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SPACE TRAFFIC MANAGEMENT: IMPLICATIONS FOR CANADIAN ARMED FORCES SPACE POWER

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ABSTRACT

The likelihood of disruption in space-based services upon which society and militaries are dependent is increasing due to the congested, contested and competitive nature of the space environment. International space law is insufficient to address contemporary issues, and through its deficiencies inadvertently contributes to the congestion, aggression and competition in outer space. Further, an international regulatory body does not exist to manage space activities to guard against collisions and interference. It is recommended that an international space traffic management (STM) system be implemented to provide the regulatory framework, organization, and mechanisms to protect space objects against harmful interference during the launch, in orbit and recovery phases of operation. Using the International Civil Aviation Organization (ICAO) and North American Aerospace Defense Command (NORAD) as case studies, this study draws parallels between aviation and space industries to envision how a STM system could be implemented.

Since the Canadian Armed Forces (CAF) recently declared outer space as an operational domain, it should actively engage with its allies and other government departments to ensure that its interests are captured in any proposed STM models. To this end, this study suggests that a similar framework to that used between NORAD and NAV CANADA be established to limit restrictions on military space operations, and restricted space zones be employed to safeguard its space assets. It recommends that distinct CAF military space occupations be created and the quality of training and education provided to space personnel be reassessed in order to produce a professional space cadre capable of meeting the demands of a future STM system.

LIST OF ABBREVIATIONS

AC OP – Aerospace Control Operator

ACSO – Air Combat Systems Officer

AEC – Aerospace Control Officer

ANR – Alaskan NORAD Region

ASAT – Anti-satellite

ATM – Air Traffic Management

CADS – Canadian Air Defence Sector

CAF – Canadian Armed Forces

CANR – Canadian NORAD Region

CANSpOC – Canadian Space Operations Centre

CDRNORAD – Commander NORAD

CDS – Chief of Defence Staff

CJCS – Chairman of the Joint Chiefs of Staff

CNS – Communication, Navigation and Surveillance

CNS/ATM – CNS System integrated with an ATM System

COLA – Collision Avoidance

CONR – Continental United States NORAD Region

Comd RCAF – Commander Royal Canadian Air Force

DND – Department of National Defence

DoD – Department of Defense

EATPL – ESCAT Air Traffic Priority List

ESCAT – Emergency Security Control of Air Traffic

EU – European Union

FAA – Federal Aviation Administration

FLT ENGR – Flight Engineer

GEO – Geostationary Orbit

GLONASS – Global Navigation Satellite System (Russian)

GNSS – Global Navigation Satellite System (Generic)

GPS – Global Positioning System

IAA – International Academy of Astronautics

IADC – Inter-Agency Space Debris Coordination Committee

ICAO – International Civil Aviation Organization

ICBM – Intercontinental Ballistic Missile

ISR – Intelligence, Surveillance and Reconnaissance

ISS – International Space Station

ITU – International Telecommunication Union

JSpOC – Joint Space Operations Center

LEO – Low Earth Orbit

MAV – Mojave Aerospace Ventures

MEO – Medium Earth Orbit

NASA – National Aeronautics and Space Administration

NORAD – North American Aerospace Defense Command

PICAO – Provisional International Civil Aviation Organization

PNT – Position, Navigation and Timing

RCAF – Royal Canadian Air Force

RFI – Radio Frequency Interference

SARPs – Standards and Recommended Practices

SATVs – Suborbital Aerospace Transportation Vehicles

SCA – Security Control Authorization

SIR – Scramble, Intercept and Recovery

SSA – Space Situational Awareness

SSN – Space Surveillance Network

SSS – Space Surveillance System

STM – Space Traffic Management

TC – Transport Canada

TFR – Temporary Flight Restriction

TOR – Terms of Reference

UN – United Nations

UN COPUOS – United Nations Committee on the Peaceful Uses of Outer Space

USAF – United States Air Force

USPACOM – Commander United States Pacific Command

VCDS – Vice Chief of Defence Staff

INTRODUCTION

When the Soviet Union launched Sputnik I into its elliptical orbit around the Earth on October 4, 1957, a fervent desire was sparked in nations worldwide to explore outer space and to place not only satellites in orbit, but humans as well. A space race then ensued between the United States and the Soviet Union during the Cold War, which peaked on 20 July 1969 when American astronaut Neil Armstrong became the first man to walk on the moon. Since those momentous occasions, the number of objects in Earth's orbit has steadily increased. The United States Department of Defense (DoD) and its allies, including Canada's Department of National Defence (DND), detects, tracks and catalogues man-made objects in orbit around the Earth through its Space Surveillance Network (SSN), and has done so ever since 1957 when Sputnik I was first launched. The tracked objects include active and inactive satellites, spent rockets, debris from collisions in outer space, and of course the International Space Station (ISS).

Although outer space is a vast commons, it is becoming increasingly "congested, contested and competitive."[1] An international law framework was put in place during the nascent stages of space activity in order to keep the commons accessible to all and to be used for peaceful purposes; however, there are many loopholes within the framework that have become exposed with advances in space technology. One particular concern is that an overarching regulatory body currently does not exist to manage issues like rights of way in order to deconflict crossing paths of satellites and launch phases for orbital insertion of space objects. Contrasted with international air travel, which is regulated by the International Civil Aviation Organization (ICAO) through the Chicago Convention,

[1] United Nations, "Outer Space Increasingly 'Congested, Contested and Competitive', First Committee Told, as Speakers Urge Legally Binding Document to Prevent its Militarization," last accessed 17 February 2017, https://www.un.org/press/en/2013/gadis3487.doc.htm.

space activities are regulated by individual nation states that may or may not be signatories to documents such as the Outer Space Treaty and the Registration Convention that form the basis of the international space law framework. Without an international body to control space activities, services that rely on space assets may become disrupted from interference or from collisions.

The contemporary world that exists on Earth is inextricably linked to space-based systems. In fact, many actions that humans perform daily are reliant on satellites in orbit around Earth. Communication satellites provide the necessary bandwidth to support international telecommunications, internet connections, television and radio broadcasts, and cellular telephones. The Global Positioning System (GPS) provides positioning and timing for navigation of multiple modes of transport, such as air and vehicular travel. Additionally GPS synchronizes the universal time standard that drives the energy and financial sectors, as well as all computer-controlled networks. Earth-observing satellites assist in weather tracking and forecasting hazardous storms, and provide information to farmers regarding soil composition and crop growth, thereby enabling productive food yields for the world's increasing population. With these examples, it is clear that the lifestyle and well-being of humanity has become dependent on outer space.[2] By extension, it can be argued that the security of the world's population is contingent on space-based systems.

