UNIVERZITA KARLOVA

Právnická fakulta

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Kosmické aktivity a ochrana životního prostředí

Diplomová práce

Vedoucí diplomové práce:	doc. JUDr. Jan Ondřej, CSc., DSc.
Katedra:	Katedra mezinárodního práva
Datum vypracování práce:	10.10.2018

CHARLES UNIVERSITY

Faculty of Law

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Outer Space Activities & Environmental Protection

Diploma Thesis

Thesis Advisor:	doc. JUDr. Jan Ondřej, CSc., DSc.
Department:	Department of International Law
Date of Submission:	10.10.2018

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PODĚKOVÁNÍ

Ráda bych tímto poděkovala vedoucímu diplomové práce doc. JUDr. Janu Ondřeji, CSc., DSc. za podnětné rady a osobní přístup při vypracování této práce. Dále bych ráda poděkovala vyučujícím z katedry Air and Space Law na Univerzitě v Leidenu, zejména Drs T.L. Masson-Zwaan za poskytnutou možnost navštěvovat přínosné lekce týkající se této práce.

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Introduction

This thesis aims to examine current international space law regime with particular regard to the environmental protection of both space and Earth. During the past decades, humankind has managed to extend its environment from Earth and its atmosphere to the outer space. The benefits arising from outer space activities became a part of everyday life for most humans, companies, and governments worldwide. For instance, the space industry serves many environmental purposes in areas of, among other things, weather forecast, land, and agricultural management and ecological planning. Other important space-related sectors include telecommunication satellites and global navigation satellite systems. The benefits of space activities are mostly well known, and a large number of entities in the public and private sector heavily rely on them.

However, the extensive use of outer space leads to its pollution, which can be described as critical at this point. Outer Space is a very competitive field, and different interests usually prevail over the environmental protection. However, at present, the environmental degradation of the outer space must not be neglected anymore, awareness regarding space-related problems, and especially space debris needs to be raised, and possible solutions of environmental issues should not only be proposed, but also executed as soon as possible. Principles included in Space Treaties, provide for a general legal framework regulating outer space activities, seem somewhat insufficient to challenge recently emerging problems that require actors to behave in an environmentally friendly manner. On the other hand, soft law instruments adopted by international organizations including various Standards, Guidelines, and Codes of Conduct require a certain degree of care and diligence to prevent further pollution of outer space.

This work consists of two main parts. Each part aims at examining different connecting factors between outer space activities and environmental protection. The first part reflects the environmental perspective of space law and also examines international legal instruments regulating space law concerning environmental protection. The second part proceeds to draw the attention to International Environmental Law issues emerging from space activities and is further divided into two sub-parts. The first sub-part of the second part of the thesis addresses

environmental problems related to outer space activities with the emphasis to space debris as the most urgent space-related environmental issue of our time.

The second sub-part of the second part examines the benefits of outer space activities to the protection of the environment of Earth. The thesis aims to provide for a unified view of the possibilities outer space activities offer to the protection of the environment and also to emphasize current legal issues space environment is dealing with. Possible future development of space activities and the use of evidence obtained from space will significantly rely on the practice of states and other entities as well as on the willingness to find solutions to achieve sustainable development.

The approach of the thesis is to analyze environmental issues of space activities, among which the most significant adverse effect is space debris and the most significant positive impact space activities have on the environment is earth observation and remote sensing industry. This thesis aims to examine general space law from the environmental perspective, address environmental issues related to space activities and draw the attention to the development of the use of space-derived data among other possible means of environmental protection from space.

The general concern of this study is, therefore, examining the effects of space activities on the environment and their regulation. Environmental awareness in the space sector is an imperative without which future outer space activities may become impossible. Specific technological requirements need to be implemented in order to maintain the sustainability of outer space activities according to which the willingness of states and other actors in space sector to encourage protection of the environment seem to be the only solution for further development.

1. Space law from an Environmental Perspective

Space law, as a relatively new field of public international law, began with launching Sputnik, the first artificial satellite by Russia on 4 October 1957. Since that time, space activities have been playing an important role both in the military and in civil society. Reliance on satellites is nowadays stronger than ever, and the commercialization of space shows the importance of those activities for life on Earth. It started as a "space race" between the military departments of the USA and the Soviet Union, but the technological and scientific development soon allowed for other subjects to be involved and therefore it is no longer a privilege of sovereign states.

Since the very beginning of space activities, states were aware of the necessity to negotiate space treaties, because of the risk of militarisation of space in the tough times of Cold War. The fear of weapons in space and the legal certainty required in the regulation of accidents, liability, and compensation, lead states to negotiate treaties and establish the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter referred to as UNCOPUOS). It is a permanent committee of the United Nations, set up by the General Assembly, with its seat in Vienna. The Committee aims to govern the exploration and use of space for the benefit of all humanity: for peace, security and development.[1] The role of the Committee in the creation of treaties was instrumental, and it provides a unique platform for international cooperation in space exploration and the use of space technology applications to meet global development goals, which are discussed in the Committee every year.

The Committee consists of two subcommittees - the Scientific and Technical Subcommittee and the Legal Subcommittee. Annual scheduled meetings provide for a flexible assessment of space-related activities, encouraging space research programmes, and studying legal problems arising from the exploration of outer space. However, no clear definition of where air ends and space starts was adopted during the meetings of UNCOPUOS showing the political resistance regarding this question of space law. The reason for this can also be derived from the fact, that the Committee works on means of consensus, which does not allow for making

1 Unoosa.org. (2018). *COPUOS*. [online] Available at: http://www.unoosa.org/oosa/en/ourwork/copuos/index.html [Accessed 17 May 2018].

decisions even if one state party is against it. This process of decision making may seem a little bit difficult, but on the other hand, the treaties that were passed under this requirement provide for the rise of binding customary law if ratified by most states and states would act in accordance with the provisions included thereof.

Another reason for the unwillingness and restraint to codify a boundary between air and space is the uncertainty of further technological development. Some authors consider the beginning of outer space the lowest altitude a satellite can orbit and the highest a plane can fly but this does not answer the question of a boundary, because it changes with the development of technology - planes fly higher than ever before, and satellites may orbit lower than ever before. Few countries even codified a boundary in their national legislation but to become binding for all states, and it would need to be done by most countries and accepted by most states as legally binding to become international customary law, which does not seem very probable at the present time.

The above reasoning for the absence of binding definition did not prevent authors from trying to define the distinction between airspace and outer space. “Outer space is all of the space surrounding the Earth where objects can move without artificial propulsion systems according to the laws of celestial mechanics, without being prevented from doing so by the frictional resistance of the Earth’s atmosphere. It extends from an altitude above the Earth of approximately 100 km upwards”.[2] It might sound like a scientific definition, but in fact, it is an attempt to clarify the distinction between air and space. Other authors consider the so-called Kármán line to be the boundary between air and space and its definition would be quite similar to the above mentioned.

However, the discussion did not bring the exact delimitation of space, the difference between the regimes of air and space is tremendous. Airspace and air law are governed by the principle of sovereignty (sovereign equality) of states, which means that there is no higher power in the territory of the country, whilst the regime of outer space and space law is governed by the principles of freedom of exploration, freedom of the use of outer space and non-appropriation.

Space-related activities are present in many areas of our lives and play an essential role in our society. Meteorology, telecommunications, Earth observation, astronomy, navigation, and

2 Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.3.

exploration are just examples of the current use of space, and plans include space tourism, exploitation and even living in space. Outer space exploration has brought about a revolution in communication and global interaction. The world society has never been more integrated: it is called a Space Age society.[3]

The regime of outer space has enormous potentialities for the evolution of world society and is born out of the human quest for knowledge and freedom.[4] The recent growth of activities in the outer space will crowd the space environment to the extent that the particular approaches in international cooperation would have to be carefully selected and specific steps will need to be taken towards reaching the goals in the outer space exploration. Professor Bhatt proposed three categories of goals in outer space exploration for humankind. The first is the scientific exploration of outer space and other planets. This field of activities focuses on obtaining new knowledge about space and Earth. The second category of goals in outer space exploration could be described as activities, which have an impact on the economic and social well-being of man on earth. These include satellites for communication, education and environment monitoring, including remote sensing.[5] The third category is based on adding new knowledge from outer space activities to common scientific problems of humankind, which includes satellites for weather observation and observation of natural disasters, such as floods and hurricanes.

The hard law (legally binding) part of the international law of outer space consists of five treaties: Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereinafter referred to as the Outer Space Treaty), Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (hereinafter referred to as the Rescue Agreement), Convention on International Liability for Damage Caused by Space Objects

3 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 28.
4 Ibid, p. 24.
5 Ibid, p. 24.

(hereinafter referred to as the Liability Convention), the Convention on Registration of Objects Launched into Outer Space (hereinafter referred to as the Registration Convention) and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (hereinafter referred to as the Moon Agreement). One of major characteristic of space law is that it declares outer space a region not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means (Article II of the Outer Space Treaty).[6] Outer space is a region that could be compared to other international spaces - the High Seas and the Polar Antarctic region for which the same legal provisions have been accepted. The provision as mentioned above in the Outer Space Treaty is derived from the article I of the Antarctic Treaty.[7]

1.1 Space Treaties

Space law treaties were concluded between the years 1967 and 1979, but the subject matter has been concerned since the beginning of the exploration of the outer space in October 1957 when the first artificial satellite Sputnik was sent into space by the Soviet Union. On 12 December 1959, United Nations General Assembly adopted Resolution 1472 (XIV) establishing a Committee on Peaceful Uses of Outer Space.[8] The Committee was instrumental in the creation of the five treaties and five principles of outer space. International cooperation in space exploration and the use of space technology applications to meet global development goals are discussed in the Committee every year. [9]

On 20 December 1961, the United Nations passed Resolution 1721 setting forth the two crucial principles applicable to outer space.[10] Firstly, International law, including the Charter of the United Nations, applies to outer space and celestial bodies and secondly, outer space and celestial bodies are free for exploration and use by all states in conformity with

6 Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.45.
7 Ibid, p. 45.
8 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 41.
9 Unoosa.org. (2018). *COPUOS*. [online] Available at: http://www.unoosa.org/oosa/en/ourwork/copuos/index.html [Accessed 17 May 2018].
10 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 41.

international law and are not subject to national appropriation. Two years later, on 13 December 1963, the United Nations took another significant step to formulate a "Declaration of legal principles" in resolution 1962 (XVIII).[11]

The principles were following: use of outer space for the benefit of all mankind, freedom of exploration and use of outer space in accordance with international law, prohibition of national appropriation of outer space and celestial bodies, to carry exploration of space in the interest of peace and security, cooperation and understanding, international responsibility of states for activities in outer space, observing interests of other nations and providing for international consultations, retention of ownership of object launched into space, international liability of states for damage and rendering assistance to astronauts.[12]

International Customary Law provided the initial setting through United Nations Resolutions on space law and since then, treaties, and agreements regarding rights, duties, and responsibility in outer space were adopted. However no specific stipulations concerning environmental protection have been adopted, those above mentioned general principles shall apply to all activities in outer space and states shall refrain from causing damage outside of their national jurisdiction. Following development and establishment of rights and duties in the space law and conclusion of treaties regulating actions of states in order to protect the space environment, have made the main impact on the International Space Law as it is nowadays. Most of the countries have their space programmes, but international cooperation is far more important in order to protect the space environment and steps will need to be taken soon to reach the goal of sustainable development in this area.

