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„The Dilemma of Space Debris
Treated at the United Nations“

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Elias Andrade

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“Man will not always stay on Earth; the pursuit of light and space will lead him to penetrate the bounds of the atmosphere, timidly at first, but in the end to conquer the whole solar space.”

(Konstantin Tsiolkvsky, 1857-1935)

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Preface

As an Erasmus Mundus Global Studies master student at the University of Vienna, Austria, I have been researching about the various aspects of multilateralism in international relations and globalisation processes. This master thesis has as theme space debris treated at the United Nations, fact which makes it well suited for the program master thesis' requirements for a subject of global context. The theme makes the thesis also very innovative, because it is an uncommon topic in academia.

Furthermore, I chose the topic on space environment because it involves several other sciences which also support the argument that space debris is a dilemma for space activities. From far above the Earth, with an outer space optical view, I could have a broader and detailed view of the processes that form globalisation, such as: world history, technology, law, social and political science and what future in outer space these processes entail for human kind. My goal is to discuss about the dilemma I think space debris represents to the environment and to our lives on Earth by exposing the latest diplomatic decision making processes that take the problem into account. This is, therefore, a paper on multilateral affairs that facilitate or at the same time threaten human space activities.

I began my scientific knowledge about outer space while taking Astronomy classes at Northern Michigan College in 2007. Both Stellar and Planetary classes helped me begin to obtain a sense for the immensity of outer space: for the size of the universe so far beyond our fragile planet Earth; and how finding the origin of the universe raise questions that challenge our knowledge, Philosophy and all sciences. Those are questions that drew me in to learn more about outer space.

To write a master thesis on this topic of multilateralism and outer space environment, I sought opportunities to be involved with scientists in the field. I have participated at

the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and its two subcommittees since 2012. I serve the Brazilian delegation as an observer, dealing with problems about the future of space law, politics, technology and capacity building. I also worked as an intern at the Office for Outer Space Affairs (OOSA), which is the organizer of the UNCOPUOS, at the United Nations Headquarters in Vienna; at the 63 International Astronautical Congress, Naples, Italy; and at the UN/Japan Nanotechnology Symposium, Nagoya Japan, both held in August 2012. A copy of my internship report and my personal notes of the fifty-fifth session of the UNCOPUOS held in 2012 are attached in the annex section.

Space has always been regarded as the future, and it has fascinated many scientists and people before me. I would like to consider myself a new member of the space academia and politics. This master thesis is also an opportunity to show my work at the world's most important diplomatic organization for the peaceful uses of outer space. It is the longest, and for me the most important academic work I have ever intended, or even thought to write on human activities in outer space. It is my wish that my audience have an enjoyable learning experience reading my master thesis on the dilemma of space debris.

Prefácio (in Portuguese)

Enquanto estudante de mestrado do programa Erasmus Mundus em Estudos Globais, pela Universidade de Viena/Áustria, tenho pesquisado vários aspectos do multilateralismo em relações internacionais e processos de globalização. Esta dissertação tem como tema os detritos espaciais investigados pela Organização das Nações Unidas (ONU), fato que faz o presente texto cumprir as exigências do programa – haja vista que tal assunto é de âmbito global – e, ademais, torna-o inovador, já que o objeto de investigação escolhido é incomum na academia.

Tal escolha foi motivada por meu interesse no fato de o tema em xeque envolver várias outras ciências, enriquecendo a discussão. Do espaço muito acima da Terra, do ponto de vista ótico aí localizado, eu poderia ter uma visão mais ampla e detalhada dos processos que influenciam a globalização, como a história, a tecnologia, o direito, a ciência política e social, e como estes processos se relacionam com a vida da humanidade. Meu objetivo é discutir sobre o dilema que o lixo espacial representa para o meio ambiente e para a vida no planeta, expondo os mais recentes processos diplomáticos decisórios que levam o impasse em conta. Esta é, portanto, uma dissertação em assuntos multilaterais que facilitam ou, ao mesmo tempo, impedem atividades de seres humanos no espaço.

Iniciei meu conhecimento científico sobre o espaço sideral durante as aulas de Astronomia na faculdade Northern Michigan College, Michigan, EUA, em 2007. Ambas as classes estelares e planetárias me ajudaram a começar a obter um sentido sobre a imensidão do espaço. O tamanho do universo em desvantagem ao nosso frágil planeta e como encontrar a origem do universo são questões que desafiam o nosso conhecimento, a filosofia e todas as ciências. Essas foram razões igualmente motivadoras de minha maior aprendizagem sobre o assunto.

Para escrever uma dissertação de mestrado sobre o multilateralismo e o ambiente do espaço sideral, busquei oportunidades de estar envolvido com cientistas em atividades na área. Tenho participado no Comitê das Nações Unidas sobre os Usos Pacíficos do Espaço Sideral (UNCOPUOS) e seus dois subcomitês desde 2012. Neles, sirvo como observador para a delegação brasileira, lidando com problemas sobre o futuro do direito espacial, política, tecnologia e capacitação. Estagiei no Escritório de Assuntos Espaciais da ONU (OOSA), que organiza o comitê, na sede das Nações Unidas em Viena; no 63º Congresso Internacional de Astronáutica, em Nápoles, na Itália; e no Simpósio Nanotecnologia UN / Japão, Nagoya, Japão, ambos realizados em agosto de 2012. Um relatório do meu estágio na OOSA e minhas anotações pessoais da UNCOPUOS estão presentes na seção anexo.

O espaço sempre foi considerado como o futuro, e ele também tem fascinado muitos cientistas e pessoas antes de mim. Eu gostaria de me apresentar como um novo acadêmico interessado na temática. Esta dissertação é também uma oportunidade para mostrar meu trabalho na mais importante organização mundial para os usos pacíficos do espaço sideral. Trata-se do mais longo, e para mim, o mais importante trabalho acadêmico que pensei em escrever sobre as atividades espaciais. É meu desejo que os leitores tenham uma alegre experiência de aprendizagem com o presente texto.

Acknowledgements

This master thesis was written in a period of three months. A year before I started writing it, I had contacts with people and institutions that helped shape my ideas. Writing this master thesis was a team effort. While as its author I had the original ideas; friends, academic professionals, and co-workers provided immense help in reviewing many drafts and giving many useful comments and resources.

Special thanks to my master thesis supervisor, the historian Prof. Dr. Friedrich Edelmayer, for the amazing job he did to make sure this thesis fits the requirements of the University of Vienna. We both were in great harmony. He has become a good friend and has always had great interest for the outer space theme, while also providing steadfast encouragement.

I would like to express big gratitude to Mr. Niklas Hedman, chief of the United Nations Committee on the Peaceful Uses of Outer Space, Policy and Legal Affairs Section at the Office for Outer Space Affairs (OOSA), UN headquarters in Vienna, for being my co-supervisor. His long experience at the committee was extremely helpful to provide me with steadfast source of literature, primary sources, and engaged debates. Without his help, it would not be possible to write a good master thesis.

Also every staff member of the OOSA has been always so kind to me, especially Dr. Werner Balogh, my internship supervisor in 2012. Other invaluable source of information came from Jerry Seller and Willey Larson, my former teacher, Dr. Irmard Marboe, and her edited book "Soft Law in Outer Space," and the European Space Policy Institute's library, to whom all I thank the chance of working together.

I had many insights from Brazilian colleagues, most from the Brazilian Commission for the UNCOPUOS, where I have been an observer. I would like to thank very much for their steady intellectual knowledge and opportunity: Ambassador Evandro Didonet, Ambassador Julio Cezar,

Minister Fábio Vaz Pitaluga, Secretary Felipe Pinto, Secretary André João, Colonel Eduardo Lucca, Prof. José Monserrat, Rozane Silva, Ana Cristina Gallego Rosa, Prof. Olavo Bittencourt Neto, Bruno Sarli, and Konrad Link.

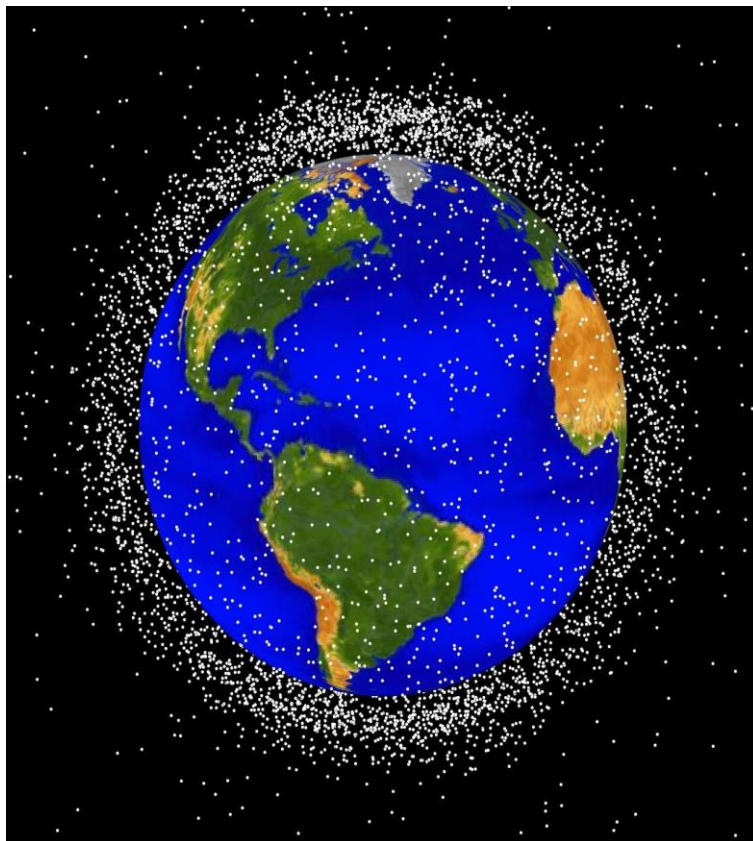
My dear friend, with whom I share a steady friendship for years, Rev. Robert Singelyn, “the old English teacher,” patiently reviewed line by line of this thesis and corrected errors. He made this work come alive comprehensively despite my messy drafts. He really did a fabulous job.

Many university students in Austria and Brazil provided steadfast intellectual knowledge on my thesis. I would like to start thanking my great friend Bashir Shehu, political science doctorate student at the University of Vienna, for making sure the basic coherence of this thesis was on the right track. For the proofreading of the Portuguese version of the abstract, I thank my friend, Avelino Neto, philosophy doctorate student at the Federal University of Rio Grande do Norte, Brazil. From the University of Vienna, Austria, I also thank: Martin Achleitner, Physics student, Christian Germaine, my friend and Erasmus Mundus Global Studies classmate, and Markus Gatschnegg, master program vice-coordinator, for the work done on the translation of the abstract from English into German.

Each person mentioned above provided invaluable key expertise, wit, and criticism for the shaping of this thesis. I share the joy of their contributions, and I take full responsibility for the entire master thesis, for any mistakes it may have or any criticism it may be given.

These two years of the Erasmus Mundus Global Studies – A European Perspective master program at the University of Vienna have been a fabulous life giving experience. I owe most of these moments to Leopold Kogler, my coordinator. Being a student is costly. Therefore, I am grateful for the tuition break from the consortium. It certainly helped me pay the program’s tuition. I am also grateful for the anonymous generosity in cash and kind of friends from all over the world whom I call angels.

The Dilemma of Space Debris Treated at the United Nations



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¹ National Aeronautics and Airspace Administration 2010.

Chapter One

Introduction and General Structure

Space debris for various reasons composes an international dilemma for space activities. It all started when the first space-faring nations sent the first rockets into space in the late 1950s. Countries assumed that parts of the rockets and satellites themselves would eventually fall back to Earth and burn through the atmosphere. However, the truth is that space debris does not return to Earth so fast. As the problem was not efficiently prevented before, the great probability is that space-faring nations will have an even harder time to mitigate it in the future. If they want to continue exploring space, it is necessary to update the current legally binding instruments, and avoid in this way the anarchy of space debris proliferation.

Due to the world's multipolar system in the last decades of the 20th century, space activities have taken on a new character. New space-faring nations and specialized organizations have developed space technologies through capacity building and cooperation. Their participation has changed the outer space military scenario from the Cold War to a more peaceful civilian and scientific characteristic for space activities. Nonetheless, they have also created more space debris, which has become a dilemma for the space community because of the technological, lawful and political implications surrounding the problem.

Donald Klesser, a former NASA scientist, was one of the first well known names in the space scientific community to speak about space debris in 1970s. Even in those years of the Cold War, Klesser had already recognized the multiplication of debris, known as the Klesser syndrome, originating either from asteroids and meteorites, or caused by the two Super Power nations during their race to conquer outer space, named then by historians as "The Space Race."²

² Gilbert 2013, p. 1.

At that time, the community of space-faring nations was limited to the Union of Soviet Socialist Republics (U.S.S.R) and the United States of America (U.S). The Soviets pulled ahead in the Space Race with the successful launch of Sputnik-1, Earth's first artificial satellite. The launch of Sputnik on 4 October 1957 is a landmark in the history of human kind. The satellite was the very first manmade object to orbit the Earth, and it operated perfectly, sending out radio signals from space back to earth. A brief treatment of the space debris dilemma that started with the launch of Sputnik-1 satellite is in the introductory chapter number one. In the next chapter (number two), one can find the methods chosen by the author to write his argument, including his research and theoretical approach.

The launch of Sputnik-1 to study Earth's upper atmosphere opened the possibility to many other human activities in outer space. After the Cold War and the space explorations of the Soviet Union and the United States, those space activities gradually became accessible to many countries, private organizations, and even universities. Humans were able to adventure out from Earth in daring missions to reach into the sky, creating space stations, to this day, the greatest creation of human kind. Those activities also included human and animal space-trips; launching of space satellites for research, science, space and Earth observations; space stations; and finally a human visit to Earth's Moon. Space activities have created a long term legacy for human kind are not free of deadly accidents and space debris. These have caught the interest of many nations and world leading organizations such as the United Nations (UN). A review of these activities can be found in chapter number three, namely "A short history of space flight and the UNCOPUOS."

The launch of Sputnik-1 and the contest of the Cold War created a real concern for other national governments about the militarization of outer space. In that context, the United Nations created the Committee on the Peaceful Us-

es of Outer Space (UNCOPUOS) to address new challenges, and to promote peace and the non-proliferation of nuclear weapons in space. Information about the committee and its two subcommittees, the Legal and Scientific and Technical Subcommittees, including their most noteworthy contributions, remarkable resolutions and documents will be found also in the historical chapter three.

Chapter number four discusses space debris in greater detail – its definition, major events that created it, how much debris is out there and where, and how it is tracked. The chapter also discusses why debris is a dilemma for space activities and provides a possible scenario for a satellite dooms day. Debris in space now represents a real threat: primarily to the functionality of satellites and the lives of astronauts, but also to the millions of people on Earth who may rely on space technology to work, communicate, allocate, and live.

The appearance of new space actors in the late 20th century required the creation and implementation of new space law, with new principles for treaties on space. These documents have become an asset to promote global cooperation and compromise among nations, governmental and non-governmental space-faring organizations. However, space debris has grown into an even bigger issue since the passing of these documents. Therefore, the space community questions whether it needs to update current legal and technical tools to mitigate the matter. Information regarding these documents will be discussed in “The United Nations on space debris” chapter number five of this thesis. Some of these documents are: United Nations General Assembly Resolutions, UNCOPUOS meetings, treaties, principles, and other binding and non-binding lawful instruments. One example is the Rio 92 and Rio +20 UN conferences on sustainability, held in Rio de Janeiro, Brazil, which serves as a basis for discussion on humankind’s needs for future space activities. In chapter number six, the author provides

his noteworthy conclusions from this text, and some recommendations.

The text is therefore a summary of the most meaningful efforts made by national governments in the multilateral arena to maintain cooperation among space-faring nations for solving the complications presented by space debris. These efforts have been made so that all nations of the world may have equal and fair opportunities to explore space in a sustainable manner. The thesis is, as well, a summary of the most recent information from global leading experts and specially the resolutions of UNCOPUOS about the matter, and how States foresee the future of all these activities being sustainably developed.

Multilateral diplomatic negotiations are necessary to accompany the political dimension of space technology with also the help from soft and hard law in the late 20th century. However, political considerations and a shying away from laws along with short budgets have often slowed down diplomatic negotiations among space-faring nations, and the application of technology as well. The lack of more comprehensive resolutions may impede further development for sustainable space activities.

Chapter Two

Methods

2.1 Research Question

This master thesis contains a very pertinent research question to human kind. The question is: how is space debris a dilemma for countries to develop sustainable ways for using outer space?

2.2 Scientific Observation and Theoretical Approach

The text combines theory with scientific observation. It is yearlong research done among the most prominent experts on outer space, including astronauts, astrophysicists, diplomats and heads of national technology ministries.

Here a clear line distinguishing theory from scientific observation is important. The Scientific observation, in this case, consists of work among experts as an observer at the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) since 2012 and its two subcommittees. The author found other sources of information at the 63rd International Astronautical Congress, held in Naples, Italy and at the United Nations/Japan Nanotechnology Symposium, held in Nagoya, Japan in October 2012, in which that the author participated while interning at the Office for Outer Space Affairs (UNOOSA). These space related events, along with research at the European Space Policy Institute's library, and a space-law university course, have been the major sources for practical field work in scientific observation.

At the same time, primary sources of updated information currently developed by space-faring nations and organisations are most of the literature used to write this master thesis. These theories guide the goals, policies and laws for sustainable technologies in outer space activities.

For the readers understanding there will be a short historical overview of human space activities; a review of the role of the United Nations Committee on the Peaceful Uses of Outer Space; the role of soft laws on space in relation to hard laws on debris; the five United Nations Space Principles, Conventions and Treaties and the status of their functionality; the Rio+20 conference; and current UNCOPUOS and General Assembly resolutions on space sustainability, debris, and nuclear power source in space.

2.3 Objectives

The main objective of this master thesis is to disclose for academic purposes important information about the dilemma of space debris. The dilemma of being space active without harming the environment or being harmed is a concern for all on Earth and those who would live or visit space. It is my interest to write an academic paper, following the University of Vienna editing guidelines, that shows to which extent space activities have been developed in a sustainable manner, and the risks these activities can directly and indirectly cause to our lives.

It is therefore, the objective of this master thesis to join with the few other academic and non-academic channels of communication and create public awareness about the dilemma space debris represents. In discussing the topic, this master thesis provides a critical reading of space activities as well as a parallel analysis from social and political theory.

This paper aims to clarify the dilemma as clear as possible. Reading about space should be comprehensible and enjoyable. This is an approach found in the best textbooks on space technology, as for example, *Understanding Space: An Introduction to Astronautics* by Jerry John Sellers.³

³ Sellers, et al. 2005. P. XV.

2.4 Delimitation

It is certain that there are a vast number of space scientists, policies and laws throughout the entire space history. Also there are a vast number of concerns about the peaceful uses of space activities and their sustainability. The Use of Nuclear Power Source, the Definition and Delimitation of Outer Space, and Space and Climate Change are also some crucial ones. It is true also that there is a wide range of experts and public, non-public, profitable and non-profitable organizations and even universities focusing to address those problems.

Given that, the central question of this thesis is how the United Nations Committee on the Peaceful Uses of Outer Space is handling the space debris dilemma. It is a subject that has been very limitedly explored in the academia. Space debris is the biggest concern for the entire space community and the United Nations Committee on the Peaceful Uses of outer Space is the world's most important intergovernmental organization treating it.

2.5 Relevance

This topic has an enormous and growing relevance to human kind and to academia. Because of increasing numbers in space-faring nations and organisations, the space topic reveals a new era in outer space activities. At the same time, it throws light on the nature of many aspects of the daily lives of people in the world at large. One can foresee in space activities aspects of world history, politics, and obtain insights about the global village where most people on earth live nowadays.

Outer space has been considered the place that holds the future. That is mostly because human kind has heavily invested in cutting-edge technology to reach space. It is also true that it is a difficult task to clean space debris. Therefore another question raised here is: is our under-

standing of this dilemma up to date? Space holds this kind of relevance. If it is possible to maintain our policies and laws up to date, there is a greater chance humankind can continue to use space to answer questions about our past, present and future.

2.6 Target Public

This is an academic paper, foreseeing in this way to fulfil the requirements for the obtention of the Erasmus Munds Global Studies Master Degree, at the University of Vienna, Cohort 2011-2013. This master thesis is moreover intended for all people interested in the subject of outer space human activities regardless of their educational background and knowledge about space. Beyond this, the author also intends to offer this master thesis to the general public for awareness of the causes and effects of space debris in space and as an insight into the multilateral affairs behind the scenes.

2.7 Important Observation

Multilateral negotiations are a slow process. They often take years to accomplish visible results. Therefore, the reader should not be discouraged, but notice this master thesis is more about the process than the results. The foot notes should provide enriching information despite the scant amount of literature on space debris itself.

Chapter Three

A Short History of Space Flight and the UNCOPUOS

Only humans would reach outer space, the final frontier, and then doom its way with junk. This is how the opening of several of the original American science fiction Star Trek movies starts their introductory text: "Space: the final frontier. These are the voyages of the Starship Enterprise; its years mission to explore strange new worlds, to seek new civilizations, to boldly go where no man has gone before."⁴ In reality, Humans have already done that with smaller spaceships called satellites, but far less not clumsily, with great precision and with huge consequences for the world.

3.1 The Early Astronomy

The way to reach outer space was long, expensive and always very dangerous – both on Earth and in Space. Space has always been motive for star gazing, poems, romance, myths, and sometimes fear of the unknown. It is historically proved that human scientific interest in outer space dates back to the earliest civilizations. The first astronomers recognized patterns in the sky that helped them to locate themselves on Earth, navigate, and create systematic calendars to count days and seasons. An example of this is the Stonehenge complex in England that dates back to 2100 B.C and is believed to be a solar calendar tool. Other example of an early civilization that used the Astros is the Babylonians, who charted the 18-year cycles of the Lunar eclipses in 1500 B.C.⁵

Some philosophers played an important role for outer space, using the patterns of stars to understand nature and human destiny. Asking many questions and trying to logical-

⁴ Star Trek: The Original Series, 1966-1969.

⁵ Sellers, et al. 2005, p. 30.

ly answer them has always been the ultimate scientific method of philosophy. The art of thinking or the love for thinking, as it is also known, played an important role for astronomy. Philosophers were the first astronomers, and because of their scientific method, they were not convinced by mythological and religious explanations about the existence and behavior of the Sun, the Moon, and other celestial bodies. Their work was fundamental for the space development humans have reached nowadays, despite some mistakes occurred. Aristarchus of Samos, 270 B.C, who defined the universe as Earth centered, as also did Ptolemy in 140 A.D. The Catholic Church defended for centuries.⁶ In 813 the Arabs began an astronomy school located in Baghdad and in 850 created a perfect astrolabe, a navigation instrument that locates and predicts the position of celestial bodies such as the Sun, the Moon and stars.⁷

The invention of the firework by the Chinese first showed that man could really go into space. The Chinese invented rockets, fueled with gun powder, first for fireworks and later as weapons, as early versions of our contemporary missiles. There are reports of the Chinese using rockets against the Mongols date back to 1232: the earliest use of our contemporary missiles. According to a Chinese legend, Wan-Hoo, a Chinese warrior of the 16th century, tried to fly to the Moon mounted on a rocket. When the rocket took off, he was sent to the sky in a huge cloud of smoke and disappeared.⁸

In the case of space-law, data shows that the Romans were the first to develop a space-law system that served as the basis for space law until the beginning of the Space Age. The Romans intended to extend the rule of law from the ground upward. They realized that the airspace above sacred sites and public highways needed to be protected by law against private construction for instance. Hugo Grotius

⁶ Sellers, et al. 2005, p. 30.

⁷ Ibid.

⁸ Mayer 2011, p. 20.

(1583–1645) was the first to state that the air is a common right of human kind. He stated that if the use of air is independent of the use of the Earth, than it cannot be subject to Earth's law (e.g. hunting birds).⁹

Galileo Galilei (1564–1642), Nicolaus Copernicus (1473–1543), Johannes Kepler (1571–1630), also Tycho Brahe (1546–1601) and Isaac Newton (1642–1727) were strong names in modern astronomy. Newton and Brahe, for example, refuted the long wrongly held notions of gravity that Aristotle believed. Copernicus discovered our universe (solar system) was Sun-centered, not Earth centered. Kepler famously developed the three planetary motion laws; and finally Galileo made many discoveries about the Sun, the Moon, Jupiter and other celestial bodies in our solar system with the use of the telescope.¹⁰

These astronomers were in danger that came from Earth not from the sky. They were persecuted and risked their lives in the name of science for contradicting religious teachings about the universe. This is the case for example of Johannes Kepler, Nicolaus Copernicus and Galileo Galilei who were famously persecuted by the Church. In a letter addressed to Kepler in 1597, Galileo admits to have adopted the ideas of Copernicus (the Copernican Revolution - Earth rotates around the Sun), and that has helped him figure out causes and effects of many natural objects. These could not be proved with Aristarchus idea of the Earth centered universe where the Sun rotates around our planet. Galileo adds that he has written many arguments against Aristarchus ideas which the Church's defended, but he did not dare to publish them for fear he would be persecuted like Copernicus was.¹¹

The Catholic Church was not the only one to persecute astronomers. Martin Luther (1483–1546), the protestant

⁹ Metcalf 1999, p. 38.

¹⁰ Sellers, et al. 2005, p. 33-39.

¹¹ Reale and Antiseri 2003, p. 251.

reformist, called Galileo a two cent cheap astronomer for believing the Earth and the Moon rotated around the Sun.¹² Only in 1992, Pope John Paul II asked forgiveness for the Church persecution on Galileo and many others.¹³

3.2 Space Science in Modern Society

Understanding about rockets among other space objects such as the balloon and the airplane is fundamental for the comprehension of satellites and anti-satellites technology, their use and their debris legacy. Russian Konstantin E. Tsiolkovsky (1857–1935), U.S American Robert H. Goddard (1882–1945) and Austrian/German Hermann Oberth (1894–1989) are important names in the space history of modern times.¹⁴ Tsiolkovsky most famous quote: “Man will not always stay on Earth; the pursuit of light and space will lead him to penetrate the bounds of the atmosphere, timidly at first, but in the end to conquer the whole solar space,”¹⁵ is a maxima of space history, an accurate scientific prediction of modern space activities.

During World War I (WWI), Goddard was hired by the U.S army to develop missiles to be used in that conflict. The U.S army also hired him again for the same purpose during World War II. In the case of Oberth, he published a book entitled “A method of Reaching Extreme Altitudes,”¹⁶ which was initially his doctoral thesis that was at first discredited but later became a book of inspiration for technology scientists.