Many of the world's armed forces rely extensively on space-based assets in order to achieve national objectives such as sovereignty and security of its people. In particular,

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[2] Richard Hollingham, "What would happen if all satellites stopped working?," last updated 10 June 2013, http://www.bbc.com/future/story/20130609-the-day-without-satellites; Lewis Dartnell, "What would happen if satellites fell from the sky?," last updated 29 April 2014, http://www.telegraph.co.uk/culture/books/10785683/What-would-happen-if-satellites-fell-from-the-sky.html.

the Canadian Armed Forces (CAF) utilizes space-based capabilities to conduct both domestic and deployed operations, viewing space effects as critical joint force enablers. Domestically, space-based assets provide the CAF with navigation assistance, beyond-line-of-sight communications and surveillance to assist with defending Canada's vast territory and in conducting search and rescue operations. The CAF also makes use of Positioning, Navigation and Timing (PNT) to synchronize movements and satellite-derived Intelligence, Reconnaissance and Surveillance (ISR) to provide situational awareness in the battle space during deployed operations. Additionally, communication satellites provide the necessary connectivity for commanders to exercise command and control.[3]

Any disruption in service of space enablers for the CAF would significantly constrain its ability to achieve mission success. However, since an international body does not exist to manage space traffic, the congested environment within which CAF space-based assets operate provides a growing risk of service interruption. Increasingly, the concept of a space traffic management (STM) organization is being contemplated at national and international levels to prevent disruptions to space-based services. In the "Cosmic Study on Space Traffic Management," the International Academy of Astronautics (IAA) defines STM as "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference."[4] The goal of STM and its regulatory organization is to achieve a "common good" to guarantee the continued use

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[3] Royal Canadian Air Force, *Canadian Armed Forces Defence Space 5-Year Roadmap* (Ottawa: DG Space, 2016), 2.

[4] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 10.

of outer space for scientific purposes, commercial services, and to achieve mission success. Accordingly, this research paper will argue that an international STM organization is necessary to control space activities in order to enable the CAF to continue to project space power for its operations. The CAF and DND should actively engage with its allies and other government departments to facilitate a dialogue of what a potential STM model would look like and to ensure that its interests are captured in any recommended solutions. This study will propose elements for consideration in devising solutions, which will be presented over the succeeding four chapters.

Chapter 1 will outline why outer space is considered congested, contested and competitive by discussing current and future space activities. It will thus provide the necessary foundation upon which the following chapters build. The chapter will examine the decreasing number of useable orbital slots for satellite insertion and their management by the International Telecommunication Union (ITU). It will also discuss the proliferation of orbital debris that has been caused by collisions, and which will continue to increase according to the Kessler Syndrome. Additionally, the chapter will briefly look at the weaponization of outer space by considering anti-satellite (ASAT) tests of countries like China.[5] The chapter will then review the competitive nature of outer space in terms of re-useable commercial rockets for launches, commercial and private human spaceflight, and asteroid mining.

[5] Harsh Vasani, "How China is Weaponizing Outer Space," last updated 19 January 2017, http://thediplomat.com/2017/01/how-china-is-weaponizing-outer-space/. The weaponization of outer space involves the placement of weapons in outer space or on celestial bodies, as well as the transit of weapons in outer space or from Earth to strike or destroy space objects. In this capacity, outer space is the area of conflict. The militarization of outer space is the use of space-based assets for command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) as a force enabler for armed forces. It is used for conflict on Earth.

Chapter 2 will analyze the legal framework of outer space by reviewing current treaties, conventions and guidelines, and will highlight the loopholes that exist, including the lack of a STM organization to control space activities. Specifically, the Outer Space Treaty and the Registration Convention will be studied, along with the Inter-Agency Space Debris Coordination Committee (IADC) Debris Mitigation Guidelines. This chapter will also focus on the ITU and how it evolved to fill one of the gaps within the space law framework.

Chapter 3 will study the ICAO ATM model to determine if this organization's role could be expanded to include STM responsibilities, or whether a separate organization should be developed. Activities that will be considered include the incorporation of tracking data within a STM system, capabilities to provide maneouvre assistance and collision avoidance, provisions for launches through air and space, the coordination of radio frequency information to minimize interference, and the protection of sensitive data. Using the ICAO model as a reference allows this research paper the ability to draw parallels and highlight intricacies that will need to be considered in any proposed STM solutions.

Chapter 4 will discuss the implications of a STM system for the CAF. While the new organization may protect sensitive data, national security will call for a higher level of protection of information, and thus a separate system managed by DND and the CAF. Parallels will be drawn between the manner in which air defence inserts itself into North American air travel through North American Aerospace Defense Command (NORAD) in order to discuss how a military subsystem could operate within an international STM model. Items that will be considered in this analysis include the use of restricted space zones and the force generation of military space personnel.

This study takes a proactive approach to the topic of STM. It considers not only the reason for its implementation, but also the type of organization that could establish a regulatory role, and the implications for the CAF, which relies on space-based assets as campaign enablers. The CAF's acknowledgement of outer space as an operational domain and the designation of the Commander Royal Canadian Air Force (Comd RCAF) as the military space authority in 2016 make it a fitting case study to identify considerations for how its emerging military space operations could integrate within an international STM system. Furthermore, the growth of its space capability serves as an excellent opportunity to proactively incorporate measures into its development initiatives. Accordingly, the study provides suggestions for future research and items to contemplate in any discussions with its allies and other government departments to ensure that its interests are captured in any proposed STM models.

CHAPTER 1 - OUTER SPACE IS CONGESTED, CONTESTED AND COMPETITIVE

Introduction

Outer space is both considerably expensive to explore and a harsh environment within which to operate. Nevertheless, increasingly more space actors are emerging, as advances in technology and partnerships lower the technological and monetary threshold to launch objects into outer space. If “cheap launches” become a reality, the number of space objects and activities will further increase and will cause additional crowding in highly sought after and limited orbital positions such as those in geostationary orbit (GEO).[6] The capability, motive, and intent of space actors are not always peaceful. Harmful interference has been demonstrated during the past and raises concerns over the vulnerability of space-based assets.[7] This fear is heightened as states begin to augment spending on military space capabilities. Alongside the increased investments in military space are the great strides being taken by the civil space sector and the rising competition of the commercial space industry.

[6] Roger G. Harrison, “Unpacking the Three C’s: Congested, Competitive, and Contested Space,” *Astropolitics* 11, no. 3 (2013), 124; Sebastian Anthony, “Space giants join forces to battle SpaceX: This is how cheap space travel begins,” last updated 16 June 2014, https://www.extremetech.com/extreme/184434-space-giants-join-forces-to-battle-spacex-this-is-how-cheap-space-travel-begins; Kelsey D. Atherton, “Cheap Rocket Launches May Be Key to National Defense: For Military Satellites, Redundancy Leads to Resilience,” last updated 10 June 2016, http://www.popsci.com/is-cheap-launch-key-to-space; Sarah Kramer and Dave Mosher, “Here’s how much money it actually costs to launch stuff into space,” last updated 20 July 2016, http://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6. The term “cheap launch” is used to describe launch capabilities such as reusable rockets that will result in a dramatic decrease in launch costs.

[7] Micheal Listner, “The continued debate about anti-satellite weapons, nine years after China’s test,” last updated 19 February 2016, http://spacenews.com/op-ed-the-continued-debate-about-anti-satellite-weapons-nine-years-after-chinas-test/. In 2007, China used a direct ascent ASAT to destroy its non-functioning Fengyun-1C weather satellite. It received widespread condemnation for this action due to the amount of debris that was created, and it raised the concern that space-based assets are vulnerable to direct ascent ASATs.

Many, especially those in the United States, acknowledge that outer space is increasingly becoming congested, contested and competitive.[8] This chapter will expand on this statement by outlining how space is used in general, the danger of orbital debris, diminishing satellite orbital slots, and overviewing collisions in space. It will then discuss radio frequency and laser interference, the use of space weapons such as ASATs, and the commercialization of space.

Utilization of Outer Space

Although it is a harsh environment within which to perform activities, outer space is used to conduct Earth observation, to transmit communication and navigation information, to explore and expand our understanding of the universe, and to carry out experiments to increase our knowledge of physics, materials and life sciences.[9] Earth observation provides high resolution images that can be used for a variety of purposes, such as crop mapping for agriculture, to observe changes in sea levels, and to track hurricanes.[10] Communication and navigation space-based systems provide rapid transmission of information worldwide, enabling systems like high-speed internet, as well as the transportation and energy sectors. The exploration of outer space not only furthers our understanding of our place within the universe, it facilitates technology advancement and the creation of new industries, and it fosters cooperation between states.[11] Finally, outer space provides a unique environment to study universal theories such as quantum

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[8] Beth Duff-Brown, "The final frontier has become congested and contested," last updated 4 March 2015, http://cisac.fsi.stanford.edu/news/security-space-0.

[9] Berndt Feuerbacher, "Space Utilization" in *Utilization of Space Today and Tomorrow* (Virginia: American Institute of Aeronautics and Astronautics, Inc., 2006), 3-7.

[10] European Space Agency, "Observing the Earth," last accessed 15 March 2017, www.esa.int/Our_Activities/Observing_the_Earth/How_does_Earth_observation_work.

[11] National Aeronautics and Space Administration, "Beyond Earth: Expanding Human Presence Into the Solar System," last updated 30 September 2013, https://www.nasa.gov/exploration/whyweexplore/why_we_explore_main.html.

theory, special and general relativity, and allows the observation of the effects of microgravity and radiation on materials and human physiology.[12]

Physiology of astronauts has been studied during and post spaceflight missions. Initially, these missions possessed the goal of landing on the Moon; however, now there is a race to land astronauts on Mars for deep space exploration. In addition to these missions, the commercial space industry has promised that soon it will not just be astronauts experiencing outer space. Private citizens will have the opportunity to pay for a suborbital flight offered by one of a few companies investing in human spaceflight technology.[13] What remains to be seen is whether the increased activity in space will impact the orbital debris issue that currently exists.

Orbital debris

Almost 60 years of launches of objects into space has turned the vast open commons into a congested environment. The primary useful orbits for the majority of human space activities include Low Earth orbit (LEO) and GEO, which are becoming increasingly populated by orbital debris, satellites, and spacecraft.[14] Examples of orbital debris include non-functioning satellites, spent rockets, astronaut tools, parts of spacecraft, fragmentation from collisions, as well as paint flecks, all of which pose risks to operational satellites and spacecraft.[15] In fact, the amount of space debris is of

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[12] Hansjörg Dittus, "Fundamental Physics" in *Utilization of Space Today and Tomorrow* (Virginia: American Institute of Aeronautics and Astronautics, Inc., 2006), 275.

[13] Evan Ackerman, "5 Spaceflight Companies Looking to Get There Soon," last accessed 15 March 2017, http://www.nbcbayarea.com/news/local/5-Spaceflight-Companies-Looking-to-Get-There-Soon-142987835.html?amp=y. Some of the companies promising suborbital flights for tourists include Virgin Galactic, Blue Origin, and XCOR Aerospace.

[14] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 3.

[15] Joseph Kurt, "Triumph of the Space Commons: Addressing the Impending Space Debris Crisis

sufficient magnitude that it threatens the safety of the ISS, forcing it to maneouvre at least once per year to avoid being punctured by debris travelling at a speed of approximately 10 km/s.[16]

According to the NASA Orbital Debris Quarterly News in April 2016, there are over 40,000 objects in space that have been catalogued by the SSN, with over 17,500 of those objects in Earth orbit.[17] These numbers reflect the size of objects that can be detected by the SSN sensors, which corresponds to objects that are larger than 4 inches (10 cm).[18] NASA estimates that there are over 500,000 objects in Earth orbit between 0.4 inches and 4 inches (1 and 10 cm), and likely the number of objects smaller than 0.4 inches is greater than tens of millions.[19] Objects larger than 0.4 inches (1 cm) tend to be of greatest concern to satellite and spacecraft operators; however, due to their large orbital speeds, even smaller pieces of debris can cause damage to a satellite or spacecraft.[20]

The primary danger associated with orbital debris is the risk of a collision that could completely destroy or create significant operating issues for space-based assets, or kill an astronaut performing operations outside of a spacecraft.[21] This danger is pervasive,

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Without an International Treaty," *William & Mary Environmental Law and Policy Review* 40, no. 1 (2015): 307.

[16] National Aeronautics and Space Administration, "Orbital Debris Program Office Frequently Asked Questions," last accessed 01 March 2017, https://www.orbitaldebris.jsc.nasa.gov/faq.html.

[17] National Aeronautics and Space Administration, "Orbital Debris Quarterly News," last accessed 01 March 2017, https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv20i1-2.pdf.

[18] United States Air Force Air War College, "Space Surveillance," last accessed 17 February 2017, http://www.au.af.mil/au/awc/awcgate/usspc-fs/space.htm.

[19] National Aeronautics and Space Administration, "Frequently Asked Questions: Orbital Debris," last updated 2 September 2011, https://www.nasa.gov/news/debris_faq.html.

[20] Kathy Jones, Krista Fuentes, and David Wright, "A Minefield in Earth Orbit: How Space Debris Is Spinning Out of Control," last updated 01 February 2012, https://www.scientificamerican.com/article/how-space-debris-spinning-out-of-control/.

[21] Lawrence D. Roberts, "Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes," *Boston College International & Comparative Law Review* XV, no. 1 (1992): 55.

as the majority of debris will continue to orbit the Earth for decades or centuries before it falls out of orbit and lands on Earth or burns up upon reentering the atmosphere. In addition, the Kessler Syndrome, which NASA scientist Donald Kessler proposed in 1978, predicts that even without additional space launches, the current amount of orbital debris will exponentially rise as a result of a cascade effect created by collisions between existing debris.[22] If this prediction is valid, LEO and GEO will become unusable, and the space-based assets that humans rely on for their quality of life and security will be rendered obsolete.

Orbital debris is a serious issue that was first considered by the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) during its thirty-first session in 1994.[23] Space debris mitigation guidelines have since been developed by an international government body, the Inter-Agency Space Debris Coordination Committee (IADC), which were then adopted by the UN in 2007; however, they are voluntary guidelines vice hard law, so there is no enforcement mechanism requiring nation states to abide by them.[24] As a result, incidents like the destruction of the Chinese weather satellite that occurred in 2007 only received condemnation from the international community, rather than a penalty or sanctions from the UN. Consequently, orbital debris has continued to rise in number, and UN COPUOS has acknowledged that the probability of

[22] Joseph Kurt, "Triumph of the Space Commons: Addressing the Impending Space Debris Crisis Without an International Treaty," *William & Mary Environmental Law and Policy Review* 40, no. 1 (2015): 307.

[23] UN COPUOS is a committee established by the UN to govern the use and exploration of outer space.

[24] United Nations Office for Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," last accessed 01 March 2017, http://www.unoosa.org/pdf/publications/st_space_49E.pdf.

collisions that will cause serious damage to space-based assets such as satellites will also increase.[25]

Satellite orbital slots

There are currently over 1,400 operational satellites in Earth orbit that occupy LEO, Medium Earth orbit (MEO), and GEO.[26] The ISS and at least half of the satellites operate within LEO, which is the easiest orbit to reach from Earth and is ideal for observation, mobile telecommunications, remote sensing, and military reconnaissance. Approximately 7 percent of satellites are found in MEO, which is an orbit that allows for the large swaths and triangulation necessary for PNT.[27] Correspondingly, United States GPS satellites operate in MEO in a semi-synchronous orbit, along with Russian communication satellites that operate in a Molniya orbit. Nearly half of all satellites are located in GEO, where they travel at the same speed as the rotation of the Earth, and thus are able to continuously view the same location.[28] This stationary view is ideal for commercial communications, weather and solar activity monitoring, missile early-warning, intelligence, and detection of nuclear testing.[29] GEO is a limited natural resource, since the laws of physics limit how many satellites can operate within this

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[25] United Nations Committee on the Peaceful Uses of Outer Space, *Technical Report on Space Debris* (New York: United Nations, 1999), 42.

[26] Union of Concerned Scientists, "UCS Satellite Database," last updated 11 August 2016, http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.WLyCQMszVDx.

[27] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 21.

[28] National Aeronautics and Space Administration Earth Observatory, "Catalog of Earth Satellite Orbits," last updated 4 September 2009, https://earthobservatory.nasa.gov/Features/OrbitsCatalog/.

[29] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 21-22.

orbital band.[30] Consequently, satellite operators are placing multiple satellites in one location, requiring sophisticated technology and resulting in congested orbital slots.[31]

The number of actors in the commercial satellite industry has increased over the past few decades and operators have been contending for orbital slots, particularly those located in GEO.[32] The International Telecommunication Union (ITU) was assigned as the UN's lead regulating body to coordinate the assignment of orbital slots in order to enable equitable access to all countries, especially developing countries.[33] The ITU accepts registrations from satellite operators on a first-come first-served basis, but the operators must bring their satellite network into regular operation within 7 years of registering.[34] Information regarding the operational satellites' orbit usage is maintained in the Master International Frequency Register and is used to protect satellites from harmful interference, but it can only be considered useful if the information provided by satellite operators is accurate.[35] The primary concern for satellite operators is to avoid collisions with other orbiting objects, as well as radio frequency interference (RFI) and laser interference.[36]

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[30] International Telecommunication Union, "Overview of ITU's History," last accessed 16 March 2017, http://www.itu.int/en/history/Pages/ITUsHistory-page-5.aspx.

[31] William Ailor, "Space traffic control: a view of the future," *Space Policy* 18 (2002): 100.

[32] Theresa Hitchens, "Debris, Traffic Management, and Weaponization: Opportunities for and Challenges to Cooperation in Space," *The Brown Journal of World Affairs* XIV, no. 1 (Fall/Winter 2007): 176.

[33] International Telecommunication Union, "Satellite Regulations," last updated 16 March 2017, http://www.itu.int/net/newsroom/wrc/2012/features/satellite_regulations.aspx.

[34] Peter B. de Selding, "Signs of a Satellite Internet Gold Rush in Burst of ITU Filings," last updated 23 January 2015, http://spacenews.com/signs-of-satellite-internet-gold-rush/.

[35] International Telecommunication Union, "Satellite Regulations," last updated 16 March 2017, http://www.itu.int/net/newsroom/wrc/2012/features/satellite_regulations.aspx.

[36] William Ailor, "Space traffic control: a view of the future," *Space Policy* 18 (2002): 100-102.

Collisions, RFI and Laser Interference

In the past, there have been several satellite collisions in outer space involving orbital debris, other satellites, missiles and ASATs. However, two collisions figure prominently in the space industry, namely because of the amount of debris that was created. The first is China's intentional destruction of the Fengyun-1C weather satellite in 2007 using an ASAT, from which 3,428 pieces of debris have been catalogued and tracked by the SSN. The second collision occurred in 2009 between a commercial communication satellite, Iridium 33, and a non-functioning Russian military satellite, Cosmos 2251, decimating both satellites and producing a combined 2,296 catalogued fragments.[37] Both of these significant collisions occurred in LEO, and the ISS has since had to perform avoidance maneouvres to evade the orbital debris.[38]

The collision between Iridium 33 and Cosmos 2251 and the intentional destruction of Fengyun-1C are events that the IADC and UN hope to avoid through their Space Debris Mitigation Guidelines. Within these guidelines are recommendations for post mission disposal of satellites from orbital bands that are highly utilized, the prevention of on-orbit collisions, and the avoidance of intentional destruction of satellites.[39] However, these are voluntary mitigation guidelines that nations must choose to follow. Carrying reserve fuel onboard a satellite in order to send it to a "graveyard orbit" upon completion of its mission adds additional funds to already expensive launch

[37] National Aeronautics and Space Administration, "Orbital Debris Quarterly News," last accessed 01 March 2017, https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv20i1-2.pdf.
[38] National Aeronautics and Space Administration, "Space Debris and Human Spacecraft," last updated 27 July 2016, https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.
[39] Inter-Agency Space Debris Coordination Committee, "IADC Space Debris Mitigation Guidelines," last accessed 17 March 2017, http://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf.

costs, and any additional fuel onboard could be used to generate more profits.[40] Moreover, many satellites that are currently in orbit were launched prior to the release of the guidelines, and thus do not have reserve fuel onboard for post mission disposal. In terms of collision avoidance (COLA), not only is the SSN not robust enough to track all objects in outer space, but the ability to determine whether a collision will occur in the future is based on probability techniques through the use of computer models. If two objects are being tracked, estimates of atmospheric parameters and solar activity are used, and the positions of the objects being studied will have some associated degree of error; therefore, ellipsoids are used to project the likelihood of collision, providing a “1 in (number)” figure.[41] In the case of intentional destruction, once again the Space Debris Mitigation Guidelines are not hard law, so the IADC and the UN do not possess powers of enforcement.

Collisions are not the only fear associated with satellites passing in close proximity of one another. RFI is an issue that can occur when two satellites are broadcasting near each other on the same frequency, causing the ground receiver difficulty in picking up the correct signal. RFI can also be caused by space weather, by incorrect positioning of the ground-based uplink antenna, through interference from ground-based networks like cellular services, and from intentional jamming.[42] In addition to managing the orbital slots for satellites, the ITU also manages the radio frequency spectrum, which is considered a limited resource and is shared by satellite operators and

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[40] Theresa Hitchens, “Debris, Traffic Management, and Weaponization: Opportunities for and Challenges to Cooperation in Space,” *The Brown Journal of World Affairs* XIV, no. 1 (Fall/Winter 2007): 176.

[41] William Ailor, “Collision Avoidance and Improving Space Surveillance,” *Astropolitics* 2 (2004): 112-114.

[42] Brian Weeden, “Radio Frequency Spectrum, Interference and Satellites Fact Sheet,” last updated 25 June 2013, https://swfound.org/media/108538/swf_rfi_fact_sheet_2013.pdf.

many terrestrial users alike. The Master International Frequency Register contains the frequency assignments for satellites, and it is noted that since frequency bands are congested it is becoming difficult for new satellite systems to become registered. Further, the ITU reports that harmful interference in the form of jamming has increased and that they have relied on the goodwill of countries to resolve the incidents, since there is no mechanism in place to enforce compliance with their regulations.[43]

In addition to RFI, satellites can be subjected to laser interference. Ground-based lasers are being used for a variety of activities, including helping improve the performance of telescopes, but the laser energy can cause temporary or permanent effects to satellites that pass through its beam.[44] The United States recognized this danger and established the Laser Clearinghouse mission within the Joint Space Operations Center (JSpOC) in 2000. It registers, schedules and deconflicts government laser programs, including DoD, as well as non-government lasers as resources permit.[45] The objective of the mission is to protect space systems and humans in outer space; however, this service is not provided internationally by JSpOC or any other organization. Highlighting this deficiency, American satellites became subject to laser interference when China intentionally aimed ground-based lasers at the satellites as they passed over its territory in the fall of 2006, causing a sudden decline in performance. China’s intent is not fully known, but it has been hypothesized that they were using satellite laser ranging technology to obtain orbital parameters of satellites, or to test if the laser would be

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[43] International Telecommunication Union, “Satellite Regulations,” last updated 16 March 2017, http://www.itu.int/net/newsroom/wrc/2012/features/satellite_regulations.aspx.

[44] William Ailor, “Space traffic control: a view of the future,” *Space Policy* 18 (2002): 100.

[45] Robert J. Volio, “Laser tagged – how the JSpOC manages laser deconfliction,” last updated 19 August 2016, http://www.vandenberg.af.mil/News/Features/Display/Article/920559/laser-tagged-how-the-jspoc-manages-laser-deconfliction.

detected by the United States.[46] Regardless of China's actual intent, incidents like these expose a vulnerability that can be exploited and weaponized, and highlight the contested nature of outer space.

ASATs

The continued development, known and alleged testing of ASATs by countries like China underscores the contested environment within which space-based assets operate.[47] The space law framework, specifically the Outer Space Treaty, prohibits the placement of nuclear weapons and weapons of mass destruction in orbit or on celestial bodies, but not other types of weapons like ASATs. Additionally, although it bans the testing of any type of weapon on celestial bodies, it does not ban their use in orbit.[48] Since the UN does not possess powers of enforcement, state parties to the Outer Space Treaty could in theory disregard the articles, despite being considered customary international law.[49] In light of the lack of regulations and enforcement powers of the UN concerning the weaponization of outer space, some have argued that outer space will become the new environment for state conflicts.[50] Evidence of this lies in the increasing

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[46] Benjamin Somers, "Experts Warn Ground-Based Lasers Could Interfere with Orbiting Satellites, Call for Stricter Guidelines," last updated 19 November 2013, https://www.aaas.org/news/experts-warn-ground-based-lasers-could-interfere-orbiting-satellites-call-stricter-guidelines.

[47] Brian Weeden, "Anti-Satellite Tests in Space – The Case of China," last updated 18 May 2015, https://swfound.org/media/115643/china_asat_fact_sheet_may2015.pdf.

[48] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 4 April 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf

[49] United Nations Committee on the Peaceful Uses of Outer Space Legal Subcommittee, "Answers from the Chair of the Space Law Committee of the International Law Association (ILA) to questions by the Chair of the Working Group of the LSC," last accessed 20 March 2017, http://www.unoosa.org/pdf/limited/c2/AC105_C2_2015_CRP25E.pdf. If state parties do not adhere to the Outer Space Treaty, they could be subject to international pressure.

[50] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 3; Brian Weeden, "Why Outer Space Matters," last updated 24 October 2016, http://intercrossblog.icrc.org/blog/why-outer-space-matters-brian-weeden-on-natural-and-human-

number of space powers investing in military space capabilities. Countries such as Japan and India have begun to acquire military space-based assets, abandoning civilian-only policies that have marked their historical practice for decades. Other countries like China, Russia and North Korea are demonstrating assertiveness in space, and there appears to be a small scale space race occurring in the Middle East to develop missile systems capable of delivering weapons of mass destruction.[51]

Space weapons in the form of missile interceptors tipped with nuclear weapons were first introduced into the United States' and Soviet Union's weapon collection in the 1950s. Between the two countries, there were nine such weapons tested in outer space from 1958 to 1962; however, these tests brought about the realization of the dangers that electromagnetic pulse radiation poses to human spaceflight and military and commercial satellites.[52] As a result, both countries signed the Partial Test Ban Treaty in 1963, which bans nuclear weapons testing in the atmosphere, in outer space, and underwater.[53] Additionally, the countries signed the Outer Space Treaty in 1967 that bans placing and stationing objects in Earth's orbit that carry nuclear weapons or weapons of mass destruction, and calls for the use of outer space to be conducted in a manner that maintains international peace and security.[54]

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generated-threats-on-satellites; Lee Billings, "War in Space May Be Closer Than Ever," last updated 10 August 2015, https://www.scientificamerican.com/article/war-in-space-may-be-closer-than-ever/.

[51] James Clay Moltz, "Congested, Contested, and Competitive," *Utne* no. 187 (Summer 2015): 71-73.

[52] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 28-29.

[53] United Nations Office for Disarmament Affairs, "Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water," last accessed 20 March 2017, http://disarmament.un.org/treaties/t/test_ban.

[54] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 20 March 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.

Nevertheless, both countries continued to develop space weapons; and particularly ASAT weapons. The last ASAT test that occurred prior to an informal international moratorium was conducted by the United States in 1985 when an F-15 launched a kinetic ASAT weapon system towards a target satellite, destroying it and producing over a thousand pieces of orbital debris. The negative impact on the space environment from this ASAT test became widely recognized, and countries such as the United States banned further testing.[55] After more than 20 years of restraint from testing ASATs, the international moratorium was broken in 2007 when China used an ASAT to destroy Fengyun-1C. This test resonated loudly across the globe, as it demonstrated the power of China's military space program and brought about not only condemnation for the amount of orbital debris created, but also prestige for its military space capabilities.[56] The United States responded by destroying its non-functioning satellite in 2008 with its Aegis sea-based missile-defense interceptor, and India announced in 2010 that it would be developing an ASAT system of its own.[57] Consequently, outer space is becoming increasingly congested due to the space debris caused by past and future ASAT tests, as well as contested through the addition of more space actors and their quest to strengthen their military space programs to outmatch others. However, despite the threat of an arms race, large stockpiles of ASATs are not known to presently exist within any country.[58]

[55] Union of Concerned Scientists, "A History of Anti-Satellite Programs (2012)," last updated February 2012, http://www.ucsusa.org/nuclear-weapons/space-security/a-history-of-anti-satellite-programs#.WNBltsszVDw.

[56] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 123.

[57] Union of Concerned Scientists, "A History of Anti-Satellite Programs (2012)," last updated February 2012, http://www.ucsusa.org/nuclear-weapons/space-security/a-history-of-anti-satellite-programs#.WNBltsszVDw.

[58] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 130.

Commercialization

Due to the high costs associated with technology and the limited means of non-government organizations, it has been governments that have traditionally steered space programs.[59] Funding for space projects is thus subject to public scrutiny and national budgetary constraints. As a result of uncertain funding and in some cases budget cuts, civil space programs have begun to rely on partnerships to help shoulder the high costs of space missions.[60] This translates to international cooperation between civil space programs, such as that seen between the five principal space agencies that provide and operate elements of the ISS.[61] Partnership between countries can enable new civil space programs to emerge that would have been unable to on their own. Public-private partnerships are also being created to maximize efficiencies and reduce costs; an example is the National Aeronautics and Space Administration's (NASA) relationship with SpaceX to transport cargo to the ISS.[62] Consequently, the number of private space companies is growing, reflecting the increased commercial benefits available to them. This in turn reflects advancements in technology, its availability and reduced prices, and the realization that the space industry has woven itself into the world's economic fabric.[63] Although competition has always existed between civil space programs, the addition of private space actors and emerging civil space programs has amplified the competition in space.

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[59] *Ibid*., 60.

[60] Marketwired, "Worldwide Government Spending on Space to Flatten Over Next Five Years," last updated 16 February 2011, http://www.marketwired.com/press-release/worldwide-government-spending-on-space-to-flatten-over-next-five-years-1397143.htm.

[61] National Aeronautics and Space Administration, "International Cooperation," last updated 9 January 2017, https://www.nasa.gov/mission_pages/station/cooperation/index.html.

[62] Samantha Masunaga, "Don't expect a space race between SpaceX and NASA. They need each other," last updated 5 March 2017, www.latimes.com/business/la-fi-spacex-nasa-20170301-story.html.

[63] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 102.

A multitude of services drive the competition in the space market. The communication satellite sector is one area that is consistently expanding with SmallSats and CubeSats emerging as cost-effective products that leverage advancements in nano technology.[64] These satellites perform at a similar level as larger conventional satellites, they can be developed quicker and at a fraction of the cost, they cost less to launch into orbit, and they orbit for only a few years before deorbiting and burning up in the atmosphere.[65] Yet, despite the greater speed at which they can be developed, their operation is limited by the availability of launch services. Since 2014, the number of SmallSats launched has declined due in large part to delays in launches, failures of launch vehicles, and other setbacks.[66]

National programs have long been the source of launch capabilities for satellites and spacecraft; however, new launch services and facilities are emerging worldwide to support both existing customers, as well as new space actors.[67] These emerging companies are looking to lower launch costs in order to accelerate the use of outer space.[68] Companies such as Virgin Galactic are currently developing launch services for SmallSats, aiming to achieve high rates of launches to meet backlogged demand.[69] Another promising company is SpaceX, which has successfully recovered eight rockets

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[64] National Aeronautics and Space Administration, "What are SmallSats and CubeSats?," last updated 26 February 2015, https://www.nasa.gov/content/what-are-smallsats-and-cubesats.

[65] "Nanosats are a go!," *The Economist Technology Quarterly*, no. 2 (7 June 2014), http://www.economist.com/news/technology-quarterly/21603240-small-satellites-taking-advantage-smartphones-and-other-consumer-technologies.

[66] Jeff Foust, "Launch woes diminish demand for small satellites," last updated 2 February 2017, http://spacenews.com/launch-woes-diminish-demand-for-small-satellites/.

[67] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 105.

[68] B.C. Cornell, "The Final Frontier: The Emergence of the Commercial Space Industry and the Loss of Space Hegemony" (Joint Command and Staff Programme Directed Research Project, Canadian Forces College, 2016), 99.

[69] Jeff Foust, "Launch woes diminish demand for small satellites," last updated 2 February 2017, http://spacenews.com/launch-woes-diminish-demand-for-small-satellites/.

and aims to develop a reusable launch capability, which once effectively completed and refined will have a significant impact on lowering the launch costs for space travel.[70] These companies are also pushing to develop human spaceflight vehicles that will enable the general public to visit the ISS in the case of SpaceX, or conduct suborbital flights to experience a few minutes of weightlessness with Virgin Galactic.[71] The increased number of launches, fueled by competition between companies, will expand the number of activities and objects in outer space and consequently the level of congestion. It will also add strain on the limited radio frequency spectrum, as more satellites and small satellites are inserted into orbit. Decreased costs for launches will also enable other commercial endeavours such as the mining of asteroids and celestial bodies like the Moon to come to fruition, and they will only serve to exacerbate the congestion issue. Furthermore, the emergence of new industries and technologies threatens national security, as technology once exclusively used by armed forces around the world is increasingly used by non-state actors.[72] These new technologies may be used for adversarial purposes, adding to the contested nature of outer space.

The increasingly contested space environment can provide significant challenges to the commercial space industry. Space systems that generate billions of dollars are at risk if restraint is not exercised to safeguard against further creation of orbital debris,

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[70] Dana Hull, "Elon Musk's SpaceX on brink of 'Wright Brothers moment' with reused rocket," last updated 27 March 2017, http://www.seattletimes.com/business/elon-musks-spacex-on-brink-of-wright-brothers-moment-with-reused-rocket/; Dave Mosher, "'Right in the bull's-eye': SpaceX just pulled off a revolutionary rocket launch," last updated 30 March 2017, http://www.businessinsider.com/spacex-reusable-rocket-launch-ses10-2017-3. SpaceX launched a Falcon 9 rocket with a telecommunications satellite as its payload on 8 April 2017, and successfully recovered the first-stage booster. The booster was initially fired on 8 April 2016, recovered and reused for this launch. It is the first time in history that any part of a liquid-fueled rocket has been recovered, reused and then recovered again.

[71] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 106-110.

[72] B.C. Cornell, "The Final Frontier: The Emergence of the Commercial Space Industry and the Loss of Space Hegemony" (Joint Command and Staff Programme Directed Research Project, Canadian Forces College, 2016), 95.

harmful interference, or direct destruction of satellites. Nonetheless, the commercialization of outer space and the associated competition poses a threat to the space environment itself. As more activities are undertaken and more space-based assets are inserted into Earth's orbit, the greater is the congestion of outer space, the risk of collisions and the need for orbital debris mitigation. Further, although competition can stimulate innovation and advancements in the space sector, conflicts between nations can arise as a result of excess competition.[73]

Conclusion

This chapter has highlighted the congested, contested and competitive nature of outer space by overviewing its utilization, the issue of orbital debris, highlighting the limited number of useable satellite orbital slots, the risk of collisions, RFI, laser interference and ASATs, as well as underscoring the commercialization of outer space. There are many benefits that humanity derives from operating in outer space, including earth observation for Earth's environment, communication and navigation services, and increased understanding of the universe, physics, materials and life sciences. Although vast in size, there is a case to be made for the diligent management of outer space congestion in order to preserve the commons for both the quality and safety of human lives in the future. As the number of space activities increases, the level of cooperation in debris mitigation and collision avoidance will become imperative, along with the avoidance of state conflicts and weapon testing in space. However, the cooperation necessary will be increasingly difficult as additional space actors emerge and the competition for prestige and market shares continues to grow.

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[73] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 9, 28.

Cooperation will need to be achieved through an appropriate legal framework. Correspondingly, the existing treaties, conventions and guidelines will be the focus of the next chapter, within which it will be argued that the current legal framework is insufficient for addressing post-Cold War space activities. In particular, it will highlight the lack of a STM organization and provisions for its establishment. It will also discuss how organizations such as the ITU have evolved to attempt to bridge gaps in space law, but do not completely address the outdated nature of the Outer Space Treaty and Registration Convention.

CHAPTER 2 – LEGAL FRAMEWORK FOR COOPERATION IN OUTER SPACE

Introduction

The defence, science and commercial actors in space largely plan activities and operate in isolation, often acting contradictory to one another in terms of space security. Indeed, these three entities define the term "space security" differently, as their visions of the future operating environment are predicated on different assumptions.[74] To maintain the equitable use of outer space for a variety of future endeavours, the congested, contested and competitive space environment must be carefully managed with cooperation from all nations and space actors. This will require striking a balance between cooperation and competition, the latter of which can drive growth in the space sector.