As already mentioned above, Space law in general consists of five treaties, Resolutions of the General Assembly of the United Nations, on the regulation of the behavior of states in the outer space. The following chapter will try to outline the most important provisions of those treaties with the emphasis on the protection of the outer space environment. This might although sound a bit enthusiastic since the Space Treaties do not include many provisions regarding the environmental protection. At the time of their conclusion, such considerations

11 Ibid, p.42.
12 Ibid, p.42

were not among the highest ranking items on the agendas of space-faring nations, and it has later proven very challenging for the actors in this area to agree on new legally binding international rules.[13]

However, not all the Space Treaties are significantly or directly relevant to the environmental protection. This chapter will further examine only three of them - the Outer Space Treaty, the Liability Convention and the Moon Agreement. Rescue Agreement and Registration Convention will be omitted not due to their lack of importance, but rather due to the fact, that they do not provide for the necessary link to the protection of the environment, which is the main focus of this thesis.

1.1.1. The Outer Space Treaty

The Outer Space Treaty is the basic treaty in space law and is often referred to be the Constitution of Space Law. Its importance is strengthened by the fact, that most of the space launching states have ratified this Treaty and the provisions included thereof are considered to be part of the customary international law and therefore binding for all countries. The Preamble to the treaty refers to the common interests of all humankind, the opening of great prospects before humankind, use of outer space for the benefit of all people, the importance of broad international cooperation in the legal and scientific aspects of space exploration and the development of mutual understanding and peaceful relations through cooperation.[14]

Article 1 of the Outer Space Treaty states in the first paragraph that "*the exploration and use of outer space, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.*" The second paragraph of Article 1 of the Outer Space Treaty 1967 recognizes freedom of exploration without any discrimination and free access to all areas of celestial bodies, while the third paragraph ensures freedom of scientific investigation in outer space and encourages international cooperation is such investigation. In brief, this article enables the

13 Viikari, L. (2008). The environmental element in space law. Leiden: Martinus Nijhoff Publishers, p.29.
14 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 43.

international community to move in outer space with cooperation and mutual benefit and to make space exploration a joint enterprise for all humankind.[15]

The term "province of all mankind" deserves further explanation which alludes to the classification made by the Roman emperor Justinian who distinguished between *res in patrimonio, res nullius, res communis, and res publica.*[16] Definition of these terms will help us to understand the purpose and nature of stipulations included in the Outer Space Treaty, which may be helpful to prevent misinterpretations and clarify the intentions of the drafters.

Res in patrimonio refers to the exclusive control of a resource by a person or a group of persons. The term covers both the present notion of property and sovereignty.[17] Article 2 of the Outer Space Treaty of 1967 expressly declares Outer space *"not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."* By the diction of the Article 1 as mentioned above, the outer space is declared to be *res extra patrimonium* which means that it can not be subject to appropriation by any possible means.

Res nullius, on the other hand, refers to resources without any owner, suitable for appropriation and being able to become someone's property through effective occupation. Article 2 of the Outer Space Treaty 1967 prohibits all kinds of appropriation, which means that the outer space cannot be described as *res nullius* either. However, some authors have been admitting to the possibility of property rights over the natural resources of celestial bodies, although they considered space resources *res extra commercium,* which by definition means, being incapable of appropriation.[18]

15 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 44.
16 Buckland, W. and Stein, P. (1966). A text-book of Roman law from Augustus to Justinian. 3rd ed., p. 182-186, in Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.45.
17[17] Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.45.
18 DE MAN, P. (2018). EXCLUSIVE USE IN AN INCLUSIVE ENVIRONMENT. [S.l.]: SPRINGER. p. 24.

Res communis refers to a resource that can not be owned by a person or by State. Outer Space, the High Seas, and the Polar region Antartica are considered to be *res communis*[19] except for its part called geostationary orbit, which is according to art. 33 par. 2 of the International Telecommunication Convention all together with radio frequencies defined as *"limited natural resources and shall be used efficiently and economically, (…) taking into account the special needs of the developing countries."*[20]

Res publica refers to a resource, common to all people, which nature requires governmental regulation to guarantee equitable access to and share of the resource. The International Telecommunication Convention is drawn up and ratified by the Member States of International Telecommunication Union, which implies that, as regards to the geostationary orbit, this is the governmental regulation required for a *res publica.*[21] The above distinction leads to a conclusion that the definition of res publica is a specification of res communis. The outer space is therefore considered to be a res communis omnium except for the specific part of it called the Geostationary orbit, which is regarded to be a res publica.

The above classification was interpreted by many authors slightly differently through history, giving enough space for ambiguity and doctrinal disunity, mainly before the adoption of the United Nations resolutions and treaties on the outer space. Legal documents adopted by the UNCOPUOS and the United Nations General Assembly on outer space carefully refrain from referring to concepts of Roman law to describe the status of celestial bodies and instead refer to the exploration and the use of outer space as the province of all humankind.[22]

Articles 1 and 2 of the Outer Space Treaty reflect the positive and the negative sides of the same fundamental freedom of all states to use outer space. The prohibition of appropriation by one state safeguards the freedom of all other nations to access the outer space.[23] Preservation

19 Ibid, p. 46.
20 Search.itu.int. (2018). [online] Available at: http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/5.11.61.en.100.pdf [Accessed 17 May 2018].
21 DE MAN, P. (2018). EXCLUSIVE USE IN AN INCLUSIVE ENVIRONMENT. [S.l.]: SPRINGER., p.46.
22 Ibid, p. 29.
23 Ibid, p. 89.

of the space environment may, therefore, be regarded as a condition for guaranteeing equal opportunities in the exploration and use of outer space by all countries. Article 3 of the Outer Space Treaty further provides that states shall carry on activities in the exploration and use of the outer space in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding.[24] This provision explicitly confirms the applicability of general international law and international environmental law to space activities.

The general principles included in the Article 2 of the Charter of the United Nations provide for, among other things, the prohibition of threat or use of force in any manner inconsistent with the purposes of the United Nations. Article 4 provides for partial demilitarisation of space and the prohibition of placing any objects carrying nuclear weapons or any other types of weapons of mass destruction. The second paragraph of Article 4 goes even further in the prohibition of any kinds of weapons on the Moon and other celestial bodies and proclaiming the use of them by states exclusively for peaceful purposes. Article 5 deals with the assistance to astronauts in the event of accident, distress or emergency landing on the territory of another state or the high seas.[25]

Article 6 is the main article in the respect of environmental protection, according to which parties to the Outer Space Treaty of shall bear international responsibility for national activities in outer space, whether carried on by governmental agencies or by non-governmental entities, in particular stating that the actions of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.[26]

24 UN General Assembly, Treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, 27 January 1967, United Nations, Treaty Series, vol. 610, p. 13, Article 3, available at: Available at: http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf [Accessed 17 May 2018].
25 Ibid, Article 5.
26 Ibid, Article 6.

It is a significant provision relating to states responsibility for activities in outer space, and it stipulates the responsibility of a state for actions of private entities under its authorization and continuing supervision. In Article 7 we find that states are internationally liable for damage caused by a space object - to other countries or its natural or juridical persons. Thus, the liability of States is restricted to damage caused by acts as a consequence of which another State Party's space activities are being compromised, and, on the basis of this Article, not to actions of a State Party which led to the pollution of the outer space itself in general. [27]

This provision is linked to the Launching state, which is the state that launches, procures a launch, whose territory or facility is used and therefore the obligation can be shared by more countries, which are all jointly and severely liable, if not otherwise stipulated. The jurisdiction principle is incorporated in Article 8 stating, that the jurisdiction is reserved in the state in whose registry the space object is launched into space. The launching state also retains the ownership over such objects.[28] This is further developed in the Registration Convention and basically, require double registration - on a national level and in the United Nations register maintained by the Secretary-General of the United Nations.[29]

Article 9 provides that States shall conduct exploration so as to avoid harmful contamination of outer space, including Moon and other celestial bodies and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.[30] This article has the major focus on environmental protection and calls for international consultations between states to avoid any damage to the space environment, which has been made a new general principle of international law alongside international cooperation.[31] The question of what is understood by

27 Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.49.
28 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 45.
29 UN General Assembly, Convention on Registration of Objects Launched into Outer Space, 12 November 1974, United Nations, Treaty Series, vol. 3235, p. 16, Article 3, Available at: http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html
30 UN General Assembly, Treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, 27 January 1967, United Nations, Treaty Series, vol. 610, p. 13, Article 9, Available at: http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf [Accessed 17 May 2018].
31 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 45.

the term “harmful contamination” arises and how this could be proved. So far, no final and exhaustive answer seems possible. Even if such proof may be established, will it be possible to indicate the State, under whose jurisdiction such contamination occurred?[32] The contamination of the outer space is nowadays almost at the irreparable level and if no further steps to decontaminate the space environment will be taken, the future space activities might not be even possible.

As already stated above, the international liability for damage only refers to damage to States or its persons, not damage to the environment caused by contamination. Space debris is produced when space activities are being realized but the question whether there is any provision which holds the contaminator liable for such contamination stays unresolved. According to the jurisdiction provision in Article 8, a State retains jurisdiction and control over its space objects and over any personnel thereof, while in outer space or on a celestial body.

The conclusion of the foregoing is that every launching State is not only internationally responsible for national activities in outer space but also for the space debris it launchings create.[33] The question remains, is it even fair to retain responsibility for every piece of debris in space which may be orbiting for thousand years? Particularly the states that could be held responsible under this provision would only be the launching states, that have already invested a huge amount of money to space exploration and their knowledge and observations are shared with the whole international community. It may be therefore difficult to ask for a reparation just those states since everyone benefits from space activities performed only by few.

In conclusion, it is important to emphasize that the Outer Space Treaty provides for the regulation of freedom of exploration, peace, scientific investigation, international consultation, the liability of states, the principle of non-appropriation, mutual assistance of states, arms control measures and environmental protection of the outer space. The Outer

32[32] Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.50.
33 Ibid, p.51.

Space Treaty is, therefore, a world charter for exploration of outer space and Moon and other celestial bodies.[34] The remaining space treaties provide for a specification of the general provisions included in the Outer Space Treaty in particular areas of liability, registration and the issues regarding the governance of conduct in relation to Moon and other celestial bodies.

1.1.2. The Liability Convention

The Liability Convention consists of internationally adopted principles as regards the prevention of the pollution of outer space and is, contrary to the Outer Space Treaty of 1967, lex specialis.[35] The definition of "damage" as "l*oss of life, personal injury or other impairment of health, or loss of or damage to property of States or persons, natural or juridical, or property of international intergovernmental organisations*" is provided in Article 1 together with the definition of "space object" which includes component parts of a space object as well as its launch vehicle and parts thereof. Thus, space debris falls within the scope of this Convention, and, consequently, within the scope of space law as regards liability and compensation for damage.[36]

This extensive interpretation supported by many authors is although a theoretical assumption based on their opinion and could be doubted by others. The question of whether space debris fall in the category of space object under the Liability Convention remains unclear. Since the Convention itself does not include the term space debris, we can only assume the intentions of the drafters of those stipulations. Space debris has never been codified or mentioned in space treaties so we can only wonder if it falls within the category of space objects. Grammatical interpretation of the definition of space object would suggest that space debris is a space object but on the other hand, the liability attributed to a launching state cannot be considered as unlimited.

34 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 46.
35[35] Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.51.
36 Ibid, p.51.

The Liability Convention establishes a just mode of compensation in the event of damage caused. Liability is absolute for damage caused on earth and based on fault in outer space. Exoneration may occur if launching state proves that damage was caused by claimant state by its negligence or omission. The Claims Commission ensures that damage is paid for.[37] The subject matter not concerned in this Convention is the damage to the elements of the environment which are not a property of entities stated in Article 1. There are vast areas of the environment which do not belong to and have not been claimed by any entity. This includes the oceans beyond the limits of national jurisdiction, much of the Antarctica, and outer space, including the Moon and other celestial bodies.[38]

This is to say that states should, as soon as possible, enter into discussion and negotiation to seek global cooperation in the competent international organisations like the United Nations and others in the field of space law, to set up Additional protocol to the Liability Convention of 1972 with a view of a creation of specific international regulation of the liability for the pollution of the outer space environment by the space debris.[39] However, this might be a difficult task, especially when the global society faces many other challenges. Negotiations regarding space debris are being promoted and discussions are being held on an international level, which clearly indicate the importance of this issue and the necessity of strengthening international cooperation.

Decision making of UNCOPUOS is based on consensus and may be found difficult to make but at the same time states are being aware of the growing threat of collisions of space debris and functioning satellites. Space treaty that would bind most of the launching states has not been concluded since the late seventies, which does not show the negligence of states, but rather the difficulties of political decision making. The international cooperation is now needed more than ever to reach the level of sustainable development of space activities. If states genuinely wish to cooperate in the area of preventing further contamination, the absence of a treaty regulating space debris should not matter at all. International cooperation

37 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 47.
38 Gorove, S. (1990). Environmental Aspects of Activities in Outer Space: Environmental Risks Arising from Space Activities, Focus on the Liability Convention, Cologne: Carl Heymanns, p. 127.
39[39] Reijnen, G. and Graaff, W. (1989). The pollution of outer space, in particular of the geostationary orbit. Dordrecht: Martinus Nijhoff, p.54.

should be encouraged by space-faring nations and perhaps supported by all states in order to maintain and not worsen the situation of the space environment. Calculations indicate that if five large objects are removed each year, the cascading effect predicted by Kessler could be halted.[40]

1.1.3. The Moon Agreement

The Moon Agreement establishes some important space law principles which help the scientific exploration of the Moon and other celestial bodies for peaceful purposes. It introduces a significant principle that Moon and other celestial bodies and their natural resources are regarded as a common heritage of mankind, provides for the protection of space environment and it further stipulates that Moon and other celestial bodies should be used exclusively for peaceful purposes.[41]

The Moon Agreement imposes on states carrying out activities in the exploration and use of Moon and other celestial bodies a general obligation to prevent "the disruption of the existing balance" of their environment. The obligation covers not only "adverse changes" and "harmful contamination" but also any other possible types of interference. Unfortunately, a substantial number of states do not participate in the Moon Agreement of 1979. Thus, important environmental provisions of this treaty have not acquired the necessary level of political and legal effectiveness. The Moon Treaty binds only a small group of states which does not include the leading space powers.[42] The reason for the political resistance to entering into the Moon Agreement may be the fact, that it deals with the term: *exploitation*, rather than exploration as the Outer Space Treaty. Exploitation is understood to include the use of space resources for commercial purposes and states refrain from the ratification of such provisions which could possibly limit their future activities.

40 Unoosa.org. (2013). [online] Available at: http://www.unoosa.org/pdf/pres/stsc2013/tech-12E.pdf [Accessed 17 May 2018].
41 Bhatt, S. (2009). *Environment protection*. New Delhi: A.P.H. Pub. Corp., p. 48.
42 Gorove, S. (1990). Environmental Aspects of Activities in Outer Space: Environmental Risks Arising from Space Activities, Focus on the Liability Convention, Cologne: Carl Heymanns, p. 172.

1.2. Other Legal Instruments

1.2.1. United Nations General Assembly Principles

The United Nations General Assembly has adopted five sets of principles applicable to the use of outer space: the 1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, the 1982 Principles Governing the Use by States of Artificial Earth Satellites for International Direct Broadcasting, the 1986 Principles Relating to Remote Sensing of the Earth from Space, the 1992 Principles Relevant to the Use of Nuclear Power Sources in Outer Space and the 1996 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.[43] This paper will further examine in the following chapters the importance of the 1986 Principles Relating to Remote Sensing of the Earth from Space as one of the possible means of regulation of the outer space activities with the connection to environmental protection of Earth.

Although the United Nations General Assembly Resolutions are not binding per se, in the area of international law of outer space, they are presented by UNCOPUOS, which means that they were adopted by means of consensus and, if such resolutions are followed by states practice, parts may become customary international law, which interestingly already happened due to the fact, that none of the states ever opposed to the provisions included thereof. The United Nations are far the most important international organization with regards to the outer space activities but not the only one. The Inter-Agency Space Debris Coordination Committee and the International Law Association also deserve our attention regarding their role in the environmental protection of the outer space and their particular influence will be examined in the following chapters.

43 Viikari, L. (2008). The environmental element in space law. Leiden: Martinus Nijhoff Publishers, p. 56.

1.2.2. Developments within certain other international bodies

1.2.2.1. The Inter-Agency Space Debris Coordination Committee

The Inter-Agency Space Debris Coordination Committee (hereinafter referred to as the IADC) is an organization of national space agencies founded in 1993. Its members are ESA and space agencies from ten countries: the Italian Space Agency, the British National Space Centre, Centre National d'Etudes Spatiales (CNES from France), the China National Space Administration, Deutsches Zentrum fur Luft- und Raumfahrt e.V., the Indian Space Research Organisation, the Japan Aerospace Exploration Agency (JAXA), NASA, the National Space Agency of the Ukraine and the Russian Federal Space Agency, Canadian Space Agency and Korea Aerospace Research Institute.[44] Its purpose is to exchange information on space debris research activities, facilitate cooperation and identify options for debris mitigation. For example, the UNCOPUOS asked the IADC to develop a set of voluntary guidelines in consideration at the 40th session of the Scientific and Technical Subcommittee.[45]

The IADC Space Debris Mitigation Guidelines aim to limit debris released during normal operations, to minimize the potential for on-orbit break-ups and collisions and to facilitate removal of non-operational objects from the densely populated orbits.[46] These particular mechanisms will be further examined in the following chapters of this work. The IADC guidelines also provide for the option of updating them in keeping with the development of space science, and at present, they seem to constitute the first international "rules of the road" document for space traffic management.[47]

44 Iadc-online.org. (2018). *Inter-Agency Space Debris Coordination Committee (IADC): Homepage*. [online] Available at: https://www.iadc-online.org [Accessed 17 May 2018].
45 Viikari, L. (2008). The environmental element in space law. Leiden: Martinus Nijhoff Publishers, p. 94.
46 Ibid, p. 94.
47 Ibid, p.96.

Although the IADC guidelines have been criticized for the absence of practical advice regarding their implementation and enforcement, their importance is shown elsewhere. They aim at shaping more effective international cooperation and regulation of the environmental management and also try to set an example for national legislators when identifying their standards for space activities. The collaboration between IADC and UNCOPUOS also shows the importance of international cooperation in this area. As described above, the UNCOPUOS is the principal international body in developing space law, and some of its reports are based on IADC space debris mitigation guidelines.[48]

1.2.2.2. The International Law Association

The International Law Association (hereinafter referred to as the ILA) is an international non-governmental organization, which has consultative status with a number of the United Nations specialized agencies and is also very influential in the area of international space law and the mitigation of the most critical environmental problem - space debris. The ILA Daft Convention on Space Debris from 1994 aims at a specification of the provisions of the Space Treaties already in force rather than amending them. A number of the rules included therein have been regarded as norms of customary international law and hence binding on states regardless of their approval thereof.[49]

The ILA Draft Convention on Space Debris applies to "space debris which causes or is likely to cause direct or indirect, instant or delayed damage to the environment, or to persons or objects. Article 2 of the Draft Convention provides for a definition of damage, which in this context means "loss of life, personal injury or other impairment of health, or loss or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organisations, or any adverse modification of the environment of areas within or beyond national jurisdiction or control".[50] The wording of this provision was mostly derived from the Liability Convention with the exception of the part regarding environmental damage, which clearly shows that the scope of the Draft Convention is wider than in the Liability Convention. The duty to cooperate is also explained in more detail in the Draft Convention and contains specific obligations to "prevent, inform, consult and negotiate in

48 Ibid, p.99.
49 Ibid, p.102.
50 Ibid, p.103.

good faith."[51] The obligation to negotiate in good faith is further specified to include not only consultations or talks but also to pursue them with a view of reaching a solution.[52]

The development of debris mitigation efforts also takes place on the regional and national levels. Both ESA and NASA are very active in debris mitigation guidelines, standards, and codes of conduct. Other actors in the space industry are also aware of the growing concern and try to find solutions. For example, satellite operators' voluntary efforts in debris mitigation and remediation are currently well recognized as well as the rise of common understanding of the need to adopt measures as soon as possible. The differences between areas of outer space also deserve our attention and will be further examined in the following chapters. Different approaches seem more feasible in different regions of space, e.g., techniques for debris mitigation and remediation used in low earth orbit and geostationary earth orbit vary tremendously.

51 Bockstiegel, Karl-Heinz. "ILA Draft Convention on Space Debris / ILA Konventionsentwurf zu Weltraumtrummern / Un Projet de Convention de l'ILA sur les Debris Spatiaux," Zeitschrift fur Luft- und Weltraumrecht - German Journal of Air and Space Law vol. 44, no. 1 (1995): p. 29-34. [online] Available at: https://heinonline.org/HOL/P?h=hein.journals/zlw44&i=42. Article 4.

52 Viikari, L. (2008). The environmental element in space law. Leiden: Martinus Nijhoff Publishers, p. 104.

2. International Environmental Law issues emerging from space activities

2.1. Environmental Problems related to Outer Space Activities

As already illustrated in the introduction, Space exploration creates pollution in all of its phases. Launching of space applications produces noise pollution, dust, and other emissions. An example of the adverse effects of launch activities is provided by a study which claims that launches at Russia's space base in Baikonur, Kazakhstan, cause serious health problems among people living below the rockets' flight path.[53] The levels of endocrine disease and blood disorders of children are reported to be over twice the regional average due to the highly toxic propellants which are released on the land under the rockets' trajectory.

Roughly estimated, dozens of unburned fuel is sprayed over the land with every launch, and the local environmental groups have campaigned against it but with a little success.[54] The Russian Space Agency operates Baikonur Cosmodrome, and both NASA and ESA pay large amounts of money to launch from there, which makes it the busiest launch site in the world.[55] Accordingly, it is a notable source of income for the Russian government, and that might also be the reason for their refusal of the direct impact of health diseases, although they have admitted that the fuel released during launches causes environmental degradation in that area.

However, the most severe environmental hazard caused by the space industry is space debris. "Space debris" is a general term referring to all tangible human-made materials in space other than functional space objects. [56] The aspect of "functionality" may, however, be difficult to determine. Although an object may seem useless for other states, it may still have some value for the launching state, for instance, it may be in reserve for future activities, carry valuable classified information or be of some other interest unknown for other countries. [57]

53 Ibid, p. 29.
54 Ibid, p. 29
55 Ibid, p. 30.
56 Ibid, p. 31.
57 Ibid, p. 33.

2.1.1. Space debris

Six decades of space flight activities have generated a significant human-made environment in Earth orbits that is referred to as "space debris." The IADC defines space debris as "all man-made objects including fragments and elements thereof, in Earth orbits or reentering the atmosphere that are non-functional."[58] The term "space debris" is not used in any of the space treaties and the commonly accepted definition thereof was not codified. However, it is a growing concern to present and future operations in space and steps need to be taken in order to prevent collisions of space debris with functioning satellites.

More than 5250 launches led to more than 17 854 objects by March 2017 which are accessible through unclassified catalogue of the US Space Surveillance Network (SSN), which is a worldwide network of radars and telescopes maintained by the U.S. military and approximately 6000 more objects are systematically tracked but are either classified or are not correlated with a launch or deployment event. The total mass of all catalog objects combined represents 7500 tons of orbit mass in 2017.[59] Objects in the catalog, which are trackable are those above diameters of 10 cm. Only 6% or 7% of the catalog entries are operational spacecrafts (1100-1200), while 28% are intact but non-functional objects and 64% are fragments, mostly resulting from explosions but also from recent collisions.[60]

Most space debris is concentrated in orbits where human activity is highest, particularly in low earth orbit (hereinafter referred to as the LEO) between 600 and 1500 kilometres, where many observation satellites are located and in geostationary earth orbit (hereinafter referred to as the GEO) at 36 000 kilometres, where most of the telecommunications satellites are placed.[61] Three out of four of the catalog objects are in LEO. Since 2007 the SSN catalog has experienced two significant step increases in spatial object density and collision risk therein: the Chinese Feng Run 1C satellite was intercepted in an anti-satellite test, generating 3433

58 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p.13.
59 Ibid, p.13.
60 Ibid, p.13.
61 Unoosa.org. (2011). [online] Available at: http://www.unoosa.org/pdf/limited/AC105_C1_2011_CRP14E.pdf [Accessed 17 May 2018]. p. 17.

catalog objects in January 2007 and the first accidental collision between two intact catalog objects Iridium 33 and Cosmos 2251 which created 2296 catalog fragments in two separate clouds in February 2009.[62]

Object below diameters of 10 cm do not fall within the catalog, and they are generally more difficult to track. It is estimated that there are more than 750 000 dangerous debris objects larger than 1 cm in the Earth orbit, each with the potential to damage or destroy satellites and thus creating more fragments.[63] Even smaller objects remain a significant threat to satellites in operation due to their high orbital speed. Two major risks from space debris posed are that it is a danger to the navigation of operational satellites and a threat to humans on the surface of the Earth.

Predicting collision risk in Earth orbits has become one of the main tasks for control centers in charge of monitoring and handling satellites. Operators manage this risk using the available data of space surveillance, the knowledge of the motion of satellites and interaction with those operating the potentially colliding spacecraft.[64] This information allows them to estimate when the distance between the objects will be minimal several days in advance and if necessary, to carry out a collision avoidance maneuver, which alters the trajectory of the satellite. The alteration of satellites trajectory usually interrupts the mission of the satellite and is therefore undesirable. Operators have to balance the risk taken with the costs of the interruption of the mission.

Another threat from space debris is the event of re-entering space objects, which also pose a risk to the life of persons in the airspace and on the ground and even to the environment of Earth. Re-entries of cataloged objects occur daily but mostly without any on-ground risk. Distinguishing between so-called controlled and uncontrolled re-entry events is essential.[65]

62 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p.13.
63 Esamultimedia.esa.int. (2017). [online] Available at: https://esamultimedia.esa.int/multimedia/publications/BR-338/BR-338.pdf [Accessed 17 May 2018], p.13.
64 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p. 61.
65 Ibid, p.85.

Uncontrolled re-entries arise when no maneuver has been performed and thus the location and time cannot be pre-determined. Controlled re-entries follow a de-orbit maneuver and therefore are associated with almost zero risks when the right selection of the target area is made.

The materials used in the development of space vehicles also pose a risk of chemical pollution and especially the dangers regarding radioactive materials used. Since 1959 two different types of nuclear energy generation have been used onboard of spacecraft: Radio-isotope Thermo-electric Generators (RTGs), based on energy gained from the natural decay of radiating material and actual nuclear reactors based on the nuclear fission process.[66] The first accident occurred in April 1964 when the US navigational satellite Transit 5BN-3 failed to reach orbit, and its RTG system for nuclear auxiliary power vaporized and dispersed 17 000 curries of Plutonium-298 over the Indian Ocean.[67]

Moreover, the former Soviet Union has launched more than 30 spacecrafts powered by nuclear reactors and several RTG powered spacecraft, whilst the US has launched only one spacecraft powered by a nuclear reactor and 22 spacecraft powered by RTGs.[68] Nuclear power systems have the advantage of long life and have been used for deep space missions that required high energy converted from a heat source into electricity in the form needed to power a particular load or application.[69] However, the main danger from nuclear power systems is the contamination of the outer space environment and the environment of the Earth with radiological debris.

Two historical events of re-entries involved reactors using U-235: Russian satellite Cosmos 954 re-entered over Canada after the loss of control and polluted the surroundings in 1978 and similarly, Cosmos 1402 re-entered over the Indian Ocean in 1983. Although the first incident involved a Russian space object re-entered over Canadian territory, and the damage was caused to the environment, no case was brought before the International Court of Justice and also no case law has ever been developed in the field of space law, perhaps due to the small

66 Ibid, p.94.
67 Hacket, G.T., 1994. Space debris and the corpus iuris spatialis, Gif-sur-Yvette: Frontieres, p. 32.
68 Ibid, p.33.
69 Ibid, p.34.

number of incidents and the willingness of parties to settle the disputes by peaceful means, mostly political negotiations and providing monetary compensations.

However, the number of uncontrolled re-entries is decreasing due to the development of technology which allows for a longer orbital lifetime of space objects. Controlled re-entries are often promoted in the South Pacific Ocean Uninhabited Area, which is the largest unpopulated ocean space on the Earth.[70] It is a common practice to pre-announce the re-entry to the relevant authorities of the concerned air, and sea space and these authorities will then issue a warning message to respective information agencies. Controlled re-entries are desirable and vehicles that could be launched several times are currently being developed. International cooperation has been encouraged, and space agencies are at the present time testing a "space rider" vehicle, which could be able to deliver payloads to orbits, re-entry, and land on a runway in the Pacific Ocean.[71]

Kessler and Cour-Palais reasoned in 1978 that the amount of space debris in Earth's orbit would reach a tipping point in which the future space debris population would be dominated by fragments produced by the mutual collision between the objects already present in the population.[72] It is known as the cascading effect or the Kessler Syndrome. In other words, space debris tends to create more debris, because when space objects collide, they break into more fragments which are subsequently followed by more collisions and the creation of more space debris.

Environmental modeling programmes provide information about satellite launch times, orbital elements over time, mass, size, collisional and non-collisional fragmentation events and they can be considered reasonably accurate for unclassified human-made objects larger than 10 cm in LEO.[73] The goal of future environment modeling is to test the effectiveness of mitigating and remediating practices that are currently being implemented. Multiple models and

70 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p.99.
71 Guided tour to ESA, ESTEC, Noordwijk, the Netherlands, 10 Feb. 2018.
72 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p. 103.
73 Ibid, p.103.

simulations done by major space agencies have all shown that the orbital debris population will continue to grow, even without any additional launches.[74]

Debris management includes two stages: mitigation and remediation of space debris. Mitigation is based on the protection of the environment by not creating any new debris, which may be achieved through internationally accepted standards and guidelines in materials, re-entries, etc. Remediation is on the other hand based on reducing the current debris population analogically with the salvage of shipwreck on the high seas and is also present in general environmental law as the obligation to clean up, commonly referred to as the "polluter pays" principle.

2.1.1.1. Debris mitigation

Mitigating measures have been implemented since 1990 when the technological development allowed for better decision making in the selection and use of more preferable materials which could, for example, burn in the atmosphere instead of using the old technology which was polluting the environment of space and even the environment of Earth during re-entries. The barrels for fuel attached to the rockets were made of titanium in the past, and they did not burn in the atmosphere and at present the space launching organizations are using aluminum instead, which has a lower melting point and therefore the barrels easily burn in the atmosphere of the Earth and pose no risk when re-entering.