World Wars I and II contributed to the modernization of rockets, especially by the Nazi German party, United States of America (U.S.), and the Union of Soviet Socialist Repub-

¹² Reale and Antiseri 2003, p. 259.

¹³ Pope John Paul II 1992.

¹⁴ Balogh 2011, p.3.

¹⁵ Ibid., p. 6.

¹⁶ Mayer 2011, p. 21.

lic (U.S.S.R). The Treaty of Versailles of 1918 prohibited heavy armament, but made no restrictions to the building of missiles. The army industry found this an opportunity to create long range missiles.¹⁷ Werner von Braun (1912-1977) is considered the founding fathers of the Modern rockets. Under the guidance of Braun, the first man-made object to reach outer space was successfully launched. It was the A4/V2 rocket, reaching the sky on 3 October 1943 in Germany. The A4/V2 reached an altitude of about 90km and weighed close to 14 tons.¹⁸

At the end of World War II (WWII), many German scientists who had previously worked under the Nazi regime moved to the Allied nations (U.S, UK and the U.S.S.R) where they helped develop missile technology. Von Braun, who first served under the Nazi army, surrendered to the U.S with his team, and later became part of NASA (National Aeronautics and Airspace Administration).¹⁹ A4/V2 was therefore the primogenitor of space rockets. Development of rocketry to deliver weapons in WWI and WWII was fundamental for the military characterization of the Space Race that occurred during the Cold War.

On 4 October 1957, the Soviet Union put into orbit Earth's first artificial satellite, the Sputnik-1, realizing in this way the dream of all space scientists. Sputnik, as it is called, made of October 4th a benchmark for the history of humankind. Russian had kicked off the Space age. After the launch of Sputnik, the Soviets and the U.S Americans began a competition to reach the sky, showing off the pride and privilege of two super powers in a bipolarized world. The Space Race during the Cold War between the U.S and the U.S.S.R gave birth to the political dimension in which space

¹⁷ Mayer 2011, p.22.

¹⁸ Balogh 2011, p. 11.

¹⁹ Balogh 2011, p.3.

debris is now embedded. Debris has been created since the first space mission, the Sputnik program.²⁰

The A4/V2 rocket was the first man-made object to reach outer space. However, the launch of Sputnik-1, (or just Sputnik as it is called) on 4 October 1957 was a remarkable day for humanity because it was the first time a man-made object, a satellite, was sent to study the Earth's upper Atmosphere and traveled the low orbit of our planet. Sputnik was comprised of a small sphere of 58 cm in diameter, carried four antennas and weighed only 83.6 kg.²¹ However, amidst the Cold War between the United States and the Soviet Union, it was more than a technological breakthrough, but became the subject of propaganda for Soviet might. A new technology era was born with the launch of Sputnik-1, and it would certainly affect the lives of all on Earth.

Soon after the Soviets broke through Earth's boundaries, the world began to experience the age of many other kinds of human activities in outer space. In 1961, the Soviets launched the first man into outer space, Yuri Gagarin (1934–1968); in 1962, the U.S American John Glenn (1921–1999) was the second man in space; in 1963, the Russian Valentina Tereshkova (1937– present) was the first woman in space;²² in 1965, the Russian Alexei Leonov was the first man to perform a spacewalk; the Apollo crew died in a horrific fire accident in 1967, but in 1969, Apollo 11 successfully landed on the Moon and the U.S American Neil Armstrong is the first man to step on the Moon; 1973 the U.S launched Skylab, the first space station carrying three astronauts. It disintegrated in 1979 leaving hundreds of space debris fragments above Australia. Sally Ride was the first U.S American woman in outer space in 1984. Pioneer 10

²⁰ Metcalf 1999, p. 48.

²¹ Mayer 2011, p. 21.

²² The author had the pleasure to personally meet with Mrs. Tereshkova in 2013 during an interview at the celebration of the 50 years of the first woman in space at the UNCOPUOS 56th session.

was the first satellite and man-made object to leave our solar system in 1986, and the Galileo satellite discovers liquid water in Europa, Jupiter's moon. In 1986, Russians launched the Mir Space Station. The Hubble Space Telescope began operation, and started an unprecedented legacy of revelations about the universe. In 1999, the International Space Station (ISS) started operation at a low Earth orbit (LEO) with a partnership among NASA, Russia, Japan, Europe, Canada, and Brazil. The ISS has become the most important symbol of international cooperation among nations and is considered the most important creation of humankind. In 2003, the Space Shuttle Columbia was destroyed while returning to Earth killing its seven members; also in 2003, the Chinese launched their Divine spacecraft, putting into orbit the first Chinese man, Yang Liewi. Liewi began preparing the Chinese Space Station (CSS), which is expected to be ready by 2020.²³

A great deal of excitement was triggered by the launch of Sputnik, but space enthusiasts historically had already earlier founded the first non-governmental space advocacy institutions. They are the German Breslau based in Verein fuer Raumschiffahrt (1927) and the British Interplanetary Society, based in London (1933). These two are recognized as the first organizations to promote human activities for the exploration of outer space. Currently, more than 70 countries are space active and the number of space organizations includes educational institutions, private corporations, governmental and non-governmental organizations.²⁴

3.3 History of the UNCOPUOS

The United Nations (UN) was officially created on October 24th, 1945. It emerged from World War II as a place of opportunity for countries to exercise peace and prevent wars, as states the Charter of the United Nations. It has also be-

²³ Sellers, et al. 2005, p. 31.

²⁴ Balogh, Institutional Aspects 2011, p. 198.

come the largest representation of all nations in the world independent of their economic and political power, size and number of citizens. The UN is a landmark and functions as an intermediary organization that facilitates multilateral negotiations among States in the most professional, diplomatic, and neutral manner, respecting the sovereignty of all nations.²⁵

It has also been the role of the UN to create programs to fight poverty, promote peace, capacity building, and fair trade in the world. In doing so, it has given the world hope for peace and fairness. Therefore, the UN is indeed the world's most important multilateral organization. The UN system contains an extensive network of bodies and organizations, starting with the General Assembly and the Security Council. Being devoted to so many world issues presents a great challenge for coordination within the system.²⁶

Since its creation, the UN has become highly politicized, and nearly every decision throughout the system needs the approval of every country involved. Contrary to what many people may think, the United Nations is not a global government that dictates or should unilaterally act upon domestic issues in any nation. When heinous crimes in the world are not prevented or solved, charging the UN seems a paradox. One may decry its slowing moving rules of procedure for not conducting urgent matters (high politics) well, or one may blame nation States for not taking the right action faster enough within the UN system, while at the same time criticizing those same nations for making politics unilaterally, bilaterally or even multilaterally outside the UN system.²⁷

²⁵ United Nations 1945, p.3.

²⁶ Ibid., p.4.

²⁷ A clear case where the UN peacekeeping operations, for instance, failed to act happened during the Rwanda Genocide of 1994, when it did not prevent the killing of approximately 80,000 to 1,000,000 people. See UN Secretary-General Kofi Anna report and apologies on the Rwanda Genocide, 1999, p. 1. See "The UN system and its quixotic quest for coordination," McLaren 1978.

The Launch of Sputnik-1 was the trigger for the political dimension of outer space. Humans were finally able to orbit outer space, was a great leap forward to our history but countries were concerned about the militarization of outer space. They feared that the Soviet Union and the United States would use Earth's outer space for military purposes, using rockets to send ballistic missiles instead of satellites. Thankfully that never occurred. With these fears in mind, the UN added to its system the ad hoc Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which is a mechanism for space-faring nations and organizations to dialogue on the nature of the legacy that space activities would certainly bring.²⁸ The committee was created to eliminate the fear of outer space as a Cold War battlefield.

The General Assembly established the UNCOPUOS in 1958 (resolution 1348 (XIII)), one year after the launch of Sputnik-1. That year, there were 18 Nation States as members of the committee, addressing the weaponization of

²⁸ G. A.-f. United Nations 2012. See other space-related institution within the UN system: International Telecommunication Union (ITU) and its Radiocommunication Sector (ITU-R); World Meteorological Organization (WMO) and its WMO Space Program; United Nations Educational, Scientific and Cultural Organization (UNESCO). International Governmental Organizations: International Telecommunication Satellite Organization (ITSO); International Mobile Satellite Organization (IMSO); Intersputnik International Organization of Space Communications (Intersputnik); European Telecommunication Satellite Organization (Eutelsat). International Non-Government Organizations: International Astronomical Union (IAU); International Astronautical Federation (IAF); International Academy of Astronautics (IAA); Committee on Space Research (COSPAR); Association of Space Explorers (ASE); Space Generation Advisory Council in support of the United Nations Programme on Space Applications (SGAC); Eurisy; The Planetary Society (TPS); National Space Society (NSS); World Space Week International Association (WSWA). For regional space-related organizations, forums, and other multilateral entities, see full list in the book *Outer Space in Society, Politics and Law*, section "Institutional aspects." Balogh 2011, p. 198.

outer space.²⁹ In 1959, a year later after its creation, the UN General Assembly made the committee a permanent UN body (resolution 1472 (XIV)) to discuss the Peaceful Uses of Outer Space, as part of the United Nations family.³⁰ By that time, the UNCOPUOS number of memberships had grown to 24. In 1961, Nation States requested during the General Assembly that the UN Secretary-General and the UNCOPUOS work together for broader discussions about new rivalries that space technology might review. This technology could open broadly the range of possibilities for human-kind progress and for the lives of all other species that inhabit our planet Earth, but might also provoke new rivalries.³¹

The General Assembly resolution 1472,³² also established basic framework for the UNCOPUOS. Members of the General Assembly acknowledged that UNCOPUOS needed to directly address on the use of space technology and its peaceful uses during the Cold War. The basic framework declared that all member States and organizations of the committee as a whole should be committed to promote peaceful activities of humans in outer space. Furthermore and very importantly, it also declared that space activities and the exploration of outer space should benefit all human kind, every state in the world, irrespective of their level of economic development. Third, work to avoid conflicts like the one between the Super Powers or technologically advanced nations. It would also consider how to deal with antagonism that might grow among new space-faring nations and organizations in a time of fear or uncertainty.

The framework established by General Assembly resolution 1472 (XIV), also included other important aspects. Be-

²⁹ United Nations General Assembly 1962, p. 5-6.

³⁰ Ibid.

³¹ See Report Secretary-General of the United Nations 2013, p. 1. "United Nations, International Cooperation in Space Activities for Enhancing Security in the Post-Cold War Era."

³² United Nations General Assembly 1959, p.5.

sides stating generally that space activities should be used for peaceful uses, promoting opportunity for all nations, and avoiding rivalries among countries, some premises were quite specific and practical. Paragraph 1 of the resolutions reads as follows:

1. "Establishes a Committee on the Peaceful Uses of Outer Space, consisting of Albania, Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, Czechoslovakia, France, Hungary, India, Iran, Italy, Japan, Lebanon, Mexico, Poland, Romania, Sweden, the Union of Soviet Socialist Republics, the United Arab Republic, the United Kingdom of Great Britain and Northern Ireland and the United States of America, whose members will serve for the years 1960 and 1961, and requests the committee:

a)

to review, as appropriate, the area of international cooperation, and to study practical and feasible means for giving effect to programmes in the peaceful uses of outer space which could appropriately be undertaken under United Nations auspices, including, inter alia:

Assistance for the continuation on a permanent basis of the research on outer space carried on within the framework of the International Geophysical year;

b)

Organization of the mutual exchange and dissemination of information on outer space research; Encouragement of national research programmes for the study of outer space, and the rendering of all possible assistance and help towards their realization; To study the nature of legal problems which may arise from the exploration of outer space; Requests the committee to submit reports on its activities to the subsequent sessions of the General Assembly."³³

³³ United Nations General Assembly 1959, p. 5-6.

3.4 The Scientific & Technical and Legal Subcommittees

In 1962, the UNCOPUOS established two sub-committees: the Scientific and Technical Sub-committee (STSC) and the Legal Subcommittee (LSC). Both were established under General Assembly Resolution 1721 B (XVI) and mandated to report to the plenary of the UNCOPUOS, which reports to the General Assembly. The two sub-committees were created to facilitate countries developing international cooperation on the global, regional and international levels, while responding to a cluster of specific legal and technical matter arising about space applications.³⁴

In its first report to the UNCOPUOS, the STSC presented a text with three recommendations that were also sent to the General Assembly. The first recommendation asks that disclosure of technical data to be available from all member countries be available to the committee on a voluntarily basis. This exchange of data aimed to support international, national, governmental and non-governmental bodies in space research and exploration. The second recommendation stimulated the creation of international programmes that foster capacity building, technological assistance, education and training. The third and last recommendation encouraged the creation of an equatorial rocket facility. This report of the Technical and Scientific sub-committee was unanimously approved by its member States and later approved by the General Assembly.³⁵

On the other hand, the report from the first meeting of the Legal Sub-Committee stated that no consensus had been reached. Proposed themes encompassed basic principles for space exploration, rescue of astronauts, liability of space vehicles and accidents. The meeting had been a great opportunity for exchange of views, and to initiate discussions on legal proposals that were in fact, approved later,

³⁴ See United Nations General Assembly 1962, p. 5-6.

³⁵ Ibid.

for instance, the current five United Nations Space Treaties that is contextualized in chapter number five named The United Nations on Space Debris. The Treaties are: Treaties on Principles Governing the Activities of States in the Exploration and Use of Outer, Including the Moon and other Celestial Bodies Space (10 October 1967); Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (3 December 1968); A Convention on International Liability for damage Caused by Space Objects (1 September 1972); A Convention on Registration of Objects Launched into Outer Space (15 September 1976); and finally the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (18 December 1979).³⁶

3.5 UNCOPUOS Early Achievements

One of the first pragmatic achievements of the Committee was to establish a form for registration of space objects launched into outer space. The registration was settled under General Assembly resolution 1721 B (XVI) in 1961 and was later reaffirmed by the Convention on Registration of Objects Launched into Outer Space passed in 1976.³⁷

While the registration may appear as a simple organizing tool, the consensus on a simple registry form was certainly a great achievement because it occurred during a delicate period when the Cold War was compromising trust and cooperation among nations. When the Soviet Union and the United States cooperated with the registry, the game changed. The world watched in 1962, when U.S. President Kennedy (1917–1963) and the U.S.S.R Chairman of the Council of Ministers, Nikita Khrushchev (1953–1964), exchanged messages expressing the will to collaborate with

³⁶ United Nations General Assembly 1966.

³⁷ United Nations General Assembly 1962, p. 5.

the registration and cooperate with one another for the peaceful uses of outer space.³⁸

The messages were viewed with much satisfaction (and relief) by members of the UNCOPUOS. It was a big step for minimizing the fear that the two super powers were militarizing outer space.³⁹ Each time another country registered the launching of a space object, clarifying its responsibility for the object and its peaceful purpose, trust and the room for cooperation was being reinforced among all nations.

The General Assembly also created the Office for Outer Space Affairs (OOSA) to assist the work of the committee and its two sub-committees. This office is now situated at the UN headquarters in Vienna, and coordinates activities of the committee with several other UN programs such as the Program on Space Application, the UN-Spider, and the International Committee on Global Satellite Navigation Systems. Furthermore, the OOSA and with the committees and its two sub-committees have worked extensively for the promotion of capacity-building and the application of space technology among developing nations.⁴⁰ They have supported several conferences on outer space, with special attention to the United Nations Conference on the Exploration and Peaceful Uses of Outer Space UNISPACE I (1968), which established the United Nations Programme on Space Applications in 1971, UNISPACE II (1982) and UNISPACE III (1999) all held in Vienna.⁴¹

UNCOPUOS and its two subcommittees work on a basis of consensus. The nature of the consensus procedure is that all members need to unanimously agree so that every decision is made in accordance with all members present. However, any country contrary to the majority can slow down the decision making process. Nonetheless, the committee has been fundamental over the years to assure the

³⁸ United Nations General Assembly 1962, p. 6.

³⁹ Ibid.

⁴⁰ Arevalo-Yepes 2010, p. 21-23.

⁴¹ United Nations Office for Outer Space Affairs 2013.

peaceful uses of space activities. All UNCOUPOS reports are sent for approval in the General Assembly, which works for most proposals, under a majority vote procedure with the present countries. Each country has one vote. Therefore, when consensus also cannot be reached by all member States within the UNCOPUOS, the committee sends the proposal to the General Assembly, which a two-thirds majority may approve or disapprove according to article 18 of the UN charter.⁴²

3.6 1992 Rio and Moscow Conferences

The United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, and the United Nations-sponsored International Conference on Conversion of Aerospace Technology in Moscow, Russia, both held in 1992, are examples of other mechanisms sponsored by the United Nations to address environment issues such as the outer space, during the Cold War.⁴³ Moreover, they produced policies that in the period were fundamental for the UNCOPUOS to continue of promoting peaceful and sustainable uses of outer space in the long term. Principal 2 of the Rio Declaration on Environment and Development, for example, states that in accordance with the UN charter, States have the sovereign right to explore their own resources within their jurisdiction, as long as they do not damage the environment of other States.⁴⁴

Since its establishment in 1958, the committee has created agenda items that strategically address cooperation for peaceful exploitations, and exploration of outer space through preventive diplomacy. It has been the responsibility of the committee to note new activities and develop-

⁴² United Nations 1945, p. 6.

⁴³ See Report of the Secretary-General 2013, p. 1. "United Nations, International Cooperation in Space Activities for Enhancing Security in the Post-Cold War Era."

⁴⁴ United Nations General Assembly 1992, p. 1.

ments in technologies that space-faring nations and the scientific community continuously unfold.⁴⁵

After the Rio 1992 conference, the United Nations sponsored conference held in Moscow in the same year. Both were essential for the conversion of space military technology. After the Cold War, the Soviet Union and the United States, the two super powers in outer space, were willing to negotiate about military use of space technology. For instance, they were willing to share details of Earth images made by remote sense satellite available only to the military. The Moscow Conference hosted 500 participants from member States, educational, governmental and non-governmental institutions. The conference produced a document called The Moscow Declaration, which presented important recommendations for the conversion of space technology.⁴⁶

The Report of the Secretary-General on the International Cooperation in Space Activities in the Post-Cold War Era, held in Rio de Janeiro Brazil, in 1992, well clarifies what was at stake for outer space. With the new world order, it was expected that space technology would increase its importance in our contemporary world. Turning aside from weaponization in space, the new order would create the possibility of space technology for civilian purposes. It could play substantive role for Earth's environment, and for development of economic, scientific and social services. UN-COPUOS, therefore, broadened its framework to promote a shift in the use of space technology from military to civilian purposes. This shift happened during the Cold War and meant that space had emerged from a threatening military into a political and diplomatic peaceful dimension.⁴⁷

⁴⁵ United Nations General Assembly 1959, p. 5-6.

⁴⁶ See Report of the Secretary-General 2013, p. 1. "United Nations, International Cooperation in Space Activities for Enhancing Security in the Post-Cold War Era."

⁴⁷ Ibid.

3.7 Chapter Conclusion

Outer space has always inspired poems and songs about human life, while awakening pertinent questions and suspicions about earlier beliefs. Man always tried to find answers about human existence: where humans come from, and if there is life as we know it outside our planet. Civilizations learned how celestial bodies behaved and use that knowledge to form the first calendars based on the patterns of the Moon and the Sun.

With World War I and II, the world saw the development of long range rockets that were used as missiles to deliver bombs. Werner von Braun is considered the father of modern rocketry by his successful launch of the A4/V2 rocket on October 3rd, 1943 in Nazi Germany. His rocket became the primogenitor of space launch vehicles after the wars when he and his team collaborated with the U.S military. However, this use of military power created fear that nations would use the atmosphere to deliver nuclear bombs, which was never occurred.

The Cold War launched a competition between the two super powers, the U.S and U.S.S.R, vying with each other to be the first and best space-fairing nation. The war also created fear that those nations would use outer space for military purposes, including using nuclear warheads. The U.S.S.R pioneered many space activities including sending the first satellite, the first man and woman, and making the first human space walk. Humankind was able to realize many accomplishments in outer space: dreams come true. However, with its many risks and some deadly accidents, space has also created the long term problem of space debris. All nations and leading world organizations, especially the U.N have great interest in space affairs. Important steps are taken in multinational collaboration for peaceful uses of space technology have been reviewed above. The following those space affairs have been in the interest of all nations and leading organizations, including the United

Nations Committee on the Peaceful Uses of Outer Space and its two subcommittees: the Scientific and Technical and the Legal Subcommittees.

Chapter Four

Space Debris

4.1 Definition

What is exactly the definition of space debris? According to the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (SDMG), space debris is “all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional.”⁴⁸ Space debris has had other more popular definition definitions like space junk, space trash, or space refuse.

As Lotta Viikari points out in her book “The Environmental Element in Space Law,” space debris could be any non-functioning man-made object in space as whole or parts of it, for instance: “entire mal-functioning satellites, spacecraft painting flaks, liquid fuels, coolant droplets, objects accidentally dropped by astronauts during space walks, garbage dumped in outer space by manned space missions.”⁴⁹ There are reports that a bag full of tools, bent CDs, pens, a screwdriver and eve a glove accidentally dropped by Astronauts during space walks and left in orbit are also named debris.⁵⁰ Absolutely any object or part of an object that man has made, located in outer space, not functioning and over which man has no control over it, is named space debris.

⁴⁸ Similar definition of space debris has been given by many international space related organizations, but currently there is no legally binding definition of space debris. Many legal texts have used the definition given by the COPUOS-STSC. See Earlier achievement of the UNCOPUOS session in chapter V.

⁴⁹ Viikari 2008, p. 32.

⁵⁰ “Lost in space: the killer screwdriver,” The Guardian. Sills 2004, p. 1.

4.2 A Trajectory Before Space Debris

Before addressing what causes space debris, what created it, and where it is located, it is necessary to understand a little about the launching process of satellites. A Satellite is defined as an object circulating a larger one.⁵¹ The Moon is our natural satellite, but humankind has created many objects, vehicles or crafts, and put them in Earth's orbit, calling them spacecrafts or artificial satellites that have numerous component parts and normally one purpose, named its mission.

Spacecrafts are designed for a specific mission. Indeed, they look much less impressive than what scientific-fiction movies show. They also contain components that could be characterized into two big categories: the payload and the bus. The payload is set of components, true paraphernalia, which operates the mission of the craft. For every mission, there is a type of payload to attend that mission, with a specific focus, named subject. For example, if the mission of a satellite is to monitor the Amazon Forest in Brazil, its payload is usually made for only that mission, and the subject of the mission would be the Forest.⁵²

The bus is no less important than the payload. It has the important function to support the payload. While the payload is the primary set of components in a satellite, the bus is the sub-set of all the components that helps the payload accomplishes its mission. So the bus is composed by the fuel system, the heating system, the electric system, and the like. It also provides communication with the ground stations, for controlling speed and direction. It helps the ground make sure the payload is moving in the correct time and place.⁵³

⁵¹ National Aeronautics and Space Administration 2013, p. 1.

⁵² Sellers, et al. 2005, p. 15.

⁵³ Ibid.

To launch a spacecraft, it is necessary to use launch vehicles which containing rockets. Rockets are powerful engines that blast from the launch pad lifting the craft away from the drag of Earth's atmosphere. Because of the weight of spacecrafts and space shuttles, one single rocket is not enough to send the craft into outer space. Usually launch vehicles contain three rockets, one big and two smaller. Those smaller rockets are named stages. In some launches where the launch vehicle is not able to deliver the spacecraft all the way to its final orbit, it delivers the object to a parking orbit. From there it travels through a transfer orbit until it reaches its final orbit. So there are three main orbits during the launch process: the parking, the transfer and the final orbit. The final orbit is a fixed path where the craft will travel, and it usually has an oval shape around Earth. Orbits are chosen carefully with much calculation as to where the payload should point its antennas, mirrors and other instruments, so that the satellite can fulfill its mission. To reach its final orbit through from a transfer one, the object uses another kick given by an upper stage, or little rocket engines called thrusters. These are located in the craft itself.⁵⁴

By reading a little about the process and components of a space mission, one can realize its complexity and appreciate how difficult it can be.⁵⁵ It really requires an expensive facility to design, build, and launch spacecrafts. Unfortunately that is an asset few countries have. Building a mission operation system, which is composed of ground and space-based infrastructure to control satellites is extremely costly. It is also very costly to maintain an expert flight-control team to operate launches and satellites once they

⁵⁴ Sellers, et al. 2005, p. 18.

⁵⁵ There are certainly more details on different orbits, rockets and spacecrafts' components. However, for the purpose of this master thesis, the technical information present here are sufficient for the understanding of how space debris are formed and in which orbits they are most present.

are in outer space. Because of that, the work of the United Nations Committee on the Peaceful Uses of Outer Space is fundamental to encourage countries to share data gathered from satellites; especially for natural disaster management and response, and advance fair and equal opportunities to explore space in sustainable manner.

4.3 The Causes of Space Debris

Now that the general process of sending satellites into space and satellite components have been explained, it is time to understand what causes space debris. According to the United Nations Space Debris Mitigation Guidelines (UN-SDMG) the main cause of debris has historically been accidental or intentional break-ups of space man-made objects and debris intentionally created during launch of space vehicles and satellites.⁵⁶

Break-ups really represent the major cause of debris. They account for 40 percent of all fragments of space objects that has been cataloged so far.⁵⁷ There are many other sources of space debris, such as intentional or unintentional explosion of spacecrafts' components. Basically, everything sent out from Earth to outer space could potentially become space debris or create space debris by colliding with other debris or functioning space objects. The cascade effect of space junk is also called the Kessler Syndrome, mentioned in the last chapter about the UNCOPUOS.⁵⁸ Space debris is a problem that continues to expand, and it will take hundreds of years for space-faring nations to mitigate the situation.

⁵⁶ United Nations Office for Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" 2010, p. 1.

⁵⁷ Viikari 2008, p. 35.

⁵⁸ Don Kessler, a former NASA scientist, is considered one of the first to discuss about space debris in the 70s. His research initially covered fragments of celestial bodies and later include man-made objects. See Gilbert 2013, p. 1.

Other sources of space debris are rocket bodies and orbital stages. Those, as explained before, are used to propel spacecrafts out of Earth's orbit and have no technology to be brought back. They are supposed to burn safely through the atmosphere without causing property damage on Earth's surface. Without these rockets and orbital stages, it would not be possible to deliver the payload, which is the most important part of the spacecraft and performs the satellite's mission.⁵⁹

Many spacecrafts have become space debris mostly because of breakups and explosions, which can be accidental or intentional as part of a mission process. Rockets, orbital stages and spacecrafts are the origin of most debris, but refuse left by manned space missions and dumped into outer space is also included.⁶⁰ It is important to know that space-faring nations have recognized that it is necessary to avoid creating more space debris. At stake now is when, how and who will clean up the existing debris in a quick and efficient manner.

