available at: <https://teknologi.bisnis.com/read/20220107/280/1486583/apa-perbedaan-jaringan-3g-4g-dan-5g-simak-ulasannya> [Accessed 11 April 2022].
- Unoosa.org. (1966). *The Outer Space Treaty*. Available at: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspace treaty.html> [Accessed 11 April 2022].
- Unoosa.org. (2022). *Space Law*. Available at: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html> [Accessed 4 April 2022].
- Urrutia, D., (2019). *India's Anti-Satellite Missile Test Is a Big Deal. Here's Why.* Space.com. Available at: <https://www.space.com/india-anti-satellite-test-significance.html> [Accessed 4 April 2022].
- Verizon.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].
- Viavisolutions.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].
- Via 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].

- Virgilia, B. et al. (2016) Risk to space sustainability from large constellations of satellites, *Acta Astronautica*. Pergamon. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0094576516300820> (Accessed: December 16, 2022).
- Wall, M. (2022) *SpaceX reveals 'Starshield' Satellite Project for National Security use*, *Space.com*. Space. Available at: <https://www.space.com/spacex-starshield-satellite-internet-military-starlink> (Accessed: January 30, 2023).
- Wallis, J.(2022) Starlink & The Tech behind its incredible internet coverage, *WEBO Digital*. Available at: <https://webo.digital/blog/starlink-tech-behind-internet-coverage/> (Accessed: December 15, 2022).
- Westover, B. (2022) How to get Starlink Satellite Internet and set it up the right way, *PCMag*. PCMag. Available at: <https://www.pcmag.com/how-to/starlink-starter-kit-how-to-get-it-and-set-it-up> (Accessed: December 15, 2022).
- Williams, D., (2022). *NASA - NSSDCA - Spacecraft - Details*. *Nssdc.gsfc.nasa.gov*. Available at: <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1957-001B> [Accessed 11 April 2022].
- Wmap.gsfc.nasa.gov*. (2022). *WMAP- Content of the Universe*. Available at: https://wmap.gsfc.nasa.gov/universe/uni_matter.html [Accessed 21 March 2022].
- Yan Huang, M. (2021) What Elon Musk's 42,000 Starlink satellites could do for - and to - planet earth, *Business Insider*. *Business Insider*. Available at: <https://www.businessinsider.com/how-elon-musk-42000-starlink-satellites-earth-effects-stars-2020-10> (Accessed: December 15, 2022).
- Yarnoz, D. (2022) *United Nations Office for Outer Space Affairs, Space Law*. Available at: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html> (Accessed: December 16, 2022).
- Yasar, K. (2022) *What is Starlink? everything you need to know*, *WhatIs.com*. *TechTarget*. Available at: <https://www.techtarget.com/whatis/definition/Starlink#:~:text=Starlink%20has%20the%20advantage%20of,the%20high%2Dcost%20factors%20involved>. (Accessed: December 15, 2022).

International Legal Instruments

2222(XXI). Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies

2777(XXVI). Convention on International Liability for Damage Caused by Space Objects

3235(XXIX). Convention on Registration of Objects Launched into Outer Space

Convention of the European Space Agency, ref. CSE/CS/73/19, rev. 7.

Convention on International Civil Aviation - Doc 7300

General Assembly resolution 1962 (XVIII) of 13 December 1963. Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space

Resolution Adopted by The General Assembly 37/92. Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting

Resolution Adopted by The General Assembly 51/122. Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries