Ghent Institute for International Studies

The Regime Complex of Global Space Governance

The International Space Politics of the 21st Century

Xavier L.W. LIAO
5/27/2016

ABSTRACT

In the course of 2007-2008, the successive anti-satellite weapon tests respectively conducted by China and the US refreshed the global concerns on the question of governing states' space actives. Various international space regime initiatives, namely the EU-led International Code of Conduct and the China-Russia sponsored PPWT, were proposed respectively outside of any existing multilateral forum and at the non-UN Conference on Disarmament. The new happenings within the galaxy of global governance drew our attention to ultimately realize there is not merely the galaxy of space governance but a number of interconnected galaxies for space governance. This particular agglomerating or federating governing force has been embedded and constantly appeared in countries' negotiations regarding the development and the control of human space activities. It was with this fundamental understanding, we put forward to decipher such interconnecting global space governance structure as a way to seize the vivid dynamics in international space politics over time. And we have chosen one of the most inspiring theoretical frameworks in our time, *regime complex* as our way to undertake a piloting analytical narrative in order to cultivate a broadened understanding of the topic.

The regime complex framework focuses on investigating various types of *interplay* between the international regimes within a specific governing issue area that fragmented the entire governance scheme. This general architectural framework provided the limits within which our research examined as its object of study all international regimes closely or more distantly related to issues of space governance. Nevertheless, bear in mind that we could not explore and study in-depth the galaxies of interconnecting governance issue areas, but merely establish a pilot analytical narrative which is expected to prove useful for further and more narrowly focused case studies in the future. In this regard, the analytical strategy proposed by colleagues at the Ghent Institute for International Studies (GIIS), which identifies how the strategic, functional and organizational driving forces led the growing institutional fragmentation within the global space governance architecture, was extremely valuable for our research.

With this analytical instrument, we have established our general understanding of the long-standing space governing issues (Chapter II), the *legal inconsistency* between different governing principles, norms, their interpretations and implementations over time (Chapter III), the highly politicized institutionalization process that from the beginning of the space age strongly stressed the de-militarization or disarmament objectives and consequently divided the entire global space governance architecture into two distinct dimensions between disarmament and the "peaceful use" of outer space, though the space affairs are never indivisible for it dual-use (Chapter IV). By applying the regime complex framework and the GIIS analytical strategy, we investigated "space security" governance by introducing the main actors, key governing issues and the institutionalization process of the sub-governing regimes constellation in order to investigate how the space security governing constellation developed toward to its current fragmented stage of regime complex. In the power-interest centered space security governance dimension, states constantly required for regime change though almost always failed in the course of the last half century. New regime initiatives such as ICoC and PPWT raised new hopes though without certainty (Chapter V). With the same methodology, we achieved our analytical narrative on global navigation satellite system (GNSS) governance, which in our view represents a microsphere

that demonstrates the fundamental problem of the whole of space governance and its structural fragmentation, the dual use that means military and civilian purposes, or nowadays “trio use” with the addition of a commercial dimension to the use of outer space. The interconnectivity of the three physical and practical dimensions naturally bring all the relating regimes together with overlapping mandate or missing competence to co-manage the space affairs.

ACKNOWLEDGMENTS

Exactly four years ago, after Ascension Day in May 2012, I descended from space with my research topic to meet Prof. Rik Coolsaet, Head of the Ghent Institute for International Studies (GIIS), and was accepted as a doctoral student of GIIS, Ghent University. Since then, I have been fortunate to enjoy open-minded and rigorous supervision from Prof. Dries Lesage and Prof. Thijs Van de Graaf who respectively accompanied me as the supervisor and the co-supervisor of my doctoral research. Without the scholarly input of these renowned International Relations scholars, I would not have been able to complete the puzzle of 'regime complex of global space governance' in a scientific way. I had the further good fortune to enjoy the privilege and honor of constantly receiving precious advice and insight from Ambassador Frank Asbeck, the Former Principal Advisor for Space and Security Policy, Security Policy and Conflict Prevention, European External Actions Service (EEAS), European Commission. With long experience in dealing with European space security issues, Frank remains one of the main protagonists who was deeply involved in the EU space diplomacy in the realm of global space governance. Furthermore, I am extremely grateful for all the precious moments he shared with me on thoroughly reviewing the historical background, political insights and technical matters that considerably impacted the evolution of the global space regime complex. These factors are definitively vital to discern the dynamics in international space politics and the vivid institutional interactions in the global space governance architecture, yet not always evident for a political scientist with limited hard sciences capability.

At the final stage of this doctoral dissertation, I have also benefited from the advice of other GIIS colleagues, such as Prof. Sven Biscop (GIIS and Egmont Institute), Prof. Mattias Mermeiren, and Dr. Peter Debaere who generously offered their rigorous critiques and open-hearted suggestions to allow me improve this doctoral dissertation. I would like to express my gratitude to Prof. Miau Jiun-ji, Former Director-General of Taiwan's National Space Program Organization (NSPO) and Distinguished Professor of the Department of Aeronautics and Astronautics, National Cheng Kung University (NCKU), Taiwan, for his generous agreement to be one of the members of my Doctoral Examination Committee. He kindly provided many inspiring insights from his experience in the field regarding the vibrant space activities in the Asia Pacific region. In addition, I wish to thank those who have kindly assisted me in proofreading various works of mine in the course of these years. They are Dr. Paul Arblaster, Paul Kelleher, Barbara Goslawski, and Michael Caluwaerts. Without their assistance, this dissertation could not have attained its required quality. Finally, I must thank Marianne Hoffmann, Christine Hui-chu Lin, and Po-lin Huang for their artistic fine touches in concretizing some illustrations and the book cover design for this work that I could only imagine without having the appropriate skills to accomplish them.

Finally, I would like to thank my dearest parents for their inexhaustible support. I also wish to thank my dearest son, Jan-Willem for all the moments he has had to bear the fact that I prioritized my intellectual commitments, leaving less time for father and son. Nevertheless, I can only believe that the future will be for him and for all coming generations.

LIST OF ILLUSTRATIONS, TABLES AND FIGURES

ABBREVIATIONS

ABM	Anti-Ballistic Missile
APRSAF	Asia Pacific Regional Space Agency Forum
ARABSAT	Arab Satellite Communication Organization
ASAT	Anti-satellite
ASBU	Arab States Broadcasting Union
BMD	Ballistic Missile Defense
ABMT	Anti-Ballistic Missile Treaty
C4SIR	Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance
CD	Conference on Disarmament
COPUOS	Committee on the Peaceful Use of Outer Space, United Nation
EEAS	European External Action Service
ELDO	European Launch development Organization
ESA	European Space Agency
ESRO	European Space Research Organization
EU	European Union
GGE-TCBMs	Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities
GIS	geographical information system
GLONASS	global navigation satellite system
GNSS	global navigation satellite systems
GPS	Global Positioning System
GSO	geosynchronous orbit
IADC	Inter-Agency Space Debris Coordination Committee
ICBM	intercontinental ballistic missiles
ICG	International Committee on Global Navigations Satellite Sysytems
ICoC (CoC)	International Code of Conduct for Space Activities

ISS	International Space Station
ITAR	International Traffic in Arms Regulations, United States
ITU	International Telecommunication Union
LEO	low Earth orbit
LTBT	Treaty on banning nuclear weapon tests in the atmosphere, in outer space and under water (also known as PTBT, NTB)
MIFR	Master International Frequency Register
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NPT	Nuclear Non-Proliferation Treaty
OECD	Organization for Economic Cooperation and Development
OST	Outer Space Treaty
PAROS	Preventing an Arms Race in Outer Space
PPWT	Prevention of the Placement of Weapons in outer space, the Treat or use of force against outer space objects
SDI	Strategic Defense Initiatives
SHF	Super High Frequency
SSN	Space Surveillance Network, the United States
TCBMs	Transparency and Confidence-Building Measures
ULA	United Launch Alliance
UN	United Nations
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WMD	weapons of massive destruction
WMO	World Meteorological Organization
WTO	World Trade Organization

CHAPTER I INTRODUCTION: HUMAN-SPACE CONNECTIONS

Abstract: The introductory chapter presents the general motivation and the academic interests of the author underlying the decision to analyze the *regime complex of global space governance* as the topic of his doctoral research project. This research project puts forward two telling recent events, the Chinese ASAT test in 2007 and the EU-initiated ICoC of 2008 as the salient historic points of reference marking a new era alongside the evolutionary international space race. Hence, international race in and through the outer space arena has become ever complicated and complex in the sphere of global space governance. The increasing creations of the new space-relevant international regimes and the continuous functional changes of existing space institutions seemed not merely related to the new common challenges for all countries to commonly overcome. The expansion and fragmentation of the entire space governance architecture has also become increasingly connected with the states' pursuit of their individual interests. To decipher the growing complex structure of the global space governance architecture, a recently developed analytical framework, the 'regime complex', was viewed valid to depict how the competitive-cooperative hybrid global space regime complex has attained its expanded and fragmented state. Furthermore, the three-logic analyzing methodology that stresses the distinct gravitational forces, namely the strategic, functional and organizational forces, offers a pertinent lens to observe how the expansion and fragmentation of the global space governance architecture has been growing individually and jointly steered by these gravitational forces.

1. THE STORY OF HUMAN-SPACE CONNECTIONS

Humankind has always watched the sky or the universe with general curiosity and enthusiasm. Because space is fascinating! Writers, artists, astrologists, astronomers, or aerospace scientists and engineers, each have their particular interests and focuses in their individual exploration of outer space. Otherwise, those interested in political science and the study of international relations are attracted by the facts that outer space, or precisely the human use of outer space, has, since the late 1950s, grown in its influence on the self-positioning of states and their interaction with each other in world politics.

Although some consider that the space age was effectively opened for all humankind when the first German V-2 rocket came down from the edge of space and exploded on the residents and buildings of London in September 1944,[1] for most of us it was the successful launch of the Soviet *Sputnik I* satellite into orbit in 1957 that inaugurated the international competition on space capability, commonly considered a 'space race', particularly between the two Cold War powers, the United States and the Soviet Union. In this race, the USSR achieved the first manned spaceflight mission in human history in 1961. The Soviet Air

[1] Lambakis, Steven. (2002). Putting Military Uses of Space in Context. In James Claz Moltz (ed.) *Future Security in Space: Commercial, Military, and Arms Control Trade-Offs*, Occasional Paper No. 10 (Monterey, CA: Monterey Institute of International Studies, Center for Nonproliferation Studies and University of Southhampton, Mountbatten Centre for International Studies, July 2002), pp. 23-24.

Force Colonel Yuri Gagarin became a Soviet hero as the first astronaut who flew to and back from orbit. This successful manned spaceflight spurred the US ultimately to fund an ambitious Moon exploration project – the Apollo Missions. As addressed by President Kennedy in his famous '*Moon speech*' delivered in 1962 at Rice University, Texas, the Americans "choose to go to the Moon to win".[2] The US Moon exploration project firmly demonstrated the American desire to pursue national pride, power and leadership through the development of its space capabilities. This subsequently resulted in the first manned Moon landing on July 20, 1969, by the US astronauts Neil Armstrong and Buzz Aldrin. This mission was one of the US Apollo Missions undertaken by the US National Aeronautics and Space Administration (NASA) in the 1960s and 1970s. Hence, during the Cold War the focused interests of states and the general enthusiasm of peoples were both directed towards developing space capabilities in order to uphold their national military capability superiority over the enemy, and to develop more sophisticated space technology applications than the adversary in and through outer space. This space race accordingly became openly and heavily politically charged.

The US and the USSR continued to develop their respective national space capability to increase their military and strategic forces during the Cold War. Various types of focused military space capability were undertaken, for example, nuclear weapons in space, intercontinental ballistic missiles (ICBMs). These weapons actually use the same rocket launch technology as space exploration, and as satellite-supported telecommunication and navigation operational systems. Once a country became heavily dependent on space systems for military purposes, it became vital to develop anti-satellite weapons to neutralize the satellites of the adversary space systems, or otherwise, to prevent anti-satellite attacks upon one's own satellites. The space capability race between the United States and the Soviet Union was not merely a race of the giants but also involved other countries, for example, the member states of the North Atlantic Treaty Organization (NATO), to support political allies. These countries were involved as relays to support the functioning of the space system of the space power to which they were respectively allied. Others might be affected by the consequences if 'star wars' were to break out. To this end, the ways and the outcomes that states individually or collectively handled such conflicting space capability competition could either contribute to the maintenance of a balance of power and to assuring continuous strategic stability and peace between the space powers and their allies, or exacerbate the race for space power toward a space war that should concern all countries. To avoid the worst scenario, the exploration and the uses of outer space became quickly and deeply politically charged by states and were decided to be arranged and regulated throughout the international negotiations via bilateral channels, and in the auspice of the United Nations (UN), the existing international regulating mechanisms and newly created space relevant international institutions.

When the Cold War reached its end after the fall of the Berlin Wall in 1989, it did not end the 'space race' even though the two Cold War space powers had to drastically reduce their efforts at building space capability and their financial investment. But, the end of the Cold War nevertheless contributed to the lift of the former 'Iron Curtain' that had prevented the free flow of space related personnel exchanges, *know-how* and technology transfers, and the trading of equipment and services between the two hostile camps. Other states than the two

[2] John F. Kennedy, Moon Speech at Rice Stadium, September 12, 1962. http://er.jsc.nasa.gov/seh/ricetalk.htm

traditional space powers gained more room to develop their own space capabilities for both military and civil purposes. In the 1991-1992 Persian Gulf War, the striking performance of the American space systems which overwhelmingly supported the US-led military coalition in the Operation Desert Strom for intelligence, communication, and navigation functions as well as guiding precision munitions and enabling "network-centric warfare" through remote command centers and live video links from the battlefield primed the spacefaring countries of the European Union, and the emerging nations such as China, India and others to seize upon the novel situation. It was the moment to develop their general or specific space capabilities for their own strategic independence and to boost a new wave of domestic industrialization in the way of accommodating space related devices manufacturing facilities and commerce in satellite telecommunication and satellite navigation services.

In parallel with the continuous space capability competitions over time, the use of outer space was also marked by its cooperative nature due to a functional necessity as well as its quality of a global public good. Undeniably, the costs of space capacity development and the need to have worldwide supportive relay ground stations or other facilities to operate a global space system will not attract any single nation to carry the full operational and financial burdens alone. If it does not involve any immediate strategic and security concern, international cooperation even between traditional rivals is without doubt more advantageous than working alone. Space powers and spacefaring nations also have benefits to cooperate with each other for maintaining their geostrategic importance and gaining geo-economic advantages. Russia and China, for example, have been getting closer to each other on making the Russian global navigation satellite systems (GLONASS) and Chinese BeiDou compatible and interoperable to break through the US GPS monopoly.

Although the Soviet Sputnik I is still widely known as the first orbiting artificial satellite in the world, the project was presented together with the US Army-Navy joint project Vanguard and the Explorer satellite projects under the international cooperation framework of the International Geophysical Year (IGY) between 1957 and 1958. The IGY was in fact an international cooperation project that brought together the Soviet Union, the United States, and sixty-five other countries to coordinate their respective scientific efforts regarding the geographical observation of the Earth, data sharing, and geophysical research findings. It was obvious that since the dawn of the space age, in parallel with the military race for security space capability as such, states have also chosen to work with each other to develop some sort of division of labor and sharing of research experience in order to maximize the outcomes of their projects for the particular and general interests of humankind. Not only that, the useful parts of outer space can to a certain extent be considered 'common pool resources' (CPR),[3] or 'global public goods'.[4] To operate any space system that supports military and civilian purposes, it is necessary to place a number of satellites in orbit and employ a certain bandwidth of radio frequency spectrum to transmit the information data. Because of the Earth's gravitational force, only a limited zone of orbit can be allocated satellites, and these satellites need to be distanced from each other.

[3] Ostrom, Elinor, Walker, James and Gardner, Roy, Covenants With and Without a Sword: Self-Governance is Possible, *The American Political Science Review 86* (2) (Jun., 1992): 404-417.
[4] Karl, Inge, Grunberg, Isabelle, and Stern, Marc A. (Eds.) (1999) *Global public goods – International cooperation in the 21st Century* published for the United Nations Development Programme (UNDP). Oxford/New York: University Press.

Otherwise, they can collide with each other or interfere with each other's radio communications. This means that rules and regulations that allocate orbital placement slots and radio frequency bandwidth are needed before any individual space system can be designed or launched.

Another example of hybrid space competition-cooperation is that, until 2016, the American launch company United Launch Alliance (ULA) continued to purchase Russian-made RD-180 rocket boosters for the Atlas 5 rocket to launch US military satellites into orbit. This despite the fact that since the Ukraine-Russia Crimea standoff in 2014, the issue has continuously been raised among US congressional concerns regarding US independent launch capability and security. Purchasing ready-made and high-quality Russian RD-180 rocket engines costs the ULA and its contractor, the US government, much less than would developing its own boosters. In order to improve the service quality of their respective global navigation satellite systems (GNSSs), Russia and the US each need the other to host the augmentation ground stations of the American GPS and the Russian GLONASS on their territory. The US agreed to share its sophisticated space situational awareness information data to allow China to save critical time for avoiding collision between Chinese spacecraft and other orbiting objects such as the International Space Station (ISS) and the space-based telescope.[5] This was not simply to the advantage of the Chinese but also of the security of all American space assets, such as satellites for various purposes and the Hubble space telescope, and of other international spacecraft, such as the International Space Station orbiting in low Earth orbit (LEO). Another example of such cooperation is that Europe has purchased satellite imagery data from some Asian countries that European geospatial satellites do not cover.

The use of outer space has brought significant benefits to millions of people who often enjoy these without even being aware of it. Further to the post-Cold War opening of the free flow on developing global space capabilities between states, there has been a popularization of the use of outer space to expand the applications of space-related technologies. This has resulted in offering wide-ranging possibilities to improve the daily lives of the population at large. Satellite communication and navigation services offer access for people who live in remote rural regions and urban areas to practice e-education, e-medicine, e-commerce and to enjoy satellite radio and TV broadcasts. The GNSSs not only support the military operations they were invented for but have become vital for humanitarian aid missions, as well as for search and rescue operations after natural disasters. GNSSs have become requirements for air, sea and land transportation and their traffic control. GNSSs now guide farmers to operate precision farming in their fields, and provide accurate synchronization services for international online banking and global financial systems with their atomic clocks. The users and drivers of Uber depend on GNSSs to find each other and their destinations. Earth observation satellites have been used for weather forecasting, natural disaster mitigation, climate change and environmental protection since the beginning of the space age. In sum, many of us are discussing the global issues on space for security and safety, space for economy and development, and space for sustainability (Illustration 1).

Nowadays, the uses of outer space offer much more extensive utilities but also face higher risks and challenges than before. For many of us, the scenario of 'a day without space' or

[5] *Defense News*, China-US space relations see small but important step. December 14, 2014.

more precisely 'a day without satellites' could be a disaster with irreversible damage. The deaths of ordinary people and additional social costs could easily result from the sudden loss of a satellite signal which might be transmitting the trajectory information of an incoming missile in order to intercept it, or guiding a maritime cargo fleet to avoid a foreseen stormy zone, or helping an ambulance to find the injured at a critical moment. This makes assuring the integrity and the effective functioning of all the space systems a global issue of general interest, concerning not only the space powers and spacefaring countries but increasingly also non-spacefaring countries and the global population. States are therefore compelled to moderate their competition and encouraged to broaden their functional cooperation when using outer space. Already from the beginning of the space age, states have explored the channels of bilateral negotiations and multilateral forums to resolve disputes and soften tensions regarding the use of outer space. They jointly created the governing principles and guidelines on the use of outer space in order to further establish legal norms, operational regulations and equipment standards to assure human safety and the protection of space assets by preventing omission and harmful acts. Last but not least, countries with different space capabilities are urged to work together in order to merge the development gap between them. In sum, there is a strong expectation that the use of outer space will be governed within a global framework.

Illustration1. Multiplication of the use of outer space in our daily lives

Concept: Author; Illustrator: Marianne Hoffman

In general, we are impressed by the uninterrupted merging connections between mankind and space in general. In particular, we are spurred to learn more about how the hybrid competitive-cooperation international relations changed as international space politics expanded its relevance. A complex global governance structure has developed that consists of various governing patterns and managing mechanisms that cover the governance of all the different global issues relating to the uses of outer space by states. We are therefore keen to start our journey to explore the universe of international space politics and the galaxy of global space governance.

2. DEFINING THE PROBLEM: THE EVER GROWING SPHERE OF INTERNATIONAL SPACE POLITICS

2.1. A NEW PHASE FOR INTERNATIONAL SPACE POLITICS AND GLOBAL SPACE GOVERNANCE: CHINESE ASAT TEST AND THE EU-LED ICOC

In December 2008, the European Union (EU) launched its 'multilateral consultations' with non-EU states to discuss the initiative of creating a new multilateral, non-binding, voluntary International Code of Conduct for space activities (ICoC or CoC)[6]. The EU ICoC[7] put forward a comprehensive approach that explicitly targeted the global governance issues related to the security, safety and sustainability of human space activities. With this stance, the EU ICoC took the position that the growing security issue is no longer limited to the traditional military security arena but already extends to other global governance issue areas, such as protecting human safety, space objects, and the space environment. Furthermore, as human space activities are becoming increasingly interconnected with the social, economic, scientific and technological development of all nations, and with the management of global issues such as the preservation of the environment and disaster management, the EU ICoC proposes that an additional sustainability approach to governing human space activity is desirable and beneficial. The EU's initiative was not proposed without outside stimulus. The ICoC initiative is widely considered a functional and strategic reaction of the European Union vis-à-vis the worrisome potential harms of space debris to space safety and sustainability, and a likely new situation of conflict in international space politics after China's Anti-satellite (ASAT) test in 2007 that was followed by the US ASAT test in 2008.

On January 11, 2007, China launched a ground-based, medium-range ballistic missile to destroy one of its own defunct weather satellites in orbit. The Bush Jr. Government in the US reacted to China's ASAT capability demonstration with a similar capability demonstration in February 2008. The immediate consequence of the Chinese ASAT test was that the destroyed satellite shattered into over 3,000 tracked pieces of orbital debris larger than 10

[6] European External Action Service (EEAS), European Union. http://eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm

[7] Preamble, Point 2, ICoC draft, version 31 March, 2014. http://www.eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf

cm.[8] The American ASAT test by contrast created a smaller amount of debris. There are myriad ways in which space debris spread through a heavily explored belt of Earth orbit has the potential to harm thousands of orbiting space assets, such as satellites, space-based telescope, manned and unmanned spacecraft, and not least to the International Space Station (ISS), which is currently owned by around 60 countries, international organizations and companies. The total amount of the existing in-orbit space debris amounts to some 21,000 pieces of 10 cm in diameter or larger (*NASA* 2013).[9] This includes the debris created by China's ASAT test as well as debris created by the US and the USSR during the Cold War, such as the thousand pieces of debris left after the US ALMV system was tested to destroy an aging Sol-wind satellite in October 1985. This 'space junk', all travelling at speeds up to 10 km per second, has the potential to cripple or destroy working spacecraft and to endanger astronauts. The movie *Gravity* (2013) provided a dramatic visualization of the serious security and human safety issue in space.

China's 2007 ASAT test, continuously hailed by China's state-owned media as a legitimate experimental orbital satellite removal operation,[10] was strongly criticized by the Western countries. According to the US Congressional Report Service, the US government responded with a formal protest to China. Australia, Canada, the United Kingdom, the European Union and China's neighboring states, such as South Korea, Japan and Taiwan, reportedly expressed concern. Russia by contrast downplayed the test.[11] The criticism and concerns were obviously due to the expectation that the test signaled the start of a new type of military space capability race between the US, Russia and likely the third space power, China. The new situation also broached the question of whether the bipolar balance of space power between the US and Russia, or the ostensible US space hegemony after the Cold War, had reached an end. However, as a matter of fact, the kinetic-kill or hit-to-kill technology that China's ASAT test applied had already been abandoned by the US and the USSR after their intensive tests in the 1960s and the 1970s respectively. Instead, since the 1980s both Cold War space powers had chosen to develop directed electromagnetic energy (laser) ASAT weaponry. This was out of tactical efficiency concerns and a desire to minimize potential harm to their own spacecraft. Nowadays, disruptive radio communication between a satellite and its users on the ground – *satellite jamming* – or developing maneuvering to derail a targeted satellite from its programmed orbit are viewed more effective and ecological. Knowing this technological insight, China's ASAT test was not so significant in showing its full range space power but about Chinese missile defense capability which is not only related to international space security but to international security and peace as well as regional stability in Chinese neighboring area.

At the global level, as far as the safety of human and space assets was concerned after the significant space debris increase caused by China's ASAT test, the United Nations Committee on the Peaceful Use of Outer Space (COPUOS) in April 2007 rapidly adopted the *Space*

---

[8] Secure World Foundation, (2014 updated). *Space Sustainability – A practical guide*, Washington D.C./Denver/: Secure World Foundation.

[9] US National Aeronautics and Space Administration. 2013. http://www.nasa.gov/mission_pages/station/news/orbital_debris.html#.VFifCNJDuGU

[10] *Global Times*, Editorial: 'By wishing the story about China's ASAT weapon development was true', January 6 2013 (环球时报社评: 愿中国研制反卫星武器传闻是真的).

[11] Kan, Shirley, China's Anti-Satellite Weapon Test, *Congressional Report Service Report for Congress*, RS22652, April 23, 2007.

Debris Mitigation Guidelines drafted and submitted by the Inter-Agency Space Debris Coordination Committee (IADC). The guidelines put forward three fundamental principles which are shared by all thirteen IADC national space agency members: "(1) Preventing on-orbit break-ups; (2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions; and (3) Limiting the objects released during normal operations."[12] Yet the IADC, an international intergovernmental forum consisting of thirteen national space agencies, is only mandated to regulate the civilian use of outer space by the thirteen national space agencies. The IADC has no regulatory power regarding the military use of outer space by national defense services, which is precisely what the ASAT test was. Thus, the ASAT test that created on-orbit break-ups (space debris) caused by the spacecraft removal operation (removing a dysfunctional satellite), fell outside the remit of the IADC guideline.

The above institutional governing complexity regarding the use of outer space can be traced right back to the beginning of the space age, since the use of outer space was 'politically charged' from the first.[13] The controversial governing principle that promotes the 'peaceful use' of space technologies and applications of military origin continuously led to divergent interpretations and implementations of the space-related treaties that came to be concluded, and generated gaps in the governance rulemaking. To illustrate this governance architectural imperfection, since 1985 mounting 'space weaponization' has led several spacefaring countries to probe the opening of an international negotiation in the Conference on Disarmament (CD) to reach international agreement to prevent an arms race in outer space (known as PAROS). The question of 'space weaponization' was in many ways related to what was banned by Article IV of the 1967 Outer Space Treaty (OST).[14] The OST prohibited the placement of weapons of massive destruction (WMD) in space. There was, however, no ban on the development and testing of 'space weapons'. Moreover, the OST does not define whether co-orbital anti-satellite weapons or 'space mines' (suicide orbiting satellites designed to collide with a targeted orbiting satellite) are to be categorized as a space weapon. No further definition of 'space weapons' has been agreed since. As from 2002, China and Russia started jointly promoting a tentative 'Treaty on the prevention of the placement of weapons in outer space, the threat or use of force against outer space objects' (PPWT). According to these two countries, the term "weapon in outer space" means 'any device placed in outer space, based on any physical principle, which has been specially produced or converted to destroy, damage or disrupt the normal functioning of objects in outer space, on the Earth or in the Earth's atmosphere, or to eliminate a population or components of the biosphere which are important to human existence or inflict damage on them.' If this definition can be globally agreed, the remaining question is whether or not the development and testing of ASAT weapons will be banned.

The safety issue raised by the space debris problem and the reemergence of the various longstanding governing institutional imperfections offered an excellent opportunity and legitimacy for different actors to stand out with the good causes for their own national security and general interests globally. To this end, after having got the EU member states

[12] Introduction, *IADC Space Debris Mitigation Guidelines,* April 2007

[13] Quote from my interview with Mr. Frank Asbeck, Principal Advisor for Space and Security Policy, EEAS on January 24, 2016.

[14] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967.

on board, the European External Action Service (EEAS) started organizing a series of informal consultations over the course of the years 2008-2010 with two traditional space powers (the US and Russia) and other spacefaring and emerging countries, such as China, Brazil, Canada, India, Indonesia, Israel, South Korea, South Africa and Ukraine, to revise the ICoC proposal. In May and November 2013 respectively, the EU organized 'Open-ended consultations' in Kiev and Bangkok. The latest revised ICoC draft was released on 31 March 2014 and a third open-ended consultation session was organized in Luxembourg in May 2014 (*European External Action Service - EEAS*).[15] The ICoC aims to create a new soft regime with a comprehensive approach to space security, safety and sustainability issues, such as space debris, satellite crowding, the saturation of the radio frequency spectrum, and so on,[16] which are directly or indirectly linked to the use of outer space for military purposes, *e.g.* the ASAT test. To accomplish its goal, the EU has chosen the unusual method of organizing 'multilateral consultation' distanced from the UNCOPUOS and the CD – the two international forums where states customarily negotiate the rules on space activities respectively for peaceful uses and on matters inherently related to space security. The justification for this unusual method is that neither of the two international forums is suitable to accommodate international discussion and negotiation of a comprehensive ICoC.[17] Looked at less favorably, it is a diplomatic maneuver with which the EU profiled itself as a global actor in international space politics.

As was said above, in parallel with the EU-led ICoC proposal, there was a working paper[18] that had already been jointly proposed to the CD in June 2002 by Russia, China, Vietnam, Indonesia, Belarus, Zimbabwe, and Syria. This document became the basic document of the PWWT jointly introduced to the CD by Russia and China in February 2008. The goal of the PPWT was 'to eliminate existing lacunas in international space law, create conditions for further exploration and use of space, preserve costly space property, and strengthen general security and arms control.'[19] It also aims to solve the outdated problem of Article IV of the 1967 OST regarding the issue of 'space weaponization', though it preserves ASAT weapons. The two newly proposed space regimes evinced a new power struggle in the arena of international space rulemaking. The United States regarded the PPWT draft as 'fundamentally flawed' because of its lack of verification measures. Without the consent of the US to provide the verification services operated by the US Space Surveillance Network (SSN, started since 1961 by the US Air Force), the PPWT would in truth be ineffective. And it would be surprising if the US would agree to open their verification facilities to support the PPWT co-sponsored by Russia and China. Not to be outdone, Russia and China pointed out that the US and Israel had repeatedly voted against UN resolutions preventing an arms race in outer space, and that the new legally binding regime proposed would outlaw the weaponization of space. As for the ICoC, the US and the UN were initially skeptical, especially because the EU was seeking to establish its own multilateral initiative by clearly avoiding the usual platform under UN auspices. The US later changed its position on ICoC to

[15] http://www.eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm.
[16] European External Actions Service (EEAS) website: www.eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm.
[17] Remark by Mr. Frank Asbeck, Principal Advisor for Space and Security Policy, EEAS at the meeting of the author's doctoral Examination Committee on April 12, 2016.
[18] Russia-China joint working paper to the Conference on Disarmament, 'Possible Elements for a Future International Legal Agreement on the Preventions of the Deployment of Weapons in Outer Space, the Threat or Use of Force against Outer Space Object', 28 June, 2002. CD/1679.
[19] Statement of Russian Foreign Minister Sergey Lavrov at the Plenary Meeting of the Conference on Disarmament, Geneva, 12 February 2008.

one of support, but without going further than committing itself to further discussions about a possible ICoC. The US also retains the option not to sign for reasons of national security and national interest.

2.2. THE CONGESTED, CONTESTED, AND COMPETITIVE SPACE ARENA

China's ASAT test and the ICoC-PPWT power struggle for global rulemaking were new manifestations of old concerns accompanying the rapid growth of human-space connectivity over the last half century. Nonetheless, the new déjà-vu underlined some significant situational changes in international space politics, or astropolitics. It is inevitable to repeat the statement of the US government[20] that space has become congested, contested and competitive. The statement was made from an America-centric viewpoint but equally recapitulates the current situation in outer space in its physical, political, and socio-economic sense. After the Cold War, (1) Space became *congested* due to a significant increase of the users population of outer space; (2) Space became *contested*, particularly viewed by two previous Cold War space powers, or by the US alone, because the spacefaring countries and the emerging space nations have started rapidly developing a wide range of space capabilities; and (3) Space is becoming increasingly competitive due to the space economic liberalization that took place in parallel with the popularization of the use of broadened space technologies and applications for civilian utilities.

1) Space became *congested*

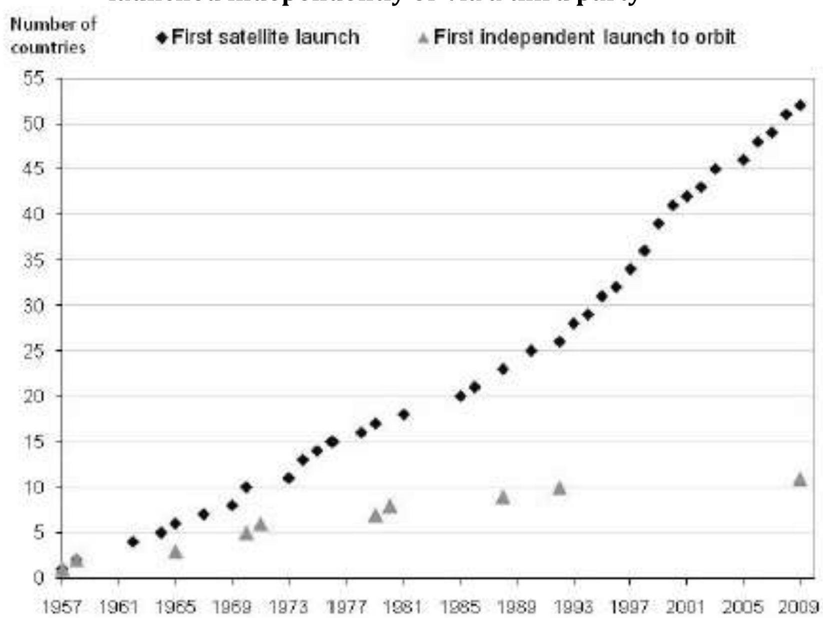
After the Cold War, the formerly politically restricted bipolar space economy systems were finally opened to a global market. In the meantime, space technologies and applications were also more broadly used for both military and civilian purposes. The spacefaring countries were keen to improve their existing space capabilities and to develop new trade sectors. As for the non-spacefaring states, some were seduced into jumping on board to industrialize their manufacturing sectors through means of space capability development. Many countries that had had no industrial capability at all used space technologies and applications to create new impetus in their domestic economy. These technologies and applications include telecommunications, transportation services, internet banking, and others. There was also a growing interest among small medium industrialized countries in developing some specific ranges of space capabilities or simply in owning a space system, without investing an astronomical budget, to possess some necessary or profitable space capabilities. This space economy, according to the OECD, comprises the space industry's core activities in space manufacturing and in satellite operations, plus other consumer activities.[21]

The overall trend of the growing population that physically started to use outer space can be seen in Graph 1. We can see that over the four and a half decades of the Cold War, up to 1990, fewer than 25 states possessed satellites. By 2010, over 50 countries possessed orbiting space assets. Between the Cold War era and the end of 2010 the

[20] Lynn, III, William J. (2011) A Military Strategy for the New Space Environment, *The Washington Quarterly 34*(3) (Summer 2011): 7-16.
[21] OECD, (2007) *The Space Economy at a Glance 2007*.

number of states owning space assets rapidly grew by a factor of two and a half. In contrast, the other remarkable trend is that although there was a significant increase in the total number of satellite-owning states, there was almost no growth in the number of launching states. Since 1993, only Iran has joined the launching states (in 2009), and more recently the Democratic People's Republic of Korea (North Korea) in 2012 seemed to have become the newest launching state. The lack of growth in the number of launching states underscores that the majority of satellite-owning states have to rely upon the minority of launching states to get their satellites into orbit and sometimes to operate them as well. This naturally is a part of space economic activities.

Figure 1. Number of countries owning an orbiting satellite launched independently or via a third party



Source: OECD (2011), The Space Economy at a Glance 2011, OECD Publishing, Paris.

Another interesting detail provided in Table 1 is that from the 1990s there was a significant increase in the number of developing countries possessing their own satellites. As mentioned above, most of them depend on the political, technical, and financial support of launching states and spacefaring nations to put their satellites into orbit and to operate these sophisticated space systems. This created more space technology, manufacturing and service interdependence with ties across different continents, in a word the *globalization* (Keohane & Nye 2000[22]) of space capacity building. Finally, it must be noted that, as the space commercial activities are mostly operated by the national space programs and national space agencies, state-owned companies, or public-private joint venture companies, the interdependence of space capacity networks and technology manufacturing service remains highly political, and cannot be purely commercial.

[22] Keohane, O. Robert and Nye Jr., Joseph S. (2000) Introduction. In *Governing in a Globalizing World* (Eds.) John D. Donahue and Joseph S, Nye Jr., Washington DC., NW: Brookings Institute Press.

Table 1. Countries with spacecraft in orbit

Period	Region	Country	Sum
Before 1980s		US & USSR	2
	Europe	Germany, France, UK, Italy, Spain, Czechoslovakia, Netherlands	7
	Asia-Pacific	Japan, China, India, Australia, Indonesia	5
	North America	Canada	1
Total before 1980s			**15**
New states in the 1980s	Europe	Sweden	1
	Asia-Pacific	Philippines	1
	Latin America	Brazil, Argentina, Mexico	3
	Middle East	Israel	1
Addition of the 1980s			**6**
New states in the 1990s	Europe	Norway, Lithuania, Greece, Portugal, Denmark	5
	Asia-Pacific	Pakistan, Thailand, South Korea, Malaysia, Vietnam, Taiwan	6
	Latin America	Peru, Chile	2
	Middle East	Egypt, Turkey	2
	Africa	South Africa	1
Addition of the 1990s			**16**
New states in the 2000s	Europe	Switzerland	1
	Asia-Pacific		0
	Latin America	Venezuela, Columbia	2
	Middle East	Saudi Arabia, United Arab Emirates, Iran, Iraq	4
	Africa	Nigeria, Algeria	2
	Central Asia	Kazakhstan	1
Addition of the 2000s			**10**
New states in the 2010s	Europe	Luxembourg, Belgium, Romania, Estonia	4
	Asia-Pacific	Singapore, North Korea	2
	Latin America	Bolivia, Uruguay, Ecuador	3
	Middle East		0
	Africa		0
	Central Asia	Azerbaijan	1
Addition of 2010-2014			**10**
Total until 2014			**57**

Table: Author arrangement; *Source:* www.sattelitedebris.net

2) *Space became contested*

From the perspectives of both the military and the civilian use of outer space, the race for national space capability previously limited to the US and the USSR expanded on a global scale after the Cold War. More interested and capable states are trying to enter the arena. So, space became contested vis-à-vis the existing space powers. These interested and capable newcomers are interested in developing their own launch capabilities that would be beneficial for the commercial reasons, or in developing their indigenous missile capabilities. Likewise, developing satellite technologies, applications and space system services are commercially lucrative but also useful to provide communication, surveillance and navigation support to military operations. The dual use of space technologies and applications make the development of various space capabilities attractive to states. This global popularization of national space capability building obviously leads to security and stability concerns, especially in some geographical areas where tensions between neighboring countries remain constantly important, such as between India and Pakistan, in the region of China, Taiwan, Japan and North Korea, and between Israel and its Arab neighbors. Furthermore, these countries have particularly heightened interests in developing their national space capabilities.

3) Space became competitive

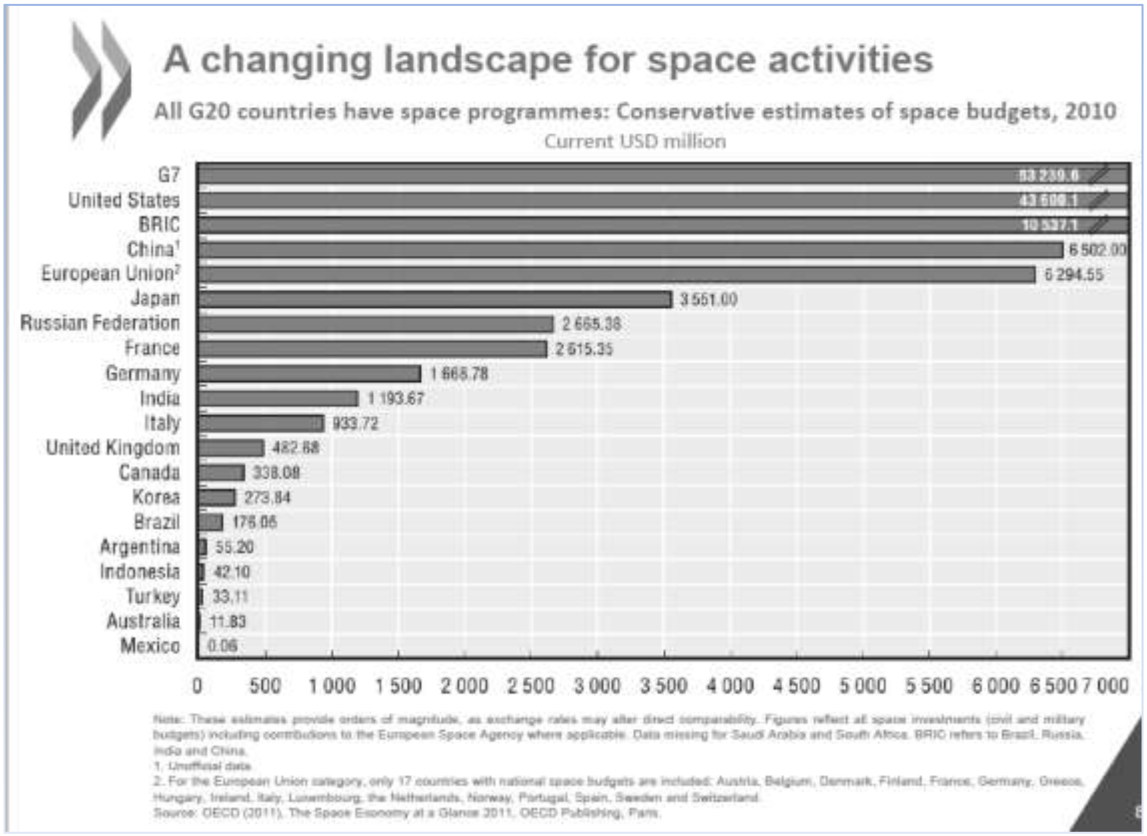
The new trend towards developing national space capability has made the realm of global space economy much more competitive than it was during the Cold War. This trend broadened and accelerated the flow of space-relevant technology transfers, and international trade in space-related equipment and services across the former politically restricted national boundary between the two opposing camps. More countries finally entered the global market either to offer their products and services related to different applications of space technologies in communications, navigation, and remote sensing, or simply to remain end users to be connected with all space related commercial activities. The term "space economy"[23] refers to 'commercial activities that have been derived over the years from the space sector's research and development programs. Additionally, it also covers several mature downstream activities which have reached mass markets, and includes information technology products and services, such as satellite television and GPS receivers.' Table 2 shows that all G20 countries have their own national space programs. It also indicates that the growing global space economy is actually in the hands of the two space powers and the emerging spacefaring countries. Adding up a conservative estimate of the national space program budgets of the US, China, the EU, Japan and Russia for 2010 suggests that these major actors were together making a total of 62.6 billion USD available to nourish global and domestic space commercial activities.

An important issue illustrated by Table 2 is that to develop and operate their space programs many countries that have their own space programs or are developing their specific space capabilities still depend heavily on the traditional space powers and the emerging spacefaring countries to acquire space scientific and technological support, precision equipment, side-products and support services. The new challenges here are particularly for the supply side. The dilemma of the countries that developed space industries early, such as the US and Russia, is that on the one hand they need to release their advanced space related products and services as quickly and broadly as possible to gain a commercial edge on aggressive competitors, but on the other hand can better dominate and steer the space economy, and better protect their strategic and national security, by keeping critical advanced know-how, technologies and operation systems to themselves. A completely free-trade space economy would weaken their national interest and security. Now, however, the strongest competition comes from emerging space nations, such as China, India, and Europe. They offer competitive products and services at a price and a quality that severely challenge the previous space economy oligarchies of the US and the USSR, and current American space leadership. The US has continuously resisted the trend towards free space trade by upholding a national trade barrier, the US International Traffic in Arms Regulations (ITAR). ITAR strictly limits US exports of sensitive (e.g. satellite-related) technologies and goods. This is however a sword that cuts two ways, the export

[23] OECD, (2011) *The Space Economy at a Glance 2011*.

control mechanism directly preventing American space industries from growing their global commercial activities, for example, in the GPS market.

Figure 2. Estimated G20 space program budgets (2010)



Source: OECD (2011), *The Space at a glance*, OECD Publishing Paris.

The situational changes have not only resulted in reshaping the balance of power in the arena of international space politics in the 21st century, but have also affected the directions in which global governance rulemaking are heading. Instead of the traditional focus on a country's individual space capability, often with military and scientific exploration capabilities to determine a county's space power, new focuses have been added to evaluate whether a country could maximize and extend all its individual space capabilities to benefit itself and also assist to other countries, or even aiming higher to benefit all mankind. Likewise, such space power can be developed in the realm of global space governance by exploring a nation's power to influence the ways in which new space relevant rules are created and designed, or in which existing international space law and space institutions are implemented or adjusted.

2.3. READING THE INTERNATIONAL SPACE POLITICS OF THE 21ST CENTURY

This new situation in the arena of international space politics and in the realm of global space governance has attracted the attention and interest of international relations (IR) scholars, space lawyers, space diplomats, national and global space policymakers, and the leaders of national space programs. Different existing approaches have been explored to analyze international space politics in the Cold War and in the 21st century. First, the conceptual frameworks of geopolitical 'astropolitics' and national military 'spacepower' have been developed, notably in the United States. These two power-centered realist approaches stress the national interest in international space politics. The two schools commonly evaluate the balance of power in international space politics at a given moment with the parameter of space-related physical forces and material capabilities between countries. The former put forward the geopolitical context to see the geopolitical power status quo. The latter, by contrast, centers on evaluating a country's own space power while taking into account the space power of others, particularly of adversaries. The realist frameworks have inspired extensive literatures analyzing the space capability competition between the US and the USSR. Nowadays, they are developed to analyze the emerging intra-regional space power competition in different geographical regions. An alternative and less developed approach is based on liberal institutionalism, or neo-liberalism. Liberalism stresses the actual interstate interdependence that is present throughout on-going space capability development and interstate space capability competition. This approach explains why and how competing states were compelled to coordinate and cooperate with each other to institutionalize common rules and regulating mechanisms. States agreed to establish international treaties, set up operational rules and equipment standards, and create international institutions to implement and verify the common rules precisely in order to preserve strategic stability, fulfill functional necessity, promote prosperity, and perhaps also for mutual interests and long-term peace. The third approach, which is fragmented, issue-focused and is close to legal study, is space policy analysis. Space policy analysis takes account of the international space political status quo as background reference yet aims at finding functional and technical solutions to overcome ad hoc or systemic political, legal, and technical challenges related to space issues.

2.3.1. REALIST POWER-INTEREST CENTERED INTERNATIONAL SPACE POLITICS

Realism, focusing on security competition and war among the great powers,[24] interprets the development of international space politics by stressing each state's concern to defend its individual national security and preserve its national interests. In the line of this thinking, *Astropolitik*[25] was conceptualized to explain the competitive political context wherein states are interested in building their space power status by developing their space capability supremacy vis-à-vis that of other states. In the absence of global space hegemony, the great powers have great interest in upholding their superior space capability and even extending this space power toward neighboring areas to dissuade potential external threats, and to assure their national security, interests and prosperity. The astropolitics concept builds upon the doctrines of *sea power* (Mahan) and *air power* (Douhet), which argued that states

[24] Mearsheimer, John J. (2002) Realism, the Real World, and the Academy, in Michael Brecher and Frank P. Harvey, eds., *Realism and Institutionalism in International Studies*. Ann Arbor: The University of Michigan Press, pp. 23-33.
[25] Dolman, Everett C. (1999). Geostrategy in the Space Age: An Astropolitical Analysis, In *Geopolitics: Geography and Strategy*, (Eds.) Colin S. Gray and Geoffrey Sloan, London and Portland, Oregon: Frank Cass; Dolman, Everett C. (2002). *Astropolitik: Classical Geopolitics in the Space Age*, London and Portland, Oregon Frank Cass.

make use of a geographical or physical regional interface (land, sea, air and space) to demonstrate their military or comprehensive power. By pursuing such power status, the great powers acquire their leadership position in given geopolitical or regional arenas, protect their national security, and maximize their national interests. The concrete means by which a great power upholds its space power status is continuously to maintain the use of space capability and to deny its use to enemies,[26] or even more broadly to possess 'the capabilities to conduct military operations in and from space and to utilize space for commercial and other peaceful purposes'.[27] Further to the post-Cold War international astropolitical situational changes, Johnson-Freese & Erickson noted that 'geotechnological balance' has replaced traditional geopolitical rivalry in which space powers only upheld their military space power status and their political influence. One critical and constructivist component of the substance of space power was added, that of 'techno-nationalism' which stresses 'the economic and political power associated with access to the most advanced technology' as the crucial determinant of a state's international power and status.[28] In this regard, space power should be extensively assessed with the support of scientific theories, philosophy, human nature, politics, economics, and geopolitics in addition to the theories of war and military affairs.[29]

This realist 'space power' approach was valuable notably to analyze the US-USSR military and space exploration capability competition that lasted from the late 1950s through to the late 1980s. Both countries adopted the zero-sum concept as well as the strategic thinking that one's defense is another's danger to assure their respective space power through the continuous development of military and civil space capability. The salient cases for the realist 'space power' approach to analyze interstate space capability competition and to simulate possible outcomes of such a game for power were the continuous technological race between the US ABM system and the Soviet ICBMs, the Moon Landing mission *vs.* the USSR full-range space capabilities, and the comprehensive US Strategic Defense Initiatives (SDI, more commonly known under the nickname 'Star Wars'), a strategic plan to counter the growing Soviet strategic force but also to bankrupt the Soviet economy.[30] Nonetheless, the space power concept is less pertinent to deciphering the latent complex interdependence between of the Cold War adversaries, and especially the fact that the two space powers still reached a certain agreement on security and safety issues related to the uses of outer space by institutionalizing international space regimes, such as, among others, the 1967 OST. Moreover there are now more than two space powers – in the broadened arena of space capability competition, it has become even more complicated to determine an absolute enemy or partner. The dimension of space-power competition has expanded toward non-military or non-security realms at both the national and global level because space technologies and applications are today broadly employed to deal with global issues of human safety, economic growth and development, and environmental and generational sustainability. In this new context, the space-power-centered analysts have deepened and

[26] Gray, Colin S. (1996) The Influence of Space Power upon History, *Comparative Strategy 15* (4) (October-December 1996): 293-308; Oberg, Jim (2000) *Space Power Theory*, Colorado Springs, CO: US Space Command.
[27] Phaltzgraff, Robert (2011) International Relations Theory and Spacepower, In *Toward a Theory of Spacepower* (Eds.) Charles D. Lutes et al. Washington DC.: National Defense University.
[28] Johnson-Freese, Joan and Erickson, Andrew S., The emerging China-EU space partnership: a geotechnological balancer, *Space Policy 22* (2006): 12-22.
[29] Hays, Peter L. and Lutes, Charles D., Toward a theory of spacepower, *Space Policy 23* (2007): 206-209.
[30] *Russia Space Web*, Ronald Reagan and his legacy in space, www.russiaspaceweb.com/reegan.html.

diversified their investigations to determine which are the great, middle, small and emerging space powers in a given geopolitical and geostrategic context where military and economic space capabilities are being developed to maintain geopolitical influence. Or, how the existing space powers struggled to uphold their power to influence and continue shaping the global or regional political order to their optimal model by utilizing their advanced space capabilities.

A significant number of publications based on the realist approach, centered on power and interest, have been produced. We name just a few, for example those that view space as a national strategy asset (Hitchens 2008[31], Johnson-Freese 2007,[32] Moltz 2008 and 2011;[33] 2010;[34] and Venet 2012;[35] Robinson 2014) and those that have monitored the current space-power equilibrium and tend to formulate new relative equations (Hitchens 2008[36]) between the shrinking space power of the US (Sadeh 2008,[37] 2012;[38] Noble 2008;[39] Logdson 2012[40]) and of Russia (Podvig 2008;[41] Sourbès-Verger 2012[42]) *vis-à-vis* the emerging space forces of the European Union (Pasco 2009,[43] 2012;[44] Nardon & Venet 2010,[45] 2011,[46] 2011[47]), China (Johnson-Freese 2007;[48] Johnson-Freese & Milowicki 2008;[49] Lele 2008,[50] Zhang 2008;[51] Cheng 2012,[52] 2012,[53] 2011[54]), Japan (Sawako 2009;[55] Anan 2013[56]) and

[31] Hitchens, Theresa. Space Wars. *Scientific American 298*: 78-85 (2008).
[32] Johson-Freese, Joan. (2007) *Space as a Strategic Asset*. New York: Columbia University Press.
[33] Moltz, James Clay. (2008, 2011). *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*. California: Stanford University Press.
[34] Moltz, James Clay. Space and Strategy: A Conceptual versus Policy Analysis, *Astropolitics* 8(3) (September-December 2010).
[35] 'International relations in space: challenges and opportunities for Europe', presented at the '*International Relations and Space: The European Approach*', conference co-organized by Institut Français des relations internationals (Ifri) and Secure World Foundation (SWF) on 13th September 2012 in Brussels.
[36] Hitchens, Theresa. Forging a Sino-U.S. "grand bargain" in space. *Space Policy 24* (3) (Aug. 2008): 128-131.
[37] Sadeh, Eligar. Export Controls of Space Technologies, *Astropolitics 6*(2) (2008): 105-111.
[38] Sadeh, Eligar. Reforming Export Controls of Space Technologies in the United States, *Astropolitics 10*(2) (2012): 93-109.
[39] Noble, Michael J. Export Controls and US Space Power, *Astropolitics 6*(3) (2008): 251-312.
[40] Logdson, John M.. La politique spatiale américaine: entre changement et continuité. *Géoéconomie 2012/2 n° 61* : 49-59.
[41] Podvig, Pavel and Zhang, Hui. (2008) *Russian and Chinese Responding to U.S. Military Plans in Space*, Cambridge, MA: American Academy of Arts and Sciences.
[42] Sourbès-Verger, Isabelle. Russie, Japon, Chine, Inde, quelles politiques spatiales en 2012 ? *Géoéconomie 2012/2 n° 61* : 61-72.
[43] Pasco, Xavier. (2009). *A European Approach to Space Security.* Cambridge, MA: American Academy of Arts and Sciences.
[44] Pasco, Xavier. Quel nouveau départ pour l'activité spatiale ? *Géoéconomie 2012/2 n° 61*: 23-30.
[45] Nardon, Laurence and Venet, Christophe, The Evolving Architecture of Space and Security in Europe. *Actuelles de l'Ifri*, 2010.
[46] Nardon, Laurence and Venet, Christophe, The Use of Space for Maritime Security in Europe. *Actuelles de l'Ifri*, June 2011.
[47] Nardon, Laurence and Venet, Christophe, The Use of Space for Civil Protection in Europe. *Actuelles de l'Ifri*, November 2011.
[48] Johnson-Freese, (2007). China's Space Ambitions. *Ifri Proliferation Papers, Summer 2007*. Paris/Brussels : Institut Français des Relations Internationales.
[49] Johnson-Freese, Joan and Milowcki, Gene V. Strategic Choices: Examining the United States Military Response to the Chinese Anti-Satellite Test. *Astropolitics 6* (1) (2008): 1-21.
[50] Lele, Ajev. China's Posturein Space and its Implications. *Strategic Analysis 32* (4) (2008): 605-620.
[51] Podvig, Pavel and Zhang, Hui. (2008) *Russian and Chinese Responding to U.S. Military Plans in Space*, Cambridge, MA: American Academy of Arts and Sciences.

India (Lele, 2014[57]; Rajagopalan 2013[58]). Recently, regional space policy studies are unsurprisingly stimulated by the proactive space diplomacy case of the European Union, the EU ICoC. A few scholars have attempted to understand the general condition of growing space regionalism (Liao 2015a, 2015b), to explain how respective space regionalism or regionalization of national space mechanisms developed in Europe (Peter 2006;[59] 2007[60]), in Asia (Lele 2013;[61] Moltz 2011,[62] 2012;[63] Noichim 2008;[64] Peoples, et al., 2013[65]) and in Africa (Aganaba-Jeanty 2013[66]), and how *Astropolitik* stands out in the competition of regionalization activities led by regional spacefaring states, for example between China and Japan (Suzuki 2013;[67] and Aliberti 2013[68]) in the Asia-Pacific region.

The space power approach has also often been taken when space policy analysts assess the national space capacity in comparison with other states to propose policy measures, overcome bureaucratic hurdles and functional obstacles to implement the policy at both the domestic and international dimension. According to Goldman, *space policy* at the national level, refers to "the decision-making process for, and the application of, public policy regarding space exploration. It includes policy regarding a country's civilian space program, as well as its policy on both military use and commercial use of outer space"[69]. Space policy usually "intersects with other policy areas, such as science, education, defense policy and so on. It also encompasses government regulation of third-party activities such as commercial communications satellites and private spaceflight. To these, space policy also encompasses the creation and applications of space law, and space advocacy organizations exist to

---

52 Cheng, Dean. Responding to China's Manned Space Challenge. *The Heritage Foundation Issue Brief No. 3648*. June 26, 2012.
53 Cheng, Dean. Meeting the Chinese Space Challenge. *The Heritage Foundation WebMemo, No. 3457*. January 18, 2012.
54 Cheng, Dean. China's Space Program: A Growing Factor in U.S. Security Planning. *The Heritage Foundation Backgrounder No. 2594*. August 16, 2011.
55 Sawako, Maeda. Transformation of Japanese Space Policy: From the 'Peaceful Use of space' to 'the Basic Law on Space,' *The Asia-Pacific Journal: Japan Focus 44* (1), November 2, 2009. http://www.japanfocus.org/-Maeda-Sawako/3243
56 Anan, Keiichi, Administrative reform of Japanese Space Policy Structures in 2012, *Space policy 29* (3): 210-218. (August 2013)
57 Lele, Ajev. (2014) *Mission Mars: India's Quest for the Red Planet*. New York: Springer.
58 Rajagopalan, Pillai Rajeswari. Synergies in Space: The Case for an Indian Aerospace Command. *OSF Issue Brief 59* October 2013), Observation Research Foundation.
59 Peter, Nicolas. The changing geopolitics of space activities, *Space policy 22*(2): 100-109. (May 2006).
60 Peter, Nicolas. The EU's emergent space diplomacy, *Space policy 23*(2): 97-107. (November 2007).
61 Lele, Ajey. (2013) *Asian Space Race : Rhetoric or Reality ?* Wien/New York: Springer
62 Moltz, James Clay. Asia's Space Race, *Nature 480* (7376). (December 8, 2011).
63 Moltz, James Clay. (2012) *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press.
64 Noichim, Chukeat, Promoting ASEAN space cooperation. *Space Policy 24* (1): 10-12 (Feb 2008).
65 Peoples et al., Special Focus: Regional approach – China's Rising Star, Japan's Re-entry: East Asia Space Security in a Global Context. *Space Policy 29*(2): 95-143, (May 2013).
66 Aganaba-Jeanty, Timiebi, Precursor to an African Space Agency: Commentary on Dr. Peter Martinez "Is there a need for an African Space Agency?" *Space Policy 29* (2013): 168-174.
67 Suzuki, Kazuto, The contest for leadership in East Asia: Japanese and Chinese approaches to outer space, *Space Policy 29* (2013): 99-106.
68 Aliberti, Marco, Regionalisation of space activities in Asia? February 2013, *ESPI Perspectives 66*, Vienna: European Space Policy Institute.
69 Goldman, Nathan C. (1992) *Space policy: An Introduction*. Ames, IA: Iowa State University Press.

support the cause of space exploration."[70] "As the military, economic and social implications of the use of outer space expanded, so it does the relevance of outer space on a world wide scale."[71] Space policy researchers, often affiliated with independent think tanks or in-house research institutes of public services and international space law schools, monitor the dynamics and maneuvers of space diplomacy, and propose policy analyses and recommendations for the parties requesting them.

In sum, the realist space-power-centered framework is valuable to analyze the international politics at a given moment based on a policy-impact causality analytical method. Nonetheless, international space politics is not only characterized by its security and industrial competitiveness, but also marked by interstate interdependence due to functional necessity and social-economic interdependence. For this, *cooperation* was omnipresent across the course of the continuous race. The space-power approach fulfills the goal of establishing a causal link between the calculated strategic actions of a space power and the impact they wish to create and in actuality create in the domestic realm and in international astropolitics. Yet it has difficulty establishing meaningful interpretations of the ambiguity that the space powers have been compelled to negotiate with other non-space power states for all possible relative gains since the very beginning of the space age. They have also released cutting-edge technology, enabling know-how, precision equipment, and supportive systems to support their allies, as well as their supposed "strategic partners" (rational partnership) in order to extract the maximum advantages from such burden-benefit sharing partnership, or to maintain strategic peace and stability in the context of dynamic regional or global astropolitics.

2.3.2. THE GALAXIES OF INTERNATIONAL SPACE REGIMES

The liberal-institutionalist or neo-liberalism approach in IR studies works from the viewpoint that states and other actors engage in mutually rewarding exchanges, including trade and commerce based on specialization and comparative advantage. Cooperation benefits states as well as individuals and groups, all of which become increasingly interdependent. Hence, order and rules emerge as self-interested units in an anarchic setting cooperate for mutual benefit. States cooperate with each other to establish norms and standards, and international institutions – in a word, *international regimes*.[72] Liberal institutionalism puts forward the effects of the international organizations and international regimes that depend on individual states power-interest stances and their superior capability to handle the cooperation and the organizational division of labor. Liberal institutionalism is also notable for explaining national space policies with a stronger focus on domestic factors. It provides a mechanism for seeing national space policy not as the output of a unitary national government, but as the end product of complex political interactions between domestic actors. Regional space cooperation, namely the merging of the European Launch Development Organization (ELDO) and the European Space Research

[70] Wikipedia, https://en.wikipedia.org/wiki/Space_policy, accessed on January 8, 2016.
[71] Tronchetti, Fabio, (2013) *Fundamentals of Space Law and Policy*, New York, Heidelberg, Dordrecht, and London: Springer, page ix.
[72] Krasner, Stephen D. (1983) Structural causes and regime consequences: regimes as intervening variables. In *International Regimes* (Ed.) Stephen Krasner. Ithaca: Cornel University Press. pp.: 61-90.

Organization (ESRO) into the European Space Agency (ESA) in the course of 1960s and 1970s is viewed as an obvious case to be deciphered with the neoliberal approach.[73]

Grawin[74] observed that the space age showed repeatedly that many of the political, economic and social issues of the Cold War period could neither be contained by, nor successfully resolved within the constraints imposed by the traditional boundaries of nation states. At the same time, the growing cooperation between different national space programs emphasized the inadequacy of traditionally autonomous states in addressing certain contemporary challenges. The high cost of space ventures, along with the associated technological interdependence, makes cooperation necessary and inevitable. Pfaltzgraff[75] noted that once states develop a presence in space as an adjunct to their terrestrial interest, they begin to form regimes that codify normative standards designed to facilitate cooperation based on agreed procedures and processes as well as common interest and shared values about space-related activities. Sheehan[76] noted that liberal interpretations are more useful in explaining those dimensions of space policy at the confluence of domestic and international politics, seeing no sharp boundary between the two. This is in line with the liberal stress on the way in which national policies adapt to the international environment during the complex bargaining sequences that are a feature of international space regimes. We see this in the governance of the geostationary Earth orbit satellite spectrum, international cooperation regarding the International Space station, and more recently space debris mitigation.

As a matter of fact, the vision of liberal institutionalism is pertinent to explaining the ambiguity that the United States and the Soviet Union, the only two space powers in the Cold War, could agree on the Legal Principles on governing the activities of states in the exploration and use of outer space in 1963 through a UN declaration. They also agreed with each other in the 1963 Treaty on banning nuclear weapon tests in the atmosphere, in outer space and under water (PTBT, LTBT or NTBT), creating the Outer Space Treaty in 1967, four more space-related international conventions in the course of the 1970s, the 1968 Nuclear Non-proliferation Treaty (NPT), and the 1972 Anti-Ballistic Missile Treaty (ABMT). Yet attaining an agreement on banning ASAT tests remains questionable. Right after the end of the Cold War, the two remaining space powers started cooperating with each other on the international space station (ISS) space exploration project. As the use of space was popularized and the space economy liberalized, the space powers and the spacefaring nations in 1996 agreed upon a UN Declaration on 'International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, taking into Particular Account the Needs of Developing Countries' (often shortened to International Cooperation Declaration). After the rapid development and ubiquitous applications of space technology for both military operations and civil utilities of the American GPS since 1993, and the growing remote sensing technology applications for Earth observation, disaster mitigation, and other uses, more international regimes were created to manage these overarching issues together, such as the UN International Committee on Global Navigation Satellite Systems (ICG) which promotes the

[73] Sheehan, Michael, (2007) *International Politics of Space*, London and New York: Routledge.
[74] Garwin, Richard, Space defense – the impossible dream?, *NATO's sixteen Nations* (April 1986): 22-26.
[75] Phaltzgraff, Robert (2011) International Relations Theory and Spacepower. In *Toward a Theory of Spacepower* (Eds.) Charles D. Lutes et al. Washington DC.: National Defense University.
[76] Sheehan, Michael (2007) *International Politics of Space*, London and New York: Routledge.

interoperability of different satellite navigation systems, the UN Principle relating to Remote Sensing (1986), the International Charter on "Space and major Disasters" (International Disaster Charter, 2000) which relies heavily on the international cooperation to use communication, navigation and remote sensing satellites for joint rescue operations, the Group of Earth Observation (GEO) coordinates the efforts to build a Global Earth Observation System of Systems (GEOSS 2005-2015). A non-exhaustive list of the proliferating international space regimes is documented in Table 2 below. The list of space regimes continues to expand.

This list reaffirmed the general trend of international institution proliferation since the postwar previously noticed by Keohane[77] and by Krasner.[78] In the similar way, the increase in the number of international space regimes made the global space governance architecture denser over time. The question is whether there is any formula with which we could discern the dynamics of competition and capture the trends of cooperation in such a complex changing system? The non-exhaustive list equally exposes what is still missing in the IR literature that requires suitable theoretical framework and empirical methodology to better understand how international space politics developed the dimension of governing space issues through international institutions. Not long ago, Stuart[79] argued that the regime theory developed in the 1980s remains pertinent to considering how states and other actors manage space related issues by establishing formal and informal regimes to satisfy the maximum actors' expectations. Indeed, the recent proposal of ICoC, PPWT and other multilateral space relevant initiatives marks a new era in the history of human-space connection. This new era is vividly illustrated by the fact but also the worry that space has become congested, contested, and competitive for all. The crowded orbital environment and the limited satellite radio frequency resources for the artificial use of outer space become veritable global issues for general interests of human safety, state security and strategic interest, and international stability. Aiming to overcome these new challenges, the initiatives such as ICoC and PPWT also targeted the current imperfect global space governance architecture wherein co-exist a myriad of outdated, incomplete, dysfunctional or even contradictory international space related regimes. Such architectural imperfection can be traced from the continuous creations of international space regime with narrow focuses regimes with a lack of technical definition, verifying measures and implementable means to regulate space security issues. Or, in the case that the UN endeavors to create the ICG for peace and development purpose, service provider states' strategic calculation and commercial interests often prevail the search for general interest of human kind. Although *restrained by the contractual conditions*[80], GNSS service providers continue deploy *rational, self-interested strategy* to maximize their influence power and advantages by involving trade rules made by the World Trade Organization (WTO).

[77] Keohane, Robert O. (1983) The demand for international regimes, In *International Regimes*, (Ed.) Stephen D. Krasner, pp141-172. Ithaca, N.Y.: Cornell University Press.
[78] Krasner, Stephen (1983) (Ed.) *International Regimes*, Ithaca, N.Y.: Cornell University Press.
[79] Stuart, Jill. Regime Theory and the Study of Outer Space Politics. *E-International Relations*, http://www.e-ir.info/2013/09/10/regime-theory-and-the-study-of-outer-space-politics/ Accessed on Nov. 26, 2013.
[80] Keohane, Robert. O. (1984) *After Hegemony: Cooperation and Discord in the World Political Economy*. Princeton: Princeton University Press.

Table 2. An overview of the international regimes (1958-2014)

Year	International Regimes	Core/related Issues
1958	*Establishment of the UN Ad Hoc Committee on the Peaceful Use of Outer Space (COPUOS)*	Comprehensive aims
1962	*ITU entrusted for safety regulation, space resources allocations related to satellite use*	Safety
1962	*WMO entrusted for atmosphere science*	Safety/capacity development
1963	*UN Legal Principles on governing the activities of states in the exploration and use of outer space*	Comprehensive aims
1963	*Treaty Banning nuclear weapon tests in the atmosphere, in outer space and under water (LTBT or PTBT)*	Security/safety
1963	*Convention relating to the distribution of program-carrying signals transmitted by satellite*	Space tech applications
1967	*Outer Space Treaty (OST)*	Comprehensive aims
1968	*ICAO Resolution A-16-11: ICAO Participation in programmes for the exploration and use of outer space*	Safety/aviation technology standardization
1968	*(Astronaut) Rescue Agreement*	Safety/Security
1972	*Anti-Ballistic Missile Treaty (ABMT)*	Security
1972	*Liability Convention for damage caused by space objects*	Safety/security
1973	*Int'l Maritime Satellite Organization became Int'l Maritime Organization (IMO)*	Safety/Economy
1975	*(Launched space objects) Registration Convention*	Safety/security
1979	*Moon Treaty*	Space exploration
1981	*CD Committee on a 'Pact a treaty on the prevention of an arms race in outer space' (PAROS)*	Security
1982	*UN Missile Technology Control Regime for reduce missile proliferation (MTCR)*	Security
1982	*UN principles governing the use by states of artificial satellite for international direct TV broadcasting*	Space tech applications
1986	*UN satellite remote sensing principles*	Space tech applications
1987	*(Inter-space agencies) Committee on Earth observation (CEOS via G8)*	Space tech applications; safety/sustainability
1992	*UN Principles relevant to the use of nuclear power sources in outer space*	Safety/sustainability
1992	*International Telecommunication Union (ITU) radio regulations for satellite radio frequency spectrum and orbital slot allocations*	Safety/space economy & capacity development
1996	*UN International Cooperation Declaration for benefiting developing countries with outer space exploration and uses*	Space tech applications; economy & development
1996	*Comprehensive Nuclear Test Ban Treaty (CTBT)*	Security/safety/sustainability
2000	*Charter on space and major (natural or technical) disaster (Disaster Charter)*	Space tech applications; Safety
2001	*Charter on the right and obligations of states to GNSS (global navigation satellite systems) services of the International Civil Aviation Organization (ICAO-GNSS Charter)*	Space tech applications; Safety
2002	*International Code of Conduct against Ballistic Missile Proliferation (the Hague CoC)*	Security
2005	*Group of Earth Observation (GEO & GEOSS 2005-2015)*	Sustainability/safety
2007	*UN resolution to enhance the practices of states and international inter-governmental organizations in registering space objects*	Safety/sustainability
2007	*UNCOPUOS Space Debris Mitigation Guidelines*	Safety/sustainability
2008	*EU-led ICoC / Russia-China PPWT*	Comprehensive aims/Security
2009	*Safety Framework for Nuclear Power source applications in outer space (IAEA/COPUOS)*	Safety/sustainability
2012	*ICAO-ITU Cooperation MOU for preventing harmful interference on GNSS for the aviation safety*	Safety/sustainability

Source: Author's creation

2.4 RESEARCH OBJECTIVES

The requests for agreement on an ICoC or a PPWT indicate there are important gaps in the entire puzzle of global space governance architecture. In this dissertation, *global governance* is used for its analytical meaning, referring to a regulatory system with "more than the formal institutions and organizations, summed up as '*international regimes',* through which the management of international affairs is or is not sustained."[81] Such a system is 'conceived to include systems of rule at all levels of human activity in which the pursuit of goals through the exercise of control has transnational repercussions.'[82] The ICoC aimed at the ambitious long-term modus operandi that should overcome current and future challenges related to issues of the security, safety and sustainability of human space activities. The PPWT, by contrast, was more focused on regulating the existing 'space weaponization' issue. These proposals reflected the incompletion and imperfection of current global space governance. First, there has been no willingness to establish a global space government, for example, an international space organization to replace the current loosening governing structure. The current global space governance was politically charged for its artificial fragmented 'labor division' between the COPUOS, the UN Fourth Committee, the CD and some other specific international regimes, such as the International Telecommunication Union (ITU), and World Meteorological Organization (WMO) as from the early space age. With the continuous innovation in space technologies and the broadened applications, new appearing issues compel states to establish new norms, regulatory rules and operational standards to avoid conflicts and abuses. It consequently remains uncertain whether either the ICoC or the PPWT if accepted would fix the existing fragmented space governing system, or make it even more complex. The expanding and fragmenting space governance architecture of international regimes corresponds to the conceptual framework of '*regime complex*', created by Raustiala & Victor,[83] and developed by Alter & Meunier[84] and later by Orsini et al.[85] from 2004 onwards. The *regime complex* refers to "*an array of partially overlapping and non-hierarchical institutions governing a particular issue-area*" (Raustiala and Victor 2004: 279) or more completely, it is viewed as "*a network of three or more international regimes that relate to a common subject matter; exhibit overlapping membership; and generate substantive, normative, or operative interactions recognized as potentially problematic whether or not they are managed effectively*". (Orsini et al. 2013:29)

For our research project, we considered exploring the 'regime complex' framework as our conceptual lens to develop a general understanding of the complex global space governance architecture. Since our investigation is a pioneering pilot project, our research objective was to answer the very fundamental research question:

How and why has the global space governance architecture attained its current form of regime complex over time?

---

[81] Rosenau, N. James, (1995) Governance in the twenty-first century, Global Governance 1(1): 13.
[82] Ibid.
[83] Raustiala, Kal & Victor, David G., (2004) The Regime Complex for Plant Genetic Resources, *International Organization 55* (2004): 277-309.
[84] Alter, Karen J. and Meunier, Sophie, The politics of international regime complexity. *Perspective on Politics* (March 2009) *7*(1): 13-24.
[85] Orsini, Armandine, Morin, Jean-Frédéric and Young, Oran. Regime Complexes: A Buzz, a Boom, or a Boost for Global Governance. *Global Governance 19* (2013): 27-39.

To answer the main question, it will be relevant to investigate the following sub-questions:

1. **What form has the global space governance architecture currently attained? And why is it complex?**
2. **What are the driving forces that shape the operation and development of the global space regime complex?**
3. **What are the prospects for renovating the global space architecture?**

3. LITERATURE REVIEW

In the groundbreaking work of Raustiala & Victor (2004) regarding the concept of 'regime complex', the authors explored the global plant genetic resources (PRG) governance case as a whole and investigated one of the salient causes, the 'interplay' (Young 2000;[86] Stokke 2001[87]), *interconnected* (*e.g.* Heer and Chia, 1995; King, 1997; Brown Weiss, 1993,[88] Young 1996;[89] 1999,[90] 2000a,[91] 2000b,[92] United Nations University 1999,[93] Gehring and Oberthür 2000,[94] 2006,[95] Stokke 2000,[96] Rosendal 2001[97]) which extended the global PRG governance networks to a regime complex. In essence, the institutional *interplay* refers to *a causal relationship between two institutions, with one of these institutions ("the source institution") exerting influence on the other ("the target institutions)*.[98]

Biermann et al. (2009[99]) later treated global environmental politics by stressing the concept of the 'issue-linkage' of the 'architecture of global environmental governance' to describe

[86] Young, Oran R. (2002) *The Institutional Dimension of Environmental Change: Fit, Interplay, and Scale*. Cambridge, Mass: MIT Press.
[87] Stokke, Olav Schram, (Ed.) (2001) *Governing High Sea Fisheries: The Interplay of Global and Regional Regimes*. Oxford: Oxford University Press.
[88] Brown Weiss, Edith (1993) International Environmental Law: Contemporary Issues and the Emergence of a New World Order, *Georgetown Law Journal 81*: 675-710.
[89] Young, Oran R. (1996). Institutional Linkages in International Society: Polar Perspectives. *Global Governance 2*(1): 1-24.
[90] Young, Oran R. (1999) *Governance in World Affairs*. Ithaca, NY: Cornell University Press.
[91] Young, Oran R. (2000a) 'Vertical Interplay: The Environmental Consequences of Cross-Scale Interactions', Hanover, NH: Institute on International Environmental Governance, unpublished draft.
[92] Young, Oran R. (2000b) 'Horizontal Interplay: The Politics of Institutional Linkage', Hanover, NH: Institute on International Environmental Governance, unpublished draft.
[93] United Nations University (1999). *Inter-Linkages: Synergies and Coordination between Multilateral Environmental Agreements*. Tokyo (www.ias.unu.edu/binaries/Interlinkages.PDF).
[94] Gehring, Thomas and Sebastian Oberthür (2000) 'Exploring Regime Interaction: A Framework for analysis', Proceedings of the Final Conference of the Concerted Action Programme on the Effectiveness of the International Environmental Agreements and EU Legislation (www.fni.no).
[95] Gehring, Thomas and Oberthür, Sebastian (2006) Introduction. In *Institutional Interaction in Global Environmental Governance: Synergy and Conflict among International and EU Policies*. (Eds.) Sebastian Oberthür and Thomas Gehring. Cambridge, Massachusetts, London England: The MIT Press.
[96] Stokke, Olav Schram (2000) Managing Straddling Stock: The Interplay of Global and Regional Regimes', *Ocean and Costal Management 43*(2-3): 205-234.
[97] Rosendal, G. Kristin (2001) Impacts of Overlapping International Regimes: The Case of Biodiversity. *Global Governance 7*(1) (Jan.-March 2001): 95-117.
[98] Gehring & Oberthür (2006), Ibid.
[99] Biermann, Frank, Philipp Patterberg, Harro van Asselt, and Fabriorz Zelli, The Fragmentation of Global Governance Architectures: A Framework for Analysis, *Global Environmental Politics 9* (4) (November 2009): 14-40.

the '*overarching system of public and private institutions that era valid or active in a given issue area of world politics*' (Biermann et al. 2009: 15). With the conceptual framework of 'regime complex' or the 'architecture of global governance for a given issue area', various studies related to other issue areas *e.g.* trade policy (Davis, 2009[100]), international security (Hofmann, 2009[101]), global refugee (Betts 2009,[102] 2013[103]), energy (Van de Graaf 2011[104], 2013[105]), international monetary and finance governance (Lesage 2013[106]), food security (Margulis 2013[107]), maritime piracy (Struett et al. 2013[108]), forestry (Haug et al. 2013[109]) were proposed one after another. The architectural approach regarding the regime complex of global space governance (Liao 2014[110]) was proposed during an international gathering of the space community which assembled international relations scholars, space lawyers, space science and technology experts, policymakers and diplomats. This view was elaborated into the formal declaration of this international gathering by recognizing that 'global space governance' is noted for its coverage of *a wide range of international regimes - counting norms* (*i.e.* international treaties and other agreements, regulations, procedure and standards, code of conduct, confidence building measures, safety concepts)*, and formal and informal international institutions* (Montréal Declaration 2014).[111]

In addition to the primary focuses of considering the regime complex of a given issue as a whole, and recognizing regime interplay as one of the causes of the fragmentation of the global governance architecture of a given issue area into a regime complex, scholars diversify their focuses more deeply, to investigate other causes or ostensible patterns, for example institutional labor division among international regimes (Biermann et al. 2009;[112]

---

[100] Davis, Christina L. Overlapping Institutions in Trade Policy, *Perspectives on Politics 7*(1) March 2009: 25-31.
[101] Hofmann, Stephanie C. Overlapping Institutions in the Realm of International Security: The Case of NATO and EDSP, *Perspectives on Politics 7*(1) March 2009: 45-52.
[102] Betts, Alexander Institutional Proliferation and the Global Refugee Regime, *Perspectives on Politics 7*(1) March 2009: 53-58.
[103] Betts, Alexander, Regime Complexity and International Organizations: UNHCR as a Challenged Institution, *Global Governance 19* (Special Focus: Regime complex): 69-81, 2013.
[104] Van de Graaf, Thijs. (2013) *The Politics and Institutions of Global Energy Governance*. London, New York: Palgrave MacMillan.
[105] Van de Graaf, Thijs. (2013) *The Politics and Institutions of Global Energy Governance*. London, New York: Palgrave MacMillan.
[106] Lesage, Dries (2013) The architecture of international monetary and finance governance. In *Routledge Handbook of International Organization*. (Ed.) Bob Reinalda. p. 486-498.
[107] Margulis, Matias E. The Regime Complex for Food Security: Implications for the Global Hunger Challenge. *Global Governance 19* (Special Focus: Regime complex): 53-67, 2013.
[108] Struett, Michael J., Nance, Mark T., and Armstrong, Diane. Navigating the Maritime Piracy Regime Complex. *Global Governance 19* (Special Focus: Regime complex): 53-67, 2013.
[109] Haug, Constanze, Harro van Asselt & Fariborz Zelli, 'Untangling the Web of Global Forest Governance: A First Step for Analyzing Institutional Complexity', paper prepared for the panel on Institutional Fragmentation of Global Environmental Governance, International Studies Association Annual Conference, San Francisco, 3-6 April 2013.
[110] Liao, L.W. Xavier, Global space governance in the 21st century: A 'Regime complex' perspective – A Brief note about the paper presented at the 2nd Manfred Lachs International Conference on Global Space Governance, 2014 Montréal, Canada, *Astrosociological Insights 3* (2): 3-5.
[111] *Montréal Declaration*, 2nd Manfred Lachs International Conference on Global Space Governance, May 29-31, 2014, McGill Institute of Air and Space Law, Montréal, Canada
[112] Biermann, Frank, Philipp Patterberg, Harro van Asselt, and Fabriorz Zelli, The Fragmentation of Global Governance Architectures: A Framework for Analysis, *Global Environmental Politics 9* (4) (November 2009): 14-40. Gehring, Thomas and Oberthür, Sebastian (2006) Introduction. In *Institutional Interaction in Global Environmental Governance: Synergy and Conflict among International and EU Policies*. (Eds.) Sebastian Oberthür and

Zürn & Faude 2013;[113] Gehring & Faude 2014[114]), horizontal cross-issue areas where governance clusters intersect, *i.e.* trade and environment (Zelli et al. 2013[115]), or vertical mutual coherence between the policy from a given issue global regime complex and their domestic implementations (Bernstein & Cashore 2012;[116] Morin & Orsini 2013[117]). Some remain at the meta-level by investigating principal explicatory elements and patterns to analyze how a regime complex of a given governance issue area was born, grew and lives in the issue areas, such as climate change (Keohane & Victor (2011[118]), the global monetary and finance system (Lesage 2013), and energy governance (Van de Graaf (2013). These studies underpin the notion that the institutional design and operation of regime complexes or 'changes of regimes' are developing alongside three interactive forces based on the rationales of 1) *distribution of interests*, 2) *issue-specific attributes* and 3) *institutional feedback mechanism* (Keohane & Victor 2011), or because of the *strategic*, *functional*, and *organizational* or *managerial* logics (Lesage 2013; Van de Graaf 2013). *These three driving forces intersected in various forms and propel the architecture's permanent expansion, deepening and reform* (Lesage 2013: 486).

3.1. OUR ARGUMENTS

In parallel to the continuous space power and capability race of space power states, space technologies and applications, or the use of outer space, have become increasingly important and even indispensable. The overarching uses of and through outer space also strengthened its federating force as states were compelled to coordinate and cooperate with each other for various functional necessities. Space technologies and applications have become vital for a wide range of governing issue areas, therefore space governance as such was no longer limited to regulating the use of outer space, but implicated the governance systems of other global issues for guaranteeing human safety, for enhancing socio-economic development, and for safeguarding environmental sustainability. These separate global governance systems are also becoming closely connected and interconnected with the space regime complex as such because of the broadened utilities of space technologies and applications. Because of this, our research scope should not be limited merely to investigating the intra-governance system regime interplay but also cover those inter-governance system interplays. For example, the *overlap* that constitutes "*a separate*

Thomas Gehring. Cambridge, Massachusetts, London England: The MIT Press. Page 6.

[113] Zürn, Michael & Faude, Benjamin. On Fragmentation, differentiation, and coordination, *Global Environmental Politics 13*:3 (August 2013) 119-130.

[114] Gehring, Thomas & Faude, Benjamin. A theory of emerging order within institutional complexes: How competition among regulatory international institutions leads to institutional adaptation and division of labor. *The Review of International Organizations 9* (4) (June 2014):471-498.

[115] Zelli, Fariborz, Gupta, Aarti, & van Asselt, Harro. Institutional Interactions at the Crossroads of Trade and Environment: The Dominance of Liberal Environmentalism? *Global Governance 19* (Special Focus: Regime complex): 105-118, 2013.

[116] Bernstein, Steven & Cashore, Benjamin, Complex global governance and domestioc policies : four pathways of influence. *International Affairs 88*: 3 (2012) 585-604.

[117] Morin, Jean-Frédéric and Orsini, Amandine, Regime complexity and policy coherency: introducing a co-adjustment model. *Global Governance 19* (2013): 41-51.

[118] Keohane Robert O. & Victor, David G. The Regime Complex for Climate Change, *Perspectives on Politics 9*(1) March 2011: 7-23.

category of linkages in which individual regimes that were formed for different purposes and largely without reference to one another intersect on a de facto basis, producing substantial impacts on each other in the process" (Young 1996:6), which can be found in the case of ICG & WTO. The ICG was created for development purpose to enhance the compatibility and interoperability between different GNSSs and Regional Navigation Satellite Systems (RNSSs). Nonetheless, the non-discriminatory trade regulations of the WTO were implicated on the inter-GNSSs/RNSSs harmonization process handled by the ICG. However, with the restraints on the scale of this doctoral research project, we unfortunately have to limit our research focus to analyzing the space regime complex as such, and in particular its general form at the current stage. In other words, we will concentrate our endeavors on building a fundamental and comprehensive 'analytical narrative' that will serve as a roadmap or an architectural blue print to continue deepening future investigations, either to enrich supportive literature about the interpreting model on the morphogenesis of regime complex, or to empirically identify different types of *institutional interaction*[119] within the existing complex of space governance architecture.

With this research scope, we argue that the formation of the space regime complex can be understood from the aspects of 1) *distribution of interests*, 2) *issue-specific attributes* and 3) *institutional feedback mechanism* or in brief, with *strategic*, *functional*, and *organizational* or *managerial* logics (Lesage 2013; Van de Graaf 2013).

First, the *distribution or dispersion of interests* refers to how states, by deploying their strategic preferences and influential capacities relevant to the issue area, can lead the creation of a regime, or change an extant regime to fulfill their self-interest. According to Krasner,[120] national power was the most ostensible driving force that maintains the power balance in global politics and also the equilibrium of the entire global governance architecture, likewise in the construction of the space governance architecture. The strategic logic was obviously discernible through the historic fact that, after the successful Soviet launch of the Sputnik I orbital satellite in 1957, US President Eisenhower before Congress in 1958 called for "a sound and safeguarded agreement" with the US ally "*for open skies, unarmed aerial sentinels, and reduced armament in order to provide a valuable contribution toward a durable peace*".

The term 'peaceful use' of outer space followed the 'Atom of peace' speech addressed by the same author to the UN General Assembly in 1953, which in 1957 led the creation of the International Atomic Energy Agency (IAEA). And this time, the desired agreement aimed to "*reverse the trend toward ever more devastating nuclear weapons; reciprocally provide against the possibility of surprise attack; mutually control the outer space missile and satellite development; and make feasible a lower level of armaments and armed forces and an easier burden of military expenditures*."[121] A similar speech was delivered at the UN General Assembly in 1958. Subsequently, the UN General Assembly adopted resolution 1348 (XIII) to establish an ad hoc committee on the peaceful use of outer space in 1958. The ad hoc committee became the permanent UN COPUOS in 1959 based on the UNGA resolution

[119] Young, Oran R. (1996) Institutional Linkage in International Society: Polar Perspectives. *Global Governance 2* (1): 1-24.
[120] Krasner, Stephen D. Global Communications and National Power: Life on the Pareto Frontier, *World Politics 43*(3) (April 1991): 336-366.
[121] Dwight D. Eisenhower, State of the Union Address given before the U.S. Congress on January 10, 1957.

1472(XIV). This irrefutably peaceful approach was actually based upon the US national security interest in impeding the rapid development of Soviet space technology which was expected to enable the Soviet military capacity for satellite surveillance, ICBMs, space platforms, and long-rang unmanned weapons. This would become a significant threat to American national security and great-power status. Therefore, creating such international regime for peaceful use was legitimate and would fulfill the US interests. Subsequently, the Soviets ought to submit their proper version for an international space regime at the UN General Assembly by calling for international cooperation in the exploration of cosmic space and the restriction of the use of space to peaceful purposes[122]. The different interpretations of two Cold War adversaries regarding 'peaceful use' of outer space became one of the 'sin's that expand and fragment the space governance architecture to its regime complex.

Secondly, the functional necessity equally motivated states to constantly create new regimes, or adjust the functional missions and organizational rules to satisfy their needs. The functional linkages appear "*when substantive problems that two or more institutions address are linked in biogeophysical or socioeconomic terms*" (Young et al. 1999:23).[123] It is first the "facts of life" interdependence that created these institution interactions because "*the operation of one institution directly influences the effectiveness of another through some substantive connection of the activities involved*".[124] In contrast, there are "political linkages" which "*arise actors decide to consider two or more arrangements as parts of a larger institutional complex*".[125] The space powers and spacefaring countries attempted to create and lead their own space-related network of interdependence to gain commercial benefits, reinforce their space capacity network, and create markets for their individual space systems. They also use these institutions for reasons of burden-benefit sharing. Countries are naturally sensitive regarding whether their efforts or investments would or would not be refunded in comparison with what other countries invest or promise to implement. In a word, states apply a functional logic to find where they can satisfy their functional necessity (*issue-specific attributes*), and within which institution to maximize their benefit (*gain linkages*). Because of this, when the non-spacefaring states expect to gain relative advantages by skipping the long process of getting critical technology and the advanced space-related systems, they agree to be part of the regional cooperative platform even together with their traditional neighboring adversaries. The institutional interaction based on such functional logic triggers 'forum shopping'.

Nowadays, the application of this functional logic is saliently discernible in the regional space governance cases. For example, China and Japan both created their respective regional space cooperation mechanisms, the Asia Pacific Space Cooperation Organization (APSCO), and the Asia Pacific Regional Space Agency Forum (APRSAF). Both regional space cooperation organizations carry functional linkages for "fact of life" interdependence as well as political linkages. They respectively gather their own regional political allies to form the two separate but functionally and geographically overlapping space institutions. When the ASEAN member states have to decide to be affiliated with the China-led Asia Pacific Space Cooperation Organization (APSCO) or with the Japan-led Asia Pacific Regional Space Agency

---

[122] UN Doc. No. A/3818 (1958).
[123] Young, Oran R. ed. (1983). *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms*. Cambridge, MA: MIT Press.
[124] Ibid, p50.
[125] Ibid.

Forum (APRSAF), or with both regional space cooperation platforms, they assess which organization will maximize their advantages for gaining technical assistance and political partnership. Similar cases have been studied, such as when the Arab League states were 'regime shopping' to choose between the Cairo-led Arab States Broadcasting Union (ASBU) and the Riyadh-led Arab Satellite Communication Organization (ARABSAT) in 1970s.[126]

Lastly, international regimes encounter institutional feedback effects (Keohane & Victor 2011),[127] or the organizational gravitational force in their evolutionary path. International space regimes were primarily created to ease political tensions, specifically those of the "space race", or to overcome common challenges, such as satellite orbital-slot and radio-frequency attribution. Certain governing principles, guidelines, norms and organization rules were agreed to ensure that the functioning of these space regimes would be well organized. These fundamental governing principles, guidelines and norms gradually generate an *embeddedness* relationship of a governance institution to overarching principles and practices,[128] such as "non-appropriation" and "peaceful use" of outer space. Sometimes, the high-level political steering groups or interagency organizations, such as the UN, the CD and the COPUOS, were compelled to consider some structural change within the extant space regimes by modifying the division of labor. *Nestedness* denotes the relationship of a smaller institution to a functionally or geographically broader institution.[129] For example, nesting the UN specialized agencies, such as the ITU for satellite orbital-slot and radio-frequency attribution, the WMO for international weather forecast cooperation, and the ICG for harmonizing inter-GNSSs interoperability and compatibility. Or, in order to improve the effective functioning and differential management of space governance as a whole, the UN decentralized space for sustainable development to the regional space cooperation forum with account of regional heterogeneity. These regimes were limited to bear the transcendent normative restraints from the existing international regimes. The ICG, for example, was created in the line of the UN development program UNISPACE. The mandate of the ICG is to accommodate technical discussions limited on regulating the "peaceful use" of such military or dual-use space technology and the applications. And the issues of harmful radio interference, and the aviation safety issues which depend heavily on GNSSs also fell outside the ICG mandate, and are only partly under the mandates of the ITU and the ICAO. It shows an important path-dependence relationship among the various space regimes that gradually fragmented the development of space governance architecture toward its regime complex.

To sum up, the development of the space regime stretched by the intersected gravitational forces as discussed above, the strategic choice/dispersion of interest (vector X), functional logic/issue-linkages (vector Y) and organizational sequence/path-dependence (vector Z), are represented in a visual model that demonstrates the regime complex of space

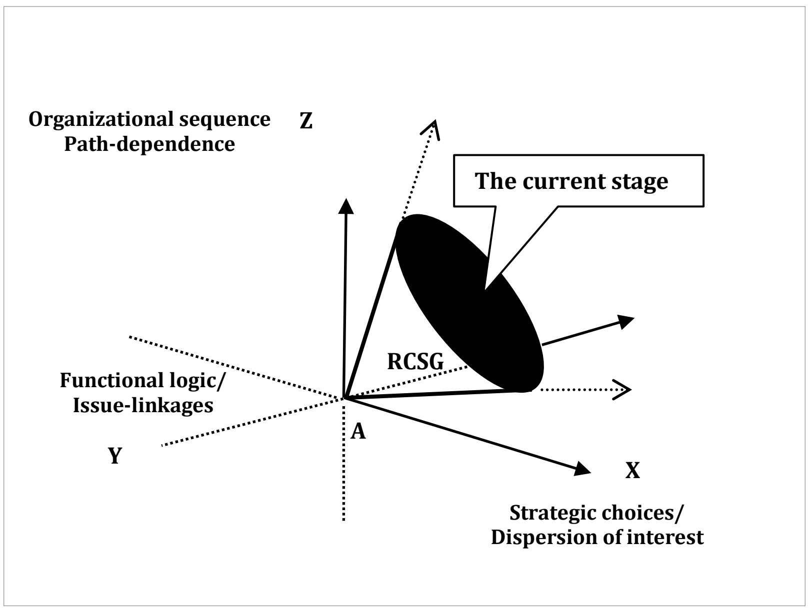
---

[126] Liao, Xavier L.W. (2015) The growing space regionalisation of the global space regime complex, *The Aviation and Space Journal XIV* (1) (January-Mach 2015): 23-34; (2016) The space regionalisation and global space governance, In ESPI Yearbook on space policy, (Eds.) Genan Al-Ekabi, Blandina Baranes, Peter Hulsroj, and Arne Lahcen. Wien: Springer Verlag.
[127] Keohane Robert O. & Victor, David G. The Regime Complex for Climate Change, *Perspectives on Politics 9*(1) March 2011: 7-23.
[128] Aggarwal, Vinod K. (1983). The Unraveling of the Multi-Fiber Arrangement, 1981: Examination of International Regime Change. *International Organization 37* (4): 617-646.
[129] Ibid.

governance (RCSG) starting from the primary regime A within the 3-dimension region. Each gravitation force pulls the A in their own direction and gradually stretches A toward the RCSG corn. The blue surface which shows the current size of the regime complex of space governance, and within this expanding RCSG, the existing various space related regimes are gradually created, reformed, or deserted and dissolved, will be demonstrated and discussed in this doctoral dissertation.

As for the dashed arrowed lines which prospect the likely expanding direction of such RCSG, the question of predicting the likely trajectory and the future dimension of such RCSG, or whether there is another hidden yet significant particular gravitational force(s) also participate/anticipate in the development of the space governance architecture toward its regime complex, just like physicists and mathematicians only gradually discovered that not only gravity but also other forces of nature, such as electromagnetic force, weak and strong nuclear forces, that intersected and steered the universe to attain its instant status quo. But this will remain for us and any interested political scientist to explore later.

Figure 3. The development model of a regime complex of space governance resulting from three driving forces



Author's model, inspired by Hawking, Stephen (1988) *A Brief History of Time*.

4. RESEARCH SCOPE, METHODOLOGY AND CHAPTER STRUCTURE

To answer our main research question regarding *how and why the global space governance architecture has attained its current form of regime complex over time,* we will take the following methodological steps to look through the entire constructing evolution of global space governance architecture by identifying the major challenges (Chapter II: The key governing issues in international space politics), the architecture blueprint (Chapter III: The governing principles and guidelines), and the governing agencies (Chapter IV: The governing institutions) of space governance in order to get its general picture. Hence, we follow the artificial division decided from the very beginning of the space age to respectively discuss the governance architecture of military use of outer space, or space security issues (Chapter V: The regime complex of space security governance), and one of growing important governing issue, the GNSS governance (Chapter VI: Regime complex on governing a "peaceful use" of outer space: GNSS governance case study). This chapter particularly indicates the ambiguous architectural design from the beginning of the space governance construction, because the GNSS technology and applications originated from the military use and are still mostly operated and controlled by the military of the service provider countries, except the European Union. Yet, the issues related to the inter-GNSSs interoperability and compatibility have not been negotiated under the space security governance scheme but, because of its broadened civilian utilities from its dual-use, as one of the issues of the "peaceful use" of outer space. Finally, Chapter VII concludes this academic work with the findings to our research questions. Some policy reflections are presented to stimulate constructive threads of thinking based on our empirical trials regarding the regime complex framework and well as to the improvement of the changing global space governance architecture.

CHAPTER II THE KEY GOVERNING ISSUES IN INTERNATIONAL SPACE POLITICS

Abstract: Chapter II presents the general and specific ongoing governing issues that have gradually created the physical or functional 'issue linkages' of space relevant regimes within the global governance architecture. The functional issue linkages are complicated because the utilities of space technologies and the applications are overarching for military, civilian, and the dual-use purposes. During the Cold War, the two space powers and their respective allies agreed to establish an ambiguous governing concept "peaceful use" of outer space to restraint each other's space military capability growth. Nonetheless, the USSR and the US continued to maintain their divergent interpretations of "peaceful use" as either "non-military", or "non-aggression" respectively. After the Cold War, the liberalization for general space capability development and the popularization of the use of outer space through advanced space technologies and applications expanded human space activities. These became ever further connected and interconnected with practically all national policy issues for military, civilian and the dual-use purposes. Therefore, the use of outer space has now expanded to four more functional governing areas: (1) military use of outer space, or space security as such; (2) space for *safety*: the use of space is expanded from its traditional security arena to search and rescue operations and disaster mitigation; (3) space for *economy and development*: space is becoming increasingly important to boost economic activities that range 'from farming to banking', and to enable national or regional (re-)industrialization by stimulating economic activities and improving peoples' daily life; and finally (4) space for *environmental and generational sustainability*: space technologies, particularly remote sensing technology and its applications facilitate the observation of terrestrial situation, water and climate change for establishing preventive measure of human lives and assets protection for now and the future generations. With the four main issue areas, it covers numerous specific space related policy issues, so expanded the global space governing scheme ever broadened. The complication of space governance is that states are never neutral when seeking and using these space technologies and their applications. They are often triggered by the dual-use of outer space. Dual-use refers to the use of outer space for physical devices and virtual services that can be dedicated for either military operations, civil utilities, or both, according to the aims of their operators and users. Concretely, the military uses of satellite telecommunication, navigation and remote sensing technologies for communication, navigation, surveillance are equally essential for civilian TV broadcasting and internet, for commercial land, sea and air transportation, and for gathering accurate geographical information data for farming, fishery activities and the Earth observation for environmental protection. These issue linkages create nuance and pitfalls for states to negotiate self-interest stressed governing rules and institutions. Such issue-linkage mapping exercise regarding the key governance issues will help us to discern what states struggle for in the international space politics in the 21st century and why they make a certain issue-linkage while jointly constructing the entire governance architecture toward its regime complex.

1. THE BROADENING "SPACE RACE"

The terminology of "space race" has generally been viewed in terms of a "space arms race" or more often dramatically simplified as "star wars" in the diplomatic forum, by the media and in the literature written by security experts. Actually, although lacking an authoritative definition, an ad hoc international committee was formally proposed at the non-UN Conference on Disarmament (CD) in 1985 to discuss the prevention of an arms race in outer space (PAROS). Indeed, space was first of all and above all developed for military use to win war and to prevent war, or in another words for international security and peace. The wide range of space technologies and their applications in telecommunication, navigation and remote sensing were already studied as early as 1946, by Project RAND.[130] The report of the US aeronautic producer analyzed the engineering possibilities of designing an artificial Earth satellite and its particular utilities for military purposes. This shows the US interests in developing space capability for military purposes. After the Soviet Union launched the world's first orbiting satellite, Sputnik, in 1957, the US President Eisenhower proposed the "peaceful use" of outer space. The approach opened the space technologies and applications developed and controlled by the military to restricted civilian uses of outer space. Hence, the neutral space capability became military, civilian or dual-use depending on its designer's will or user's desires and control.

The US President Kennedy's "Moon speech" in 1962[131] illustrates this broadened international "space race" as representing the ultimate challenge for men to explore, for countries to conquer and prove their power, but also to protect and share with others. He pointed out that, in order to accomplish all or any of these objectives, his fellow Americans should support his Administration to work on 1) stronger military capabilities, 2) better capacities in civilian space activities than foreign competitors, and perhaps 3) smart but autonomous generosity to share these capacities with others through global cooperation. So the US would be enabled 1) to develop critical scientific know-how and accurate technology as well as advance industry and increase financial ability to build up a space program, 2) to maximize and maintain such power dominance based on a cost-benefit, cost-effective and efficient method, and 3) to engage partners without losing its own autonomy and superiority. The strategic vision of the US President sounded legitimate, pacifying, and stimulating for the US citizens. The address simultaneously disclosed the paradox that such ambitious human project to connect man and space was not only based on a pure universal ideal but also due to the competition between the US and the Soviet Union at that time. The "space race" therefore expanded more and more its arena from its limited "space arms race" toward an all-range competition on individual state's space capability development and possession. This competition consequently also affected the following international space cooperation to functionally share the political, technical, and financial burden as well as in the process that states negotiate general governing principles, common operational rules and international technical standards related to the use of outer space.

[130] Douglas Aircraft Company, Santa Monica Plant, Engineering Division, "Preliminary Design of an Experimental World-Circling Spaceship", SM-11827, 2 May 1946.
[131] President J.F. Kennedy, speech at Rice University on September 12, 1962.

2. FOUR SPACE-RELATED GOVERNING ISSUE AREAS & KEY ISSUES

Nowadays, the original military-focused use of outer space has expanded to four major governing areas in total. (1) Military use of outer space, or *space security* per se; (2) *space for safety* because the uses of space have expanded to search and rescue operations and disaster mitigation through the use of satellite telecommunication, navigation and remote sensing technologies; (3) *space for economy and development*: space become increasingly beneficial for economic activities ranging 'from farming to banking', and to enable national or regional (re-)industrialization in order to improve the quality of peoples' daily life; and finally (4) *space for environmental and generational sustainability*: space technologies, particularly remote sensing technology and the applications facilitate the Earth observation on terrestrial situation, water and climate change for establishing preventive measure of human lives and assets protection for now and the future generations. Within the four main issue areas, it covers numerous specific space-related policy issues, so expanding the global space governing scheme ever further.

2.1. ISSUES ON SPACE SECURITY

2.1.1. BANNING NUCLEAR WEAPONS IN OUTER SPACE

The first space security governing issue seemed to be due to the general fear, after the two atomic bombings in Japan in 1945, that a likely third world war would result in mutual destruction throughout nuclear warfare. With the inter-continental ballistic missiles with nuclear warhead, a nuclear war can kill significantly more people and destroy more assets. But in fact, this fear did not prevent the two Cold War powers from developing nuclear weapons through and in space until 1963. They stopped only when both powers had exhausted their nuclear weapons tests and realized that cost-benefit considerations make nuclear weapons inefficient way to kill the main targets, orbiting satellites. The weapon is unsafe because it creates space debris that can hit all orbiting satellites. It is also unsafe to astronauts and a threat to human lives more generally because of the remaining nuclear fuel in space and the radioactive material fallout into the atmosphere and on the ground after detonating the nuclear weapon in atmosphere or in space. Because of this, in 1963 the Soviet Union, the United Kingdom and the United States agreed the Treaty banning nuclear weapons tests in the atmosphere, in outer space and under water, often abbreviated as the Partial Test Ban Treaty (PTBT), or Limited Test Ban Treaty (LTBT). The two space powers subsequently became more concerned about a possible arms race in outer space. In 1967 the Soviet Union and the United States agreed on the "peaceful use" of outer space and to abstain from placing nuclear weapons and any other kind of weapons of mass destruction (WMD) in space, as proscribed in Article IV of the *Treaty on principles governing the activities of states in the exploration and use of outer space, including the Moon and other celestial bodies* (known as the "Outer Space Treaty", OST). The remaining issue is that in addition to the countries that are keen to develop nuclear capability for "peaceful" or even explicitly for military purpose, such as Iran and North Korea, a number of other states still retain the capability to break their formal promise and use their remaining nuclear weapons to defend their national security. The issue of governing nuclear weapons in space is not closed.

2.1.2. THE PEACEFUL USE OF OUTER SPACE

The continuous "space race" between the USSR and the US attained its first critical moment after the Soviets successfully launched the world's first satellite, Sputnik, on October 4, 1957. On the US side, already in early 1957 President Eisenhower had stated that the country not only faced the problem of determining what the US wanted to do in space but also what kind of rules for unilateral activity and mutual interaction should prevail in space.[132] Following President Eisenhower's five-point disarmament speech to the US Congress, the US presented a disarmament proposal to the UN General Assembly in 1958 to call for a sound and safeguarded international agreement for open unarmed skies (known as "open skies") and reduced armament. The disarmament proposal for establishing a space security governing agreement actually embedded strategic calculations. The key technical elements concerned military security, such as international inspection for satellites, intercontinental missiles, space platforms, and long-range unmanned weapons addressed in this talk were actually what the Soviet Union was more advanced than the US at that time. The US had a vital interest in institutionalizing any international regime as an instrument to restrain the Soviets. By contrast, if a possible international agreement could slow down, not stop, the arms race, it could be beneficial for the Soviets to reduce its efforts and investment for arming itself. In this sense, proposing the "peaceful use" of outer space gained moral support from all. Consequently the Soviet Union also submitted a proposal to the UN General Assembly in 1958, equally calling for international cooperation in the exploration of cosmic space and the restriction of the use of space to peaceful purposes.[133] Knowing that not all governing issues, especially space-related matters, could be brought in the UN agenda to start negotiating for any formal agreement, the act demonstrated the great interest and concerns of the two space powers regarding the nature and the use of outer space.

With the agreement of the two space powers and the endorsement of the UN, the OST was signed by 104 countries on January 27, 1967. The term "peaceful use" that has been hence repetitively employed in many subsequent UN documents and space law treaties still remains problematic as it lacks an authoritative definition.[134] The terminological problem triggered divergent interpretations for its substance, between "non-military" and "non-aggressive". The former considers any military activities in outer space to be not peaceful. The latter by contrast provides leeway, in practice that all military uses of outer space were to be permitted and lawful as long as they remain "non-aggressive".[135] Primarily, the "non-military" interpretation was used by both the US and the Soviet Union. Due to the gap in military space capability innovation between the two powers, the US had gradually attained superior space capability vis-à-vis the Soviets and therefore began to push for the "non-

---

[132] Dwight D. Eisenhower, State of the Union Address given before the U.S. Congress on January 10, 1957.
[133] UN Doc. No. A/3818 (1958).
[134] Institute of Air and Space Law, Faculty of Law, McGill University (2005) *Background Paper - "Peaceful" and military uses of outer space: Law and Policy*.
[135] Vlasic, Ivan A. (1995) "Space Law and the Military Applications of Space Technology" in N Jasentulyianan, ed., *Perspectives on International Law*, Boston: Kluwer Law International. p385-394.

aggressive" rather than the "non-military" meaning. In contrast, the Soviet Union insisted that all military activities in outer space are non-peaceful and unlawful but in practice continued placing a growing number of military payloads in orbit. Actually, as both space powers and then more and more countries increase their dependence on space technology in their military planning and operations, the reality is that space has been constantly militarized regardless, although not yet claimed for any aggression. In sum, as some admitted at the Conference on Disarmament, "even in some contexts 'peaceful' means 'non-military', any ambiguity has been clarified by States practice which had not been contradicted in a forceful manner by any State formally protecting military utilization of space".[136] This means that although the "peaceful use" of outer space remains legally unclear it still seems politically manageable.

2.1.3. MILITARIZATION & WEAPONIZATION OF OUTER SPACE

Besides the non-defined "peaceful use" of outer space, Article IV of the OST also prohibits states *to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner*. This explicit prohibition has been viewed as imperfect and triggered a long-running debate because some stressed the "placement a weapon" in outer space as the "militarization of outer space", others focused on the "weapons in space" (or "space weapons") considered as the "weaponization of outer space". Nair argued that the fine line between militarization and weaponization may exist if taking outer space as an interface of military operation, or as the battlefield of warfare.[137] The distinction is similar to another way of categorizing the military assets between the "force support" (communication, command and control, sensor and surveillance) and "force applications", *i.e.* striking weapons according to Johnson [138] and Rosas[139]. Such distinctions would not change the application of each term in its substance if the final objective of the act is to physically harm the adversary people and assets to paralyze their military capability.

In the realm of space governance, the core technical issue causing the continuous debate is the problem of when the dual-use of space technologies and applications tips over into military use and being a weapon. As said above, any satellite designed and operated for civilian utilities carries the potential of being turned to military use in a given context according to the will of its operators and end users. More extensively, the information collected and retrieved from satellite encrypted data, such as real-time weather reports, remotely sensed geographical information of land, water and air about a given region, and the recorded trajectory of moving people and objects followed by the navigation satellites are precious intelligence to prepare and coordinate military operations in and outside of the

[136] UN Doc. CD/1165 of August 12, 1992.
[137] Nair, Kiran (2007) Putting Current Space Militarization and Weaponization Dynamics in Perspective: An Approach to Space Security. *Celebrating the Space Age: 50 Years of Space Technology of the Outer Space Treaty – Conference Report*, 2-3 April 2007, Geneva, UNDIR, 2007.
[138] Johnson, R. « Space Security: Opinions and Approaches", Paper presented at the "Outer Space and Global Security" Conference, Geneva, 26-27 November 2002.
[139] Rosas, Allan, The Militarization of Space and International Law, *Journal of Peace Research 20*(4) (Dec. 1983):357-364.

warfare battle field. The US *space shuttle* space exploration program (1981-2011) developed by NASA was claimed to be a mere space transportation system carrying civilian and military payloads but it may also have had an ASAT or other attack capability.[140] If following the same line of technical feasibility, the LEO orbiting space lab has the similar potential. Finally, in an unusual situation, any remote controllable spacecraft can be manipulated to be a suicide "ASAT weapon" to neutralize other hostile orbiting satellite by physically colliding them. This way of transforming a civilian-use spacecraft into a war machine is doubtless costly and therefore unusual. But it is certainly a possibility, comparable to the Japanese Kamikaze suicide fighter planes and their pilots near the end of the World War II.

As for the arena of international space security politics, the major technological concern was stressed on the international continental ballistic missiles (ICBMs) that made the Soviets capable of hurling their rockets with warheads across vast distances, flying them through orbit before descending on their targets. This weapon was viewed as direct destructive aggression from outer space. Because of this, the US ballistic missile defense (BMD) was developed with the similar technologies though stressing the reactive tactic of intercepting incoming missiles before their entry from space. Since BMD depends on satellite support, various types of anti-satellite weapons were therefore developed and intensively tested during the Cold War. The development and deployment of a variety of US Space Control systems (ability to assure access, freedom of operations, and deny it to the enemy), capable of damaging or destroying adversary spacecraft[141] were constantly developed by strategists and among militaries. The Space Control systems became essential for assisting distant military operations. The evidence can be traced since the 1991 Gulf War and the 1999 Kosovo airstrikes and so on. The NATO alliance reportedly used various satellites to their advantage,[142] including what the Americans claimed was the "accidental" bombardment of the Chinese embassy in Belgrade during the NATO air offensive against Yugoslavia.[143] The bombardment incident was suspected of having been intended to neutralize a spying mechanism embedded in the Chinese embassy. Similar technologies and equipment were more broadly applied in the US anti-terrorism military campaign in Afghanistan. Together with the Soviet Union, China has been consistently concerned about the issue of "space weaponization". In 1985, China and the Soviet Union, then Russia, introduced a working paper to the CD to oppose the placement of weapon in space. Since 2001, China prompted its concerns to the fact that Donald Rumsfeld, US Secretary of Defense in the Bush Jr. Administration, delivered a congressional report by calling for the National Space Policy to include the option of deploying weapons in space to deter threats to, and if necessary, defend against attacks on US interests.[144] Many Chinese officials assumed that China was the real target for US missile defense and space planning. From their perspective, it is implausible that the US would expend such massive resources on a

[140] Melby, Svein, (1982) On Recent ASAT Technology, Anti-satellite Weapons, the Strategic Balance and Arms Control, *NUPI-rapport No. 69* (Norsk Utenrikspolitisk Instituttt), Oslo: 27-96.
[141] Pike, John. (1998) American Control of Outer Space in the Third Millennium, *INESAP Information Bulletin 16*: 29-33.
[142] Chen, Dean. (2001) Space and Chinese Views of Future Warfare. *2001 CAPS-RAND PLA Conference*.
[143] *Janes' Information Group*, "China's Intelligence and Internal Security Forces". October 1999: 74
[144] Report to the Commission to Assess United States National Security Space Management and Organization, Washington, DC. January 11, 2001.

system that would be purely defensive and aimed only at "rogue" states.[145] In sum, the confusing governing issues on "space militarization" and "space weaponization" are not only about the a priori legal definition and the a posteriori lack of verification means. Both need political good will. Adequate verification depends on a state's good will to register its space launch beforehand and release sensitive information regarding the payload of its spacecraft. Once the spacecraft is in orbit, only the astronomically valued space surveillance system can trace spacecraft. For instance, only the US can afford such verification system. Finally, a state's national security and interest prevails the functional necessity of setting up clear governing rules.

2.1.4. ANTI-SATELLITE (ASAT) WEAPONS

An on-going space security issue is some states' concern with anti-satellite (ASAT) weapons. The debate has been revivified by safety concerns about space debris generated by the Chinese ASAT test in 2007, and the growing interest of countries such as India, and perhaps the DPRK (North Korea), in developing ASAT capability in parallel with their missile development and satellite launch capability. The technological rationale of developing anti-satellite weapons was to neutralize or disturb the orbiting communication and surveillance satellites of hostile countries in order to damage or reduce the enemy's military operation support capability. One way of damaging the targeted satellite is with a direct kinetic weapon, such as missiles or a suicide spacecraft of any kind, to collide with the target. The Soviet ICBMs can be used for this purpose. As said previously, in an extreme case, satellites, a space shuttle, or even the ISS, Hubble space telescope, and so forth, can also become a "space mine" to collide with a targeted satellite whether lawfully or not. Other technologies, such as blinding or dulling a satellite with a laser beam or jamming satellite radio signals have been developed to paralyze satellites partially or entirely. The latter can efficiently disturb military C4ISR[146] space control systems without leaving space debris in orbit that can equally harm the attacking state's own orbiting spacecraft.

The USSR and the US had probed and tested various ASAT technologies during the Cold War. Since the international political endeavors were centered on banning all military activities in and through outer space in the late 1950s, the two space powers both increased their efforts to test their ASAT capacities. The Soviets started testing a co-orbital ASAT system from 1963 and continued at different periods during 1976-1977 and 1978-1982, until the ASAT program was decommissioned in 1993. Meanwhile, the US President Reagan in 1983 proposed a space-based missile defense system – the "Brilliant Pebbles" program of small, satellite-based non-nuclear interceptor missiles and on the existing research efforts of space-based lasers. The program was part of the Strategic Defense Initiative (SDI) popularly known as "Star Wars". The ambitious SDI programs stimulated great expectations yet subsequently were incomplete due to various circumstances. Nonetheless, the SDI achieved the development of various types of space-based interceptors for the US to possess intrinsic ASAT capacities. In 1985, a US F-15-based homing vehicle (missile guidance) system was successfully tested. Afterwards, the US anti-ballistic missile system was deployed in Alaska

[145] Zhang, Hui, (2005) Action/Reaction : U.S. Space Weaponization and China, *Arms Control Today*, Arms Control Association: www.armscontrol.org
[146] Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance.

and California. The attempt was viewed by adversaries as a historical flash point that showed the US was weaponizing outer space and stimulating an arms race in space.

In 1997, the US Space Command published its *Vision for 2020* under the Clinton Administration. This *Vision for 2020* argues that an increased dependence upon space capabilities for "commercial, civil, international, and military interest and investments" could lead to increased vulnerabilities of the national security of the United States. Because of this, "*dominating the space dimension of military operations to protect US national interests and investment… [and] integrating space force into war fighting capabilities arcos the full spectrum of conflict*"[147] is critical. This proposal to develop US space military power was not granted support at the time. Only later did the Bush Jr. Administration again pledge to deploy missile defenses. The "Rumsfeld (Space) Commission"[148] issued a report about a possible "Space Pearl Harbor" which foresaw potential hostile attacks against the US due to the weaponization of outer space by other states. At that time, numerous countries possessed ballistic missiles and became interested in developing space-assisting systems to improve their space security capability. In that regard, US military decided to transform its space capabilities in the areas of assured access to space and on-orbit operations, space situation awareness, earth surveillance from space, global command, control and communication in space, defense in space, homeland defense and the projection of power in, from and through space.[149]

President Obama unveiled a plan for European missile defense. By 2005, 28 countries already possessed ballistic missiles that could reach low-Earth orbit (LEO) satellites, and all had the technical capability to develop an LEO anti-satellite system by modifying their missiles (Graham, 2005).[150] China held a successful ASAT test by destroying a Chinese-owned dysfunctional orbital satellite with a kinetic kill vehicle (KKV) warhead in January 2007. By doing so, China became the third state that has tested ASAT weapons, after Russia and the US. The act particularly stimulated the security concern of the US. On February 21, 2008, the US destroyed a malfunctioning satellite to counter-demonstrate its ASAT capabilities, though the kinetic hit has now become less considerable. In fact, the other countries that possess ASAT capability still all need to test the effectiveness of their potential ASAT weapons. China's ASAT test can therefore be said to have evoked a great potential of the ASAT test proliferation. India, for example, claimed to develop a hit-to-kill ASAT system based on a laser sensor and exo-atmospheric kill vehicle originally planned for ballistic missile defense purposes.[151] An expanding ASAT weapons competition is in prospect.

2.2. SPACE SAFETY

[147] US Space Command Lang Range Plan, April 1998.
http://www.fas.org/spp/military/docops/usspac/lrp/toc.htm

[148] Commission to Access United States National Security Space Management and Organization.

[149] Report of the Commission to Access United States National Security Space Management and Organization, Washington DC (Public Law 106-65), January 11, 2001.

[150] Graham, Thomas Jr. (2005) Space Weapon and the Risk of Accidental Nuclear War, Arms Control Today, December 2005. http://wwwarmscontrol.org/print/1953. (12/12/2012)

[151] De Selding, P.B. 2010 India developing anti-satellite spacecraft. Sapce.com, January 11, 2011.

Scientists and engineers developed artificial satellites that can orbit around the Earth with different kinds of payloads to transmit radio signal of telecommunication, navigation and remote sensing information data. To these utilities, the Universe is not as infinitive as we imagined. The safety related issue regarding the scarcity of limited outer space resources for all is the problem of attribution of the orbital slots and radio spectrum frequency for each orbiting and stationing satellite. First, just like car driving in the highway, when the individual satellites have no sufficient safe distance between them, they risk collide each other and cause damage. Second, when two satellites have an insufficient interval between them, their radio transmissions interfere with each other. In a time that people depend heavily on those space systems for telecommunication, navigation and remote sensing utilities for global financial markets and bank transactions, military and civilian aviation, search and rescue operations, and land, water and air situation observation, any brief black-out of can cost people's life and cause an irreversible loss of assets. Thus, making a global plan that delimits the orbit slots for every single satellite to avoid collision and to prevent radio signal transmission interference is one of the governing issues in "space for safety".

2.2.1. SPACE RESORUCE SCARCITY: SATELLITE ORBITAL SLOT & RADIO SPECTRUM

The International Telecommunication Union (ITU) has since 1963 been required by the UN to manage such space resource attribution issues as satellite orbital slots and related radio frequencies. A logical rationale of the UN was, since the ITU was already the international regime for radio frequency attributions, and the delimitation regarding the interval distance between individual satellites is co-related with the avoidance of satellite signal transmission, the ITU should elaborate two connected issues within one management plan. Therefore, the ITU Master International Frequency Register (MIFR) or the Master Register was established to oversee satellite access to geostationary and other orbits. At that time, only a few countries possessed and operated space systems with orbiting satellites. There was more than enough room to place this small number of satellites. So, the ITU adopted the "first-come, first-served" rules to attribute access for state and private applicants for the requested orbital slots with related radio frequency spectrum.

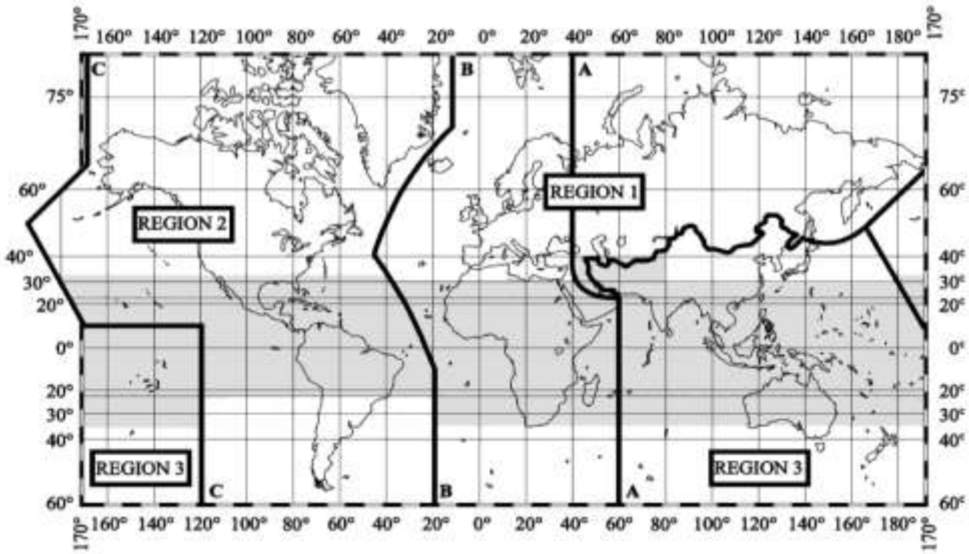
The "first-come, first-served" rule evoked an equity concern that developing countries will be limited with very few opportunities to compete with spacefaring nations and their private sector to have access to the limited orbital resources. Another problem is that the increasing inquiries from states and from private-sector actors to the access for placing their satellites evoked the problem of Hardin's "The Tragedy of the Commons"[152] which described the problems of the public use of the limited common resources, or in a word, the problem of common resource scarcity. These two problems called the ITU rules into question.

In response to the first problem, the ITU established an *a priori* system that provides a preferred access opportunity, but without either orbital slot registration or a legal right, to any *Administration* attributing allotments per geographical region. States with or without any space capability have legal shares of GEO satellite slots. This *a priori* system has generated some "paper satellites", or more precisely cases of "reservation of capacity

[152] Hardin, Garrett, The Tragedy of the Commons, *Science,* New Series, (Dec 13, 1968) *162* (3859) :1243-1248.

without actual use".[153] In practice, those states lacking of space capability can trade their allocated orbital slots with satellite frequencies with other spacefaring states or satellite operators for significant financial advantages or exchanging space capability development assistance. One well-known case is Togasat. After the equity-stressed allocation system created in 1985 and 1988, the Kingdom of Toga attempted to register sixteen orbital slots between 1988 and 1990. Toga ultimately acquired six orbital slots and relevant radio frequencies. A nationally funded satellite firm Togasat hence undertook the launch of the virtual satellites. But actually, Togasat proceeded to rent out an allotment to Unicorn, a Colorado company, and afterwards auctioned off its remaining slots for $2 million per year for each orbit.[154] In 2014, a Chinese firm also appeared to bid in Togasat's auction.[155] These paper satellites eventually made satellite orbital slots and radio frequency allocations more intricate. In addition, the orbital slots trading also engendered the complication for liability determination if harmful radio interference problems and disputes occur.

Figure4. Regions for purposes of orbital slots and frequency allocation, ITU



Source: International Telecommunication Union

Another challenge for the ITU to overcome in limited space resource management is to make its inquiry procedure more efficient and economical. The ITU grants seven years as proceeding period before the expiration of an allotment registry for an orbital slot register request. This lengthy process is regarded, particularly by spacefaring countries, as an irrational and inefficient way of governing limited space resources. Such non-spacefaring-friendly rules respond to claims from developing nations for priority access to an orbital slot, despite having no practical capability to finance the construction, launch, and operation

[153] Allison, Audrey (2012) *Paper Satellites, virtual satellites : Managing Satellite Orbital and Spectrum Resources in an Increasingly Competitive and Congested Environment*, Master Thesis, International space University.
[154] Galeriu, Iulia-Diana, "Paper satellites" and their free use of outer space, January/February 2015. *NYU Law Global*. http://www.nyulawglobal.org/globalex/Paper_satellites_free_use_outer_space.html
[155] *The Tonga Herald*, "Politics of Tongasat kills useful model for Tonga business, growth", August 4, 2014; "Demo party leader asks China to intervene and influence domestic politics", July 29, 2014.

of a satellite within the seven-year timetable.[156] In the meantime, many exploitable orbital slots and relevant radio frequencies have to remain unused. Since 1994, Article 44 of the ITU Constitution prescribes[157] that the limited radio frequencies and the geostationary-satellite orbit natural resources must be used *rationally*, *efficiently* and *economically*.[158]

2.2.2. FREQUENCY OVERLAY & SIGNAL JAMMING

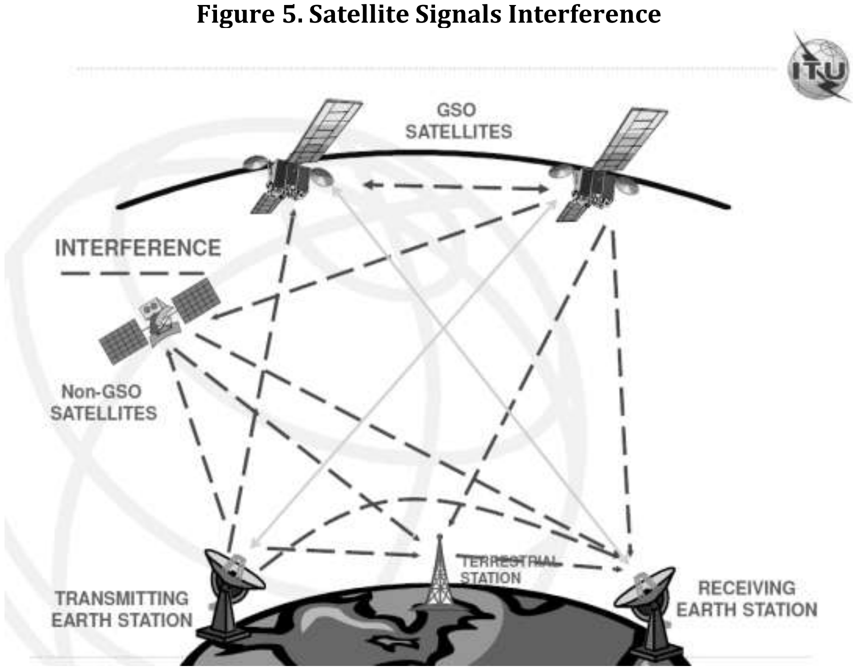
The more countries depend on the services provided by satellite supported systems to communication, disaster management, meteorology, distance education, e-health, and managing natural resources, the less useable or safe satellite orbital places and radio frequency bands are available for everyone. The growing lack of available space resources has not only generated the equal common public goods (re-)distribution problem, but is also closely connected with safety issues. As the good functioning of all space systems depend on the continuity of the satellite radio signal transmission, the ITU is responsible for making safe and efficient radio frequency bandwidth allocations for all inquiries as well as for protecting the ITU MIFR registered assignments from harmful interference. The interference issue is vital for the continuity of all civilian purposes services, and is even more especially important for dual-use GNSSs services.

In general, when satellites transmit their signals, it is the Super High Frequency (SHF) bandwidth (between 3GHz and 30 GHz) that is the most suitable radio frequency. The technical solution is to allocate fixed positions and define their relevant radio frequency spectrum before sending any single satellite into orbit. The allocation of satellite orbital slots as well as their radio frequency bands has become intricate since the increase of multiple satellite services providers and users would wish or have to co-exist in the same range of the radio frequency bandwidth. It is even more complicate for GNSSs because within the SHF bandwidth, the GNSS satellites constantly need two or more frequencies in L band to transmit positioning-navigating-timing (PNT) signals that contain ranging codes and navigation data to allow the users to compute the travelling time from satellite to receiver and the satellite coordinates at any moment. As navigation frequencies occupy such a fairly small neighborhood on the radio spectrum, all GNSSs contend with each other to use the same radio spectrum. Once the number of GNSSs and user population grew, the individual needs for frequency increased as well. If there is a requested frequency overlay, this needs to be settled or regulated. Otherwise, different GNSSs' radio signals can interfere with each other and then diminish the operation quality of the GNSS services concerned. The ITU should be the global regulating mechanism for such issue. Nonetheless, the ITU is only entrusted to register the MIFR but not to arbitrate any dispute. So the ITU has no regulating power with GNSSs signal overlays because the disputes cannot be resolved as the matter of satellite signal interference. The military have more problems because overlay

[156] Roberts, Lawrence D. (2000) A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union, *Berkeley Technology Law Journal 15*(3) 1095-1144.
[157] "In using frequency bands for radio services, Members shall bear in mind that radio frequencies and the geostationary-satellite orbit are limited natural resources and that they must be used rationally, efficiently and economically, so that countries or groups of countries may have equitable access to both, taking into account the special needs of the developing countries and the geographical situation of particular countries.", Article 44, ITU Constitution.
[158] Italics added for emphasis.

makes it impossible intentionally to jam another network without jamming one's own frequency. The issue can only be resolved between concerned parties. All in all, as space security matters are implicated in such disputes, national interest naturally overwrote the general interest. It made the governance more complicated. More details regarding the GNSS governance will be further discussed in the Chapter VI.

Figure 5. Satellite Signals Interference



Source: International Telecommunication Union (ITU)

Intentional satellite signal jamming cases are not infrequent, like the Eutelsat vs. Iran case in 2011. Five international television and radio broadcasters called on the ITU to address the issue of intentional satellite signal interference in January 2011. According to the five satellite user companies, their Persian-language broadcasting program into Iran and other countries were being jammed with Iranian satellite beaming[159]. In retaliation, a year later Eutelsat agreed with the media services company Arqiva to remove the program from the official Broadcasting Service of the Islamic Republic of Iran to reinforce EU sanctions aimed at punishing human rights abuses.[160] The ITU claimed it is effectively powerless to do anything about this measure taken by the EU side.[161]

2.3. SPACE SUSTAINABILITY

Space Sustainability or the "long-term sustainability of outer space activities" is one of the latest elaborated governing realms after the space security and space safety issue areas. For instance, the UN COPUOS governing efforts relating to space sustainability are space debris

[159] *Space News*. Broadcasters Call for ITU Action on Satellite Jamming by Peter B. de Selding, 9 December 2011.
[160] Associated Press, EU Sanctions Prompt Eutelsat To Block Iranian Broadcasts. 15 October 2012.
[161] *Space News*. Eutelsat Drops Iranian Channels by Peter B. de Selding, 15 October 2012.

mitigation, nuclear power source applications in outer space, and the "long-term sustainability of outer space activities".

Taking the short-term operational management measures first, outer space is facing traditional security threats caused by the military build-up of major space powers such as ASAT-caused space debris, spectrum interference, targeted electromagnetic jamming, malware weaponization and directed energy weapons.[162] As for long-term risk prevention objectives, they are more related to political and socio-economic threats such as the growing space capacity gap between the spacefaring countries and non-spacefaring countries. The impacts of and the measures for both short-term and long-term threats have been assessed and solutions based on an incremental approach suggested. It is obvious that, instead of efforts to further space science and technological progress, maximize the space technologies applications to improve people's lives, and gradually bridge the gap between spacefaring and non-spacefaring nations by transferring space capacities in respecting difference bio-chemical and social environments[163] for future generations, many spacefaring nations are afraid of losing their dominant positions, and aim to preserve their dominance or leadership under the banner of national security or the national interest. For instance, we can identify issues such as terrestrial environment and sustainable development, and space debris and nuclear power resources (NPS) in outer space as the most concerned sustainable issues.

2.3.1. ON EARTH

2.3.1.1. ENVIRONMENTAL ISSUES

The use of space technology applications, such as remote sensing, has been developed from the very beginning of the satellite age but mainly for the purpose of military reconnaissance and surveillance. Aside from its military utilities, civil-use related international cooperation issues like meteorology, the development of international atmospheric observation and telecommunication networks, and the promotion of research, were quickly assigned as some of the missions of the World Meteorology Organization (WMO). The WMO Space Programme now promotes the availability and utilization of satellite data and products for weather, climate, water and related applications of WMO Members. It aims to leverage an "end-to-end system" for weather and climate services. This ranges from capturing of data and over calibration to quality control, dissemination and user training.[164] Other applications of remote sensing, together with satellite communications and global positioning, navigation and timing systems (GNSS) have increasingly facilitated activities aimed at achieving of sustainable goals and targets set by the UN. At least three UN work areas have been emphasized: 1) protecting the Earth's environment and natural sources management (Agenda 21)[165]; 2) disaster risk reduction (Hyogo Framework for Action:

[162] Martinez, Larry. (2012) Is There Space for the UN? Trends in Outer Space and Cyberspace Regime Evolution. *ESPI Perspectives 56*. (January 2012). European Space Policy Institute. p4.
[163] von Prittwitz, Volker, (2011) Space as Environment: On the Way to Sustainable Space Policy? *ESPI Perspectives 50* (August 2011). European Space Policy Institute.
[164] http://www.wmo.int/pages/prog/sat/activitiesandobjectives_en.php
[165] Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forest were adopted at the UN Conference on Environment and Development,

Building the Resilience of Nations and Communities to Disasters)[166]; and 3) the Millennium Development Goals[167]. Concretely, satellite remote sensing technology has been used to monitor and forecast weather for farmers and to monitoring crop development to help predict agricultural outputs in advance. Such information is crucial in assessing vulnerability and managing food security. Likewise, space-based information provides effective and efficient tools for disaster management and emergency response. An "International Charter for Space and Major Disaster" was activating in 2000 and signed by national space related agencies[168] to coordinate satellite data providers' response to major space and terrestrial disasters.

2.3.1.2. SUSTAINABLE DEVELOPMENT

As for the sustainable development of space capacity applications, it has been noted in a UN resolution[169] that the UN Members States recognize the importance of global mapping as a necessary element in developing global environmental observation systems, also noting data collected by developing countries. The short-term cooperation can start from collecting and sharing data beneficial in building up long-term global environmental observation systems. That can immediately be helpful for disaster mitigation or humanitarian aid, or risk assessment for adequate measures on climate change issues. Once these systems are operational, scientific communities, governments, NGOs and the private sector would use such global environmental observation systems to assess then design the best planning, programs and operational projects for sustainable purposes.

Challenges that come with building up such global environmental and sustainable observation systems remain and obtaining accurate geographical information is related to a dual use for both environmental and military purpose. Both space-faring and non-space-faring still shares common concerns. Space-faring countries compete with each other for bidding the positions of maintaining global data sources whereas non-space-faring countries prefer develop their own data collecting systems or at least not to authorize full access to the data collecting or to share collected data in consideration of their vulnerability in terms of national security and interests.

2.3.2. IN OUTER SPACE

2.3.2.1. SPACE DEBRIS

Since 1999, the UN Committee of peaceful use of outer space (COPUOS) recognized that some space debris has the potential to damage spacecraft, leading to loss of missions, or loss of life in the case of manned spacecraft, and also assessed that for manned flight orbits, space debris mitigation measures are highly relevant due to crew safety implementations. The UN has adopted the "Space Debris Mitigation Guidelines" in 2007 which defined "space

Rio de Janeiro, 3-14 June 1992.

[166] World Conference on Disaster Reduction, 18-22 January 2005.

[167] The Millennium Development Goals, UN Millennium Declaration, Millennium Summit, 2000.

[168] Argentina, Algeria, Brazil, Britain, Canada, China, France, Germany, India, Japan, Korea, Nigeria, Turkey, USA, ESA, and EUMETSAT.

[169] Paragraph 274, GA resolution 66/288 of 11 Sept. 2012. "The future We Want".

debris" as all man-made objects, including fragments and elements therefore, in Earth orbit or re-entering the atmosphere, that are non-functional. Knowing that the main causes of man-made space debris are from launching operations (every launching leaves at least one part of rocket in orbit), unexpected break-up during space operational phase, accidental collision (against other spacecrafts or space debris) in orbit, as well as intentional destruction and harmful activities (like ASAT), post-mission dysfunction or break-ups. The Guidelines took two categories of measures to reduce future space debris and to remove existing debris. The Chinese ASAT test was criticized by the US and other states for the space safety concern because the massive debris generated by the test were dispersed in orbit and dangerous to all the spacecrafts.

The challenges remain on the angles of technological capacities, political willingness and notably economic concerns for such responsibility sharing. Those who possess more assets in orbit have more concerns on space debris issues and have the capacities and the means to reduce and remove space debris. However, they expect all space catchers including non-space-faring countries and related space industries to share the operational costs for the benefit of the future generations. For space catchers and non-space-faring countries or companies, it is understandable that space debris may not be listed on their development or operational priorities since the efforts and means tend to be more devoted to space capacity building or other domestic socio-economic issues rather than space debris mitigation. Furthermore, in spite of the awareness that ASAT tests create massive space debris, as was the case with China's ASAT test in 2007, space catchers remain eager to continue to develop such efficient military means to either demonstrate national power, or deploy national defense measures. Little hope for reaching a static equilibrium amongst these competitive and cooperative dynamics looks likely to be observed in future global governance on space debris issue.

2.3.2.2. NUCLEAR POWER SOURCES (NPS)

Due the general fear that a likely third world war would be resulted in a mutual destruction nuclear warfare, the USSR-US-UK have attained the Partial test ban treaty in 1963. Much later, the UN Comprehensive nuclear test ban treaty was concluded in 1996 which prohibits the nuclear tests and any other nuclear explosion in the atmosphere or in space. Hence, the nuclear power resources (NPS) for use in outer space have been developed and used where specific space mission requirements and constraints on electrical power and thermal management are precluded. The NPS safety in the atmosphere and in space concerns are mainly concerned in the case of an nuclear fallout, the presence of radioactive materials or nuclear fuels in space and their potential for harm to people and the environment in Earth's biosphere requires that safety should always be an inherent part of the design and application of space NPS. In this regard, the UNCOPUOS, together with International Atomic Energy Agency (IAEA), published the UN-IAEA Safety Framework for NPS applications in outer space in 2009. The focus of the Safety Framework is the protection of people and the environment in Earth's biosphere from potential hazards associated with the launch, operation and end-of-service mission phases of space NPS applications. As unsafe NPS technologies can have harmful long-term impacts, the major concerns are therefore to prevent accidental nuclear disaster and to avoid intentional aggression and harmful operations which will cause irreversible consequences to people and to the environment. There are remaining risks that several emerging space nations, often in conflict with other states, had no chance to test their "space weapons" with or without nuclear warheads. As a result, the restraints of international law may not be sufficient to dissuade their attempt.

2.3.2.3. LONG-TERM SUSTAINABILITY OF OUTER SPACE ACTIVITIES (LST)

The 1992 UN Declaration on Environment and Development (known as the "Rio Declaration") launched the idea that "*human beings are at the centre of concern for sustainable development. They are entitled to a healthy and productive life in harmony with nature*" (Article I). And "*the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations*" (Article III). With the generational concerns, international cooperation efforts should be devoted to "*ensure that all humanity can continue to use outer space for peaceful purposes and socio-economic benefit*"[170] by bridging the gap between the space-faring and non-space-faring countries. In sum, general ideas surrounding environmental concept may be applied to space policies of respecting difference between bio-chemical and social environments.[171]

The idea of developing "Long-term Sustainability of Outer Space Activities" (LST) was discussed within the framework of the UNCOPUOS in 2004. In 2008, the French delegation announced it would submit an official proposal to the UNCOPUOS to add a sustainability item to the agenda. This led to its inclusion on the agenda of the Scientific and Technical Subcommittee (STSC) in 2010 and the establishment of an official UN LTS working group on the topic.[172] The Working Group's goal is to examine and propose measures to ensure the safe and sustainable use of outer space for peaceful purposes and for the benefit of all countries.[173] Decoding this objective, at least two time-wise approaches, short-term operational management and long-term risk preventive approach, were suggested to deal with space sustainability concerns on Earth and in outer space. Focused challenges undertaken by the LTS Working Group include defining the term "sustainability", "space surveillance awareness" (SSA), "space-faring", and "safety", in order to established common agreed terminologies in the future outcome; whether new regimes, e.g. UNGA resolutions or guidelines would limit the established space nations' freedom of act in space; whether new regimes would impose unacceptable barriers to new entrants in the space arena; and if there will be legal and economic implications to be considered.[174] The Working Group is tasked with producing a consensus report containing voluntary (non-binding) best-practice guidelines for all space actors to attain the objective. The official working plan called for finalizing the candidate guidelines by 2016, followed by referral to the UN General Assembly.

---

[170] Secure World Foundation. (2010). *Space Sustainability – A Practical Guide*. Washington D.C..: Secure World Foundation.
[171] von Prittwitz, Volker, (2011) Space as Environment: On the Way to Sustainable Space Policy? *ESPI Perspectives 50* (August 2011). European Space Policy Institute.
[172] 53rd UNCOPUOS Report A/65/20, 2010.
[173] 53rd UNCOPUOS Report *Annex II, Terms of reference and methods of work of the Working Group on Long-Term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee*, A/66/20, 2011.
[174] Martinez, Peter, Chair, COPUS WG on LTS, *Development of UN COPUOS guidelines for space sustainability – A status update*, presented at JSF SSA Symposium, Feb 2015.

2.4. SPACE COMMERCE

It was President Ronald Reagan, while welcoming the return of the test space shuttle Columbia on 4 July 1982 at Edwards Air Force Base, who inaugurated a new era of space commerce which would move forward to capitalize on the limitless potential offered by the new frontier. The Reagan administration pushed hard to help the private industry and capitalize on the commercialization of the US space industry. President Reagan believed that would not only stimulate domestic technological innovation and boosting American high-tech production, but also create opportunities for the US to compete with Europe and Japan. Three decades later, an embryonic private spaceflight industry continues to emerge, seeking to capitalize on new advancements, reliable, reusable, and relatively affordable launching technologies to suborbital trajectories and into low Earth orbit. This has stimulated global trade interests in the space commerce sector and engendered competition as well as tension among governments and the private sector on both aspects, national and sector, trade interests and security concerns.

Space commerce has primarily covered the sectors of communication and transportation. It covers satellite manufacturing and launch services, advanced navigation products and the provision of satellite-based communications. According to *The 2013 Space Report*,[175] the global commercial space economy continues to thrive, with estimated annual revenues (commercial revenue and government budget) in excess of $304 billion, up 6.7% from 2011 and 37% since 2007. Individual consumers are a growing source of demand for these services, particularly satellite television and personal GPS devices. In addition to orders for satellite fleet replenishment, manufacturers and launch providers are looking to the robust demand for new space-based services to spur new satellite orders. Such commercial activities would support increased access to space products and services.

A popularization of space capacity building, such as lower launch costs for commercial satellites, has enabled greater accessibility to space, particularly by developing countries that in the past found space access prohibitively expensive. Yet increased access to space affects international space commercial activities both positively and negatively. As more entities, both governmental and private, are able to reach space, the benefits of the resources spread, ideally in an equalizing manner. Increased access to space also translates into a more congested market environment, making effective regulatory mechanisms for the allocation of scarce resources more urgent. Therefore, improving the regulations and mechanisms of global space governance related to space commerce is envisaged as the next great challenge. Again, as many foreseen space commerce issues are still beyond current scientific and technological capacities, an integrating approach is often applied to look for short-term functional regulations on Earth, and long-term preventive measures might happen in space and other celestial environments in the future.

2.4.1. SPACE COMMERCE ON EARTH

There are challenges or tensions in three areas where coordination as well as comprehensive measures and regulations are needed, namely imagery data of remote sensing; radio-frequency market liberalization and export control regulations. Since the

[175] *The 2013 Space Report*, Space Foundation. http://www.spacefoundation.org/programs/research-and-analysis/space-report (2013/04/30)

issue on radio-frequency was already briefly discussed in the previous section, we will focus on the issues of remote sensing imagery data and export control regulations of space commerce.

2.4.1.1. IMAGERY DATA OF REMOTE SENSING

The remote sensing technology is overall a powerful instrument for military surveillance and operation planning. The remote sensing satellites using very high-resolution (VHR) capabilities were formerly exclusively used by the military. Since the end of the Cold War, VHR data have become available on the civil market and for commercial purposes. However, the commercial use of such data can be restricted when national security is at stake. A few years ago, Earth-imaging data was only available to a select number of governments. Today any individual or organization with access to the Internet can use these services at no cost. Google Maps and Google Earth are just two examples of the various widely available online mapping applications. These remote sensing applications serve public authorities by improving environmental policies, meteorological services as well as crisis management and civil protection actions. Likewise, remote sensing data is useful for private users in forestry exploitation, agriculture or cadastral uses. However, the different destinations of the utilized imagery have created tensions between the support of public policies and that for private utilization.

At the global governance level, it was not until 1986 that the UN Principles on Remote Sensing was adopted by consensus. The US resolution opening access to remote sensing data established the right of user countries to obtain access to data on an open and non-discriminatory basis.[176] The "Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters" (the Aarhus Convention) in 1998 reinforced this right by allowing free access for the public to these environmental information through public authorities, yet also established the obligation for public authorities to ensure an adequate and transparent flow of information about activities that may significantly affect the environment. Such right to information is not commercially supported and leads to debates on Intellectual Property (IP) considerations, and some would suggest be exempted by public security considerations. For the imagery data companies, intellectual property rights are an important consultation when regulating applications for satellite imagery as they allow generators of RS information to reap benefits for their investment.

2.4.1.2. EXPORT CONTROL REGULATIONS

In principle, export activities are by nature trading activities and are subject to trade rules and economic considerations. Yet, the strategic use of space related to technological applications and services also involves national security concerns. That explains why governments, notably that of spacefaring countries such as the US, often face a dilemma between selling more to gain more profits but at the same time also limiting sales to protect their short term market dominance and long-term cutting-edge leadership. Additionally, there are especially serious security concerns such as preventing space catchers obtaining core technologies or know-how thus limiting their ability to develop counter- or

[176] A/RES/41/65 Principles relating to remote sensing of the Earth from space.

competitive appliances which could compete against the existing space club monopoly as well as the military space technologies cartel. This has resulted in a business as usual approach since the end of the Cold War as two ideological camps engage in a other global products' standardization war. Nonetheless, such practices are contradictory to the rules of the World Trade Organization (WTO), one of the most important global trade governance mechanisms. A case which clearly demonstrates this kind of tension is that between the US "International Traffic in Arms Regulations" (ITAR) and the WTO "Agreement of Government Procurement" (GPA) which is based on the principles of openness, transparency and non-discrimination.

The US ITAR governs transfers of arms but can apply to business activities far removed from what one might consider to be arms exports (the shipment from the US of, for instance, missiles, tanks, military aircraft, and warships). The "arms" to which the ITAR applies are identified on the US Munitions List (USML). In addition to those commodities clearly listed as weapons on the USML, common electronic devices such as infrared focal plane array and lasers that are specifically modified or configured for military applications, as well as all spacecraft (including research and communication regarding commercial products specifically for a military (or space) application will be taken as the modified product to apply the USML in the US. Such regulations were obviously designed to protect the national security and economic interests of the US while few spacefaring nations were still dominating the global space market. But in the context of the complex global space commerce flow and continuous relocation of production activities, the US seemed to have no choice but to keep extending the ITAR list and perpetuating the non-conformity of the ITAR to the non-discrimination principle of the GPA under the WTO. The ITAR remains as an important issue that should be covered within the discussion for global space governance.

2.4.2. EXPLORATION OF NATURAL RESOURCES OF CELESTIAL BODIES

The rise of emerging global powers and the competition for energy and rare minerals has resulted in a global battlefield upon which many States, especially the developed countries and emerging powers, are dependent on these natural sources. Various science-fiction-like solutions have been thought of and proposed when knowledge and technological capacity become available. These technologies include collecting solar energy through solar panels in space then sending them to the Earth and Moon or Mars mineral resources exploitation. The recent NASA Mars Mission and President Obama's asteroid retrieval plan[177] to catch potentially hazardous asteroids has triggered the imagination somewhat as to whether a new prospecting for natural resources in outer space is about to start. Once asteroid capture operations become available, man can start bringing back mineral resources from these celestial bodies to the Earth. However, these exploration exercises remain costly and inefficient at the current stage. However, given that energy and natural resource scarcity has become a global issue, and countries do possess ambition to develop feasible technologies in that regard, such issues may become another topic in the governance of space commerce. In November 2015, the U.S. Congress passed the Commercial Space Launch Competitiveness Act in which it give the right to mine asteroids, extends America's

---

[177] *Huffpost Tech*, "Obama's Asteroid Goal: Tougher, Riskier Than Moon", by Seth Borenstein, AP., April 9, 2013 http://www.huffingtonpost.com/2010/04/17/obamas-asteroid-goal-toug_n_541665.html

commitment to the International Space Station (ISS). The new law aims to facilitate the start-up of private space companies domestically. It also requires that US authorities specify the way that asteroid mining will be regulated and organized which will surely become sooner or later a new international issue because the issue is related to the 1967 OST and the 'failed' Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (known as the Moon Treaty) that turns jurisdiction of all celestial bodies over to the international community. So, all activities must conform to international law, including the UN Charter.

3. CONCLUDING REMARKS

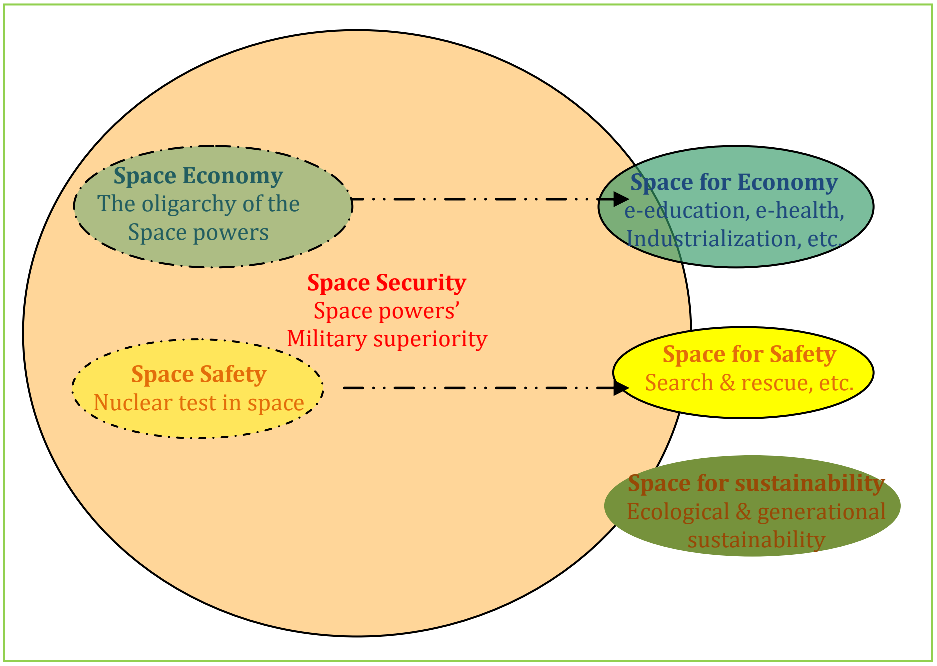
We have showed that there is a continuous "space race" on the military space capability primarily between the two Cold War powers, and then added by a number of spacefaring and emerging countries, toward a global course for national space capability building. Further to this popularization of space activities and the liberalization of the space economy, the issues of global space governance have simultaneously expanded its primary security-focused issue area toward other issue areas, such as space for *safety,* space for *economy and development,* and space for *environmental and generational sustainability*. We note that the growth and the shifts of focus on different space related issues over time have been highly politicized. In a word, although the vital input for progress in human space activities comse from the scientific community and from industry, it has depended on the will of states to gather massive means and personnel to develop some focused areas, and particularly for military uses. This strategic mindset has affected space rulemaking when states, due to their functional necessity, initiated or were compelled to establish international space laws and institutions. In the space security arena, e.g. the segmented nuclear proliferation regimes related to space security and safety, and the long-lasting terminological debates regarding the "peaceful use", "militarization", and "weaponization" of outer space, were initiated when the space powers had exhausted their technical tests then changed their interpreting stances toward these vague legal terms. They were compelled to change their strategic attitude when the general safety issue prevailed, for example after the Chinese ASAT test that generated massive space debris in orbit. The legitimacy of protection general interests overwrote individual state interests. However, this did not cause any state to cease the course of their competition on the military space capability. For both military capability and space commerce, states were compelled to create an international institution to settle attribution matters on satellite orbital slots and radio frequency. Nonetheless, the rules were not perfectly conformed with other space governing principles, such as free access to outer space for all states. From the early space age onwards, such *legal inconsistencies*[178] have often resulted in international space rules and institutions being inapplicable and dysfunctional. The nuance embedded in the legal inconsistency and the lack of verification or implementation tools has also engendered hurdles for the later established regimes. More details will be discussed in Chapter III.

Further to the situational changes after the Cold War, such ambiguity has not been reduced. In contrast, the situational changes strengthen this governing ambiguity because of the intensified dual-use of outer space. The dual-use of space technologies and their

[178] Raustiala & Victor (2004). *Cit.*

applications stimulated more and more states and non-state actors to take part in space activities and also to influence the international space rule making. It sparked more ***issue-linkage*** in the use of outer space and the intensified the interconnection between the space related regimes complex toward other issue-areas governing realms for safety, economy and development, and ecological and generational sustainability in which they also respectively consist of numerous international regimes dedicated to their individual focused issue-areas.

Figure 6. The evolutionary interconnection between space issue area toward other issue areas

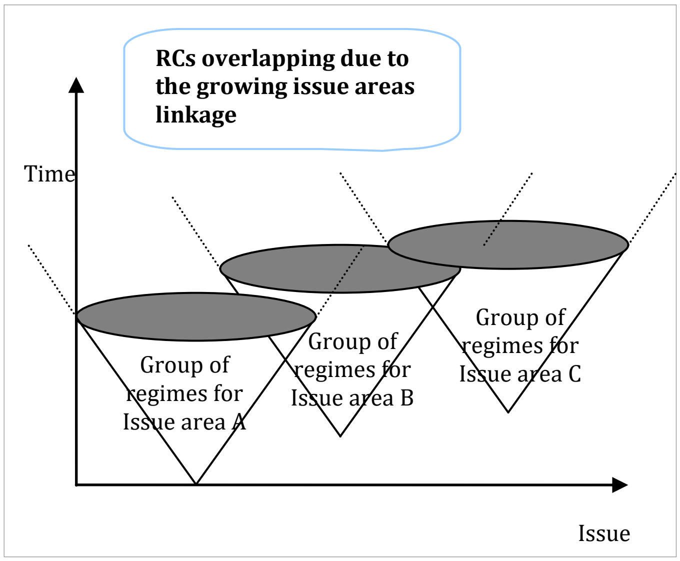


Source: Author's creation

Figure 6 is a visual tool to summarize the shifting interconnecting trend of the different major space governing issues over time. Space security issues (red circle) continue to occupy a completely dominant position that embedded the space economy (blue circle with dashed border line) and space safety (yellow circle with dashed border line) issues in its coverage. After the Cold War, although the situation had changed this did not destabilize the dominance of the space security issue within the entire space governance framework. Nonetheless, both space safety and space economy moved to expand their coverage toward its broadened safety and economy rather "space for economy" (blue circle) and "space for safety" (yellow circle), for example search & rescue, aviation navigation, and space for economy, for example e-education, e-health and enabling industrialization. The new governance domain that became interconnected with space governance issues is space for sustainability. The issue linkage between space and this issue-area have grown due to the rise of ecological and generational sustainability concerns.

Figure 7 demonstrates a holistic model that the growing issue-linkages between different issue-areas governance constellations, e.g. A. regime constellations for space related regimes, B. safety related regime constellation, C. development and economy issues governing constellation, D. sustainability issues, etc., in the general global governance dimension. The respectively A, B, C, etc… continuously grew their own governance architectures toward each other. The institutional interactions among A, B, and C also increased over time. When the overlap occurs, different types of institutional interplay can be expected according to regime complex theory. In our case study, it is essential to first complete the puzzle of the jungle where those small woods of different issue area naturally or artificially grew, embedded, interconnected with each other. Afterward, we would be able to see where the forest of the space regime complex stands.

Figure 7. The growing overlapping regime constellations of different issue areas



Source: Author's creation

CHAPTER III THE LEGAL GOVERNING PRINCIPLES & INTERNATIONAL SPACE TREATIES

Abstract: Chapter III is dedicated to highlighting the role of the legal governing principles prescribed in the UN resolutions as well in the international treaties with which the entire global space governance architecture was founded and able to be developed. These legal principles and international conventions with the emphases on the "non-appropriation of", "free access to", and then the undefined "peaceful use of" outer space were mostly negotiated and concluded under UN auspices in the hostile circumstance in the Cold War. The existence of these legal regimes counter-proved the *sui generis* of human space activities because they have progressed in an ambiguity where states, primarily especially the powerful ones and then the ones who seek power, continued to maximize their space capabilities for both military and civilian utilities, to exploit such strategic and public common goods for their own national interest, and to choose either compete, cooperate or both with other states to avoid conflicts. To satisfy all different states' concerns, these legal instruments were all expected to be concluded in sequence yet often resulted in political compromises that created the derived regimes, which do or do not correspond to its original ideal. This generated a legal inconsistency content-wise, and a *path-dependence* whenever new rules were mooted. In addition, because of the popularization of human space activities and the liberalization of space-related trade exchange after the Cold War, these legal frameworks became outdated *vis-à-vis* the changing international politics, the rapid progress in space technologies and the new socio-economic perspectives for now and for the future. To update and upgrade these legal regimes is necessary yet requires thorough work to review and to elaborate all the relevant legal texts. And mostly importantly, it requires the political willingness of all states to agree on both the content and the procedure for any revision of the existing legal regimes. Otherwise, creating substituting regimes are also explored as alternatives. These subsequently provoked the expansion and fragmentation of the global space governance architecture into a regime complex.

1. INTRODUCTION

Although the human space activities only began in the 1950s, the endeavors to improve the space technologies and the applications have been intensified to satisfy people's desires to conquer the "High Frontier" of the sky, air, or outer space. Historically, the discovery of the orbital dynamics following Nicolaus Copernicus's *De revolutionibus orbium coelestium* (1543) made the exploration of space imaginable. Then Johannes Kepler was the first to successfully model planetary orbits to a high degree of accuracy, publishing his laws in 1605. In 1687 Isaac Newton published more general laws of celestial motion in his *Philosophiæ Naturalis Principia Mathematica*. As from the first successful manned flight, *Gliders*, conducted by German engineer Otto Lilienthal between 1891 until his fatal flight in 1896, a new era to explore the third dimension – airspace – finally began. Hence, individual and collective scientific and engineering efforts supported by industries continued to improve aviation engineering designs, navigational instruments and radio communication technology.

During World War II, states, particular the Western countries increased their interests to innovate the aviation vehicles, radio communication instruments and computing technologies for military utilities. These sophisticated instruments were developed to go higher, farther, faster and with better accuracy in order to destroy the targets. After World War II, many outstanding German scientists and engineers moved to the US or the Soviet camp and continued improving the technologies they had developed during the war.[179] These scientists contributed to building the space capability for both the Soviet Union and the US toward their space powers. Hence, building space capability also became one of the national policy goals. And as a matter of fact, only states possess the political authority and sufficient means to mobilize thousands of specialists, allocate capital-intensive financial supports to construct large and costly infrastructure to build up adequate space capabilities, naturally mainly military.

As the course of technological progress brought human activities from the land, to the sea, and then to the air, the delimitation of the national boundary where states can exercise and control these activities have always been the utmost concern for countries. The same concerns arose from human space activities. In this regard, the issue of national "space sovereignty", or the ownership of outer space, and the question how to use outer space in peacetime, were the main concerns for all states. Since the military use of the air extended to "space" or "outer space", powerful states had a particular interest in establishing international rules and operational standards in order to avoid mutual harmful interference in peacetime. The immediate internationalization of space rulemaking after the launch of the Soviet Sputnik in 1957 was one of the discernible evidences. In another word, the governance realm of space rulemaking is also an arena or an instrument with which states try to maximize their power and interests.

Since 1963, the UN has adopted several space-related resolutions and then succeeded in concluding a number of international treaties. The *Declaration on Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space* (known as the *Declaration of Legal Principles*)[180] in 1963 and the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (often shortened to *Outer Space Treaty* - OST)[181] concluded in 1967 were the two fundamental legal regimes that led the entire space governance architecture to its expansion and for its consolidation. These legal regimes, on the one hand, showed a bright side that states demonstrated their belief or good will to reduce conflict in the human space activities throughout the rule of law. On the other hand, the existence of these legal regimes counter-proved the sui generis that the human space activities have always been progressed in an ambiguity in which states, especially the powerful ones and then the ones who seek power, continued to maximize their space capabilities for their national security and interest to exploit such "strategic goods" also "public goods" for their own interests, and often deliberately chose the method, either compete, cooperate or both to interact with other

[179] Etienne, Genovefa and Moniquet, Claude (2001) *Histoire de l'espionnage mondial, Tome 2 : De la guerre froide à la guerre antiterroriste*. Bruxelles : Luc Pire
[180] UN General Assembly, Resolution 1962 (XVIII), December 13, 1963.
[181] UN General Assembly, Resolution 2222 (XXI), December 19, 1966.

states for such conflict reduction. In this Chapter, we will outline the foremost legal regimes created to solve the key areas of conflict in international human space activities. We also pinpoint that many of them were imperfect due to lacking of authoritative definition on the key terms and the absence of verification and control instrument to implement them. Because of these imperfections, the legal inconsistence continuously appeared when developing further implementing instruments and regulating institutions.

2. THE LEGAL PRINCIPLES OF SPACE GOVERNANCE

2.1. THE QUESTION OF NATIONAL SPACE SOVEREIGNTY

When effective aviation technologies became available for cross-border military and civil operations, the international lawyers also became interested in the issue of air governance, or more precisely the governance of air space. Basic questions were raised: *who owns the air space above the states?* And, *how should the owner use this air space?* The same type of questions were equally raised when states began to develop space activities.

In a pioneering study[182] the French lawyer Paul Fauchille in 1901 argued that the air (airspace), like the high seas, is free, a *res nullius* not subject to effective occupation and control by the subjacent state and as *res communis* open to everyone's use. Fauchille claimed that the "*freedom of air* (air space)" – including traffic and radio communication – was to be considered to be in the public and commercial interest of all nations. The Englishman Westlake further defined the state's *sovereign right* in the use of such common *subject* should be viewed based on a rather functional and technical approach. Westlake also refined the subject 'air' that its basic element of concern should not be *air* (*aer*, in Greek, means more the air we breathe) but the *air space* (*coelum* in Latin) of the state. He induced a future delimitation of air(-space) based on the doctrine of *cujus est solum ejus est usque ad coelum* (*et inferos*) that private rights attached to real estate also extend above (and below) the surface of the earth, so that the territorial power of the state extended 'from heaven to hell'.[183] The argument allowed the ownership of airspace to be attributed to states according to their terrestrial boundaries. The primordial need is obviously to assure national sovereignty and security by assuming the superjacent airspace. And he elaborated the "*freedom of air*" or "*res communis*" into the cases of innocent passage of aircraft (similar to the innocent passage of navigation in the sea) over the state. In other words, certain airspace should be viewed and used neutrally.

During the two World Wars, the belligerent states mutually destroyed adversary aircraft. These aircraft, lacking a technical legal definition, could be used for military or civil

[182] Fauchille, Paul (1901) La Domaine Aérien et le Régime Juridique des Aérostats, *8 Revue Générale de Droit International Publi*c.
[183] Schick, F.B. (1961) Space Law and Space Politics. *The International & Comparative Law Quarterly* (Oct. 1961) *10(4)*: 681-706.

purposes depending on their operators' and users' desires.[184] Thus, protecting the national airspace as the national "*complete and exclusive sovereignty*" raised the concerns from both the belligerent countries and the neutral states. Complete and exclusive national airspace sovereignty naturally protects the belligerent's own controlled national superjacent airspace, yet restrains their flights going to and passing through the airspace of other countries. Neutral states, often lacking sufficient capacity to control their own airspace, naturally preferred the legal protection of their airspace sovereignty for their national security and territorial integrity via the legal protection of the national airspace (Zollmann, 1927;[185] Jessup & Taubenfeld, 1959;[186] Schick, 1961[187]). The 'sovereign airspace' was adopted in both the "Convention on the regulation of Aerial navigation" signed in Paris in 1919 (often abbreviated to "Paris Convention") and the "Convention with Other Governments Respecting International Civil Aviation" signed in Chicago in 1944 (the Chicago Convention). It was stated in article 1 of both air conventions that "*the contracting state has complete and exclusive sovereignty over the air-space above its territory*".[188]

There is an ambiguity, or a legal inconsistency, in both the Paris and the Chicago Convention. The two treaties were primarily initiated to establish rules for commercial air navigation, so the *res communis* doctrine should be privileged. However, both treaties explicitly emphasize national airspace sovereignty and demonstrate the preference of the states for the sovereignty doctrine. Yet the legal delimitation of the national airspace is fundamentally vital for civilian aviation traffic control and aviation safety management. Whereas both treaties have also incorporated – without legal qualifications or authoritative definition – the countervailing *res communis* principle by stipulating that "international aerial circulation is free" with the condition that "*each contracting state undertakes in time of peace to accord freedom of innocent passage above its territory to the aircraft of the other contracting states*".[189] Pépin[190] and Shawcross[191] noted, the *res communis* doctrine translated as "freedom of air traffic" only aimed at mitigating disputes in the realms of civil use of airspace. In practice, knowing that radio communication, aviation, and then communication satellites and remote sensing technologies operating through the interface of the airspace – *res communis* could harm a country's military and economic security, the questions about when and how to refine the use from the '*res communis*-sovereign air space' or 'civil-military' nexus merely depends on states' goodwill rather than the international agreements which were often without a means of verification and enforcement. Indeed the reality is, a country may, by international agreement, assume responsibility for controlling parts of international airspace, such as those over the oceans. For example, the US still provides air traffic control services over a large part of the Pacific Ocean, even though the airspace is international. As for wartime and peacetime, countries in conflicts have not hesitated to challenge or "violate" each other's sovereign airspace.

[184] Peng, Ming-Min (1957) *Le statut juridique de l'aéronef militaire*, La Haye : Martinus Nijhoff.
[185] Zollmann, Carl. (1927) *Law of the Air*. Milwaukee, Wisconsin: Bruce Publishing Company.
[186] Jessup, Philip Caryl & Taubenfeld, Howard Jack. (1959) Controls for Outer Space and Antarctic Analogy. New York: Columbia University Press
[187] Schick, F.B. (1961) Space Law and Space Politics. *The International and Comparative Law Quarterly 10* (4) (Oct. 1961): 681-706.
[188] Article 1, 1919 Paris Convention; and Article 1, 1944 Chicago Convention.
[189] Article 2. 1919 Paris Convention.
[190] Pépin, Eugène. (1957) The legal Status of the Airspace in the Light of Progress in Aviation and Astronautics, *McGill Law Journal 3*(1):70-77.
[191] *Shawacross and Beaumont Air Law* (1951) What is Airspace, *Shawacross and Beaumont on Air Law 175*.

When the use of outer space became an international issue, the principal question of a state's national vertical sovereignty over "air until space" was naturally raised. The 1963 *Declaration of Legal Principles* resulted in outer space being classified as a new medium as *res communis* to be explored and used "for the benefit and in the interests of all mankind" (Principle 1). Outer space is "free for exploration and use" (Principle 2), and especially "not subject to national appropriation" (Principle 3). A legal answer with technical definition over the national "space sovereignty" was given though kept more questions in practice.

2.2. NON-APPROPRIATION OF OUTER SPACE

The 1963 *Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space* (Declaration of Legal Principles)[192] attained one of the space governing principles on "non-appropriation of outer space". This legal principle noted reached based on *opinio juris generalis* because it was *not* ought to be in its nature, but in the general consensus that states subsequently denied their sovereign rights over outer space.[193] The two space powers desired mutually restrain their national power expansion toward the use of space. The others, with no space capability, agreed to renounce their sovereignty over outer space. This question about the ownership of, or the rights to use outer space was minor important due to the fact that most of the states have no capability to exercise such sovereign rights.

Legally, the exclusive sovereign use of outer space provides jurisdiction protection to protect state's national security and the national integrity. But it remains difficult to obtain political consensus on demarcating where the exclusive sovereignty effectively starts and stops though a physical boundary between the atmosphere and outer space has been practically accepted as the Kármán line lies at an attitude of 100 above the Earth's sea level. Technically speaking, besides of the spacecraft in geostationary orbit, other spacecraft orbiting in the low level orbit are continuously flying over the subjacent territory of states, the extension of national sovereignty to outer space would therefore have neither the same effect, nor the same way for assessment as the terrestrial sovereignty effects. In this line, the exclusive space sovereignty has less effective means, and especially the great majority of states remain incapable of protecting their outer reaches of space superjacent to their territory. The question on "whither exclusive and complete sovereignty" in the international space laws therefore seemed little relevant to the practical and technical levels of global space governance.

Nowadays, with all the growing interests in (re)conquering the Moon, exploring Mars, and mining comets, the "right of exploitation of outer space" is thrown into question. To a certain extent, states' agreement on the principle of the non-appropriation of outer space indicated their preference to preserve outer space as a sanctuary free from any occupation rather than controlled by a few space powers. The non-appropriation principle seems to be challenged by the lately updated US commercial space legislation, the Space Act of 2015,[194]

[192] UN General Assembly, Resolution 1962 (XVIII), December 13, 1962.
[193] Goedhuis, D. The Changing Legal Regime of Air and Outer Space. *The International and Comparative Law Quarterly 27* (3): 576-595. (July 1978).
[194] 'Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015', H.R.2262, enacted by the

passed in November 2015. The full name of the act is *Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015*. By arguing that the legal principle of “non-appropriation” was only applicable to “states” in the international space treaties, this updated US law explicitly allows “US citizens to engage in the commercial exploration and exploitation of 'space resources' [including ... water and minerals].” The right does not extend to biological life, so anything that is alive may not be exploited commercially. The Act further asserts that "the US does not [(by this Act)] assert sovereignty, or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body.” It would be interesting to see further reactions from other space powers, namely Russia, China and the European Union, that have not explicitly expressed their stances yet might share the same view on the advantages about competitiveness when their individual space mining capability will attain the same level as the US.

2.3. PEACEFUL USE OF OUTER SPACE

In the previous chapter, we have already addressed the issue of the “peaceful use of outer space” as one of the long existing problematic issues of global space governance. From the legal regime aspect, the “peaceful use of outer space” has also been criticized for its absence of authoritative definition, lacking of international verification and control capability. The cleavage between the Soviet Union and the Western camp at that time was sharply clear through these comments. The debate reported in the fifteenth session of the UN General Assembly in 1961 on the issue of the placement of weapons in outer space pinpointed this lack of political willingness to solve the problem.

> The US delegate observed that ‘*the primary obstacle in the way of disarmament negotiation, including the use of outer space for peaceful purpose only, in the past fifteen years had been the profound difference in purposes between the Soviet Union and the Western nations, and the resulting distrust.*’
>
> A Polish delegate stated that ‘*his delegation could not understand why the Western powers had not responded to the appeal by Soviet Premier Nikita Khrushchev, who had stated his willingness to accept any Western suggestion concerning control, if the Soviet Unions’ proposals on disarmament were accepted as well*’.

Ten years after the US skies disarmament proposal, the “peaceful use” was legally inked in the 1967 Outer Space Treaty, notably in Article III and Article IV. Article XI. ‘*States Parties to the Treaty shall carry on activities in exploration and use of outer space, including the Moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding*’. The interpretations of this legal term of “peaceful use of outer space” were, as was discussed in Chapter II, divided, with if being read as “non-militarization” by the Soviet side, but as “non-aggression” by the US. The OST eventually provided one way to concretize the peaceful use of outer space defined in its article IV to prohibit the states parties to ‘*place in orbit around the Earth any objects*

114 US Congress, effective as from 25 November 2015.

carrying nuclear weapons or any kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any manner'. But the "space weapon" stimulated another terminological debate. All in all, since the term "peaceful use of outer space" was launched and then codified, no progress has been made in resolving the problem of legal inconsistency. Nonetheless, all states have incorporated the term into their political discourses and emphasize the term to justify their declarative acts whenever they are involved in dealing with space-related issues.

2.4. THE INTERNATIONAL SPACE TREATIES

Prior to the 1963 *Declaration of Legal Principles*, a series of preparatory resolutions relating to global space governance were gradually endorsed by the General Assembly of the UN. They were the UN resolution 110 on the "measures to be taken against propaganda and the inciters of a new war"[195] in 1947, and the UN resolution on "principles of international cooperation in the peaceful uses of outer space"[196] in 1961. The declarative UN resolutions were not legally binding, but rather represented a collective affirmation of the guiding principles to which the member states proposed to adhere. Four years after the adoption of the 1963 *Declaration of Legal Principles*, the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* ("Outer Space Treaty", OST) was endorsed in 1966 under UN auspices. It entered into force in 1967 .

The *Outer Space Treaty* reaffirmed the principles of "non-appropriation", "free access and use of outer space for all states", "the rule of law governing method", and concretely prohibited to place in orbit around the Earth or station on the Moon and other celestial bodies any objects carrying nuclear weapons or weapons of mass destruction. Nonetheless, the OST bans neither *the use of military personnel for scientific research or for any other peaceful purposes, facilities necessary for peaceful exploration,* nor *the use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies* (Article IV, OST). Technical guidelines for international cooperation in outer space, like astronaut rescue assistance, the state's responsibility for national activities in outer space, requirement for the information regarding State's space activities, avoidance of harmful contaminants and also adverse change in the environment of the Erath, were set out in the OST. Nonetheless, the OST remained imperfect in the views of some states. The OST marked the beginning of an era that saw a significant amount of political will aimed at the adoption of formal legal instrument.[197] Hence a series of international treaties were gradually established and endorsed by the UN. The legal regimes step by step defined the legal space governing principles, norms and rules, and attributed the institutional labor division (see Chapter VI) under the auspices of the UN.

In parallel with the positive side, a year later than the entry into force of the Outer Space Treaty, the Soviet delegation already expressed their disappointment regarding the slow

---

[195] UN General Assembly, Res A/2/110, November 3, 1947.
[196] UN General Assembly, 1721(XVI), December 20, 1961.
[197] Kopal, V. The role of United Nations declarations of principles in the progressive development of space law, *Journal of Space Law 16*(1) (1998), p.10.

progress of the Legal Sub-committee of the COPUOS in providing a 'definition of outer space' which was deemed vital '*to harmonize the principle of state's sovereign rights over its airspace and its security needs with the desirability of easy access to outer space for peaceful purposes of exploration and development*'. In addition to the Soviet critics, the French delegation expressed their reservation about a lack of verification and sanction to prevent the excesses or abuse of the freedom in the utilization of outer space. The fact was judged hard to understand.[198]

After the Outer Space Treaty, other generic treaties were soon established by the UN General Assembly. These were the *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space* ("Rescue Agreement", 1968).[199] The *Rescue Agreement* elaborates on elements of Article 5 and 8 of the OST, provides that states shall take all possible steps to rescue and assist astronauts in distress and promptly return them to the launching state, and that states shall, upon request, provide assistance to launching States in recovering space objects that return to Earth outside the territory of the launching state.[200] The *Convention on International Liability for Damage Caused by Space Objects* ("Liability Convention", 1971)[201] entered into force in September 1972. The *Liability Convention* elaborating on Article 7 of the OST provides that a launching state shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft and liable for damage due to its faults in space. The Convention also provides for procedures for the settlement of claims for damages.[202] The *Rescue Agreement* and the *Liability Convention* were concluded and had minor impact on international politics, especially since at the moment of negotiating and concluding these treaties, there were only a few states that possessed spacecraft or had ongoing manned space missions. Nowadays, the two space treaties have become more important for non-state actors since they continue increasing their weight in the human space activities in the trends of the popularization of space capability and the liberalization of the global space economy. The *Liability Convention* has been criticized with complications.[203] As a matter of fact, over the years only 9 or 10 states with sufficient space launch capability have launched other states' spacecraft and commercial payloads into orbit. Mostly, these launching states have made a bilateral or multilateral agreement with the client states and companies about liability issues. The issue was often resolved via international or private arrangements. Nonetheless, the definition of launching state remains a legal lacuna.

After the OST, the *Rescue Agreement* and the *Liability Convention*, a mechanism that provided states with a means to assist in the identification of space objects was created as the *Registration of Objects Launched into Outer Space* ("Registration Convention", 1976)[204]. The *Registration Convention* was considered and negotiated by the Legal Subcommittee

[198] Political and Security Questions: Discussion record of the UN First Committee meeting on October 17-20, and 26, 1967. *International Organization 22*(3) (Summer 1968): 698-728.
[199] UN General Assembly, Resolution 2345 (XXII), December 19, 1967.
[200] UN Office of Outer Space Affairs.
www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introrescueagreement.html
[201] UN General Assembly, Resolution 2777 (XXVI), December 2, 1971.
[202] UN Office of Outer Space Affairs. Ibid.
[203] Hassanabadi, Babak Shakouri, Complications of the legal definition of "launching state", The Space Review, September 2, 2014. www.thespacereview.com/article/2588/1
[204] UN General Assembly, Resolution 3235 (XXIX), September 15, 1976.

from 1962 onwards. It was only adopted by the General Assembly in 1975 and entered into force on 15 September 1976. As launch registration was closely connected with national security and commercial secrecy, states were bound to register their launches yet might well time the moment of registration in light of particular national security and commercial petition concerns. Because of this, it took almost a decade after the 1967 OST for parties to negotiate and ratify it. The *Registration Convention* expanded the scope of the UN Register of Objects Launched into Outer Space which had been established by resolution 1721B(XVI) in December 1961 and addressed issues relating to states parties responsibilities concerning their space objects. The *Registration Convention* evoked serious military and commercial concerns from governments, the private sector and also scientific communities.

After President Kennedy's famous "Moon speech" in 1962, the US invested tremendous efforts into funding and developing the Apollo program between 1962 and 1972. The US Moon program, happening as it did during the Cold War, not only demonstrated the superpower status of the US but also signaled a victory in the international astropolitical arena. The *Agreement on Governing the Activities of States on the Moon and Other Celestial Bodies* ("Moon Agreement")[205] was signed in 1979 and only entered into force in 1984 for the ratifying parties. The *Moon Agreement* aimed to prevent the Moon from becoming an area of international conflict due to the benefits which may be derived from the exploration of the natural resources of the Moon and other celestial bodies. The other ambition of the *Moon Agreement* was to establish an international regime for human activities on the Moon and other celestial bodies. The *Moon Agreement*, following all principles of the previous treaties, had no jurisdiction definition on the nature of the Moon or other celestial bodies, but provided principles about how to use them. Up to now, only thirteen States have ratified the Agreement, and four have signed but not ratified. In 2012 Turkey became the 8th country to accede and the 17th party to the Agreement. Following the end of the Apollo Program, no further Moon exploration activities took place. NASA only recently successfully landed the Mars rover "Curiosity" in 2012. However, as mentioned formerly, space capabilities have been moving towards "space mining" activities on the Moon, Mars and on comets or other celestial bodies, which could potentially pose new challenges to the existing Moon Treaty.

3.5. OTHER UN ADOPTED RESOLUTIONS & DECLARATIONS

Apart from the above UN-endorsed space treaties, the UN General Assembly has adopted resolutions that support the existing body of international space law. These UN resolution consist of the *Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting* (Broadcasting Principles)[206] in 1982 was undertaken after the successful trials of direct broadcasting by satellite (DBS) made broadcasting satellite services (BSS) operational in some space-faring countries. Queries to establish international rules to regulate the forthcoming commercialization of BSS were raised. As BSS are transmitted by satellite in specific frequency bands, a need to allocate frequency zones by region was urged. Actually already in 1977, the International

[205] UN General Assembly, Resolution 34/68, December 2, 1979.
[206] UN General Assembly, RES A/37/92, December 10, 1982.

Telecommunication Union (ITU) had adopted an international BSS Plan under which each country was allocated specific frequencies at specific orbital locations for domestic service segmented by regions. The UN *Broadcasting Principles* in addition dealt with the principle of non-intervention on the allocated frequency by all parties, as well as human rights, namely, the rights to freedom of expression and information. It also took consideration of the possible political, social, and economic impact further to BSS commercialization. Maintaining international peace and security interests as well as assistance with educational, social and economic development to developing countries were all included in the resolution with respect to the political and cultural integrity of all states.

In 1986 the UN General Assembly also adopted a resolution on the *Principles Relating to Remote Sensing of the Earth from Outer Space* (Remote Sensing Principles).[207] The resolution of *Remote Sensing Principles* was aimed at strengthening international cooperation in the use of this technology for the purpose of improving the management of natural resources, land use and the protection of the environment, and was to benefit and be in the interests of all countries, while also taking into consideration the needs of developing countries. The principle of non-discrimination with regard to data sharing was stressed to reach the goal of protecting the Earth's natural environment and mankind from natural disasters. It was the first time, more than two decades on from the *Declaration of Legal Principles* in 1963, that the environmental protection issue appeared explicitly in an agreement relating to outer space.

With the fear of the radioactive fallout from the atmosphere and space from the use of nuclear weaponry in outer space, the USSR, the US and the UK reached an international agreement on the *Limited Test Ban Treaty* (LTBT) in 1963. The LTBT prohibits nuclear tests and any other nuclear explosion in the atmosphere or in space. Hence, the nuclear power sources (NPS) for use in outer space are supposed to be developed and used when specific space mission requirements and constraints on electrical power and thermal management are precluded. Further to the accidents at Three Mile Island (1979) and Chernobyl (1986), the UN in 1992 adopted a resolution on the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space* (Nuclear Power Source "NPS" Principles).[208] The aim of the *NPS Principles* was to "protect individuals, populations and the biosphere against radiological hazard" (Principle 3.1(a)). Like all other UN resolutions, it was, in a word, soft law. It was not until the year 2009 that the COPUOS, together with International Atomic Energy Agency (IAEA), published the UN-IAEA Safety Framework for NPS applications in outer space. As mentioned in Chapter II above, there are remaining risks that several emerging space nations, often in conflict with some other states, have had no opportunity to test their "space weapons" with or without nuclear warhead. Because of this, the legal restraints of international law may not suffice to dissuade their attempt.

The *Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries* (Benefits Principles[209] or International Cooperation Principles)[210] was adopted in 1996. It urged all member countries to fairly and reasonably undertake

[207] UN General Assembly, RES A/41/65, December 3, 1986.
[208] UN General Assembly, RES A/47/68, December 14, 1992.
[209] UN Office of Outer Space Affairs, *Cit.*.
[210] UN General Assembly, RES A/51/122, December 13, 1996.

international space collaboration to bridge the gap between space-faring and non-spacefaring countries. The concerns about the legitimate rights and interests of the parties, namely intellectual property rights were emphasized. It also mentioned that international space cooperation could be conducted by countries through governmental, non-governmental, commercial and non-commercial, global, multilateral, regional or bilateral mechanisms in the effective and appropriate modes. The *Benefits Declaration* promoted the international space cooperation to further develop space science and its applications, fostering relevant and appropriate space capabilities in interested countries, and facilitating the exchange of expertise and technology among states on mutually acceptable basis.

4. CONCLUDING REMARKS

This chapter outlined the legal principles on governing the space relating issues established either in form of the non-binding UN resolutions or the international treaties with law force. The declarative UN resolutions were not legally binding, but rather represented a collective affirmation of the guiding principles to which the member states proposed to adhere. These governing principles with the emphases on "space sovereignty", "non-appropriation of", "free access to", and then the "peaceful use of" outer space, were negotiated and agreed in the hostile circumstance of the Cold War. These resolutions and space treaties were decided when there were only a few powerful states with space capability and owned strong influence when these space rules were decided. The rest of the world possessed no physical capability but only meaningful legal right to the space activities. Subsequently, these legal regimes demonstrated the entire space governing legal framework has been progressed in an ambiguity where states, primarily especially the powerful ones and then the ones who seek power, continued to maximize their influence n space rule-making and to deliberately choose either compete, cooperate or both with other states to avoid conflicts. To satisfy all different states concerns, these legal instruments could only be negotiated and concluded in a sequential progress yet often resulted in political compromises. As a result the derived or the following regimes did not correspond to the original ideals, presenting a problem of legal consistency between these related legal regimes.

Further to the conclusion of the OST and the other space treaties, the problem of *legal inconsistency* continued to appear with the absence of legal definitions over the same terms, such as "peaceful use", that led to further debates on state "militarization" and "weaponization" of outer space. The reality of "free access" of states to outer space remained that most of the countries depend on only a few states with space launch capability to launch their national spacecraft into orbit. The unrealistic definition of the "launching state" created various legal complications when the liability of the responsible state required to be clarified if the launch follows the legal procedure of registration. To resolve such continuous legal inconsistence, as well as to deal with the new situations, e.g. the growing popularization of the human space activities and the liberalization of space related trade exchange after the Cold War, these out-of-date legal frameworks and their implementation institutional instrument were inquired for reform, change or to be substituted. This subsequently led the global space governance architecture not only to its expansion but also fragmentation – regime complex.

CHAPTER IV THE INSTITUTIONAL ARCHITECTURE OF GLOBAL SPACE GOVERNANCE

The aim of Chapter IV is to present the existing institutional architecture of global space governance. Because of the dual-use nature of space activities, since the establishment of the UN Committee on the peaceful use of outer space (COPUOS) in 1958, the "labor division" of global space governance was artificially split into two distinct governing dimensions, space security and the "peaceful use" of outer space. The former aimed at reducing the political tension to prevent war by focusing on the avoidance of an arms race in and through the states' space activities. The latter put forward the "peaceful" applications of the space technologies which can benefit all mankind in the domains of safety, socio-economic, cultural heritage preservation, and assuring ecological sustainability. The discussions and negotiation about space security governance have been undertaken outsides of the UN multilateral forum, such as the Conference on Disarmament, and very often between the space powers themselves, for example the Limited Test Ban Treaty between the Soviet Union and the United States. By contrast, the governing issues about the "peaceful use" were structurally attributed to be discussed and negotiated in the different UN specialized agencies, such as the ITU, the WMO, the ICAO, the IMO, the ICG, the IAEA, and, the FAO, the UNESCO, and others. The COPUOS plays the key role to propose the targeted task labor division and coordinate the inter-institutional coordination. Many of these multilateral mechanisms were not directly related to matters of space governance primarily but have become gradually connected with space activities because the progress of space technologies and the applications increasingly affected their mandated governing missions. For example, when creating the COPUOS, the ITU and the WMO were explicitly mandated by the UN General Assembly to oversee the technical regulating issues relevant to the radio frequency allocations and the international cooperation on weather research respectively. The ICAO, the IMO, and the ICG are connected due to the navigation safety issues. The FAO and the UNESCO were also involved when the satellite communication and remote sensing technologies are increasingly used for smart farming and cultural heritage preservation. The inter-institutional interactions have intensified after the Cold War in the popularization of space activities and the liberalization of space economy. The intensified inert-institutional linkages through space activities are constructive if the structural mission labor division and the inter-institutional coordination attain its adequacy. Otherwise, the fragmentation of the entire governing structure can affect the good functioning of the connected institutions caused by respective mandates of, the overlapping membership in, and the distinct policy decision-making procedure between different relevant institutions. Consequently, the inter-institutional interactions weaken the governing outcomes and ought to be harmonized.

In this chapter, we follow the artificial labor division made from the early space age, and will firstly decipher the inter-institutional interactions in the governing dimension of the "peaceful use" of outer space where the functional necessity and organizational factors have a more significant impact on the evolution of international regime change. However, it does not mean that states' political and strategic calculations have no effectiveness on leading these regime changes. Space security governance will be discussed in Chapter V.

1. INTRODUCTION

As the use of outer space is a particularly sensitive subject and covers wide ranges of human activities and related political issues, e.g. security and national defense, safety, socio-economic development, environmental protection, and scientific research and technologic innovation, it has created unique governance challenges for the international community. Because of this, issues relating to space governance were immediately internationalized by global consensus. Since the creation of the ad hoc UN Committee on the peaceful use of outer space (COPUOS) in 1958, the history of global governance of outer space use has been marked by the splitting of the "space security" and the "peaceful use" of outer space due to the dual-use nature of space technologies and applications.

Space security issues continued to be negotiated mainly in the Geneva-based non-UN Conference on Disarmament (CD) as well as in the First Committee of the United Nations, in which the UN member states discuss disarmament and international security matters. The CD and the UN First Committee are distinct international regimes which have overlapping member states and distinct decision-making procedures. Splitting the space security matters from the "peaceful use" of outer space issues has hardly reached satisfactory outcomes over time. The powerful space nations' national security and strategic interests continuously dominated the policy discussion and international agreement negotiations. Actually, it has often been impossible to get certain issues on to the agendas of the multilateral forums. Because of this, states continuously proposed new initiatives to either retail the general space security issue to numerous sub-categories in order to complete the entire package at the end, or to elaborate the old and new issues, namely space arms race avoidance, space "militarization", space "weaponization", "ASAT weapon" issues, and the lately raised safety problems caused by space debris, into a comprehensive deal. We will discuss this in more detail in the following chapter.

Regarding the issues of the peaceful use of outer space, the COPUOS became the unique platform at the global level to monitor and to discuss issues concerning the international cooperation in peaceful uses of outer space, studying space-related activities that could be undertaken by the United Nations, encouraging space research programs, and studying legal problems arising from the exploration of outer space. The COPUOS was instrumental in the creation of the five treaties and five principles of outer space. Yet, as from 1962, other UN specialized agencies, such as the World Meteorological Organization (WMO) and the International Telecommunication Union (ITU) were respectively entrusted with international cooperation on atmosphere science, and the safety regulation and source allocation related to satellite use. Hence, such inter-institutional interactions were even formally created. These long-established international regimes do not deal with space affairs only but have their own missions. As specialized agencies of the UN, they share a certain degree of membership overlap but do not share either the same governing approach or the same vision on these interconnected issue governance. Furthermore, they have different decision-making procedures from each other.

After the Cold War, the popularization of national space capability development and the liberalization of space economy, the governance dimension has been expanded toward the ever larger connections with other global issue areas related to safety, to socio-economic development, to ecological and generational sustainability, and also international trade. The issue-linkages by nature involved a myriad of established and new specific international regimes to jointly deal with the new situations related to space governance. Accordingly, the entire architecture of global space governance became even more diffuse and fragmented. The architectural expansion and fragmentation of the entire global space governance scheme should not be necessarily destructive. However, it can be constructive if the technical labor divisions can be coordinated and harmonized with political good will. So far, this has not often been the case alongside the global space governance construction.

2. UN AGENCIES RELATING TO THE "PEACEFUL USE" OF OUTER SPACE

2.1. THE COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE (COPUOS)

At the global space policy-making level, it is the UN Committee on the Peaceful Uses of Outer Space (COPUOS) that deals with non-military outer space-related issues. At the thirteenth General Assembly in 1958, the UN established an eighteen-member Ad Hoc Committee on the Peaceful Uses of Outer Space (COPUOS).[211] The Ad Hoc COPUOS become a permanent committee since 1959 and serves as a particular body to discuss international space cooperation related issues and provides recommendations to consolidate international cooperation in the line of peaceful outer space uses. COPUOS was requested by the General Assembly to address the question of the nature of legal problems which may arise in the carrying out of programs to explore outer space at the time. Several priorities, like 1) freedom of exploration and use in outer space; 2) liability for injury or damage caused by space vehicle; 3) allocation of radio frequencies; 4) avoidance of interference between space vehicles and aircraft; 5) identification and registration of space vehicles and coordination of launchings; 6) legal problems involved in the re-entry and landing of space vehicles were reported to the Assembly. COPUOS also designated "non-priority" questions on the matter of where outer space begins and sovereign airspace ends; protection of public health and safety, safeguards against contamination; questions relating to exploration of celestial bodies; and avoidance of interference among space vehicles. The studies of COPUOS paved the way for the establishment of several UN space treaties. The Committee reports to the Fourth Committee of the General Assembly, which adopts an annual resolution on international cooperation in the peaceful uses of outer space.

Between 1959 and 2015, COPUOS membership has grown from its original 24 to 77 and it is now one of the largest Committees in the UN.[212] COPUOS has 34 Permanent Observers (OOSA, 2015)[213] from space-related intergovernmental organizations, regional space-related forums and organizations, NGOs, multilateral entities and space law institutions. The principal focus of COPUOS is on non-binding, technical approaches to security in space. With the two subcommittees, the Scientific and Technical Subcommittee and the Legal Subcommittee, the missions of COPUOS are to review the scope of international cooperation

[211] UN General Assembly, Resolution 1348 (XIII), December 13, 1958.
[212] UN Office for Outer Space Affairs, *Cit.*
[213] http://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html

in peaceful uses of outer space, to devise programs in this field to be undertaken under UN auspices, to encourage continued research and the dissemination of information on outer space matters, and to study legal problems arising from the exploration of outer space.[214]

2.2. UN OFFICE FOR OUTER SPACE AFFAIRS (UNOOSA)

The UN Office for Outer Space Affairs (UNOOSA) is the United Nations office responsible for promoting international cooperation in the peaceful uses of outer space. UNOOSA serves as the secretariat for COPUOS and deals exclusively with international cooperation in the peaceful uses of outer space. The Office has two sections: the Space Applications Section, which organizes and carries out the UN Program on Space Applications, and the COPUOS, and the Committee (COPUOS), Policy and Legal Affairs Section, which provides substantive secretariat services to the COPUOS, its two COPUOS subcommittees and its working groups. The Policy and Legal Affairs Section also prepares and distributes reports and publications on international space activities and on international space law. It prepares and distributes reports, studies and publications on various fields of space science and technology applications and international space law.

The UNOOSA is located at the United Nations Office at Vienna, Austria and responsible for implementing the Secretary-General's responsibilities under international space law and maintaining the United Nations Register of Objects Launched into Outer Space. Through the UN Programs on Space Applications (UNISPACE I, II, II), UNOOSA conducts international workshops, training courses and pilot projects on topics that include remote sensing, satellite navigation, satellite meteorology, distance education and basic space sciences for the benefit of developing nations. It also maintains a 24-hour hotline as the United Nations focal point for satellite imagery requests during disasters and manages the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER). Additionally, UNOOSA is the current secretariat of the International Committee on Global Navigation Satellite System (ICG).

2.3. UN BODIES RELATED TO THE SPACE ACTIVITIES FOR SAFETY

Although the COPUOS is considered as the only UN body dealing with the space relevant issues, it actually needs to coordinate and cooperate with other UN specialized agencies on specific matters, or vice versa. Because of this, the major mandate overlaps and institutional interconnection lie mainly in the areas of international cooperation for safety, socio-economic develop and cultural heritage preservation via space activities. To these categorizations, there are UN specialized agencies for safety, such as ITU, ICG, ICAO, IMO, are respectively dedicated to space resource attribution and the avoidance of radio interference, inter GNSSs interoperability and compatibility, aviation and maritime traffic controls and safety measures, and IAEA for nuclear safety regulations.

---

[214] UN Office for Outer Space Affairs, *Cit.*

2.3.1. THE INTERNATIONAL TELECOMMUNICATION UNION (ITU)

Space resources like radio frequencies and satellite orbital slots are indispensable but limited resources for all space systems operations. Without adequate an interval between orbiting satellites, the safety of states' space assets and the operations of the space systems will be at stake. In 1959, the International Telecommunication Union amended its Radio Regulations to add definitions for earth stations, space stations and initial space services, thereby beginning to address space communications matters. In 1963, the ITU convened its first space conference – the Extraordinary Administrative Radio Conference to Allocate Frequency Bands for Space Radiocommunication Purposes – to start the process of allocating spectrum to radio services. In this Conference, the ITU decided that administrations, naturally including GNSS service providers, would obtain access to spectrum and orbital resources on a per request basis, subject to following the provisions of the Regulations and not causing harmful interference to stations of other countries duly recorded in the Master International Frequency Register (MIFR) or the Master Register. Hence, the ITU oversees satellites access to the geostationary and other orbits through management of the coordination process, maintenance of the MIFR, and the allocation of radio spectrum to radio services.

The ITU, which was established in 1932 and distantly originated in the International Telegraph Union founded by Napoleon III of France in 1865, became one of the UN's specialized agencies in 1947. The ITU is governed by a series of conventions that are reviewed at the ITU Plenipotentiary Conferences every four years. These conventions determine the general ITU policies. By 2015, the ITU has a membership of 193 countries and almost 800 private-sector entities and academic institutions.[215] Since 1963, the ITU started its mandates of the allocation of global radio spectrum and satellite orbits, development of the technical standards that ensure networks and technologies seamlessly interconnect, and commitment to improving access to ICTs for under-served communities worldwide. Precisely, it is the Radiocommunication Sector of the ITU (ITU-R) was entrusted to coordinate the assignments of orbital and radio frequency spectrum amongst operators, and to set up and implement "rational, equitable and efficient"[216] regulatory rules to the concerned parties.

Retrospectively, the geostationary orbital (GSO) allocation issue was not the mandate of the ITU but a part of the Outer Space Treaty (OST) negotiation handled through the UN COPUOS. The geostationary orbit (GSO) is an area at an altitude of around 36,000 km from the equator of the earth and has a radius of 42,000 km in space. The GSO allows a satellite to remain in orbit over a single point on the earth's surface because of the gravitational pull of the Earth, the Moon, and other planets. The radius of GSO is expansive, yet it only allows a limited number of satellites to be hosted. This limitation is because, while occupying a slot in space, a satellite requires a specific radio frequency in the electromagnetic spectrum. These radio frequencies must be different and the satellites must be a certain distance apart so that there is no interference between the different transmissions. The GSO became vital when most telecommunications, broadcasting, weather, and navigation satellites must park in an orbit over a specific point of the earth. In order to avoid interference among these satellites, the issue of orbital slot allocation became connected with the issue of the satellite

[215] International Telecommunication Union (ITU), http://www.itu.int/en/about/Pages/default.aspx, 2015/12/24.

[216] ITU, http://www.itu.int/ITU-R/index.asp?category=information&rlink=itur-welcome&lang=en

radio frequency spectrum. With the increase of national authorities and commercial firms that all require available orbital slots and satellite radio frequencies, the governance also faces significant challenges to ensure space sustainability and security.

The 1985 and 1988 sessions of the Space World Administrative Radiocommunications Conference (WARC) established a system built around the principles of equity and efficiency to manage geostationary (GEO) satellite slots and radio frequency allocations. In practice, this is based on the "first-come, first-served" request/acquisition order but also with an *a priori* allotment system that every ITU member state is granted for an allotment of nominal orbital position and relevant satellite frequency. In the 1992 ITU Plenipotentiary Conference in Geneva, the ITU established the radiocommunication sector (ITU-R) to adopt the detailed rules, procedures, and standards for ensuring interference-free use of radio frequencies and orbital positions and their routine implementation. As was discussed in Chapter II above, the ITU's "first-come, first-served" rules and the "*a priori*" allotment system for the satellite slot allocation have evoked considerations that the developed nations have already established a virtual monopoly in the occupation of geostationary slots, leaving very few opportunities for the upcoming developing countries (Rao, 2003).[217] While developing countries have alternate means of providing services related to communication, disaster management, meteorology, education, health and management of natural resources, many of them however can solely depend on their own or available space assets for these vital applications. The ITU has been pursuing reforms to address slot allocation backlogs.

Signal conflict and interference is another issue for the ITU to regulate. Intentional satellite signal jamming cases have been known, for example the Eutelsat vs. Iran case in 2011.[218] Nonetheless, the disputes concerning the government restricted frequency overlay between the different global navigation satellite systems (GNSSs) such as the stand-off between the US GPS M-code and the European satellite Galileo Public Restrict Signal (PRS)[219] and the frequencies disputes since 2010 between China's BeiDou (Compass) and the EU's Galileo PRS, the ITU has claimed for its lack of effective mandate to intervene.

2.3.2. INTERNATIONAL COMMITTEE ON GLOBAL NAVIGATION SATELLITE SYSTEMS (ICG)

The GNSSs are the most popular use of outer space, for purposes that range from farming to banking. The GNSSs technologies and applications can improve a country's infrastructure for urban areas, rural and remote areas and people's daily lives with e-education, e-health, e-government, and other e-services via satellites. Possessing capabilities of manufacturing GNSS-relevant products and being able to operate GNSS services also help countries to stay on the track of continuous industrial and commercial modernization, so to economic growth. For this, the UN COPUOS in 2001 established the Action Team on Global Navigation Satellite Systems with the voluntary participation of 38 Member States and 15 organizations. The

[217] Rao, U.R. (2003) Space benefit Security. *Pugwash Meeting 283*, Pugwash Workshop on Preserving the Non-Weaponization of Space, 22-24 May 2003.
[218] *Space News*. Broadcasters Call for ITU Action on Satellite Jamming by Peter B. de Selding, 9 December 2011; Associated Press, EU Sanctions Prompt Eutelsat To Block Iranian Broadcasts. 15 October 2012.
[219] *Space News*. EU, China Schedule December Meeting on Navigation Dispute by Peter B. de Selding, 9 October 2012.

Action Team on GNSS subsequently led to the establishment of the UN International Committee on GNSS (ICG) to promote the enhancement of universal access to and compatibility of space-based navigation and positioning systems in order to improve the efficiency and security of transport, search and rescue, geodesy and other activities.

The origin of the ICG establishment was addressed at the Third UN Conference on the Exploration and Peaceful uses of Outer Space (UNISPACE-III) in 1999 that the world should seize significant opportunities for human development through advances in space science and technology. Thus, the UN General Assembly endorsed "The Space Millennium: Vienna Declaration on Space and Human Development" adopted by UNISPACE-III specifically for enabling space technology providing PNT services.[220] The Vienna Declaration called for action, notably to improve the efficiency and security of transport, search and rescue, geodesy and other activities by promoting the enhancement of, universal access to and compatibility of space-based navigation and positioning systems. Consequently, the UN invited GNSS and augmentation system providers to consider establishing an international committee on GNSS in order to maximize the benefits of the use and applications of GNSS to support sustainable development in 2004.[221] In 2005, the UN established a separate body completely devoted to GNSS – the International Committee on GNSS Navigation Satellite (ICG) for which UNOOSA acts as Executive Secretariat.[222]

In this dissertation, we use the governance of GNSSs as a case study, and more detailed discussion on this topic will be undertaken in Chapter VI.

2.3.3. INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

The International Civil Aviation Organization (ICAO) is the UN agency promoting the safe and orderly development of civil aviation worldwide, developing international air transport standards and regulations and the medium for cooperation in all fields of civil aviation. With Annex 10 to the Convention on International Civil Aviation (1944 Chicago Convention), ITU has been dedicated to setting standards for the communications, navigation, surveillance/air traffic management (CNS/ATM) system and utilizes satellite technology for its ICAO CNS/ATM Systems and to bear the compelling importance of the Aeronautics Telecommunications Network (ATN). ICAO applies satellite technologies to distribute meteorological data, supports communications in remote and oceanic air spaces, also used for support of search and rescue services, and global navigation coverage for all phases of flight. Therefore, ICAO is involved in the UN Inter-Agency activities such as implements the World Area Forecast System in co-ordination with WMO, enhances aircraft emergency locator systems in co-ordination with the International Satellite Systems for Search and Rescue (COSPAS-SARSAT)[223] and International Maritime Organization (IMO), develops

[220] Resolution 54/68, UN General Assembly, December 6, 2001.
[221] Resolution 59/2, UN General Assembly, July 31, 2004.
[222] UNOOSA (2011) *10 Years of Achievement of the United Nations Global Navigation Satellite Systems*, New York: United Nations.
[223] The COSPAS-SARSAT Program Agreement was signed in 1979 by Canada, France, the former USSR Russia and the US and declared operational in 1985. The program aims at providing accurate, timely, and reliable distress alert and location data to help search and rescue authorities assist persons in distress.

Global Navigation Satellite System (GNSS) in co-ordination with IMO, and works on spectrum issues in co-ordination with ITU and IMO.

As for directly space-related issues, the ICAO Assembly adopted Resolution A32-19 in 2001, the Charter on the Rights and Obligations of States Relating to GNSS Services (GNSS Charter) which originated from a proposal at the ICAO Council in 1995 to set up a legal Framework (of conduct) with regard to GNSS. The current ICAO policy is that the GNSS should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' global positioning system (GPS) and the Russian Federation's global orbiting navigation system (GLONASS), towards an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its use by civil aviation.[224] As global space power balance changes, an International Civil Aviation Organization for Outer Space has already taken place in the academic discussions. It noted that the GNSS Charter would not be totally destitute of effect in establishing certain obligations for States to perform. It becomes, however, a reckonable force in international relations, if not at international law, particularly since ICAO resolutions are highly persuasive and carry much political leverage and could pave the way for an international convention that is binding on States' Parties (Abeyrante, 2004:198).[225]

A future issue that ITU may be concerned with is space flight safety standard setting. Viewing the rapid international commercialization of outer space, in particular in the field of telecommunication, there is more and more interest and activity regarding navigation and launch services from the private sector of commercial human spaceflight, such as the American SpaceX, Russian International Space Station (ISS) cargo and space travelling shuttles and facilities, and ambitious space tourism projects such as Virgin Galactic or the alleged Mars One expedition recruitment project. The widening range of financial commitments and business risks will make outer space more crowed, congested and competitive. There seems great promise about the further commercial potential of outer space for the world economy. The safety risks will also become real and growing. International cooperative efforts are, therefore, required to balance the multiple commercial interests in outer space with internationally agreed and nationally enforceable safety and risk-mitigation standards. That would be necessary to develop technical space standards for global use to deal with the commercial space safety issues, like launch and ground-processing hazards, orbital and suborbital flights safety such as avoiding orbital debris, space traffic management and accidents in outer space that impact other spacecraft, and additionally, risks from spacecraft re-entering the atmosphere and landing. It noted that ICAO is for instance better placed to merging air space and outer space security and safety issues, along with commercial and trading issues including market access and competition (Abeyratne, 1997:192).[226] It appears that the International Standards Organization (ISO) had attempt to develop space standards for global use to deal with the

[224] www.icao.org

[225] Abeyratne, Ruwantissa. (2004) ICAO's involvement in outer space affairs – A need for closer scrutiny? *Journal of Space Law 30*(2), Fall 2004: 185-202 (University of Mississippi School of Law).

[226] Abeyratne, Ruwantissa. (1997) The aerospace plane and its implications for commercial air traffic rights. *The Aviation Quarterly 186, 192*.

commercial space safety issues. So far, the ISO mission is aimed to develop industrial standards to facilitate international commerce but not safety.[227]

2.3.4. INTERNATIONAL MARITIME ORGANIZATION (IMO)

The International Maritime Organization (IMO)[228] originated from the Inter-Governmental Maritime Consultative Organization (or IMCO) within the United Nation on the basis of a convention adopted in Geneva in 1948. The IMO Convention entered into force in 1958, which led to the formal establishment of the Organization a year later. IMO changed its name from IMCO in 1982. It provides a machinery for co-operation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade, and encourages and facilitates the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships.

In 1973, IMO decided to establish a new maritime communication system based on satellite technology. In 1976, the IMO Council adopted the Convention on the International Maritime Satellite Organization (IMSO), together with an Operating Agreement. The Convention defines the purpose of setting up an International Maritime Satellite Organization (Inmarsat) as being to improve maritime communications, thereby assisting in improving distress and safety of life at sea communications, the efficiency and management of ships, maritime public correspondence services, and radiodetermination capabilities. The Operating Agreement set an initial capital ceiling for the Organization of US$ 200 million. Investment shares were determined on the basis of utilization of the Inmarsat space segment. Inmarsat began operations in 1982. The 1994 amendments changed the name of the International Maritime Satellite Organization (Inmarsat) to the International Mobile Satellite Organization (IMSO). The change reflected evolution since the organization was formed and the extension of its services from the maritime sector to other modes of transport.

In 1998, Inmarsat's Assembly of member Governments agreed to privatize Inmarsat from April 1999. The new structure comprises two entities: Inmarsat Ltd[229] – a public limited company which forms the commercial arm of Inmarsat. The company has taken on all the commercial activities of Inmarsat and was completely privatized in 2003. The other entity became International Mobile Satellite Organization (IMSO)[230] – an intergovernmental body established to ensure that Inmarsat continues to meet its public service obligations, including obligations relating to the Global Maritime Distress and Safety System (GMDSS). IMSO is an observer at IMO meetings. IMSO aims at guaranteeing that services are provided by Inmarsat Ltd. free from any discrimination and in a peaceful way to all persons living or working in locations that are inaccessible to conventional, terrestrial means of communication. IMSO also ensures that the principles of fair competition are observed.

[227] Sgobba, Tommaso. (2008) An International Civil Aviation Organization for Outer space? In *Security in space: The next generation*. *UNIDIR Conference Report*, March 31- April 1, 2008. Geneva: United Nation Institute for Disarmament Research. pp.103-120.
[228] The International Maritime Organization, www.imo.org
[229] Inmarsat Ltd., www.inmarsat.com.
[230] The International Mobil Satellite Organization, www.imso.int

2.3.5. INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

The International Atomic Energy Agency (IAEA) was created in 1957 in response to the deep fears and expectations resulting from the discovery of nuclear energy. Its fortunes are uniquely geared to this controversial technology that can be used either as a weapon or as a practical and useful tool. The IAEA's genesis was US President Eisenhower's "Atoms for Peace"[231] address to the General Assembly of the United Nations on 8 December 1953. These ideas helped to shape the IAEA Statute, which 81 nations unanimously approved in October 1956.[232] As for the year 2015, total IAEA membership attains 168 countries. The (IAEA) has a mandate to develop nuclear safety standards and, based on these standards, promotes the achievement and maintenance of high levels of safety in applications of nuclear energy, as well as the protection of human health and the environment against ionizing radiation. To the same regard, IAEA is the UN entity to regulate nuclear safety in outer space. Practically, IAEA also uses satellite data to observe nuclear infrastructure (Balogh, 2012: 204-205) for security concerns.

In space, a primary risk on board the satellite comes from the material that composes the different forms of nuclear power sources (NPS), basically plutonium and uranium. These sources of energy contain large amounts of radioactive material and require adherence to stringent safety requirements (Bouvet, 2004:210).[233] The risk involved in the use of this source of energy for space mission, from the time of the launch, through the injection into orbit, and during the life of the spacecraft around the Earth, or during its trip into deep space. The first mission that launched a spacecraft powered by radioactive material into space took place in 1961 by the US Navy. The former Soviet Union, now Russia, and France have also conducted experiments and operations with the same technology. Nowadays, nuclear sources have often been used to serve space mission requirements that cannot be covered by other sources of energy, namely solar energy. The current Mars Rover "Curiosity" depends on nuclear energy sources instead of solar power to fuel its mission of the first two years as well as to drill rocks in the red planet.

There were two well-known space nuclear accidents in 1978. The Soviet satellites Cosmos 954 and Cosmos 1402 caused no impact near human presence, but dispersed radioactivity in the high atmosphere over the ocean. A working group was established within the Scientific and Technical Subcommittee of COPUOS soon after the Soviet Cosmos 954 accident in 1978 that pushed two space nuclear safety conventions that were adopted on September 26, 1986: the Convention on Early Notification of a Nuclear Accident (Notification Convention) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention). The Conventions assign IAEA a mandate to be notified of an accident and to communicate the accident to those States which are, or may be, physically affected, and coordinates emergency assistance amongst those States. The space nuclear safety issue continued to raise concerns and led to the 1992

[231] *Cit.*

[232] International Atomic Energy Agency, www.iaea.org/about/history

[233] Bouvet, Isabelle. (2004) Use of nuclear power sources in outer space: key technology legal challenges. *Journal of Space Law 30(2)*, Fall 2004: 203-226 (University of Mississippi School of Law).

Principle Relevant to the Use of Nuclear Power Sources in Outer Space (NPS Principles) under the form of a UN Resolution, a non-binding legal document" (Bouvet, 2004:203).[234]

2.4. UN BODIES RELATED TO SPACE FOR SOCIO-ECONOMIC DEVELOPMENT

The space technologies and their applications, in particular satellite telecommunication, satellite navigation, and remote sensing technologies, became vital to support the UN socio-economic development goals and targets, such as the Sustainable Development (Rio+20), Millennium Development Goals[235] and the UN Framework Convention on Climate Change (UNFCCC). The services provided via different types of space systems support the applications to improve the essential human daily activities from farming to banking. The satellite telecommunication is practical to support the e-education, e-health and e-government and e-commerce activities in the remote geographical regions. The satellite remote sensing technologies became indispensable to monitor environmental situations, so are vital to protect the Earth's environment, support natural resources management (Agenda 21),[236] mitigate disaster risk (Hyogo Framework for Action: Building the Resilience of Nations and Communities to Disasters)[237] and bridge the socio-economic gaps between developing and developed countries.

There are for instance twenty-six various UN agencies and entities, listed in the "Directory of Organizations of the UN Coordination of Outer Space Activities",[238] applying space facilities under different banners of the UN goals. The following UN specialized agencies are increasingly dependent on space systems to attain their missions related to "space for socio-economic development": the World Meteorology Organization (WMO), the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the United Nation Educational, Scientific and Cultural Organization (UNESCO), the World Bank, the World Intellectual Property Organization (WIPO). With their respective organizational missions, their member states negotiate and lead collective actions with space applications.

2.4.1. WORLD METEOROLOGY ORGANIZATION (WMO)

The World Meteorology Organization (WMO) was one of the two UN specialized agencies that were assigned to deal with the atmosphere research matters together with the COPUOS and the ITU since 1958. WMO includes 191 member states and territories, in pursuit of its normal tasks regarding the atmospheric sciences, has become involved in space-related activities in 1950 and has been mentioned in virtually all the UNGA resolutions on space. Its tasks have included the application of meteorology to weather prediction, the development

[234] Bouvet, Isabelle. (2004) Use of nuclear power sources in outer space: key technology legal challenges. *Journal of Space Law 30(2)*, Fall 2004: 203-226 (University of Mississippi School of Law).
[235] The Millennium Development Goals, UN Millennium Declaration, Millennium Summit, 2000.
[236] Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forest were adopted at the UN Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992.
[237] World Conference on Disaster Reduction, 18-22 January 2005.
[238] www.uncosa.unvienna.org/uncosa/en/directory/index.html

of international atmospheric observation and telecommunication networks, and the promotion of research. Weather and atmosphere information depending on Earth observation (EO) technologies is crucial for farming and fishery activities, aviation and maritime navigation safety, for ordinary peoples' daily convenience, and indispensable for military operations and national defense.

In 2009, WMO endorsed a Space Program with a 2025 Global Observation System (SOS) vision plan.[239] The vision plan includes a nominal configuration and a global contingency for EO satellites. It promotes availability and utilization of satellite data and products for weather, climate, water and related applications for WMO members and to create a Global Observation System (GOS). It aims to leverage an "end-to-end system" for weather and climate services, which ranges from capturing of data, over calibration to quality control, dissemination and user-training. To realize this global plan for operational GEO and LEO satellites, WMO undertakes consultations among its members and satellite operators within the Coordination Group for Meteorological Satellites (CGMS) by calling for global collaboration on the enhanced data sharing, interoperability and integration; data homogeneity and traceability. Success of such GOS vision plan will depend on the good will of all stakeholders as well as close coordination with ITU and its members since the technical integration of the potential GOS are again linked with radio frequency spectrum and satellite slot allocation issues[240] for which only ITU has the mandate with its own member states and policy decision-making procedure.

2.4.2. FOOD AND AGRICULTURE ORGANIZATION (FAO)

The UN Food and Agriculture Organization (FAO) was founded in October 1945 with a mandate to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the conditions of rural populations to the growth of the world economy. The intergovernmental organization has 194 Member Nations, two associate members and one member organization, the European Union. The FAO has its headquarters in Rome and is present in over 130 countries.[241]

FAO started using space technology applications in the early 1970s and has its own Environmental and Natural Resources Service (SDRN). The SDRN contains remote sensing, geographic information system (GIS), agrometeorology, environment, and energy programs. The ultimate mission of the FAO SRDN is to assist member states in developing necessary capacity to ensure the timeliness and cost-effectiveness of earth observing technologies for inventorying, managing natural resources, monitoring of environment and impact assessment at various levels for food security and sustainable agriculture. Under the aforementioned UN goals, FAO has involved the World Bank for a Regional Environmental Information Management Projects in Central Africa since 1996 for environmental monitoring programs. For climate change issue, FAO participated the World Climate Program since 1979, became a member of the Inter-Agency Committee on the Climate Agenda and works actively with international bodies such as United Nations Framework

[239] Approved by WMO Commission Basic System (CBS)-XIV and adopted by EC LXI in June 2009.
[240] www.wmo.int
[241] www.fao.org/about/who-we-are/en/

Convention on Climate Change (UNFCCC), Inter-governmental Panel on Climate Change (IPCC) and WMO. As for its use of the Earth observation data, FAO has been participating in the work of the Committee on Earth Observation Satellites (CEOS) as an associate member. FAO is, jointly with UN Environmental Program (UNEP), UNESCO and WMO, a founding member of the Global Terrestrial Observation System (GTOS) to provide policy makers, resources managers and researchers with decision support tool and access to the data needed to detect, qualify, locate, understand and warn of changes (especially reduction) in the capacity of terrestrial ecosystems to support sustainable development. UNEP and FAO are using Earth Observation data to assess the status of Earth environment and to monitor food security (FAO, 1999[242]).

The new FAO mission is to achieve food security for all to make sure people have regular access to enough high-quality food to lead active, healthy lives. As stated in the contribution of COPUOS to Rio+20 on the topic of harnessing the use of space-related geospatial data for sustainable development, the Committee pointed out to the space-related geospatial data would strengthen decision-making in many sectors, including in agricultural and food security. Selected areas where the UN entities use space technology for agricultural development and food security cover monitoring agricultural production, biodiversity, water and irrigation, oceans and mariculture, land use mapping, forestry and forestry monitoring, vegetation fires, desertification, droughts, floods, adverse weather conditions, disasters, food security, and humanitarian operations (IAMOS, 2013). [243] With the deployment of operational telecommunication satellites and the launches of civilian Earth observation (EO) satellites which have been used to monitor and forecast weather for farmers and to monitor crop development to help predict agricultural outputs in advance, EO information becomes crucial in assessing vulnerability and managing food security.

It is worth mentioning that the data retrieved from the satellite remote sensed geographic information system (GIS) over the territories or water of countries are equally important information for military operations, and for natural resource mining exploration. This information is legally protected to a certain extent, though it remains available for a fee. The space data sharing and data commerce issue can be at large related to the IPR issues or to the international trade matters.

2.4.3. UN EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

The mandate of the United Nations Educational, Scientific and Cultural Organization (UNESCO) is to foster international cooperation in the fields of education, science, culture and communication, and to assist in narrowing the gap in those areas between the developed and developing countries. This organization has 195 members and 10 associate members. The UNESCO headquarters is in Paris.

---

[242] Space-related activities of FAO, (1999)*SD Dimensions*, Sustainable Development Department, FAO. www.fao.org/sd/EIdirect/EIre0076.htm Accessed: 2013/05/08

[243] Space for agriculture and food security- special report of the Inter-Agency Meeting on Outer Space Activities on the use od space technology within the United Nations system for agricultural development and food security, IAM/2013/CRP.8, *UN COPUOS*.

UNESCO promotes the free flow of ideas by word and image and, as a strategy, focuses on the application of communication and information technologies for development, democracy and peace. UNESCO's space related activities aim to bring the benefits of space technologies to developing member states. In 1972, the UNESCO General Conference proclaimed a Declaration of Guiding Principles on the Use of Satellite Broadcasting for the Free Flow of Information, the Spread of Education and Greater Cultural Exchange.[244] In 1974, UNESCO and the World Intellectual Property Organization jointly convened the conference on the Convention relating to the distribution of program-carrying signals transmitted by satellite (also known as the 1974 Brussels satellite Convention). The Brussels Satellite Convention put forward the problem in the Field of Copyright and of the Protection of Performers, Producers of Phonograms and Broadcasting Organizations Raised by Transmission via Space Satellites held at Nairobi (Kenya) from 2 to 11 July 1973. The Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite was opened for signature on 21 May 1974 in Brussels and entered into force on 25 August 1979. As of 2014, the convention has been ratified by 37 states; there are 10 other states that have signed it but have not yet ratified it.[245]

Nowadays, UNESCO demonstrates that space can significantly contribute to science, education, culture and communication. They are also designed to create awareness among member states by showing the full potential of space technologies for the well-being of humanity. UNESCO recent space activities are mainly committed on three areas: 1) supports the Global Ocean Observing System (GOOS) building, 2) enhances the Earth Observation capacity building and 3) implements the Open Initiative on the Use of Space Technologies to Support the World Heritage Convention.

1) In 2009, the Global Ocean Observing System (GOOS) is created to become the over arching coordination tool for the observation systems. The implementation of GOOS is through Joint WMO-IOC[246] Technical Commission for Oceanography and Marine Meteorology (JCOMM) which works with national agencies coordinating deployment of instrumentation systems. JCOMM has an operational office in Toulouse, France and WMO partner offices in Geneva, Switzerland. The data and information needs of GOOS are satisfied by the Intergovernmental Oceanographic Data and Information Exchange, which is headquartered in Oostende, Belgium. UNESCO is supporting the ocean science research in this inter-agencies program.

2) In 2002, the World Summit on Sustainable Development and the G8 launched in 2002 a call for action in order to create an infrastructure that will interconnect a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment. The Group on Earth Observation (GEO) was launched in response to this call with the aim of coordinating efforts to build the Global Earth Observation System of Systems (GEOSS), the structure that proactively links together existing and planned observing systems around the world and support the development of new systems where gaps currently exist. It promotes common technical standards so that data from the thousands of different instruments can be combined into coherent data sets. UNESCO has a

---

[244] UNESCO, November 15, 1972.
http://portal.unesco.org/en/ev.php-URL_ID=17518&URL_DO=DO_TOPIC&URL_SECTION=201.html
[245] Anderson, Ruper W. (2015) *The Cosmic Compendium – Space Law*, Lulu.com. p10.
[246] Inter-governmental oceanographic Commission, UNESCO

close collaboration with the GEO and is currently a member of two committees established by GEO to guide the implementation of the 10-Year plan: the Science and Technology Committee and the Capacity Building Committee.

3) Space technologies, implemented by a large network of UNESCO space partners, are assisting the famous World Heritage sites. For some of these sites the monitoring is extremely complex: the sites are very large, some are impossible to access, for this purpose Earth Observation from space is a valuable added tool to assist heritage managers in these very complex monitoring tasks. It was in 2001 that the European Space Agency (ESA) and UNESCO began working on an international call to all space agencies, space research institutions and the space private sector, to assist the World Heritage Convention. In 2003, at the Paris Air Show in Le Bourget (France), UNESCO and ESA signed an agreement to encourage the use of Earth observation satellites to monitor cultural and natural World Heritage sites. The Open Initiative Convention aims to develop a framework of co-operation, open to all types of space partners, in order to assist developing countries in managing and protecting their natural and cultural heritage with the benefits of space technologies. Its objective is to use space technologies and the data they can provide to monitor these sites, thus allowing local authorities to identify potential threats, such as land use changes that could place the sites in danger, in time for them to elaborate and implement mitigation strategies. The Open Initiative has today over 50 space partners mainly space agencies, space research universities and private sector space companies.

2.4.4. UN BODIES DISTANTLY RELATED WITH SPACE TECHNOLOGY & APPLICATIONS

There are also UN entities that play a supportive role or are distantly related to space applications within the UN system, such as the World Bank. The World Bank has the world's largest source of development assistance and uses its financial resources, highly trained staff, and extensive knowledge base to help each developing country onto a path of stable, sustainable, and equitable growth in the fight against poverty by means of the use of space applications and building capacity for space technologies.

The World Health Organization (WHO) uses remote sensing space technologies to trace trans-border epidemics, as well as satellite communication to provide e-health medical facilities to remote areas and to coordinate international health work.

As was mentioned above, the World Intellectual Property Organization (WIPO) and UNESCO jointly convened the Conference on the Brussels Satellite Convention in 1974. WIPO is responsible for the promotion and protection of intellectual property throughout the world through cooperation among states and, where appropriate, in collaboration with other international organizations, and for the administration of various treaties dealing with intellectual property rights related to space technologies.

There is an emerging regionalization on space capability development cooperation inspired by the successful joint force between the EU and the European Space Agency. The Japan-led Asia Pacific Regional Space Agency Forum (APRSAF), the China-sponsored Asia Pacific Space Cooperation Organization (APSCO) has become increasingly important in building and consolidating the foundation of global space governance. Nonetheless, they are also considered as the new instruments for certain states to demonstrate their power in regional geopolitics and astropolitics. We will discuss this further in Chapter VI.

4. CONCLUDING REMARKS

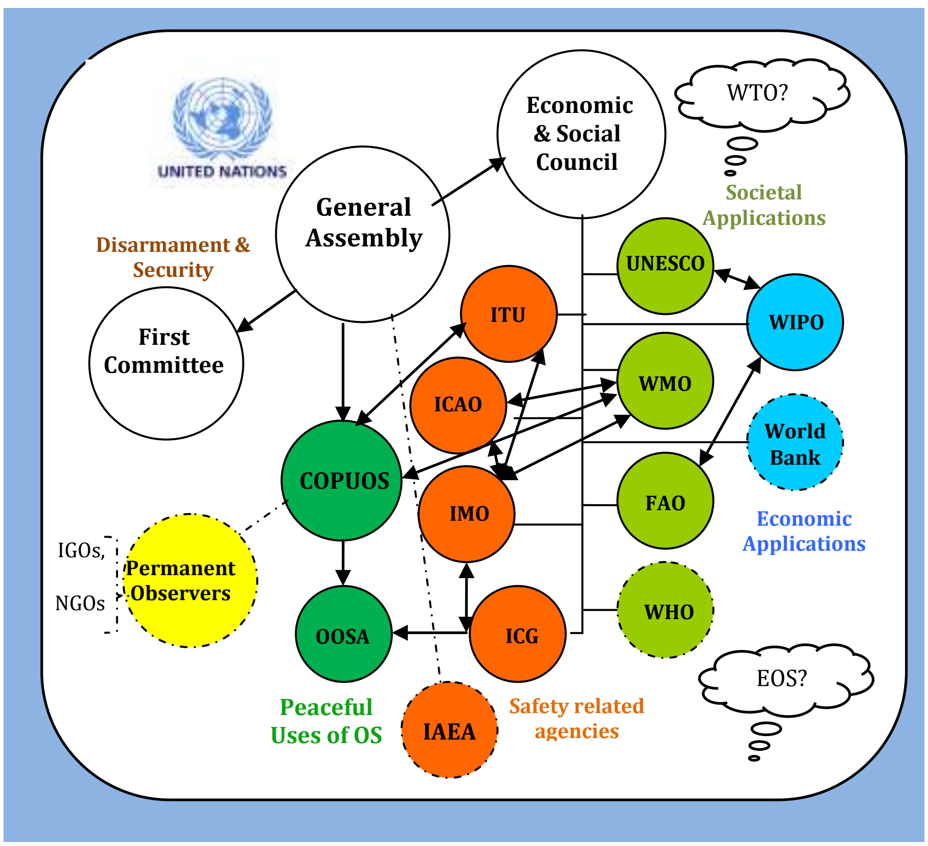
The establishment of COPUOS was the historical milestone that states agreed to institutionalize the international cooperation related to space activities of a dual-use nature. The appearance of COPUOS, pinpointed the organizational logic by which states and the international institutions themselves – UN, ITU, WMO – pushed the comprehensive governance structure toward fragmentation. Due to the individual strategic calculations of the two space powers, the UN member states could not attain a general agreement on creating a comprehensive regime over all space-related issues. The resulting institutional compromise chosen was to split up the space-relevant governing issue area into two sub-categories, that of "peaceful use" of outer space and that of security-related issue areas. This primary politicized organizational choice was developed on the following institutional labor division within the UN space governance structure.

By nature, the institutional choice of promoting the "peaceful use" of outer space throughout international cooperation has advanced some steps toward a number of UN targeting goals, namely in the domains of space for safety, socio-economic development and environmental sustainability as we presented in this chapter. Yet, the sounding labor division did not change the dual-use nature of the space activities. It did not modify the competitive character of such strategic instruments, perhaps because states are all keen to deploy them to maximize their interests. As a result, promoting the popularization of space capability toward all countries, particularly the developing countries, remains in accordance to the good will and concrete space capability supports from the space powers and the spacefaring nations. Concretely, these space powers, spacefaring countries and emerging space nations only support other countries' space capability development if their strategic and economic interests and functional necessity can be fulfilled. COPUOS and other UN specialized agencies related to space issues have no political power, financial means or technical capability but organizational scheme to promote these costly and highly technical targeted goals. Such point will be further developed in our GNSS governance case study in Chapter VI.

As regarding the subcategorized governing dimension on the "peaceful use" of outer space, although COPUOS became the unique platform at the global level to monitor and to discuss the issues about the international cooperation in peaceful uses of outer space, the other UN specialized agencies, namely the ITU and the WMO, remain autonomous from each other and COPUOS with their respective institutional mandate and issue focuses and strategic approach, different decision-making methods from each other. The same pattern continued in the interconnection between COPUOS and OOSA and a number of existing and newly established UN specific institutions that have become connected with the space matters over time. Figure 8 shows the general landscape in the global space governance architecture under UN auspices.

As Figure 8 shows, the institutional architecture of UN space governance was split up to two governing issue areas, that of disarmament and security, or effectively the "space security" issues, and the other, the socio-economic dimension, or the international cooperation on the "peaceful use" of outer space. In the realm of disarmament and security, it is the First Committee that is mandated under the UN auspice. Yet most of the space security have been discussed and negotiated in the non-UN Conference on Disarmament (CD). By contrast, in the realm of "peaceful use" of outer space, since the foundation of the COPUOS and OOSA (olive green pillar) which are specialized in dealing with space issues, the regimes constellation continued to expand its scale by involving other UN specialized agencies from the pillar of "space for safety" (orange pillar) that consists of ITU, ICAO, IMO, ICG and the IAEA, the pillar of "space for socio-economic development" (apple green pillar) that made connection with WMO, FAO, UNESCO and WHO, the pillar of economic governance (blue pillar) which implicated the institutions, namely WIPO and World Bank. There are naturally other pillars, such as the two issue areas that are increasingly connected with space governance, namely "space commerce" and Earth Observation (EO) for environmental and sustainable development.

Figure 8. An architectural overview on the global space governance institutions



Author's creation

Currently, the World Trade Organization (WTO), a non-UN multilateral international trade forum, and many UN-led international initiatives and non-binding frameworks of environmental issues, e.g. GEOSS solicited to be connected with space matters, because the achievement to their targeted goals will depend upon the use of space technologies and applications. Therefore, the two governing dimensions, shown as "clouds", are included in our figure of UN institutional governing architecture.

As the main focus of this chapter and the entire dissertation was to prepare an introductive "analytical narrative" to our further in-depth case studies, we have here only highlighted the discernible institutional interactions between those institutionalized UN specialized agencies connected by their common involvement in issues relating to space governance. Without having sufficient time to deepen our discussion of the complications or the causes of each institutional interaction, we could not identify if the architectural fragmentation has been affected because of the particular patterns, such as "membership overlap", "forum shopping", "mission creep", "nested, parallel and overlapping regimes", and so forth, according to the regime complex theoretical framework. By contrast, it was evident that, within an established governance scheme such as the UN auspice, the organization logic has led the institutional labor division on the basic of technical criteria of space related affairs governance. Such labor division, considered natural and necessary, constantly affected not only the expansion of but also the fragmentation of the entire space governance. As noted formerly, the creation of and the role COPUOS plays is a counter proof to such a viewpoint.

COPUOS is a significant and veritable intermediary to conciliate the world of space for peace and that of space for security. The existence of COPUOS demonstrated the efforts and political willingness of space powers and spacefaring nations can be effective under the UN scheme, particularly and explicitly in the realms of "peaceful uses" of outer space for safety, socio-economic and environmental sustainability. Although on the basic of vague governing principles, establishing governance institutions to negotiate and implement technical and operational regulations and standardizations are possible. This labor attribution of "peaceful use" space governance looks absolutely constructive. However, COPUOS is neither by nature nor by law a world space regime for all space issues. It has constantly borne the burdens and challenges of harmonizing cooperation and coordination between all the UN agencies that have become involved in the overarching space governance arena. In these cases, COPUOS ought to depend on the core yet partly responsible space governing bodies, such as ITU, ICG, ICAO, IMO and IAEA to come to technical arrangements. In another word, such labor attributions are perfect in its organization meaning, but imperfect in the practical sense. Finally, COPUOS has no mandate when it comes to security issues in space. As most of the space governing challenges came from its dual use nature, in many cases, the success of governance is heavily dependent on the political willingness of a few states to combine their strategic calculations and functional necessity. An ideal collective governing goal has often totally failed or was derived from its origin design. These points will be further discussed in the next two chapters.

CHAPTER V REGIME COMPLEX OF SPACE SECURITY GOVERNANCE

Abstract: In this chapter, we will study the space security regime complex by first reviewing the changing meanings of 'space security', which has shifted from its initial military aspect to its current broadened reading elaborating security, safety and sustainability senses. By recognizing that the evolution of space security governance has been heavily influenced by the four key space powers' strategic mindsets over time, we briefly introduced the respective space security policy line and capability building path of these space powers to illustrate their views and desires about space security and the governance on this issue. The different national readings on "space security" subsequently led these powers to institutionalize space security regimes by differentiating the governing tasks to the particular focused categories, such as nuclear proliferation in space, "space militarization", "space weaponization", and more recently space security *at large*. Over time, various regime institutionalization initiatives were proposed, either under UN auspices, or at the Conference on Disarmament (CD) but hardly successfully due to the tension between the space powers. Some regimes were established without adequate verification and enforcement measures. In order to repair the existing regimes, states chose to resolve these imperfections by proposing new overlapping or parallel regimes. It consequently thrust the entire global space security governance architecture toward expansion and fragmentation – a regime complex. In the second part of this chapter, we will analyze the morphogenesis of such space security regime complex based on the notion that a regime complex was led by intersecting strategic, functional and organizational driving forces. In our analytical narrative overview, we briefly indicate some discernible regime interplay cases according to the regime complex theoretical framework. Finally we present some policy reflections that aim to improve the inadequacy in the space security regime complex.

1. INTRODUCTION

The early focus of human space activities was on developing military space capabilities, namely by the two Cold War space powers that paradoxically aimed to maintain international peace and security. The two military space powers also foresaw that the internationalization of regulating space issues was necessary or inevitable because the human space activities, especially the satellite and its technological applications, would surely become greatly applied for military and civilian telecommunication, TV broadcasting, weather forecasting and navigation. So, the space governance framework was established through the United Nations with an artificial division of the uses of outer space for security and for peace.

In the realm of international cooperation for the "peaceful use" of outer space, as we have discussed, the construction of the global space governance scheme has been undertaken under the UN auspice driven by a strong labor division mindset. By contrast, the governance on space for security was not included in the UN framework and has constantly met failures and regular standoffs in its slow progress. It was clear from an early stage that the two space powers and the spacefaring countries desired to keep their powers and controls over space matters for their own national security and interests. It was beneficial if they held the power on space capability transfers and to influence the orientations international space governance progressed. By their own or with the oligarchy of a few states, better with their political and security allies, the arena of space for security or "space security" governance developed. Further to the popularization of general space capabilities and the liberalization of the space economy after the Cold War, space activities became even more *congested, contested, and competitive*[247] between space powers and spacefaring countries and expanded from the space for security toward the issue area of space for economy. To this, the "space race" continues among the key space actors, namely the US, Russia, China and the European Union, and a few emerging nations. They do not merely compete with each other in the realm of the physical space capability superiority but also in their respective interpretation about "space security" and its focused substances which ought to be translated into the governing policies and practices of the relevant international regimes. These space regimes, often in forms of bilateral arrangements, international treaties and multilateral forums within or autonomous from the United Nations auspices[248], are respectively entrusted by their member states to carry some specific part of the global space governing issues.

To make our analytical narrative on the space security governance discernible, we are inspired by the theoretical framework of 'regime complex'[249] that refers to "*an array of partially overlapping and non-hierarchical institutions governing a particular issue-area* (Raustiala and Victor 2004: 279) or more completely, it is viewed as "a *network of three or more international regimes that relate to a common subject matter; [that]exhibit[s] overlapping membership; and generate[s] substantive, normative, or operative interactions recognized as potentially problematic whether or not they are managed effectively* (Orsini et al. 2013:29)[250]. While applying the regime complex analytical framework, we put forward particular methodology suggested by the colleagues from the Ghent Institute for International Studies (GIIS) that the development of a regime complex is essentially steered by intersecting strategic, functional and organizational driving forces over time.

In the morphogenesis of the regime complex of global monetary governance[251] and energy governance,[252] for example, states constantly pursued their individual power and interests by exploring international regimes to include and exclude other nations, established particular beneficial issue linkages, and designed tailor-made decision-making rules of the international regimes in favor of their respective advantages. The three driving forces intersected the global governance architecture by continuously triggering new creations, reforms, sometimes disappearances of international regimes of their kind, and

[247] Lynn, III, William J. (2011) A Military Strategy for the New Space Environment, *The Washington Quarterly 34*(3) (Summer 2011): 7-16.
[248] Krasner, Stephen D. (1982) Structural Causes and Regime Consequences: Regimes as Intervening Variables. In *International Regimes*, (Ed.) Stephen D. Krasner. Ithaca: Cornell University Press. pp.1-21.
[249] Raustiala, Kal and Victor, David (2004). The Regime Complex for Plant Generic Resources. *International Organization 58* (2): 277-309.
[250] Orsini, Armandine, Morin, Jean-Frédéric and Young, Oran. Regime Complexes: A Buzz, a Boom, or a Boost for Global Governance. *Global Governance 19* (2013): 27-39.
[251] Lesage, Dries (2013). The Architecture of International Monetary and Financial Governance. In *Routledge Handbook of International Organization. Routledge Handbooks*. pp.486-498.
[252] Van de Graaf, Thijs (2013). *The Politics and Institutions of Global Energy Governance*. Basingstoke: Palgrave Macmillan.

subsequently expanded and fragmented the constellation of international regimes toward its complex form. In the realms of global space security governance, an innovation driving force needed to be added. Innovation is encouraged and even believed by the interested states to either preserve their space leadership and superiority, or to offer opportunities, namely for non-spacefaring countries, to reshape the existing global and regional astropolitical order. Furthermore, the rapid and tireless space technology innovation creates new issues and requires more additional rules or new international regimes for governance. This equally caused the increasing number of international regimes and exacerbated the fragmentation of the space security regime complex.

In this chapter, we will study the space security regime complex by firstly identifying the key states actors and their respective national "space security" policy. Their different readings on national space security policy directly reflect their positions toward their desired space security governing focuses. Their different political or strategic understandings of space security were naturally expected to be translated into the agenda and the negotiating process to institutionalize the specific governing regimes. Over time, the emphasized space security issues were about namely the nuclear proliferation in space, "space militarization" (related to the race between Soviet ICBMs and US anti missile defense systems), "space weaponization" (on banning the placement of weapons in space), and "space security" at large (focused on broadened security definition that include safety and sustainability, notably after China's 2007 ASAT weapon test). Finally, we highlight the evidence of how the three driving forces affected the morphogenesis of the space security regime complex.

2. AN OVERVIEW OF THE SPACE SECURITY GOVERNANCE ARCHITECTURE

2.1. DIFFERENT READINGS ON "SPACE SECURITY" OF KEY STATE ACTORS

Space for security and national defense as such, or "space security", has always been a highly politicized issue in national policy making, in the international space political arena, and in the realm of global space governance, even after the large utility expansion from military toward civilian and commercial purposes. Up to now, there is still no conventional definition but numerous competing interpretations of what is meant by "space security".[253] At the current stage, there is no authoritative legal definition in the realms of "space security" governance, even though the importance of the topic is widely recognized. In this dissertation, we have no intention to discuss or to define the meaning of "space security" per se. We will follow a general understanding of the issue as space for "security" as such or at large. Nevertheless, what interests us the most is to identify different key state actors' national visions or priorities relating to "space for security" or "space security". These different interpretations of key space actors have been the core issue that made clear impacts on the entire space security governance construction. Furthermore, the states' different interpretations and focused priorities have not been consistent but often changed

[253] Sheehan, Michael (2015) Defining Space Security, In *Handbook of Space Security* (Eds.) Kai-Uwe Schrogl, Peter L. Hays, Jana Robinson, Denis Moura and Christina Giannopapa. New York: Springer; Golston, Daniel and Baseley-Walker, Ben (2015) *The Realities of Middle Power Space Reliance*, Geneva: UNIDIR.

over time. Some obvious cases were, for example, the divergent interpretations of "peaceful use" of outer space favored by the Soviet Union and the United States during the Cold War, the question about the "militarization" and the "weaponization" of outer space (see Chapter III above). After the Cold War, the US expanded its pursuit of military space power for national security toward "the foreign policy and economic interests, and to US scientific knowledge".[254] In a similar line, the EU started promoting its comprehensive approach to interpret "space security" with its proposal for a non-binding International Code of Conduct for space activities (ICoC) that elaborated a trinity of security (as such), safety, and sustainability[255] to deal with space relevant issues. As for the other two space powers, Russia and China, they remain with the traditional per se security mindset that excludes the broadened meanings of safety and sustainability.

2.1.1. THE US SPACE SECURITY STRATEGY

The US is renowned for its full range of space capabilities but also its dependence on space systems for both military and civilian utilities. The US has now repetitively stressed that the increasingly *congested, contested*, and *competitive*[256] human space activities have become a new threat and challenge for its military superiority and civil space capability leadership. So, space security means protecting US national security and preserving American interests.

Apart from all efforts the US made throughout its National Aeronautic and Space Administration (NASA) since 1958, it merely marked the sharp division between the US military and civilian space exploration and research programs, each enjoying distinct financial supply and administrative mechanisms within the US national policy areas. During the Cold War, American national security concerns were focused on a space arms race with the Soviet Union. To be competitive with the Soviets' sophisticated intercontinental ballistic missiles (ICBMs), President Reagan (in office 1981-1989) in 1983 proposed the historic *Strategic Defense Initiative* (SDI, better known as *Star Wars*) to develop a comprehensive anti-missile defense system, including laser ASAT weapons placed in orbit. The SDI was also considered an instrument of re-industrialization to boost the American economy by stimulating the space industry sector. President Reagan also released the military-operated US Global Positioning System (GPS) for civilian aviation purposes. President Bush Jr. (2003-2008) forged an even closer link between US national security and space, particularly by endorsing a national strategy of space dominance. The space dominance strategy allowed the use of weapons in the event of a "Space Pearl Harbor"[257] striking the US, so placing weapons in space could be a response. Hence, the US adopted two concrete stances regarding space security. Space is an instrument useful for defending national security, and outer space itself became a vulnerable physical asset to be secured.

[254] Rose, Frank A. Official Remarks delivered at the Transatlantic Partnership Conference 'Defining Space Security for the 21st Century' co-organized by the European Space Policy Institute and Prague Security Institute on June 13, 2011 in Prague.
[255] International Code of Conduct for Space Activities (ICoC), the latest draft version March 31, 2014. www.eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf
[256] *Cit.*
[257] Report of the Commission to Assess United States National Security Space Management and Organization (also known as "Rumsfeld Commission Report", January 11, 2001.

As addressed in the US *National Space Policy* in 2006, the US needs to ensure "the sustainability, stability, and free access to, and use of, outer space in support of the nation's vital interests." The *National Space Policy* of President Obama in 2010 followed the similar line that space security became a subject that the US should "develop capabilities, plans, and options to deter, defend against, and if necessary, defeat efforts to interfere with or to attack US or allied space systems."[258] The *National Security Space Strategy*[259] appeared in 2011 and proposed to maintain and enhance the national security benefits that the US derives from its activities and capabilities in space while shaping the strategic environment and strengthening the foundations of the American enterprises. In the policy approach, as the US depends more heavily than other countries, the US defends space security merely based on its national security and interests. In practice, the American space security approach overlaps with the European comprehensive space security yet only if no conflict with the US national security and interest.

2.1.2. THE SOVIET AND RUSSIAN SPACE SECURITY FOCUSES

Similar to the US, the Soviet space capability has also been developed for military goals and geostrategic requirements. For this reason, the world's first satellite, Sputnik, was in fact a by-product of the ICBMs designed to negate US strategic nuclear weapons which could be carried by US forward-based aircrafts and missile deployment stations in Europe and Asia.[260] By the early 1970s, Soviet space activity had surpassed that of the US in both number of launches and total payloads orbited. In the period 1968-1975 particularly, the use of reconnaissance satellites during major international conflicts demonstrated that space systems had become an integral part of Soviet crisis monitoring and war planning systems.[261] Therefore, the use of outer space was claimed to support defending Soviet security and also to ensure international peace and security. After the Cold War, Russia followed the Soviet line to continue developing its space power with particular focuses on the launchers for ICBMs and for spacecraft launches. However, as Arbatov noted, Russia had gradually reduced the dependence of its conventional military operations on space systems. Only reconnaissance and communications systems are of some value.[262] Facon and Sourbès-Verger observed that Russian strategic forces continued to be indoctrinated with the launch-on-warning (LOW) concept in the development of the early-warning satellite for its ICBM deployments. Additionally, the satellite telecommunications and navigation, such as Globalnaya Navigazionnaya Sputnikovaya Sistema or Global Navigation Satellite System (GLONASS), are becoming more important for Russian military-civilian (dual-use) utilities.[263]

---

[258] President B. Obama, (2010) *The National Space Policy of the United States*, June 28, 2010.
[259] Department of Defense & Intelligence Community (2011) *National Security Space Strategy*, January 2011.
[260] Arbatov, Alexei (2013) Russian Perspectives on Spacepower, *International Security Network* (ISN). www.isn.ethz.ch/Digital-Library/Articles/Special-Feature/Detail/?lng=en&id=163261&tabid=1454267623&contextid774=163261&contextid775=163258
[261] Stares, Paul B. (1985) *The Militarization of Space: U.S. Policy, 1945–1984*. Ithaca: Cornell University Press.
[262] Arbatov. Ibid.
[263] Facon, Isabelle and Sourbès-Verger, Isabelle (2006) La spatial russe: implications nationales et internationales d'une apparente remontée en puissance. *Recherches & Documents*. Paris: Fondation pour la Recherche Stratégique.

Nowadays, Russia has put forward its national space policy priority on boosting its existing space industry and commercial activities.[264] This could not mean that space security issues have become less important. It was claimed that only major provocation might change Russia's policy on the issues, such as a potential US deployment of space-based ASAT system threatening Russian early-warning satellites, or a massive US deployment of space-based Ballistic Missile Defense (BMD) intercept or support systems which would threaten Russia's strategic nuclear deterrence capability.[265] In the global space security governance arena, Russia and China have been campaigning together for a treaty on preventing the placement of weapons in outer space, the threats or use of force against outer space objects (known as PPWT) since 2008 through the Conference on Disarmament (CD), an ostensive counteraction to the US space dominance strategy. In 2015, Russia's Defense Ministry established the Russian indigenous Aerospace Monitoring Forces (AMF), which aim to provide security to spacecraft and the International Space Station (ISS) and to enforce international rules of space conduct. The AMF is expected to use an extensive network of satellites and ground stations to track those who break international law, especially space traffic regulations.[266] It might be asked whether Russia is likely to adopt a broadened space security approach. It looks as though Russia still has no intention to align itself with the line of comprehensive space security. Yet, viewing its active space security and safety capability development, Russia certainly shares the concerns about the realities of environmental space security and would probably shift its declaratory stance until it attains sufficient space security capability.

2.1.3. THE EU'S COMPREHENSIVE SPACE SECURITY APPROACH

Europe has a long but stable general space capability building path. Alongside its long regional integration, the EU has slowly achieved its substantial space capabilities, particularly through all the spacefaring states, such as, France, Germany, Italy, and the United Kingdom. The merging in 1975 of the European Launchers Development Organization (ELDO) and the European Space Research Organization (ESRO) into the European Space Agency (ESA) paved the way for a *de facto* European Space Union for developing non-military space capabilities. ELDO was created through an international convention of 9 European countries in 1962 with the charge of developing and constructing satellite launchers. ESRO was also set up in 1962 but under another international convention with 11 member states. ELDO was mandated to manage programs for the construction and application of satellites. From its creation, ELDO had been suffering from constant dispute between the UK and France over control of various aspects of the program.[267] The problem of organization came to a head in 1972 with the failure of the first test launcher leading to the abandonment of the development of the 'Europa' missile, and the NASA's rejection of ELDO's offer to collaborate on the construction of a space laboratory.[268]

---

264 *Space Daily*, Russia must be more competitive in commercial space market. May 21, 2015.
265 Arbatov. Ibid.
266 *Space War*, Guardians of the Galaxy: Russia Creates International Space Patrol. April 12, 2015.
267 Sheehan, Michael. (2007) Chapter 5 European Integration and Space, in *The International Politics of Space*. London, New York: Routledge. p72-90.
268 Meyer, Patrick R. (1993) *Succession between International Organizations*. Kegan Paul International then (2011)

In the dimension of space for security, the US-led North Atlantic Treaty Organization (NATO) offered the European states a convenient security framework for reducing considerable budgetary burdens. Because of this, Europe has lacked an immediate need and political motivation for defending its general security, and accordingly has no explicit stress on space security in its well-developed space programs. Consequently, Europe had been taught by the cross-Atlantic alliance in which the US has strong power to influence European security autonomy. For example, Washington disapproved of the European project for a global navigation satellite system known as GALILEO started around 2003. The US had equally heavily exploited its influence on some NATO states to discourage the EU-China partnership at the starting phase of the international European GNSS consortium (see further discussion in Chapter VI).

In 2005, the EU Council accepted the recommendation made by the Space and Security Panel of Experts (SPASEC) convened by the European Commission (EC)[269] to give "a high relevance on its security applications of space". The EC SPASEC report pointed out the underdevelopment of the EU on the security aspects for the use of space in comparison with other EU policy areas. Afterwards, the EC and ESA jointly drafted a *European Space Policy* and released it in 2007. A subsequent Space Council resolution of September 2008[270] defined "space and security" as one of four new priority areas. The Lisbon Treaty of 2009 reinforced the legal basis for EU's involvement in space matters as a competence shared with the EU Member States. The former EU High Representative Aston recognized in her Final Report of October 2013, entitled "Preparing the December 2013 European Council on Security and Defense", that the role of networks (including space) in today's globalized world "cannot be overestimated" and that "security of space is crucial for modern societies". A study conducted by the DG for External Policies of the European Parliament[271] stressed that an independent, reliable and responsive access to space depending on 'security from space' – for the autonomous launch systems – and on 'security in space' – with a comprehensive space system including ground infrastructure – are vital to European security and to worldwide peaceful and sustainable activities in space.

The rather late European policy linkage between space and security seized an opportunity to leap to the forefront right after the Chinese ASAT test blew thousands of pieces of debris into orbit in 2007. Brussels took a solid stance on space security by exploring the extensive coverage of the issue. The EU proposed that space-based assets and entire space systems have become indispensable for human safety, economic growth and social development, environmental sustainability, and naturally also security as such. Thus space security forms an integral part of EU Space Policy. In the same line, the European Union in 2008 proposed a draft International Code of Conduct for Space Activities (ICoC) to promote comprehensive space security for security, safety and sustainability concerns. Hence, space security has not only become part of European Union space policy, but also was put forward as an action of the EU's foreign relations.

Oxon, New York: Routledge

[269] Report of the Panel of Experts on Space and Security, March 2005.

[270] Council of the European Union, 'Taking forward the European Space Policy', 13569/08, Brussels, September 29, 2008.

[271] Policy Department, Directorate, General for External Policies, European Parliament, *Study: Space, Sovereignty and European Security – Building European Capabilities in An Advanced Institutional Framework*, January 2014.

2.1.4. CHINA'S GROWING SPACE SECURITY INTERESTS

Now ranked as the fourth space power, after the US, the EU and Russia, and followed by Japan and India,[272] China has pursued its space-capability building to support its national development strategy in the objective of preserving the country's independence from foreign powers regarding sovereignty, independence, territorial integrity, and political system.[273]

Although the Chinese government had already published national scientific and technology development guidelines in 1956 that explicitly aimed to develop indigenous atomic bombs, ballistic missiles and artificial satellites (兩彈一星) and had started its space program in 1965 with the Chinese Defense Ministry's Fifth Academy, it was only in the 1970s that China started developing its space orbit program. When Deng Xiaoping succeeded Mao in 1978, military space considerations were even less of a priority.[274] After the impressive US space system coordinated the Desert Shield/Desert Storm Operation in 1991, China's armed forces, the People's Liberation Army (PLA), started a range of tasks and missions that would correspond to aspects of counter-space activities.[275]

In parallel with China's rapid development of a civil space program marked by the first Chinese space walk in 2008, unmanned space station (Tiangong 1) in 2011, and Moon unmanned rover (Yutu) in 2013, Chinese analysts increasingly argue that space will be the center of gravity in future wars and see space as something that must be seized and controlled.[276] The concept was similar to the US 'space control' doctrine. In other words, it combines the two readings of space security that space is useful for defending national security, and outer space itself has become a vulnerable physical asset to be secured. As a matter of fact, China tested its anti-satellite (ASAT) capability by destroying its own dysfunctional satellite in 2007 and continues to improve its ballistic missile defense system. In the Chinese National Defense White Paper released in 2015, the People's Liberation Army (PLA) for the first time explicitly stated that it would be expected to build air-space capabilities in order to conduct "active defense" operations, namely for strategic early warning, air strike, air and missile defense, information countermeasures, airborne operations, strategic projection and comprehensive support in the course of developing China's Armed Forces.[277]

In the arena of global space security governance, Beijing kept seeking to transform the international system to better suit its interests. It probed taking a more active role on the stage of global space governance as well as in the Asia-Pacific regional space governance

---

[272] *Space News*, China ranked 4th among world space powers. May 27, 2015.

[273] *Chinese Space Activities in 2011* (China's Space White Paper). http://www.china.org.cn/government/whitepaper/node_7145648.htm

[274] Cheng, Dean (2012) China's Military Role in Space. *Strategic Studies Quarterly 6* (1) Spring 2012): 55-77.

[275] Cheng, Dean (2015) The PLA's Interest in Space Dominance, Testimony before the U.S.-China Economic and Security Review Commission, February 18, 2015. Source: www.heritage.org/research/testimony/2015/the-plas-interest-in-space-dominance

[276] Pollpeter, Kevin, Anderson, Eric, Wilson, Jordan, and Yang, Fan (2015) *Chinas Dream, Space dream: China's Progress in Space Technologies and Implications for the United States*, March 2 2015. www.uscc.gov/Research/china-dream-space-dream-chinas-progress-space-technologies-and-implications-united-states

[277] *China's Military Strategy*, the State Council Information Office of the People's Republic of China. May 2015, Beijing. Source: http://eng.mod.gov.cn/Database/WhitePapers/

theater in order to create a more favorable environment for itself vis-à-vis the global competitor, the US, and its main regional competitor, Japan. To restrain US space strategic dominance, China and Russia in 2008 co-proposed a PPWT at the Conference on Disarmament (CD) in order to ban the placement of weapons in outer space, and threats or use of force against outer space objects (PPWT). The drafted treaty, nonetheless, does not cover ASAT tests of the type that China and perhaps other countries are still experimenting with to attain their mature capability.

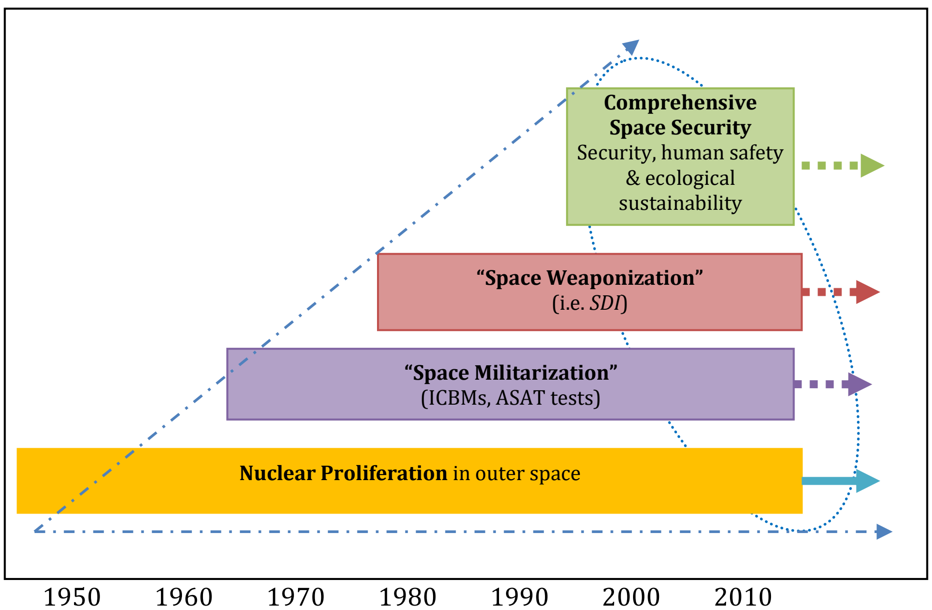
To sum up, although not all space powers have explicitly stressed the comprehensive notion of space security in their national space policy or their governing stance, they in practice recognize the importance that the two readings of space security should coexist: that space is useful for defending national security, and outer space itself has became a vulnerable physical asset to be secured. However, states decide which reading suits them better on the basis of their individual temporary strategic considerations as well as their specific space capability maturity.

2.2. THE KEY ISSUES OF GLOBAL SPACE SECURITY GOVERNANCE

There are several long-standing issues in the realm of space security governance that are raised and debated by the three space powers and the EU again and again. These were nuclear proliferation and the "peaceful use of outer space" before the Outer Space Treaty was concluded in 1967. After the OST, the undefined "peaceful use" evoked some states' particular concerns about the interpretations and implementation of the avoidance of "space militarization", and "space weaponization". Lately, notably after the Chinese and the US ASAT weapon tests in 2007 and 2008 respectively, the European Union proposed a comprehensive draft ICoC that elaborates "space security" with a broadened definition covering security (as such), safety and sustainability. The interpretative question raised by different states' stances regarding these space security issues has already been discussed in Chapter II above, and will not be repeated here. Instead, we highlight the evolutionary timeline of these long-standing issues.

Figure 9 outlines the evolution over time of the governing focuses on space security and negotiation topics. It started in the late 1950s with the early space security governing focus on nuclear proliferation in outer space. The issue was an aspect of the general disarmament discussions on nuclear proliferation. The LTBT signed in 1963 ended the nuclear test issue in its legal sense. The question remains if the emerging space nations will in practice follow the rule or not (yellow rectangle with arrow line). From the 1960s until the late 1970s, the Soviet ICBMs achieved greater sophistication and both the USSR and the US intensively tested their kinetic energy or hit-to-kill ASAT weapons. The concerns about space militarization were greatly increased. The question remains without authoritative answer, after those military space experiments, whether the final utility of these devices and vehicles stay as a part of military property or to be deployed for aggression purposes (purple rectangle with dashed arrow line). As from the 1980s, the US developed its Ballistic Missile Defense systems including laser ASAT weapons vis-à-vis the rapid sophistication of Soviet ICBMs. In response to this ASAT weapon that fell outside the banned category of "space weapon" in orbit, Russia and China developed a "space weaponization" argument to restrain American military space capability development. This issue is still under debate though with a concrete Russia-China PPWT proposal (red rectangle with dashed arrow line). Further to the post-Cold War popularization of space capability development and the liberalization of the global space economy since the 1990s, the increase of national and private space asset possessions and the growing dependence on space systems to support a wide range of continuous real-time operations and services, the successive Chinese and American ASAT weapon tests in 2007 and 2008 awoke the world to the vulnerability of their space systems vis-à-vis the problem of space debris and harmful radio interference. Therefore, the elaborated approach covering security per se, safety and sustainability was requested (green rectangle with dashed arrow line). Finally, we return to our visual model introduced in Figure 3, Chapter I (page 31), the blue cone with dashed border line to highlight that over time the governing issues about space security were increasingly diversified toward all the fragmented items mostly without closed ends.

Figure9. Long lasting space security governing issues over time



Source: Author's creation

3. MORPHOGENESIS OF THE SPACE SECURITY REGIME COMPLEX

The growing regime complex of global space security governance is marked by the increasing number and specialization of the various regimes related to space security that have over time expanded and fragmented the governance architecture. These international space security regimes appeared in the forms of "implicit or explicit principles, norms, rules and decision-making procedures around which actors' expectations converge in a given area of international relations"[278] – such as space security that concretely resulted in the

[278] Krasner, Stephen D. (1982) Structural Causes and Regime Consequences: Regimes as Intervening Variables. In *International Regimes* (Ed.) Stephen D. Krasner. Ithaca: Cornell University Press. pp.1-21. ; Keohane, Robert O. (1984) *After Hegemony: Cooperation and Discord in the World Political Economy*. Princeton, NJ: Princeton University

establishment of international treaties, international organizations, or informal intergovernmental forums related to space security governance. Under UN auspices, the General Assembly and the First Committee on disarmament and security, and the UN-supported international space treaties, such as the Outer Space Treaty (OST) and the Moon Treaty, are the formal general governing instruments for space security. Within this framework, since 2005, Russia, China and other countries have kept proposing the establishment of transparency and confidence-building measures (TCBMs) for space activities. The joint proposal resulted in the establishment of a Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities (GGE-TCBMs) and a report released by the GGE-TCBMs in 2013. In 2015, a Russia-led[279] UNGA resolution on an Arms Ban in Outer Space – 'No first placement of weapons in outer space' (NFP) – acquired 126 yes votes, 4 no votes and 46 abstentions. The NPT was considered an important intermediate measure on the way towards PPWT.[280]

In parallel with UN auspices, most of the technical discussions and negotiations about space security governance have taken place at the non-UN Committee on Disarmament (CD). At this multilateral disarmament forum, the attempts to create an international agreement on the Prevention of an Arms Race in Outer Space (PAROS), and a draft *Treaty on the prevention of the placement of weapon in outer space and of the threat or use of force against outer space objects* (PPWT) were raised in 1985 and in 2008 respectively. By contrast, the EU-proposed draft *International Code of Conduct for space activities* (ICoC) chose a unique path by undertaking the new space-security regime-making through three rounds of "Open-ended Consultations" to promote such non-binding voluntary regime.

3.1. THE UN AND GLOBAL SPACE SECURITY GOVERNANCE

After the first successful Soviet *Sputnik I* satellite orbit flight in 1957, the UN General Assembly (UNGA) became the main international forum for countries to discuss space-related issues. This international forum deals with general and specific space-related questions, such as space security, international cooperation for space explorations and space science, and so on. By adopting the General Assembly resolutions, the UN created mandates for the UN agencies, established special *ad hoc* UN committees, and set up national experts panels to seek solutions to outer space issues. For space security matters, it is the First Committee on disarmament and international security which deals with disarmament, global challenges and threats to peace. The First Committee considers all disarmament and international security matters within the scope of the UN Charter or relating to the powers and functions of any other organ of the United Nations; the general principles of cooperation in the maintenance of international peace and security, as well as principles governing disarmament and the regulation of armaments; promotion of cooperative arrangements and measures aimed at strengthening stability through lower

Press.

[279] The NFP has 34 countries as co-authors. *Sputnik International*, UN passes Russian-Proposed Resolution Banning Arms Race in Outer Space, December 4th 2014 http://sputniknews.com/politics/20141204/1015510727.html

[280] Statement by the Representative of the Russian Federation at the 2015 session of the UN Disarmament Commission. April 7th 2015.

levels of armaments. The Committee works in close cooperation with the UN Disarmament Commission and the Geneva-based Conference on Disarmament. It is the only Main Committee of the General Assembly entitled to verbatim records coverage.[281]

As to the UN resolutions and international treaties related to space security, as already presented in Chapter III, they were mostly established in the line of "peaceful use" of outer space at an early stage. Furthermore, there has been hardly any successful regime change since then. We will here only focus on the recent initiative under UN auspices.

3.1.1 THE GROUP OF GOVERNMENTAL EXPERTS ON TRANSPARENCY AND CONFIDENCE-BUILDING MEASURES

Due to a constant absence of consensus resulting in a failure to establish any form of operable space security regime, in 2005 the Russian Federation began proposing a UNGA resolution on transparency and confidence-building measures (TCBMs) for space activities. The TCBM is supposed to be an efficient diplomatic tool to bring adversary states closer to each other. Transparency, here, refers to "the degree of openness in conveying information and a device of strategic negotiations signaling the trustworthiness of the actor in negotiation".[282] The Russia-sponsored space security TCBMs proposal has attracted wide support in the UN General Assembly yet has been rejected yearly by the US from 2005 to 2008. In between, the UN Secretary-General issued a report in 2007 compiling the views of member states on TCBMs in space.[283] In 2009 the US Obama Administration shifted to abstaining instead of voting against the proposal.

In 2010, Russia and China sponsored an initiative through the UN First Committee, and on January 13, 2011, this was endorsed by the UN General Assembly as Resolution 65/68.[284] Because of this, the UN Secretary General Ban Ki-moon in 2011 convened a Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities (GGE-TCBMs) to examine and report on methods for improving cooperation in space, and on reducing the risks of misunderstanding, mistrust, and miscalculations. Actually, there was already a similar GGE was convened between 1991 and 1993 to examine confidence-building measures in outer space activities, and produced a report.[285] The GGE-TCBMs established in 2011 delivered its final report by consensus in July 2013 to the UN Secretary General.[286] The GGE report proposed a set of TCBMs for space security, such as exchange of information between countries about their space policy and activities, risk reduction notifications and visits by experts to national space facilities. Establishing increased coordination between the Office for Disarmament Affairs, the Office for Outer Space Affairs, and other appropriate UN entities was equally recommended. The UN General Assembly endorsed the report at its 68th session in late 2013, and encouraged UN Member

[281] UN First Committee – Disarmament and International Security, www.un.org/en/ga/first/
[282] Ball, Carolyn. What is transparency? *Public Integrity 11*(4) (2009), p.294.
[283] UN A/62/114, and A/62/114/Add.1.
[284] UN General Assembly, A/RES/65/68. January 13, 2011.
[285] Prevention of an Arms Race in Outer Space: Study on the application of confidence-building measures in outer space – Reported by the Secretary General, U.N. GAOR, 48th session, U.N. Doc A/48/305, Oct. 1993.
[286] Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities, U.N. GAOR, 68th session, U.N. Doc A/68/189, July 29, 2013.

States to review and implement the proposed measures through relevant mechanisms on a voluntary basis.[287]

The TCBMs initiatives sponsored by Russia and China were constantly resisted by the US. While the US has since publicly declared its support for the GGE-TCBMs process, it abstained from voting on the resolution, objecting to its mention of the Chinese-Russian draft Treaty on the Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT). Additionally, the composition of the TCBM GGE was also criticized for failing to give fair representation to the actual stakeholders.[288] The GGE constituted a group of experts nominated by 15 nations. These were the permanent five (P-5) of the UN Security Council, plus Brazil, Chile, Italy, Kazakhstan, Nigeria, Romania, South Africa, Sri Lanka, and Ukraine. Not all of these are spacefaring nations, while India, despite being an important emerging space nation had no expert in the group.

3.1.2. NUCLEAR PROLIFERATION RELATED TO SPACE SECURITY

Nuclear proliferation and space security are linked because orbiting ballistic missiles with nuclear warheads can be either "weapons through space" or ASAT weapons. More broadly, there is the trauma caused by the dropping of atomic bombs on Japan, and the dilemma of how to use nuclear power to maintain international peace and security. In the mid 1960s, when the countries with nuclear capabilities were still limited to the US, the UK, the USSR, France and China, there was a strong incentive for any power to avoid starting a nuclear war. However, as more nations achieved nuclear capability, particularly developing nations that lay on the periphery of the balance of power between the two Cold War superpowers, this balance risked being disrupted and the system of deterrence would be threatened. Moreover, if countries with volatile border disputes became capable of attacking with nuclear weapons, then the odds of a nuclear war with truly global repercussions increased. This made the nuclear states reluctant to share nuclear technology with developing nations, even technology that could be used for peaceful applications. All of these concerns led to international interest in a nuclear non-proliferation treaty that would help prevent the spread of nuclear weapons.[289] Subsequently, the nuclear *Non-Proliferation Treaty* (NPT) was opened for signature in 1967 and entered into force as from March 1970. Among the 190 NPT signatories, nine possess nuclear weapons: the five nuclear weapons states recognized under the NPT (US, Russia, China, UK and France), three non-NPT nuclear weapons states (Israel, India and Pakistan), and the Democratic People's Republic of Korea (DPRK), which withdrew from the NPT in 2003.

Apart from the NPT, Moscow and Washington continued to test their respective nuclear space weapons until they signed the *Limited Treaty Banning nuclear weapon Tests in the atmosphere, in outer space, and under water* (LTBT, also known as Partial Test Ban Treaty, PTBT). The LTBT, primarily negotiated between the UK, the US and the USSR, resulted in a Soviet-US-led bilateral treaty. More than 120 nations signed the LTBT in 1963 to prohibit

287 Transparency and Confidence-Building Measures in Outer Space Activities, U.N. Res.68/50, Dec.10, 2013.
288 Lele, Ajey, Effective mechanisms for space security, *The Space Review*, Tuesday May 28, 2013. www.thespacereview.com/article/2031/1
289 https://history.state.gov/milestones/1961-1968/npt

nuclear explosion tests in the atmosphere, the ocean and space, allowing them only underground. Hence, none of the LTBT signatories is allowed to conduct nuclear weapon tests in space though the peaceful use of nuclear power sources (NPS) for peaceful space missions remain unbanned. In 2009, the UNCOPUOS and the International Atomic Energy Agency (IAEA) jointly published a 'Safety Framework for Nuclear Power Sources Applications in Outer Space'. There seems, though, to be no discussion of whether the peaceful use of NPS implies potential security concerns.

Further to the LTBT, there was the *Comprehensive Test Ban Treaty* (CTBT), negotiated within the Conference on Disarmament (CD) and opened for signature in 1996. The relevance of the CTBT to space security issues was actually not because of the nuclear proliferation, but because of the packaged bloc-binding negotiations between CTBT, FMCT and PAROS at the CD. We will discuss this institutional relevance below. Finally, it is worth mention that almost all the UN member states ratified the CTBT though it is not yet in force due to its specific conditions. Actually, the CTBT was designed to enter into force 180 days after the 44 states listed in *Annex 2* of the treaty had ratified it. The "*Annex 2* states" are those that participated in the CTBT negotiations before 1996 and possessed nuclear power reactors or research reactors at that time. As of 2015, still eight *Annex 2* states have not ratified the CTBT. Among them, China, Egypt, Iran, Israel and the US have signed but not ratified the treaty. India, North Korea and Pakistan have not signed the treaty.

3.2 THE CONFERENCE ON DISARMAMENT

The Geneva-based CD originated from the Ten-Nation Committee on Disarmament (1960), the Eighteen-Nation Committee on Disarmament (1962–68) and the Conference of the Committee on Disarmament (1969–78). In 1979, the UNGA appointed the CD as the sole multilateral negotiating forum for international disarmament agreement to eventually ban nuclear weapons, destroy chemical weapons and strengthen the prohibition on biological weapons. Formally, the CD is not a UN organization although it has a special link to the UN. A personal representative of the UN Secretary-General works as the CD Secretary-General. With this linkage, the UNGA often requests the CD to consider specific disarmament matters. In turn, the CD reports its annual activities to the Assembly. The CD has a limited membership of 65 states. Furthermore, as the negotiation tasks are related to states' national security interests, the CD works strictly on the basis of consensus. Such a decision-making procedure grants any country a veto right to single-handedly block progress. The CD has been dedicated to dealing with the questions relating to the militarization of outer space.[290]

3.2.1. ATTEMPT ON PREVENTING AN ARMS RACE IN OUTER SPACE (PAROS)

In 1981, the UNGA mandated the CD to explore possibilities for an international agreement on preventing an arms race in outer space (PAROS). There was a difference regarding the exact focus of this agreement. The first resolution (A/RES/36/97), sponsored by the

[290] www.unoosa.org/oosa/en/aboutus/history/index.html

Western Europe and Others Group (WEOG), sought the CD to focus on negotiating "an effective and verifiable agreement to prohibit anti-satellite systems". The second resolution (A/RES/36/99), sponsored by the Eastern European and other states, wanted the CD to focus on negotiating a treaty to prohibit the stationing of weapons of any kind in outer space. While some states within the neutral and non-aligned group urged that the two resolutions be amalgamated to avoid presenting the CD with two sets of instructions, the lead sponsors of the resolutions demurred, saying that each resolution has its own identify and approach and should be handled separately. Thus it can be said that differences of perspective and priority have colored the CD's consideration of PAROS from the beginning.[291]

The CD established an *ad hoc* Committee on the Prevention of an arms race in outer space (PAROS) in 1983. The *ad hoc* PAROS Committee met annually from 1985 to 1994, and each year failed to move forward in any agreed pathway. The *ad hoc* PAROS Committee ended its work in 1994 and was not re-established. From 1995 onward, although with the support of all other UN member states, the constant vetoes and abstentions of the US and Israel in the CD General Assembly rejected the re-establishment of the PAROS committee. As for the attempt to put the PAROS on the UNGA agenda, the US has vetoed all the major resolutions and papers to limit and control space weaponization introduced at the CD.

In the years following the *ad hoc* Committee's demise, Canada, China and Russia kept their interests in PAROS at the CD. In 1998, Canada proposed a new *ad hoc* committee to negotiate the non-weaponization of space. In 1999, China proposed the establishment of an *ad hoc* negotiation committee to prevent the "weaponization of space", while Pakistan and others have used the term "militarization" which could include satellites used for military purposes. In 2000, China submitted a working paper proposing that the *ad hoc* Committee can be revived with a mandate to negotiate a "new international legal instrument prohibiting the testing, deployment, and use of weapon, weapon systems and components in outer space". In 2003, 174 UN member states voted in favor of a resolution to prevent an arms race in outer space. Only the Federated States of Micronesia, the Marshall Islands, Israel and the US abstained. The US cast a negative vote in 2005.[292] Israel has since reverted to abstaining. 160 UN member states have voted for the resolution. In 2006, 2009 and 2011, informal debates on PAROS were held to unblock the deadlock. The US continues to argue that "as long as the potential for such attacks [on satellite] remains, the US continues to consider the possible role that space-related weapons may play in protecting our assets". The US justified their stance because their concept of 'peaceful uses' includes "appropriate defensive activities in pursuit of national security and other goals."[293] The attempts to put a formal PAROS discussion on the CD agenda still has no success up to now.

The failure to get the tentative PAROS on to the CD's agenda was due to many reasons. First, the differences among states regarding the fundamental questions of whether or not new

[291] *UNIDIR Resources: The CD and PAROS – A Short History*. April 2011, Geneva: United Nations Institute for Disarmament Research (UNIDIR)
[292] United Nations General Assembly, "UNGA First Committee Voting Record on Prevention of an Arms Race in Outer Space," A/C.1/60/L.27, 25 October 2005, Reaching Critical Will, online: www.reachingcriticalwill.org/political/1com/1com05/votes/L.27.pdf.
[293] Mohanco, John. (2006) Delegation of the United States to the Conference on Disarmament, Geneva 13 June. http://www.reachingcriticalwill.org/political/cd/speeches06/13JuneUS.pdf

legally binding measures were required *vis-à-vis* the existing space treaties (the OST, for example), what threats (conventional nuclear and mass destructive weapons in space *vs.* new types of ASAT weapons) were actually real and present dangers, and whether the Committee should continue discussions or instead develop a negotiating mandate.[294] In the course of the PAROS discussions, each state had its own strategic concerns. China insisted that there should be negotiations on PAROS. The US agreed only to discuss the matter[295] since it believes that "it is not possible to develop an effectively verifiable agreement for the banning of either space-based "weapons" or terrestrial-based anti-satellite (ASAT) systems."[296] China was reluctant to put a cap on its own strategic nuclear capabilities until the US was willing to put a cap on its national missile defense plans. India was unlikely to be left out of the PAROS debate without gaining posture by possessing or at least testing any Indian ASAT weapon capability prior to the negotiations. Other nations, such as Pakistan, Iran and North Korea, may also consider their ASAT options as they further develop their long-range missile and space launch capability.[297]

The other complexity is that a likely PAROS was included in the three-deal package for the Comprehensive Nuclear Test Ban Treaty (CTBT). The other two parts of the CTBT deal were the formation of an *ad hoc* committee to discuss the future of nuclear disarmament, and a universal Fissile Material Cut-off Treaty (FMCT) to cut off the fissile material production for nuclear weapons programs. For the FMCT deal, two South Asian countries and Israel were believed to be continuing to produce fissile materials for their stockpiles.[298] India, on the basis of a regional geopolitical mindset, will not sign the FMCT without China joining in. Pakistan will not sign unless India does. As the FMCT deal falls in the same disarmament package as a PAROS, there will be no PAROS deal until an FMCT deal is struck. The CTBT finally opened for signature in 1996, but has still not entered into force. As for the attempt to put the PAROS on the UNGA agenda, the US has vetoed all the major resolutions and papers to limit and control space weaponization introduced at the CD. Since 1995, the US and Israel consistently abstained in votes calling on the CD to re-establish an *ad hoc* PAROS committee in all its aspects.

3.2.2. RUSSIA-CHINA-SUPPORTED PPWT

Further to the failure of the PAROS agenda-setting and the continuous development of the US ground and sea-based missile defense systems which could be used as space weapons, Russia and China[299] jointly proposed a working paper to the CD in 2002 entitled *Possible*

[294] UNIDIR (2012) *The Conference on Disarmament: Issues and Insights*. New York & Geneva: United Nations Institute for Disarmament Research.
[295] Singer, Clifford, (2002) Space weapons and the Conference of Disarmament, *INESAP Information Bulletin 20*, August 2002: 25-26. p25.
[296] Karen, E. House, United States Public Delegation to the 63th Session of the United Nations General Assembly, Delivered in the debate on outer space (Disarmament Aspects) of the General Assembly's First Committee, October 20th 2008, Arms Control Update, U.S. Delegation to the Conference on Disarmament, Geneva.
[297] Hitchens, Theresa, (2009) Saving Space: Threat Proliferation and Mitigation, a research paper for the International Commission on Nuclear Non-Proliferation and Disarmament.
[298] Zhang, Hui, (2002) FMCT and PAROS: A Chinese Perspective, *INESAP Information Bulletin 20*, August 2002: 21-24.
[299] Also co-sponsored by Viet Nam, Indonesia, Belarus, Zimbabwe, and Syria.

elements for a future international legal agreement on the prevention of the deployment of weapons in outer space, the threat or use of force against outer space objects. This working paper served the basic document for a draft *Treaty on the prevention of the placement of weapons in outer space and of the threat or use of force against outer space objects* (PPWT) also co-submitted by China and Russia in 2008 at the CD.

The PPWT seeks to outlaw space weaponization by means of an international legally binding treaty because 'modern international space law does not prohibit deployment in space of weapons which do not belong to the category of weapons of mass destruction (WMD)'. 'The PPWT can prohibit the deployment of weapons of any kind in space, and the use or threat of force against space objects.'[300] The 2008 PPWT version was criticized, namely by the US, for its 'significant flaws' (for example that the PPWT will be unverifiable[301]) and was rejected by many states. Further to this criticism, a consolidated version was submitted in 2014. The US countered that 'arms control proposals and concepts should only be considered by the international community if they are equitable, effective, verifiable, and enhance the security of all.' To them, the PPWT does not meet the necessary criteria, namely, it lacks an effective verification regime to monitor compliance, and terrestrially based anti-satellite systems, that pose the greatest and most imminent threat to space systems, are not included."[302] In 2015, a Russia-led[303] UNGA resolution on an Arms Ban in Outer Space – 'No first placement of weapons in outer space' (NFP) – acquired 126 yes votes, 4 no votes and 46 abstentions. The NPT was considered an important intermediate measure on the way towards PPWT.[304] Georgia, Israel, Ukraine and the US were the four countries opposed to the draft resolution.

3.3. EU-LED INTERNATIONAL CODE OF CONDUCT FOR OUTER SPACE ACTIVITIES

In 2008, the European Union proposed a draft *International Code of Conduct for space activities* (ICoC) in response to UN General Assembly Resolution 61/75 (2006)[305] and 62/43 (2007),[306] which had invited all members to submit concrete proposals on international outer space TCBMs in the interest of maintaining international peace and security and promoting international cooperation and the prevention of an arms race in outer space. The aim was a voluntary set of principles and guidelines regarding space security matters, such as space debris and the operation of spacecraft or satellites in space. Therefore, the ICoC developed its three principles on the basis of 1) all countries' inherent right to use space for

[300] Statement by Russian Foreign Minister Sergey Lavrov at the Plenary meeting of the Conference on Disarmament, Geneva, February 12th, 2008.
[301] Listner, Michael, and Rajeswari Pillai Rajagopalan, The 2014 PPWT: A new draft but with the same and different problems. *The Space Review*, August 11, 2014. www.thespacereview.com/article/2575/1
[302] Rose, Frank A., 'Continuing Progress on Ensuring the Long-Term Sustainability and Security of the Space Environment', official statement at Conference on Disarmament Plenary, Geneva, June 10th, 2014.
[303] The NFP has 34 countries as co-authors. See UN passes Russian-Proposed Resolution Banning Arms Race in Outer Space. *Sputnik International*, December 4, 2014. http://sputniknews.com/politics/20141204/1015510727.html
[304] Statement by the Representative of the Russian Federation at the 2015 session of the UN Disarmament Commission. April 7th 2015.
[305] UN General Assembly, A/RES/61/75, December 16, 2006.
[306] UN General Assembly, A/RES/62/43, January 8, 2008.

peaceful purposes; 2) protection of security and reliability of space objects in orbit; and 3) consideration for states' legitimate defense interests.

The primary ICoC draft was rejected by most significant space nations including the US, China, Russia, and India, because of the EU decision to keep the ICoC outside the purview of the CD. To respond to such criticism, an argument based on the same institutional approach was given that neither the CD nor the COPUOS has the fully mandated competence to accommodate the request to discuss and negotiate the comprehensive approach of the EU's ICoC.[307] Because of this, a third way could not be unlawful and should even be considered logical. Had the EU made an effort to reach out to all the established spacefaring states, Rajagopalan noted, the impact of the Code could have been different.[308] This view relates to some states demonstrating their concerns regarding a lack of transparency and disappointment about the EU's insufficient consultation with other states.[309] As a result, many Asian and African states objected to "an otherwise acceptable document."[310] Otherwise, most countries saw the ICoC draft as an innocuous measure because it listed a few desirable steps to be taken by states that would ensure the sustainable use of outer space and avoid possible accidental and intentional mishaps.

During 2011-2012, the US Obama administration had debated whether to endorse the EU code, pending a Pentagon assessment as to whether it would have an operational impact on the military's uses of space. Most officials believed that it would not, as its provisions concur with all US space plans and policies. The US and the EU had engaged in four rounds of consultations about the code, after which the EU incorporated suggested US language, such as on the right to self-defense in space. However, in February 2011, thirty-seven Republicans noted that they were "deeply concerned" about the code because inadequate Obama administration briefings led to the mistaken belief that it could constrain missile defenses or ASAT weapons.[311] Ultimately, on February 17, 2012, Hillary Clinton, Secretary of State for the Obama Administration, formally endorsed the code on behalf of the US. Hence, Canada Australia, Japan, India had also endorsed the Code.

Beijing, Moscow and some others[312] kept pointing to the security references in the draft, notably the reference to "self-defence". Russia, China, Thailand, Brazil, Ethiopia, Ukraine and Belarus argued that the ICoC aimed at dealing comprehensively with the issues of the safety and sustainability of the space environment, and that the issues of stability and security in outer space were inadequately developed. In their view, the ICoC actually only deals with "peaceful uses" of outer space, so, a change of ICoC title sounds desirable to an "international code for peaceful uses in space". In parallel, a common African position focused on whether the Code would limit or make it more difficult for those non-spacefaring

[307] Remark made at my First Doctoral Examination Committee Meeting by H.E. Frank Asbeck, the Former Principal Adviser for Space and Security Policy, European External Action Service, European Commission.
[308] Rajagopalan, Rajeswari Pillai, (2016) Chapter 9 The International Code of Conduct and Space Sustainability, in *European Space Policy Institute Yearbook on Space Policy 2014 – The Governance of Space*. Wien: Springer Verlag: 229-241.
[309] Russia, Brazil, China, Bangladesh, India, and numerous Latin American states.
[310] Rajagopalan, Rajeswari Pillai, (2011) "Debate on Space Code of Conduct: An Indian Perspective," ORF Occasional Paper No. 26, Observer Research Foundation, October 2011.
[311] Zenko, Micah, A Code of Conduct for Outer Space, Policy Innovation Memorandum No. 10, Council on Foreign Relations, November 2011.
[312] Also with Indonesia, the Philippines, Thailand, Brazil, Mexico, Venezuela, Sri Lanca and Laos.

states to be part of future space activities, so they asked to improve the ICoC with greater inclusivity. It seems to us, the inclusive-sounding procedural approach remains as idealist and vague as other existing language and terminology repeated in the development path of the entire space security governance dimension, such as "peaceful use" of outer space. The important relative soft force of such constructive argument is unquestionable. It reduces the tension caused by states' security-interest centered stances and facilitates their engagement in bilateral and multilateral dialogues. Nonetheless, it remains doubtful whether the major space states would unconditionally join an inclusive project. Over the course of space governance development, the fulfillment of states' functional necessity, such as nuclear safety concerns, seems more often to have attained its goals so is probably more attractive.

3.4. THE US INTERNATIONAL TRAFFIC IN ARMS REGULATIONS (ITAR)

As a greater number of countries become interested in military space capabilities, acquiring critical know-how and components through international trade to satisfy their national security objectives and their economic interests, this generates dynamics pushing countries strategically to choose their security allies and business partners in international astropolitics. This also creates significant impacts on the global governance of space security. Since the US SDI program opened the doors for American industry to capitalize on space by boosting the US domestic high-tech innovation and productivity to compete with their European and Japanese competitors, the US expanded its export barriers to preserve American leadership and its space capability advantage.

The US created an important export control mechanism that also has impacts on global space security issues. The US International Traffic in Arms Regulations (ITAR), enacted in 1976, was actually a part of the US Munitions List (USML). The ITAR together with the US Arms Control Export Act (ACER) continued the multilateral embargo policy made by the US-led Coordinating Committee for Multilateral Export Controls (CoCoM) to export critical technology toward the Soviet-led Eastern Bloc and China.[313] ITAR governs the transfers of arms and applies to business activities that are far removed from what one might consider to be arms exports. It is not only applicable to the activities to sending or taking any ITAR-controlled commodities or information out of the US territory but also the transfers of ITAR listed commodities or information to non-US employees of US companies. In particular, ITAR has extraterritorial applicability over a listed commodity of information wherever it is located in the world. As a result, transfers of the commodity or data outside of the US also require prior State Department approval.

In consequence, ITAR has been an efficient instrument to preserve the US arms and space-tech leadership and military space power vis-à-vis the Soviet Bloc countries in the past, and nowadays Russia and China. China has been and still is an ITAR-listed country under a sat-tech embargo since China was found to be receiving technical data from US satellite manufacturers. After the latest China-US Joint Commission for Commerce and Trade in 2012, the Chinese government press agency Xinhua criticized Washington for breaking its own

[313] Congress of the United States, Office of Technology Assessment, (1979) Chapter VII Multilateral Export Control Policy: The Coordinating Committee (CoCom), In *Technology and East-West Trade*. p153-172.

pledge on Sino-American partnership by upholding restrictions on satellite exports to China while relaxing them for other countries.[314] Nonetheless, it has also created disadvantages for the US and NATO allies and for the American companies when it comes to the export of satellites and satellite components.[315] For example, the EU Galileo navigation system, promoted as an alternative to the US GPS service, is not entirely free of US regulatory authority since it includes US-built subsystems.

ITAR also has perverse impacts on US international cooperation and global space cooperation for civilian purposes. A France-China cooperation project in space-based astronomy and biomedical research has been slowed by continual US redefinition of what is and what is not allowed for export to China.[316] In 2014, the US Government finalized a draft regulation that removes some satellite hardware and technology from the USML as well as from ITAR. Nevertheless, exports of space-related items to China and certain other countries remain barred. European industries that need to sell telecommunications and Earth observation satellites independent of US technology could not escape from the US ITAR even if technology made in Europe is intended for their companies.[317]

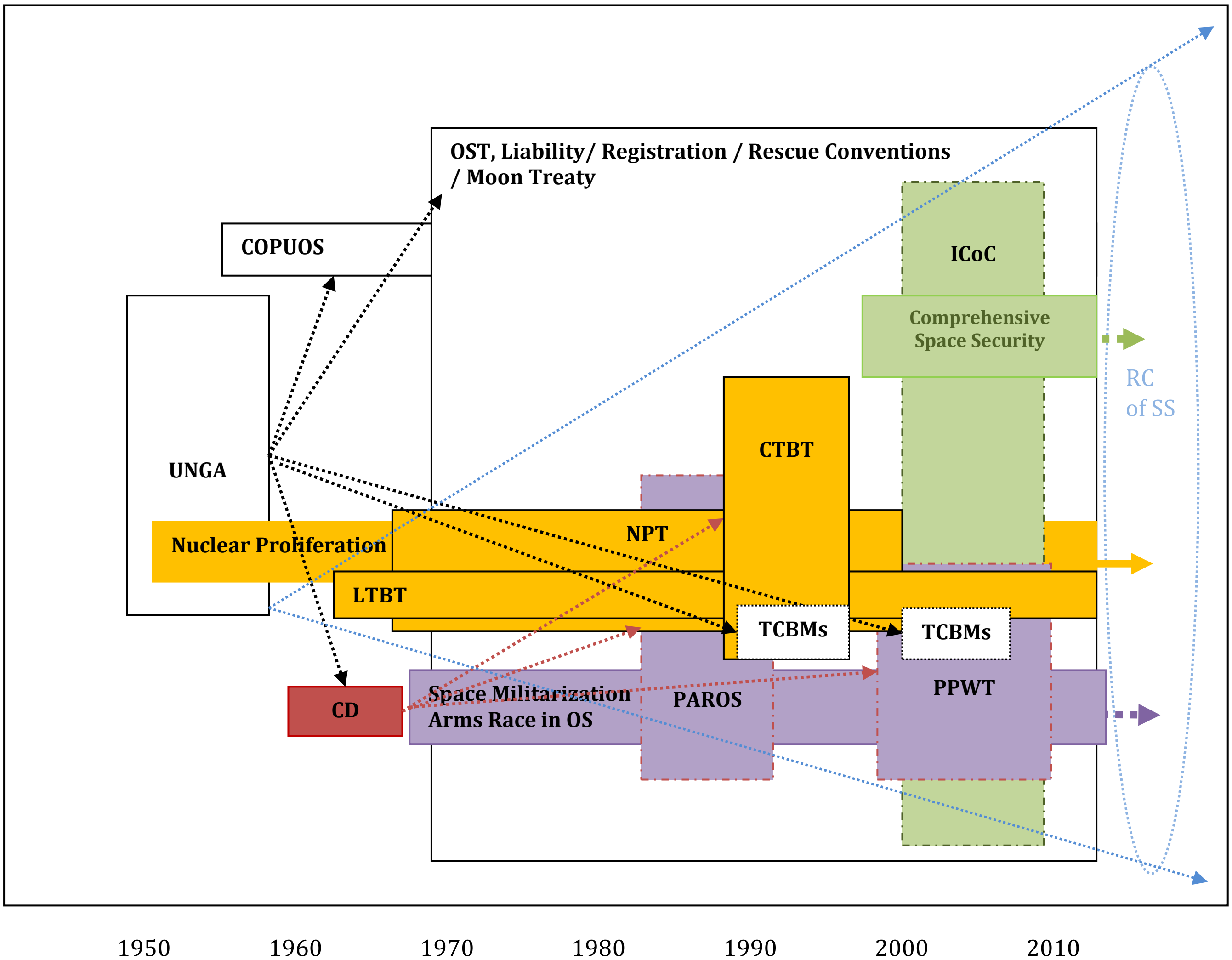
To sum up, Figure 10 offers a visual overview of the expansion and fragmentation of the space security institutional architecture. In this evolution, space security governing institutional architecture was firstly split up between the UN (covered by blue cone with dashed frame at the top) and non-UN dimension, the Conference on Disarmament. In the non-UN dimension, it was the issue area on nuclear proliferation (yellow zone) viewed with the mostly successful regime institutionalization, such as the 1963 Partial Test Ban Treaty (LTBT), and the 1967 Nuclear Proliferation Treaty (despite the failure in 2003), and the 1996 Comprehensive Test ban Treaty (CTBT). The institutionalization of these regimes (framed with solid line) almost followed a step-by-step move to gradually complete the goal of ending nuclear proliferation.

By contrast, the less successful is on the issue area of preventing an arms race in outer space (purple zone). States continuously attempted to propose various initiatives in order to update the outdated exiting regime, i.e. the OST, to prohibit either ASAT weapons, or placement of weapon in space. PAROS was 1985-1994 (framed with dashed line), which was bound to the CTBT-FMCT-PAROS package deal. From the late 1990s, other Russia-China sponsored PPWT (also with dashed line) continued their goal of prohibiting the placement of weapons in space. The EU started another pillar of space security discussion over a comprehensive approach elaborating security, safety and sustainability. The UN also had initiated twice to request the TCBMs (white rectangles) policy recommendations without concrete following actions afterwards. All in all, in addition to the regime complex

[314] *Xinhua News*, China Voice: Cold War mentality fuels U.S. satellite export prejudice by Wang Aihua, Gui Tao. http://news.xinhuanet.com/english/china/2013-01/08/c_132088119.htm
[315] *The Space Review*, Key Space Issues for 2013 by Jeff Foust, December 31, 2012. www.thespacereview.com/article/2211/1
[316] *Space News*, U.S. Export Rules Complicate Sino-French Cooperation by Peter B. de Selding, Sep. 18th 2014. www.spacenews.com/article/civil-space/41907/us-export-rules-complicate-sino-french-cooperation
[317] *Space News*, U.S. Satellite Export Regs Remain a Frustration for European Industry by Peter B. de Selding, Feb. 7th 2014. www.spacenews.com/article/satellite-telecom/39414us-satellite-export-regs-remain-a-frustration-for-european-industry ; *Space News*, European Satellite Still Heavily Dependent on U.S. parts by Peter B. de Selding, January 29th 2015. http://spacenews.com/european-satellite-still-heavily-dependent-on-u-s-parts/

that consists of all general international regimes related to space issues discussed in Chapter II, and Chapter III, the (sub-)regime complex of space security governance (RC of SS) gradually got its form, in the lines with all the regime institutionalization initiatives with similar general goals yet distinguished by their different issue focuses according to the proposal sponsoring states' security and interest centered calculations.

Figure 10. The Regime complex of space security governance



Source: Author's creation

4. THE DRIVING FORCES OF THE SPACE SECURITY REGIME COMPLEX FORMATION

We have seen from the above historical overview that despite all attempts to create international regimes to reduce tension by either banning "militarization", "weaponization" of outer space, or by constructively proposing transparency and confidence-building measures, hostility and competition between a few spacefaring states have brought the architecture of global space security governance to its current fragmented form summarized as a regime complex. The 'regime complex' refers to "*an array of partially* *overlapping and non-hierarchical institutions governing a particular issue-area* (Raustiala and Victor 2004: 279)[318] or more completely, as "a *network of three or more international regimes that relate to a common subject matter; [that]exhibit[s] overlapping membership; and generate[s] substantive, normative, or operative interactions recognized as potentially problematic whether or not they are managed effectively* (Orsini et al. 2013:29).[319]

The GIIS colleagues proposed that the intricate morphogenesis of such a regime complex is generally cross-formed by strategic, functional and organizational driving forces over time. First of all, states are motivated to create or to choose to join certain international regimes to fulfill their pursuit of power, leadership and interest, rather than to pursue the common interest. Hence, states create new international regimes, or reform or sometimes desert existing multilateral institutions with the attempts to align or convert the functions of these international regimes to their power stance and national interests.[320] The *strategic logic* of *interest attribution* leads states to create or choose particular international regimes through which they maximize their own advantages and achieve their own policy agenda. Secondly, states equally select the issue areas in which they possess a dominant capability position and so gain greater weight to influence the rulemaking in these governing issue areas.[321] The *issue linkage* is noted as the *functional driving force* that stimulates states desire for regime change. Thirdly, the different structural and relational frameworks of international regimes on their membership, policy decision-making process through secretary agenda making and voting procedure subsequently turned to *organizational burdens* that do not only limit the individual state's margin of manoeuver to influence the institutional choices toward their preferences so as *path dependence*, but also affect the regime interplay when common issue brought different regimes to compete, cooperate or coordinate with each other. These different driving forces intersected in the construction course of the space governance architecture and fragmented the entire structure with *legal inconsistence* in the governing principles and norms as shown in Chapter III, and the regime interplay, e.g. the *nested*, *overlapping* and *parallel* regimes in this chapter.

In addition, we note that *innovation* played a particular role in the realm of space governance, perhaps not as a general driving force but a particular enabling force that reinforced the three intersected driving forces to accelerate the fragmentation of the space governance architecture. This enabling force was intentionally suppressed by the two space powers during the Cold War but became evident when the emerging space nations (again) arose. The innovation can be viewed in its material, e.g. space capability, and its immaterial sense, e.g. moral pressure. The innovation force resulted in the popularization of space capability development and liberalization of space economy especially led by Asian countries like China, India, South Korea, and Taiwan, and Arabic states, e.g. United Arab Emirates, hence injected new factors and created new challenges which did not previously exist in the governance realm. The innovation by generating moral pressure, e.g. the "peaceful use", the "special regards toward developing countries", and "space sustainability" were good examples. The innovation enabling force is different from the three discerned compelling forces that states were passively acted and reacted to the situation and the

[318] Raustiala, Kal & Victor, David. *Op.cit.*
[319] Orsini, Armandine, Morin, Jean-Frédéric and Young, Oran. Regime Complexes: A Buzz, a Boom, or a Boost for Global Governance. *Global Governance 19* (2013): 27-39.
[320] Simon, Herbert A. (1982) *Models of Bounded Rationality*. Cambridge, MA: MIT Press.
[321] Keohane, Robert O.. *Op.cit.*

momentum within the existing political, legal and social-economic framework. Innovation enabling force is bring in active choices that innovating states introduced themselves as new actors with new concepts that offered leverage for them to change the rules and naturally created new governance challenges into the realm of space governance. In consequence, it also stimulated and accelerated regime changes, so fragmented the governance architecture.

4.1. STATES' STRATEGIC DISPERSION IN DIFFERENT SPACE SECURITY REGIMES

Countries pursue their relative power and individual interests when deciding to create or enter different space security regimes where they tried to steer the design and the functions of any interested international regimes in favor of their leverage power, or choose the moment of entrance to these international regimes that most suits their interests.

Along the evolution path of nuclear proliferation governance building, the USSR and the US only signed the LTBT (1963) after they had both exhausted all their tests of nuclear weapons in space to understand the effectiveness and cost-effect benefits of such powerful weapons. However, the LTBT preserved some leeway by not prohibiting underground nuclear testing, enabling the P-5 nuclear powers to continue their nuclear power capability leadership. This only changed when another international regime, the Non-Proliferation Treaty (1967), opened decision-making powers in global nuclear governance to the rest of the world.[322] Likewise, multilateral debate and bilateral negotiations regarding space weapons only started in the late 1960s after the US and the Soviet Union had tested their first anti-satellite system in 1959 and 1968 respectively.[323] The different interpretations of the "peaceful use" of outer space between the American version and the Soviet provide another vivid example. Each interpretation led the respective camps to continuously proposed regime creation initiatives to prohibit "militarize" in avoidance an arms race in outer space or "weaponize" outer space with placement of "weapons" in outer space. More recently, China became interested in a PAROS in the 1990s because that was when the US was imposing limits on Chinese strategic nuclear capabilities. After the failure of the PAROS attempt came the Russia-China co-sponsored PPWT initiative and the EU-led ICoC proposal, the former motivated by the Russia-China coalition to restrain US space power, and the latter based on the new strategy of the European Union to gain more space autonomy and to explore the EU's space diplomacy. In the eyes of many, none of these strategic actions was considered feasible to consolidate unanimity of global space security governance, but exacerbated the fragmentation of the space security regime complex over time.

4.2. THE FUNCTIONAL ISSUE-LINKAGE TO MEET STATES' INTERESTS

[322] Lele, Ajey (2013) Effective mechanisms for space security. *The Space Review*, May 28, 2013. www.thespacereview.com/article/2301/1

[323] Jasani, Bhupendra (Ed.) (1987) *Space Weapons and International Security – The Arms Control Dilemma*. Oxford: Oxford University Press.

The broad ranges and the growing diversity of the military, civil and commercial uses of outer space have confronted states with political, technical and sustainability issues related to space security. They are forced to look for collective rules and solutions for necessity. Nevertheless, states often tactically put forward their favorite and downplayed their undesired issues in order to advance or slow the negotiation. Hence, numerous functional international regimes, imperfect as they are, are constantly created, modified, or abandoned over time in order to meet the interests and needs of collective or particular groups of states.

The tactical issue linkage of the troika which aimed to make a package deal on PAROS, CTBT and FMCT at the CD at the same time showed that, concluding such packaged deal of three issues sounded legitimate and good for all parties. Nevertheless, states all proposed their own version of linkages to hold their political stance. The Western CTBT and FMCT and the Russia-China sponsored PAROSUS were put together as a sine qua non package deal. These issue linkages failed in the end because they met neither China's own strategic interest, nor that of two other mutually hostile countries, India and Pakistan. The two hostile countries equally tried to make their own sine qua non issue-linkage by attaching their deal to China's decision. Ultimately, the CTBT was concluded on paper, but with no chance of having concrete effects in reality. The PAROS failed and even triggered more initiatives, such as PPWT, to negotiate new deals in similar fields. Making particularly focused sectorial arrangements seemed a circuitous tactic to overcome entrenched positions, yet subsequently all the sectorial negotiations will still turn back to its conflicting origins that cannot accelerate any progress but rather create even more interconnected issue areas. The seemingly successful deals all failed to meet their initial goals and generated architectural fragmentation that spilt over between two regime constellations of space and nuclear proliferation.

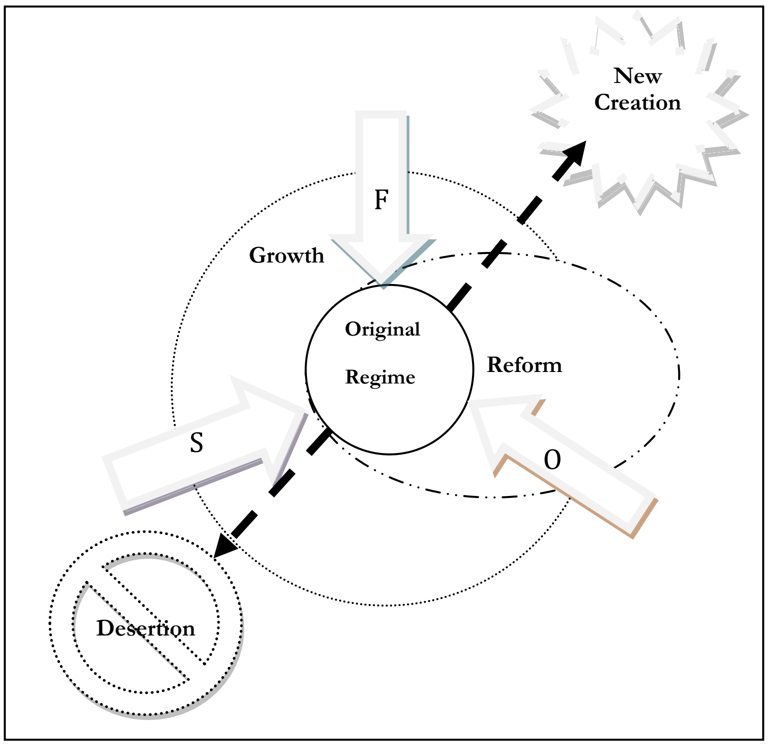
4.3. ORGANIZATIONAL PATH-DEPENDENCE LIMITS INSTITUTIONAL CHOICES

The *specialization* and *decentralization* method that discharged the UNGA mandates toward the non-UN international forums, such as the Conference on Disarmament (CD), to negotiate space security relevant issues was based on the rationale of professionalization and burden sharing in order to make the entire deal successful. Yet, these practices equally created organizational constraints and triggered the fragmentation of the entire governance constellation.

The specialization and decentralization practices often faced the hurdles caused from the differences of managerial cultures, bureaucratic structures and decision-making procedures between different international space security regimes. Hence, there is no guarantee for the success of the entire global space security governance. The failure for a cap deal of CTBT and a specialized PAROS at the CD demonstrate these patterns. The UNGA discharged the space arms race prevention negotiation to the Conference for Disarmament, a smaller international forum than the UNGA. The 65 member states of the CD continued to discharge the overarching CTBT negotiation into a PAROS and the other two focused deals. The consensus decision-making procedure of the CD led to no resolution because every member state has simply the veto power to delay one deal and then stop the other deal. The PAROS failure led the space security governance toward a greater fragmentation with the appearance of the other tactical proposals, such as TCBMs, and the ICoC.

We use Figure 11 to sum up the point that it was commonplace that the intersecting strategic (S), functional (F), and organizational (O) driving forces jointly twisted a space security regime to its creation, growth, reform, or desertion, and stimulates the creation of a new regime since it can no longer fulfill some influential states' expectation or desires. The single case became multiplied as we have demonstrated in the morphogenesis of the space security regime complex over time. By accumulating the transformations of multiple individual space security relevant regimes, it thrust the space security governance architecture toward its regime complex.

Figure 11. The three intersecting driving forces thrust an individual regime to change



Author's creation

5. CONCLUDING REMARKS & POLICY RECOMMENDATIONS

The strategic-mindset-led space security regime complex

We have presented an overview of the different degree of space security capability and their strategic stances of four major space powers alongside the entire evolutionary path of space security governance construction. In the course of the global space security governance formation, various international regimes were proposed, created, grew, improved, or failed. In this process, states, and especially space powers played the vital roles which alone or collectively influenced the way a space security regime could become based on their strategic calculation and functional interests. The United States and the Soviet Union straight away internationalized the space security issue by promoting the peaceful use of outer space but actually in order to limit each other's military space capability development. However, those disarmament agreements were often concluded only when the two space powers have accomplished their technical assessment on the cost-effect value of their space weapons. Otherwise, no concrete regulating agreement could be accomplished. Afterward, many of these established space security relevant regimes have a lack of effective verification and disinclining measures to constraint states outlaw behaviors. Because the applications of these international rules could only depend on the good will of states, when there were more states that possessed mature space capability, they started seeking ways to fix the imperfection of the existing regimes by either reforming them, involving other established space security regimes to complement the missing measures, or simply creating a new regime to fix all the problems at once. Subsequently, these old and new regimes and initiatives expanded and fragmented the entire space security regime governance architecture to its current complicated form as a regime complex. This complexity in form should not be destructive. It can be constructive if this regime complex can be better managed through the method of an intelligent labor division according to individual state's space capability and regional particular necessities. Yet, in our opinion, there exist more fundamental issues about the space security regime complex that are needed to be solved with a long-term strategy.

Further openness in popularizing space security capability

Retrospectively, one aspect of the strategic thinking regarding the US *SDI* (Star Wars) was to engage the Soviets in a costly space arms race that would bankrupt the Soviet economy. As a defense strategy it was not successful but it was beneficial in the domestic realm by giving a boost to the US space aeronautic and astronautic industries and space tech exportation. In such a game for two, states' strategic calculations actually hardly worked out in the real situation. The long existing space security oligarchy was compelled to open to China, the EU, and others. With more critical mass, governance became complex and probably also less effective to endure. In this context, it is important to not close the door of engaging more key space actors into the rulemaking but involve all interested states to learn together about to-do and not-to-do by all, even with the power and interest centered mindset. Only by letting all actors realize that space activities were becoming physically congested, contested, and competitive, is it possible to avoid selfish acts and omissions that would generate lose-lose consequences for all.

CHAPTER VI REGIME COMPLEX OF GNSS GOVERNANCE

Abstract: Harmonizing the interoperability and compatibility between different existing and future global navigation satellite systems (GNSSs) is one of the most challenging governance issues nowadays. The GNSSs highlight the ambiguity of governing the dual-use of outer space since existing and future GNSSs are and will be almost all military-operated but are already widely employed for civilian purposes, e.g. land, sea and air navigation, search and rescue, and economic activities "from farming to banking". Furthermore, the ubiquitous uses have brought GNSS governance to overarch different governance issue areas, namely security, safety and trade, which has led to the creation of a new specialized regime, the International Committee on GNSSs (ICG) to harmonize inter-GNSSs interoperability and compatibility issues. It also naturally involved other existing international regimes, such as ITU, ICAO, IMO, and WTO, to only resolve some part of the various problematic issues. Nonetheless, in many respects, GNSS provider states remain autonomous to negotiate bilateral arrangement between them to reduce technical conflicts. In this regard, the case of GNSS governance is valuable for its representativeness, providing a microcosm through which we can observe how the three driving forces thrust this sectoral governance architecture got extended and gradually fragmented.

We will introduce four existing and future GNSSs, including the regional navigation satellite systems and their service provider states to illustrate the international GNSSs politics landscape. Afterwards, we look at the key governing challenges of GNSS governance, such as (1) the general space resource scarcity on satellite orbital slots and radio frequency attribution that physically impacted on the frequency overlay between the four GNSSs' governmental only, mainly for military and other sensitive services. (2) The continuity of GNSS services remains critical for security and safety utilities. They are vital to provide a continuous global and positioning navigation, and timing (PNT) service for coordinating military operations, search and rescue, and for land, sea and air traffic controls. (3) In the socio-economic realm, since the GNSSs became ubiquitous and indispensible in many public policy areas, developing countries should be enjoying the GNSS services offered by different GNSS service providers. Nonetheless, these distinct systems should be integrated, interoperable and compatible. (4) The institutional spillover from the global space governance to international trade governance is caused by the commercial competition that service provider states and their downstream manufactured products probe impeding inter-GNSSs interoperability and compatibility in order to protect their distinct markets and economic interests. Technical trade barriers or discriminatory market access measures to prevent foreign GNSS services and products to enter the national market were often set. So, GNSSs also became a trade-related governing issue. Finally, we are interested in exploring the main driving forces that thrust the entire GNSS governance toward its fragmented complex form. With our analytical method, we investigate that both spacefaring and non-spacefaring countries were stimulated to join in and became involved with their traditional allies and short-term business partners to gain issue linkages in order to fulfill their strategic interests and functional necessities. The regime interplay within the space governance ITU-ICG, safety regimes ICG-ICAO-IMO, and ICG-WTO trade regime will also be discussed.

1. INTRODUCTION

The utilities of GNSSs, far different from spacefaring-nations-led space exploration projects, such as the ISS or Moon and Mars exploration or comet landings, are physically valuable for most states and populations. GNSSs provide ubiquitous services not only for the military missions that were originally stressed, but also for land, sea, and air navigation and traffic control, for search and rescue safety operations, piloting farmers' tractors for cultivating their land, tracking cattle in remote areas, and synchronizing international financial operations across different time zones with the inbuilt atomic clocks in the GNSS satellites, often *from farming to banking*.

The GNSS technology and applications were developed already from the 1960s by the US navy for military purposes. In the late 1980s, the US decided to open the world's first Global Positioning System (GPS) service for civilian use. Nowadays, the number of the current and future GNSSs and regional navigation satellite systems (RNSSs) has grown from the US GPS to add others, the Russian GLONASS, Chinese BeiDou and European Galileo. The three latter GNSSs are expected to achieve their full operational capability (FOC) by 2020. Besides, there were regional augmentation systems as well, such as the European EGNOS, Japan's QZSS and India's IRNSS, which were originally complementary to the extant GNSSs, gradually became autonomous regional satellite navigation systems (RNSSs). The GNSS is a space system consisting of segments of space-based satellites, ground stations and end users. The space system agglomerates all ranges of fundamental and cutting-edge space technologies to provide applications for telecommunications, navigation, accurate timing, and high-resolution remote sensing services for military operations. The reason there is not one world GNSS that coordinates different regional supportive systems but multiple autonomous GNSSs is not technical but political. Because apart from the functional advantages of GNSS for safety and development, the GNSS has become a vital support instrument for states' military operations, and an enabling tool to generate advantages for national space capability development, a high-tech manufacturing ability that creates GNSS-related commerce. Hence, spacefaring nations are all vying for their own autonomous global or regional GNSSs. As for the user countries, they seemed to enjoy multiple choices for the best fit for their interest.

To operate any single GNSS constellation to its FOC without discontinuity requires about 20 satellites or more. This naturally put the fundamental question of space resource scarcity on the limited satellite orbital slots and their related radio frequency more evident. To this, service provider states can reshuffle their own space systems' satellite constellations or ought to negotiate with other countries for technically adequate orbital slots and satellite frequency to their entire GNSS satellites constellation. Secondly, the GNSS service providers have been reluctant with regard to safety-focused and development-oriented inter-GNSSs interoperability and compatibility policy out of concerns for system independence and commercial interest. This has made it difficult to establish universal equipment standards and common operational rules for all GNSSs. This problem not only divides GNSS service providers but also places burdens on GNSS users when selecting their GNSS service provider(s) and production partners due to the system exclusivity. The interoperability and compatibility issues are naturally related to the trade disputes in which some counties have established national market barriers to impede undesirable foreign GNSSs products and services. To solve this challenge, states are forming regional and international trading blocs for GNSS products and services.

To better harmonize the military-controlled GNSSs that are largely used for civilian and commercial ends, the UN International Committee on Global Navigation Systems (ICG) was created in 2005 to promote and harmonize inter-GNSS interoperability and compatibility issues so as to arrive at the best outcome for development objectives. The establishment of the ICG was in response to the goals defined at the Third UN Conference on the Exploration and Peaceful uses of Outer Space (UNISPACE III) in 1999, the UN General Assembly endorsed "The Millennium: Vienna Declaration on Space and Human Development" with which the UN called for enabling space technology proving PNT services. Since then, in spite of its origin and heavy relevance to security and military uses, the GNSS governance architecture was founded in the governing dimension where safety, socio-economic pillars are the most important. Furthermore, various international regimes become relevant to GNSS governance international regimes.

Naturally, the OST and other international space treaties and the UN space-related multilateral forum and specialized agencies, such as the COPUOS, are connected with GNSS governance. Other more specific issues were dispersed to be handled within other UN specialized agencies, such as the International Telecommunication Union (ITU) for allocating satellite orbital slots and radio frequency and preventing satellite frequency interference issues. The International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) were required to guarantee the safety for GNSS-related aviation and maritime navigation by establishing specific equipment standards and operational regulations. The World Trade Organization (WTO) is expected by some to limit discriminatory access of national markets for GNSS-related trade. Others are developing regional GNSS augmentation systems to acquire necessary technology transfer from the global service provider, develop domestic manufacturing capabilities and commerce, conquer regional markets for GNSS-related products and services, and to resist Western-led global trade mechanisms. This can be regarded as space regionalization.[324] The regional powers and their security alliances, such as the North Atlantic Treaty Organization (NATO), regional space cooperation regimes, *e.g.* the European Community (EC) and European Space Agency (ESA), the Eurasian Economic Union (EEU) and the Silk Road Economic Belt (SREB), the China-led Asia-Pacific Space Organization (APSCO), and the Japan-led Asia Pacific Regional Space Agency Forum (APRSAF) have been developed to attain these goals. International groups such as BRICs have also been created or utilized for similar purposes.

The new GNSS-focused international regime creations and the functional shifts of existing GNSS-related regimes thrust the entire GNSS regimes constellation to a continuous expansion and growing fragmentation, viewed as a *regime complex*.[325] This GNSSs regime

[324] Liao, L.W. Xavier, (2015). The Growing Space Regionalization of the Global Space Regime Complex, *The Aviation & Space Journal XIV* (January/March 2015) (1): 23-34; (forthcoming in 2016). The Space Regionalization and Global Space Governance, in *ESPI Yearbook of Space Policy 2014* (Eds.) Peter Hulsroj and Arne Lahcen. Wien/New York: Springer. p187-198.
[325] Raustiala, Kal and Victor, David (2004). The Regime Complex for Plant Generic Resources. *International Organization 58* (2): 277-309.

complex was, as noted above, generally driven to imperfection by three intersecting strategic, functional and organizational forces;[326] likewise for GNSS governance.

In the following sections, we study the global GNSSs regime complex by first introducing the key actors, the four global GNSSs 'service providers' and three regional augmentation systems by presenting their respective technical capabilities and political motivations in a nutshell. Further, we look at the key governing challenges regarding GNSS governance. They are about 1) the general problem regarding the satellite slots and relevant satellite radio frequency allocations, and particularly the encrypted GNSS signal frequency overlay among several GNSSs services. The issue is directly related to the guarantee of continuous GNSSs services for states national security and safety utilities. 2) The interoperability and compatibility of GNSSs are not only important for security and safety but also for national capability autonomy. They are vital to provide a continuous global GNSS service for the traffic controls of civil aviation and maritime transportation. In addition, the issues are beneficial for the developing countries to not be cornered by one single GNSS but enjoy an interoperable and compatible integrated multiple GNSSs service so as to improve daily life for their nation and their people. 3) Economically, the GNSS service providers and their downstream product manufactures seem to impede the inter-GNSSs interoperability and compatibility solutions in order to protect their distinct markets and economic interests. Therefore, trade barriers or discriminatory market access measures that make it harder for foreign GNSS services and products to enter the national market have often been instituted. Finally, we attempt to analyze the intersecting dynamics that over time drive the entire GNSS governance architecture toward regime complex status.

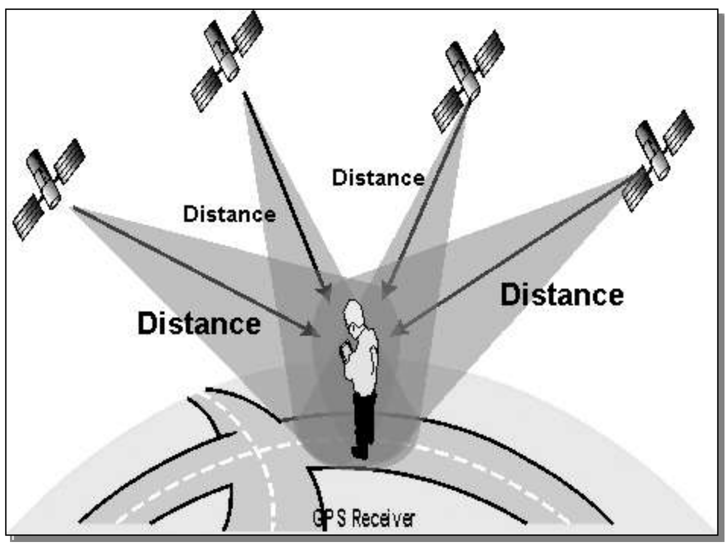
Furthermore, we explore the main driving forces that thrust the entire GNSS governance architecture toward a complex and fragmented form with the "three driving forces" analytical model. In this, ambitious states were motivated to build their leverage power by creating institutions under their own lead or choosing the most convenient moment to be part of an international regime. Both spacefaring and non-spacefaring countries sought to involve and support their traditional allies and short-term business partners by expanding governance issue linkages in order to serve their strategic interests and functional necessities. Once states are bounded by international regimes, many would try to steer the organizational structure and decision-making procedure of these international regimes in their favor, either to safeguard existing advantages, or to gain more leverage by growing their influence within these multilateral governing mechanisms. The framing practices would nevertheless elicit counter-reactions that continuously adjusted the institutional development path closer or away from its ideal development route, creating organizational burdens or path dependency. We also address a few fragmenting processes in regime change, e.g. the creation of the ICG, and regime interplay between ICG, WTO and the new role played by the regional space cooperation platforms.

[326] Lesage, Dries (2013). The Architecture of International Monetary and Financial Governance. In *Routledge Handbook of international organization. Routledge Handbooks*. pp.486-498. Van de Graaf, Thijs (2013). *The Politics and Institutions of Global Energy Governance*. Basingstoke: Palgrave Macmillan.

2.1. GLOBAL NAVIGATION SATELLITE SYSTEMS AND ASTROPOLITICS

The technical basis of a global navigation satellite system (GNSS) is a satellite positioning constellation of at least four orbiting satellites which constantly measure the distance between our positions to the locations of those satellites in order to calculate our position's coordinates of latitude, longitude, and altitude at any given moment (see Figure 12). Further with an American ground-breaking engineering invention that uses space-based atomic clocks to synchronize the position data through extremely precise timing signals with an error of one billionth of second – a nanosecond – equals about one foot of error on the ground[327] to the ground stations, GNSS can hence provide an integrated position, navigation and timing (PNT) data services.

Figure 12. Global navigation satellite system operation diagram



Source: www.wirelessdictionary.com

The US was the first state in the world to develop a global, all-weather, continuously available, highly accurate positioning and navigation system for locating ballistic missiles, submarines and other ships at sea in the 1970s. From 1982, the Soviet Union became the second nation to start developing its own global navigation satellite system (GLONASS) to counter the US military PNT service. In 1983, Korean Airlines Flight 007 was shot down because it had strayed into Soviet airspace. As a result, President Reagan promised to make the American GPS Standard Positioning Service available to the worldwide aviation sector when the GPS attained its Full Operation Capability (FOC) by 1988. The White House kept the GPS Selected Positioning Service exclusively for its own military and security uses. Only

[327] Easton, Richard D. and Frazier, Eric F. (2013) *GPS Declassified: From Smart Bombs to Smartphones*, University of Nebraska Press: Potomac Books.

in 1991 did Washington announce the fulfillment of its promise at the Tenth Air navigation Congress of the International Civil Aviation Organization (ICAO). At the same time, the 1991 Persian Gulf War showed the magnitude of US GPS-supported military combat operations, sparking a global enthusiasm for these sophisticated technologies and their applications. Within a few years, other ambitious spacefaring nations, such as the member states of the European Union and the European Space Agency, and China, began to develop their own GNSSs, namely the European Galileo and Chinese BeiDou (or Compass) systems. Other regional augmentation systems – the European Geostationary Navigation Overlay Service (EGNOS), the Japanese Quasi-Zenith Satellite System (QZSS) – were built to complement and be compatible with the US GPS. India began to develop its own regional navigation satellite system (IRNSS), intended to be compatible with GPS, GLONASS and Galileo to improve the reliability and accuracy of the positioning data for each system. The applications and services of the GNSS became popular for thousands of civilian purposes, for example for search and rescue, aviation and maritime safety and traffic control, for farming, distance education, e-health care and e-banking for remote areas, as well as for the urban economy, e.g. Uber, and also for environmental monitoring and protection. The hybrid utilities for both military and civilian purposes, or in other words peaceful use, of the GNSSs triggered continuous discussions about how to regulate such a popular dual use of space capabilities.

2.2. DIFFERENT GNSSS AND RNSSS IN THE WORLD

The multiplication of these global and regional navigation satellite systems has created congestion, competition, and contests in the arenas of global GNSS astropolitics, space capabilities building, and markets for GNSS-related products and service. Below we will present a general picture of the different GNSS and RNSS service providers that are all vying for strategic position, and dual-use space capability development, as well as their global and regional coverage and business market expansion. Each keeps trying to involve partnerships among their traditional and security allies and neighboring regional cooperation organizations in order to maximize the use of their GNSSs and RNSSs.

2.2.1. THE US GLOBAL POSITIONING SYSTEM (GPS)

The US was the first state in the world to develop a satellite global position system. From the early 1960s, the US Department of Defense (DoD) started to develop a global, all-weather, continuously available, highly accurate positioning and navigation system. The project was to meet the US Navy's requirement for locating adversary ballistic missile, submarines and other ship at the ocean's surface.[328] By the late 1960s, the US Air Force (USAF) joined the venture to improve the Navy's PNT system. In 1981, the US Department of Defense, which responded to the Federal Aviation Administration (FAA) request, opened the use of a "civilian" signal outside the US.[329] After the 1983 downing of the Korean Airline

[328] Pace et al. (1995) *The Global Positioning System: Assessing National Policies*, Santa Monica: RAND: iii.
[329] F.R. 20724, April 7, 1981. Notice by the Secretary of Defense re NAVSAT GPS Navigation Satellite Systems Status. Pace et al. (1995) *The Global Positioning System: Assessing National Policies*, Santa Monica: RAND. p180.

flight, President Reagan inaugurated the GPS dual-use to the civil aviation community. In the course of 1987-1988, the GPS reached its full operational capability (FOC).

The longstanding development of the American military-use GPS attained its full flowering during Operation Desert Storm in the 1990-91 Persian Gulf War. The American satellite PNT services were widely employed in combat situations on the ground and in the air, and hence continued to serve the military and peacekeeping operations of the US and its allies, or the military and civil dual-purpose operations. During the Balkan crisis in the 1990s, GPS assisted in delivering aid to the Bosnians by dropping troops, food and medicine at night.[330] During Operation Restore Hope in 1993, GPS was used by the US army to airdrop food and supplies to remote areas of Somalia due to a lack of accurate maps and ground-based navigation facilities. The US forces relied on GPS when entering Haiti in 1994. In 1995, as the GPS achieved its FOC, President Clinton confirmed the US commitment to provide GPS signals for international civilian use at an ICAO meeting in Montreal.[331] In 1996, Washington pledged to provide GPS "for peaceful civil, commercial and scientific use on a continuous worldwide basis, free of direct user fees."[332] In the year 2000, President Clinton announced that civilians could have more access to the new GPS technologies utilizing the one-time DoD navigation system – with the degradation feature Selective Availability (SA).[333]

Nowadays, the US GPS is used for all sorts of purposes, from complex military operations down to how athletes train. According to the US GPS Agency, there are four million GPS-enabled devices worldwide, a number that is expected to double by 2020.[334] As of 2015, the second-generation GPS system (GPS II) had been in service for two decades already. The US Air Force is preparing the Third Generation GPS system (GPS III), which is expected to provide improved anti-jamming capabilities as well as improved accuracy for precision navigation and timing. Completion of GPSIII was foreseen for 2018, but in 2015 a delay was announced extending release until 2021,[335] to start incorporating the common L1C signal which is compatible with the European Galileo global navigation satellite system and complements current GPS services with the additional new civil and military signals.

2.2.2. THE GLONASS OF THE SOVIET UNION AND RUSSIA

In 1982, four and half years after the first GPS prototype satellite went into orbit, the Soviet Union launched the first satellite of its own Globalnaya Navigazionnaya Sputnikovaya Sistema or Global Navigation Satellite System (GLONASS).[336] The GLONASS constellation was completed in 1995 and is operated by the Russian Aerospace Defense Forces. GLONASS is considered a Russian version of GPS, with a 24-satellite constellation covering the same area as the 31 GPS satellites.[337] In terms of accuracy, GLONASS outperforms GPS in northern

[330] Pace et al. (1995) The Global Positioning System: Assessing National Policies, Santa Monica: RAND.
[331] Bill Clinton, President of the United States, letter to the International Civil Aviation Organization, March 16, 1995.
[332] The White House, Office of Science and Technology Policy, "US Global Positioning System."
[333] Public Papers of the President of the United States: William Clinton, Washington D.C.: United States Government Printing Office.
[334] *GPS Daily*, Global Positioning System: A Generation of Service to the World, by Mike Slater, July 03, 2015.
[335] *Space News*, GPS3 Ground Segment faces Two More Years of Delay, by Mike Gruss, December 10, 2015.
[336] Kleusberg, Alfred (1990) Comparing GPS and GLONASS, *GPS World* (Nov/Dec 1990).
[337] *Sputnik International*, Russia's GLONASS Proves More Than a Match for America's GPS, July 14, 2015.

latitudes, as it was originally developed for northern latitudes, unlike the US GPS, which was developed for southern latitudes.

After a capacity decline due to lack of steady political support and sufficient financial means in Russia since the later 1990s, the restoration of GLONASS has now again become a priority for the Kremlin. Moscow is currently pushing GLONASS to penetrate into the commercial markets mostly occupied by GPS services, in particular before the European Galileo attains its FOC foreseen by 2020. President Putin substantially increased GLONASS funding from 2001. To accelerate its FOC achievement, Russia, in the course of 2014-2015, convinced Brazil,[338] China,[339] Iran,[340] and Nicaragua,[341] as well as members of the Eurasia Economic Union, namely Kazakhstan and Belarus,[342] to host Russian GLONASS ground stations in their territories. Israel was approached to host a Russian GNSS ground station under an Israel-Russia cooperation framework.[343] Other countries, such as India[344] and Mexico,[345] have expressed their interest in cooperating with Moscow. Up to 2015, the GLONASS network consisted of 28 satellites, allowing real-time positioning and speed data for surface, sea and airborne objects around the globe. From the end-user side, up to 151 smart phone manufacturers, including Apple, Samsung, HTC, Motorola, Sony, and Nokia, among others, are reported to be GLONASS service supporters.[346] In the global race for the GNSS services market, Moscow is trying to produce its own electronic devices as from 2018,[347] and is working with Beijing to develop a BeiDou-GLONASS-GPS compatible device in order to preserve competiveness in both Chinese and Russian GNSS user markets.[348]

2.2.3. THE EUROPEAN GALILEO

Europe had no presence in GNSS development before the 1990s because there was little pressure for an indigenous European satellite navigation system. Policymakers and industrialists became interested in it only when GPS was made available to civilian users as well as when conflicts erupted close to EU borders in the Balkan Peninsula in the 1990s.[349] European skepticism gradually grew, particularly with the US maintaining the capability to degrade civilian GPS accuracy immediately upon direction, though US President Clinton had reconfirmed his policy to make improved accuracy to approximately 10 meters of civilian-accessible GPS selectively available in 2000.[350] In 2000, a joint ESA/EC Report "A European

[338] *Sputnik*, Russia, Brazil Sign Contract for GLONASS Ground Measuring Station, September 17, 2015
[339] *Xinhua News Agency*, Russia to place global navigation stations in China, November 14, 2014.
[340] *RIA Novosti*, Iran to Host Russian Satellite Navigation Facility, May 15, 2014.
[341] *Sputnik*, Nicaragua to Host Russian GPS-Equivalent Ground Stations, August 24, 2015.
[342] *Xinhua News Agency*, Russia to place navigation stations in China, November 14, 2014.
[343] *Space News*, Israel Could Host GLONASS Ground Station Under Framework Deal with Russia, by Barbara Opall-Rome, April 4, 2011.
[344] *Sputnik International*, India Interested in Russia's GLONASS Satellite Navigation System, February 06, 2015.
[345] *Sputnik News*, Mexico, Russia Deepening Cooperation in Space, April 17, 2015.
[346] *Sputnik International*, Russia's GLONASS Proves More Than a Match for America's GPS, July 14, 2015.
[347] *Sputnik News*, Glonass system can fully switch to domestic electronics in 2 years, October 06, 2015.
[348] *GPS daily,* Russia, China to finalize satellite navigation chip set deal by year-end, quoted from Sputnik News, December 15, 2015.
[349] Lembke, Johan (2001) The Politics of Galileo, *European Policy Paper No. 7*, April 2001. Pittsburgh: European Union Center/Center for West European Studies. p4.
[350] European Commission, "The European Dependence on US-GPS and the Galileo Initiative". Technical note. Brussels: Directorate-General for Energy and Transport, European Commission, February 14 2002.

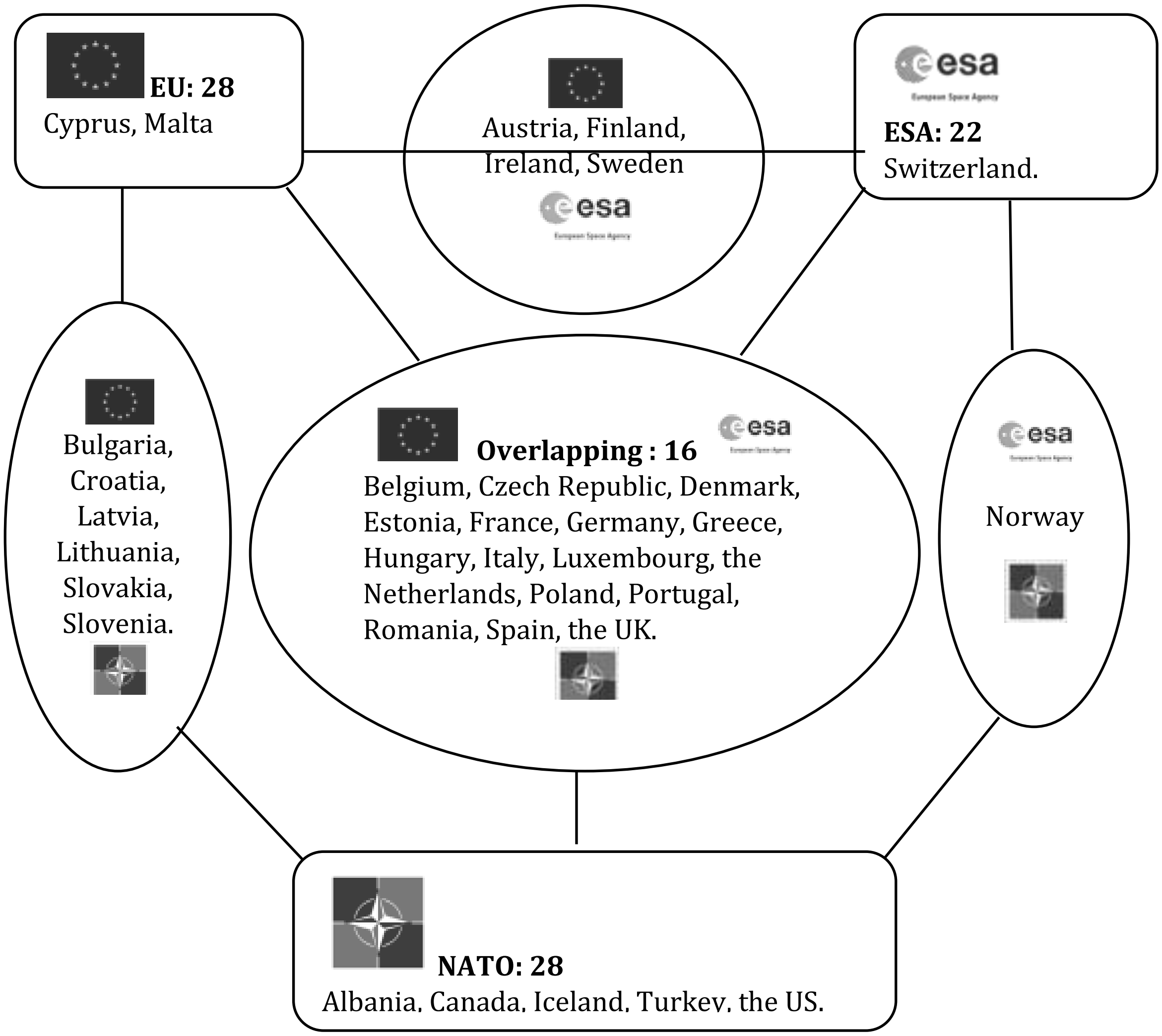
Strategy for Space" (sometimes known as the Bildt report) provided its central conclusion that Europe should not become dependent on an external 'space infrastructure' for strategic or commercial applications.[351] It was noted later that, with a European GNSS project (Galileo) Europe can achieve political, security,[352] and technological independence from the US.[353] Furthermore, Europe was expected to envision overthrowing the US monopoly on GNSS by expanding the European GNSS market share and creating new GNSS world standards.[354] French President Jacques Chirac went so far as to state that if Europe did not fund Galileo it would become an "American vassal."[355] Lately, the European Commission planned to complete the entire GNSS constellation of 30 satellites and their supporting ground stations to provide full services by 2020.[356]

The initial phase and the slow development of the European Galileo were intricate. EU and ESA overlapping Member States (MSs), such as France, Italy and Spain, appeared particularly motivated to strengthen Europe's global strategic independence with a European GNSS. They considered Galileo rather a public service than a pan-European commercial project.[357] France in particular was keen on Europe's strategic independence as well as for sales through the Public Regulated Service (PRS), Galileo's equivalent to GPS Selected Availability. This prospect was not, however, sufficient to win agreement from all member states for the costly Galileo project, especially with the well-performing GPS already in place. Furthermore, the financial contribution shares and the governance structure of the future Galileo equally divided European member states. Any major decision would in fact need to satisfy at the same time the overlapping member states of the European Union and of the European Space Agency. The 28-member transatlantic security institution, the North Atlantic Treaty Organization (NATO) can be also implicated in the Galileo policy decision process since the US-led NATO compelled its member states to use the American GPS for operational and security reason instead of using any other GNSS system. There are also overlapping European states between EU, ESA and NATO. As different member states and three independent regional regimes have not always shared the same visions, strategic concerns and budgetary restraints about the ambitious European GNSS project, it took a long time to harmonize the conflicting stances of all parties, delaying the take-off and significantly inhibiting the entire development of the European GNSS.

---

351 Bildt, Carl et al., *Towards a Space Agency for the European Union*, March 2000.
352 European Commission, Directorate-General Energy and Transport. "The European project on radio navigation by satellite" Information note, posted on March 26, 2002.
353 European Space Agency (2003) *Why Europe Needs Galileo* ; Beidleman, Scott W. (2006) *GPS versus Galileo: Balance for Position in Space*, CADRE Paper No. 23, Maxwell Air Force Base: Air University Press. page: vii.
354 de Palacio, Loyola, vice President of the European Commission. "The Importance of Galileo for Europe." Address, Internationaler Kongress Kommerzielle Anwendung der Satelliten-Navigation. Munich, Germany, April 26, 2001.
355 Steven Kettmen, "Europe Gives Go-ahead to Galileo, " March 18, 2002, Wired Magazine, http://www.wired.com/news/politics/0,1283,51130,00.html; Luca De Biase, "Galileo, chi era costui?" http://europa.tiscali.it/futuro/inchieste/200112/21/europa_minima.html
356 *European Commission*, DG Grow, One Third of Galileo Constellation now in Orbit. Access: October 13, 2015. http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8434&lang=en
357 Lembke, Johan (2001) The Politics of Galileo, *European Policy Paper No. 7*, April 2001. Pittsburgh: European Union Center/Center for West European Studies. P7.

Figure13. The Complex Governance of the EU Galileo



Source: Author's creation

Externally, the European Galileo project drew the non-EU and non-ESA countries' attention regarding Europe's security and diplomacy ambitions. This delicately implicated the traditional transatlantic relationship and the relations between the European Union and the member states of the North Atlantic Treaty Organization (NATO). The US primarily downplayed European calls for Galileo and took measures to forestall its development. The European Galileo PRS initially overlay with the future GPS III M-code. As for US-led NATO, there were concerns that Galileo could provide enemy forces with a PNT service which could not be jammed without also blocking the existing US-operational GPS,[358] thus the well-known stand-off on Galileo PRS and GPS III M-Code overlay.

[358] *New Scientist*, NATO claims Galileo could jeopardise operations, June 21, 2002. https://newscientist.com/article/dn2447-nato-claims-galileo-could-jeopardise-operations/

By 2002, all NATO MSs except France had reached an agreement that prioritized the GPS military code for NATO operations. This meant that NATO should be able to deny access to any other satellite navigation system during a conflict, including Galileo. In turn, two traditional Atlantic partners reached the compromise that Washington accept Galileo as an independent GNSS in exchange for Brussels accepting the US security and commercial concerns with a GPS-Galileo cooperative agreement to produce an interoperable and compatible system for global navigation.[359] The US agreed to develop a common standard for satellite navigation and by taking steps to strengthen the commercial and military competiveness of GPS.[360] Concerning the European interests in sharing the global GNSSs market, Brussels accepted that both US and the EU should apply the non-discrimination and open markets principles of the World Trade Organization (WTO) in terms of the trade of satellite-related goods and services, and agreed to provide open access to information concerning signal specifications, signal structures, and frequency characteristics. This meant the US companies would have full access to Galileo technical information and markets in order to compete in the market for Galileo applications and services.

2.2.4. CHINESE BEIDOU (COMPASS)

Chinese satellite PNT technology research could be traced to the 1960s. Nevertheless, further to a series of single-star (satellite), double-star, three-star and five-star regional navigation satellite constellation tests, a Chinese satellite PNT system plan was documented only from 1983.[361] In 1994, a "double stars rapid positioning system" paved the way for the BeiDou-1 two-satellite radio determination satellite service (RDSS) system (Graph 10). According to the press, the impetus for such systems seemed to be Chinese military requirements for more accurate missile targeting.[362]

In the later 1990s, China was preparing newer BeiDou satellites. Some years later, China and Europe agreed that China become part of the European Galileo consortium – Galileo Joint Undertaking (GJU) as from 2003. Too soon, conflicting factors and intricate situations ended the Chinese GJU joint venture by 2006. First, the intra-regional divergence and the complex governing model of the European GNSS project slowed the progress of Chinese Galileo participation. Second, the unhappiness of the US and the NATO allies about the Galileo project constantly impeded its development. Moreover, Beijing's participation was itself thought to be one of the security and commercial concerns of Washington. Finally, as a GNSS Supervisory Authority of the EC/ESA was created to take over the GJU by 2006, the new European GNSS Authority did not extend the partnership with China after the former GJU accord expired.[363] All in all, Beijing had acquired 20 atomic clocks, one of the critical

---

[359] Beidleman, Scott W. (2006) *GPS versus Galileo: Balance for Position in Space*, CADRE Paper No. 23, Maxwell Air Force Base: Air University Press. p4.

[360] Parkinson, Brad, Capability and Management Issues for GPS/Galileo Positioning and Timing. Presentation. *Council on Foreign Relations*, November 7, 2003.

[361] 鄭大誠, 北斗: 中共的千里之眼 中共成功發射第二顆北斗二代衛星之意義與成效, *尖端科技 299* (2007 年 7 月): 82.

[362] Pace, Scott, Expert Advice: The Strategic Significance of Compass (BEIDOU), *GPS World*, December 1, 2010.

[363] Gleason, Michael P. (2009) *Galileo : Power, Pride, and Profit : The Relative Influence of Realist, Ideational, and Liberal Factors on the Galileo Satellite Program*. Doctoral Dissertation. George Washington University. p. 290.

components for GNSS, from a Swiss firm throughout the GJU.[364] Hence, China accelerated the development of its own GNSS, BeiDou. The Chinese BeiDou system (BDS), with a 35-satellite constellation, currently centered on the Asia-Pacific region and is to attain global coverage by the year 2020. The first experimental satellite of the BDS was launched in 2007. By late 2012, BDS started providing commercial and public GNSS services with short message capabilities as a RNSS covering the area of China and other Asian countries.[365] The international Maritime Organization (IMO) ratified the performance standard of a receiver of the ship-borne BDS in 2014.[366] Beijing is upgrading the BDS to ICAO standards in order to apply it to carriers.[367]

The success of China's BDS has important political, military and economic significances. The political significance means that China is growing its national military space power. China's People's Liberation Army (PLA) planned to deploy BeiDou terminals to all its brigades/regiments, PLA Navy (PLAN) ships, the Second Artillery Force (SAF) and the Air Force (PLAAF) for disaster and emergency response, and to support public security and military operations.[368] Externally, Beijing probed building up its regional space leadership by involving South East Asian nations as part of BeiDou system. Thailand, Laos, Brunei and Pakistan[369] and other ASEAN nations have gradually agreed to use the BeiDou service and to host its ground facilities on their territories. In the realm of the commercialization of Chinese GNSS services, China signed a commercial agreement with Singapore to avoid jamming problems.[370] Both China and Russia kept jointly promoting the compatibility and interoperability between BeiDou and GLONASS to be accommodated by the BRICS group members.[371] In the recent (2015) Ministerial Meeting of the China-led Central Asia partner group, the Shanghai Cooperation Organization (SCO), China and Russia announced that a GLONASS-BeiDou global international navigation system will be used by the member states of BRICS and SCO groups.[372] After the MH 370 and MH 17 incidents, China proposed a "Space Silk Road" program, which can use the BeiDou system to create a live-feed "black-box" which would provide constant global coverage of all air, shipping and overland routes.[373]

2.2.5. EMERGING REGIONAL NAVIGATION SATELLITE SYSTEMS

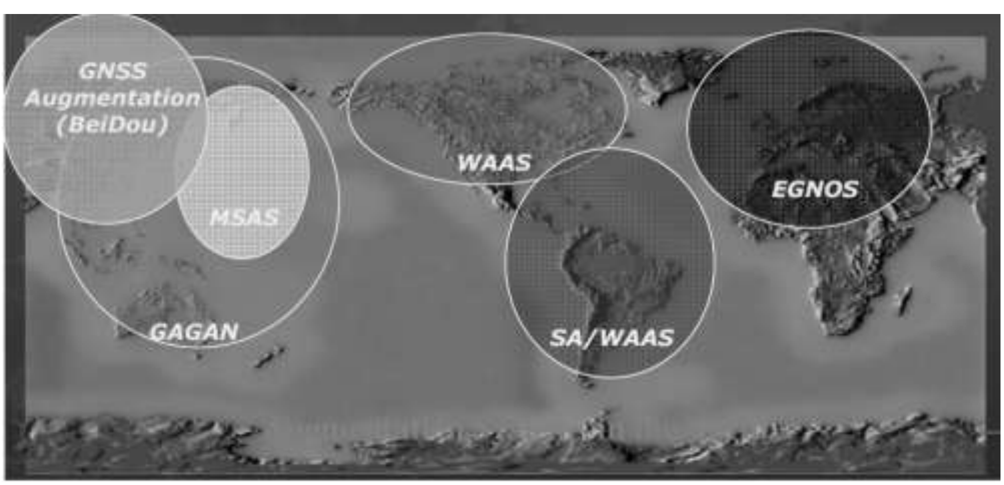
Each GNSS service has its optimal geographical coverage, technical limitations and vulnerability to resist harmful interference and physical collision. The different GNSS services purportedly compensate each other's deficiencies, including liability, integrity, and

[364] *Reuters*, Special Report – In satellite tech race, China hitched a ride from Europe, David Lague, December 22, 2013.
[365] *Xinhua News Agency*, Beidou satellites begin autonomous operation in space, August 19, 2015.
[366] *Xinhua News Agency*, China's BeiDou system standard ratified by IMO.
[367] *Xinhua News Agency*, China's satellite navigation system to expand coverage globally by 2020, August 27, 2015.
[368] McCauley, Kevin N. Putting Precision in Operations: The BeiDou Satellite Navigation System, *China Brief XIV*(16):11-14, August 22, 2014.
[369] *Agence France Press*, Pakistan adopts Chinese rival GPS satellite system. May 27, 2014.
[370] *Space News*, Singapore and China to Collaborate on BeiDou Applications, Peter B. de Selding, June 11, 2015.
[371] *Sputnik News*, Russian, Chinese Navigation Systems to accommodate BRICS members. July 7, 2015.
[372] *Sputnik News*, Russia, China develop navigation system draft for SCO, BRICS. December 16, 2015.
[373] Lele, Ajey, The 'Road' to Success for the "Silk Road Initiative" is via Aerospace. *IDSA Comment*, October 21, 2015. IDSA: Institute for Defense Studies and Analyses

inadequate civilian accuracy.[374] Regional augmentation systems based on different geographical areas worldwide are the solution. The GNSS global service providers on the one hand all need these complementary systems to better service accuracy and continuity. Nonetheless, they remain cautious if unexpected congestion, competition, and contests would appear to be detrimental to their own system utilities and other specific interests. Nor would spacefaring nations develop a regional augmentation system only expecting to support and complete any of the existing and future GNSSs. Developing a regional augmentation system helps a spacefaring state to improve its space capabilities *via* the acquisition from critical technologies transfers from an extant GNSS service provider. Meanwhile, these countries enjoy all the advantages of operating these sophisticated services to resolve its national policy areas in security, safety, economic growth and development, and environmental protection and sustainability. To the maximum advantages, spacefaring countries could develop its global GNSS via the development of a RNSS if all astropolitical, financial and market challenges would be overcome.

In the development of various regional GNSS augmentation systems, the European Geostationary Navigation Overlay Service (EGNOS), Japan's MTSAT Satellite Augmentation System (MSAS) and Indian GPS Aided Geo Augmented Navigation (GAGAN) all started their initial phase as the American GPS augmentation systems. (Figure 4) Hence, Europe continued to develop its own GNSS – Galileo. Japan started to develop its regional navigation satellite system – QAZZ. India is preparing an indigenous Indian Regional Navigation Satellite System (IRNSS). Chinese BeiDou created its own regional system before attaining a Chinese GNSS. The developments of European and Chinese GNSSs were presented the above. We, hereby, only introduce Japan's QAZZ and India's IRNSS. As shown in the Figure 12, the geographical coverage of the individual regional GNSS augmentation system does not only divide the world by geographical regions but also geostrategic regions. The overlaying of the Chinese, Indian and Japanese RNSSs in Asia-Pacific is particularly remarkable and, to a certain extent, significant that indicates the uprising space capability development competition and conflicting space security situations in this region.

Figure14. Worldwide GNSS Augmentation systems



Source: European Space Agency

[374] *GPS Daily*, GPS III Launch Services RFP Released by Air Force. October 06, 2015.

2.2.5.1. JAPANESE QUASI-ZENITH SATELLITE SYSTEM (QZSS)

Since the end of World War II, Article 9 of the Japanese Constitution has outlawed war as a means to settle international disputes involving the country. Accordingly, Japan's national space program ought to be non-military, R&D oriented. In 2008, the Japanese Basic Space Law knocked out the door to dual-use space technologies.[375] Related space policy was modified and became effective in 2009[376] and 2013[377] which proposed a space utilization-driven approach to stimulate economic activity in Japan after multiple decades of stagnation. Tokyo's new plan, issued in 2015, potentially switched the focus of the Japanese Space Policy away from the market and towards the military.[378] These successive adjustments of Japanese national space policies are noted to complicate the development of Japanese QZSS, particularly the longstanding Tokyo-Washington space relationship. The conflicting GPS-QZSS cooperation appeared to be in the arenas of 1) the encrypted military GPS code; 2) procurement (trade); and 3) the need for a long-term Japanese strategy in its navigation satellite system.[379] Actually, Washington signed a joint statement on GPS cooperation with Tokyo in 1998. In 2002, the cooperation was reinforced by the cooperation between the US GPS and Japan's regional constellation – Quasi-Zenith Satellite System (QZSS). With a constellation of seven satellites, Japan's QZSS will be a dual-purpose system containing both a commercial S-band communication payload and a navigation payload. It is foreseen that the QZSS will start its primary service in 2018 with four satellites that will cover Asia and Pacific region.[380]

For various reasons, including the US-Japan common security and economic interests *vs.* China's BeiDou in the Asia-Pacific region, the GPS-QZSS alliance came to offer QZSS a functional GNSS complementary and augmentation capability and a newly developed GNSS application, messaging service. In turn, the QZSS will offer the country sustainable domestic GPS-like services and equally serves as a back-up option to the US GPS system in the event of malfunction.[381] The QZSS is promised to use the same frequencies and protocols as GPS, and would be in effect a regional extension of GPS, rather than a competitor. For the economic rationale, Japan may not want to promote a new or modified standard that would harm its installed base of users or the companies involved in the manufactures of GPS equipment in Japan. Otherwise, the security and societal needs were stressed by Tokyo for having a national RNSS instead of a GNSS augmentation service. It was argued that Japan's geography is poorly suited for accurately capturing GPS data due to its mountainous terrain and urban canyons.[382]

---

[375] Aoki, The national Space Law of Japan: Basic Space Law and the Space Activities Act in the Making. http://www.iislweb.org/docs/2011_galloway/Aoki.pdf

[376] *Basic Plan for Space Policy*, 2009. http://www.kantei.go.jp/jp/singi/utyuu/keikaku/pamph_en.pdf

[377] *Basic Plan on Space Policy*, 2013. www8.cao.go.jp/space/plan/plan-eng.pdf

[378] Rajagopalan, Rajeswari Pillai, Japan's Space Policy Shift Reflects New Asian Realities, *Space News*, February 23, 2015. http://spacenews.com/op-ed-japans-space-policy-shift-reflects-new-asian-realities/

[379] Beckner, Christian, et al. (2003) *US-Japan Space Policy: A Framework for 21st Century Cooperation.* Washington: Center for Strategic and International Studies (CSIS)

[380] Office of National Space Policy, Cabinet Office, Government of Japan. 2014.

[381] La Regina, Veronica (2015) *Business partnership and technology transfer opportunities in the Space sector between EU and Japan*. Tokyo: EU-Japan Centre for Industrial Cooperation.

[382] An urban canyon, or street canyon, is a place where the street is flanked by tall buildings on both sides creating a canyon-like environment.

2.2.5.2. INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)

In the year 2001, the Airport Authority of India (AAI) and the Indian Space Research Organisation (IRSO) jointly conceived the GPS Aided GEO Augmented Navigation (GAGAN) project which aimed to enhance accuracy of GPS over the Bay of Bengal, southeast Asia, the Indian Ocean, the Middle East and Africa, in fact, up to 1,500 kilometers beyond the country's borders. In 2013, IRSO launched the first satellite for its satellite-based air navigation services and entered the group of nations comprising the US (WAAS), EU (EGNOS) and Japan (MSAS) that each have similar regional satellite-based augmentation systems (SBAS). The GAGAN system fills a vital gap in the areas of coverage between the European Geostationary Navigation Overlay Service (EGNOS) and Japan's Multi-functional Satellite Augmentation System (MSAS). GAGAN is inter-operable with other international SBAS and is useful for aviation, smart transportation, shipping, highways, railways, surveying, geodesy, security agencies, the telecom industry, personal users of location applications, and so forth.

While GAGAN attempts to redefine navigation over Indian airspace, India is simultaneously developing an Indian Regional Navigation Satellite System (IRNSS) covering the Indian region. The basic difference between GAGAN and IRNSS is that GAGAN will be for civilian use whereas IRNSS will be for India's national defense.

In 2001 the Indian Space Research Organisation (IRSO) launched an Indian Regional Navigation Satellite System (IRNSS) initiative to develop an independent satellite-based navigation system to provide PNT services for users across the Indian region. The system uses a constellation of seven satellites and a vast network of ground systems. The first three satellites were launched in 2013-2014. The fourth satellite was successfully launched on March 28, 2015. The entire IRNSS constellation of seven satellites is expected to be completed in mid-2016.[383] The IRNSS will be a dual-use regional PNT system which is foreseen to provide both standard position service (SPS) and restricted [encrypted] service (RS).

The strategic requirements of New Delhi for a space-based navigation system were suggested to be regional. For security reasons, India would need its own RNSS to defend its national security and territorial integrity because its regional adversaries, China and Pakistan, have nuclear weapons and a significant inventory of state-of-art missiles. Furthermore, China has committed to providing Pakistan with a "military-quality" signal from its BeiDou system. For all these reasons, India needs to have an independent reliable and accurate space-based navigational system. As India has purchased military equipment of Russian origin and from the US and Israel, IRNSS could therefore in principle share commercial market interests with these spacefaring states, and so maintain a certain strategic parity for the country.[384] In 2015, New Delhi announced the extension of GAGAN and IRNSS applications to South Asia Association for Regional Cooperation (SAARC) countries,[385] including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, a new direction in India's space diplomacy and a step towards conquering a new market. After all, India will be the third of the BRICS countries to have its own

[383] *GPS Daily*, ISRO is hoping its 'Big' offering would gain popularity in the market. July 29, 2015.
[384] Lele, Ajey, India's indigenous satellite navigation system, *The Space News*, March 30, 2015.
[385] *The New Indian Express*, ISRO Looking to Extend Services to SAARC Countries, October 08, 2015.

navigation system, after China and Russia. At present Brazil operates the Russian system GLONASS.

Finally, Table 2 summarizes the current GNSSs and RNSSs landscape, which highlights progress made towards building fully operational capability, geographical regional coverage (only about the two RNSSs), and their ally users and their commercial services targeted regional markets.

Table 3. A comparison of the different global and regional navigation satellite systems

GNSS Provider	Year of FOC	Coverage	Key Users & Targeted Regional Markets
GPS (US)	1988		US allies, NATO
GLONASS (Russia)	2020		EEU, SCO, BRICs
GALILEO (EU)	2020		EU, NATO, ESA
BEIDOU (China)	2020		SCO, BRICs, ASEAN
QZSS (Japan)	2018	Asia-Pacific	Japan
IRNSS (India)	2016	Indian Region	SAARC, India

Source: Author's creation

3. THE EXPANDING AND FRAGMENTING GNSS GOVERNANCE ARCHITECTURE

3.1. THE INTERCONNECTED GNSS GOVERNING ISSUES

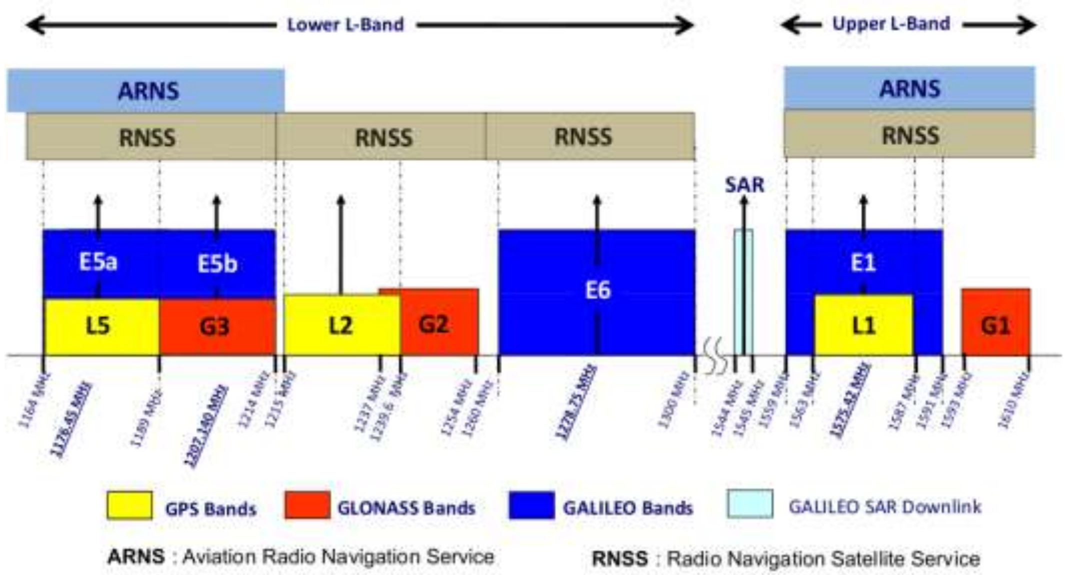
As the dual-use GNSSs expand from primarily military use toward multiple civilian utilities for safety, for economic growth and space capability development, and for environmental and generational sustainability, the entire GNSS governance architecture equally increasingly involves different international regimes of these interconnected governing issue areas. Within these policy realms, several longstanding issues have had to be solved, either via bilateral arrangements or through multilateral institutions. So, we look the key challenges facing GNSS governance, such as 1) the general problem regarding the attribution of satellite orbital slots and relevant radio frequency that indirectly created the frequency overlay between the four GNSSs' governmental only services. The issue is directly related to national defense and the search and rescue utilities of these GNSS service provider countries, so GNSSs for *security and safety.* 2) Inter-GNSS interoperability and compatibility are not only important for security and safety but also for national capability autonomy. They are vital to provide a continuous global GNSS service for the traffic controls of civil aviation and maritime transportation. Likewise, the issues can help the developing countries to not be cornered by one single GNSS but can enjoy the integrated interoperable and compatible GNSSs to improve their nations and peoples life, so GNSSs for *safety and development.* 3) The GNSS service providers and the manufacturers of their downstream products seemed to impede the inter-GNSSs interoperability and compatibility issues in order to protect their distinct markets and economic interests. Therefore, trade barriers or discriminatory market access measures to impede foreign GNSS services and products to enter national market were often set for this goal, so GNSSs for *economy*.

3.1.1. GNSS MILITARY AND GOVERNMENT-ONLY FREQUENCY OVERLAYS

A growing challenge to governing space is the scarcity of the limited orbital slots and related satellite radio frequency does not exclude GNSSs. For GNSS, the satellite radio frequency overlay became intricate since the growth of multiple GNSSs services. The GNSS satellites constantly need two or more frequencies in L band to transmit PNT signals that contain ranging codes and navigation data to allow the users to compute the travelling time from satellite to receiver and the satellite coordinates at any moment. As navigation frequencies occupy such a fairly small neighborhood on the radio spectrum, all GNSSs contend with each other to use the same radio spectrum. Once the number of GNSSs and user population grew, the individual needs for frequency increased as well. If a requested frequency overlays, this needs to be settled or regulated. Otherwise, individual GNSS's radio signal can interfere with each other and then diminish the operation quality of the GNSSs services concerned. The UN specialized agency, the International Telecommunication Union (ITU), is the global regulating mechanism for this issue. Nonetheless, the ITU has no regulating power with GNSSs signal overlays because it cannot be resolved as a matter of satellite signal interference. The military have more problems because overlay makes it impossible intentionally to jam another network without jamming one's own frequency. The issue can only be resolved between concerned parties.

Figure 15 shows the results of how radio frequency bands have been allocated by the International Telecommunication Union (ITU) to the various global and regional navigation satellite services. Yet, when military GNSS overlays occur, namely between the US and the EU, between the EU and China, this fell outside the ITU's mandate. It came back to the negotiations between the concerned parties who planned to use the same frequency bandwidth to resolve the problem themselves. Accordingly, agreement would depend solely on the good wills of the concerned parties to respectively make feasible frequency shift or share the overlay bandwidth. Otherwise, radio transmitting interference, intentional or not, between different GNSS space systems remains. There was a GPS M-code and EU Galileo Public Restricted Service code overlay when the EU announced their GNSS project in the early 2000s. The problem was solved between the US, NATO and the EU. So the GNSS signal overlays remain between GPS L5 / Galileo E5 / GLONASS G3 and GPS L1 / Galileo E1 / GLONASS G1 signals with up to 52MHz bandwidth while using only one common baseband. The other overlay dispute started after the non-extended EU-China GJU partnership. China decided to place the encrypted "government-only" (military) of its BeiDou navigation service on a section of radio spectrum that overlays with Galileo quasi-military PRS and GPS M-code service.[386]

Figure15. GNSSs Signals Overlays



Source: European Space Agency

3.1.2. INTER-GNSS COMPATIBILITY FOR SAFETY AND DEVELOPMENT

When the GPS and GLONASS were the only GNSS service providers, managing respective intra-system no-harm compatibility and limited interoperability between security-oriented military operations and safety-oriented civil navigation management was already quite complicate. Once more different GNSS services appeared and would attain their full operational capability, the inter-system compatibility and interoperability will be even more intricate to handle. Because there will be simply more satellite orbital slots and relevant frequencies are needed by the different PNT services side. From the users' side, they will have to choose to equip their appliances compatibly for one or more GNSSs in order to enjoy the services.

The issue of inter-GNSS interoperability is primordial for the safety issue area. Civil aviation management and airline tracking are one of the uncompleted issues related to GNSS governance. In place of cross-border radar air controls, GNSS services possess more accurate real-time PNT service that can increase the efficiency and safety of air traffic management. Further to the mysterious disappearance of the Malaysian Airlines flight MH 370 and the same company's tragically shot-down flight MH 17, the international aviation community proposed systemically transferring the GNSS-tacked airplanes location data via space-based and ground-based routes to improve the aviation safety and rescue efficiency. As for inter-GNSS compatibility, it allows the users to shift from a single GNSS to another therefore become dual, and multiple GNSS signals receivers when the overlay and interference happens. It would also result in the receivers of these GNSSs being built more

[386] *Space News*, EU Space Policy Document Calls for Dialogue with China, by de Selding, Peter B., April 5, 2011.

easily and inexpensively. In such perfect user-friendly case, the different GNSSs need to be mutually compatible and interoperable in order to be able to enhance the effectiveness, efficiency of these respective systems, and maximize their profits because of the enlarged user market.

The hurdles of applying such ideal applications of GNSS services appear in two arenas. First, in the context that national airspace sovereignty and territorial security prevails, systematically transferring the GNSS-tracked flight location data of aircraft flying over a country and across borders arouses all countries' concerns. Moreover, even an international operation standard would be attained by all countries, establishing international operational and equipment standards[387] to allow aerospace industry and airliners to produce and purchase compatible and interoperable equipment to all GNSS providers services instead of limited exclusive choice. In sum, although the safety issues and development counties concerns matter, both national sovereignty and security, and commercial advantages of GNSS services providers have constantly been ruling the situation.

3.1.3. DISCRIMINATORY MARKET ACCESS FOR GNSS PRODUCTS AND SERVICES

As discussed above, states' reluctance to set universal inter-GNSS compatible equipment standards and interoperable operation rules are due not only to their national security concerns. Such reluctance can result in creating technological barriers to trade that prevent undesirable foreign GNSS products and services from entering a domestic market. This is used to protect one's own and one's partners' GNSS product manufacturers and service operators. It could also be explored to preserve the one GNSS market leadership or resist against the quasi-monopoly of some.

It was pointed out that the true GNSS race actually happens in the equipment and services industry sector.[388] Not only the civil aviation community and the maritime community but now also many other sectors "from farming to banking" need GNSS application services, as was explained above. Preserving the exclusivity of manufacturing standard equipment that respect GNSS operation regulations can generate lucrative benefits for a GNSS service provider nation. The service provider state will naturally wish to have access to national markets worldwide in order to sell their GNSS services and at the same time find reliable but lower cost manufacturers in such exporting markets. If a state is probing its own GNSS or already has its political preferences to work with certain GNSS systems, it can create various discriminatory measures in favor of its own products and services that raise technical barriers to discourage the importation of foreign GNSSs.

The American GPS was the first and so far remains the dominant service provider in the global GNSSs market. This global GNSS market dominance has been laid on a long-term GPS strategic alliance and building of user market networks. Since 1978, ten NATO member

[387] Berz, Gerhard, "Authorization and Operation of GNSS Aviation Services in Non-Core Constellation States", Presentation at the Civil GPS Service Interface Committee, Tampa, USA, Sept. 8th 2014.
[388] Mike Shaw, Director of US National Coordination Office for Space-Based Position, Navigation and Timing (PNT), intervention at Munich High-Level Satnav Summit, March 2009, "GPS, GLONASS, Galileo, Compass: What GNSS Race? What Competition?", Glen Gibbons, *Inside GNSS*, March 23, 2009.

states and Australia have become part of the GPS technological development and have established a network for information flow. Israel, Korea, and Japan[389] have also been part of the consortium. Although the US understood that interoperability could create a free ride for any potential non-GPS service provider to reduce their own infrastructure costs as there are already available compatible infrastructure and service networks once the GPS loses its quasi-monopoly position. The participation of these states from every corner in the world not merely consolidated the US-led strategic and security alliance, dispersing critical extraterritorial GPS ground stations segments, but also enlarged overseas markets for the US industries to export GPS-related products and service to those countries.

In spite of enlarging the GPS user markets, the US cautiously protects the quasi-monopoly of GPS technology. To protect the GPS quasi-monopoly in the global GNSSs market and to prevent likely critical and sensible space technology transfer from the US partners toward non-allied states, most GPS users' equipment shipped abroad prior to 1991 required individual validated license to ensure compliance with various US export control programs, for example, the International Traffic in Arms Regulations (ITAR). ITAR has extraterritorial applicability over a listed commodity of information wherever it is located in the world. It has been an efficient instrument to preserve the US arms and space-tech leadership and military space power. Nevertheless, the US governmental export controls kept affecting GPS markets. Facing the currently strong competition in the global space market, the US ITAR has been criticized for equally creating disadvantages for US companies when it comes to the export of satellites and satellite components, even to NATO allies and other US-friendly nations.[390] When the Galileo project was launched, Washington warned that Brussels should not use regulations or system-driven standards to mandate the use of Galileo thereby limiting the GPS manufacturers, service providers, and users.[391] A mutual respect for GPS-Galileo open access to the markets of both sides of the Atlantic was ultimately attained between Washington and Brussels.

In 2014, the US Federal Communications Commission (FCC) announced that it would introduce a compulsory licensing procedure of the navigation signal and certification of user devices. The restrictive measure of licensing providers of the GNSSs, certifying multisystem receivers, and imposing restrictive measures was noted as a discrimination against using GLONASS. Russia argued the US regulations are pushing away the largest manufacturers of navigation receivers from using GLONASS and would narrow its market. At the same time, it could also stimulate a number of countries to follow the US example, this means to introduce the procedure of signal licensing and device certification.[392]

Russia and China, who are not part of the WTO agreements barring technical barriers to trade in each others goods, and on rules governing government procurement practices, have been proactively expanding their joint GNSSs markets externally. To be competitive in a GPS-dominated GNSSs market, both Beijing and Moscow helped their traditional allies and

[389] Pace et al. (1995) The Global Positioning System: Assessing National Policies, Santa Monica: RAND. p.257.
[390] *The Space Review*, Key Space Issues for 2013 by Jeff Foust, December 31, 2012. www.thespacereview.com/article/2211/1
[391] US Department of States, Office of the Spokesman, "Media Note Explains U.S. Position on GPS Galileo," March 7, 2002.
[392] *Sputnik News*, Russia to Debate US Discrimination of CLONASS System in UN: Reports, December 29, 2014.

established strategic partnership to use their respective GNSSs products and service. They are jointly developing multisystem receivers for both GLONASS-BeiDou for the Eurasian Economic Union (EEU) and member states and the Silk Road Economic (SREB) markets[393] as well as the member states of Shanghai Cooperation Organization (SCO) and BRICS group[394]. The EEU, including Russia, Kyrgyzstan, Armenia, Belarus, and Kazakhstan, is an integration association that aims to streamline the flow of goods and services between its members. The SREB, consisting of the countries situated on the ancient Silk Road route, starting from China, via Central Asia, West Asia, the Middle East, into Europe, is designed to strengthen economic ties between Asia, Europe and the Gulf states. The SCO-BRICS navigation system was announced to extend the use of GLONASS and BeiDou's global and regional navigation satellite systems in Brazil, Russia, China, South Africa and Pakistan as well as in Tajikistan, Kyrgyzstan and Uzbekistan. The two partner countries are also working on various GLONASS-BeiDou-GPS multisystem receivers in order to become more flexible to penetrate into more GPS-dominated GNSSs national markets worldwide.[395]

3.2. INTERNATIONAL REGIMES OF GNSS GOVERNANCE

As the civilian and commercial use of GNSSs have strong relevance to comprehensive civil navigation safety governance, these issues were dealt under the UN auspice, between several UN specific agencies and multilateral forum. Naturally, the GNSS governance architecture laid on the OST, and other international space treaties. More specific issues were dispersed to be handled within other UN specialized agencies, *i.e.* the International Telecommunication Union (ITU) for allocating satellite orbital slots and radio frequency and preventing satellite frequency interference issues. The International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) were required to guarantee the safety for GNSSs related aviation and maritime navigation by establishing specific equipment standards and operational regulations. The World Trade Organization (WTO) is expected by some to limit discriminatory access of national market for GNSS related trade. Others are developing regional GNSS augmentation systems to acquire necessary technology transfer from the global service provider, developing domestic manufacturing capabilities and commerce, conquering regional GNSS related product and service market, and to resist Western-led global trade mechanism, thus a space regionalization.[396] The regional powers and their security alliances, such as North Atlantic Treaty Organization (NATO), regional space cooperation regimes, *e.g.* the European Community (EC) and European Space Agency (ESA), the Eurasian Economic Union (EEU) and the Silk Road Economic (SREB), China-led Asia-Pacific Space Organization (APSCO), Japan-led Asia Pacific Regional Space Agency Forum (APRSAF) have been developed to

[393] *Sputnik News*, GPS Daily, Russian-Chinese Sat NavSystems to Launch on Silk Road, EEU Markets, October 15, 2015.
[394] *Sputnik News*, Russia, China develop navigation system draft for SCO, BRICS, December 16, 2015.
[395] *Sputnik News*, Russia, China to Finalize Satellite Navigation Chip Set Deal by Year-End, December 15, 2015.
[396] Liao, L.W. Xavier, (2015). The Growing Space Regionalization of the Global Space Regime Complex, *The Aviation & Space Journal XIV* (January/March 2015) (1): 23-34; (forthcoming in 2016). The Space Regionalization and Global Space Governance, in *ESPI Yearbook of Space Policy 2014* (Eds.) Peter Hulsroj and Arne Lahcen. Wien/New York: Springer. p187-198.

attain these goals. International groups such as BRICS were also created for a similar purpose.

3.2.1. THE INTERNATIONAL TELECOMMUNICATION UNION (ITU)

All space-based systems, including GNSSs, need adequate orbital slots and relevant radio frequencies to avoid their satellites collide with other orbiting spacecraft and to transmit their data signals without interference. The ITU, which was established in 1932 and distantly originated in the International Telegraph Union founded by Napoleon III of France in 1865, became one of the UN's specialized agencies in 1947. The ITU is governed by a series of conventions that are reviewed at the ITU Plenipotentiary Conferences every four years. These conventions determine the general ITU policies. By 2015, the ITU has a membership of 193 countries and almost 800 private-sector entities and academic institutions.[397] Since 1963, the ITU started its mandates of the allocation of global radio spectrum and satellite orbits, development of the technical standards that ensure networks and technologies seamlessly interconnect, and commitment to improving access to ICTs to underserved communities worldwide.

Satellite signal conflicts are not an uncommon occurrence. These conflicts were sometimes deliberately caused, often as a retaliatory measure. ITU is responsible for providing international protection from harmful interference of the ITU registered assignments in the MIFR. The interference issue is critical for GNSSs because GNSSs signals are particularly vulnerable to harmful interference due to their very low transmission strength. The concerned states should deal with the overlay problems among themselves. This was the case of the US-European satellite navigation discussion during the Galileo design phase as an example. We see that at the time, some European Galileo backers wanted Public Regulated Service (PRS) to overlay the GPS M-code that the US and China both reserve for military and civil-security uses. The issue was if a US GPS M-code or Chinese BeiDou signal overlay with PRS, it will not impinge on the operations of either system, but will make it difficult for either one to jam the signals of the other in the event of conflict. To preserve the existing monopoly of M-code, the US therefore threatened to cease all satellite navigation cooperation with Europe unless the PRS signal was moved away from the M-code frequencies. European governments ultimately agreed to the US request.[398] Another dispute between Chinese and the European global navigation systems frequencies originated in 2010. The case was due to go to ITU for settlement in 2012.[399] The ITU claimed it had no legal instrument to handle the government-only encrypted service radio spectrum overlay disputes, because the issue fell outside the ITU mandate.

[397] International Telecommunication Union (ITU), http://www.itu.int/en/about/Pages/default.aspx, 2015/12/24.
[398] *Space News*. EU, China Schedule December Meeting on Navigation Dispute by Peter B. de Selding, 9 October 2012.
[399] *Space News*. China and Europe Taking Navigation Dispute to the ITU by Peter B. de Selding, 2 October 2012.

3.2.2. THE INTERNATIONAL COMMITTEE ON GLOBAL NAVIGATION SATELLITE SYSTEMS (ICG)

We have already established that GNSSs are the most popular day-to-day use of outer space, with applications that can have beneficial impacts on infrastructure, education, health, farming, banking, and so forth. Possessing capabilities of manufacturing GNSS-relevant products and being able to operate GNSS services also help countries to stay on the track of continuous industrial and commercial modernization, so to economic growth. For this, the UN COPUOS established in 2001 the Action Team on Global Navigation Satellite Systems with the voluntary participation of 38 Member States and 15 organizations. The Action Team on GNSS subsequently led to the establishment of the UN International Committee on GNSS (ICG) to promote the enhancement of universal access to and compatibility of space-based navigation and positioning systems in order to improve the efficiency and security of transport, search and rescue, geodesy and other activities.

The origin of the ICG establishment was addressed at the Third UN Conference on the Exploration and Peaceful uses of Outer Space (UNISPACE-III) in 1999 that the world should seize significant opportunities for human development through advances in space science and technology. Thus, the UN General Assembly endorsed "The Space Millennium: Vienna Declaration on Space and Human Development" adopted by UNISPACE-III specifically for enabling space technology providing PNT services.[400] The Vienna Declaration called for action, notably to improve the efficiency and security of transport, search and rescue, geodesy and other activities by promoting the enhancement of, universal access to and compatibility of space-based navigation and positioning systems. Consequently, the UN invited GNSS and augmentation system providers to consider establishing an international committee on GNSS in order to maximize the benefits of the use and applications of GNSS to support sustainable development in 2004.[401] In 2005, the UN established a separate body completely devoted to GNSS – the International Committee on GNSS Navigation Satellite (ICG) for which UNOOSA acts as Executive Secretariat.[402]

The ICG grouped the six global and regional system providers in a Providers' Forum to conduct discussions of mutual interest focused on improving coordinated services provision to benefit humankind. The Providers' Forum is not a policymaking body, but provides ways and means of promoting communication among system providers on key technical issues and operational concepts such as protection of the GNSS spectrum and orbital debris/orbit de-confliction." The decision-making is based on *consensus* agreed guidelines for provision of open services, including transparency, cooperation, performance monitoring and spectrum protection; and agreed principles for ensuring compatibility and interoperability among systems.[403]

[400] Resolution 54/68, UN General Assembly, December 6, 2001.
[401] Resolution 59/2, UN General Assembly, July 31, 2004.
[402] UNOOSA (2011) *10 Years of Achievement of the United Nations Global Navigation Satellite Systems*, New York: United Nations.
[403] Terms of Reference of Providers' Forum, UN International Committee on GNSS.

3.2.3. THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

GNSSs provide navigation services for land, maritime, and air transportation, and in so doing provide at least two types of advantage. They improve safety by providing traffic control facilities, and they improve efficiency by saving navigating time and energy consumption. As from the early 1980s, the international civil aviation community became interested in using satellite-based navigation aids as particular means of enabling aircraft to land in bad weather and at night. Since the advantages provided by satellite navigation systems for safety, accuracy and cost-benefit gains are so obvious, the aviation community intensified its strategic efforts to push a gradual transition from conventional navigation systems to global navigation satellite systems.[404] To this end, the International Civil Aviation Organization (ICAO), a UN specialized agency, attempted to create an integrated global system of air traffic management, which should include the US GPS, the Russian GLONASS and other future GNSSs, over which Contracting States exercises a sufficient level control on aspects related to its use by civil aviation. The ICAO originated from the 1944 Chicago Convention and Annex, has 190 contracting states by 2015. The ICAO policies are decided in the ICAO General Assembly and the ICAO Council, which consists of 36 states. The ICAO is mandated to promote standards and recommended practices (SARPS) regarding the safety of international civil aviation.

The ICAO proposed the concept of Communication, Navigation and Surveillance/Air Traffic Management (CNS/ATM) in 1991. The navigation element of CNS/ATM systems is meant to provide accurate, reliable and seamless position determination capability, worldwide, through introduction of satellite-based aeronautical navigation. Therefore, the CNS/ATM concept involved the establishment of a standard GNSS around 2005, with a second system (GNSS-2) – relying on a civil satellite constellation – to be installed around 2010. In 1994 and 1996, the US and Russia in turn offered to provide ICAO with GPS/GLONASS services for the foreseeable future on a continuous worldwide basis and free of direct user fees. In 1998, the ICAO General Assembly issued two resolutions: A32-19, "*Charter on the Rights and Obligations of States Relating to GNSS Services*", and A32-20, "*Development and elaboration of an appropriate long-term legal framework to govern the implementation of GNSS*". The use of satellite navigation for aviation was given a significant boost when ICAO recognized the benefits of this system resolved for global implementation of satellite navigation-based routes and fight procedures generically called Global Navigation Satellite System (GNSS) procedures in 2007.

The ICAO Charter related to GNSSs embodies certain fundamental principles applicable to the CNS/ATM implementation and operation. Firstly, the *safety of international civil aviation* should be fully safeguarded by states and individual service providers at all times in the operation of GNSS, including during modification to the systems. Secondly, the multiple providers and commercial competition are expected to provide a natural basis for guaranteed GNSS accessibility, therefore a *universal accessibility without discrimination* needs to be guaranteed. Nonetheless, the remaining issue is how to render it generally applicable. Thirdly, the principle of GNSS *service continuity* is closely related to the issue of non-discriminatory access. The "continuity" may be understood in either a technical or a legal sense. In the narrower technical sense, continuity may refer to effective arrangements

[404] Lembke, Johan (2001) The Politics of Galileo, *European Policy Paper No. 7*, April 2001. Pittsburgh: European Union Center/Center for West European Studies. P5.

to minimize the operational impact of unavoidable system malfunctions or failure and achieve expeditious service recovery. In a wider legal sense, continuity may also mean the principle that the services are not to be interrupted, modified, altered or terminated for military, budgetary or other non-technical reasons. It is recommended that States provide adequate safeguards to the principle of continuity in both the technical and legal meaning in the implementation and operation of CNS/ATM systems. The Charter states that every State providing GNSS services shall ensure the continuity, availability, integrity, accuracy and reliability of its services, including effective arrangements to minimize the operational impact of system malfunctions or failure, and to achieve expeditious service recovery. Fourthly, the principle of respect of states' sovereignty over the airspace above their territory when states implement and operate CNS/ATM via GNSS shall neither infringe nor impose restrictions upon state sovereignty, authority or responsibility in the control of air navigation and the promulgation and enforcement of safety regulations. By contrast, the US and Russian have respectively agreed with the ICAO that the GPS and GLONASS will only provide navigation aid signals for use in aircraft positioning. Finally, the ICAO Charter equally urges *compatibility of regional arrangements* with as well as *cooperation and mutual assistance* for the global planning and implementation of CNS/ATM systems.

The ICAO and ITU have been working together on the avoidance of harmful interference with GNSSs, which as stated previously are vulnerable to harmful interference because of their very low transmission strength. The *ICAO-ITU Memorandum of Cooperation* was signed soon after the unlawful harmful interference that occurred in the Incheon region of South Korea in 2011 and 2012. In 2011, 106 airplanes of 18 airlines were registered as affected. In 2012, 1016 aircraft of 33 different airlines and 16 states were disrupted.

3.2.4. THE INTERNATIONAL MARITIME ORGANIZATION (IMO)

Maritime users are viewed as a small community in comparison with other large user groups of a future GNSS. Nevertheless, in the General Assembly of the International Maritime Organization (IMO) in 1997, the UN specialized agency for maritime safety proactively recognized the need for a future civil and internationally-controlled GNSS that can provide ships with navigational position-fixing throughout the world for general navigation, including navigation in harbor entrances and approaches and other waters in which navigation is restricted. Together with the ICAO, the two UN specialized agencies have been working the aviation and maritime requirements for a future GNSS.[405] The IMO of 171-Member States and three Associate Members, therefore established a set of positioning requirements for future GNSS to ensure that these requirements are considered in the development of future GNSS(s). Like the major considerations of the ICAO related to GNSSs, maritime safety, equipment and operational standardization with regard to GNSSs are the issues with which the IMO has primarily concerned itself.

[405] International Maritime Organization, Resolution A.860 (20), adopted on 27 November 1997, Maritime Policy for A Future Global Navigation Satellite System (GNSS).

3.2.5. THE WORLD TRADE ORGANIZATION (WTO)

The popular GNSSs can keep a country on the track of continuous industrial and commercial modernization to generate economic growth. Developing GNSS-relevant manufactures and service sectors can stimulate industries and commerce to move from the low tech to high tech range. To keep their industrial and commercial leadership positions, or to protect their own domestic industries and commerce, GNSS service providers were reluctant to inter-GNSS interoperability and incompatibility proposals, and set certain technical barriers to hurdle undesirable foreign GNSSs products and services entering its domestic and allies' markets. For this issue, some GNSS service providers, namely the US and the European Union, but not China and Russia, choose the World Trade Organization as an international platform to handle disputes related to GNSS market access discrimination.

Since 1948, the General Agreement on Tariffs and Trade (GATT) has provided the rules for the global tariff and trade system. Over the years GATT evolved through several rounds of negotiations. The last and largest GATT round, was the Uruguay Round which lasted from 1986 to 1994 and gave birth to the World Trade Organization (WTO). Whereas GATT had mainly dealt with trade in goods, the WTO and its agreements further cover trade in services, and traded inventions, creations and designs (intellectual property). The first fundamental WTO principle to be applied in international trade is "most-favored-nation" (MFN) treatment. Under the WTO agreements, countries cannot normally discriminate between their trading partners. Grant someone a special favor (such as a lower customs duty rate for one of their products) and you have to do the same for all other WTO members. In general, MFN means that every time a country lowers a trade barrier or opens up a market, it has to do so for the same goods or services from all its trading partners – whether rich or poor, weak or strong. Nevertheless, the WTO agreements allow countries to introduce changes gradually, through "progressive liberalization". Developing countries are usually given longer to fulfill their obligations.

The second fundamental principle is "national treatment**".** This means treating foreigners and locals equally. Imported and locally produced goods should be treated equally – at least after the foreign goods have entered the market. The same should apply to foreign and domestic services, and to foreign and local trademarks, copyrights and patents. National treatment only applies once a product, service or item of intellectual property has entered the market. Therefore, charging customs duty on an import is not a violation of national treatment even if locally produced products are not charged an equivalent tax.

The US recognized that World Trade Organization (WTO) rules applied to commercial GPS activities. In 2014 the US and the EU signed a wide body of satellite navigation agreements designed to promote open market access and interoperability.[406] During the GPS-Galileo standoff (2004-2009), the US Government position was that any preferential treatment the EU gave to the Galileo PNT network would violate WTO agreements. Of particular concern to the Americans was that the EU was "weighing equipment mandates for aviation, car-

[406] *The White House, Office of the Press Secretary, Fact Sheet*: "US-EU Summit: Agreement on GPS-Galileo Cooperation, June 26, 2004.

accident reporting and emergency-call regulations that could unfairly tip the scale in favor of Galileo to the detriment of US GPS-enabled hardware."[407]

Because of the competition and cooperation of US GPS and EU Galileo, the World Trade Organization became partly involved in solving likely GNSSs related disputes. Otherwise, not all GNSS service providers, namely China and Russia, chose the WTO to rule the GNSSs trade matters. Meanwhile, China and Russia are proactively developing BeiDou-GLONASS interoperability and interoperable markets with the member states of various regional economic cooperation regimes, such as the Eurasia Economic Union (EEC), the Shanghai Cooperation Organization, the Association of Southeast Asian Nations (ASEAN), and the Silk Road Economic Belt (SREB). Ostensibly, GNSSs trading group other than the WTO is taking its shape.

4. THE LOGICS OF GNSSS REGIME COMPLEX FORMATION

The morphogenesis of the entire GNSSs related international regimes constellation recalls the liberal institutionalism approach. The concept underlined that harmonizing individual national stances on the dual use GNSS technologies and services by establishing common rules, operational standards, and managing institutions – international regimes is desirable by countries to avoid chaos and conflicts in the global GNSS astropolitics. Nonetheless, the continuous creations of new regimes and the shifted functions of extant international institutions could not completely reflect this approach. Because although states chose to solve a common problem by setting up an international regime instead of handling it alone or simply with a small group of countries, they nevertheless sought to align the institutional mandates, policy-making methods and organizational structure of these regimes to pursue their relative power and satisfy their own interests. Because of this, some stressed that the more issue-specific power an actor has in these international institutions, the greater its weight relevant to the issue area.[408] States therefore are stimulated to sponsor the institutionalization of an international regime, choose the well-timed moment and look for the best participation formula to be part of an international regime in order to maximize their strategic advantages, satisfy their functional needs and solve the practical problems, as well as safeguard their interests and basic rights. In practice, new international regimes are often created on top of the existing regimes with overlapping membership to attain states' various objectives.

Lesage and Van de Graaf of the Ghent Institute for International Studies (GIIS) have suggested that the intricate morphogenesis of a particular governance issue area regime complex is mainly driven by the strategic, functional and organizational dynamics.[409] These intersecting driving forces subsequently thrust the governance architecture, of GNSS issue-area for example, toward expansion and fragmentation into a regime complex.[410] In their view, countries becoming part of an international regime depends on their general and particular interests, or simply on functional necessity. The moment at which a country enters or leaves an international regime is also well timed. Powerful nations seem to have

[407] de Selding, Peter B., US Warns EU Against Making Galileo Mandatory, *Space News*, November 2014.
[408] Keohane, Robert O.. *Op.cit.*
[409] Lesage, Dries; Van de Graaf, Thijs (2013). *Op cit.*
[410] Raustiala, Kal & Victor, David. *Op.cit.*

no hesitation in influencing the missions and organizational design of the targeted multilateral forums in order to assure their leverage powers in the international institution, such as some groups of weaker and emerging nations. When the internal changes within a regime are not satisfactory, states will not hesitate to create new regimes, shift the institutional missions of existing bodies, or even desert an existing institution to satisfy their strategic calculations and interests. International regimes are also created or reformed to satisfy states' capability building interests and to fulfill their functional necessity in the cases of GNSS governance. This might be for the GNSS service providers to group their supportive nations to host the ground stations of their system in the territories, or from the supportive states viewpoint, for them to become part of the different GNSSs for the interest in developing their own national and regional GNSS capabilities.

In addition to the strategic concerns and functional requirements, the creation and changes of international regimes are equally constrained by a path dependency in its development, which can be legal and technical framework from the extant regimes and their institutional structure. These legal, technical and institutional frameworks have both descendent and transcendent power that limit individual states' influential power to make policy choices toward their preferences on the one hand, and implicate other international regimes into competition or cooperation. An ostensive example of such overruling force is the equity approach in the GNSS governance. The equity emphasis has been constantly utilized by the developing countries and the emerging nations to improve their space capability vulnerability and legitimize their uprising in the vibrant global GNSS astropolitics and competitive markets. By consequence, such equity stress has not only often successfully downplayed the spacefaring states' pure strategic calculations towards some equitable compromises in the bargaining processes on GNSS governance. It has resolved functional needs and even gained strategic advantages and commercial profits for some developing countries and particularly emerging nations.

4.1. STATES' STRATEGIC DISPERSION IN DIFFERENT INTERNATIONAL REGIMES

Whether countries decide to be part of an international regime or not depends on their general and particular interests, or simply functional necessity. The timing to become in-and-out of an international regime is well-timed as well. Powerful nations seem to have no hesitation about influencing the missions and organizational design of the targeted multilateral forums in order to assure their leverage powers in the international institution, or indeed some groups of weaker and emerging nations. When the internal changes within a regime are not satisfactory, states will not hesitate to create new regimes, shift the extant institutional missions, or even desert an existing institution to satisfy their strategic calculations and interests.

In the realm of GNSS governance, the GPS M-code vs. Galileo PRS then later the GPS M-code/Galileo PRS vs. BeiDou government-only overlays were salient cases in which all GNSS service providers were vying for their own strategic and security interests by owning their own GNSS and operating it independently in the security arena. Already from the intra-regional level, the debates among the overlapping EU and ESA member states about whither European indigenous GNSS and Galileo PRS were virulent. France, an ambitious spacefaring nation with nuclear and space capabilities, had a strategic plan to arm its future forces with Galileo PRS along with the use of the GPS M-code via NATO access. It was also pushing for an independent Galileo PRS in order to develop future Galileo-related arms sales in global and regional markets.[411] The United Kingdom restricted its Galileo participation to civilian uses and would not use Galileo PRS for British forces. As a consequence, London sought to deny other European states' use of PRS. The UK argued that the GPS M-code is sufficient for the UK, making Galileo PRS redundant.[412] This strong resistance has long evoked French suspicion that the British preference not to adopt PRS seemed a camouflaged way of defending GPS's M-code and its use by its allied governments,[413] mainly the US and the US-led transatlantic security ally, NATO. Germany as well has refused to express whether to accept PRS because the government-only encrypted code would greatly increase the Galileo budget.

With regard to transatlantic relations, in order to protect the military superiority and market quasi-monopoly of the US GPS, Washington with its NATO allies continuously pressed Brussels to compromise its PRS overlay with the GPS M-Code around 2002-2003. The US had concern that China and Israel, two non-European partners of the Galileo Joint Undertaking (GJU), would be involved in managing Galileo's encrypted, government-only PRS once the Galileo attains operationality. The non-EC partnerships could complicate the jamming risk management for both GPS M-code and Galileo PRS. The European PRS plan would compromise regional navigation warfare in the future in which any US adversary was using PRS signals. Since Europe had tiny room to hold its leverage over GPS NAVWAR operations, ultimately sacrificed its strategic independence by ceding the point and moved PRS off the M-code frequencies.

In the arena of GNSSs worldwide commercial race, it was easily understood that GNSSs civilian use would generate great trade revenues and business opportunities for service providers and the downstream components manufactures. Once the GPS quasi-monopoly or the GPS-GLONASS disproportional shared oligarchy fails, other service providers would immediately enter the GNSSs markets to sell their exclusive or compatible GNSS products and services in an interoperable GNSSs global market. Before the foreseen opening of the GNSSs global market, the US from 1976 had its domestic International Traffic in Arms Regulations (ITAR) as a unilateral American arms embargo against the Soviet-led multilateral Coordinating Committee for Multilateral Export Controls (COMECON) of the Cold War Eastern Bloc countries. ITAR governs the transfer of arms and applies to business activities that are far removed from what one might consider arms exports, including satellite and space technology relevant components and space-tech transfer. ITAR remains as an efficient instrument to preserve the US arms and space-tech leadership and its military space power still until now though has also created impediments for American companies to export satellites and satellite components even to its NATO allies and other US-friendly nations.[414] In 2014 again, the US Federal Communications Commission (FCC)

---

411 Divis, D.A. (2002) "GPS, Galileo Draw Closer." *GPS World* (Nov. 1).

412 *Space News*, Europe Looks To Broaden Base for Encrypted Galileo Service, by de Selding, Peter B., December 7, 2012.

413 *Space News*, Britain, France At Odds Over Military Use of Galileo Service, by de Selding, Peter B., June 19, 2006.

414 *The Space Review*, Key Space Issues for 2013 by Jeff Foust, December 31, 2012. www.thespacereview.com/article/2211/1

stated that it would introduce a compulsory licensing procedure of the navigation signal and certification of user devices. Russia considered the US' practices to license GNSSs providers, certify multisystem receivers, and impose restrictive measures in its domestic market would create US internal market discrimination against using GLONASS. Furthermore, if the US regulates the users of GLONASS, the largest manufacturers of navigation receivers may abandon using GLONASS in their system, which would narrow the market. By consequence, a number of countries could follow the US example, introducing the procedure of signal licensing and device certification.[415]

For the European GNSS, when it appeared as the third GNSS service in the global market, Washington pushed Brussels to make Galileo more open in international trade terms, which meant that American firms would have full access to Galileo technical information and markets in order to compete in the market for Galileo applications and services. It was argued that both the EU and its member states and the US recognized that World Trade Organization (WTO) rules applying to commercial GNSS-related activities, in particular regarding the market access non-discrimination issue. As to the two other GNSS service providers, China and Russia, which do not fully apply the WTO rules yet related to the global GNSSs market, are developing their own joint market to resist the US GPS monopoly. China has been suffering from the US ITAR sat-tech embargo until now. Nonetheless, Beijing has completed its full range space capabilities and aims to expand its BeiDou relevant products and services toward the global GNSSs market throughout the member states of the China-led regional cooperation organizations, such as Silk Road Economic Belt (SREB), the Shanghai Cooperation Organization, and with the Association of Southeast Asian Nations (ASEAN) via the Beijing-sponsored Asian Pacific Space Cooperation Organization (APSCO). Together with Russian GLONASS, China is developing other potential BeiDou user markets via the member states of the Russia-sponsored Eurasian Economic Union (EEC) and the international group BRICS.

4.2. THE FUNCTIONAL ISSUE-LINKAGE FOR STATES' INTERESTS

International regimes are also created or reformed to satisfy states' capability building interests and to fulfill their functional necessity in the cases of GNSS governance. Either for the GNSS service providers to group their supportive nations to host the ground stations of their system in the territories, or from the supportive states viewpoint, to become part of the different GNSSs for the interest in developing their own national and regional GNSS capabilities.

Although the US GPS has been leading the GNSS military sphere and global market, Washington had no choice to but to make bilateral agreements with the Kremlin in 1993 and 2001 that ten GPS ground stations would be built on the territory of the Russia Federation and will be under the control of Moscow.[416] For the same functional concern, Russia needs to deploy 50 GLONASS ground data-collection stations outside of its national territories, such as in Antarctica,[417] and opened negotiations with 36 other countries,[418]

---

[415] *Sputnik News*, Russia to Debate US Discrimination of CLONASS System in UN: Reports, December 29, 2014.

[416] *GPS Daily*, Moscow to suspend American GPS sites on Russian territory from June, May 15, 2014.

[417] *Voice of Russia*, Russia to deploy up to 7 GLONASS ground stations outside of national territory in 2014. February 19, 2014.

including BRICS members[419] – in particular China, Brazil[420] and South Africa – Iran,[421] Nicaragua,[422] and the Western countries Germany, Canada, France, Japan and the United States[423] to guarantee the stability and affordability of GLONASS. Israel was also approached.[424]

The GNSS cooperation regimes were surely not only created for functional reasons. Security and market interests are, unsurprisingly, embedded in them. The GLONASS realignment that gathered the old Soviet states and new neutral partnerships of necessity became in vogue in the course of the standoff between Russia and the West over the Crimea crisis. Russia has announced that it will develop cooperation with BRICS members in defiance of any possible Western sanctions. Moscow pronounced that the technological partnership should be directed at the countries that are close to Russia in mentality and which in general constitute an emerging geopolitical force that Moscow could rely on in a hostile world. This is why the BRICS countries are the first and foremost.[425] To prepare for the most, Russia considered that refusing "everything foreign" in the production of GLONASS navigation satellites was not yet possible. However, under the Western sanctions, Russia would order microelectronics and machines for rocket and space equipment from China, South Korea and other Asian countries.[426] Moscow also planned to create a "common navigation space" with Kazakhstan and Belarus, its partners in the Customs Union.[427]

In such a context, China also foresaw good prospects for cooperation with Russia's GLONASS on regional support and chipsets development, which actually means working on mutual navigation compatibility. Russia expects an agreement with China, which allow the countries to build three ground operational stations on each other's territories, for GLONASS needs to place satellites on three orbits, as every single satellite has its own frequency.[428] As for India, New Delhi was interested in GLONASS services in Indian toll paying systems, rapid response emergency systems and asset management,[429] though India is accelerating development of its own regional navigation satellite system (IRNSS), which is equally compatible with the US GPS.

In many cases, a state's strategic and security concerns and even diplomatic objectives would prevail when they intersect with functional necessity. In 2014, the US President Obama signed the 2014 Defense Bill rules that the navigation systems of other countries must not harm the American GPS system by making it less commercially attractive and obliged to transmit only non-encrypted data.[430] The US did not want GLONASS (tracking) stations on its territory. The White House seemed afraid that Russia's GLONASS global

---

[418] *Xinhua News Agency*, Russia eyes building GLONASS station in 36 countries, April 25, 2014.
[419] *Xinhua News Agency*, Russia to place global navigation stations in China, November 14, 2014.
[420] *RIA Novosti*, Western sanctions fail to impede GLONASS satellite production, September 16, 2014.
[421] *RIA Novosti*, Iran to host Russian satellite navigation facility, May 15, 2014.
[422] *RIA Novosti*, Russian lawmakers approve satellite navigation hub in Nicaragua, April 02, 2014.
[423] *Voice of Russia*, Russian Space Agency set to resume GLONASS talks with US, May 23, 2014.
[424] *Space News*, Israel could host ground station under framework deal with Russia, April 4, 2011.
[425] *Voice of Russia*, Russia may join forces with China to compete with US, European satnavs, June 10, 2014.
[426] *RIA Novosti*, Russia unable to reject foreign parts in GLONASS satellites, September 22, 2014.
[427] *Xinhua News Agency*, Russia eyes building GLONASS station in 36 countries, April 25, 2014.
[428] *Voice of Russia*, Russia, China expand cooperation on satellite navigation, June 5, 2014.
[429] *Sputnik International*, India interested in Russia's GLONASS satellite navigation system. February 6, 2015.
[430] *Voice of Russia*, US ban Russia's GLONASS for spying fears, December 31, 2013.

satellite navigation system might be used to spy on the US homeland. In turn, Russia threatened to suspend the work carried out for US GPS stations sited within its borders if no agreement is reached to set up GLONASS ground stations in the US.[431] This meant that the US-Russia bilateral GPS ground stations agreements signed in 1993 and 2001 no longer guaranteed what the two GNSS service providers have promised each other.

Another example was that the US Federal Communications Commission (FCC) attempted to prohibit the use of non-US satellites, currently meaning Russian GLONASS, requiring wireless providers to be able to transmit emergency indoor cellular phone calls to 911 call centers. The dilemma is that more satellites mean better accuracy and increased chances to fulfill the domestic emergency rescue and search necessity for identifying any location at any given time. Although the American cellular carriers – AT&T, Sprint, T-Mobile and Verizon – could rely on both the US GPS and Russian GLONASS services for increasing the reliability and accuracy of the US E911 system,[432] there was no green light for this from the US FCC.

4.3. ORGANIZATIONAL PATH-DEPENDENCE LIMITS INSTITUTIONAL CHOICES

In addition to the strategic concerns and functional requirements, the creation and changes of international regimes are equally constrained by its development path-dependency, which can be laid out in the legal and technical framework of the existing regimes and their institutional structure. These institutional frameworks have both descendent and transcendent powers that limit individual states' power to influence policy choices toward their preferences on the one hand, and on the other to implicate other international regimes in competition or cooperation. In the evolution of the GNSS regime complex, these descendant and transcendent restraints were found in those regimes with specific functional mission and from their organizational designs.

The existing international regimes created descendent framing force over the later appearing regimes related to the similar governing issues. As Murray argued, space related technological development has not been occurring in a legal vacuum, even on the contrary. There are much pre-existing laws to be aware of and new laws will evolve. It was pointed out that when the ICAO established GNSS related CNS/ATM system, the established concepts of international law such as state sovereignty, nationality and jurisdiction have automatically applied to these humankind's activities in space.[433] These formerly accepted fundamental principles and institutional framework descended to bring forth other newly desired and required norms and the reformulation of the extant international space regimes. It occurred when an extant international regime became unbearable to some states' individual interests, the options of creating a new regime, reforming or deserting an existing regime appeared as a radical solution. Nonetheless, it was almost impossible to create a new regime without applying similar international customary laws, universal

[431] *Voice of Russia*, No More US GPS stations from June 1 – Russian Vice-Premier, May 13, 2014.
[432] *Sputnik International*, Russian satellites prohibited for emergency 911 calls in US, February 1, 2015.
[433] Murray, Kim (2000) The Law Relating to Satellite Navigation and Air Traffic Management Systems – A View From the South Pacific. *Victoria University of Willington Law Review 31*: 383-400.

principles, decision-making rules, and the existing technical standards and operational rules which are already made and applied throughout the existing regimes.

In the development of orbital slots and radio frequency common resource governance, which is connected with the GNSS and any other space-related governance issues, the questions of sovereignty and equitable access to GSO continued to be raised frequently, in particular by non-spacefaring nations.[434] The well-known 1968 Bogotá Declaration was also successively brought out in several ITU conferences and in other UN venues over the years.[435] On the eve of concluding the Moon Treaty, eight equatorial states in the World Radio Conference claimed their legitimate national sovereignty over their GSO. They argued that the orbital existence depends solely on the gravitation force of the Earth. So the Equatorial states have a legal right to protect their sovereign airspace extended until the geostationary orbit slot above their terrestrial territory.[436] This claim was subsequently rejected by the nations which have launched satellites into GSO as well as developing countries which have not yet launched such satellites. The collective action nevertheless pointed out the arguable equality between those who theoretically and effectively enjoy the right of free access to outer space. The developing countries were finally successful in amending the ITU Convention in 1982 to include in the article on the Rational Use of the Radio Frequency Spectrum and the Geostationary Satellite Orbit provision that the special needs of developing countries and the geographical situation of particular countries must be taken into account. Later, the Space WARC on the Use of Geostationary-Satellite Orbit and the Planning of Space Services Utilizing It in 1985 and 1998 reconciled the principle of guaranteed and equitable access with that of the efficient and economic use of two limited geostationary orbit and the radio frequency spectrum. That combined the *a priori* allotment and first-come, first-served *per request* principles. The hybrid ruling methods may not limit the dominant steering power of spacefaring nations, yet cost them more to keep their power, for example by paying billions of dollars per year for having the right of using a satellite slot and radio frequency attributed to a developing state.

There is equally the transcendent force, by which an international regime involved other international regimes, subsequently expanding and fragmenting the entire GNSS governance architecture into a complex constellation. It is known that the International Telecommunication Union process does not allocate the frequencies or orbital positions that are registered. The authority to place a satellite into orbit and employ frequencies for its use actually rests with each sovereign state. The ITU only acts as an efficiency-enhancing resource management regime when sovereign states attempt to avoid potential usage conflicts and as a convenient forum for resolving disputes that arise. Otherwise, the ITU cannot intervene if economic incentives perpetuated by the process as well as the legal preferences accorded to successful applicants to use geostationary system.[437] The ITU also

[434] Vogel, John (2000) *The Global Commons. Environmental and Technological Governance*, Chichester: John Wiley, 2nd ed. p.97 & 112; Soroos, Marvin S. (1982) The Common In the Sky: the radio spectrum and geosynchronous orbit as issues in global policy, *International Organization (36)* 3, (June 1982): 665-677; Beck, Susan (1998), *The Global Commons. An Introduction*, Washington, D.C.: Island Press.

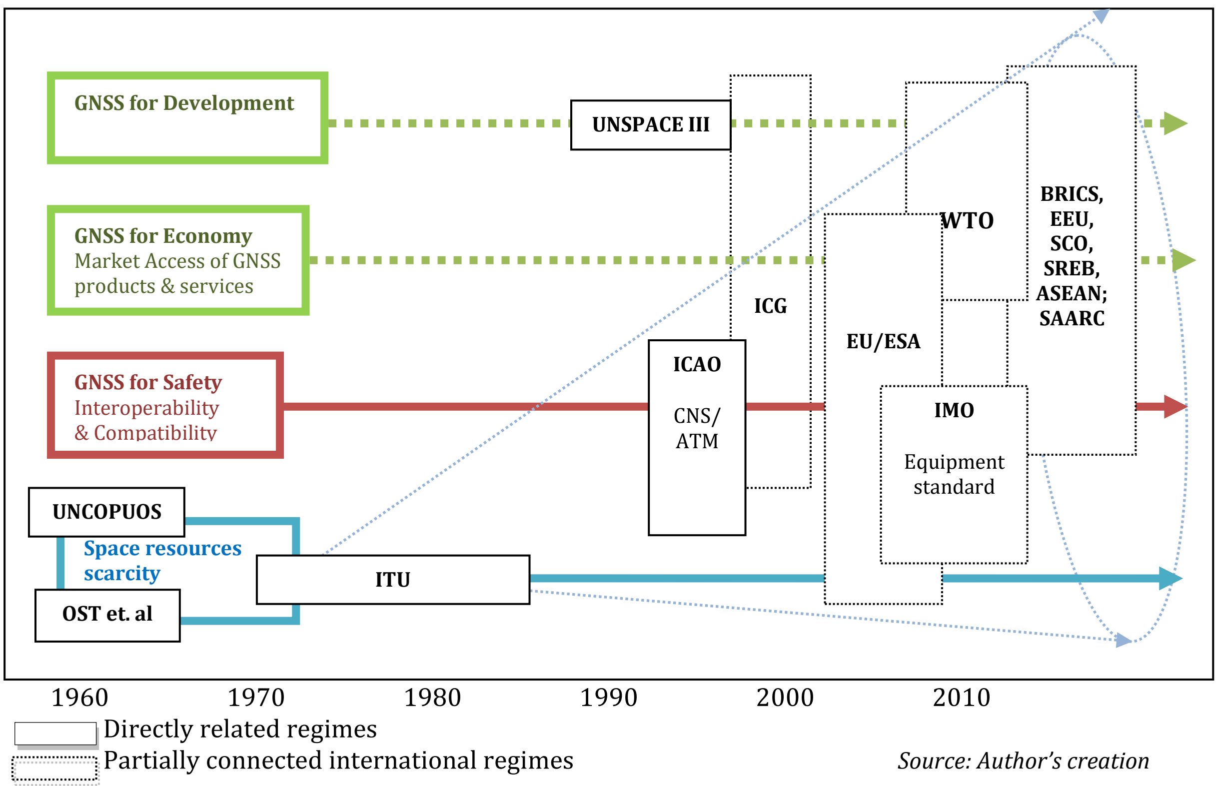
[435] Lyall, Francis and Larsen, Paul B. (2009) *Space Law: A Treatise*. Surrey: Ashgate.

[436] Declaration of the First Meeting of the Equatorial Countries, Dec. 3, 1976, ITU Doc. WARC-BS 81-E (1977).

[437] Roberts, Lawrence D. (2000) A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union, *Berkeley Technology Law Journal* 15(3) 1095-1144.

lacks the means to be an independent international monitoring system. And there are no sanctions within the ITU regulatory system. The institutional imperfection of the ITU has already evoked many questions whether the system will be flexible enough as well as sufficient robust to deal with the beak neck speed of ever expanding and complex needs for radio frequencies and geostationary orbital position.[438] In the case of GNSS governance, other questions regarding the military use, equipment and operational standards and trade issues, or even the core business of the ITU, to prevent the harmful radio interference cannot be completely dealt only throughout the 150 year-old regime but in other multilateral mechanisms. The question remains whether expected outcomes of a new regime, such as the ICG, or any (re)formed regimes, for example, ICAO, IMO or WTO are a complement to or would be an obstruction to each other. Subsequently, the increase of duplicated regimes with similar objectives has fragmented the entire GNSS governance constellation.

Figure 16. The Emerging GNSSs Regime Complex over time



Source: Author's creation

Figure 17 presents a visual scheme which summarizes the emerging GNSS regime complex over time. It shows the global governance architecture of the military-origin security-controlled GNSSs has been developed merely in the dimension where security issues do not belong to the institutional mandates. It remains states', more precisely service provider states to settle their own arrangement. States' security-interest centered strategic calculations dominate the regulating outcomes in such invisible governance pillar. The UN

[438] Jakhu, Ram and Singh, Karan (2009) Space Security and Competition for Radio Frequencies and Geostationary Slots, *Zeitschrift für Luft- und Weltraumrecht (German Journal of Air and Space Law) 58*(1): 74-93.

used the issue-linkage between space for safety and for socio-economic development to create the ICG which only plays a supportive role but not ruling power. To a certain extent, it can be wondered whether the creation of ICG eventually opened a new exclusive arena only for the GNSSs service providers. The answer would only be discernible when all GNSSs enter their FOC. After the US connected the WTO rules for GNSSs commercial matters, China and Russia seemingly use the linkage between GNSSs for regional development and GNSSs commerce to legitimize their GNSSs commercial expansion.

5. KEY FINDINGS

Our case study regarding the regime complex of GNSS governance indicates that states often developed their space capabilities with a focus on gaining military, political and economic advantages. States could work together for international space exploration projects, and particularly creating international regimes to resolve common problems, such as a space for safety, socio-economic development, and sustainability dimension. Nonetheless, when the cooperation encountered competitive elements, states' strategic and national security concerns and functional necessity reigned. Moral obligations, such as the equity issue, could even be compromised to a certain extent. Further to the primary military focused utilities, the applications of GNSSs expanded to allow both military and civil (so dual-use) and commercial purposes that help countries to manage multiple policy areas, such as human safety protection, economic growth and space capabilities development, and environmental and generational sustainability – or in sum, peaceful uses. The broadened use of GNSSs naturally connected its governance coverage toward that of the above governing issue areas. Subsequently, the growing GNSSs governing issues linkage connected other GNSSs indirectly relevant international regimes over time, so expanded and fragmented the global GNSS governance architecture to its complex dimension.

Because of this phenomenon, the holistic regime complex framework was valuable to analyze the current expanded and fragmented intricate GNSS international regimes constellation. It provided an approach to systematically analyze the formation of a specific issue-area regime complex that, as has been noted, was undertaken by three intersecting strategic, functional and organizational dynamics over time. In our focused research on GNSS governance, it was demonstrated that when countries joined an international regime depended upon their general and specific interests and functional necessity. Within the international regime, powerful spacefaring nations seemed not to hesitate to influence the missions and organizational design of the regime in order to assure their leverage force, so as some groups of small or emerging nations. When the internal changes within a regime are unsatisfactory, states created new regimes, shifted the existing institutional missions, or even deserted an existing institution to fulfill their strategic goals and calculated interests. In the case of GNSS governance, the different international regimes were created, reoriented their missions, or restructured for these causes. In addition, the incarnations or transformations of the international regimes were often constrained by its own along the way of its development – path dependency. The existing customary, legal and technical frameworks set by the existing regimes and their own institutions established the descendent and transcendent constraints that firstly limited individual states to influence the institutional policy choices toward their preferences. They also drew other international regimes into competition or cooperation with them.

Overall, the intersecting strategic, functional and organizational dynamics subsequently fragmented the entire global GNSS governance toward its current imperfect form – a regime complex. Apart from the strong leading influences from the driving forces, an equity emphasis has been constantly explored in the development of the GNSS governance. Developing countries and emerging nations have explored this moral stance to improve their space capability and justify their uprising in the vibrant global GNSS astropolitics and competitive markets. It seemed also became a tool together with their force as a competitive market to accommodate GNSSs powers' bit for their supports. This instrument on the one hand resolved functional problems and even gained strategic advantages and commercial profits not only for a certain developing countries and emerging nations. Spacefaring countries on the other hand also took advantage from it to consolidate and reengage their security allies as well as enlarged the users markets. Nonetheless, the equity stress did not always downplay spacefaring states' strategic calculations for making equitable compromises on GNSS governance issues.

According to our analysis of the GNSS regime complex, the continuous expansion and fragmentation of its international regimes constellation seem unlikely to end its process, or processes. It is naturally because the ubiquitous applications of GNSS technologies continued to become relevant to more and more governing issue areas. So, it kept expanding the GNSSs governing architecture. In parallel, the populations of GNSSs service providers and their users did not cease to increase. The growth in scale and in number both simultaneously engendered and seems to grow the governance complexity more. Notwithstanding, this does not mean the GNSSs regime complex would be unmanageable. On the contrary, the expansion of the GNSSs regime complex would push the urges for a universal GNSSs regime louder and stronger in the long term. To a certain extent, the establishment of the ICG for GNSS governance indicated such a tendency. The EU-led ICoC for comprehensive space security as we discussed previously seemed similar.

Regarding the governance architecture's fragmentation, this depends upon whether regime proliferation leads to either the negative fragmentation or constructive differentiation. The former could bring the architecture to it collapse or abandonment. As for the latter, it can be expected to take into account heterogeneous countries' motivations and capability, functional needs, and their ideal organizational expectations regarding the governance of the GNSSs issues, to harmonize these differences and suggest pragmatic solutions. The specialization on targeting particular governing topics as well the decentralizing management method fragment and perhaps weaken the entire governance architecture. However, the differentiated treatments with the account of the particularities of different geographical regions, cultural groups and their accommodation capabilities can sort the general challenging issues offbeat in different shapes and tailor-made solutions. It would be more effective, so constructive. Finally, the dynamic GNSSs regime complex seems to be a system with its own dynamics. Its creation was led by the three major intersecting driving forces described. There were and will be some others which were unfortunately not sufficiently investigated within the limited scope of our research. This opens various avenues to explore in the future.

CHAPTER VII CONCLUSION

1. THE DEPARTURE AND THE PATH IN OUR ASTROPOLITCAL JOURNEY

This doctoral dissertation departed from our research interests in seizing the vivid dynamics in international space politics over time and particularly in deciphering the growing complex connectivity in the galaxies of international space-related regimes from the early space age until our days in the 21st century. Factually, it is evident that the uses of outer space, notably the military, civilian and commercial applications of space-relevant technologies, such as rocket launching, satellite communication, navigation and remote sensing, have become vital and even indispensable in people's daily life and for countries to implement their national policy over a wide-range of issue areas, including national defense, homeland security, search and rescue, and services ranging "from farming to banking" for socio-economic development, and finally Earth Observation activities to preserve the sustainability of ecological environmental and generational prosperity.

Retrospectively, because of its cross-national border, inter-scientific disciplinary and overarching applications characteristics, the question of the use and the control of outer space became quickly a global issue put on the agenda at various multilateral forums, for example, the United Nation, the International Telecommunication Union, and the World Meteorological Organization. At that time, the agenda setting on discussing and negotiating international arrangements relating to space issues was conducted in the shadow of two Cold War space powers, the Soviet Union and the United States. Many space relevant international regimes were created and designed with a strong emphasis on de-militarization because the use of outer space was primarily developed for military purposes by both space power. These international bodies, e.g. the UN Committee on the Peaceful Uses of Outer Space (COPUOS), the Outer Space Treaty, etc. were all established with the mindset of de-militarization of outer space, so aiming the "peaceful use" of outer space. Hence, the architecture of global space governance was built on such politicized foundation to expand its governance dimensions as well as structural consolidation.

In the course of 2007-2008, the successive anti-satellite weapon tests respectively conducted by China and the US refreshed the global concerns on the question of governing states' space actives. Various international space regime initiatives, namely the EU-led International Code of Conduct and the China-Russia sponsored PPWT, were proposed respectively outside of any existing multilateral forum and at the non-UN Conference on Disarmament. The new happenings within the galaxy of global governance drew our attention to ultimately realize there is not merely the galaxy of space governance but a number of interconnected galaxies for space governance. This particular agglomerating or federating governing force has been embedded and constantly appeared in countries' negotiations regarding the development and the control of human space activities. It was with this fundamental understanding, we put forward to decipher such interconnecting global space governance structure as a way to seize the vivid dynamics in international space politics over time. And we have chosen one of the most inspiring theoretical frameworks in our time, *regime complex* as our way to undertake a piloting analytical narrative in order to cultivate a broadened understanding of the topic.

The regime complex framework focuses on investigating various types of *interplay* between the international regimes within a specific governing issue area that fragmented the entire governance scheme. This general architectural framework provided the limits within which our research examined as its object of study all international regimes closely or more distantly related to issues of space governance. Nevertheless, bear in mind that we could not explore and study in-depth the galaxies of interconnecting governance issue areas, but merely establish a pilot analytical narrative which is expected to prove useful for further and more narrowly focused case studies in the future. In this regard, the analytical strategy proposed by colleagues at the Ghent Institute for International Studies (GIIS), which identifies how the strategic, functional and organizational driving forces led the growing institutional fragmentation within the global space governance architecture, was extremely valuable for our research.

With this analytical instrument, we have established our general understanding of the long-standing space governing issues (Chapter II), the *legal inconsistency* between different governing principles, norms, their interpretations and implementations over time (Chapter III), the highly politicized institutionalization process that from the beginning of the space age strongly stressed the de-militarization or disarmament objectives and consequently divided the entire global space governance architecture into two distinct dimensions between disarmament and the "peaceful use" of outer space, though the space affairs are never indivisible for it dual-use (Chapter IV). By applying the regime complex framework and the GIIS analytical strategy, we investigated "space security" governance by introducing the main actors, key governing issues and the institutionalization process of the sub-governing regimes constellation in order to investigate how the space security governing constellation developed toward to its current fragmented stage of regime complex. In the power-interest centered space security governance dimension, states constantly required for regime change though almost always failed in the course of the last half century. New regime initiatives such as ICoC and PPWT raised new hopes though without certainty (Chapter V). With the same methodology, we achieved our analytical narrative on global navigation satellite system (GNSS) governance, which in our view represents a microsphere that demonstrates the fundamental problem of the whole of space governance and its structural fragmentation, the dual use that means military and civilian purposes, or nowadays "trio use" with the addition of a commercial dimension to the use of outer space. The interconnectivity of the three physical and practical dimensions naturally bring all the relating regimes together with overlapping mandate or missing competence to co-manage the space affairs.

2. GENERAL DISCOVERIES

Our investigation showed that the changes in the over-all landscape of international space politics and the space governing paradigm shifts have grown in magnitude in the following three ways. 1) From the end of the Cold War into the first decade of the 21^{st} century the arena of international space politics has gradually opened up to more actors. Simultaneously, the paradigm of handling space issues followed the shift from a pursuit of balancing the former US-USSR, the East-West divide during the Cold War, toward the paradigm of managing governance complexity to satisfy multiple power interest centered key space players. 2) Space powers and the spacefaring nations adopted their former hostile stances toward a more pragmatic and functionality-centered paradigm of regime making in the growing trends of the popularization of space capability development and the liberalization of the global space economy. The previous model of antagonistic competition has partly moved to the hybrid competitive-cooperation pragmatic model especially to the governance issue areas relating to safety, socio-economic development and environmental sustainability, but not space security issues. 3) With more key players, the rulemaking process became much more complex and complicated, the demand about the institutional form of new space related regimes became generally more and more flexible, e.g. instead of continuing to seek to establish legal binding rules, a non-binding code of conduct appeared as a new method to involve more general participation.

2.1. SITUATIONAL CHANGES BROADENED THE DIMENSION OF SPACE GOVERNANCE

During the Cold War, space powers developed their respective military space capability against their adversaries. Although they came to agree on the legal rights for all states to enjoy free access to outer space, they strictly controlled the flow of space capability transfer merely within their respective allied countries, therefore giving no chance for countries without technical capability to enjoy the use outer space. Those countries without space capability were counted but remained insignificant in the multilateral forum where space powers dominated the rulemaking of space governance. After the Cold War, the traditional space powers themselves faced major new challenges. Domestically, they had great difficulty to justify the continued astronomical governmental expenditure to maintain their space capabilities, notably when international politics seemingly turned less hostile. Along the way, the former race for military and scientific capability lost its ideological significance. Yet another type of “space race” has opened the space economy to more states through scientific personnel exchanges, technology transfers, trade in innovative products and space system services related to the use of outer space. In the course of this “race” for the popularization of space capability development and the liberalization of the space economy, more countries joined the game and therefore ought to become more involved in space governance. In this trend, states shifted from their previous strong demilitarization and disarmament centered governing focuses toward other broadened issues areas. The growing problems of managing the scarcity of space resources and the growing competition between the multiple GNSSs demonstrate this. States with a lack of space capability have obtained more attention because they can fulfill the needs of space powers and spacefaring states as their manufacturing partners or as extensive markets for selling space products and services. With the increase of key players and general consumers, the use of space expanded to cover the relating issue areas in safety, socio-economic development, preservation of environment, the sustainability governance approach was also accommodated. All these ever more widely broadened the scope of space governance issues and naturally generated more complexity and hurdles in the process of making rules to control the behavior of states.

2.2. GOVERNING PARADIGM SHIFTS IN INTERNATIONAL ASTROPOLITICS

After the Cold War, space powers and the spacefaring nations adopted their former hostile stances toward a more pragmatic and functionality-centered paradigm on regime making. In other words, they moved the traditional antagonist competition model to a hybrid competitive-cooperation pragmatic model especially in negotiating the regime making in the issue areas relating to safety, socio-economic development and environmental sustainability.

States adapted themselves to the new post-Cold War situation, shifting their approach to institutionalizing global space regime making. In the Cold War, states were used to holding the prevailing assumption that *space meant power, privilege, and pride*. Accordingly, the process of space-related regime making was marked by a rigid competitive model. This competitive paradigm appeared to fortify the space capability of each camp in order to lead the course in the 'space race'. Afterward, this Cold War competitive paradigm shifted to the hybrid competitive-cooperative functionality-centered paradigm. On the one hand, the traditional space powers continued their military and commercial "race" in or through outer space, e.g. ICBMs *vs.* BMD, and GPS *vs*. GLONASS, though bearing harsh domestic check-balance budgetary controls. On the other hand, they cautiously started a few symbolic and tentative cooperative space projects, for example, the International Space Station (ISS), which offered more scope for the industrialized countries to cooperate for scientific and civilian purposes. In addition, the industrialized states and a few emerging economies captured the new momentum to enter the global space economy with their limited and specific space capacities. They proactively developed new partnerships, notably with the developing countries, by applying the hybrid cooperative-cooperative paradigm for their highest benefits. This approach is also obviously found in our cases study about the regime complex of GNSS governance.

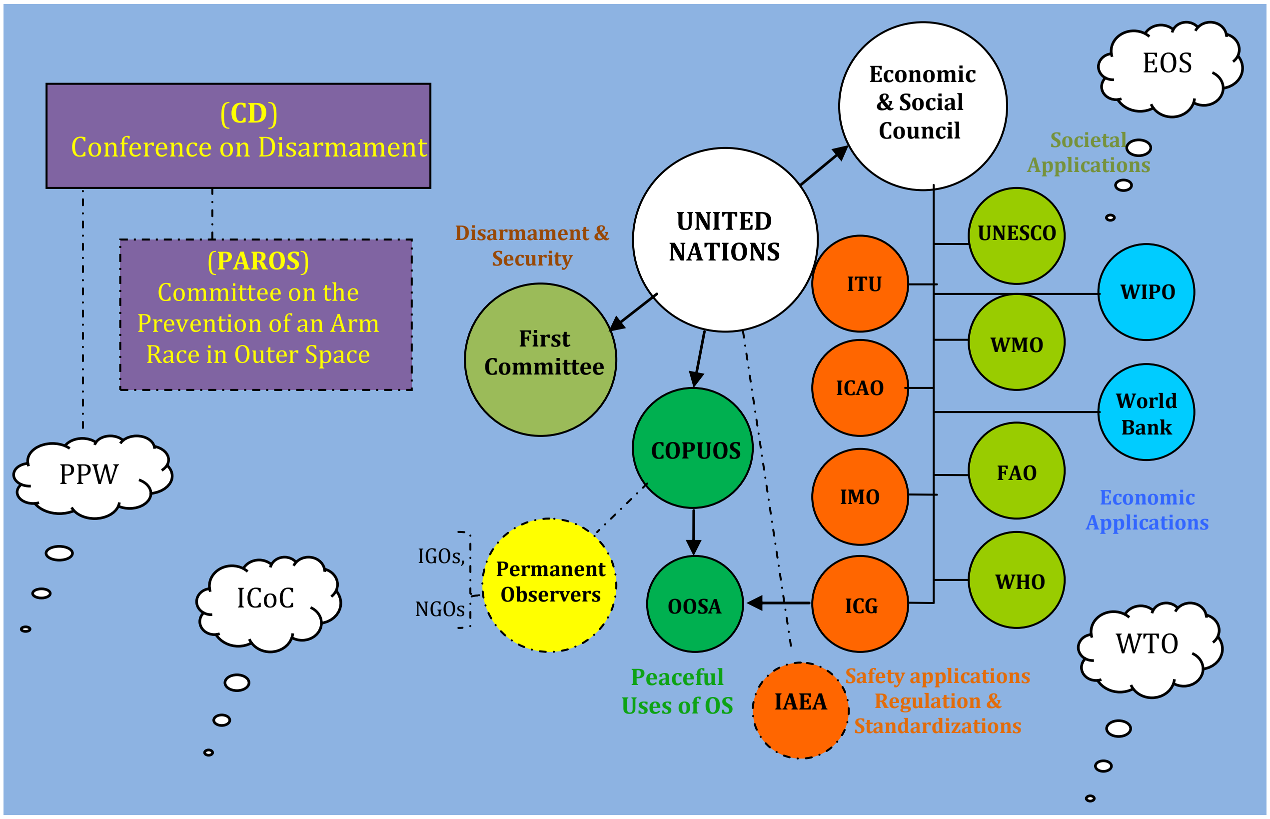
The popularization of space capability development and the liberalization of the global space economy also divided states' focuses in regime making. In the arena of security-related issues, space powers continued hold their respective defensive line thus attained no more significant success after the 1967 OST. Actually, we can even say that content-wise, the OST was not as successful as it should have been because the competitive rulemaking model resulted in divergent interpretations, and unverifiable and unimplementable legal texts generated further governance problems. Problematic cases of legal inconsistency were evident in the 'peaceful use', demilitarization, and de-weaponization of outer space. After the entry of some new mature game changers on the scene of world space politics, particularly but not solely China, the EU, and India, the traditional competitive paradigm was not wiped away. It remained obvious in the cases of PAROS vs. CTBT, PPWT vs. ICoC, that the competitive divide between East and West remains discernible. By contrast, in the governing issue areas relating to 'space for safety', 'space for socio-economic development' and 'space for sustainability', states adopted a more hybrid competitive-cooperative regime-making approach to satisfy their own functional necessity in the trend of growing interconnection between these dual-use issue linkages. Under UN auspices and at the regional space cooperation levels, the institutionalization of technical rules and cooperative mechanisms was more easily established.

2.3. INSTITUTIONAL ADAPTATION OF THE INTERNATIONAL SPACE REGIMES

We have found that states, notably the space powers, started exploring the international regimes to gain their security guarantee and strategic advantage from the early space age. In this process, international space regimes were continuously created and functioned with an ambiguity in their different interpretation of various terminologies, lacking means of verification, and with no possibility of implementation, or of legal consistency. International regimes were established for form's sake yet often with the leeway of not including particular issues in content as the ultimate compromise. For example, the primarily creative space diplomacy invented the rhetorical 'peaceful use' of outer space which ultimately gained universal acceptance, but this has nonetheless borne different interpretations either to achieve the goal of the 'demilitarization' of outer space, or to use outer space to maintain the means for self-defense and to assure the international peace and security by upholding the bottom-line of 'non-aggression'. The different politicized interpretations actually pushed the entire global space governance architecture on to a path towards artificial differentiation. The regime-making matters considered related to the 'peaceful use' of outer space were mainly under UN auspices, for example through COPUOS, ITU, IAEA, WMO, and more. Space security-related regime making was in the UN First Committee and the CD.

The novel situation after the Cold War brought in new elements to the existing space governance scheme. The popularization of the use of outer space evoked the creation, adaptation of mandate, or abundance of space related regimes to greater respond to countries' general requests and specific problems. The ITU confirmed its mandate to manage the satellite orbital slots and radio frequency allocations as from 1992. The UN General Assembly endorsed the 1992 UN principles relevant to the use of nuclear power sources in outer space. The verification task was attributed to the UN specialized agency, the International Atomic Energy Agency (IAEA). In 1996, the UN endorsed the International cooperation declaration for benefiting developing countries with outer space exploration and uses (*International Cooperation Declaration*) to promote the popularization of the use of space to benefit more people. When the explorer and user population grew massively, states and their citizens became more aware of the risks caused by the maladministration and mismanagement of space issues. The concept of inclusive global space governance gained greater acceptance and accommodation because of functional necessity. The International Committee on GNSS (ICG) was created not only to deal with GNSS technical issues but also with strongly connections to the use of GNSSs for economic growth and for development. The international space regimes became more interconnected than ever. This also led to the initiative for establishing an International Code of Conduct (ICoC) that attempted to stimulate a regime making that can cover the security, safety and sustainability issue for space activities. It resulted in a complex governance scheme, as illustrated in Figure 17.

Figure 17. An architectural overview of the global space governance institutions



Author's creation

3. SPECIFIC FINDINGS

3.1. VALUABLE RESEARCH FRAMEWORK AND ANALYTICAL METHODOLOGY

The second part of this dissertation was dedicated to looking through focused case studies at how the use of outer space has been governed. We were inspired by the revealing *regime complex* research framework to answer these questions. This holistic framework offered a comprehensive viewpoint to look into a given constellation of international regimes in which "*an array of partially overlapping and non-hierarchical institutions governing a particular issue-area*", or more completely, as "a *network of three or more international regimes that relate to a common subject matter; [that] exhibit[s] overlapping membership; and generate[s] substantive, normative, or operative interactions recognized as potentially problematic whether or not they are managed effectively*. With this framework, we could put forward the different focuses by investigating the institutional interaction (*regime interplay*), the interdependency and the issue-linkage between of different international regimes and their overlapping membership, as well as their *labor division* development in the entire governance ecosystem.

Our research objective being to establish the first piloting literature, we presented an overview of the regime complex of space security governance and undertook a case study on the increasingly fragmented regime complex of the GNSS governance scheme. To complete the groundbreaking, we applied the analytical methodology proposed by GIIS colleagues that argues that the growth of a *regime complex* is usually stimulated by three intersecting driving forces, summarized as the strategic, functional and organizational logics. 1) The *strategic input* guided states to create or be part of one or various international regimes with attempt to gain their upmost interests. 2) The direct and indirect functional interdependency agglomerates states to involve themselves in different international regimes to fulfill their *necessity.* 3) The constellation of international regimes could become a loosely attached system itself. These linkages between different regimes appearing in the form of competition, cooperation, coordination or labor division could become customary and create managerial burdens within the global governance scheme. The tri-logic prism was convenient to decipher the hindered spectrums that disguised the entire evolution of space governance regime complex over time.

3.2. STRATEGIC FORCE POLITICIZED THE GOVERNING ARCHITECTURAL DIVISION

Countries pursue their relative power and individual interests when deciding to create or enter different space security regimes where they tried to steer the design and the functions of any interested international regimes in favor of their leverage power, or choose the moment of entrance to these international regimes that most suits their interests.

Already in the course the genesis of space regimes building in the late 1950s, making rules on governing space issues were decided to promote security and peace with the use of outer space. This decision was political, not with technical rational. This division basic on strategic reasons led the respective camps to continuously proposed space security regime creating initiatives to prohibit "militarize" in avoidance an arms race in outer space or "weaponize" outer space with placement of "weapon" in outer space. More recently, China became interested in a PAROS in the 1990s because that was when the US was imposing limits on Chinese strategic nuclear capabilities. After the failure of the PAROS attempt came the Russia-China co-sponsored PPWT initiative and the EU-led ICoC proposal, the former motivated by the Russia-China coalition to restrain US space power, and the latter based on the new strategy of the European Union to gain more space autonomy and to explore the EU's space diplomacy. None of these strategic actions was considered feasible to consolidate unanimity of global space security governance, but exacerbated the fragmentation of the space security regime complex over time.

3.3. FUNCTIONAL LINKAGES BIND THE GNSS REGIME COMPLEX

The GNSSs regime complex case study presented another fragmented pillar within the entire global space governance architecture. The GNSS services were opened for civil utilities as from the early 1990s. GNSS services require continuous transmission between the three segments between the dispersed ground stations, their satellites constellation and the end users. The regional augmentation systems are also important to improve the accuracy of the positing function. The popularization of the military controlled but largely civilian used GNSS services is one of the most salient cases to expose the problematic fragmentation in the pillar of 'peaceful use' of outer space in the entire architecture. Because of the ubiquitous use of GNSSs applications and extensive services, it also spilt over its governance dimension toward other governance issue areas from security to safety, socio-economic development and sustainability. The governing issues such as resolving the military or government-only satellite radio frequency overlays for their military operators, the challenges of managing the scarcity of outer space resources, the protection on the guaranteed continuity of the GNSSs services for navigation safety which directly requires the inter-GNSSs interoperability and compatibility which are highly connected with the market access discriminatory measures for different GNSSs providers to protect their markets and commercial interests. The overarching utilities of the GNSSs have continuously drawn the international regimes that are mandated in harmonizing the above issue areas into the GNSS governance constellation. The functionality-centered GNSS governance scheme with cooperative stress has been equally an arena for strategic competition instrument, particularly for the emerging game changers that involved their military ally countries and commercial partners to join their respective group of GNSS interdependencies. These different GNSS interdependent groups of states generated competitions, tensions between the concerned states and fragmented the GNSS governance constellation. In our case study, we have presented the complex GNSSs interconnectivity that has created ICG, involved ITU, ICAO, IMO, WTO and more and more regional cooperation organizations to join the governance constellation. None of them has completed mandate to handle all GNSSs related cases alone.

3.4. ORGANIZATIONAL PATH DEPENDENCY GROWS REGIME COMPLEX

In the studies on space security and the GNSS regime complex, we noticed that the entire space governance architecture was founded upon the politicized division for the reason of the dual-use nature of outer space utilities. Furthermore, the entire space regime constellation was not constructed without any precedent regime. Quite to the contrary, ITU and WMO were two intergovernmental organizations that had existed long before the creation of COPUOS. They were immediately connected with the space governance for technical reasons. Therefore, COPUOS could not act alone when coordinating and promoting the 'peaceful use' of outer space that are related to the mandates of ITU or WMO. The clear distinction between the dimension of space security and 'peaceful use' also made the space activities governance more difficult, not easier. The EU initiative for an ICoC demonstrated this problem since the draft ICoC promotes rulemaking on space activities with the comprehensive aspect that covers security, safety and sustainability. The ICoC in the end found no place in the organizational reality that could provide a legally adequate multilateral platform to undertake the progress of this non-binding, voluntary initiative. This organizational imperfection resulted in the continuous regime changes that often aim to fix the labor division problems yet often ended up fragmenting even more the regime complex.

4. REFLECTIONS ON THE FUTURE OF GLOBAL SPACE GOVERNANCE

It is to be hoped that this work can open a certain novel perspective upon the future development of global space governance, though we bear in mind that the current global space regime constellation will not cease its architectural expansion and fragmentation in the near future, precisely because of those intersecting driving forces we have identified in this dissertation. These new challenges slowly stimulated a growing general sense of crisis on the question about the appropriate use of space for now and for future generations. Under these circumstances, we were also brought to consider the question of how the complex global space governance could be functionally and organizationally improved in order to more efficiently, effectively and sustainably govern space-relevant matters.

We think a new governance paradigm that encourages more *inclusive popularization* of space capability development with greater support from the spacefaring countries will be necessary and beneficial. This new paradigm would require more *affordable and responsible burden-sharing* by both spacefaring countries and non-spacefaring nations to jointly assure a balanced dynamic governance environment to cultivate cooperative projects. 2) A structural rationalization of the current space regime complex should be undertaken, especially by applying the strong interdependency or the federating force of human space activities to fixing the imperfection of the current space architecture and the division of labor in its regimes. This can happen through the less politicized regime coordination and merging process toward an emphasis on technical specialization at the global level. It should also happen simultaneously by enhancing the tailor-made decentralization space capability scheme at the regional level to stimulate general awareness and bottom-up regime reform initiatives so can discharge the concentrated rule making burdens at the global level and also link the global rule-making impacts closer to the terrains. We noted that this specialization process became explicit in the growing regionalization of space. Regionalized capability-building cooperation and regional space economy development are constructive forces to consolidate the foundation of the global space governance architecture and could repair the current regime complex. Because of this, further studies along these lines are needed.

Ultimately, it seems that we have accomplished one step on a fascinating journey of discovery. Yet apparently, another vibrant exploration could start soon again because our enthusiasm has grown even greater to look toward other twinkling spots in the infinite universe.

BIBLIOGRAPHY

BOOKS AND JOURNAL ARTICLES

Abeyratne, Ruwantissa (1997) The aerospace plane and its implications for commercial air traffic rights. *The Aviation Quarterly 186*.

Abeyratne, Ruwantissa (2004) ICAO's involvement in outer space affairs – A need for closer scrutiny? *Journal of Space Law 30*(2): 185-202 (University of Mississippi School of Law).

Aganaba-Jeanty, Timiebi (2013) Precursor to an African Space Agency: Commentary on Dr. Peter Martinez "Is there a need for an African Space Agency?" *Space Policy 29* (2013): 168-174.

Aggarwal, Vinod K (1983) The Unraveling of the Multi-Fiber Arrangement, 1981: Examination of International Regime Change. *International Organization 37* (4): 617-646.

Aliberti, Marco (2013) Regionalisation of space activities in Asia? *ESPI Perspectives 66*, Vienna: European Space Policy Institute.

Allison, Audrey (2012) Paper Satellites, virtual satellites : Managing Satellite Orbital and Spectrum Resources in an Increasingly Competitive and Congested Environment, Master Thesis, International space University.

Alter, Karen J. and Meunier, Sophie (2009) The politics of international regime complexity. *Perspective on Politics 7*(1): 13-24.

Aoki, The national Space Law of Japan: Basic Space Law and the Space Activities Act in the Making. http://www.iislweb.org/docs/2011_galloway/Aoki.pdf

Anan, Keiichi (2013) Administrative reform of Japanese Space Policy Structures in 2012, *Space policy 29* (3): 210-218.

Anderson, Ruper W. (2015) The Cosmic Compendium – Space Law, Lulu.com.

Arbatov, Alexei (2013) Russian Perspectives on Spacepower, International Security Network (ISN). www.isn.ethz.ch/Digital-Library/Articles/Special-Feature/Detail/?lng=en&id=163261&tabid=1454267623&contextid774=163261&contextid775=163258

Ball, Carolyn (2009) What is transparency? *Public Integrity 11*(4).

Beck, Susan (1998), The Global Commons. An Introduction, Washington, D.C.: Island Press.

Beckner, Christian, et al. (2003) *US-Japan Space Policy: A Framework for 21st Century Cooperation*. Washington: Center for Strategic and International Studies (CSIS)

Beidleman, Scott W. (2006) GPS versus Galileo: Balance for Position in Space, *CADRE Paper No. 23*, Maxwell Air Force Base: Air University Press.

Bernstein, Steven & Cashore, Benjamin (2012) Complex global governance and domestioc policies : four pathways of influence. *International Affairs 88* (3): 585-604.

Berz, Gerhard, "Authorization and Operation of GNSS Aviation Services in Non-Core Constellation States", Presentation at the Civil GPS Service Interface Committee, Tampa, USA, Sept. 8th 2014.

Betts, Alexander (2009) Institutional Proliferation and the Global Refugee Regime, *Perspectives on Politics 7*(1): 53-58.

Betts, Alexander (2013) Regime Complexity and International Organizations: UNHCR as a Challenged Institution, *Global Governance 19* (Special Focus: Regime complex): 69-81.

Biermann, Frank, Philipp Patterberg, Harro van Asselt, and Fabriorz Zelli (2009) The Fragmentation of Global Governance Architectures: A Framework for Analysis, *Global Environmental Politics 9* (4): 14-40.

Bouvet, Isabelle (2004) Use of nuclear power sources in outer space: key technology legal challenges. *Journal of Space Law 30*(2): 203-226 (University of Mississippi School of Law).

Brown Weiss, Edith (1993) International Environmental Law: Contemporary Issues and the Emergence of a New World Order, *Georgetown Law Journal 81*: 675-710.

Cheng, Dean. (2001) Space and Chinese Views of Future Warfare. 2001 CAPS-RAND PLA Conference.

---- (2011) China's Space Program: A Growing Factor in U.S. Security Planning. *The Heritage Foundation Backgrounder No. 2594*.

---- (2012) Meeting the Chinese Space Challenge. *The Heritage Foundation WebMemo, No. 3457*.

---- (2012) Responding to China's Manned Space Challenge. *The Heritage Foundation Issue Brief No. 3648*.

---- (2012) China's Military Role in Space. *Strategic Studies Quarterly 6* (1): 55-77.

---- (2015) The PLA's Interest in Space Dominance, Testimony before the U.S.-China Economic and Security Review Commission, February 18, 2015. Source: www.heritage.org/research/testimony/2015/the-plas-interest-in-space-dominance

Cheng, Dachen 鄭大誠 (2007) 北斗: 中共的千里之眼 中共成功發射第二顆北斗二代衛星之意義與成效, *尖端科技 299* (2007 年 7 月): 82.

Davis, Christina L (2009) Overlapping Institutions in Trade Policy, *Perspectives on Politics 7*(1): 25-31.

Dolman, Everett C (1999) Geostrategy in the Space Age: An Astropolitical Analysis, In Colin S. Gray and Geoffrey Sloan (eds) *Geopolitics: Geography and Strategy*, London and Portland, Oregon: Frank Cass;

Dolman, Everett C (2002) *Astropolitik: Classical Geopolitics in the Space Age*, London and Portland, Oregon: Frank Cass.

Easton, Richard D. and Frazier, Eric F. (2013) *GPS Declassified: From Smart Bombs to Smartphones*, University of Nebraska Press: Potomac Books.

Etienne, Genovefa and Moniquet, Claude (2001) *Histoire de l'espionnage mondial, Tome 2 : De la guerre froide à la guerre antiterroriste*. Bruxelles : Luc Pire

Facon, Isabelle and Sourbès-Verger, Isabelle (2006) La spatial russe: implications nationales et internationales d'une apparente remontée en puissance*. Recherches & Documents*. Paris: Fondation pour la Recherche Stratégique.

Fauchille, Paul (1901) La Domaine Aérien et le Régime Juridique des Aérostats, *Revue Générale de Droit International Public 8*.

Galeriu, Iulia-Diana (2015) "Paper satellites" and their free use of outer space, *NYU Law Global*.

Garwin, Richard, Space defense – the impossible dream?, NATO's sixteen Nations (April 1986): 22-26.

Gehring, Thomas and Sebastian Oberthür (2000) 'Exploring Regime Interaction: A Framework for analysis', Proceedings of the Final Conference of the Concerted Action Programme on the Effectiveness of the International Environmental Agreements and EU Legislation (www.fni.no).

Gehring, Thomas and Oberthür, Sebastian (2006) Introduction. In *Institutional Interaction in Global Environmental Governance: Synergy and Conflict among International and EU Policies*. (Eds.) Sebastian Oberthür and Thomas Gehring. Cambridge, Massachusetts, London England: The MIT Press.

Gehring, Thomas & Faude, Benjamin (2014) A theory of emerging order within institutional complexes: How competition among regulatory international institutions leads to institutional adaptation and division of labor. *The Review of International Organizations 9* (4):471-498.

Gleason, Michael P. (2009) Galileo : Power, Pride, and Profit : The Relative Influence of Realist, Ideational, and Liberal Factors on the Galileo Satellite Program. Doctoral Dissertation. George Washington University. p290.

Goedhuis, D (1978) The Changing Legal Regime of Air and Outer Space. *The International and Comparative Law Quarterly 27* (3): 576-595.

Goldman, Nathan C. (1992) *Space policy: An Introduction.* Ames, IA: Iowa State University Press.

Golston, Daniel and Baseley-Walker, Ben (2015) *The Realities of Middle Power Space Reliance*, Geneva: UNIDIR.

Gray, Colin S (1996) The Influence of Space Power upon History, *Comparative Strategy 15* (4): 293-308;

Hardin, Garrett (1968) The Tragedy of the Commons, *Science, New Series 162* (3859): 1243-1248.

Haug, Constanze, Harro van Asselt & Fariborz Zelli (2013) 'Untangling the Web of Global Forest Governance: A First Step for Analyzing Institutional Complexity', paper prepared for the panel on Institutional Fragmentation of Global Environmental Governance, International Studies Association Annual Conference, San Francisco, 3-6 April 2013.

Hays, Peter L. and Lutes, Charles D (2007) Toward a theory of spacepower, *Space Policy 23*: 206-209.

Hitchens, Theresa (2008) Space Wars. *Scientific American 298*: 78-85.

---- (2008) Forging a Sino-U.S. "grand bargain" in space. *Space Policy 24* (3): 128-131.

---- (2009) Saving Space: Threat Proliferation and Mitigation, a research paper for the International Commission on Nuclear Non-Proliferation and Disarmament.

Hofmann, Stephanie C (2009) Overlapping Institutions in the Realm of International Security: The Case of NATO and EDSP, *Perspectives on Politics 7*(1): 45-52.

Jakhu, Ram and Singh, Karan (2009) Space Security and Competition for Radio Frequencies and Geostationary Slots, *Zeitschrift für Luft- und Weltraumrecht* (German Journal of Air and Space Law) *58*(1): 74-93.

Jasani, Bhupendra (ed.) (1987) *Space Weapons and International Security – The Arms Control Dilemma*. Oxford: Oxford University Press.

Jessup, Philip Caryl & Taubenfeld, Howard Jack (1959) *Controls for Outer Space and Antarctic Analogy*. New York: Columbia University Press

Johnson, R (2002) "Space Security: Opinions and Approaches", Paper presented at the "Outer Space and Global Security" Conference, Geneva, 26-27 November 2002.

Johson-Freese, Joan. (2007) *Space As A Strategic Asset*. New York: Columbia University Press.

---- (2007) China's Space Ambitions. Ifri Proliferation Papers, Paris/Brussels : Institut Français des Relations Internationales.

Johnson-Freese, Joan and Erickson, Andrew S (2006) The emerging China-EU space partnership: a geotechnological balancer, *Space Policy 22*: 12-22.

Johnson-Freese, Joan and Milowcki, Gene V (2008) Strategic Choices: Examining the United States Military Response to the Chinese Anti-Satellite Test. *Astropolitics 6* (1) (2008): 1-21.

Karl, Inge, Grunberg, Isabelle, and Stern, Marc A. (eds.) (1999) *Global public goods – International cooperation in the 21st Century published for the United Nations Development Programme (UNDP)*. Oxford/New York: University Press.

Kan, Shirley (2007) China's Anti-Satellite Weapon Test, Congressional Report Service Report for Congress, RS22652, April 23, 2007.

Keohane, Robert O (1983) The demand for international regimes, In *International Regimes*, (ed.) Stephen D. Krasner, Ithaca, N.Y.: Cornell University Press. p141-172.

---- (1984) *After Hegemony: Cooperation and Discord in the World Political Economy*. Princeton: Princeton University Press.

Keohane, O. Robert and Nye Jr., Joseph S. (2000) Introduction. In Governing in a Globalizing World (Eds.) John D. Donahue and Joseph S, Nye Jr., Washington DC., NW: Brookings Institute Press.

Keohane Robert O and Victor, David G (2011) The Regime Complex for Climate Change, *Perspectives on Politics 9*(1): 7-23.

Kopal, V (1998) The role of United Nations declarations of principles in the progressive development of space law, *Journal of Space Law 16*(1).

Krasner, Stephen (1983) (ed.) *International Regimes*, Ithaca, N.Y.: Cornell University Press.

---- (1991) Global Communications and National Power: Life on the Pareto Frontier, *World Politics 43*(3): 336-366.

Lambakis, Steven (2002) Putting Military Uses of Space in Context. In James Claz Moltz (ed) *Future Security in Space: Commercial, Military, and Arms Control Trade-Offs*, Occasional Paper No. 10 (Monterey, CA: Monterey Institute of International Studies, Center for Nonproliferation Studies and University of Southampton, Mountbatten Centre for International Studies, July 2002), p 23-24.

La Regina, Veronica (2015) *Business partnership and technology transfer opportunities in the Space sector between EU and Japan*. Tokyo: EU-Japan Centre for Industrial Cooperation.

Lele, Ajev (2008) China's Posture in Space and its Implications. *Strategic Analysis 32* (4): 605-620.

---- (2014) *Mission Mars: India's Quest for the Red Planet*, New York: Springer.

---- (2013) *Asian Space Race: Rhetoric or Reality ?* Wien/New York: Springer

---- (2015) The 'Road' to Success for the "Silk Road Initiative" is via Aerospace. *IDSA Comment, October 21, 2015*. IDSA: Institute for Defense Studies and Analyses

Lembke, Johan (2001) The Politics of Galileo, European Policy Paper No. 7, April 2001. Pittsburgh: European Union Center/Center for West European Studies.

Lesage, Dries (2013) The architecture of international monetary and finance governance. In *Routledge Handbook of International Organization* (Ed.) Bob Reinalda. p.486-498.

Liao, L.W. Xavier (2014) Global space governance in the 21st century: A 'Regime complex' perspective – A Brief note about the paper presented at the 2nd Manfred Lachs International Conference on Global Space Governance, 2014 Montréal, Canada, *Astrosociological Insights 3* (2): 3-5.

---- (2015) The growing space regionalisation of the global space regime complex, *The Aviation and Space Journal XIV* (1): 23-34.

---- (2016) The space regionalisation and global space governance, In *European Space Policy Institute Yearbook on Space Policy 2014 – The Governance of Space*, (Eds.) Genan Al-Ekabi, Blandina Baranes, Peter Hulsroj, and Arne Lahcen. Wien: Springer Verlag.

Logdson, John M (2002) La politique spatiale américaine: entre changement et continuité. *Géoéconomie 61*: 49-59.

Lyall, Francis and Larsen, Paul B. (2009) Space Law: A Treatise. Surrey: Ashgate.

Lynn, III, William J. (2011) A Military Strategy for the New Space Environment, *The Washington Quarterly 34* (3): 7-16.

Margulis, Matias E (2013) The Regime Complex for Food Security: Implications for the Global Hunger Challenge. *Global Governance 19* (Special Focus: Regime complex): 53-67.

Martinez, Larry (2012) Is There Space for the UN? Trends in Outer Space and Cyberspace Regime Evolution. *ESPI Perspectives 56*, Wien: European Space Policy Institute.

Mearsheimer, John J (2002) Realism, the Real World, and the Academy, in Michael Brecher and Frank P. Harvey, (eds.), *Realism and Institutionalism in International Studies*. Ann Arbor: The University of Michigan Press, p. 23-33.

Melby, Svein (1982) On Recent ASAT Technology, Anti-satellite Weapons, the Strategic Balance and Arms Control, *NUPI-rapport No. 69* (Norsk Utenrikspolitisk Instituttt), Oslo: 27-96.

Meyer, Patrick R. (1993) *Succession between International Organizations*. Kegan Paul International then (2011) Oxon, New York: Routledge

Moltz, James Clay (2008) *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, California: Stanford University Press.

---- (2010) Space and Strategy: A Conceptual versus Policy Analysis, *Astropolitics 8*(3).

---- (2012) *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press.

Morin, Jean-Frédéric and Orsini, Amandine (2013) Regime complexity and policy coherency: introducing a co-adjustment model. *Global Governance 19*: 41-51.

Murray, Kim (2000) The Law Relating to Satellite Navigation and Air Traffic Management Systems – A View From the South Pacific, *Victoria University of Willington Law Review 31*: 383-400.

Nair, Kiran (2007) Putting Current Space Militarization and Weaponization Dynamics in Perspective: An Approach to Space Security. Celebrating the Space Age: 50 Years of Space Technology of the Outer Space Treaty – Conference Report, 2-3 April 2007, Geneva: UNDIR.

Nardon, Laurence and Venet, Christophe (2010) The Evolving Architecture of Space and Security in Europe. *Actuelles de l'Ifri*.

---- (2011) The Use of Space for Maritime Security in Europe, *Actuelles de l'Ifri*.

---- (2011) The Use of Space for Civil Protection in Europe, *Actuelles de l'Ifri*.

Noichim, Chukeat (2008) Promoting ASEAN space cooperation, *Space Policy 24* (1): 10-12.

Noble, Michael J. (2008) Export Controls and US Space Power, *Astropolitics 6*(3): 251-312.

Oberg, Jim (2000) *Space Power Theory, Colorado Springs*, CO: US Space Command.

Orsini, Armandine, Morin, Jean-Frédéric and Young, Oran (2013) Regime Complexes: A Buzz, a Boom, or a Boost for Global Governance. *Global Governance 19*: 27-39.

Ostrom, Elinor, Walker, James and Gardner, Roy, (1992) Covenants With and Without a Sword: Self-Governance is Possible, *The American Political Science Review 86* (2): 404-417.

Pace et al. (1995) *The Global Positioning System: Assessing National Policies*, Santa Monica: RAND.

Parkinson, Brad (2003) Capability and Management Issues for GPS/Galileo Positioning and Timing. Presentation. Council on Foreign Relations, November 7, 2003.

Pasco, Xavier (2009) *A European Approach to Space Security*. Cambridge, MA: American Academy of Arts and Sciences.

---- (2012) Quel nouveau départ pour l'activité spatiale ? *Géoéconomie 61*: 23-30.

Peng, Ming-Min (1957) *Le statut juridique de l'aéronef militaire*, La Haye : Martinus Nijhoff.

Peoples et al.(2013) Special Focus: Regional approach – China's Rising Star, Japan's Re-entry: East Asia Space Security in a Global Context. *Space Policy 29*(2): 95-143.

Pépin, Eugène. (1957) The legal Status of the Airspace in the Light of Progress in Aviation and Astronautics, *McGill Law Journal 3*(1):70-77.

Peter, Nicolas (2006) The changing geopolitics of space activities, *Space Policy 22*(2): 100-109.

Peter, Nicolas (2007) The EU's emergent space diplomacy, *Space Policy 23*(2): 97-107.

Phaltzgraff, Robert (2011) International Relations Theory and Spacepower, In *Toward a Theory of Spacepower* (Eds.) Charles D. Lutes et al. Washington D.C.: National Defense University.

Pike, John (1998) American Control of Outer Space in the Third Millennium, *INESAP Information Bulletin 16*: 29-33.

Podvig, Pavel and Zhang, Hui (2008) *Russian and Chinese Responding to U.S. Military Plans in Space*, Cambridge, MA: American Academy of Arts and Sciences.

Political and Security Questions: Discussion record of the UN First Committee meeting on October 17-20, and 26, 1967*. International Organization* 22(3) (Summer 1968): 698-728.

Pollpeter, Kevin, Anderson, Eric, Wilson, Jordan, and Yang, Fan (2015) Chinas Dream, Space dream: China's Progress in Space Technologies and Implications for the United States, March 2 2015.

Rajagopalan, Rajeswari Pillai (2013) Synergies in Space: The Case for an Indian Aerospace Command. *OSF Issue Brief 59*, Observation Research Foundation.

---- (2011) "Debate on Space Code of Conduct: An Indian Perspective," *ORF Occasional Paper 26*, Observer Research Foundation, October 2011.

---- (2016) 'The International Code of Conduct and Space Sustainability', in *European Space Policy Institute Yearbook on Space Policy 2014 – The Governance of Space*, Wien: Springer Verlag: 229-241.

Rao, U.R. (2003) Space benefit Security. Pugwash Meeting 283, Pugwash Workshop on Preserving the Non-Weaponization of Space, 22-24 May 2003.

Raustiala, Kal and Victor, David (2004) The Regime Complex for Plant Generic Resources. *International Organization 58*(2): 277-309.

Roberts, Lawrence D. (2000) *A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union*, Berkeley Technology Law Journal 15(3): 1095-1144.

Rosas, Allan (1983) The Militarization of Space and International Law, *Journal of Peace Research 20*(4): 357-364.

Rosenau, N. James, (1995) Governance in the twenty-first century, *Global Governance 1*(1): 13.

Rosendal, G. Kristin (2001) Impacts of Overlapping International Regimes: The Case of Biodiversity. *Global Governance 7*(1): 95-117.

Sadeh, Eligar. Export Controls of Space Technologies, Astropolitics 6(2) (2008): 105-111.

---- (2012) Reforming Export Controls of Space Technologies in the United States, *Astropolitics 10*(2): 93-109.

Sawako, Maeda (2009) Transformation of Japanese Space Policy: From the 'Peaceful Use of space' to 'the Basic Law on Space', *The Asia-Pacific Journal: Japan Focus 44* (1) http://www.japanfocus.org/-Maeda-Sawako/3243

Schick, F.B. (1961) Space Law and Space Politics. *The International & Comparative Law Quarterly 10*(4): 681-706.

Sgobba, Tommaso. (2008) An International Civil Aviation Organization for Outer space? In Security in space: The next generation. UNIDIR Conference Report, March 31- April 1, 2008. Geneva: United Nation Institute for Disarmament Research. p.103-120.

Shawacross and Beaumont Air Law (1951) What is Airspace, Shawacross and Beaumont on Air Law 175.

Sheehan, Michael, (2007) International Politics of Space, London and New York: Routledge.

---- (2015) Defining Space Security, In *Handbook of Space Security* (Eds.) Kai-Uwe Schrogl, Peter L. Hays, Jana Robinson, Denis Moura and Christina Giannopapa. New York: Springer;

Simon, Herbert A (1982) *Models of Bounded Rationality*. Cambridge, MA: MIT Press.

Singer, Clifford, (2002) Space weapons and the Conference of Disarmament, *INESAP Information Bulletin 20*: 25-26.

Soroos, Marvin S. (1982) The Common In the Sky: the radio spectrum and geosynchronous orbit as issues in global policy, *International Organization 36*(3): 665-677

Sourbès-Verger, Isabelle (2012) Russie, Japon, Chine, Inde, quelles politiques spatiales en 2012 ? *Géoéconomie 61*: 61-72.

Stares, Paul B. (1985) *The Militarization of Space: U.S. Policy, 1945–1984*. Ithaca: Cornell University Press.

Stokke, Olav Schram (2000) Managing Straddling Stock: The Interplay of Global and Regional Regimes', *Ocean and Costal Management 43*(2-3): 205-234.

---- (ed.) (2001) *Governing High Sea Fisheries: The Interplay of Global and Regional Regimes*. Oxford: Oxford University Press.

Struett, Michael J., Nance, Mark T., and Armstrong, Diane (2013) Navigating the Maritime Piracy Regime Complex*. Global Governance 19* (Special Focus: Regime complex): 53-67.

Stuart, Jill (2013) Regime Theory and the Study of Outer Space Politics. E-International Relations, http://www.e-ir.info/2013/09/10/regime-theory-and-the-study-of-outer-space-politics/ Accessed on November 26, 2013.

Suzuki, Kazuto (2013) The contest for leadership in East Asia: Japanese and Chinese approaches to outer space, *Space Policy 29* (2013): 99-106.

Tronchetti, Fabio (2013) *Fundamentals of Space Law and Policy*, New York, Heidelberg, Dordrecht, and London: Springer.

UNIDIR (2012) *The Conference on Disarmament: Issues and Insights*. New York & Geneva: United Nations Institute for Disarmament Research.

United Nations University (1999) *Inter-Linkages: Synergies and Coordination between Multilateral Environmental Agreements*. Tokyo (www.ias.unu.edu/binaries/Interlinkages.PDF).

Van de Graaf, Thijs (2013) *The Politics and Institutions of Global Energy Governance*. London, New York: Palgrave MacMillan.

Vlasic, Ivan A (1995) "Space Law and the Military Applications of Space Technology" in N Jasentulyianan, (ed.) *Perspectives on International Law*, Boston: Kluwer Law International. p385-394.

Vogel, John (2000) *The Global Commons. Environmental and Technological Governance*, Chichester: John Wiley

von Prittwitz, Volker (2011) Space as Environment: On the Way to Sustainable Space Policy? *ESPI Perspectives 50,* Wien: European Space Policy Institute.

Young, Oran R (ed) (1983) *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms.* Cambridge, MA: MIT Press.

---- (1996) Institutional Linkages in International Society: Polar Perspectives. *Global Governance 2*(1): 1-24.

---- (1999) *Governance in World Affairs*. Ithaca, NY: Cornell University Press.

---- (2000a) 'Vertical Interplay: The Environmental Consequences of Cross-Scale Interactions', Hanover, NH: Institute on International Environmental Governance, unpublished draft.

---- (2000b) 'Horizontal Interplay: The Politics of Institutional Linkage', Hanover, NH: Institute on International Environmental Governance, unpublished draft.

---- (2002) *The Institutional Dimension of Environmental Change: Fit, Interplay, and Scale*. Cambridge, Mass: MIT Press.

Zelli, Fariborz, Gupta, Aarti, & van Asselt, Harro (2013) Institutional Interactions at the Crossroads of Trade and Environment: The Dominance of Liberal Environmentalism? *Global Governance 19* (Special Focus: Regime complex): 105-118.

Zenko, Micah (2011) A Code of Conduct for Outer Space, *Policy Innovation Memorandum No. 10*, Council on Foreign Relations.

Zhang, Hui, (2002) FMCT and PAROS: A Chinese Perspective, *INESAP Information Bulletin 20*: 21-24.

---- (2005) Action/Reaction : U.S. Space Weaponization and China, *Arms Control Today*, Arms Control Association: www.armscontrol.org

Zollmann, Carl (1927) Law of the Air. Milwaukee, Wisconsin: Bruce Publishing Company.

Zürn, Michael & Faude, Benjamin (2013) On Fragmentation, differentiation, and coordination, *Global Environmental Politics 13*(3): 119-130.

MEDIA SOURCES

Agence France Press, Pakistan adopts Chinese rival GPS satellite system. May 27, 2014.

Associated Press, EU Sanctions Prompt Eutelsat to Block Iranian Broadcasts. 15 October 2012.

China Brief, Putting Precision in Operations: The BeiDou Satellite Navigation System McCauley, Kevin N., XIV (16):11-14, August 22, 2014.

Defense News, China-US space relations see small but important step. December 14, 2014.

Global Times, Editorial: 'By wishing the story about China's ASAT weapon development was true', January 6, 2013 (环球时报社评: 愿中国研制反卫星武器传闻是真的).

GPS Daily, Moscow to suspend American GPS sites on Russian territory from June, May 15, 2014.

---- Global Positioning System: A Generation of Service to the World, by Mike Slater, July 03, 2015.

---- ISRO is hoping its 'Big' offering would gain popularity in the market. July 29, 2015.

---- GPS III Launch Services RFP Released by Air Force. October 6, 2015.

---- Russian-Chinese Sat NavSystems to Launch on Silk Road, EEU Markets, October 15, 2015.

GPS World Comparing GPS and GLONASS, GPS World by Alfred Kleusberg, November / December 1990.

---- Galileo Draw Closer by D.A. Davis, November 1 2002.

---- Expert Advice: The Strategic Significance of Compass (BEIDOU) by Pace, Scott, December 1, 2010.

Inside GNSS, Mike Shaw, Director of US National Coordination Office for Space-Based Position, Navigation and Timing (PNT), intervention at Munich High-Level Satnav Summit, March 2009, "GPS, GLONASS, Galileo, Compass: What GNSS Race? What Competition?" Glen Gibbons, March 23, 2009.

New Scientist, NATO claims Galileo could jeopardise operations, June 21, 2002. https://newscientist.com/article/dn2447-nato-claims-galileo-could-jeopardise-operations/

Reuters, Special Report – In satellite tech race, China hitched a ride from Europe by David Lague, December 22, 2013.

RIA Novosti, Russian lawmakers approve satellite navigation hub in Nicaragua, April 02, 2014.

---- Iran to Host Russian Satellite Navigation Facility, May 15, 2014.

---- Western sanctions fail to impede GLONASS satellite production, September 16, 2014.

---- Russia unable to reject foreign parts in GLONASS satellites, September 22, 2014.

Secure World Foundation (2010) Space Sustainability – a practical guide. Washington D.C.: Secure World Foundation.

---- (2014 updated) Space Sustainability – A practical guide, Washington D.C./Denver/: Secure World Foundation.

Space Daily, Russia must be more competitive in commercial space market. May 21, 2015.

Space News, Britain, France At Odds Over Military Use of Galileo Service, by de Selding, Peter B., June 19, 2006.

---- 2010 India developing anti-satellite spacecraft by Peter B. de Selding, January 11, 2011.

---- Israel Could Host GLONASS Ground Station Under Framework Deal with Russia, by Barbara Opall-Rome, April 4, 2011.

---- EU Space Policy Document Calls for Dialogue with China, by Peter B. de Selding April 5, 2011.

---- Broadcasters Call for ITU Action on Satellite Jamming by Peter B. de Selding, December 9, 2011.

----China and Europe Taking Navigation Dispute to the ITU by Peter B. de Selding, October 2, 2012.

---- EU, China Schedule December Meeting on Navigation Dispute by Peter B. de Selding, October 9, 2012.

---- Eutelsat Drops Iranian Channels by Peter B. de Selding, 15 October 2012.

---- Europe Looks to Broaden Base for Encrypted Galileo Service, by Peter B. de Selding, December 7, 2012.

---- US. Export Rules Complicate Sino-French Cooperation by Peter B. de Selding, September 18, 2014.

---- US Warns EU Against Making Galileo Mandatory by Peter B. de Selding, November 2014.

---- US. Satellite Export Regulations Remain a Frustration for European Industry by Peter B. de Selding, February 7, 2014

---- European Satellite Still Heavily Dependent on U.S. parts by Peter B. de Selding, January 29, 2015.

---- Japan's Space Policy Shift Reflects New Asian Realities by Rajagopalan, Rajeswari Pillai, February 23, 2015.

---- China ranked 4th among world space powers. May 27, 2015.

---- Singapore and China to Collaborate on BeiDou Applications by Peter B. de Selding, June 11, 2015.

---- GPS3 Ground Segment faces Two More Years of Delay by Mike Gruss, December 10, 2015.

Space War, Guardians of the Galaxy: Russia Creates International Space Patrol. April 12, 2015.

Sputnik, Nicaragua to Host Russian GPS-Equivalent Ground Stations, August 24, 2015.

---- Russia, Brazil Sign Contract for GLONASS Ground Measuring Station, September 17, 2015

Sputnik News, Mexico, Russia Deepening Cooperation in Space, April 17, 2015.

---- Russia to Debate US Discrimination of CLONASS System in UN: Reports, December 29, 2014.

---- The NFP has 34 countries as co-authors. Sputnik International, UN passes Russian-Proposed Resolution Banning Arms Race in Outer Space, December 4, 2014

---- Russia to Debate US Discrimination of CLONASS System in UN: Reports, December 29, 2014

---- Russian, Chinese Navigation Systems to accommodate BRICS members, July 7, 2015.

---- GLONASS system can fully switch to domestic electronics in 2 years, October 6, 2015.

---- Russia, China to Finalize Satellite Navigation Chip Set Deal by Year-End, December 15, 2015.

---- Russia, China develop navigation system draft for SCO, BRICS. December 16, 2015.

Sputnik International, Russian satellites prohibited for emergency 911 calls in US, February 1, 2015.

---- India Interested in Russia's GLONASS Satellite Navigation System, February 6, 2015.

---- Russia's GLONASS Proves More Than a Match for America's GPS, July 14, 2015.

The New Indian Express, ISRO Looking to Extend Services to SAARC Countries, October 8, 2015.

The Tonga Herald, "Demo party leader asks China to intervene and influence domestic politics", July 29, 2014.

---- "Politics of Tongasat kills useful model for Tonga business, growth", August 4, 2014

The Space Review, Key Space Issues for 2013 by Jeff Foust, December 31, 2012.

---- Effective mechanisms for space security by Ajey Lele, May 28, 2013.

---- The 2014 PPWT: a New draft but with the same and different problems by Michael Listner and Rajeswari Pillai Rajagopalan, August 11, 2014.

---- India's indigenous satellite navigation system by Ajey Lele, March 30, 2015.

Voice of Russia, US ban Russia's GLONASS for spying fears, December 31, 2013.

---- Russia to deploy up to 7 GLONASS ground stations outside of national territory in 2014. February 19, 2014.

---- No More US GPS stations from June 1 – Russian Vice-Premier, May 13, 2014.

---- Russian Space Agency set to resume GLONASS talks with US, May 23, 2014.

---- Russia, China expand cooperation on satellite navigation, June 5, 2014.

---- Russia may join forces with China to compete with US, European satnavs, June 10, 2014.

Wired Magazine, Europe Gives Go-ahead to Galileo by Steven Kettmen, March 18, 2002 http://www.wired.com/news/politics/0,1283,51130,00.html;

---- "Galileo, chi era costui?" by Luca De Biase, March 18, 2002 http://europa.tiscali.it/futuro/inchieste/200112/21/europa_minima.html

Xinhua News Agency, China Voice: Cold War mentality fuels U.S. satellite export prejudice by Wang Aihua and Gui Tao, January 8, 2013.

---- Russia eyes building GLONASS station in 36 countries, April 25, 2014.

---- China's BeiDou system standard ratified by IMO. May 21, 2014.

---- Russia to place global navigation stations in China, November 14, 2014.

---- BeiDou satellites begin autonomous operation in space, August 19, 2015.

---- China's satellite navigation system to expand coverage globally by 2020, August 27, 2015.

Chinese Government Chinese Space Activities in 2011 (China's Space White Paper). http://www.china.org.cn/government/whitepaper/node_7145648.htm

---- China's Military Strategy, the State Council Information Office of the People's Republic of China. May 2015 http://eng.mod.gov.cn/Database/WhitePapers/

Conference on Disarmament, Russia-China joint working paper to the Conference on Disarmament, 'Possible Elements for a Future International Legal Agreement on the Preventions of the Deployment of Weapons in Outer Space, the Threat or Use of Force against Outer Space Object', 28 June, 2002. CD/1679.

---- Statement of Russian Foreign Minister Sergey Lavrov at the Plenary Meeting of the Conference on Disarmament, Geneva, 12 February 2008.

Council of the European Union, Taking forward the European Space Policy, 13569/08, Brussels, September 29, 2008.

Douglas Aircraft Company, Santa Monica Plant, Engineering Division, "Preliminary Design of an Experimental World-Circling Spaceship", SM-11827, 2 May 1946.

European Commission, Bildt, Carl et al., Towards a Space Agency for the European Union, March 2000.

---- de Palacio, Loyola, vice President of the European Commission. "The Importance of Galileo for Europe." Address, Internationaler Kongress Kommerzielle Anwendung der Satelliten-Navigation. Munich, Germany, April 26, 2001.

---- "The European Dependence on US-GPS and the Galileo Initiative". Technical note. Brussels: Directorate-General for Energy and Transport, European Commission, February 14 2002.

---- Directorate-General Energy and Transport. "The European project on radio navigation by satellite" Information note, posted on March 26, 2002.

---- DG GROW, One Third of Galileo Constellation now in Orbit. Access: October 13, 2015. http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8434&lang=en

European Parliament, Policy Department, Directorate, General for External Policies, European Parliament, Study: Space, Sovereignty and European Security – Building European Capabilities in An Advanced Institutional Framework, January 2014.

European Space Agency (2003) Why Europe Needs Galileo ; Beidleman, Scott W. (2006) GPS versus Galileo: Balance for Position in Space, CADRE Paper No. 23, Maxwell Air Force Base: Air University Press. page: vii.

Japanese Government, Basic Plan for Space Policy, 2009. http://www.kantei.go.jp/jp/singi/utyuu/keikaku/pamph_en.pdf

---- Basic Plan on Space Policy, 2013. www8.cao.go.jp/space/plan/plan-eng.pdf

OECD (2007) The Space Economy at a Glance 2007.

---- (2011) The Space Economy at a Glance 2011.

UNOOSA (2011) 10 Years of Achievement of the United Nations Global Navigation Satellite Systems, New York: United Nations.

United Nations, Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forest were adopted at the UN Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992.

US Government, President Dwight D. Eisenhower, State of the Union Address given before the U.S. Congress on January 10, 1957.

---- President J.F. Kennedy, Speech at Rice University on September 12, 1962.

---- President Bill Clinton, President of the United States, letter to the International Civil Aviation Organization, March 16, 1995.

---- US Space Command Lang Range Plan, April 1998. http://www.fas.org/spp/military/docops/usspac/lrp/toc.htm

---- Report of the Commission to Assess United States National Security Space Management and Organization (also known as "Rumsfeld Commission Report", January 11, 2001.

---- The White House, Office of the Press Secretary, Fact Sheet: "US-EU Summit: Agreement on GPS-Galileo Cooperation, June 26, 2004.

---- President B. Obama, (2010) The National Space Policy of the United States, June 28, 2010.

---- Rose, Frank A. Official Remarks delivered at the Transatlantic Partnership Conference 'Defining Space Security for the 21st Century' co-organized by the European Space Policy Institute and Prague Security Institute on June 13, 2011 in Prague.

---- Department of Defense & Intelligence Community (2011) National Security Space Strategy, January 2011.