4.4 Major Events Creating Space Debris

Accidental collisions and intentional satellite collisions are the major events creating space debris. This is the case of anti-satellites technology (ASAT) and the anti-ballistic missile (ABM) programs of the Soviet Union and the United States and China. The programs consisted of ballistic interceptors launched from airplanes flying in high altitudes and also laser based on the ground.⁶¹

The first major accident is the crash of the Soviet nuclear (uranium) powered satellite Cosmos 954 on 23 January 1978 in Canada. The satellite was launched on 18 September 1977, but weeks later it lost control until it finally hit the ground. The accident was also the first one where a

⁵⁹ Viikari 2008, p. 35.

⁶⁰ Ibid.

⁶¹ Grego 2012, p. 2.

State filled a claim against another for property damage. The Soviet Union paid Canada about three million Canadian Dollars for the damage the defunct satellite caused in Canadian soil. However, Canada estimates that the cleanup costs were actually above 14 million Canadian dollars. The accident is so far one of the most dangerous in space history because the defunct satellite contaminating with uranium radioactive debris large parts of the country. This is indeed an important example of the risks of space debris and the use of nuclear power sources in outer space.⁶²

The Soviet Union was the first to create an anti-satellite project as part of their strategic defense program during the Cold War. The first Soviet ASAT missile, namely IS ('Istrebitel Satellite,' satellite destroyer) was successfully launched on November 1, 1963. From 1968 and 1976, the Soviet launched a series of AST missiles hitting successfully targeted satellites. The Soviet program was also a response to the U.S space shuttle program of early 1970s. The Soviets were able to develop several AST projects, including the ground base lasers, manned and unmanned satellites interceptors.⁶³

In response to the Soviet AST program, the U.S. began developing their AST technology in the late 1950s. Later the U.S Air Force and Navy created a ground-based laser technology, MIRACL, first tested in 1997 hitting a satellite at 420 km of altitude. They called it kinetic-kill or hit-to-kill technology.⁶⁴ On 20 February 2008, the United States military successfully launched a hit-to-kill missile to intercept the USA-193 satellite launched on 14 December 2006. The object had a highly classified payload, which indicates it was a spy satellite, and it was operated by the National Reconnaissance Office (NRO). A few hours after it entered in orbit, the US military lost total control over the spacecraft,

⁶² Schwartz and Berlin 1987, p. 677.

⁶³ Encyclopedia Astronautica 2013, p. 1.

⁶⁴ Grego 2012, p. 2.

and later decided to destroy it. The decision came after it was confirmed that the satellite was falling into the atmosphere, and its fuel tank of the craft was carrying 453.59 kilos of hydrazine, a very hazardous material, threatening both the space environment and the functionality of other satellites. USA-193 was hit despite its speed of over 7.560 kilometers per second. No explosive was necessary in the hit-to-kill operation.⁶⁵ Even with no use of explosive, the hit created hundreds of debris.

On 11 January 2007, China also made use of hit-to-kill technology to destroy the FY-1C meteorological satellite creating hundreds more space debris fragments. According to the report of the International Interdisciplinary Congress on Space Debris Remediation and on On-Orbiting Satellite Servicing at the STSC forty-ninth session, held in February 2012, named "Active Debris Removal – An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space,"⁶⁶ the F-1C collision presently accounts for 40 percent of the catalogued debris. This makes it the largest event creating space debris in history. The move caused a stir about the Chinese. Their military might overtake the United States and Russia's predominance in space. The Chinese Foreign Ministry spokesman Liu Jianchao had officially reported the plan to the United States, Japan and other allies. His statement reinforced China's previous commitment for the peaceful uses of outer space. Jianchao's statement also vowed that the country is not trying to create another space race competing against the United States and Russia.⁶⁷ Neither China nor the U.S. used any explosive making their hits.⁶⁸

⁶⁵ "Missile strikes a falling satellite falling from its orbits," The New York Times. Shanker 2008, p. 1.

⁶⁶ UNCOPUOS-STSC Forty-ninth session 2012, p. 16.

⁶⁷ "China confirms satellite downed," News. Hollingham 2007, p. 1.

⁶⁸ The use of ASAT and ABM is thought also to be a protectionist strategy against spy satellites over countries space territories, once there is no legal universal definition of the delimitation of space. However, this theory has not been claimed by any nation. In my point of view, the

Article IV of the Outer Space Treaty does not rule out the use of military force in outer space but only ban the use of nuclear weapons or any other type of weapons of mass destruction in outer space. The article creates another dilemma of whether placing other kind of weapons in outer space is a legal act or not because it does not specify the scale of damage mass destruction represents to outer space.⁶⁹ A weapon that could cause little damage on Earth and thus would not be considered of mass destruction could actually make a mass destruction in outer space. Such is the case of the missiles used to destroy the FY-1C, as well as the USA-193. Both countries did not break any international law, nor specifically article IV of the Outer Space Treaty. However, they both created a massive number of space debris that fortunately until now has not injured or killed any person on Earth and astronauts in space.

According to the same report of the International Interdisciplinary Congress, another collision created twenty percent of the debris so far catalogued. That was accidental collision over Siberia on 10 February 2009 between the U.S. Iridium 33 communications satellite and the defunct Russian Cosmos-2251, another communications satellite.⁷⁰ The Space Surveillance Network of the United States (US-SSN) detected 700 pieces of debris that were created immediately from that collision.⁷¹ Later Information from NASA reported that so far the cataloged debris from Cosmos 2251 has reached 1603 fragments, while 84% of it (1342 fragments) is still in orbit. On the other hand, Iridium produced

press has over reacted on the Chinese anti-satellite test in comparison to those operated by the USA.

⁶⁹ United Nations General Assembly 1966, p. 4.

⁷⁰ UNCOPUOS-STSC Forty-ninth session 2012, p. 16.

⁷¹ See current data on the collision between Iridium and Cosmos satellites on the internet (<http://www.space-track.org>). For general information on space debris and other collisions, see NASA's Orbital Debris Quarterly News (<http://orbitaldebris.jsc.nasa.gov/newsletter/newsletter.html>).

fragments which 598 have been cataloged, while 80% of it (479 fragments) is still in orbit.⁷²

Space Debris, created by mal functioning satellites or those intentionally destroyed, have already caused some trouble on Earth but without fatalities so far. This is the case of Skylab in 1979, the world's first space station; an incredible massive NASA space laboratory of more than 78 tons that fell on Earth's surface and created over 500 fragments. It is the case also of a scientific satellite that fell in the Persian Gulf in 2002.⁷³ On 23 September 2011, the UARS, an elephant size defunct satellite weighing six tons operated by NASA, fell in Calgary, Canada, creating more than twenty-six pieces of debris, leaving it behind at between 482 and 1.287 kilometers of altitude. The UARS was the biggest piece of space debris to fall on Earth since Skylab, but thankfully it did not hurt anyone. Other examples of falling defunct satellites are the German Roentgen Satellite (2.4 tons) in 2011, the Russian Grunt Probe (13.5 tons) in 2012,⁷⁴ and one piece of debris fell in the small Northern Brazilian village of Anapurus, Maranhao State in 2012.⁷⁵

4.5 Tracking Space Debris

Tracking and cataloging space debris is not an easy task. Debris travels in space at high speeds in free fall around the Earth's atmosphere. Because there is not enough strength from Earth's gravity to pull debris immediately from outer space, debris can stay in orbit for a long time till eventually it falls back to Earth. In other cases debris is hit by other debris, satellites, space shuttles, or pushed out of the at-

⁷² National Aeronautics and Space Administration 2012, p. 3.

⁷³ "US warns out-of-control spy satellite is plunging to Earth," The Guardian. Harris 2008. See also National Aeronautics and Space Administration, Reentry of NASA Satellite 2011, p. 1.

⁷⁴ "NASA' UARS Re-Enters Earth's Atmosphere," NASA News Releases. Dickey and Cole 2011.

⁷⁵ "Space Junk Falls on Brazilian Village: Reports," Space.com 2012.

mosphere by solar waves. On a few occasion NASA reported hits of debris on its space shuttles.⁷⁶

The U.S Space Surveillance Network (U.S SSN), a program of the U.S Department of Defense (DoD), has tracked approximately 17.000 pieces of space debris larger than 10cm. It is expected that there are millions of fragments smaller than 10cm that cannot be tracked because of their size and speed which can reach thousands of kilometers per second.⁷⁷ Most of the debris 10 to 20 cm in diameter is found in the low Earth orbit (LEO – approximately 1500 to 2000 km in altitude) where the ISS flies. Other debris, larger than 1 meter in diameter is found in the Geostationary Orbit, also known as the geosynchronous Earth orbit (GEO - approximately 784 km) above the Equator.⁷⁸

Below, one can find two tables with the latest information from NASA space debris catalog. Table number 1's graphic also shows the quantity of cataloged debris. The first ones started to appear in 1957 with the launch of Sputnik-1 by the Soviet Union. In 1961, it was possible to see approximately 50 pieces of debris that could be tracked or estimated. That number has obviously increased and as of 2013 there are approximately: 100 pieces caused by rocket bodies (space vehicles and stages); almost the same number of Mission-related debris, that have come from the bus and payload themselves, like antennas, explosive bolts, vehicles shrouds, telescope lids and cracked mirrors. Approximately 2.500 entire spacecrafts have lost contact with the base on Earth. The various reasons include: regular end

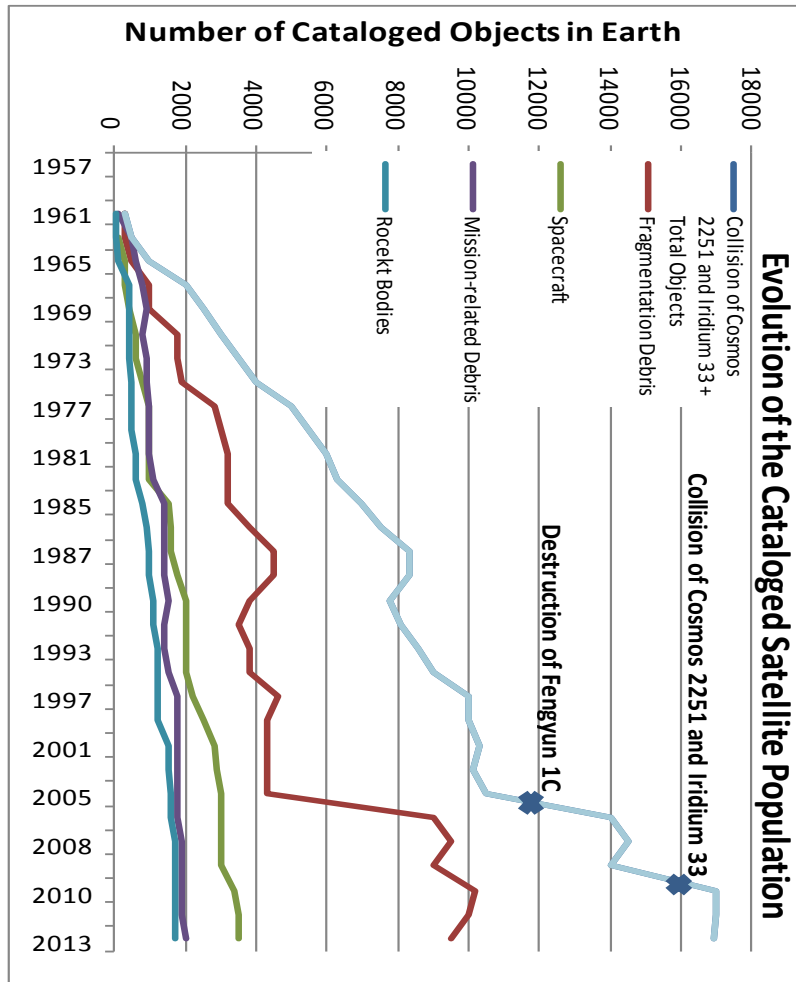
⁷⁶ National Aeronautics and Space Administration 2012, p. 8.

⁷⁷ The European Space Agency has the Database and Information System Characterizing Objects in Space (DISCOS), and Russia has its own space debris tracking system. Other countries have also their own space debris tracking system. However, the US-SSN is known for pursuing the latest technology and sharing the largest data of tracking space debris, according to Viikari 2008, p. 35.

⁷⁸ Viikari 2008, p. 34-35.

of mission or life expectancy, radioactive, electrical or mechanical problems, and collision with debris.⁷⁹

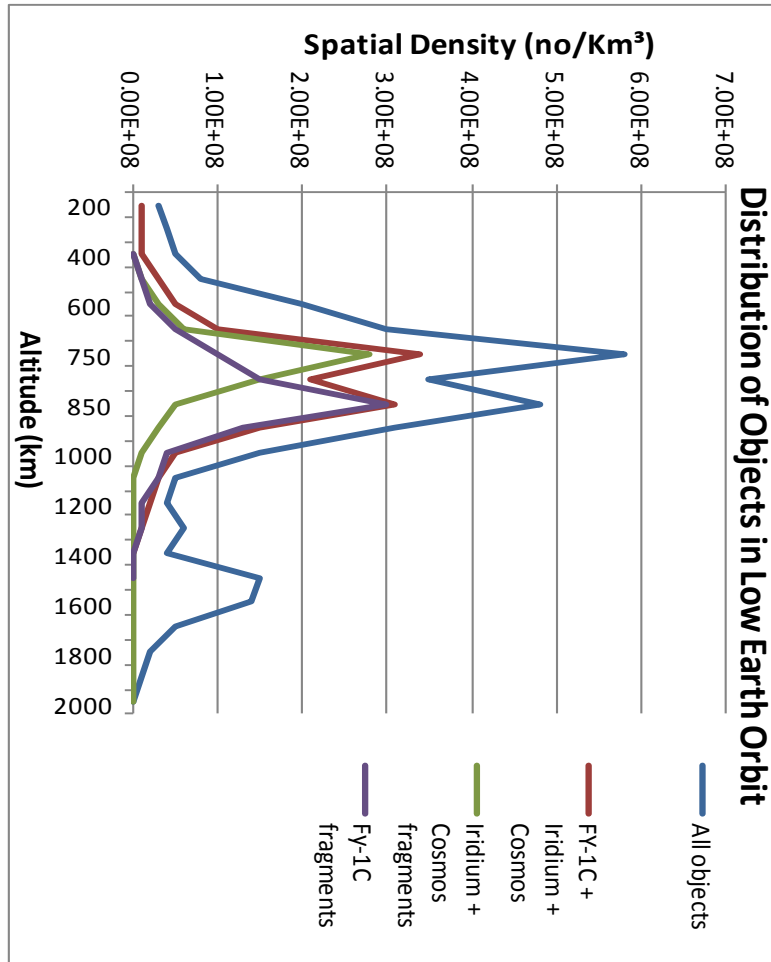
Table 1 Original Source: NASA Catalog of Satellite Population 2013⁸⁰



⁷⁹ National Aeronautics and Space Administration 2012, p. 3

⁸⁰ Ibid.

Table 2. Original Source: NASA catalog of objects in low Earth orbit (LEO).⁸¹



Then the fragmentation debris comes, caused by accidental break-ups or sometimes intentionally as mentioned before. Last but not least, the graphic shows the number of fragments caused by the destruction of the Chinese Fengyun-1C, the collision between Cosmos 2251 and Iridium 33, and the total number of cataloged debris in outer space: approximately 17,000 pieces larger than 10 cm in diameter,

⁸¹ National Aeronautics and Space Administration 2012, p. 4.

able to be tracked by the most advanced technology available.⁸²

In table number two, a graphic shows the altitude where the cataloged debris can be found. Most occupy a range of approximately 6 thousands km³ and are found between 700 and 800 km of altitude. In the graphic it is also possible to see the altitude where the fragments from FY-1C, Iridium and Cosmos mix together and also where their fragments are mostly separated.⁸³

This way, the two graphics have the newest data about space debris. Table number 1 shows the evolution of debris, including also the highest peak during the Iridium and Cosmos collision and the destruction also of the Fengyun-1C by the Chinese anti-satellite test in 2007. The table, however, does not provide information of the range of debris caused by the anti-satellite missile the U.S used to destroy its spy satellite USA -193 in 2008. Table number 2 shows the distribution of all objects in the LEO.⁸⁴

Even though 17,000 is the approximate number of cataloged objects, in reality, the SSN has identified approximately 23,000 space debris in the process of being cataloged and tracked. In May 2013, two spacecrafts experiences dramatic change in their altitude which makes NASA believed to be caused by space debris. The first incident happened on 22 May, when the NOASS's GOES 13 spacecraft (International Designator 2006-018A, U.S. Satellite Number 29155) altitude was abruptly changed. The craft had no damage and it was possible to send it to its original position. The second incident happened the next day on 23 May. Only one month old, the NEE-01 Pegaso 10 cm cube satellite (International Designator 2013-018B, U.S Satellite Number 39151) altitude was also abruptly changed. It was believed this small satellite had collided with a Soviet rocket body, but an assessment made by the SSN team did not

⁸² National Aeronautics and Space Administration 2012, p. 3

⁸³ Ibid., p. 4.

⁸⁴ Ibid. p. 3-4.

confirm that possibility because no new debris was created in the supposed collision.⁸⁵

Because space debris causes a threat mostly to functioning satellites and astronauts in the International Space Station, there have been a number of maneuvers in the sky to avoid collisions. Since 1999, the International Space Station (ISS), located about 300 km in altitude, also made maneuvers to avoid collisions with space debris. In 2012, there were three maneuvers: 13 January to avoid debris from Iridium 33; 28 January to avoid debris from Fengyun-1C; and last, 31 October to avoid debris from Iridium 33. On 24 March 2012, astronauts in the ISS had to shelter in the Soyuz spacecraft and be ready to escape back to Earth if necessary. The reason was debris from the Cosmos satellite was passing by relatively close to the station and there was not enough time to make a maneuver.⁸⁶

In table number three below, it is possible to see all the eight maneuvers supported by NASA to avoid collision between U.S satellites and space debris in 2012.

Table 3. Original Source: NASA. Maneuvers supported by NASA to avoid collision between U.S satellites and space debris.⁸⁷

Mean Altitude	Spacecraft	Object Avoided	Maneuver date
550km	GLAST (2008-029A)	Cosmos 1805	3 April 2012
700 Km	AURA (2004-026A)	Cosmos 2251 Debris	17 May 2012
	CALIPSO (2006-016B)	Cosmos 2251 Debris	2 October 2012
	CLOUDSAT (2006-016A)	Sinoh 1	8 September 2012
	LANDSAT 5	Agencia D state	1 July 2012

⁸⁵ National Aeronautics and Space Administration 2013, p. 8.

⁸⁶ Ibid.

⁸⁷ Ibid.

700 Km	(1984-020A)	Debris	
	LANDSAT 7 (1999-020A)	Fengyun-1C Debris Meteor 1-1- Debris	9 March 2012 17 April 2012
825 km	NPP (2011- 061A)	Agena D sta- ge Debris	1 February 2012

Most of the maneuvers were made in reference to fragments from the Cosmos 2251 satellite once operated by Russia. Only one maneuver was required to avoid fragments from the Chinese Fengyun-1C.

4.6 Risks for Satellites and People on Earth and in Outer Space

Functioning satellites and humans in space are most likely to be the first victim of space debris simply because they share the same “space.” As it was previously mentioned, debris can hit functioning satellites and pose a risk to astronauts. Chunks of debris have fallen on the Earth’s surface, like it did in Australia, Brazil, and Canada. However, there was no report of injured people or property damage so far. So, if the chance to be hit by space debris is nearly zero, then how can it affect our lives on Earth? ⁸⁸

An article from the British Broadcasting Corporation - Future (BBC), titled “What would happen if all satellites stopped working?”⁸⁹ brings light to the issue. The article, written by Richard Hollingham, discusses how much people depend on satellites and space technology but do not realize that they do. He pictures how would be the first hours of the day all satellites stop working for any number of reasons. That includes: space debris, and satellite breaking down, but also possibly massive solar storms, and even cy-

⁸⁸ As in page 45.

⁸⁹ Hollingham 2013, p. 1.

ber attacks. The loss of television satellite, for instance, would inconvenience of people watching their favorite television show in the first hours of the break down. Loss of phone and internet connection, which could cause quite a stir. The cut off to long distance communication would raise danger, especially for security staffs and world leaders. Global Positioning System (GPS) would not work, causing also confusion on the ground, in the sea and air traffic. In 24 hours, there would be chaos everywhere. If the problem persisted, it would bring long term damage to the environment as well. There would be no possibility to track climate change, or deforestation in the Amazon forest. It is most unlikely that all satellites would be hit by space debris and stopped working. Nonetheless, the article takes at what would happen in a smaller scale on a small scale if one crucial satellite stopped working. That is a more realistic scenario.⁹⁰

This article shows that people on Earth are more dependent on space technology than they might ever think. Space technology has been adapted in many ways to make our lives on Earth safer and more comfortable. Many of the inventions people use to relocate and communicate, like phones and GPS, are originally for military purposes that gradually became available to civilians after the Cold War.⁹¹ Space-faring nations have used cutting edge technology to facilitate the lives of astronauts in space, and have also shared much of that legacy back to Earth.

NASA was the major creator of much technology transported to civilian purposes. This technology can be seen in a typical Western house. In the bathroom, for example, one may find space technology present in ingestible toothpas-

⁹⁰ Hollingham 2013, p. 1.

⁹¹ See Report of the Secretary-General 2013, p.1. "United Nations, International Cooperation in Space Activities for Enhancing Security in the Post-Cold War Era."

te.⁹² In the toilet system and sewage treatment, aerospace engineers applied cutting edge technology to reduce the amount of water by recycling it with Bacteriostatic Water Softeners and using other fluids to clean toilet disposals in space. The same technology is being used on Earth for drinking water and to wash our hands. The appliance is called a water purifier or water filter. A polished Brass Finish, normally applied in the shower, is another one. NASA created that material to resist deterioration from salt and humidity. Now it is being used for plumbing. Space technology has also influenced other materials: comfortable and resistant shoes and clothing derived from space suits; pillows made of temper foam; and work surface desk bulbs. Space technology is present in portable x-ray devices; ultraviolet resistant sunglasses; wireless headsets and electric guitars; insulated paints; refrigerator internet connections and computer software programs of course; solar energy panels; enriched baby food. Space technology is common now in airplanes, automobiles, sports and public safety equipments, medical tools, in the manufacturing sector, and even in groceries.⁹³

As one can see, space technology is indeed present in one's everyday life, and it is also the key for monitoring agriculture, climate change, and has contributed to advance medicine, as well. This entire legacy is being jeopardized by space debris. One could call debris the anti-technology legacy. It is the other side of the coin, the dark side, for the most innovative technology humankind has ever. What

⁹² See webpage NASA@HOME AND CITY seen in 2013. As astronauts in the International Space Station are out of Earth's pull of gravity, in constant free fall skipping Earth, there is no running water. That means when water is released, it splashed in all directions but not down to the center of the Earth how it normally does with gravity. It's hard for them to rinse their mouth after brushing their teeth; therefore, the ingestible toothpaste was created so they can swallow it after brushing it, instead of spitting it out.

⁹³ Ibid. The author highly recommends seeing it for quiet surprising objects and trainings containing space technology developed by NASA.

began as very useful is now no longer helping. Instead it threatens functioning satellites and the entire space environment.

4.7 Chapter Conclusion

Space debris has potential to become the biggest environmental issue of the 21st century if the biggest space polluters do not create effective measures to clean up space.⁹⁴ In 50 years of major space exploration for scientific and military research, humankind has created over 23,000 pieces of space debris, of which approximately 17,000 have been cataloged and tracked. The main cause of space debris is breakups from spacecrafts, collisions among debris and functioning satellites, collisions made by accident or anti-satellite missiles, and solar waves. Space vehicles and their stages can become sources of debris. Debris includes mostly delicate parts of the satellites' bus and payload: cracked mirrors, lids of cameras and telescopes, fuel, paint flakes, but also tools accidentally dropped by astronauts during spacewalks.

Space debris may be tracked depending on its size and location. It does not usually pose a threat to individuals and property on Earth, but instead represents a risk to functioning spacecrafts and humans visiting or working in outer space, and to the space environment in general. Currently, space explorations have reached a tipping point because the increasing accumulation of space debris already com-

⁹⁴ Space debris has not become a visual environmental problem such as those caused by pollution and climate change, which can be immediately noticed by human kind. The effects of climate change can be visually seen through the disordered weather changed and rise of sea levels, and refuse can be seen blocking rivers and harming marine life. On the other hand, space debris cannot be seen by the naked eye from Earth. Therefore, it is mostly under concerned by society, which may counter argue that debris is not a dilemma yet. It is a dilemma that society can only see it in few occasions with the naked eye, when debris rarely falls on the ground.

promises space missions, which are always very expensive and the fruit of long term scientific research. As shown in this chapter, advanced levels of technology allow space-faring organizations to track and catalog space debris larger than 10 cm in LEO. This is a first step in debris mitigation treated at the United Nations, and which will be discussed in the next chapter.

Debris jeopardizes the development of space exploration and may halt the use of space technology back on Earth. The problem does not just limit the creation of new gadgets but against the observation of Earth's environment from space, which is facing rapid climate change. Debris represents a paradox for space technology. The same space technology designed to help the world achieve social and economic progress, has now become an anti-technology threatening that progress.

Chapter Five

The United Nations on Space Debris

5.1 Space Debris' Technical Dilemma

In the previous chapter the definition, causes and danger of space debris was explained. It is time now to discuss ways of mitigating it. Responses from space-faring nations to mitigate space debris can be grouped in three main spheres, just like also the UNCOPUOS and its two subcommittees. One finds political resolutions, legal principals and treaties, and then technical guidelines for efforts to mitigate space debris. These three spheres, most of the time, overlap at their basis so they must be understood with their interconnections.

The issue of Space Debris was not the priority of the UNCOPUOS at its creation. It was over looked the legacies of the Cold War. Only in 1994 did space debris officially entered in the Scientific and Technical committee's agenda, and even then after long resistance from developed space-faring countries.⁹⁵ The STSC adopted its own Space Debris Mitigation Guideline (STSC-SDMG) in 2007 under the General Assembly Resolution 62/217 of 22 December 2007.⁹⁶ The document includes considerations from the existing practice of mitigation, and proposals from nation states and from the Inter-Agency Space Debris Coordination Committee (IADC).⁹⁷

⁹⁵ Viikari 2008, p. 98.

⁹⁶ See Resolution adopted by the General Assembly on the report of the Special and Decolonization Committee (Fourth Committee). United Nations General Assembly 2007, p. 1.

⁹⁷ United Nations Office for Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," 2010, p. iii. The IADC is an international governmental forum for coordination of man-made space debris and natural debris. It is currently formed by 12 member space agencies. See www.iadc-online.org 2013.

The STSC-SDMG may be divided in two categories: the first category is more preventive and concerns about mitigating space debris in the short term by limiting mission-related space debris, and very importantly, limiting breakups. The second concerns mitigating space debris in the long run by creating mechanisms that remove defunct satellites, space vehicles and vehicle stages from the sites of functioning satellites and the International Space Station.⁹⁸ These guidelines are seven: 1. “Limit debris released during normal operations.” 2. Minimize the potential for break-ups during operational phases.” 3. Limit the probability of accidental collision in orbit.” 4. Avoid intentional destruction and other harmful activities.” 5. Minimize potential for post-mission break-ups resulting from stored energy.”⁹⁹ 6. “Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission.” 7. “Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.” Those guidelines are recommendations, thus non-legally binding, that countries should voluntarily adopt or adapt into their own debris mitigation mechanisms.¹⁰⁰

Despite the creation of the guidelines, there have been some major collisions, as shown in the Events Creating Space Debris section of chapter IV, the one between the Iridium 33 and Cosmos 225 satellites in February 2009, and the reentry of the UARS decommissioned satellite in Sep-

⁹⁸ United Nations Office for Outer Space Affairs, “Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space,” 2010, p. 1.

⁹⁹ The most effective way to minimize post-mission break-ups is the passivation of spacecraft. Passivation means the elimination of stored energy from storage devices and elimination of residual of propellants fluids. *Ibid.*

¹⁰⁰ *Ibid.*, p. 2-4. See the entire Space Debris Mitigation Guidelines of the UNCOPUOS in the annex I section.

tember 2011, leaving hundreds of debris fragments behind, broke guideline number 3. Also, China's anti-satellite missile test that destroyed its own Fengyun 1-C satellite in January 2007, months before the formal adoption of these set of guidelines, breaks guideline number 4. This shows that space debris continues as a dilemma for humankind because some countries have, either by accident or by choice, not been able to voluntarily comply with some of the UN guidelines.¹⁰¹

The expert group B, in the Working Group on the Long-term Sustainability of Outer Space Activities, proposed new guidelines during the STSC Fifty-sixth session in 2013. These are under discussion. The proposed guidelines are as follows: "B.1 Share space debris monitoring information; B.2 Ensure space debris mitigation measures are implemented;

¹⁰¹ While there is not a proof for this information, there are probably military reasons behind China anti-satellite test. As they tested the missile few months before the adoption of the Space Debris Mitigation Guidelines of the UNCOPUOS, they might have done so to avoid legitimate international pressure, giving them time to show themselves equal in the same hit-to-kill space technology of the United States. China and the United States have been global economic and political partners but competitors at the same time since early 1970s, when China opened its markets. Some scholars think there is a space race between the two nations - see "The New Space Race: China vs. The United States" by Erik Seedhouse 2010. While the author agrees there is space competition between the two countries, it is early to say it is a space race, if compared to the historical one between the U.S and Russia. During UNCOPUOS plenary meeting held in June 2013, the delegate from the Holy See (Vatican), which holds observer status within the UN, asked Mr. Charles F. Bolden, NASA's director, if the NASA and China would bilaterally cooperate for peaceful space activities. Mr. Bolden answered that U.S congress has so far prohibited bilateral cooperation, but the two countries are cooperating in commercial activities through multilateral partnership and data exchange. For other implications between China and the U.S, see the Report of the Center for Strategic & International Studies titled: "Chinese Soft Power and Its Implications for the United States: Competition and Cooperation in the Developing World." Carola McGiffert 2009. See also "China's Military Spending: Soft Rise or Hard Threat?" Sean Chen and John Fetter 2006.

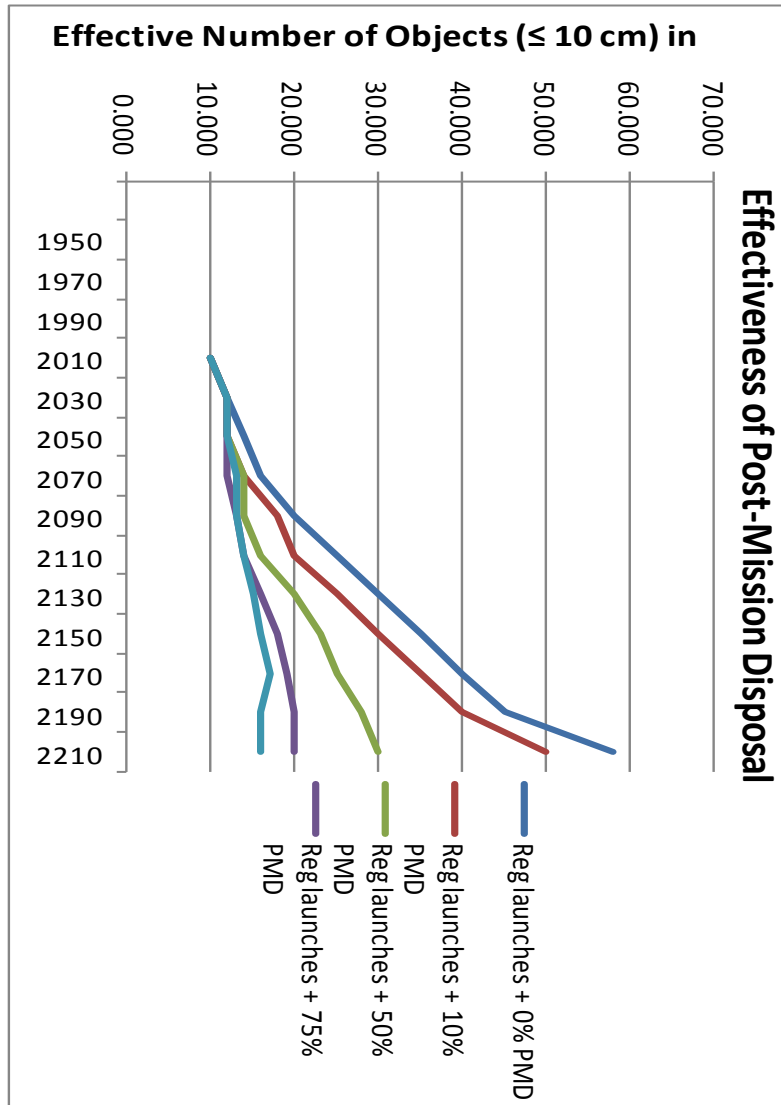
B.3 Limit the risk to people and property from controlled spacecraft and launch vehicle orbital stages re-entries; B.4 Investigate increasing the accuracy of orbit knowledge; B.5 Perform conjunction assessment during all phases of flight; B.6 Perform conjunction assessment prior to changes in trajectory; B.7 Provide other States with contact information for spacecraft operations and conjunction-assessment entities; B.8 Use standard formats when sharing orbital information on space objects; Provide registration information to assist in the identification of objects.”¹⁰² Those are new guidelines that are under consideration to be added in the current UNCOPUOS mitigation guidelines.

Table number 4 below shows a graphic created by NASA in which the organization estimates the aftermath of space debris if space-faring nations strictly follow the mitigation guideline number 5. By applying Post-Mission Disposal technology (PMD), it is expected that satellites’ owners will be able to return their spacecraft back to Earth, or to a safe haven in the LEO.¹⁰³ In the graphic, it is estimated that with the implementation of 75% of PMD, the emission level of space debris would fall to nearly 16.000 by the year 2210 in comparison to almost 60.000 if no PMD is applied. It is a long term commitment needing space-faring nations need to comply.

¹⁰² United Nations General Assembly 2013, p. 5.

¹⁰³ The author has heard many experts estimating to limit the life of all satellites to 25 years after launch. However, that information is not yet written in the UN Mitigation guidelines.

Table 4. Original Source: NASA. Expectation of debris mitigation according to Post-Mission Disposal.¹⁰⁴



Besides the PMD, other robust measures are being taken to mitigate space debris. A few space-faring nations and

¹⁰⁴ National Aeronautics and Space Administration 2012, p. 13.

related organizations have already developed methods to remove debris from space. Members of the International Astronautical Federation presented at the STSC fiftieth session, held in 2013, the technical efforts currently under way for debris removal. This is the case, for instance, of the U.S Active Debris Removal (ADR) and the Just-in-Time Collision Avoidance (JCA) Efforts.¹⁰⁵ According to the presentation, there are few technological options that could or have partially worked: The ElectroDynamic Debris Eliminator, using Earth's electromagnetic field to push debris against the atmosphere, which has worked; laser removal from the ground, which has not been proved efficient yet, but it could be a game changing advance, for it has no need to send another space craft into space, that could create new debris while removing the old ones. Tungsten Dust (JCA), sends a cloud of gas toward debris or a functioning satellite to avoid a collision.¹⁰⁶ It is imperative to know that every orbital solution brings costs and risks of creating new debris. Using launches always has the potential for creating more debris, consumes an incredible amount of power to propel the "cleaner" spacecrafts, and during operation these may cause more break-ups. NASA and the US Department of Defense (DoD) estimated that to remove about 30 to 50 debris fragments with ADR would cost from \$100 mi to \$1bi. With the JCA, moving debris away from a functioning spacecraft rather than removing it, the cost would be between \$10 mi. to \$10b.¹⁰⁷

This presentation has noted earlier that the United States is at odds with its removal debris program expenses. The country puzzles over whether it should pay the high costs and face the technical challenges to remove debris soon, or can wait develop new technologies to make the operations cheaper and less risky. This odd situation is part

¹⁰⁵ Mcknight 2013, p.2.

¹⁰⁶ Ibid. p 7.

¹⁰⁷ Ibid. p.13

of the dilemma space-debris poses to space-faring nations, the super developed ones and the developing ones. It is a common issue they need to deal with.¹⁰⁸

In line with the guidelines, the OOSA have created concrete educational initiatives to mitigate space debris and help countries develop sustainable ways of using space. The Basic Space Technology Initiative (BSTI), a program under the Space Application Section of the OOSA, is an example of programme created since the organization of UNISPACE III in 1999. BSTI has provided concrete example of capacity building, for instance, with the development of the Educational Curricula and the UN Regional Centres for Space Science and Technology Education since 1988. The centres have facilities located in developing countries such as Mexico, Brazil, Morocco, Nigeria, Jordan, and India. One more centre is scheduled to be open in China in 2013. The curricula already in practice are titled: "Satellite Meteorology and Global Climate, Communications, Space Science, Remote sensing and geographic information systems, and the Global Navigation Satellite Systems."¹⁰⁹

In October 2012, the BSTI initiated the creation of a master program named Education Curriculum on Space Engineering, which focuses on the creation of cube satellites by utilizing nanotechnology. The curriculum is expected to be finished by 2015. Cube satellites are satellites much smaller than the conventional ones, approximately only 10³ cm in diameter. They represent an approach for

¹⁰⁸ Many concepts have been developed to remove space debris. For complete list of the presentations and concepts see United Nations Office for Outer Space Affairs, Scientific and Technical Subcommittee: 2013 Fiftieth session 2013. The German on Orbit Servicing Mission DEOS has been published in the BBC article titled "urgent need to remove space debris," see <http://www.bbc.co.uk/news/science-environment-22299403> 2013.

¹⁰⁹ United Nations Office for Outer Space Affairs 2013. For more BSTI's activities, workplan, fundings, see "Activities in 2012-2013 and plans for 2014 and beyond." United Nations General Assembly 2013, p. 1.

mitigating space debris in the short term, the first category of the UN mitigation guideline. Cube Sats, as they are called, are smaller in size, have a smaller body (payload and bus), and therefore, cause less break-ups in space. They also contain more advanced technology (nanotechnology) to make them smaller than but, yet just as efficient as conventional payloads. This educational curriculum, which is a two year master course, was developed also with the volunteer help from airspace-engineers, worldwide related organizations and educational institutions. Work on the curriculum was officially initiated at the United Nations/Japan Nano-Satellite Symposium, held in Nagoya, Japan, October 2012.¹¹⁰

5.2 Space Debris' Legal, Political and Economic Dilemmas

As mentioned earlier, it was only in 2012 that this issue was raised for official treatment by the Legal subcommittee (LSC) in 2012. It entered into agenda item 11, General Exchange of Information on National Mechanism Relating to Space Debris Mitigation.¹¹¹ The late adoption of space debris into the agenda of the UNCOPUOS and into the agenda of the LSC delayed the issue of space debris mitigation from being discussed at the STSC. The STSC needed a solid legal consultation to define space debris for technical research

¹¹⁰ While interning at the OOSA, August to November 2012, the author had the opportunity to work directly on the development of the ECSE master program. He was responsible for collecting material, finding volunteer airspace engineers interested in contributing for the curriculum, presenting my results at the United Nations/Japan Nano-Satellite Symposium 10-13 October 2012, and making my own scope of the master program. See the author's internship report in the annex II section "Capacity Building in Basic Space Technology Development: Education Curriculum on Space Engineering." The announcement of the new Centre in China was made in June 2012 during the UNCOPUOS plenary meeting.

¹¹¹ United Nations General Assembly 2012, paragraph 136, p. 21.

on debris mitigation.¹¹² The LSC had previously other opportunities to place space debris on its agenda but chose not to do so until 2012.¹¹³

The reason for delays on part of the LSC is that creating legal frameworks and definitions of outer space activities poses philosophical and practical procedural questions: if the LSC adopts a legal definition for space debris, for instance, would it restrict the works of the STSC? In other words, should the LSC modify the definition created and in use by the STSC or should it wait and possibly have to modify it later? Which possibility would be more fare? There are no easy answers to these questions. What is most important to know is that both subcommittees are required to work together aiming to avoid philosophical and practical deadlocks.¹¹⁴ The dilemma for the space lawyer is well explained by Katrin Metcalf in her book titled “Activities in Space – Appropriation or Use?” with the following quote: “it has always been a dilemma of the space lawyer, to decide whether it is desirable to determine the law before situations have materialized, or if it is instead better to wait for factual developments even with the risk of waiting too long.”¹¹⁵

As mentioned before, with is no legal definition for space debris so far, there can be no legally binding instrument for reducing space debris. There have been debates over debris based on other treaties and principals. These may provide

¹¹² United Nations General Assembly 2012, paragraph 136, p. 21.

¹¹³ As notes Viikari in foot note 211, p.159 about the LSC report of the 45th session, paragraph.150. Previous attempts of including the legal aspects of space debris in the LSC report has been made as early as 1995.

¹¹⁴ This is an important discussion the author had witnessed during UNCOPUOS. If the LSC approves a definition for every space activity, it can be under scrutiny for being speculative and violating international rights. On the other hand, if it waits, worse complications from debris can develop. The LSC needs to use its uttermost judicial skills to balance prevention and remediation.

¹¹⁵ Metcalf 1999, p. 35.

light for the understanding of the pros and cons of legally binding instruments (hard law) and the role of non-legally binding instruments (soft law) in outer space. Inter alia State conferences and declarations such as the Rio Declaration on Environment and Development of 1992 and Rio+20 Declaration named “The Future We Want,” are examples of soft law instruments.¹¹⁶ Given that, it is quite clear that costs and politics are influencing the role of international law in outer space.¹¹⁷

Kai-Uwe Schrogl, in an article entitled Space Debris Mitigation, gives two reasons behind this lack of legal definition and binding rules for space debris. The first is that the most powerful space-faring nations do not want international law to regulate states that are not really space active. Schrogl goes further saying this problem was partially solved with the creation of the IADC, formed by the only twelve members with self sufficient launch and capabilities. The same who have shared information to the STSC-SDMG. The second reason is more based on costs. “Space-powers” do not want to bind themselves to international law because that means they would have to make expensive technical modifications to their launch vehicles and spacecraft. Schrogl also argues this view is slowly changed because these space-faring nations understand that space debris will be even more expensive in the long run.¹¹⁸ Until now, the STSC-SDMG are the only international regulations the world has for the members of the IADC circle and beyond.

Venezuela has strongly supported the Czech Republic’s argument that the STSC-SDMG are not sufficient to mitigate the debris issue. The country argues that international legally binding rules are needed. Venezuela stated during UNCOPUOS fifty-sixth session (2013) that approximately

¹¹⁶ Tronchetti 2011, p. 620.

¹¹⁷ Marboe 2012, author’s preface.

¹¹⁸ Schrogl 2010, p. 605-606.

22.000 man-made objects are in Earth's orbit, of which only 1.100 of them (5%) are functional. The rest (95%) are debris. At the same time, there are 32 nuclear reactors in Earth's orbit, 13 core fuel reactors, and 8 thermal radio generators. The entire mass of thermal radio and nuclear fuel is of approximately 150 kg while there are 1000 kg of radioactive fuel on board of the nuclear reactors in Earth's orbit.¹¹⁹ The United States counters that it is not yet time to create binding international laws. The country is proud to have been the pioneer in space debris mitigation technology and insists that its national debris mitigation effort is the core of the IADC mitigation guidelines, and the basis for the STSC-SDMG. This statement by the U.S during UNCOPUOS-LSC Fifty-second session reads:

“The distinction (between legally and non-legally binding space debris rules) is important because we sometimes hear the view expressed that the solution to the debris challenge is to elaborate technical debris mitigation guidelines into international legal obligations. Based on our experience, we believe States are motivated first and foremost by enlightened self-interest in the safety and sustainability of space activities. We do not believe that the force of legal obligations is necessary for states to take measures to mitigate debris...Given the evolving technical aspects of debris mitigation, and the practical, economic reality that existing platforms cannot be replaced overnight, we do not see the wisdom in ossifying debris mitigation standards onto international law at this time.”¹²⁰

¹¹⁹ Venezuela retorically asked in its statement during UNCOPUOS Fifty-fifth session 2013: in this perspective, what is the UNCOPUOS doing? See Republic of Venezuela's Delegation 2013, p. 1.

¹²⁰ Israel 2013, p. 4.

The two countries statements are a clear example of the impasse around space debris. Indeed the lack of a legal definition of space debris has caused political and economic multilateral issues, especially when it comes to liability questions. For this reason, it is important to reflect about our current space law system and admit that it is most likely not up to date for answering questions raised by advances in the application of space technology.

Some of these questions came up, raised by the Secure World Foundation, a permanent UNCOPUOS observer. In 2013, during the STSC Fiftieth session, it registered the following concerns: “Before interacting with a piece of space debris, does the removing entity need to identify the Launching State (s)? What if they cannot? What role does the Launching State (s) * State of Registry play in negotiating ADR contracts and operations?”¹²¹ Many questions were asked regarding the use of laser to eliminate space debris from the ground: “How do you prove to other satellite operators that their satellites won’t be accidentally ‘dazzled?’ The U.S military currently operates the Laser Clearing House. Do we need an International Laser Clearing House?”¹²²

Those were questions with no easy answers, but nonetheless, they have been put on the table for discussion. In addition to the Czech Republic, Venezuela and the Secure World Foundation, the report of the UNCOPUOS Working Group on National Legislation Relevant to the Peaceful Uses of Outer Space on the work conducted under its multi-year work plan of 2012, also confirms a growing concern about liability: “The working group noted that the Convention on Liability for Damage Caused by Space Objects contained a liability regime with no ceiling.”¹²³ In addition, the report

¹²¹ Secure World Foundation 2013, p. 3-9.

¹²² Ibid.

¹²³ United Nations General Assembly 2012., paragraph 25-26. For further work on the need of a regulatory aviation and space, see Jakhu,

confirms that some nations are indeed trying to avoid liability over space objects: “the working group observed that it was in the interest of all States engaging in space activities to protect themselves against international liability.”¹²⁴ Liability is about damage compensation, and therefore it is in the interest of most States to protect themselves against charges. This is very crucial to understand the dilemma because if a legally binding liability law on debris is adopted, all countries will bind to it, but the most space active countries will eventually be the most liable. This is the reason why the United States, for example, has been more concerned than other countries on creating binding rules for debris because they have been the most active in outer space.

This is a long debate taking place at the UNCOPUOS. However, lacking an updated legally binding system to accommodate space issues in the 21st century may eventually turn the system to Anarchy. An anarchical system can be described as one without rules in which parties allow themselves to act according to their own interest without respecting the rights of other members in the system. Given that definition and the landscape of space debris proliferation, the only criteria for principals that might prevent the debris situation from falling into the category of Anarchism would be the common interest of States to mitigate the matter. The dilemma represents a non-zero sum game in international relations, because all States have recognized a common interest to mitigate debris.¹²⁵ Nonetheless, they face a complicated procedure in deciding together whether non-legally binding rules are enough or legally binding ones are necessary. Also the economic question remains about if it is the right time to pay high costs for sustainable space technology.

Sgobba and Dempsey 2011, “The Need for a Regulatory Regime for Aviation and Space.”

¹²⁴ Ibid., paragraph 26.

¹²⁵ Akinboye and Ottoh 2005, p. 79.

Knowing this, is it correct to say space debris anarchy circling above world space programs, waiting to fall upon the entire orbital system? It would seem that yes would be the answer for that question. In addition to the accidents that have created space debris, there are the non-accidental ones, which include anti-satellite technology tests by the United States and more recently by China. These could represent a measured show of power and a sign of renewed militarization of space. Although the STSC-SDMG were voluntarily adopted after those tests, there are continuing concerns over debris which those launching states did not take into consideration. Lastly, it is correct to point out that it is unethical and morally wrong that some States do not want to adopt a legally binding regime on debris simply because of the high cost sustainable technology would impose on them.

This is evidence of the misuse of space by space-faring nations and organizations in private or public sectors that created space debris as a result from a lack of legally binding rules. They have created millions of debris fragments and many problems within the space community. Since space debris is not yet legally regulated, there are a few who have been persuaded with side talks - non-legally binding instruments,- to act according to some common interests. However, no one can guarantee that they will avoid creating more debris.

Article 1 and paragraph (d) of the Convention on International Liability for Damage Caused by Space Objects, defines space objects as “component parts of a space object as well as its launch vehicle and parts thereof.”¹²⁶ Also article III of this convention and article VII of the Outer Space Treaty, both say that launching States are liable for any

¹²⁶ United Nations Office for Outer Space Affairs, Convention on International Liability for Damage Caused by Space Debris 1972. Besides the lack of a legal debris definition, the Liability Convention two definitions of launching states overlap: A state which launches or procures the launching of a space object; A state from whose territory or facility a space object is launched. Ibid., article I (i) and (ii).

damage caused by the components of their space objects on Earth and in Space.¹²⁷ Space debris could fall into that category, and the legal wrangle over the definition would be solved. However, the component definition does not include the STSC technical definition of space debris seen in the beginning of chapter IV which says debris is composed of non-functional components nor does include a legal definition because there is none. Some countries, like Czech Republic and Venezuela push for the acceptance of the STSC-SDMG as legally binding. Therefore, the five treaties mentioned in chapter three, which are the only legally binding space law in force until now, are ambiguous and not designed to rule on debris.¹²⁸ Thus liability questions over debris removal cannot be answered.

Both views in favor and against binding instruments are noted in the LSC report on its fifty-first session held in March 2012. Paragraph 46 on section III "Status and application of the five United Nations treaties on outer space"¹²⁹ says that some States find non-binding solutions in the treaties more realistic. Paragraph 141 notes that some states have implemented the UN and IADC space debris mitigation guidelines. On paragraph 147, it also states that some delegations wish that the space debris issues be treated in a way that will not jeopardize the development of space technology of space-faring nations, especially their own developing nations. Paragraph 148 also reports that some delegations would like to have the Space Debris Mitigation Guidelines go through legal analysis. While in paragraph 150, other delegations go further to specify that the guidelines should not be only legally analyzed, but also transformed in principals (non-binding) that the General Assembly should adopt.¹³⁰

¹²⁷ United Nations General Assembly 1972, p. 10

¹²⁸ Ibid.

¹²⁹ United Nations General Assembly 2012, p.10-23.

¹³⁰ United Nations General Assembly 2012, p. 9-23.

The LSC report of 2013 reflects similar views. Some delegations, (looking at section III “Status and application of the five United Nations treaties on outer space,”) state that the treaties should be reviewed without undermining peaceful cooperation in outer space (paras. 40 and 45). In section X, “General exchange of information and views on legal mechanisms relating to space debris mitigation measures, some delegations support taking into account the following: The work of the Scientific and Technical Subcommittee debris mitigation guidelines should go under legal analyses (paras. 144); Granting the guidelines a higher legal status may give the regulatory framework a global level (paras. 145); In paragraph 146, it says the LSC should develop a legally binding mitigation standards so that costs are not imposed on developing countries’ space programs. In Paragraph 147, it says the issue of space debris cannot be analyzed only through technological aspects or treated just on a voluntarily basis because incidents with debris could result in legal issues. In paragraph 150, it says the LSC should work with STSC for binding mitigation rules. However, immediately in paragraph 151, it says non-binding rules could be very effective if nations apply them domestically with their own space policy and regulation.¹³¹ Therefore, it really seems there are a greater number of views that support a review of the regulatory regime, including the five UN space treaties, and the creation of legal binding space debris mitigation guidelines. Only a lesser number are opposed.

It is noted in paragraph 109 of the Report of the Committee on the Peaceful Uses of Outer Space, Fifty-fifth Session (June 2012) that “some delegations expressed the view that the future of space activities largely depends on space debris mitigation and they urge countries that had not yet done so, to implement the STSC guidelines.”¹³² The views

¹³¹ United Nations General Assembly 2013, p. 9-22.

¹³² United Nations General Assembly 2012. The UNCOPUOS report of the Fifty-sixth session is currently not finished yet. However, similar

presented during the UNCOPUOS plenary meetings reflect from the work of the STSC and LSC sessions. It is crystal clear that our current laws and policies need to be updated to accommodate the debris and other challenges in outer space.

Given all that, what is the future we want for outer space? One may find answer for that in the “Note by the UNCOPUOS Secretariat on the Rio+20 and beyond,”¹³³ the United Nations conference on sustainable development. While the note does not directly address space debris, the entire document expresses the view that humanity wants sustainable development for the future of space activities. Paragraph 14, for instance, says that GA resolution 66/228 acknowledges the seriousness of space-technology-based data.

Yet in the same note, the Rio+20 reports that Space technology has played an important role for monitoring space weather and its impact in the world, climate change, agriculture and water resources. Because of this, reliable geospatial information will continue being key for the world economy and policy making, in a world that is daily more globalized and natural resources more scarce. Paragraph 16, addresses many other areas where space technology fits within the UN millennium goals of eradicating poverty, while also providing food security, water and sanitation and other human rights. Similar views are found in the “Post-2015 development agenda” from the same note.¹³⁴

For those reasons, the Rio+20 summits just reinforced the future “we” want. It is the sustainable space-technology needed so urgently today to mitigate space debris and safeguard space for the exploration of future generations. For this to happen, it is necessary that space-faring nations commit themselves to the peaceful uses of outer space.

views on space debris from the previous STSC, LSC and UNCOPUOS 2012 were expressed during the 2013 plenary session.

¹³³ UNCOPUOS Secretariat 2013, p. 2.

¹³⁴ UNCOPUOS Secretariat 2013, p. 10.

The Rio 92 and Moscow conferences helped open the doors for peaceful space activities to all nations after the Cold War, and the Rio+20 pointed the path where space-faring people need to walk.¹³⁵

5.3 Chapter Conclusion

Space technology started to become a fundamental subject for dialogue and multilateral cooperation among nations after the Cold War. UNCOPUOS was created in 1958 and became a permanent UN body, part of the UN family, and has shown institutional and multilateral leadership to deal with outer space challenges. Outer space challenges have also been discussed in numerous UN sponsored conferences. The end of the Cold War in 1991 brought new challenges to the United Nations and two important conferences were fundamental in dealing with the use of outer space technology for that new political arena. The first conference was held in Rio de Janeiro and the second in Moscow, both in 1992 after the Cold War.

Since its creation in 1958, UNCOPUOS has proved to be an important body to space cooperation and global coordination, improving space operations and capacity building. This cooperation would not be possible without the work of the UNCOPUOS and its two sub-committees. The committee has facilitated through the application of preventive diplomacy for the use of outer space activities to move away from global competition to global cooperation on regional, international and global levels. The OOSA has also played a significant role in facilitating the work of the committee to move space activities away from a military to a civilian character, making space technology gradually more applicable to society, the economy, and the environment, both in outer space and on Earth.

Indeed, there has been much work to do and obstacles to overcome. At the time during the Cold War when UN-

¹³⁵ Secretary-General of the United Nations 2013, p. 1.

COPUOS was created, the weaponization of space composed the biggest concern. In the 21st century, concern about the space debris that seriously threatens continuing activities in outer space is the biggest issue for countries, specialized agencies and educational institutions. The five United Nations Treaties and Principles on Outer Space are ambiguous and do not cover space debris because it became a dilemma only after the ratification of the treaties. An update of the treaties with legal binding rules instead of non-legally binding rules, called soft laws, to address the debris and other issues on outer space is currently under discussion. Some countries are in favor the creation of new rules while others oppose them for economic and political reasons. An update of the legal system is necessary to avoid a growing anarchy in dealing with more space debris. UN-COPUOS has increased to 74 members as to the year of 2013, and more countries are applying for membership. It is one of the largest committees in the United Nations System. With more members, there will be more pressure to change the system. It remains to be seen whether it will change or be left as it is.

Chapter Six

Concluding Remarks

It is unfortunate that in our modern society, progress has developed with a paradox to sustainability. Humans have taken many leaps forward by creating all kinds of fascinating inventions to communicate and move faster to places. The cell phone, the internet, the car and the airplane are only few examples. However, the use of those objects has always caused deterioration of the environment in the long term. With space technology the paradox has been the same. Space exploration has not accompanied green space technology, therefore our sky is now doomed with debris.

Humans became space-faring people when they were finally able to reach outer space with the help of high technological spacecrafts. The first time man successfully made a spacecraft circulate the upper atmosphere occurred in 1957 with the launch of Sputnik-1, Earth's first satellite. To become space-faring brought pride that only a few nations in the world could afford. It was a privilege of a few that has gradually become less expensive and more available to many nations, private, public and educational organizations. However, as space-faring persons, men also need to have laws. Without binding rules the continuing creation of space debris and failure to deal with related new space issues can spin their space efforts into anarchy.

To arrive at this point of peaceful international collaboration for outer space exploration, humankind went through an extended history of space flight. The wonders of space have inspired songs and poems for humankind, along with some superstitions. Early civilizations learned how to use the pattern of the stars, the Sun and the Moon to create the first calendars and guide themselves in long journeys over the ocean, and through the continents beyond. The Babylonians are considered as the first ones to have developed a Lunar calendar in 1500 B.C. The first astrono-

mers to actually develop a theory of the universe and the Solar system were at the same time philosophers. An example is Aristarchus of Samos, 270 B.C, who described the universe as Earth centered, as also did Ptolemy in 140 A.D. The assumption that Earth is central incorporated into the teaching of the Catholic and Protestant Churches but was later proved wrong by modern astronomers. As history progressed, humankind gradually developed a more accurate understanding of the Solar system. The Romans were the first to create airspace rules that became the basis for space law, until the beginning of the space age. Nonetheless, Modernity was the age of the space discoveries, or at least confirmations.

In the late 1500s that Copernicus, Klepper, Galileo and Brahe made important discoveries about our planetary system being Sun centered instead of Earth centered, and that Earth is rounded instead of flat. About a century later Newton consolidated the theories of the previous three mentioned, for example, about the pull of gravity. All the findings of the first astronomers together with the rockets developed by the ancient Chinese to use as fireworks or at battles against enemies, culminated in the successful launch of the first long range rocket in 1943, the A4/V2, created by the German scientist Werner von Braun, in Nazi Germany. After the loss of the war, von Braun with many other German scientists surrendered to the allies. This transferred the German technology to the U.S, U.K, and the U.S.S.R.

It was after World War II, during the Cold War that the Space Age became a reality. The U.S and the Soviet Union used the German technology to create rockets capable of launching a satellite and even people into outer space. The Soviets pulled ahead in the space race by launching Sputnik-1 on 4 October 1957, and few years later by sending also Yuri Gargarin, the first man, and Teresa Tereshkova, the first woman to outer space. The U.S was able to catch up in 1969 when Neil Armstrong set his feet on the Moon.

The Space Age was a reality that many early astronomers unfortunately were not alive to see. Nevertheless, it sparked a true explosion of excitement in the world of space-enthusiasts who were creating the first non-governmental organizations to promote activities in the areas of space-technology applications and space-law. Space exploration however, did not accompany sustainability. This means, humankind was able to reach outer space for pride and for scientific research, but did not measuring the consequences it was causing to both space and terrestrial environments. One of those outcomes has been the cascading effect of space debris, mostly created by intentional and unintentional break-ups of space crafts, space-shuttles, and objects accidentally dropped by astronauts while making space walks.

The United Nations, as the most important representation of world governments, has taken a lead in space-affairs. In 1958, a year after the launch of Sputnik, It created UNCOPUOS, the ad hoc Committee on the Peaceful Uses of Outer Space, primarily to respond fears of militarization and nuclear weaponization in outer space. UNCOPUOS began promoting the peaceful uses for human space activities. The ad hoc committee few years later created two subcommittees: the Legal Subcommittee (LSC) and the Scientific and Technical Subcommittee (STSC) to address legal and technical aspects of space activities, while the plenary concentrates in political aspects of space exploration. During its existence, UNCOPUOS, which is now formed by 74 member States in addition to other observing member organizations, has made several important contributions as the most important space governing body in the world. The five treaties and principals in outer space have been the main ones: Treaties and Principals Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967); the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer

Space (1968); the Convention on International Liability for Damage Caused by Space Objects (1972); Convention on Registration of Objects Launched into Outer Space (1976); and finally the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1984).

These Treaties and Principles Governing Outer Space is considered the “Magna Carta of outer space.” Those treaties (legally binding) and principals (non-legally binding) have guided space-faring nations and organizations on the use of outer space, while a vast array of non-legally binding instruments, called soft-law, has also been proposed.

Space-treaties, however, do not address subjects that have become major dilemmas in the 21st century. This is the case, for example, of the delimitation of the boundary between Earth and outer space, and the most urgent issue, namely space debris. Since the launch of the first satellite, Sputnik, space-faring nations have not been able to implement technologies that create less debris or effectively diminish it. Debris has multiplied from a number of accidental collisions between satellites, and debris was also caused deliberately by anti-satellite technology when tests in Russia, United States and China destroyed satellites in orbit, creating thousands of debris fragments. Technical procedures or simply technical failure of spacecrafts increase debris. Debris has many and continues to multiply by colliding as it travels on its own paths with more debris and take even longer to burn through the atmosphere. This is because either they are far off in their low Earth orbit (LEO), or because sun waves keep pushing them out.

NASA’s Orbital Debris Program Office and the U.S Department of Defense together have been able to track the largest amount of space debris to date. It is estimated that there are approximately 23,000 objects in orbit, and of those, only five percent are functioning objects. NASA has been able to track approximately 17,000 debris pieces larger than 10cm. Current technology at its best, allows without being too optimistic only the clearance of approximate-

ly, fifty pieces of debris annually. Debris flies in outer space at a speed of thousands of kilometers per second. It is a big danger to functioning satellites, astronauts and on a few occasions has fallen on Earth's surface but no fatality has been reported so far.

Debris causes space-faring nations political, legal, technical, and above all, economic dilemmas. It will not be possible to continue space exploration with debris multiplying at this rate. At the same time, States that have developed space technology do not want the creation of legally binding rules that will make them liable to States that are not technologically developed. In addition, countries like the United States have always been opposed to legally binding rules on debris. They fear that rules to speed up debris reduction would lock the new technology to immense costs. Therefore, for those nations, it is better to mitigate space debris on a volunteer basis by using non-legally binding instruments, and wait to develop a sustainable technology first, before creating the rules.

One example of a non-legally binding regulatory instrument for debris control is the United Nations Space Debris Mitigation Guidelines, adopted by the UNCOPUOS-STSC (STSC-SDMG) in 2007. The guidelines take into consideration proposals from various nations, but specially the Intern-Agency Space Debris Coordination Committee, a group formed only from technologically developed space-faring organizations. The guidelines are presented to be fully adopted or adapted on a voluntary basis. Some States who do not belong to the group such as Venezuela and Czech Republic, have insisted that the STSC-SDMG guidelines are insufficient; thus they need to be improved and then become legally binding.

Legally intervening in technological developments has always been a dilemma for space lawyers. Would they be acting too soon or too late? If they act too soon, they might impede new space achievements. If they act too late, they might miss the chance to avoid an inevitable worse future

impasse. The case of space debris is one in space lawyers are clearly missing their chances to avoid the worst. Until now space debris has no legal definition or binding rules, and a system without binding rules eventually may fall into anarchy, taking away from developing countries any opportunity to become space-faring. For that reason, it is recommended that the current space law system be updated to accommodate the issues raised in the 21st century. Whether this happens or not is the question waiting at UNCOPUOS.

Given all those circumstances, it is important to note some recommendations that might make the mitigation of space debris more viable at the United Nations. In the legal dimension, the first recommendation is certainly the adoption of binding rules on debris. Proposals for rules already exist and States need to encounter a common ground to adopt them. Non-binding instruments on debris are clearly not satisfying the demand to reduce debris. Second, in UNCOPUOS, it would be ideal to vote on issues with victory decided by the majority instead of the current consensus procedure. However, modifying voting from consensus to a majority, in line with the General Assembly practice presents a dilemma issue of its own which is not discussed in this thesis. The third and last recommendation falls into the technical category. It invites nations to rethink whether it is necessary to be authorized to remove debris from a third party. This is a point the five UN Space Treaties do not clarify. This procedure needs to be reconsidered because debris is simply debris and needs urgently to be removed. Any technical delay caused by bureaucracy is a step backwards for debris mitigation.

The future humankind wants for space is well expressed in the report of the UNCOPUOS-Secretariat on the UN conference Rio+20 and beyond, in the text titled "The Post-2015 development agenda and realizing the Future We want." Although it does not refer to space debris directly, it firmly states that Space-technology has been crucial for

humankind in this time of climate change to monitor water and our scarce natural resources. Therefore, it is the interest of all nations that the applications of space-technology be used for peaceful purposes, sustainably, and shared fairly with all nations, independently of their economic and technological development. Space should always be used for the benefit of all humankind.

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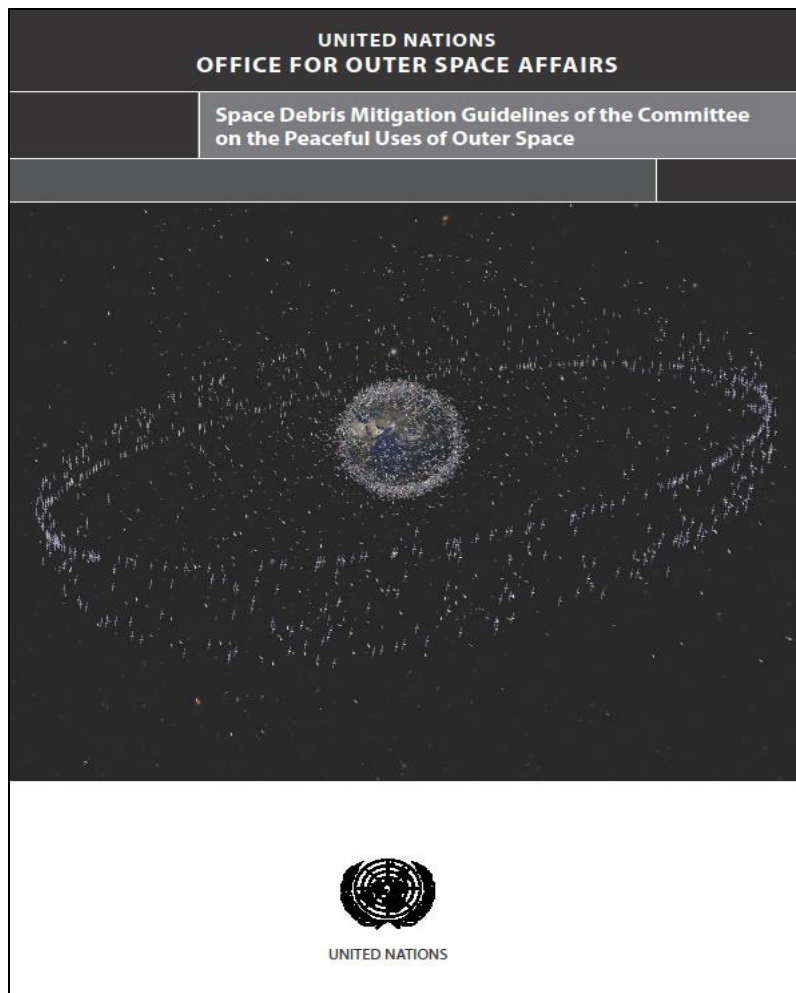
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Annex I Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space

Double click on the picture below, with the Microsoft Word version of the master thesis, to see the pdf version of the official Space Debris Mitigation Guidelines document of the Committee on the Peaceful Uses of Outer Space.

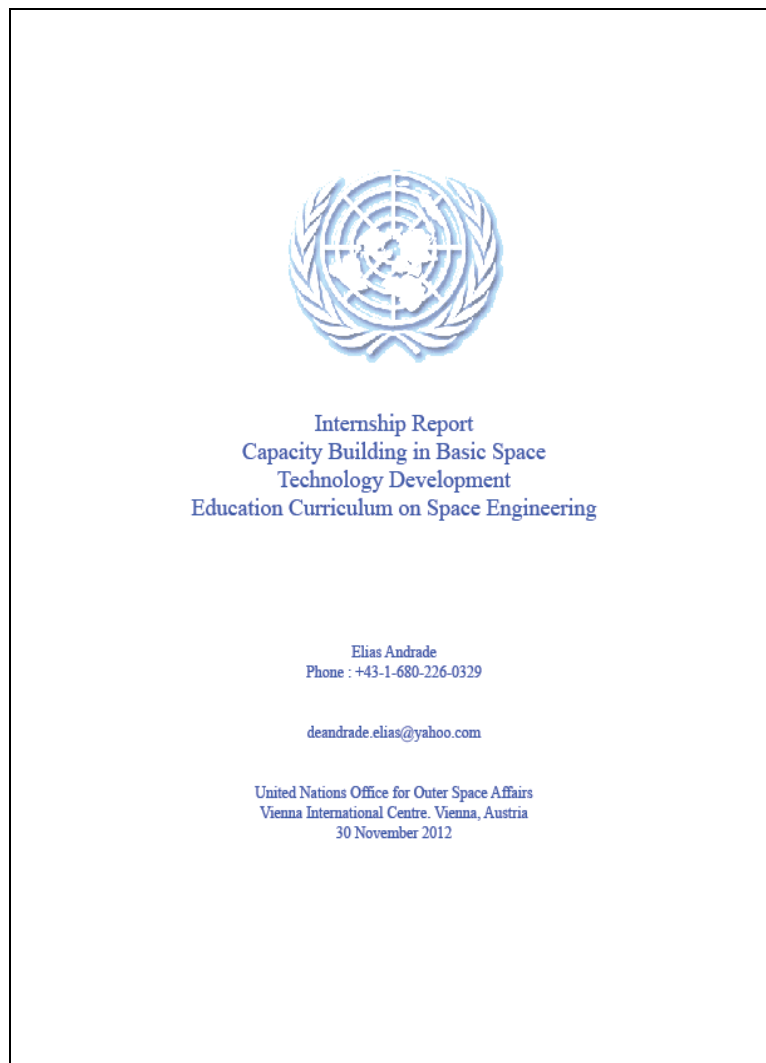


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¹³⁶ United Nations Office for Outer Space Affairs 2010.

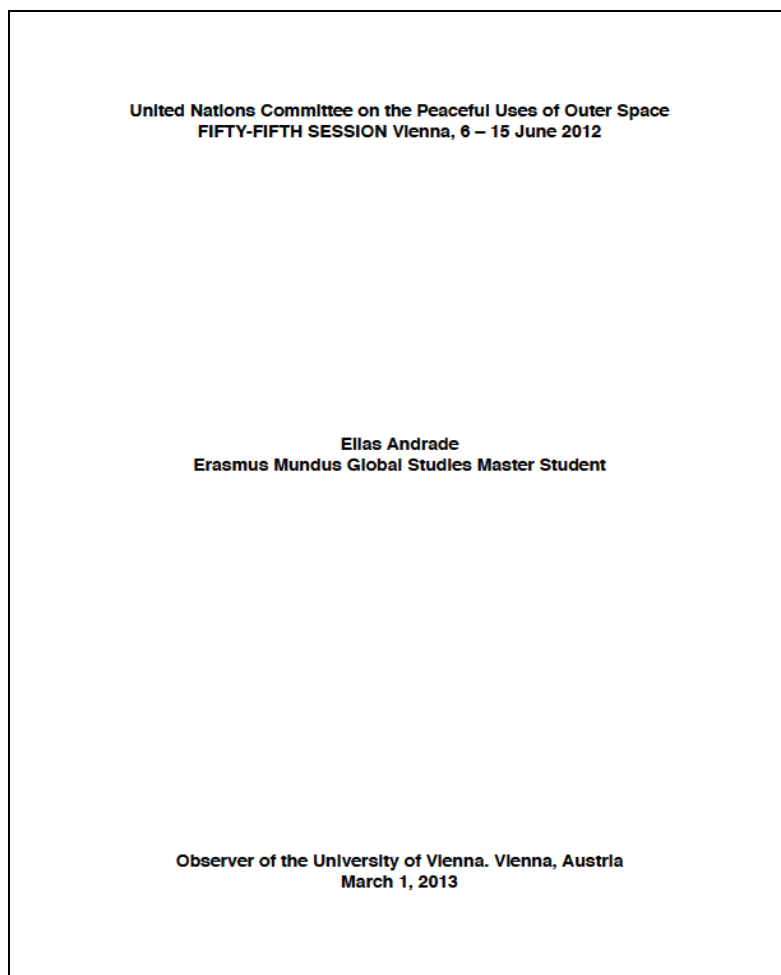
Annex II Author's Internship Report to the United Nations Office for Outer Space Affairs

Double click in the picture below, with the Microsoft Word version of the master thesis, to see the author's internship report for the United Nations Office for Outer Space Affairs in pdf version. The 30 page list of experts on page 35 have been purposely omitted to preserve people's identity.



**Annex III Author's Personal Notes of the Fifty-Fifth Session
of the Committee on the Peaceful Uses of Outer Space**

Double click in the picture below, with the Microsoft Word version of the master thesis, to see the author's personal notes of the Fifty-fifth Session of the United Nations Committee on the Peaceful Uses of Outer Space, Vienna, 6-15 June 2012.



Abstract

Outer space has intrigued philosophers and inspired poets and song writers. Early human civilizations learned how to use outer space long ago. Historians accredit the Babylonians, for example, with being the first ones to create a lunar calendar, based on the patterns of the Moon, Earth's natural satellite in 1500 B.C. Between the 15th and 17th centuries, astronomers such as Johannes Kepler, Tycho de Brahe, Galileo Galilei, and Isaac Newton made many important discoveries about our solar system. Their discoveries, together with the use of firework rockets developed by Early Chinese civilization, made it possible for the first rocket to reach outer space during World War II. In the Cold War, rocket technology had developed enough to let humankind send the first artificial satellites and manned missions outside the Earth's atmosphere. The Space Age had then become a reality, and after the Cold War ended with the fall of the Berlin Wall in 1989, more countries were able to move into the Space Age. However, the advent of space technology did not accompany sustainability, and that has caused much harm to the environments of the Earth and outer space. Such is the case of space debris, which are non-functional, man-made objects and their remains left behind in outer space. Since the Soviet Union launched Sputnik-1, Earth's first artificial satellite in 1957, countries have attached great importance to the peaceful uses of outer space activities. At that time, there was a growing fear of the militarization of outer space because of the rivalry between the Soviet Union and the United States. The end of the Cold War allowed for the possibility of the civil uses of space technology, which have greatly contributed to the world economy, social progress and the environment. In this master thesis, the author argues that space debris represents a dilemma for outer space activities, multilateral affairs, and space technology applications on Earth, and that space-faring nations should act faster to mitigate the

problem. While doing so, they should promote the peaceful and sustainable uses of outer space without damaging functioning spacecrafts or threatening human lives in space and on Earth. The author uses the United Nations Committee on the Peaceful Uses of Outer Space and related organizations as case studies of continuous multilateral work to mitigate space debris.

Key words: Space • History • States • Technology • Satellites • Debris • Multilateralism • Law • Policy • United Nations

Abstract in Portuguese (Resumo)

O espaço sideral tem intrigado filósofos, poetas inspirados e escritores de canções. As civilizações antigas aprenderam a usá-lo há muito tempo. Os historiadores acreditam que os babilônios, por exemplo, foram os primeiros a criar um calendário lunar, com base nos comportamentos da Lua, satélite natural da Terra, em 1500 a.C. Entre os séculos XV e XVII, astrônomos como Johannes Kepler, Tycho de Braille, Galileo Galilei e Isaac Newton fizeram muitas descobertas importantes sobre o nosso sistema solar. Suas descobertas, juntamente com o uso de fogos de artifício desenvolvidos por antigas civilizações chinesas, tornou possível a chegada do primeiro foguete ao espaço sideral durante a II Guerra Mundial. Na Guerra Fria, a tecnologia de foguetes tinha se desenvolvido o suficiente para permitir à humanidade enviar os primeiros satélites artificiais e missões tripuladas para fora da atmosfera da Terra. A Era Espacial tinha então se tornado uma realidade, e quando a Guerra Fria terminou com a queda do Muro de Berlim, em 1989, mais países foram capazes de entrar na Era Espacial. No entanto, o advento da tecnologia espacial não foi acompanhado por sustentabilidade, causando muitos danos aos ambientes da Terra e do espaço. Tal é o caso de detritos espaciais – que são objetos não-funcionais – e suas partes, feitos pelo homem e deixados para trás no espaço. Desde que a União

Soviética lançou o Sputnik-1 em 1957, primeiro satélite artificial da Terra, os países têm dado grande importância para os usos pacíficos das atividades no espaço sideral. Naquela época, havia um medo crescente de militarização do espaço por causa da rivalidade entre a União Soviética e os Estados Unidos. O fim da Guerra Fria viabilizou a possibilidade de usos civis da tecnologia espacial, que muito têm contribuído para a economia mundial, o progresso social e o meio ambiente. Nesta dissertação de mestrado, o autor argumenta que o lixo espacial representa um dilema para as atividades do espaço, assuntos multilaterais e aplicações da tecnologia espacial na Terra, e que as nações espacialmente ativas devem agir rápido para minimizar o problema. Concomitantemente, elas devem promover a utilização pacífica e sustentável do espaço sem danificar naves espaciais em funcionamento ou ameaçar vidas humanas no espaço e na Terra. O autor usa o Comitê das Nações Unidas sobre os Usos Pacíficos do Espaço Sideral, além de organizações afins, como estudos de caso contínuo sobre o trabalho multilateral para mitigar detritos espaciais.

Palavras chaves: Espaço Sideral • História • Estados • Tecnologia • Satélites • Detritos • Multilateralismo • Direito • Política • ONU.

Abstract in German (Zusammenfassung)

Das Weltall hat Philosophen fasziniert und Dichter und Sänger inspiriert. Frühe menschliche Zivilisationen haben gelernt das Weltall zu benützen. Zum Beispiel schreiben Historiker den Babyloniern zu die ersten gewesen zu sein, die einen Mondkalender im Jahr 1500 vor Christus erstellt haben. Zwischen dem 15. und dem 17. Jahrhundert haben Astronomen wie Johannes Kepler, Tycho de Brille, Galileo Galilei und Isaac Newton viele wichtige Entdeckungen über das Sonnensystem gemacht. Ihre Entdeckungen gemeinsam

mit dem Aufkommen von Feuerwerksraketen, entwickelt in der frühen chinesischen Zivilisation, machte es möglich, das erste Raketen das Weltall während des Zweiten Weltkriegs erreichen konnten. Im Kalten Krieg entwickelte sich die Raketentechnik weit genug, damit die Menschheit die ersten künstlichen Satelliten und bemannte Missionen außerhalb der Atmosphäre der Erde ins Weltall schicken konnte. Das Zeitalter der Raumfahrt wurde eine Realität und nachdem der Kalte Krieg mit dem Fall der Berliner Mauer 1989 zu Ende ging, war es für mehr Länder möglich geworden in das Zeitalter der Raumfahrt einzusteigen. Allerdings ging mit dem Beginn der Weltraumtechnologie keine Nachhaltigkeit einher, und dies hatte große Umweltschäden auf der Welt und im Weltall zur Folge. Das sieht man zum Beispiel am Weltraummüll, der aus nicht funktionierenden, von Menschen erschaffenen Objekte und deren Überreste im Weltall besteht. Seit die Sowjetunion mit Sputnik-1 den ersten künstlichen Satelliten der Erde 1957 gestartet hat, haben Länder der friedlichen Nutzung des Weltalls eine große Bedeutung zugemessen. Zu dieser Zeit gab es eine wachsende Angst vor der Militarisierung des Weltalls auf Grund der Rivalität zwischen der Sowjetunion und den USA. Das Ende des Kalten Krieges erlaubte die Möglichkeit der zivilen Verwendung von Weltraumtechnologie, welche viel zur Weltwirtschaft, sozialen Fortschritt und Umweltschutz beigetragen hat. In dieser Masterarbeit argumentiert der Autor, das der Weltraummüll ein Dilemma für Weltallaktivitäten, multilaterale Beziehungen und Anwendung von Weltraumtechnologie auf der Erde darstellt, und das die weltraumfahrenden Nationen schneller agieren müssten um das Problem zu entschärfen. In diesem Prozess sollten sie die friedliche und nachhaltige Nutzung von Weltraumtechnologie fördern ohne dabei funktionierende Weltraumfahrzeuge zu beschädigen oder menschliches Leben im Weltraum oder auf der Erde zu gefährden. Der Autor benutzt das United Nations Committee on the Peaceful Uses of Outer Space und verwandte Organisationen als Fallstudie zur kon-

tinuierlichen multilateralen Arbeit an der Lösung des Problems des Weltraummülls.

Schlüsselworte: Weltall • Geschichte • Staaten • Technologie • Satellit • Ablagerung • Multilateralismus • Gesetz • Politik • UN.

About the Author



(Image Credit: Elias Andrade)

Elias Andrade is an internationalist with ambitions to become an international officer at the United Nations or at another related organization. Originally from Recife, Brazil, he earned in 2007 a full sponsorship by the Chalfont Foundation, the Chateau Chantal Winery and friends to embark onto his academic and professional career in the United States and in Austria.

He started in Traverse City, MI USA in 2007 completing in July 2008 his first academic degree, the Associate Degree in Liberal Arts from Northwestern Michigan College in Traverse City, MI. After that, he received a grant for a Cultural Sharing Scholarship St. Cloud State University, in St. Cloud, MN, helping him complete his Bachelor of Arts and Science Degree with three majors: Global Studies, Philosophy, and Sociology, in 2010. After graduating with his Bachelor Degree, he received the tuition fee waiver from the Erasmus Mundus Global Studies – A European Perspective master program, where he is completing this two year master degree at the University of Vienna, cohort 2011-2013.

While doing his Bachelor Studies, the author had the great opportunity to intern in the headquarters of Amsted Rail, one of the largest steel companies in the world. He was responsible for managing senior Human Resources and Finance data in the Chicago, IL headquarters and in Sao Paulo, Brazil; also developing a contingency plan for the company's facility in the state of West Virginia. As a master student, he has had the great opportunity to intern at the United Nations Office for Outer Space Affairs (UNOOSA), working in the initial development of the United Nations Education Curriculum on Space Engineering; serving with the United Nations at the 63th International Astronautical Congress, Naples, Italy, and at the UN/Japan Nano-Satellite Symposium, Nagoya, Japan, both held in October 2012. Since the year of 2012 also, the author has accompanied the Brazilian delegation, as an observer, at the United Nations Committee on the Peaceful Uses of Outer Space and its two Subcommittees: the Legal and the Scientific and Technical Subcommittees.

**UNITED NATIONS
OFFICE FOR OUTER SPACE AFFAIRS**

**Space Debris Mitigation Guidelines of the Committee
on the Peaceful Uses of Outer Space**



UNITED NATIONS

Cover illustration: European Space Agency.

This image is an artistic impression. The sizes of the objects in relation to the Earth have been exaggerated for illustrative purposes.

UNITED NATIONS
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**Space Debris Mitigation Guidelines
of the Committee on
the Peaceful Uses of Outer Space**



UNITED NATIONS
Vienna, 2010

Preface

The Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space are the result of many years of work by the Committee and its Scientific and Technical Subcommittee.

At its thirty-first session, in 1994, the Subcommittee considered for the first time, on a priority basis, matters associated with space debris under a new item of its agenda (A/AC.105/571, paras. 63-74). In accordance with the agreement of the Committee, the Subcommittee considered under that item scientific research relating to space debris, including relevant studies, mathematical modelling and other analytical work on the characterization of the space debris environment (A/48/20, para. 87).

In addressing the problem of space debris in its work, the Subcommittee at its thirty-second session, in 1995, agreed to focus on understanding aspects of research related to space debris, including debris measurement techniques; mathematical modelling of the debris environment; characterizing of the space debris environment; and measures to mitigate the risks of space debris, including spacecraft design measures to protect against space debris. Accordingly, the Subcommittee adopted a multi-year workplan for specific topics to be covered from 1996 to 1998. The Subcommittee agreed that at each session it should review the current operational debris mitigation practices and consider future mitigation methods with regard to cost efficiency (A/AC.105/605, para. 83).

At its thirty-third session, in 1996, the Subcommittee agreed to prepare a technical report on space debris that would be structured according to the specific topics addressed by the workplan during the period 1996-1998 and that the report would be carried forward and updated each year, leading to an accumulation of advice and guidance, in order to establish a common understanding that could serve as the basis for further deliberations of the Committee on that important matter (A/AC.105/637 and Corr. 1, para. 96).

At its thirty-sixth session, in 1999, the Subcommittee adopted the technical report on space debris (A/AC.105/720) and agreed to have it widely distributed, including by making it available to the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), the Legal Subcommittee at its thirty-ninth session, in 2000, international organizations and other scientific meetings (A/AC.105/736, para. 39).

At its thirty-eighth session, in 2001, the Subcommittee agreed to establish a workplan for the period from 2002 to 2005 (A/AC.105/761, para. 130) with the goal of expediting international adoption of voluntary debris mitigation measures. In addition to the plan to address debris mitigation measures, it was envisaged that member States and international organizations would continue to report on research and other relevant aspects of space debris.

In accordance with that workplan, at the fortieth session of the Subcommittee, in 2003, the Inter-Agency Space Debris Coordination Committee (IADC) presented its proposals on debris mitigation, based on consensus among the IADC members. At the same

session, the Subcommittee began its review of the proposals and discussed means of endorsing their utilization.

At its forty-first session, in 2004, the Subcommittee established a working group to consider comments from member States on the above-mentioned proposals of IADC on debris mitigation. The Working Group recommended that interested member States, observers to the Subcommittee and members of IADC become involved in updating the IADC proposals on space debris mitigation for the Working Group's consideration at the next session of the Subcommittee.

During the forty-second session of the Subcommittee, in 2005, the Working Group agreed on a set of considerations for space debris mitigation guidelines and prepared a new workplan for the period from 2005 to 2007, which was subsequently adopted by the Subcommittee. The Working Group also agreed on the text of the revised draft space debris mitigation guidelines (A/AC.105/848, annex II, paras. 5-6), submitted the text to the Subcommittee for its consideration and recommended that the revised draft space debris mitigation guidelines be circulated at the national level to secure consent for adoption of the guidelines by the Subcommittee at its forty-fourth session, in 2007.

At its forty-fourth session, in 2007, the Subcommittee adopted the space debris mitigation guidelines (A/AC.105/890, para. 99).

At its fiftieth session, in 2007, the Committee endorsed the space debris mitigation guidelines and agreed that its approval of those voluntary guidelines would increase mutual understanding on acceptable activities in space and thus enhance stability in space-related matters and decrease the likelihood of friction and conflict (A/62/20, paras. 118-119).

In its resolution 62/217 of 22 December 2007, the General Assembly endorsed the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space and agreed that the voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number of national and international organizations, and invited Member States to implement those guidelines through relevant national mechanisms.

Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space

1. Background

Since the Committee on the Peaceful Uses of Outer Space published its Technical Report on Space Debris in 1999,¹ it has been a common understanding that the current space debris environment poses a risk to spacecraft in Earth orbit. For the purpose of this document, space debris is defined as all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional. As the population of debris continues to grow, the probability of collisions that could lead to potential damage will consequently increase. In addition, there is also the risk of damage on the ground, if debris survives Earth's atmospheric re-entry. The prompt implementation of appropriate debris mitigation measures is therefore considered a prudent and necessary step towards preserving the outer space environment for future generations.

Historically, the primary sources of space debris in Earth orbits have been (a) accidental and intentional break-ups which produce long-lived debris and (b) debris released intentionally during the operation of launch vehicle orbital stages and spacecraft. In the future, fragments generated by collisions are expected to be a significant source of space debris.

Space debris mitigation measures can be divided into two broad categories: those that curtail the generation of potentially harmful space debris in the near term and those that limit their generation over the longer term. The former involves the curtailment of the production of mission-related space debris and the avoidance of break-ups. The latter concerns end-of-life procedures that remove decommissioned spacecraft and launch vehicle orbital stages from regions populated by operational spacecraft.

2. Rationale

The implementation of space debris mitigation measures is recommended since some space debris has the potential to damage spacecraft, leading to loss of mission, or loss of life in the case of manned spacecraft. For manned flight orbits, space debris mitigation measures are highly relevant due to crew safety implications.

A set of mitigation guidelines has been developed by the Inter-Agency Space Debris Coordination Committee (IADC), reflecting the fundamental mitigation elements of a series of existing practices, standards, codes and handbooks developed by a number of national and international organizations. The Committee on the Peaceful Uses of Outer

¹United Nations publication, Sales No. E.99.I.17.

Space acknowledges the benefit of a set of high-level qualitative guidelines, having wider acceptance among the global space community. The Working Group on Space Debris was therefore established (by the Scientific and Technical Subcommittee of the Committee) to develop a set of recommended guidelines based on the technical content and the basic definitions of the IADC space debris mitigation guidelines, and taking into consideration the United Nations treaties and principles on outer space.

3. Application

Member States and international organizations should voluntarily take measures, through national mechanisms or through their own applicable mechanisms, to ensure that these guidelines are implemented, to the greatest extent feasible, through space debris mitigation practices and procedures.

These guidelines are applicable to mission planning and the operation of newly designed spacecraft and orbital stages and, if possible, to existing ones. They are not legally binding under international law.

It is also recognized that exceptions to the implementation of individual guidelines or elements thereof may be justified, for example, by the provisions of the United Nations treaties and principles on outer space.

4. Space debris mitigation guidelines

The following guidelines should be considered for the mission planning, design, manufacture and operational (launch, mission and disposal) phases of spacecraft and launch vehicle orbital stages:

Guideline 1: Limit debris released during normal operations

Space systems should be designed not to release debris during normal operations. If this is not feasible, the effect of any release of debris on the outer space environment should be minimized.

During the early decades of the space age, launch vehicle and spacecraft designers permitted the intentional release of numerous mission-related objects into Earth orbit, including, among other things, sensor covers, separation mechanisms and deployment articles. Dedicated design efforts, prompted by the recognition of the threat posed by such objects, have proved effective in reducing this source of space debris.

Guideline 2: Minimize the potential for break-ups during operational phases

Spacecraft and launch vehicle orbital stages should be designed to avoid failure modes which may lead to accidental break-ups. In cases where a condition leading to such a failure is detected, disposal and passivation measures should be planned and executed to avoid break-ups.

Historically, some break-ups have been caused by space system malfunctions, such as catastrophic failures of propulsion and power systems. By incorporating potential break-up scenarios in failure mode analysis, the probability of these catastrophic events can be reduced.

Guideline 3: Limit the probability of accidental collision in orbit

In developing the design and mission profile of spacecraft and launch vehicle stages, the probability of accidental collision with known objects during the system's launch phase and orbital lifetime should be estimated and limited. If available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance manoeuvre should be considered.

Some accidental collisions have already been identified. Numerous studies indicate that, as the number and mass of space debris increase, the primary source of new space debris is likely to be from collisions. Collision avoidance procedures have already been adopted by some member States and international organizations.

Guideline 4: Avoid intentional destruction and other harmful activities

Recognizing that an increased risk of collision could pose a threat to space operations, the intentional destruction of any on-orbit spacecraft and launch vehicle orbital stages or other harmful activities that generate long-lived debris should be avoided. When intentional break-ups are necessary, they should be conducted at sufficiently low altitudes to limit the orbital lifetime of resulting fragments.

Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy

In order to limit the risk to other spacecraft and launch vehicle orbital stages from accidental break-ups, all on-board sources of stored energy should be depleted or made safe when they are no longer required for mission operations or post-mission disposal.

By far the largest percentage of the catalogued space debris population originated from the fragmentation of spacecraft and launch vehicle orbital stages. The majority of those break-ups were unintentional, many arising from the abandonment of spacecraft and launch vehicle orbital stages with significant amounts of stored energy. The most effective mitigation measures have been the passivation of spacecraft and launch vehicle orbital stages at the end of their mission. Passivation requires the removal of all forms of stored energy, including residual propellants and compressed fluids and the discharge of electrical storage devices.

Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission

Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the LEO region should be removed from orbit in a controlled fashion. If this is not possible, they should be disposed of in orbits that avoid their long-term presence in the LEO region.

When making determinations regarding potential solutions for removing objects from LEO, due consideration should be given to ensuring that debris that survives to reach the surface of the Earth does not pose an undue risk to people or property, including through environmental pollution caused by hazardous substances.

Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission

Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the GEO region should be left in orbits that avoid their long-term interference with the GEO region.

For space objects in or near the GEO region, the potential for future collisions can be reduced by leaving objects at the end of their mission in an orbit above the GEO region such that they will not interfere with, or return to, the GEO region.

5. Updates

Research by Member States and international organizations in the area of space debris should continue in a spirit of international cooperation to maximize the benefits of space debris mitigation initiatives. This document will be reviewed and may be revised, as warranted, in the light of new findings.

6. Reference

The reference version of the IADC space debris mitigation guidelines at the time of the publication of this document is contained in the annex to document A/AC.105/C.1/L.260.

For more in-depth descriptions and recommendations pertaining to space debris mitigation measures, Member States and international organizations may refer to the latest version of the IADC space debris mitigation guidelines and other supporting documents, which can be found on the IADC website (www.iadc-online.org).

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Internship Report
Capacity Building in Basic Space
Technology Development
Education Curriculum on Space Engineering

Elias Andrade
Phone : +43-1-680-226-0329

deandrade.elias@yahoo.com

United Nations Office for Outer Space Affairs
Vienna International Centre, Vienna, Austria
30 November 2012

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I.Introduction

A growing number of countries have become space-active in the past fifty years. Despite that, nowadays many countries still lack space technology due to insufficient basic human, technical, financial and even political resources to start the most basic activities related to space such as meteorological, communications and natural-resources management.

For that reason, the United Nations Programme on Space Applications was created in 1971. The General Assembly resolution 2601 A (XXIV) of 16 December 1969 ratified the recommendations of the United Nations Office for Outer Space Affairs to establish the office aiming to enhance knowledge on space applications to all nations in the world.

Countries have established desire to develop basic space technology, especially after universities and small institutions have created and launched small satellites with low cost. Research and development of space technology has ignited the development of medicinal instruments, today's society infrastructure, and technological instruments people use to facilitate their day lives, such as cell phones, GPS, internet, computers devices, and the like.

Therefore, the Basic Space Technology Initiative (BSTI) was created in the framework of the United Nations Programme on Space Application. The BSTI aimed to support capacity building in base space technology focusing in the making and use of small satellites.

The BSTI has supported many space activities. One of them is the United Nations Education Curriculum for Space Engineering (ECSE), which is a very important tool for capacity building through education. The BSTI has developed the ECES through a number of workshops, symposiums, intern's support and collaboration from experts from several countries and other space activities. Its main challenge is making the curriculum as universal as possible so it can be an invaluable asset for the individuals from world-wide who will benefit from it.

In support of the activities of the United Nations Basic Space Technology Initiative, I, Elias Andrade, started on October through November 2012, an unpaid internship at the Space Application Section of the United Nations Office for Outer Space Affairs. Below, I identify the goals, methods and results of the internship.

II.Objectives

The assignments for my internship were specified in the internship admission letter as follows:

As the main project of this internship the incumbent will support the preparatory work for the development of a United Nations education curriculum on basic space technology development (ECSE). This will involve the following tasks:

- (a) Review the procedures for the development of earlier education curricula;
- (b) Based on the content of earlier education curricula prepare a draft outline of the ECSE;
- (c) Based on the information available from earlier BSTI activities compile an archive of materials that will be relevant for the drafting of the ECSE;
- (d) Compile a list of other materials (books, websites, teaching materials etc.) for the drafting of the ECSE;
- (e) Based on the information available from earlier BSTI activities prepare a list of aerospace engineering experts in academic institutions worldwide that would be qualified to contribute to the development of the ECSE;
- (f) Assist with informing experts in space engineering about the ECSE at the 63rd International Astronautic Congress, to be held in Italy from 1-5 October 2012;
- (g) Assist with preparing a special session to discuss ECSE at the UN/Japan Nano-Satellite Symposium to be held in October 2012;”
- (h) Update the UNOOSA Space Application Website through HTML Programming.

III.Methods

Researching was the main method I used to support the creation of the Education Curriculum for Space Engineering (ECSE). Since the first day of the internship, I have researched for material (books, websites, courses, and other types of publications) related to aerospace engineering that would be relevant for the ECSE. I have encountered most of the material on the web and at the United Nations and at the European Space Policy institute libraries.

Moreover, I have also contacted aerospace engineers from world-wide institutions who could be potential members of the International Panel of Experts (IPE). The creation of the IPE is fundamental as the contributions of experts are an invaluable asset for the creation of the ECSE.

I have contacted many of experts by email with an attached survey letter written by Dr. Werner Balogh. The letter contained a survey and an information note explaining the background, goals, and in which ways those interested in becoming members of the IPE could support the ECSE.

Other experts I have contacted personally at the International Astronautic Congress, held in Naples, Italy, 1-5 October 2012 at the UN/Japan Nano-Satellite Symposium, held in Nagoya, Japan, 10-13 October 2012. At these two events, I had a chance to address the goals of the ECSE, inform about what progress the Space Application Section has already made, and ask if they would be interested in kindly being a member of the IPE.

The first time expert in space engineering contributed as members of the IPE was at the Education Curriculum Section of the UN/Japan Nano-Satellite Symposium. The session was the kickoff of the program, which was conducted by a group dynamic with challenging questions Dr. Willey Larson presented regarding the curriculum's framework. Also at this section, participants proposed several names for the education curriculum.

At the symposium, besides photographing and writing minutes of the presentations, I assisted Ms. Ayoni Oyeneyin, OOSA Research Assistant, administrating payments of the individuals who were granted financial support to participate at the conference. Moreover, I assisted Miss Ray (put her last name and the other Japanese) with the set up of the conference rooms.

III.1 Summary of the UN/Japan Nano-Satellite Symposium

The symposium was also a great opportunity to make helpful contacts for the ECSE. We had an entire education curriculum section on 13 October 2012 where Dr. Werner and I dedicated to present to the participants the entire goal of the curriculum. I had a chance to give a speech to report what we had already accomplished and how those interested in becoming a member of the International Panel of Experts could contribute more. Many experts gave me advice for the ECSE and requested me to send them a copy of the survey letter.

At the end of the section, Dr. Willey Larson coordinated a group dynamic where he proposed challenging questions to the participants. The questions aimed to intrigue discussion about the outline of the curriculum. Dr. Larson divided the audience in approximately ten groups and each group was responsible to give their opinion about the scope and outline of the ECES. Also at this section, participants proposed several names for the education curriculum.

The UN Symposiums related to Nano-Satellites and Technology are commonly held in Graz, Vienna. However, for the first time, the OOSA in cooperation with the University of Tokyo and other partners held the symposium in Nagoya from 10-13 October 2012, as an initiative to reach more participants from the Asia-Pacific region. In 2013, the OOSA will hold the symposium in Toronto, Canada.

III.2 Summary of the 63rd IAC

I participated at the 63rd International Astronautic Congress (IAC) in Italy. I had a chance to converse to aerospace engineers, scientists, lawyers and many other people related to space activities, and explain to importance of the ECSE for students in the developing world who will benefit from it at the four regional centers where it will be taught. Moreover, I also could participate at seminar in space law, space policy and space technology, which I gained very enriching knowledge about activities in space from them.

IV. Results

The United Nations Education Curriculum for Space Engineering (ECSE) is a project under the Basic Space Technology Initiative headed by Dr. Balogh. I have been assisting Dr. Balogh in the researching and surveying of experts for curriculum, a method that has been the framework of the internship. The draft of the ECSE will be a long term project commitment for him, collaborators, and next interns.

The framework of the internship relied on researching and interviewing experts for the ECSE. During my period at the United Nations Office for Outer Space Affairs (OOSA) working on the draft of the curriculum, I have dedicated most of my time researching on the internet for courses, papers, publications, websites, and literature related to aerospace engineering, satellite, astronautics, applications, communication, earth observation, micro-engineering, nano-physics, nano-chemistry, nano-technology, propulsion, space education, and the like.

I have found literature also at the facility of the European Space Policy Institute and at the United Nations library in the E-building of the Vienna International Center. Moreover, I also have been reading the book entitled *Understanding Space: An Introduction to Astronautics* by Dr. Jerry Sellers, a great book which has raise my knowledge about astronautics.

Substantive results first came in response to the survey letter. Since 5 September 2012, I have sent over sixty copies of the letters and until 30 November 2012, I have received over thirty positive replies. Nine of those who replied already sent important information. They included names of books, software, websites, courses, etc.

The Education Curriculum Session at the UN/Japan Nanotechnology Symposium provided major results for the curriculum. I have received until 30 November 2012 sources from six groups with a proposal outline for the curriculum. Their proposal contained objectives for the ECES, names and length of courses, class requirements, syllabus, and the like.

The result of my work includes a record of all of those who I contacted aside the list of material. The record includes: a copy of each email ever sent, a copy of each letter in PDF with the names of the addressees. I also forwarded all replies to those who affirmed they would like to contribute to the ECSE or replied they could not contribute at the moment to the BSTI email account so this way Dr. Balogh and Mr. Takao Doi, can have

broader access to data after my elias.andrade@unvienna.org email account becomes deactivated due to the end of the internship.

The development of the curriculum will require more intern-assess and support. Because of that, there are few remarks I should inform the next interns working for the BSTI under the Space Application Section and who will support the continuation of this education curriculum. First, it is necessary that one becomes familiar with other education curricula in space engineering so that he or she can improve the rough draft of the outline I could provide during my term. Second, as far as the end of the development of the curricula approaches, it will be necessary to finalize the outline more accurately and make the template appear nicely. A third suggestion, which goes along the second, it will be necessary even more to be familiarized with the United Nations correspondent and writing style so that the final outlining of the curricula matches with the other four existing educational curricula.

The main challenge for the development of the curriculum relies in making it more standardize to most – if not all, education curricula in space engineering. The United Nations, under the Program on Space Application, has developed other four education curricula, and the ECSE is another effort to create educational opportunities for capacity building. Therefore, it is of extreme importance to build a curriculum that will be compatible world standards so the individuals who will benefit from it, can actually apply what they learned world-wide.

A part from the curricula, there is one important task that I could not finalize due to time constrain. This task comprises of updating part of the UNOOSA website. The BSTI had realized several symposiums held in Graz, Vienna, prior to the 2012 symposium in Nagoya, Japan. The presentations to the symposium from 2009 up to 2011 have not yet been uploaded to the website, not enabling this way, viewers to check the presentations in PDF. I have so far created a PDF of every presentation, and started building the frames for the 2009 presentations through HTML work at the cms.unvienna webpage. An account to the cms webpage has to be acquired through the internship mentor. The presentations need to be uploaded and appear in the website in the same order and style they appear at the symposium reports.

V. Conclusion

The admission letter specified the internship learning opportunities as follows:

- (a) Working within the culture and organizational structures of a United Nations entity;
- (b) Establishing working contacts with worldwide leading educational institutions and learning about United Nations correspondence style
- (c) Organizing United Nations meetings/workshops
- (d) Preparing United Nations documents and (optionally) research papers
- (e) Learning about latest developments in international space policy and space technology development
- (f) Work on the education curriculum could also be integrated with the requirements of preparing a masters thesis for a MSc degree programme.

I would like to make some concluding remarks stating how I believe I have reached much of these learning opportunities and more. I learnt in practice to communicate at a diplomatic way because my work required me to read the United Nations Correspondence Manual, interact with diplomats and several employees and staff members of outside organizations in Vienna and overseas. Because of that, I really feel I have developed in myself a broader international and diplomatic character.

Moreover, as I needed to survey and converse with scientists and individuals related to space activities and engineering, I have learnt about educational institutions, private organizations and events related to space activities that I did not know before. I have established contact for the ECSE and for my career with many of them.

To what corresponds of organizing meetings and workshops, I help in the UN/Japan Nano-Satellite Symposium, held in Nagoya, Japan, in October 2012. The Japanese, I firmly affirm, had all the logistics under absolute control. Participating at the UN/Japan Symposium on Nano-Satellite was the highlight of my internship.

I have learned a great lesson from this internship. I am personally happy to know that the work I have done will help develop a much greater work, which is the ECSE, which will later benefit people around the world. Therefore, the internship has indeed provided the

learning opportunities the admission letter stated. I have learned very much how the United Nations system works, and the challenges workers there face to do their part on helping the world. The internship also cleared helped me decide the United Nations is definitely an international organization where if possible I would continue my career.

VI. Acknowledgements

I would like to finalize by stating how this internship was important for my career. It has been important for my master thesis research about the future of human space activities. Moreover, the internship gave me great opportunities to work with renowned experts and scientists from all over the world.

I would like to conclude by thanking all the people I worked with. At the European Space Policy Institute: Peter HULSROJ, Director, and Blandina Baranes. Thank you for welcoming me at using your facility/library.

From Japan: I would like to thank Dr. Shinichi Nakasuka, and Dr. Michiko Oshima, University of Tokyo; and Mr. Etsuko Adachi and Mrs. Rei Kawashima, UNISEC. It was a pleasure working with them at the UN/Japan Nano-Satellite Symposium.

I would like to thank the friendship and cooperation of the people I worked closely with at the VIC, Vienna: Mr. Ahmed Osman, David Stevens, Levent Canturk, Markus Woltran, Niklas Hedman, Sergiy Negoda, Takao Doi, and Misses Ayoni Oyneyin, Heli Pahlman, Natercia Rodrigues, Romana Kofler, and Sharafat Gadimova.

Very especial thanks go to Dr. Werner Balogh, my internship mentor. I thank him very much for being very patient and for helping me grow professionally and enjoy the great opportunities that came along with the internship.

Thank you all so much and congratulations to the 50th years anniversary of United Nations Office for Outer Space Affairs. It is my personal wish that the continuation of the work of the OOSA will enhance capacity building and sustainable development to all countries.

VII. Annexes

VII.1 Description of Internship Documents

The following is a description of the file structure of folder G:\doc\SAP\BSTI\Education Curriculum which includes all data and files produced during this internship.

- (a) Folder “Attachments for ECSE” contains all the replies with attachments for the ECSE sent by experts who replied to the survey letter. All others who replied with no attachment had a copy of my answer thanking their intention forwarded to the BSTI email account.
- (b) Folder “ECSE Letters Sent – “able to contribute, unable to contribute, haven’t responded yet, unable to reach,” contains a copy of all emails sent from me to those who replied to the BSTI email confirming they would or not would like to be a member of the International Panel of Experts (IPE); also those who I was not able to reach. Please, be remindful that the survey letter kindly requested the addressees to reply to the BSTI email account, where Dr. Werner has access to it.
- (c) The folder “Letters Sent” contains a copy of all the letters sent to prospective members of the IPE who have confirmed in writing that they would be able to contribute. Answers received are stored in folder.
- (d) The “Database” for UNECSE revised for Nov. 30 resumes the status of all replies and emails sent/received, and all material gathered until Nov. 30, 2012. This database together with this report are the most important file for drafting the ECSE until now.
- (e) Folder G:\doc\SAP\BSTI\Regional Conferences\Japan 2012\Space Education Curriculum Session\Working Group Feedback\Groups answer revised, contains all answers to Dr. Larson’s “challenge questions” written in Word Document.

VII.2 Outline for the Education Curriculum on Space Engineering

Based on outlines of other United Nations Education Curricula, I propose an outline with the scope and structure for the ECSE including the results of the research from the internship. The draft I have prepared, of course, also includes answers the experts gave to Dr. Larson “challenge questions” during the ECES session at the UN/Japan Nano-Satellite Symposium.

Background Information and Purpose

The United Nations Programme on Space Applications was created in 1971. The General Assembly resolution 2601 A (XXIV) of 16 December 1969 ratified the recommendations of the United Nations Office for Outer Space Affairs, establishing the office aiming to enhance knowledge on space applications to all nations in the world.

The Basic Space Technology Initiative (BSTI) was created under the framework of the United Nations Programme on Space Application. The BSTI aimed to support capacity building in base space technology focusing in the making and use of small satellites.

The Basic Space Technology Initiative has been developing the United Nations Education Curriculum for Space Engineering. The curriculum has been created to assist countries to fulfill their lack of higher level knowledge and expertise on space engineering. The ECSE will be delivered as a master program at the four United Nations Regional Centres for Space Science and Technology Education in English, French, and Spanish Languages.

The first centre was inaugurated in India in 1995. After, two more Centres were inaugurated in Morocco and Nigeria in 1998; one in Brazil and another in Mexico, in 2002; and the last one was opened in Jordan in 2012. In that manner, the centres are located at the four United Nations Economic Commission Regions: Africa, Asia and the Pacific, Europe, Latin America and the Caribbean, and Western Asia. They aim to help countries finding solution of global, regional and national environmental and resource management issues.

The ECSE remains as another support for education and development in those regional areas. Countries need support to grow capacities that will enable them to build knowledge and practical experience in Space Engineering. With that, it is expected that the graduate students who will take the ECSE course should have potential to work in any field of space technology, learn how to design and build a mission spacecraft, and disseminate that knowledge for the economic and sustainable development of society.

Methodology

The Education Curriculum on Space Engineering should be delivered at the Regional Centres for Space Science and Technology Education affiliated to the United Nations. The International Panel of Experts (under the Basic Space Technology Initiative) should develop the curriculum under the framework of the teaching activities and culture of each centre.

The UN/Education Curriculum for Space Engineering (ECSE) should be a two-year Master Level Educational Program. In accordance to the activities of the regional centres, the curriculum should be undertaken in two major phases. In phase 1, it should emphasize the development and enhancement of the knowledge and skills of university educators and research and application scientists in both the physical and natural sciences as well as in the analytical disciplines. That is accomplished over a nine-month period as laid out in the curricula of the education programme of each centre. In phase 2, it should focus on ensuring that the participants make use of the skills and knowledge gained in phase 1 in their pilot projects, which are to be conducted, over a one-year period, in their own countries.

The length of the courses shall be decided by the instructors. The goal of the ECSE is to offer the Regional Centres a most complete and up to date syllabus containing a number of key courses/subject in Space Engineering from inputs of the IPE. However, it is expected that the dissent body make the necessary adjustment to fit courses into the time schedule of their corresponding Regional Centre.

The ECSE shall include a model syllabus with suggested teaching materials from the International Panel of Experts, intern-sessional work, and collaborators. The syllabus should be include most of the disciplines in space engineering, mission design, project management, satellites bus and subsystems, and it should also include inputs from syllabus from world-wide educational institutes. Disciplines about relevant legal issues should certainly cover the lack of legislation to define nano-satellites from regular larger satellites.

Classes should be delivered in the traditional way (in classroom and laboratory). Like the other postgraduate courses offered at the Regional Centres, the ECES should also have duration of 9 months followed by a 1-year pilot project. The ECSE, in-line with previous education curricula, will be tailored to these requirements and will provide suggestions for the pilot project phase, including such activities as nano-satellite development.

Syllabus

- 1) The two year Education Curriculum on Space Engineering should comprise:
 - (a) 35 hours hands-on courses and associated projects and activities
 - (b) 2-3 hours outside class (labs) for every hour of class: 420 + 840+ 1260

- 2) The candidate for the Education Curriculum on Space Engineering should have the assets below in order to be eligible for the master program:
 - (a) Be close to completion of a recognized undergraduate degree related to space engineering with Global Point Average or the equivalent to above 3.0.
 - (b) Considerable understanding of the space industry, organizations and related events.
 - (c) Knowledge of space science and engineering
 - (d) Manage space related projects
 - (e) Pursue space system approaches
 - (f) Produce/Apply technology for problem solving in a space
 - (g) Project/collaborative environment/multi-disciplinary approach.

- 3) Programme objectives: learn how to design and build a mission and spacecraft.
 - (a) Technical: background, technical subsystems.
 - (b) Non-technical: legal, regulatory, policy, politics.
 - (c) Give students a common foundation of technical and non-technical topics.
 - (d) Basic physics: courses and labs on mechanics and magnetism, gravity, gyros, etc.
 - (e) Basic electricity: electronics, components soldering.
 - (f) Space applications: communications, EO, Science, now
 - (g) Space environment: labs on vacuum, vibration, changing, etc.

- (h) Non-technical: ITU regs, frequency spectrum.
- (i) Rationality for space activities: economics, political, practical, e.g. “high-ground, global coverage.
- (j) Provide detailed course and lab work in spacecraft design:
- (k) Power: basic power generation, storage, distribution, harnessing,
- (l) Communications: EM spectrum, link budgets, protocols
- (m) APGS: Sensors and actuators – labs to familiarize.
- (n) Thermal and structural: FEMs, analyzes
- (o) Propulsion
- (p) AI & T facilities (Artificial intelligence & technologies?).

Assuming the program will be located near AI & I facilities, e.g. clean room, testing for vibration, TVac or have them on-site. Be located near a major s/c engineering and manufacturing company or facility. Telemetry, tracking and command (TT & C): uplink: commanding and telemetry downlink.

- 4) Payloads and P/L managements.
 - (a) Mission control.
 - (b) Ground and Operation Systems, Systems Engineering / design process
 - (c) Budgets: mass, power communications link budget, through input, margin.
 - (d) Standards: e.g., ISO, MIL-Std, standard procedures
 - (e) Unit test: system test.

- 5) Project management:
 - (a) Team structure, roles
 - (b) Regulatory requirements
 - (c) ITU regulations; registration of satellite in orbit; frequencies
 - (d) Liability issues, insurance.
 - (e) Policy issues.

- 6) Key topics, length and possible courses title. Introduction to Space Mission Design.
- (a) Systems Engineering
 - (b) Applicable space law (frequency, registration, ITU...)
 - (c) Statistics and Probability
 - (d) System Integration
 - (e) CFD
 - (f) Environmental Testing / Space Environment
 - (a) Project Management
 - (b) Team Work, Communication, Scheduling
 - (c) Space Technology Development Infrastructure
 - (d) Quality Assurance & Risk Management
 - (e) Cost Analysis
 - (f) Mission Design & Planning
 - (g) Subsystems
 - (h) Micro Controllers
 - (i) Thermal
 - (j) Structure & Materials
 - (k) TTCC Telecommunications, Telemetry, Command Control
 - (l) Orbital Determination & Manoeuvres, ADCS
 - (m) Power (Solar, Batteries, ...)
 - (n) Propulsion
 - (o) Payload Design
 - (p) Ground Stations
 - (q) Space Applications and Applications of Space Technology to real-World problems
 - (r) Orbital Mechanics/Astrodynamics
 - (s) Launch Vehicle
 - (t) Operations Research (optimization techniques, algorithms)\

- (u) Systems Dynamics and Modelling
 - (v) Space Business
 - (w) Hands-on Exercises/Projects (final year project)
 - (x) Computer Programming and Application.
 - (y) Telecommunications Systems
- 7) Delivery methods:
- (a) Direct instruction
 - (b) Digital framework
 - (c) Problem-base learning / scenario-based learning / contest (MIC)
 - (d) Group project /discussion
 - (e) Video conferencing
 - (f) On the job training
- 8) Desired outcomes for Participants:
- (a) Graduate able to operate (EO, telecom) spacecraft
 - (b) Graduate able to use special data for specific objectives Graduate able to draft clear/concise designs for nano-satellite
 - (c) Ability to create different components
 - (d) Graduate able to design a nano-satellite mission
 - (e) Graduate employable by aerospace industry
 - (f) Ability to transfer knowledge to their organization
 - (g) Able to apply knowledge to practical missions
 - (h) Expected to have good confidence in his/her knowledge/experience

VII.3 Survey Letter

Dr. Balogh created the International Panel of Experts (IPE) to include all experts interested in supporting the ECSE. Because of that, I revised the survey letter he wrote to potential members of the IPE, and that Mr. Takao Doi, head of the Space Application Section at the OOSA, approved. We have sent the letter while contacting scientist around the world asking if they would be interested in kindly participating in the IPE necessary to facilitate the creation of the education curriculum.

The survey letter asked two main questions: if they would like to be a member of the IPE, and if they could kindly contribute with the type of material I mentioned before. Since 5 September 2012, I have sent by email approximately sixty-five copies of this letter. Dr. Balogh and I selected many of the addressees from the United Nations/Austria/European Space Agency Symposium 2008-2011 and carefully selected twenty more from different countries and educational institutions from around the world. Until now, I have received approximately twenty-five positive replies, and some of them already replied with valuable information which I added to the ECSE database.

The positive replies from the experts are a very important asset for the ECSE. It is necessary a long term commitment and effort to create such an important curriculum, which will be beneficial for many students around the world who will, for instance, take the programme at the four United Nations Regional Centers for Space Science and Technology Education. Therefore, we have worked intensely to make our job organized, explanatory, and rewarding to keep the interest of every IPE members.

Below is a copy of the original Survey letter and the information note explaining the background of the curriculum. By clicking on it, one will both files in PDF format.



UNITED NATIONS
Office for Outer Space Affairs

5 September 2012

**Request for Expression of Interest to Contribute to the Development of an
EDUCATION CURRICULUM ON SPACE ENGINEERING (ECSE)
in the framework of the United Nations Programme on Space Applications**

Dear Colleagues,

We are contacting you today as a former participant in one of the events organized under the Basic Space Technology Initiative (BSTI) of the United Nations Programme on Space Applications and/or as a space educator or space technology development professional whose expertise could be relevant to our activities.

We would like to take this opportunity to inform you that in-line with the work plan of the Basic Space Technology Initiative, the United Nations Office for Outer Space Affairs is planning to develop an Education Curriculum on Space Engineering (ECSE). It is expected that the development of nano-satellites, such as CubeSats, will be a specific focus of the ECSE as they are especially well suited for educational and training purposes.

The education curriculum will be prepared in close consultation with space technology development educators from around the World. For this purpose, the United Nations Office for Outer Space Affairs plans to establish an International Panel of Experts (IPE).

The education curriculum will contain information such as a model syllabus and suggested teaching materials similar to the content of the already existing education curricula prepared under United Nations guidance and in use at the Regional Centres for Space Science and Technology Education, affiliated to the United Nations and in other academic institutions around the World. Additional details about the ECSE can be found in the attached Information Note.

At this point we would be grateful if you would indicate to us your interest in contributing to the development of the ECSE, by answering the following two questions:

- Q1:** Would you be interested in serving as a member of the IPE and, if so, what would you be able to contribute to (e.g. teaching expertise, educational materials, etc.)?
- Q2:** Would you be able to help us identify useful teaching resources, such as references to books, papers, existing space engineering class syllabi and education curricula, relevant websites, online courses, software tools, educational hardware and other materials that may be useful in teaching space engineering course and that may be relevant for inclusion into the ECSE? Please provide us with a list of references, including a brief description.

VII.4 Challenge Questions

During the Education curriculum Section at the UN/Japan Symposium in Nano-Satellite, Dr. Larson created a group dynamic where the participants were asked to answer the “challenge questions” below:

UN/Japan Nano-Satellite Symposium 10-13 October 2012
 Education Curriculum on Space Engineering Section Oct. 13th
 Curriculum Scope and Content Presentation (By Dr. Willey Larson)

Challenge 1

- (a) Curriculum of which level (BSc, MSc, PhD...)?
- (b) 12:35 – contact-hr hands-on courses and associated projects/activities, plus between 2-3 hours of outside class work for each hour in class – $420lc + 840oc = 1260$ hours
- (c) Program objectives
- (d) Assumptions and pre-requisites –entry requires at least a bachelor ‘s degree in a technical or scientific discipline.

Challenge 2

- (a) Key topics...possible courses titles.
- (b) Length of course (approx. 1 year with possibility to spread over several years)
- (c) Desire outcome for participants (“a graduated should be able to...”).

Challenge 3

- (a) Potential delivery methods – traditional in class, online, blend on-line and in-class, perhaps create a learning management system.
- (b) Resources to be included (books, websites, others...)

Challenge 4

- (a) Deliverable- aprox. 30 pages curriculum description to include details of the program description of courses , possible projects, potential providers?
- (b) Propose a name for the curriculum

IPE Working Group on Challenge Questions

The following lists contain the answers from the working groups containing answers for the “challenge questions” that the IPE members have sent by 30 November 2012:

Working Group 1

Elias Andrade, UN-OOSA
 Kamel Besbes, U.Monastir, Tunisia
 Kaizer Moroka, DST, South Africa
 Muhammad Alkalili, Kyushu I.T
 Larry Reeves, Geocentrix Tech., Canada

Answering challenge 1 regarding course objectives and requirements

Challenge 1

- (a) The UN/Education Curriculum for Space Engineering should be a Master Level
- (b) Educational Program.
- (c) 35 hours hands-on courses and associated projects & activities
- (d) 2-3 hours outside class (labs) for every hour of class: 420 + 840+ 1260

Programme objectives: Learn how to design and build a mission and spacecraft.

- (a) Technical: background, technical subsystems.
- (b) Non-technical: legal, regulatory, policy, politics.
- (c) Give students a common foundation of technical and non-technical topics.
- (d) Basic physics: courses and labs on mechanics and magnetism, gravity, gyros, etc.
- (e) Basic electricity: electronics, components soldering.
- (f) Space applications: communications, EO, Science, now
- (g) Space environment: labs on vacuum, vibration, changing, etc.
- (h) Non-technical: ITU regs, frequency spectrum.
- (i) Rationality for space activities: economics, political, practical, e.g. “high-ground, global coverage.

Provide detailed course and lab work in spacecraft design:

- (a) Power: basic power generation, storage, distribution, harnessing, efficiencies.
- (b) Communications: EM spectrum, link budgets, protocols
- (c) APGS: Sensors and actuators – labs to familiarize.
- (d) Thermal and structural: FEMs, analyzes
- (e) Propulsion
- (f) AI & T facilities (Artificial intelligence & technologie?).

Assuming the program will be located near an AI & I facilities, e.g. clean room, testing for vibration, TVac or have them on-site. Be located near a major s/c engineering and manufacturing company or facility.

- (a) Telemetry, tracking and command (TT & C): uplink: commanding and telemetry downlink.

Payloads and P/L managements.

- (b) Mission control.

Ground and operation systems/ Systems Engineering / design process

- (c) Budgets: mass, power communications link budget, through input, margin.
- (d) Standards: e.g., ISO, MIL-Std, standard procedures
- (e) Unit test: system test.

Project management:

- (a) Team structure, roles

Regulatory requirements

- (b) ITU regulations; registration of satellite in orbit; frequencies
- (c) Liability issues, insurance.
- (d) Policy issues.

Working Group 2
Unknown Members

Challenge 2

Regarding key topics, length and possible courses title

The UN Education Curriculum for Space Engineering master course should have a duration of two years: Once year should comprise courses and another one year of project.

As pre-requisite, the course should require all engineering disciplines.

The objectives: To deliver the required knowledge and hands on experience to undertake space engineering projects.

1. Number of courses:

- (a) 3-5 per semester during 2 semesters
- (b) 2 advanced math courses

2. Possible names for classes:

- (a) Space Environment
- (b) Orbital mechanics
- (c) Space propulsion
- (d) Attitude Det and Control
- (e) Spacecraft Systems Engineering I and II
- (f) Space systems Int and test Lab
- (g) Space regulations and Law
- (h) Project work (applied design project)

Working Group 4
Unknown Members

Challenge 2

Regarding key topics, length and possible courses title.
Introduction to Space Mission Design.

- (a) Systems Engineering
- (b) Applicable space law (frequency, registration, ITU,)
- (c) Statistics and Probability
- (d) System Integration
- (e) CFD
- (f) Environmental Testing / Space Environment
- (g) Project Management
- (h) Team Work, Communication, Scheduling
- (i) Space Technology Development Infrastructure
- (j) Quality Assurance & Risk Management
- (k) Cost Analysis
- (l) Mission Design & Planning
- (m) Subsystems Micro Controllers
- (n) Structure & Materials
- (o) TTCC Telecommunications, Telemetry, Command Control
- (p) Orbital Determination & Manoeuvres, ADCS
- (q) Power (Solar, Batteries, ...)
- (r) Propulsion
- (s) Payload Design
- (t) Ground Stations
- (u) Space Applications and Applications of Space Technology to real-World problems

- (v) Orbital Mechanics/Astrodynamics
- (w) Launch Vehicle
- (x) Operations Research (optimization techniques, algorithms)
- (y) Systems Dynamics and Modeling
- (z) Space Business
- (aa) Hands-on Exercises/Projects (final year project)
- (bb) Computer Programming and Applications
- (cc) Telecommunications Systems

Challenge 3

Regarding the length of Courses:

Regional Centres: 9 months class room teaching & 1 year project

Thailand: Bachelors 4 years, Master 2-3 years, Short courses

Sudan: to be integrated into Bachelor courses engineering/telecoms/GIS (MSc level), proposal submitted for satellite engineering

Masters: minimum 2 years

3. Curriculum Structure:

Core Courses/Modules

- (a) Advanced/Specialized Modules
- (b) Suggestions for practical projects (CanSat, CubeSat, Projects,)

Option to deliver courses online/distance teaching

Possibly 2 years seems to be most reasonable

4. Desired outcomes for Participants:

- (a) Graduate able to operate (EO, telecom) spacecraft
- (b) Graduate able to use special data for specific objectives
- (c) Graduate able to draft clear/concise designs for nano-satellite
- (d) Ability to create different components
- (e) Graduate able to design a nano-satellite mission

- (f) Graduate employable by aerospace industry
- (g) Ability to transfer knowledge to their organization
- (h) Able to apply knowledge to practical missions
- (i) Expected to have good confidence in his/her knowledge/experience

Working Group 5

Unknown Members

Topics Length of Courses

Outcome

- (a) 3m. Orbital Dynamics / Understanding of Orbital Elements and Dynamics, incl.
 - i. trajectory calculation
- (b) 3m. Space Project Management / Organization of Space projects, Phases and Schedules, Documentation, Review Preparation (Data packages) Standards & Regulatory Issues
- (c) 3m. International Standards (e.g. ECSS) and Regulatory Issues (ITU, Space Debris Mitigation, ITAR)
- (d) 6m. Spacecraft System Design / Understanding of the different Subsystems of a Satellite, Specification Management
- (e) 6m. Writing and reading of functional, technical and procurement Specifications (e.g. RFI, RFP, System Functional Spec, System technical Spec..)
- (f) 6m. Spacecraft Environment and Environmental Testing writing and reading of functional, technical and procurement Specifications (e.g. RFI, RFP, System Functional Spec, System technical Spec..)
- (g) 6m. Reliability and Quality assurance /PA plan for space projects, basic requirements and standards, NCR system, Review boards
AIT

- (h) 6m. Integration planning and operation, functional Testing (incl. EMC, inter compatibility) Space Software Design and Software Specification
- (i) 6m. Basic Understanding of reliable and reusable software design / Space Electronic Design
- (j) 6m. Special requirements for space electronics (including analogue electronic)
- (k) AOCS
- (l) 6m. Design and testing (SIL, HIL, system test) of Attitude and Orbit Control System Applications and Payloads
- (m)6m Typical Applications and required Sensors and Payloads, Measurement principles / Cost Estimation of Space Projects
- (n) 6m Estimation of costs in the different program phases, including recurring and non-recurring costs

3 Month Project – Feasibility Study

- 3m In depth training under guidance of Agency/Industry advisors

Working Group 7

Esau Vicente
 Pieter Botma
 Takashi Hiramatsu
 Soha Badry
 Naomi Mathers

Challenge 3

Regarding potential educational methods for the UNECSE

Wide variety of tools for professional educators to use within their framework
 Written materials (books, technical papers, etc)
 Digital resources (websites, podcasts, models, etc)
 Access to experts

1. Delivery methods:

- (a) Direct instruction
- (b) Digital framework
- (c) Problem-base learning / scenario-based learning / contest (MIC)
- (d) Group project /discussion
- (e) Video conferencing
- (f) On the job training

Provide a wide variety of tools and materials for an expert educator to use to provide quality standardized education with international relevance.

Unknown Working Group

Members: Thu Vu Trong, etc.

Challenge 1

Curriculum of which level (BSc, MSc, PhD...)?

I think we should start the development with BSc level, then move up to MSc, PhD...

12:35 – contact-hr hands-on courses and associated projects/activities, plus between 2-3 hours of outside class work for each hour in class – 420lc + 840 oc = 1260 hours Program objectives

Assumptions and pre-requisites –entry requires at least a bachelor ‘s degree in a technical or scientific discipline.

Agree, entry should requires at least a bachelor ‘s degree in a technical or scientific discipline

Challenge 2

Key topics...possible courses titles.

Key topics

- (a) Orbital elements, different satellite orbits and their uses, satellite pass prediction and tracking
- (b) Main satellite subsystems: structure, power supply, communication, onboard computer and flight software, with a focus on small satellites
- (c) Satellite applications (telecommunications, optical remote sensing, SAR radar imaging, ships traffic monitoring, education, technology demonstrations...)
- (d) Introduction of launch vehicles, their interface to satellites and the launching environment.
- (e) Ground station design and operations.
- (f) Length of course (appros. 1 year with possibility to spread over several years).
- (g) Should be flexible and with a limit (e.g. max 3 years).

(h) Desire outcome for participants (“a graduated should be able to...”).

Challenge 3

Potential delivery methods – traditional in class, online, blend on-line and in-class, perhaps create a learning management system. It should offer all delivery methods: traditional in class, online, blend on-line and in-class.

Resources to be included (books, websites, others...)

- (a) NASA JPL’s Basics of Spaceflight online tutorial (<http://www2.jpl.nasa.gov/basics/>)
- (b) TSTI’s Understanding Space online course
- (c) Challenge 4
- (d) Deliverable- approx. 30 pages curriculum description to include details of the
- (e) Program description of courses , possible projects, potential providers?
- (f) Name of the curriculum
- (g) Group dynamic: count off 1-12, gather in your group # 30 min activity, identify facilitator recorder.

Unknown Working Group

Answering Challenge 4, regarding 30 pages curriculum description to include details of the program, description of courses, projects, potential providers.

1. Motivation for the Undergraduate or Postgraduate. Get people trained to:

- (a) Operate
- (b) Develop and Design
- (c) Innovate
- (d) Work in industry
- (e) Create/attract industry/Space satisfying National Goals
- (f) Technology development
- (g) Societal problem solving

(h) Job and industrial demands

2. Skills and abilities

- (a) General understanding of space industry
- (b) Knowledge of space science and engineering
- (c) Manage space related projects
- (d) Space system approach
- (e) Produce/Apply technology for problem solving in an space project/
collaborative environment/multi-disciplinary approach.

3. Why

- (a) Need people with immediate impact in industry
- (b) Need people to create/innovate/originate solution/pertinent
- (c) Have adequate solutions to the Local/National/International environment in
order to have real competitive solution for the problem

4. How

- (a) CDIO – Concept Development Implementation Operation
- (b) Hand On learning Impact
- (c) Get skilled people to participate in international projects/programs for solving
global/national challenges
- (d) Flexible people to work on changing and constrained projects interfacing with
other professionals
- (e) Practical solutions

5. Possible project

- (a) Academic Projects
- (b) System development
- (c) Cansat
- (d) Cubesat
- (e) Microsat
- (f) Robotics

6. Government (National Spatial Data Infrastructure – Space Data)

- (a) Monitoring system
- (b) Agriculture
- (c) Landuse/Landcover
- (d) Disaster management

7. Private Business Requirements

8. Potential provider

- (a) Government
- (b) Industries (Telecom Operators, Electronic and Manufacturing Industries etc.

VII.5 Names for the ECSE

Below are the names the IPE members suggested for the ECES at the UN/Japan Nano-satellite Symposium ECSE Session on 13 October 2012. One important decision during the drafting of the ECSE concerns the naming of the United Nations Education Curriculum. Several names have been considered. In order to take a decision it was decided to ask the space education community for their input on possible names for the ECSE. Below are the names the IPE members suggested for the ECES at the UN/Japan Nano-satellite Symposium ECSE Session on 13 October 2012:

1. Aerospace Systems Engineering and other Related Applications (ASSA)
2. Astronautics;
3. Education Curriculum on Small Satellite Design and Space Practice Management;
4. Engineering the Future: Systems Engineering for Space Technologies;
5. Flexible and Efficient Satellite Engineering (Building Satellites from Start to End);
6. Get interacted with Space Engineering Curriculum;
7. Global Curriculum on Space Education;
8. Higher Learning Space Curriculum;
9. Learn Space by doing Space;

10. MS in Space Engineering
11. MSc. Space System and Engineering Techniques
12. Practice the Space Engineering Curricula;
13. Science & Technology for Space Applications;
14. Space Educational Curriculum form Theoretical to Realization;
15. Space Engineering Basics & Practice;
16. Space Engineering: the inside out or Space technology: a practical approach;
17. Space for All;
18. Space for Benefit of Mankind;
19. Space Science & Engineering Building for a Better World;
20. Space Science and Engineering Curriculum;
21. Space Science and Space Technology Program- 3 SEP
22. Space Science and Technology
23. Space Science and Technology Curriculum;
24. Space Science and Technology For Small Satellites;
25. Space Systems Engineering, UN Curriculum;
26. Space Systems;
27. Space Technology and Applications Research and Training (START)
28. Space Technology Program;
29. Space_Sat (Space Science and Technology for Small Satellites);
30. STEP (Space Technology and Engineering Program or Space Technology Education Program);
31. Study Space Engineering with Experts;
32. UN SAT Curriculum
33. UN SPEC - UN Space Engineering Curriculum;
34. UNISPEC - UN International Spacecraft Engineering Curriculum;
35. United Nations Imagineering Initiative

VII.6 List of Material and Experts

United Nations Office of Outer Space Affairs United Nations Education Curriculum for Space Engineering							
<u>COUNTRY</u>	<u>Institution</u>	<u>Name</u>	<u>Type</u>	<u>Language</u>	<u>Webpage</u>	<u>Cost</u>	<u>Date Added</u>
BRAZIL	INPE	Terra View	GIS Application	English	http://www.dpi.inpe.br/terraview_eng/index.php	Free	24Aug.2012
BRAZIL	INPE	Terra Lib	GIS Functions and Library	English	http://www.terralib.org/	Free	24Aug.2013
BRAZIL	INPE	Spring Web	Data visualization	Portuguese	http://www.dpi.inpe.br/spring/portugues/sprweb/springweb.html	Free	24Aug.2012
USA	MIT	MIT	Open Courseware	English	http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-00-introduction-to-aerospace-engineering-and-design-spring-2003/	Free	24Aug.2012
INTERNATIONAL	Khan Academy	Khan Academy	Open Courseware	English	http://www.khanacademy.org/	Free	24Aug.2012
USA	Open Culture	Open Culture	Open Courseware	English	http://www.openculture.com/	Free	27Aug.2012
USA	Various	Degree programs on Space Engineering	All kinds	English	http://astronauticsnow.com/degreeprograms/index.html	pay	21 Sept. 2012
USA	Various	Applied Technology Institute Courses (On-line)	All kinds	English	http://www.atcourses.com/space_courses.htm	Pay	24 Sept. 2012
UK	Ranfield College	Astronautics and Engineering	Master Programme	English	http://www.cranfield.ac.uk/soe/postgraduatestudy/astronautics/	Pay	24 Sept. 2012

The charts above contain the list of relevant material for the drafting of the ECSE and names of engineering experts in academic institutions world wide that would be qualified to contribute to the development of the ECSE. The picture is linked to the table. By clicking on it, one is able to view the spreadsheets in Microsoft Excel containing all data I have gathered until 29 November 2012. Data can be found under G:\doc\SAP\BSTI\Education Curriculum.

End of Report

Office for Outer Space Affairs
United Nations Office at Vienna

Email: oosa@unoosa.org

Tel: +43-1-26060-4942

Cell: +43-1-680-226-0329

Elias Andrade

elias.andrade@unoosa.org

deandrade.elias@yahoo.com

UNOOSA Website: www.unoosa.org

United Nations Office for Outer Space Affairs

**United Nations Committee on the Peaceful Uses of Outer Space
FIFTY-FIFTH SESSION Vienna, 6 – 15 June 2012**

**Elias Andrade
Erasmus Mundus Global Studies Master Student**

**Observer of the University of Vienna. Vienna, Austria
March 1, 2013**

Introduction

In 1959, the General Assembly of the United Nations set the Committee on the Peaceful Uses of Outer Space (resolution 1472 (XIV)). The committee is coordinated by the United Nations Office for Outer Space Affairs, at the United Nations Office in at the Vienna International Center.

The role of the committee has been to coordinate space-faring nations, organizations, and other space actors, for the peaceful uses of human activities in outer space. Its role has been also to disseminate information, encourage research and dialogue among its members and non-members of the United Nations on what regards the peaceful uses of outer space. The committee has also two subcommittees: one that deals with the legal aspects of outer space activities called Legal Subcommittee and another that deals with technical aspects of outer space activities called Scientific and Technical Subcommittee.

Meetings of the COPUOS (Committee on the Peaceful Uses of Outer Space) are schedule every month of June, while the Scientific and Technical Subcommittee meets in February, and the Legal Subcommittee meets in April.

In 2012, the COPUOS met between June 6 to 15. During this COPUOS' meeting, among many issues regarding space activities that space-faring nations proposed resolutions, two of them drew the attention and energy of all participants and observers: the first one was the draft of the Outer Space Code of Conduct. The second and most important was the argument of the delegation of Azerbaijan against the membership candidacy of Armenia to the COPUOS, which made of this meeting very particular.

Below is a transcript of the dialogues among the countries delegation. It is written in the order certain countries exposed their opinion on the agenda items. The delegation of Russia is concerned the translation of the Code of Conduct into Russian is not accurate, while Azerbaijan has been critical on the membership of Armenia and other countries try to come up with another easy but yet legal solution.

The transcript below comprises my notes, as observer, of the the most crucial days on these two matters. The official report about the COPUOS resolutions can be found at the United Nations Office for Outer Space Affairs web page at the link:

<http://www.unoosa.org/oosa/en/COPUOS/copuos.html>

United Nations Committee on the Peaceful Uses of Outer Space
FIFTY-FIFTH SESSION Vienna, 6 – 15 June 2012
THURSDAY, 7 JUNE 2012

No. 2. Room M1.
03:00 a.m.-6:00 p.m.

Agenda Item No. 6
Ways and Means of Maintaining Outer Space for Peaceful Purposes. (continued
by the Russian Delegation)

Delegation of Russia

Because of the different position of states, there will be no result anyway on creating binding laws, and maybe there will be no agreement on the peaceful purposes for outer space.

Why do the purposes of maintain the peaceful uses remain unmade? The behavior of some countries do not go accordingly to previous agreement of the peaceful use of the outer space.

New political players excite us with their presence.

The committee should address purposes that tend to change indirectly our commitment our long sustainable technologies, then this council needs to sharply address these nations according to the code of conduct by the European Union. Such situation threatens the trust of other states because there is not a consistent of act.

The principal of freedom of the outer space for research distinguishes from the international maritime law. There is no freedom of the sea as well as of space. We confirmed again that correlated to the right of freely use of the outer space, we need to link remediation of space but broad the contest of the exploration of the space.

We trust that with the curse of time, we will reach an agreement. Russia was the first one told that we could not deploy any weapon into space. Now it is time for Russia to tell the same to the world. The issue of keeping space safe have to be addressed with real diplomacy.

Agenda Item No. 9
Report of the Legal Subcommittee on its fifty-first session

Delegation of the United States of America

Many states, including members of the COPUOS, have not accepted some treaties. The United States encourages them to do so. The outer space is not to be owned by any governmental or non-governmental organization, specially privet corporations, and the US believes that. We could like also to congratulate Dr. Irmgard Marboe for heading the legal framework of outer space code of conduct.

Delegation of Saudi Arabia

We see that many states and private companies engaged in space activities. Therefore, we should make an effort to keep them up to date.

Agenda Item No. 12 Space and Water

Delegation of Japan

Future experiments - Japan has two geostationary geophysical satellites.

The two satellites will be first used in the United States for forecast and natural disaster tracking.

Delegation of the United States

We would like to discuss the current and future space activities in the US. Because of the increase of the population, there is a huge pressure on access of water. Space information on water can be used to inform policy makers. Satellite technology has been crucial on that, and that's why the US is willing to invest on it. Ground water and other types can have their data provided in real time about land surface and water resources management activities.

Agenda Item No. 13 Space and Climate Change

Delegation of Austria - Space weather activities at the Austrian Institute of Technology (AIT)

SWEETS, Space Situational Weather (SSA) - Space weather
Informed about solar radiation. 7 events in 1998 of solar particle events.

Global Change Observation Mission (Water)

1. Observation of the Sea Surface temperature
2. Global rainfall map in the real time
3. Production of GSMaP from Multi-satellite Data
4. Global data based on satellite observation is updated every hour.
5. International cooperation - put satellites 10 min from each other so they can observe the same place on earth at the same time.
6. Cooperation between JAXA and NOAA

United Nations Committee on the Peaceful Uses of Outer Space
FIFTY-FIFTH SESSION Vienna, 6 – 15 June 2012
FRIDAY, 8 JUNE 2012

No. 2. Room M1.
10:00 a.m.-1:00 p.m.

Agenda Item No. 5
General Exchange of Views

Delegation of Thailand

Satellite data plays a big role in Thailand for disaster management. Therefore, the Thailand government appreciates the efforts to make photographic data more available.

Delegation of Republic of Korea

We hope concrete measures will be taken for a sustainable method of the outer space exploration. Korea wants to promote such a peaceful space activity to improve the lives of the Korean people.

They have two satellites in orbit: Concept 1 launched in 2006; Concept 3 was launched last month. Both satellites have high resolution cameras. Korea wants to launch conception 5 and we are working with Russia to create a space vehicle, despite the last failures.

Delegation of Ukraine

The study of space must be supported by the Ukrainian government in the international level. Ukraine's development program has been supported by the East European countries, US, and Brazil, also entities in Russia, Korea, etc.

Ukraine has made agreements with Russia on technologies of protection of the outer space. Cyclon 4, C-star conferences are examples of these projects. Last year there were 6 launches from the Ukraine, which is important to establish the country in the outer space field.

On the international code of conduct of the outer space: the country has participated to contribute to this document. We hope our contribution will be considered in the final draft, in the meeting happened in June 6 of this year in Vienna. We want to focus on this code, and we have worked on it since 2009. We agree to these principals: use exclusively to peaceful purposes, access should be applied without discrimination, and that the outer space bodies should not be owned by any country and used for military purposes.

Delegation of Germany

Space technology can be used to improve human living condition

Space technology effects on our daily lives: they trace gases like carbon dioxide, and others gases. We would like to mention the German-Dutch satellite to study the ozone hole, and help find political solutions for the issue.

Our delegation would like to stress on the dangers of weapons going to the outer space. This growing issue is jeopardizing human lives. We need to increase our security level.

Delegation of Cuba

Private companies do not belong to our constitution, so we need Western countries to do something to limit their actions on outer space.

We have not defined outer space borders, and we must resolve this as soon as possible. We hope there will be significant discussion about space border because it is dangerous the fact we do not have a binding definition.

We affirm our concern about space debris. We condemn the creation of spy satellites of the United States that do not contribute to lives on Earth but only the American own good.

We urge COPUOS to intensify cooperation among countries.

We affirm the exploration of the outer space without discrimination.

Delegation of France

We would like to endorse the statement of the European Union we did on June 6.

We support long term sustainable activities.

We are also concerned about debris, and the presence of men and women in space.

France has developed specific legislation on the main UN treaties on the basis that launches and many other activities are under the code on conduct and binding the UN regulations.

Attention to the 67th General Assembly of the United Nations.

France is supporting the code of conduct. We hope to promote the voluntary participation by countries, and help the whole diplomatic paradoxes on the issue. We want together to make a draft to improve the security of the outer space.

Delegation of Libya

Supports international criteria between advance and developing countries to serve the common interests of all countries on the use of the outer space.

We are also concerned about privet corporations on the exploration of the outer space and the development of those corporations in developing countries.

We are also concerned about space debris and the risk they bring, their accumulation and the threat of collision between space objects, especially those powered by atomic energy.

We believe the definition and delimitation of outer space will help also define the liability of countries and other institutions that are space active, and also ensure sovereignty of countries' airspace

We welcome the admission of Jordan.

Delegation of Venezuela

Venezuela's space program (satellite Simon Bolivar) is run by 30 experts who studied in China. There are 56 Venezuelans working in China to improve exchange of technology.

Other technology partners: Brazil, UK, India.

Venezuela has made the use of image for environment watch.

The country is concerned about the nuclear energy use in space, debris, and definition of outer space borders.

Delegation of Brazil

Welcomes Costa Rica, Jordan, Armenia as new members.

Brazil is supportive to the full commitments of the use of the outer space by the United Nations for peaceful and sustainable space activities.

Brazil will host the Rio+20. The principals of Rio 92 are still valid today. We research for a sustainable use of Earth for human kind, and the outer space is also included in it.

Sustainability includes space and space includes sustainability. If we do not act to prevent a disaster in space, we are not being sustainable.

The greatest threat we face today is an arms race in the outer space. We believe to be transparent to prevent this race. For that, soft/voluntary law instead of binding space law is not significant. Negotiations on legally binding is a long process, but they are the only way to do an enforcement of the code of conduct. No code of conduct based on thresholds will work either.

Agenda Item No.6

Ways and Means of Maintaining Outer Space for Peaceful Purposes.

International telecommunication Union

European Space Agency -

Emissions from right after the Big Bang is already giving incredible data.

Also reported about high resolution satellites and their launches.

First ESA launch vehicle was launched with more than 3,000 kg to the ISS and is spending 5 months in orbit. 27 August 2012 is the end of the mission.

Agenda Item No. 8

Report of the Scientific and Technical Subcommittee on its Forty-Ninth Session

Swiss Space Center

CleanSpace One - challenges.

Risks - be careful to not bring down the wrong space object. So they are working on identification of the objects.

The program is possible to help remove debris and for a reasonable price.

Delegation of China

Has 11 satellites in orbit today.

By 2020 they want to reach global service - precision accuracy of less than 10 meters.

We will use it to promote industrialization to catalyze large scale deployment.

China Satellite Navigation Conference (CSNC-2012)

United Nations Committee on the Peaceful Uses of Outer Space
FIFTY-FIFTH SESSION Vienna, 6 – 15 June 2012
WEDNESDAY, 13 JUNE 2012

No. 2. Room M1.
10:00 a.m.-1:00 p.m.

Agenda Item 5
General Exchange of Views

Delegation of Kazakhstan

Kazakhstan is satisfied with the level of contribution of the committee to address global issues of using the outer space for peaceful purposes and equal use of the outer space independently of their economic level.

Our activities: program for development technology aims to create a full activity for space. We have built an assembly facility for satellites and rocket complex, near the city of Almati. July 16, 2011, Kazasat 2 was sent using the operation system of Kazakhstan. In December it became fully operational.

On June 2011, with Russia company satellite system, we started working on sat. 3. Areal system has been developed in the USA, and road system for the facility has also been finished.

As part of the project for satellite navigation system, 10 different station were satellite and also for mobile.

Legal framework: we have done a lot to finalize our legal instruments. In January 2012, a law was passed so that all space activities will be based on law from now on. We have officially informed COPUOS on that new Law. We have signed 3 agreements and international treaties to assure our peaceful uses of the outer space. Saudi Arabia is a partner, also with Germany, regarding the preparation of the rock technology control regime.

205 Kazakh students have been studying in Russia and others have been trained in the designing facilities in Toulouse, France.

Chairman

Side talks were made on the application of Armenia, Costa Rica and Jordan

Many countries support to accept the application of these countries together.

As all countries are trying to use the outer space peacefully, all countries should sign up the treaty.

Therefore, I would like to ask all delegations if there is any concern with the chair takes action on the application of those three applications.

Delegation of Azerbaijan

I clearly explained my countries concerned about Armenia's application and on their application together as those applications have been made jointly. Therefore we are against these both proposals.

Chairman - a consensus can't be made by the chair yet. We will do it this afternoon.

Chairman - is there any delegation that would like to talk about the Rio+20

Delegation of Austria

With regard to space and water items, we would prefer to keep this item on the agenda committee. We could also expend the item on space and society.

Delegation of Indonesia

We understand that climate change is a very abroad issue to address. Under environment issues, and land degradation, food security, ecosystem efficiency, are also issues that are in our agenda and that we would like to address.

Delegation of the United States

We fully support the proposals made by you in the items in our agenda. Perhaps in our report, we should note that the chair of the working group may need sometime to work and give you mr chairman, could have more time to make quality decisions.

Delegation of France

We agree with the US. Yes it is true. The groups working on long term sustainability are very important, and we should give them all the support they need. We have to be able to work in the best conditions. There are several proposals/ideas that have been mentioned regarding methods, and organizations regarding the subcommittee. Therefore, we need a consensus to discuss this work.

Delegation of Mexico

We agree with the USA, and would like this paragraph to be extended. We would like to have more time to this working group in the next year session, so that the group can accomplish its activities.

Chairman - Space, Water and Climate Change items will be kept for the next year. Space and Society items could be merged together.

Secretariat - The package could be the following: Space and Society, and also the sustainable item. These three could be merged and consolidate/rename into "space and sustainable development" there also will be time for the working group on objects and the working group on sustainability.

Delegation of Austria

We would fully support on the merging these agendas and also rename them. Also support giving more time to the working group on sustainability.

Delegation of Italy

We are very much in support. At the same time, I have a question: space and development will also include climate change? Would that one do a follow up on the Rio +20, but can we also include the society item? That item will include educational issues, nothing too related to the Rio+20.

Secretariat - we can't have everything into only one item because that can cause confusion. Those two are already too broad.

Director of the Office of Outer Space Affairs

Referred to the 50 years of outer space exploration - and first space flight made by a woman in June 1963. The anniversary will be celebrated next year COPUOS. We will have a special panel about it. We propose a half day event to acknowledge the female presence on space technology.

Delegation of Russia

We want to thank the secretariat for his initiative and would like to promote it.

Delegation of Italy

We have continued to work for more effectiveness inside the UN budget, so we will continue to show the effectiveness of our work. We would like to come back our position on the legal subcommittee. Finding ways of more action oriented than reports, we would like this committee to consider our report, and take these measures into consideration.

We would like to have less agenda items discussed in our agenda work. This won't affect the openings the items we need, but it could be a measure to construct our work, so delegations could be more concise and direct, so the chair doesn't have to close sessions earlier.

Delegation of France

We fully support the previous statement made by the Italian delegation. This type of action and the proposal they made. Maybe all states in an informal matter, could work together on this issue. This could also work both in the COPUOS and in the subcommittees of COPUOS.

Delegation of Hungary

We would like also to support the statements of Italy and France.

Delegation of Ecuador

The G77 and China would like to make a statement. The duration of the legal committee should remain the same. There are several items which are globally important, but for international corporations among others. Further more, every year other items are always proposed. Therefore, delegations should keep in mind about time schedule.

Agenda Item 9
Report of the Legal Subcommittee on its fifty-first session

Dr. Marboe.

Thanks for the informal opportunity for talks.

We unfortunately have not completed the draft on the Code of Conduct because of translation problems. We hope we will continue these informal consultation this afternoon, so that the changes can be incorporated in the English version, and that we can agree on that Friday.

Agenda Item 14
Future Role of the Committee

Strategic framework of the office of the outer space affairs, and membership of the committee's sub-items.

No delegation wanted to take the floor.

Agenda Item 16
Other Matters

Chairman - let's proceed on the membership of the new members. There is no consensus on the issue of Armenia by Azerbaijan. Therefore, I suggest we will discuss this tomorrow.

Delegation of Azerbaijan

We are against to look at this item as the package application of this country, so we should follow immediately to the vote. Also, we would like to ask which countries have been consulted informally.

Chairman

is there any delegation would like to talk about this matter?

Delegation of the United States

We should return to this question tomorrow. We believe their nomination should all be taken at the same time. We should try to take consensus on this session to take all them together, and if we can't, we should think of something else. Our work should not be disturbed because of that. We should take a smooth procedure.

Delegation of Jordan

We hope we will reach a consensus on their application. We have met all the requirements to candidacy and consensus to all the states. Mr. Secretary, are applications to be taken together or separately? and if we can't solve this question, what procedure are we gonna take?

Delegation of Costa Rica

As one of the affected countries in this case, I would like to call all members to apply to reach a consensus as soon as possible, and would like to close discussion for today and continue tomorrow.

Secretariat

When it comes to application of a state, we have a set of practices that have changed in the 50 years of this committee. Today, there are no rules on the regulations of this committee whether the application is considered together or separately. There was a concern in the committee that delegations were growing too fast. So any new member wishing to become member of this committee was considered by geographical regions in the world. So delegations should consider to continue consulting whichever way they want to procedure.

Delegation of Egypt

On the notion of taken candidature as a packaged, has any historical fact that this kind of package has been done before or is this the first time?

Secretariat

The principal of geographical distribution has been imperative in this committee. However, recently we started the rotational form, but for many years we stopped that practice since ten years ago. Since then we have not had any concerns on the growth of the committee. But again, there has been no rule on how we do this vote. The only rule is that all members of the UN can apply. Applications usually is done individually. States apply and we vote. But some times like now, other states ask for package voting, and others request that they be done separately. Now, it is a policy matter. That's why the chair asked for continue consultation and work on it tomorrow. but there is no rule on grouping individual applications together. This is a policy issue for delegates together.

Delegation of Egypt

There is no historical precedent of package before?

Mexico Delegation

My delegation would like to recall that there is a precedent. In the pas if delegations check our file, there was an ad hoc committee with 18 members, then it went to 24, 32, but at that time it was to maintain the geographical balance so we have to vote as a package to create a balance. We agree there is no rule, but we support that this be done as a package.

Delegation of Austria

The basic culture and values practice of our committee - it has been a culture of inclusion and not exclusion. We would like to remind the chair that our culture has been of inclusion not of exclusion for the peaceful uses of the outer space.

Delegation of the United States

It is clear that has been practice in the past concerning how we handle membership voting. In the past, when we had multiple members applying, like it had been before, and in other occasions where further discussion was needed, and therefore the discussion would be carried on to the GA where the decision was made.

Our inability to arrive to a consensus is not good

Delegation of Russia

The situation regarding membership is not something that lands itself in resolution. All of us are feeling embarrassed. I feel extremely embarrassed because both two countries used to belong to my states. I would like to call them both to follow and eliminate the precedent of this issue, which they had to talk even with the president of Russia. I would call the two countries to arrive at a decision that goes with the purpose of COPUOS.

Delegation of Egypt

We apologize for taking up the floor so often.

The reason why we asked for this was because I wanted to know if are we here trying to create a precedent to send to the GA the candidature of a single candidature? also are we trying to make a policy here of judge one country singularly.

Delegation of Venezuela

My delegation would like to make a final court to the peaceful existence of all states. COPUOS is a scenario for peaceful states. Despite our differences, we can seat here for a better world, a world in peace. Let's not make this a place for confrontation and hate. My delegation will be mature enough to deal with these issues itself.

Secretariat

I will make reference to a couple of documents so members of this committee will be reminded of other situations:

In 2002, Algeria had applied for membership in the committee. The committee noted that the group of Latin America and the Caribbean, G77 and China, Africa had supported the country' application. The Libyan delegation had applied for membership in the committee, and the group of African states had endorsed the Libyan application. IPg. 49, takes notes as Algeria application to be become a member of the committee and the support of the G77 and other regional groups decided to accept its membership according to pg.41 of the General Assembly.

In 2004. A/5920 document membership of the committee 58/59 General Assembly resolution. we accepted the membership of the Libya.

In the mean time 2007, the committee also notes the application of Thailand. The committee agreed with the membership of Libya and Thailand. This is to show that application of countries are done individually. So the 3 applications have been treated individually in that sense. We deal with it separately in every paragraph as you have heard the example.

However, the final decision is taken by the General Assembly.

Delegation of Azerbaijan

I would like also to repeat our concern of the Armenian application. The behavior of the republic of Armenia is not with the principals of the COPUOS. Armenia is impeding Azerbaijan space activities, including the halting of a satellite launch. This is the case, not that we are politicizing this voting application.

Delegation of Turkey

On this application matter, it is much more preferable to reach consensus before us, but so far this has been impossible to make individual applications. I thank the secretariat for the explanation and the data and example provided a concrete example for the commission.

Individual application of membership may be taken now because in the future if we do more packages, we have more issues.

Delegation of the United States

In all cases, individual or not, countries are allowed to go to the General Assembly and make their application. What we are doing now is to take that opportunity away from Armenia. My delegation has no problem with any of these country is not the case. But the case is what policy we are creating for future applications?

Delegation of Azerbaijan

We are against Armenia's application and also to send their nomination to the General Assembly. So we kindly ask you to procedure immediately with the application of Costa Rica and Georgia and we are just wasting time on consultation about this issue because we won't change our position.

Chairman

Yes, we understand and have heard your concerns. However, the work of COPUOS is reach a consensus and we still have some time.

Delegation of Armenia

We do not even want to reply the issues only one country has (Azerbaijan) and would like to have the vote postpone to Friday.

Conclusion

As we can see from the discussion among the countries, the Committee on the Peaceful Uses of Outer Space has pledged its goals of promoting dialogues among space-faring nations and organizations that are space active. Despite the difference in interests of its members, and specially when those events become a multilateral issue, the Office for Outer Space Affairs has conducted dialogues in the COPUOS in a professional manner aiming to always respect the sovereignty of all countries.

In this meeting of the COPUOS, two issues took most importance among all agenda items. The first one, the draft of the Outer Space Code of Conduct, draft by Space Lawyer Dr. Ingrid Marboe, and backed by the European Union, was not sent to be voted at the General Assembly due to translation problems alleged by the Russian Federation. The draft has been translated again and revised, and its new version will be presented in 2013 at the next COPUOS meeting in June.

In the second and most frustrating case, members of the COPUOS also did not reach a consensus on the membership of Armenia. Due to the pertinent disapproval of Azerbaijan, the committee could not approve the vote of the three candidates (Armenia, Costa Rica and Jordan) together as a package. Also to provide solidarity with Armenia, the other two candidates and full members did not choose to vote on the Costa Rica and Jordan, leaving Armenia behind. The solution found by the committee was therefore to note the candidacy of the countries in the official annual report to the General Assembly, requesting the General Assembly to decide on the membership of the three candidates.

It is very expected that during the General Assembly, which proceeds by majority of votes, contrary to the COPUOS which works with consensus, that all three countries applying for membership at the committee will be approved. The decision has been previewed by member states because it is clear no country should be deprived of the right of participating at a peaceful committee at the United Nations. The General Assembly, as well as the Security Council, have the authority to rule out or approved any decisions of any other organization or committee within the United Nations.

Thus it is therefore the wish of every 71 members of the COPUOS that the committee increase its number of members visioning to promote dialogue for peace and fairness of outer space activities. It is the wish of its members and most people of good will in the world that the work of the United Nations be effective, professional and respecting the sovereignty of every nation in the world.