The IADC defines space debris mitigation measures as "consisting of all efforts to reduce the generation of space debris through measures associated with the design, manufacture, operation and disposal phases of a space mission."[75] Space debris mitigating guidelines have been concluded under UNCOPUOS, European Space Agency (ESA) and European Union (European Code of Conduct) but their legal force is questionable. As a part of the soft law, which is not legally binding per se, those guidelines form an essential base for nudging behavior, which would be sustainable in the long term. Other initiatives may include the

74 unoosa.org. (2018). [online] Available at: http://www.unoosa.org/pdf/limited/AC105_C1_2011_CRP14E.pdf [Accessed 17 May 2018], p.19.
75 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p. 117.

Long-term sustainability of outer space activities which is one of the working groups of UNCOPUOS, set up in 2009 and the Code of Conduct proposed by the European Union, which was, unfortunately, less successful.

The general objectives and fundamental principles of space debris mitigation guidelines, applied by nations and international organizations are to take measures to limit the number of objects released during operations, to minimize the potential for on-orbit break-ups, to prevent on-orbit collisions and to dispose of spacecraft that have reached their end of life.[76] The goal of debris mitigating guidelines is to refrain from the further pollution of the space environment, thus not to create more space debris. Modification of designs and operational practices primarily in the most extensively used orbits (LEO and GEO) need to be taken into account in order to prevent further contamination of the outer space. However, mitigating measures should be accepted and promoted by the whole international community to become binding for all.

Two protected regions have been recognized because of the extensive use for space applications. The LEO protected region extends from the Earth's surface up to an altitude of 2000 kilometers, and it is crucial because most of the Earth observation and remote sensing satellites are located therein. Special attention to the protection of the LEO must also be considered because it is also a place where human space flights take place, and the protection of astronauts against threats from space debris carefully needs to be taken into account. The GEO protected region is on the other hand densely populated with telecommunication satellites, which are of great interest of commercial companies. The GEO protected region extends from 200 kilometers below the geostationary altitude (35 786 kilometers) to 200 kilometers above the geostationary altitude.[77]

Although the debris population in GEO is relatively lower than in the LEO, there is almost no atmospheric drag that removes objects from the environment. Most of the debris generated in the GEO will remain there permanently, and therefore the protection of the GEO environment is crucial for the long-term sustainability of outer space activities. The generally accepted

76 Ibid, p. 117.
77 Ibid, p.118.

view is that it would be cost ineffective to maneuver no longer functional satellites to the Earth's atmosphere, so the so-called "graveyard orbit" is being created above the GEO. A contrary, the LEO may be "easily" cleaned up from large pieces of space debris by Active Debris Removal, which will be further examined in the following chapter. Rocket bodies and spacecraft in the LEO region should be de-orbited (preferred option is the controlled re-entry) or where appropriate maneuvered into an orbit with a reduced lifetime. It is recommended that the remaining orbital lifetime should be reduced to less than 25 years at the end of a mission.[78]

Natural forces, especially the atmospheric drag clean space debris from the LEO region efficiently below 700 kilometers. For satellites in higher altitude may be necessary to be equipped with propulsion systems which could actively reduce the remaining orbital lifetime and satellites without de-orbiting capability should not be launched to the LEO protected region if their post-mission lifetime is higher than 25 years.[79] In the use of mitigating measures and the re-entry of large space objects, operators should also assess the risks posed to humans on Earth and the environment. Scientific knowledge and technological development allow for better decision making in the use of materials for spacecrafts, but the old technology remains in the outer space and therefore pose a future risk by fragments surviving uncontrolled atmospheric re-entry.

2.1.1.2. Debris remediation

Space debris remediation is the process of removing abandoned artificial space objects. Although the debris mitigation guidelines have been developed and applied internationally, it is not sufficiently possible to control the growth of the space debris population in the future. Space environment, especially the LEO is already full of space debris, and the risk of collision break-ups will be growing even without any new objects being placed in space. Twenty years ago, debris removal mechanisms were considered more of a science fiction, more precisely as a measure of last resort, as they were challenging to undertake and cost inefficient.[80] In

78 Ibid, p.120.
79 Ibid, p.120.
80 Ibid, p. 40.

contrast, the present international community has already recognized the need for technological development in the area of active debris removal and space agencies are currently testing various mechanisms for lowering the risk of collision and preservation of the space environment, so that future space activity may still be possible.

Some methods for Lethal Non Trackable (hereinafter referred to as the LNT) debris and Catalogued Fragments (hereinafter referred to as the CF) do not seem technically feasible nor cost-effective to reduce the risks from space debris at this time, so the focus is on preventing Intact Derelict Objects (IDO) from colliding with each other, and the primary measure to reduce the risk of collision is the Active Debris Removal (hereinafter referred to as the ADR).[81] The ADR includes the removal of derelict objects from the LEO back to the Earth's atmosphere and also the removal of no longer functioning satellites from the GEO to the "graveyard orbit" above it, which is however just a short-term solution.

The ADR involves the removal of large derelict objects in a number of ways, which mostly require a rendezvous, grappling and stabilization of tumbling objects in order to perform the debris removal mechanism.[82] Space agencies are currently developing and testing various methods of ADR, e.g., the ESA's ADR method of launching another satellite, equipped with a grappling arm, which will synchronize with the abandoned space object, grab it and re-enter to the Earth's atmosphere with it. Another method of ADR currently being tested in ESTEC, the Technological Centre of ESA is the vast net, which would capture the derelict space object and would drag it back to the Earth's atmosphere, analogically with what the fishermen do with the fish in the sea.[83]

Researchers now aim to establish a priority list of objects, that need to be removed first, due to the high collision risks in the near future. ADR is a long-term process aiming at preventing collisions pro futuro. Optimistic assumptions suggest, that removal of 5 objects a year would prevent the LEO from becoming unstable. However, it may be one of the biggest threats to space activities, the most critical questions regarding space debris removal remain unsolved.

81 Ibid, p.126.
82 Ibid, p.129
83 Guided tour to ESA, ESTEC, Noordwijk, the Netherlands, 10 Feb. 2018.

The ADR methods are currently being developed within space agencies, the testing is in progress, but no international agreement regarding this issue was made. On the other hand, the agreement may not be necessary if the majority of space-faring nations agree upon the debris removal. At least some form of political negotiation should be encouraged in order to solve the sensitive question of launching and financing the future ADR missions. It has also been suggested to establish an international fund for financial matters of the space debris removal, but the discussion seems to be stacked.

Several legal issues arise from space debris, although no internationally binding rules were stipulated on debris mitigation and remediation. Nevertheless, guidelines and standards may be transposed into national law and thus become compulsory in the national legal order. If the majority of states does this and if it is generally accepted as binding, parts may become customary international law. Although it takes a long time for rules to become customs, it may be possible due to states practice and opinio iuris, that some rules will become binding with no need of codification in an international treaty. However, if a rule of customary international law is codified in a convention that is ratified by the majority of states, the legal certainty of such provisions is strengthened.

This year, 2018 is the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space: UNISPACE+50. The shared goal is to build comprehensive agenda Space 2030 for the contribution of space activities to the achievement of the sustainable development goals. During preparations of UNISPACE+50, series of high-level fora: Space as a Driver for Socioeconomic Sustainable development were organized in 2016 and 2017. This series of high-level fora was intended to facilitate constructive dialogue between policy-makers and key stakeholders from different parts of the government, civil society, business, and industry.[84] The United Nations recently recognized the importance of the contributions of all relevant partners, in particular, the private sector, and outlined recommendations for enhancing cooperation between the United Nations and the private sector. The United Nations enters an era of increasing resource constraints. The 2030 Agenda

84 Markus Woltran, United Nations Office for Outer Space Affairs. *The Outer Space Treaty*. [Online]. Available at: http://www.unoosa.org/oosa/en/ourwork/hlf/hlf.html [Accessed 17 May 2018].

can only be realized with a strong commitment to partnerships at all levels between governments, the private sector, civil society, and others.[85]

However, space activities contribute to the fulfillment of most of the sustainable development goals through earth observation, satellite navigation, satellite communication, space exploration, and space education. The realization of the sustainable development goals requires global effort with the involvement of the most important actors in the area of space exploration. The increasing commercialization and privatization of space activities contributed to the implementation of obligations to the national legislation in many states. The development of national rules on space debris may lead to harmonization and perhaps eventually to internationally binding rules.[86] The common interest of the whole international community, including private entities, is to safeguard the space environment for the purposes of future use.

2.1.2. General International Law Regulation

The Outer Space Treaty, the most general and important treaty regarding the outer space activities reflect the customary international law in its provisions, and the treaty itself refers to customary law.

International law requires continuous state practice and the conviction that the practice is required by law to create a rule of customary international law and in fact, no state has ever opposed to the use of space in the way prescribed by the Outer Space Treaty. Under the customary international law, states have rights and for sustainable development, more importantly, obligations arising from those rights. Rules of international law limit the freedom of action of sovereign states in general. The question of whether the international environmental law is also applicable to outer space must be answered in the positive when analyzing pollution caused by space debris.

85 unoosa.org. (2018). [online] Available at: http://www.unoosa.org/documents/pdf/hlf/HLF2017/presentations/Day1/Side_event_Global_Partnership/Global_Space_Partnership_for_Sustainable_Development_Goals_v1.0.pdf [Accessed 17 May 2018], page 4.

86 Bonnal, C. & McKnight, D.S., 2017. *IAA situation report on space debris 2016*, Paris, France: International Academy of Astronautics (IAA), p. 145.

Duty not to cause damage to the environment was recognized as a provision of customary international law and is also reflected in two resolutions regarding international environmental law: the Stockholm Declaration on the Human Environment and the Rio Declaration on Environment and Development, as well as in the national legislation.[87] The Stockholm Declaration was approved by 113 states in 1972 and consists of 26 principles regarding the protection of the human environment.[88] Principle 21 of the Stockholm Declaration addresses the issue of national jurisdiction with respect to the environment and provides that: "*States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction"*.[89] This provision clearly shows the importance of protection of the environment beyond national jurisdiction recognized by customary international law as a duty to prevent harm to the environment of other states but also to the environment beyond national jurisdiction.

Principle 21 of the Stockholm Declaration enunciates the basis of delict responsibility of States by referring to a standard of due diligence but not as an absolute duty to prevent pollution.[90] The legal nature of the Stockholm Declaration is however not binding per se but provides for the universally recognized fundamental need for a satisfactory environment which allows for the enjoyment of human rights. The transposition reflects the importance of such stipulation to other agreements, such as the Article 194 of UNCLOS[91] and the Preamble to the Convention on Long-Range Transboundary Air Pollution.[92] Each "component" of the

87 Hacket, G.T., 1994. Space debris and the corpus iuris spatialis, Gif-sur-Yvette: Frontieres, p.138.
88 un-documents.net (1972). [online] Available at: http://www.un-documents.net/unchedec.htm [Accessed 17 May 2018].
89 Ibid, Principle 21.
90 Hacket, G.T., 1994. Space debris and the corpus iuris spatialis, Gif-sur-Yvette: Frontieres, p.141.
91 The United Nations Convention on the Law of the Sea, 10 December 1982, United Nations, Treaty Series, vol. 1833, Available at: http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf [Accessed 17 May 2018].
92 The United Nations Convention on Long-Range Transboundary Air Pollution, 13 November 1979, United Nations Treaty series, vol. 1302, p.217, Available at: http://www.unece.org/fileadmin//DAM/env/lrtap/full%20text/1979.CLRTAP.e.pdf [Accessed 17 May 2018].

environment is regulated separately even though interactions occur and all components of the environment are of course connected. Principle 21 therefor most generally oblige states to prevent damage to the environment also in the areas beyond national jurisdiction, but possible further development into customary international law would rely on state practice and opinio iuris in the protection of the environment of the outer space. However, the efforts of the international community to discuss the issue of space debris, it is still unenforceable to impose international responsibility for the pollution of outer space under the customary international law.

As a last possibility to find norms for the protection of the environment of the outer space, general principles of international law shall be analyzed. The only valuable principle for this issue is "sic utere tuo, ut alienum non laedas" which was first introduced by Sir Edward Coke in the 17th century without giving any precise definition and therefore there is no clear understanding of the content of the term.[93] The principle of "sic utere tuo" is sometimes reflected in the rule that it is "the obligation of every state not to knowingly allow its territory to be used for acts contrary to the rights of other states" and is viewed as an element of the principle of good neighborliness. However, the general principle of good neighborliness is too vague and may only be used to help in the interpretation of other provisions of the international environmental law rather than to determine international responsibility for the damage occurred.[94] Another important principle with regard to the international environmental law is the bona fides principle, which does not, unfortunately, allow for invoking of international responsibility either.

The principle of "sic utere tuo, ut alienum non laedas" was introduced by an arbitration tribunal in 1941 in the Trail Smelter case between the USA and Canada into international environmental law in the matters of transboundary air pollution.[95] The tribunal did not find any international precedents for this case and therefore relied on decisions of the Supreme Court of the United States and deducted the following as a principle of international law: "no state has the right to use or permit the use of its territory in such manner as to cause injury by

93 Hacket, G.T., 1994. Space debris and the corpus iuris spatialis, Gif-sur-Yvette: Frontieres, p.146.
94 Ibid, p.147.
95 Ibid, p.148.

fumes in or to the territory of another or the properties of persons therein, when the cause is of serious consequences and the injury is established by clear and convincing evidence."[96] This case was presented by two common law countries invoking the principle of strict liability without the need of fault as the additional element required by the civil law countries. The International Court of Justice regarded the principle of good neighborliness in other cases, e.g., the Corfu Channel case between Albania and the United Kingdom. Albania was held responsible for damaging two British warships in the territorial sea of Albania. Likewise, it was held that it must be proved that the state had the knowledge of facts giving rise to its responsibility.

The concepts of "sic utere tuo," good neighborliness and the equality of states may serve the affected country which can be regarded as having suffered infringements of its right to an unimpaired environment according to those principles, although none of them includes the space environment per se.[97] The space environment is therefore protected only indirectly, and it would seem challenging to claim infringement of rights of the states to the unimpaired environment. No international treaty or declaration was concluded regarding the environment of outer space which may not matter if countries agree on such a desirable behavior, which would not cause further contamination. The absence of a treaty does not show the lack of importance of this issue but rather the difficulties to make an agreement on the political level and the unwillingness of states to bear the obligation to clean up.

The general environmental law includes another important rule: the polluter pays principle, which is not directly applicable to the space environment either. It may be difficult and even unfair to require only space launching countries to decontaminate outer space from all space debris, due to their contribution and financial investment already made in order to enable all states to use the results of their space programmes. Awareness needs to be raised in order to prevent future contamination to the extent, in which it would be impossible to launch any other space applications. Space environment was in the past considered to be unable to become crowded, because of its nature, but the contrary is the unfortunate truth. More and more scientists and legal scholars are aware of the high risk of collision of space objects and

96 Ibid, p. 149.
97 Ibid, p. 150.

the importance of preserving space environment for future use. International cooperation is required to prevent further pollution and also to decontaminate large pieces of space debris to avoid collisions, that would result in the creation of more fragments and therefore increased the risk of Kessler Syndrome.

On the other hand, outer space activities do not only create space debris and pollute space environment. Space applications also help in the protection of the environment by the analysis of the outcomes from earth observation, remote sensing and by the use of navigation systems and satellite communications. The following chapters will be focused on various means of how the space applications help to protect the environment of Earth. Our society is facing multiple environmental problems, which mostly have a global character and may pose future disasters. Space activities allow for a better understanding of the environment of space but also of the environment of Earth. Technology is rapidly developing, and launching satellites has never been easier for states and private entities. Earth observation and remote sensing are just examples of the possible means to protect the environment of our planet. Protection of the environment is not the only field of knowledge in which space applications may help us in decision making. However, it is regarded as one of the most important. Monitoring of endangered or highly migrative species, quality of waters, air quality monitoring, monitoring of fertility of soil, natural disaster management support, elimination of the effects of natural disasters, early warning systems, drought monitoring, natural resources management, and more space-based activities help us in the protection of the environment.

The contributions of space-based technologies and applications to support sustainable development goals are well recognized among scientists and scholars around the world. Protecting nature and biodiversity in specific is of vital importance in that context, especially in a period when climate change, population expansion and increased levels of wildlife crime among other factors are putting significant pressure on biodiversity and wildlife globally. Many space technology-based solutions exist to support the management of ecosystems and to assess or study biodiversity and wildlife, in addition to the growing use of Unmanned Aerial Vehicles (UAVs) for example. Earth Observations and satellite-based positioning but

also satellite telecommunications are being used in various projects around the globe.[98] Satellites also contribute to the monitoring of greenhouse gases related to deforestation and industrial processes, the changing of ice in polar caps and glaciers, sea-level rise, temperature changes, as well as several essential climate variables. Space technology is also crucial for the continued observations and long-term monitoring of the Sun's effects on Earth's environment and climate, for aiding climate change modeling, or for the observation of the change in the ozone layer and its impact on the environment and human health, to mention a few.[99]

2.2. Preserving the Environment of Earth through space

Environmental protection and the principle of sustainable development play an essential role in the international cooperation regarding environmental law since the negative impacts that humankind has on the planet Earth, were scientifically proven. States and international organizations developed the international legal framework for the protection of the environment, and many of the principles included in legal instruments have already become parts of the customary international law. Non-governmental organizations aiming to protect the environment have been established since the beginning of the twentieth century, but the importance of environmental protection was emphasized just after the second world war. The dilemma between economic development and the obligation to protect humans and the environment forced states to adopt several documents during international environmental conferences.

Sustainable economic development should meet the needs of the present generation without compromising the ability of future generations to be able to meet their own needs and is recognized as a fundamental concept towards economic development with the protection of the environment. The international community nowadays well accepts principles of Due Diligence, Environmental Impact Assessment, prohibition of causing damage to the environment of other states and also beyond the areas of national jurisdictions and their importance should be emphasized. Nations should in all cases obey the rules of customary international law, prevent the pollution of the environment by acting with due care and

98 unoosa.org (2018). [Online] Available at: http://www.unoosa.org/oosa/en/ourwork/psa/emnrm/biodiversity.html [Accessed 17 May 2018].
99 unoosa.org (2018). [Online] Available at: http://www.unoosa.org/oosa/en/ourwork/psa/emnrm/climatechange.html [Accessed 17 May 2018].

diligence, minimizing the negative impacts of economic development and should use all means necessary to preserve the environment for future generations.

Space-based technologies offer unique solutions to a large number of issues that our society is facing. The Millennium Declaration, adopted in 2000 by all 189 Member States of the UN at that time, defined a fundamental framework for global cooperation in the 21st century.[100] Environmental sustainability is one of the primary goals and space applications already play an essential role in the fields of, e.g. natural resources management and environmental impact assessment. Remotely sensed data, in particular, provide an unparalleled view of the Earth for studies that require periodic observations such as agriculture, hydrology, geology, mountain ecological studies, mineralogy, land cover or land use. Space-derived information, its analysis, and its visualization offer substantial input into decision-making processes throughout the world today and can become even more critical in actions developed towards achieving internationally agreed sustainable development goals, in line with ongoing efforts to define those goals in the post-2015 development agenda.[101]

2.2.1. Earth Observation and Remote Sensing

2.2.1.1. Earth Observation

Satellite observation of the Earth's environment is crucial in predicting risks and in offering possible reactions to situations that require the active conduct of parties as a response to mitigate adverse impacts. Protecting nature and biodiversity, monitoring the environment and managing the natural resources are just a few examples of how space activities contribute to the maintenance of the international environment. Observations of the climate of Earth which are currently developed to the extent that they allow for near real-time collection of data and, as a matter of fact, help scientists and law enforcing bodies to make decisions based on the assessment of exact and recent information. Satellite Communications and Global Navigation Satellite Systems offer unique solutions regarding search and rescue systems, navigation in all

100 unoosa.org (2018). [Online] Available at: http://www.unoosa.org/oosa/en/ourwork/psa/emnrm/index.html [Accessed 17 May 2018].
101 Ibid.

forms of transportation and emergency response. The use of space applications for environmental protection is well regarded, and many of the goals for sustainable development stipulated in environmental agreements can be achieved through space.

In 2006, the UNOOSA established the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (hereinafter referred to as the UN-SPIDER).[102] The Platform develops solutions especially for developing countries which often have limited access to technologies that can be essential in the management of disasters and the reduction of risks they pose. The UN-SPIDER's mandate is to enable developing countries to use all types of space-based information in all phases of the disaster management cycle including prevention, preparedness, early warning, response, and reconstruction. [103] Sharing of knowledge, facilitating of cooperation between data providers and different groups of users are the main objectives of this platform.

The possible link between climate change and the increase in the number of natural disasters, such as floods, hurricanes, tsunamis, etc. is attracting the attention of scientists and decision makers at this present time, and the society as a whole should use all necessary means to mitigate the adverse effects that such disasters pose. The Sendai Framework for Disaster Risk Reduction is a new global agreement on climate change for the period of 2015-2030. Space applications can offer continuous monitoring and evaluation through objective measuring systems. UN-SPIDER is able to support the Sendai Framework role of stakeholders and international cooperation by initiation of efforts to develop International Network for Multi-Hazard Early Warning and global partnership focusing on Earth observations. The members of the partnership are currently discussing the terms of reference on how the space community shall best support the implementation of the Sendai Framework. [104]

102 unoosa.org (2018). [Online] Available at: http://www.unoosa.org/oosa/en/ourwork/un-spider/index.html [Accessed 17 May 2018].
103 Ibid.
104 un-spider.org (2018). [Online] Available at: http://www.un-spider.org/sites/default/files/NewsletterPost2015_online.pdf [Accessed 17 May 2018].

Still, there is a remaining long and challenging road to bring Earth Observation commitments onto the operational agenda of countries. Recognition of Earth Observation as a valuable, affordable and timely instrument still needs work in many government entities. A large number of actors in the acquisition, provision, analysis, and dissemination of Earth Observation products requires effective coordination in order to ensure that countries know what to request, what to expect and how to benefit from such information.[105] Satellite data can be helpful in a wide range of cases, such as prosecuting environmental crimes at the national level or crimes against humanity by the International Criminal Court. However, the rather general international legal principles that were adopted during the last century do not address all legal aspects that arise from the use of satellite data.

2.2.1.2. Remote Sensing

Remote sensing is "the science of extracting information from an object through the analysis of data acquired by a sensor that is not in direct contact with that area."[106] More technical definition is provided for the purposes of Principles Relating to Remote Sensing of the Earth from Outer Space in its Article 1(a) and is as follows: "the term "remote sensing" means the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment."[107] More importantly, the definition provided for the purposes of the Principles of Remote Sensing contain the meaning of these Principles, which is the protection of the environment and improving natural resources management.

One of the most imminent environmental problems of our planet at the present time is global warming and satellite remote sensing is useful in monitoring the oceans, ice, atmosphere, and forests to provide essential information on the environmental components, as well as the evidence of the global warming.[108] Collected past and present data can be compared and thus provide for the assessment of the issues of deforestation, desertification, melting of ice and

105 Ibid.
106 NPA Group, Final Report BNSC Sectors Studies Programme Applications of Earth Observation to Legal Sector, BNSC, London, 2001, p. 16. in Atsuyo, I., 2011 Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 3-4.
107 United Nations General Assembly Principles relating to remote sensing of the Earth from outer space, 3 December 1986, [Online] Available at: http://www.unoosa.org/pdf/gares/ARES_41_65E.pdf [Accessed 17 May 2018].
108 Atsuyo, I., 2011: Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 8.

the presence of toxic materials in all of the components of the environment. Satellites provide data on earthquakes, floods, landslides, fires and can be used to monitor the progress of such natural disasters, as well as measure the damaged areas in the aftermath.[109]

The Principles of Remote Sensing never made it into an international treaty and their legal status as a United Nations General Assembly Resolution is debatable, but parts of it can indeed be said to have gained the status of international customary law, and therefore are binding upon all states.[110] The commercialization and privatization of remote sensing activities and although there will always be issues of national security that cause nations to exercise some form of control over what exactly is freely available on the market, and the privacy and copyright issues will further impact the free use of satellite data, we can generally say that remote sensing has been through a landslide evolution and is now an everyday business that makes the lives of many much easier.[111]

The international customary law nature and purpose of the Principles of Remote Sensing is indeed a re-establishment of legitimacy for data collection from space, which was already an accepted practice inferred under the Outer Space Treaty and provided for specific rules concerning data access and availability at the international level.[112] Nevertheless, the negotiations before the adoption of the Principles, took more than fifteen years, due to the different positions and conflicting interests of states. The United States and many Western states insisted upon the freedom of acquiring and imparting information as a human right, whilst developing countries and Soviet-led socialist countries insisted upon the principle of state sovereignty over natural resources.[113]

109 Ibid, p. 8.
110 Purdy, R. and Leung, D., 2012: Evidence from Earth Observation Satellites - emerging legal issues, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p.xxx.
111 Ibid,p. XXX.
112 Atsuyo, I., 2011: Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 45.
113 Ibid,p. 46.

The final version of the Principles of Remote Sensing adopted mostly reflects the view of the United States and is a result of a high degree of compromise by the developing states. The Principles serve as general guidelines for activities in the field of remote sensing, and so far no disputes have arisen with regard to their application.[114] The most fundamental of these Principles, the principle of sensing from space without prior consent, has not raised any action of protest from the states whose interests were affected. The fact of high availability of satellite data and derived products via Internet, and their access on a non-discriminatory basis, in conjunction with the absence of protests from any state, supports the international customary law nature they have earned through incorporation into continuing state practice.

2.2.2. The use of data from space for the protection of the environment

2.2.2.1. International Environmental Law

The degradation of the environment both in space and on Earth is a serious and imminent problem. A wide range of environmental treaties is addressing various ecological issues, from which a large number could be better understood and dealt with employing the use of satellite remote sensing. Principle 10 of the Principles of Remote Sensing provides that: “remote sensing shall promote the protection of the Earth’s natural environment” and also; “states participating in remote sensing activities that have identified information in their possession that is capable of averting any phenomenon harmful to the Earth’s natural environment shall disclose such information to States concerned”.[115]

General principles of environmental law include sustainable development, the obligation not to cause transboundary harm, common but differentiated responsibility, the prevention and precautionary principle, the right to environmental information, and the “polluter pays” principle.[116] Remote sensing can enhance the performance of states under their environmental

114 Ibid,p. 56.
115 United Nations General Assembly Principles relating to remote sensing of the Earth from outer space, 3 December 1986, [Online] Available at: http://www.unoosa.org/pdf/gares/ARES_41_65E.pdf [Accessed 17 May 2018].
116 Atsuyo, I., 2011: Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 106.

agreements by providing tools for observation and assessment in order to meet their obligations. Some countries lack the capacity to comply with multilateral environmental agreements, despite their willingness to do so, and remotely sensed data further analyzed by external experts from international bodies could help those states to evaluate the causes of non-compliance and to develop possible remedies.[117]

Besides, remote sensing facilitates the participation of non-governmental entities in environmental protection by assisting them in achieving compliance with the regulation on the domestic level, which strengthen the implementation of international agreements. Private entities have recognized the advantage of obtaining near real-time data regarding the environment during the past years, and they benefit both as users and as operators of remote sensing satellites.[118] On the other hand, remote sensing can also help executing bodies through the supply of relevant information to process, review and evaluate the implementation of environmental obligations. [119]

All phases of environmental protection, such as negotiation, identification of a problem and enforcement can be strengthened through the effective use of remote sensing. The data obtained from satellites could serve as a tool for better understanding of the specific environmental problem, which is essential for making appropriate decisions. Remote sensing can also be used to detect and reveal non-compliance, as well as the source and extent of environmental damage, which happened i.a. after the Chernobyl accident in 1987, where the information obtained from space played an important role in prompting the response from the former Soviet Union and its disclosure of information concerning the disaster.[120]

However, the full benefits of satellite remote sensing have not been realized due to the obstacles as to the use of data for enforcement purposes. The nature of evidence obtained from space makes them susceptible to errors and manipulation, which together with the absence of an international framework addressing the digital evidence, have unfortunately

117 Ibid, p.124.
118 Ibid,p.125.
119 Ibid,p.125.
120 Ibid,p.126.

limited their use for verification.[121] Development of more clear data policies and legal framework, in general, will soon become essential to fully enhance the use of data obtained from space, in order to successfully face environmental challenges and to protect the environment of Earth.

2.2.2.2. Disaster Management

Natural disasters can not be prevented, but their impacts can be mitigated tremendously. Space applications, in particular, earth observation and remote sensing, can extensively contribute to disaster management. Its capability to provide for both global coverage and the ability to make repeated views of specific areas allow for monitoring the progress and effects of disasters. Space technology has been used in all stages of disaster management: risk assessment, mitigation, response, and reconstruction.[122] Space technology contributes through the remote sensing data in all of the phases of disaster management, and international cooperation has recently been encouraged, i.a. through the establishment of the UN-SPIDER.

The UN-SPIDER was established by a resolution of the General Assembly in 2006 as a programme of the United Nations, under the UNOOSA with the following mission statement: "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle".[123] It aims at enabling particularly developing countries to gain access to all kinds of data concerning all phases of disaster management and also at facilitating cooperation between satellite data providers and different groups of users of that information. The objective is a better flow of information on disaster risks or disaster impacts between all stakeholders and affected populations.[124]

121 Ibid,p.148.
122 Ibid, p.149.
123 unspider.org (2018), [Online] Available at: http://www.unspider.org/about/what-is-un-spider, [Accessed 17 May 2018].
124 unoosa.org (2018), [Online] Available at: http://www.unoosa.org/oosa/en/ourwork/un-spider/index.html [Accessed 17 May 2018].

In general, disasters can be divided into two categories, natural disasters, and human-made disasters. Examples of natural disasters include earthquakes, floods, hurricanes, tornadoes, cyclones, drought, erosion, volcanic eruptions, and epidemic.[125] Human-made disasters can result either from technological negligence or deliberate actions, such as armed conflicts. It should also be noted, that some of the disasters fall into both categories, such as landslides, which primarily occur from natural causes, but are partly a consequence of large-scale deforestation.[126] This chapter will be mostly focused on natural disasters and the involvement of different space-based measures in all of the phases of disaster management. However, capacities to involve actions heavily rely on timely and accurate information and therefore the images obtained from space serve such purpose.

Prevention of natural disasters is generally not possible, but the negative impacts can be mitigated by implementing measures beforehand. Such measures include evaluation of hazards, risk and vulnerability analysis, and the establishment of regulatory standards.[127] Satellite images provide for hazard mapping of floods and tectonic activity, and in combination with other geological and geophysical data to identify earthquake hazards, supplement the missing information on seismic history.[128] They can also provide the assistance in preparation for impending disasters or possible future disasters, thus eliminating the negative impacts they pose. Appropriate direction for aid can be given based on the assessment from space, and in combination with other sources of information, can produce helpful knowledge to face the disaster and minimize its negative impacts successfully. [129]

Satellite-based information is also commonly used for the purpose of recovery and reconstruction after the disaster, due to their ability to provide knowledge to facilitate effective planning of the reconstruction. Increasing number of space agencies and other earth observation entities voluntarily participate in disaster management programmes and

125 Atsuyo, I., 2011: Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 150.
126 Ibid, p.151.
127 Ibid, p.151.
128 Ibid, p.181.
129 Ibid, p.182.

initiatives.[130] A notable example is the International Charter on Space and Major Disasters (hereinafter referred to as the Disaster Charter), which is a worldwide collaboration among space agencies, through which satellite-derived information and products are made available to support disaster response efforts.[131] This programme strengthens the legal regime of disaster management by establishing a predictable mechanism of assisting affected regions through the timely and effective distribution of information.

However, the Disaster Charter is a non-binding legal instrument and is based on goodwill, and therefore the cooperation is voluntary, which means that no services are guaranteed. Members will be held liable neither in the case of non-activation of the Charter nor the case of unsuccessful operations.[132] On the other hand, the Disaster Charter provides for the appointment of a project manager for each case, who is responsible for directing satellite operators to provide data for imaging a particular location, and thus improves the response time.[133] The Disaster Charter represents a model of voluntary, yet coordinated disaster relief based on satellite data, which could be described as the Good Samaritan (voluntary assistance without liability) model of disaster response.[134] The above mentioned supports the importance of voluntary efforts of entities in the protection of the environment, and it shall be noted, that the absence of a legally binding instrument shall not be seen as an obstacle to the effective use of space-derived data in the disaster management worldwide.

The increased availability of satellite remote sensing applications to disaster management, through constellations of satellites and their coordinated framework, allows all users to gain the understanding of situations related to disasters in time to support governments and other decision-makers in their actions towards mitigating negative impacts through the use of timely and precise information obtained from space. The contribution of space based technology to disaster management is most evident in the post-disaster phases, through the

130 Ibid, p.183.
131 un-spider.org (2018), [Online] Available at: http://www.un-spider.org/space-application/emergency-mechanisms/international-charter-space-and-major-disasters, [Accessed 17 May 2018].
132 Atsuyo, I., 2011: Legal Aspects of Satellite Remote Sensing, Martinus Nijhoff Publishers, Dordrecht, Netherlands, p. 189.
133 Ibid, p.190.
134 Ibid, p.195.

possibility to allocate exposed regions, and direct them appropriate aid. The knowledge obtained from space and especially the comparison of images before and after the disaster occurs is crucial for decision making concerning the recovery and reconstruction of the areas affected, and moreover, for allowing vulnerable regions to better prepare for possible future disasters.

The present legal regime seems suitable for the effective use of satellite-derived information for the purposes of disaster management rather than a codification of unified rules, which would require governments and international organizations to be bound by the regulation, and most likely discourage them from providing assistance rather than facilitate effective cooperation.[135] The Disaster Charter represents a viable model of coordinated voluntary disaster relief, which is based on data obtained from space, and provide for a sufficient base for decision making entities through the provision of timely and precise data, which allows them for informed actions to prevent unnecessary harm to humans and the environment. International cooperation is motivated through various programmes with particular regard to the needs of developing countries, and often their lack of capacities is aimed to be compounded by implementing measures to mitigate adverse impacts, particularly in the areas repeatedly affected and therefore more vulnerable.

135 Ibid, p.195.

Conclusion

The general legal framework governing outer space activities is based on five space treaties: the Outer Space Treaty, Rescue Agreement, Liability Convention, Registration Convention, and the Moon Agreement. Each of them shows the significance of space law in a different manner. The Outers Space Treaty often referred to as the "Constitution" of space law is the most ratified among the space treaties, and its provisions are considered to be part of the customary international law. It is an essential legal document governing space law, and the other space treaties provide for a specification of the provisions included therein.

Freedom of exploration, prohibition of appropriation, and the responsibility of states for national activities in outer space are the most fundamental principles of the Outer Space Treaty. The authorization and continuing supervision of the activities of private entities in space provide for a guarantee by the state that gives rise to its international responsibility, including the environmental protection. The Liability Convention, on the other hand, provide for compensation in the event of damage, however, does not include the damage to the elements of the environment behind national jurisdiction. The Moon Agreement introduced some significant provisions concerning the exploitation of outer space, which could limit their future activities, and that might be the reason for the unwillingness of space-faring nations to ratify it.

Environmental protection was not among the highest ranking priorities in the time of the conclusion of the space treaties, but it is becoming more and more evident that it should not be neglected anymore in order to find solutions to achieve the goal of sustainable development of the outer space activities. Soft law provisions, including the United Nations General Assembly Principles applicable to the use of outer space, presented by UNCOPUOS, and adopted by means of consensus clearly show the ability of the international community to reach an agreement. Their role is further strengthened by the development within certain other international bodies, such as the IADC, and the ILA. Regional and national initiatives are becoming more and more relevant to environmental protection as well. Guidelines, standards, and codes of conduct play an essential role in the voluntary efforts regarding debris

mitigation, and remediation for many actors in the space industry which could be seen as the beginning of the use of environmentally conscious techniques in outer space, even without the need for a legally binding instrument.

Environmentally friendly solutions to the use of outer space vary in different regions of space. The presence of many observation satellites characterizes the LEO, whilst the GEO is typically used for telecommunication, and different approaches to employing environmentally conscious solutions to the space debris problem are being introduced therein. Debris remediation in the LEO will become a necessary step towards the possibility of future use of this region of space. Preventing the intact derelict objects from colliding with each other will be the primary measure introduced in the near future. Space agencies are currently developing and testing multiple active debris removal methods, and the solution could be seen in the removal of no longer functioning satellites from the LEO back to the Earth's atmosphere, and the removal of derelict objects from the GEO to the "Graveyard orbit" above it. The priority list of objects that need to be removed is being established among researchers in order to prevent collisions, and optimistic assumptions suggest that removing five derelict objects a year would prevent the LEO from becoming unstable.

The increasing commercialization and privatization of the space industry contribute to the implementation of the obligations to the national legislation in many states because the common interest of the whole international community is to safeguard the space environment for the future use. The fulfillment of most of the sustainable development goals can be achieved through space. The contribution of space-based technologies to support the management of ecosystems is also well-known and is currently used to monitor the greenhouse gases, sea-level rise, temperature changes, change in the ozone layer and the overall impact of the climate change on the environment and human health. The dilemma between economic development and the obligation to protect humans and the environment encouraged states to adopt various documents with the aim to achieve sustainable development.

Environmental sustainability is one of the essential goals of the international community, and space applications are able to support it through, among other things, natural resources

management, and environmental impact assessment. Information obtained from space offer substantial and near real-time data to help decision-makers in assessing possible solutions for particular environmental issues of our time. All phases of environmental protection can be strengthened through the effective use of space-derived data. Satellite remote sensing and earth observation offer a reliable tool to enhance the performance of states under their environmental agreements by providing the means to assess the development in order to meet their obligations. Besides, remote sensing facilitates the participation of non-governmental entities in the protection of the environment, and also help the executing bodies through the supply of relevant data.

Space-derived information can also extensively contribute to all stages of disaster management: risk assessment, mitigation, response, and reconstruction. The role of the UN-SPIDER platform needs to be emphasized in this context. It aims at enabling particularly developing countries to gain access to all kinds of data concerning disaster management and also a better flow of information on disaster risks and impacts between all stakeholders. The prevention of natural disasters is generally not possible, but the adverse effects can be mitigated tremendously by the effective use of satellite-derived data. Therefore, it is of vital importance to prevent further pollution of the outer space and provide for its sustainable development in order to not disable space activities for future generations.

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Treaties and Legislation

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Kosmické aktivity a ochrana životního prostředí

Abstrakt

Tato diplomová práce se zabývá analýzou různorodých spojujících faktorů mezi činnostmi ve vesmírném prostoru a ochranou životního prostředí. Zkoumá současný právní režim kosmického prostoru s ohledem na ochranu životního prostředí. Dále je uvedena analýza nejdůležitějších kosmických smluv, přezkoumání jednotlivých ustanovení týkajících se ochrany životního prostředí a podrobně řeší aktuální otázky životního prostředí vesmíru. Je zdůrazněna významná úloha mezinárodních orgánů, stejně jako současné výzvy, kterým čelí právní režim úpravy vesmírných aktivit. Ačkoli vesmírné aktivity nabízejí rozsáhlé možnosti ochrany životního prostředí Země, vesmír je aktuálně vystaven bezprostřednímu nebezpečí nazývanému vesmírný odpad, které by v případě nadálého ponechání bez povšimnutí mohlo zamezit všem možným budoucím vesmírným aktivitám. Znečištění vesmírného prostředí je nyní na kritické úrovni a mezinárodní společenství bude nezbytně muset v krátké době učinit kroky k jeho nápravě. Opatření ke zmírňování budoucího znečištění již nebude nadále efektivní bez dalších aktivních opatření ke snižování počtu nefunkčních objektů ve vesmíru.
Na druhé straně, kosmická činnost již v dnešní době značně přispívá k ochraně životního prostředí Země, mimo jiné prostřednictvím monitorování přírodních zdrojů, skleníkových plynů, teplotních změn a nárůstu hladiny moře. Mezinárodní právní režim ochrany životního prostředí extenzivně čerpá z přínosů kosmických aktivit (pozorování Země, dálkové snímání a řízení přírodních katastrof) a je dále analyzován v souvislosti se schopností plnit cíle udržitelného rozvoje stanovených státy během několika mezinárodních konferencí. Kromě toho lze většinu současných cílů v oblasti životního prostředí dosáhnout prostřednictvím kosmických aktivit, a tudíž je nezbytné, aby mezinárodní společenství úspěšně čelilo ekologickým problémům co nejdříve.

Klíčová slova: **kosmické aktivity**

ochrana životního prostředí

vesmírné právo

vesmírný odpad

Outer Space Activities & Environmental Protection

Abstract

This thesis aims at addressing various connecting factors between outer space activities and environmental protection. It examines the present legal regime of the outer space with particular regard to the environmental protection. The analysis of the most relevant space treaties is provided, reviewing the provisions concerning the protection of the environment, while addressing the emerging environmental issues. The significant role of international bodies is being emphasized, as well as the current challenges the regime of outer space is facing. Although the space-related activities offer an extensive tool to enhance environmental protection of Earth, the environment of space is nowadays being exposed to an imminent threat called space debris, which could prevent all possible future space activities if left unattended. The pollution of the space environment is at a critical level, and the international community is required to respond within a short time in the future. The introduction of mitigating efforts will no longer itself be effective without the addition of active employment of remediating measures, such as the active debris removal.

On the other hand, space activities already widely contribute to preserving the environment of Earth through, among other things, the monitoring of natural resources, greenhouse gases, temperature changes, and sea-level rise. The international environmental legal regime extensively benefits from space activities (earth observation, remote sensing, and disaster management) and is further analyzed in connection with the ability to fulfill the goals of sustainable development as set forth by states during multiple international conferences. Besides, most of the present environmental goals can be achieved through space, and therefore, it is necessary for the international community to face ecological challenges successfully as soon as possible.

Key words: **outer space activities**

environmental protection

space law

space debris