Cooperation is not a novel concept in outer space affairs, nor is consensus as a method for decision-making. One of the prime historical examples of cooperation is the Outer Space Treaty that was brought into force in 1967 during the space race between the United States and the Soviet Union. This treaty was developed through consensus and is the foundation upon which several other space treaties are based.[75] One of the succeeding treaties, pertinent to the subject of this research paper is the Registration Convention of 1976. This treaty, along with the Rescue Agreement of 1968 and the Liability Convention of 1972, was also developed through consensus and demonstrate the achievements of

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[74] Jeffrey Boutwell, Theresa Hitchens and James Moltz, "Enhancing Space Security by Improving Stakeholder Cooperation," *Astropolitics* 2, no. 2 (2004): 100.

[75] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 54.

international cooperation.[76] Nevertheless, these treaties reflect the time during which they were created – the Cold War era.

This chapter will demonstrate that the current international space law framework is not sufficient to address contemporary issues of congestion due to orbital debris, growing numbers of space actors, and increased mechanisms for outer space utilization. It will begin with an overview of relevant articles of the Outer Space Treaty, followed by those of the Registration Convention. It will then examine the stopgap measures that have been put in place to address the shortcomings within international space law, such as the IADC Debris Mitigation Guidelines and the ITU regulatory body for satellite orbital slot and radio frequency management. Finally, it will propose that a STM organization is necessary to manage space activities to avoid concerns such as collisions, RFI, and laser interference.

Outer Space Treaty

The Outer Space Treaty, formally known as "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," was devised during the Cold War. Significantly, the time period was an "east-versus-west era" marked by state actors, namely those of the United States and the Soviet Union.[77] This is reflected in the formal title in addition to the content of the treaty. Of the 17 articles, 16 use the term "States" or "States Parties" and the remaining article discusses claims of sovereignty, which is defined as "the authority of a

[76] Eilene Galloway, "Consensus Decision-making by the United Nations Committee on the Peaceful Uses of Outer Space," *Journal of Space Law* 7, no. 1 (Spring 1979): 8.

[77] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 273.

state to govern itself or another state."[78] As the founding document for international space law, the Outer Space Treaty does not directly address non-state actors, for example private companies like SpaceX. Although Article VI directs that the authorization and supervision of non-government entities is to be conducted by the appropriate state, this requires a reliance on states to devise their own management programs and to ensure companies' compliance with international law. This results in the absence of direct accountability of non-government entities to the international community.

Relying on states to regulate the activities of its private space actors raises significant issues. First, disparities can occur between states in the manner in which they regulate space activities. Some states may not apply the same level of rigour and enforcement as others to their national rules and procedures, thereby jeopardizing the safety of space activities. Second, multinational companies may choose to usurp strict national regulations by launching their space objects from another state with less restrictive rules [79] With an increasing number of private companies emerging in the competitive space environment, including international companies, there is an increasing need to remedy the lack of international governance over these space actors.

Upon review of the content of the Outer Space Treaty, Article I and II are arguably the most important, as they outline the fundamental rules for the usage of outer space. Article I classifies outer space as the "province of all mankind," and its exploration

[78] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 4 April 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf; English Oxford Living Dictionaries, "Sovereignty," last accessed 4 April 2017, https://en.oxforddictionaries.com/definition/sovereignty.

[79] B.C. Cornell, "The Final Frontier: The Emergence of the Commercial Space Industry and the Loss of Space Hegemony" (Joint Command and Staff Programme Directed Research Project, Canadian Forces College, 2016), 65, 68, 104.

and use is for the benefit of all countries "without discrimination of any kind."[80] It further requires that scientific investigation be conducted freely and in a manner that encourages international cooperation. This allowance for freedom of use has inevitably created the congested and competitive space environment of today, since exploration can quickly turn into exploitation. Article II specifies that outer space, including celestial bodies, cannot be appropriated by any means; however, it does not specify what constitutes a celestial body. Further, the allowance of private ownership of extraterrestrial resources is not clear, since the Outer Space Treaty governs states and not non-state space actors.[81] For this reason, it is not certain whether commercial asteroid mining is considered permissible. Once proven feasible and profitable to conduct, asteroid mining can turn into exploitation of outer space's natural resources and cause further congestion of the commons due to increased activities. Additionally, it is not apparent whether the appropriation of outer space includes the occupation of satellite orbital slots. Satellites could inhabit orbital slots for many years, both as operational and non-functioning, thereby in a sense appropriating a portion of outer space through occupation.[82]

Article III of the treaty is a broad sweeping statement that requires all space activities to be conducted in accordance with international law, including the United Nations Charter. It also reaffirms that space activities are to be undertaken to maintain

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[80] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 4 April 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.

[81] B.C. Cornell, "The Final Frontier: The Emergence of the Commercial Space Industry and the Loss of Space Hegemony" (Joint Command and Staff Programme Directed Research Project, Canadian Forces College, 2016), 68.

[82] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 60-61. The term "occupation" is a term used in international law that entails "being there" and possessing the intention to "act as sovereign" with regards to the occupied area. Thus, the intention of the space operator is the key item of this two-part test to determine if it is occupying an orbital slot.

international peace and security, and promote cooperation. The principal of cooperation is repeated again in Article IX. To assist with the maintenance of international peace and security, Article IV prohibits the placement of nuclear weapons or weapons of mass destruction in Earth's orbit, stationed on celestial bodies or in any part of outer space. It also calls for the use of the Moon and other celestial bodies "exclusively for peaceful purposes."[83] Yet, Article IV does not specifically prohibit the use of other space weapons, such as ASATs. As a result, countries like China can attempt to exploit this gap in international space law and continue to develop and test ASATs.[84] In line with this thought process, the space environment will consequently continue to be contested, and congested due to the proliferation of orbital debris.

There is a requirement of states under Article IX to avoid "harmful contamination" of outer space, which by extrapolation could include orbital debris. However, the issue of orbital debris was not on the agenda for the United Nations at the time of the drafting of the Outer Space Treaty.[85] Article IX further requires that the state or supervising state of the activities consult the international community before proceeding with any activity that could potentially cause harmful interference with other states' activities. The testing of an ASAT may constitute an activity that could cause

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[83] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 4 April 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.

[84] Brian Weeden, "Anti-Satellite Tests in Space – The Case of China," last updated 16 August 2013, https://swfound.org/media/115643/china_asat_testing_fact_sheet_aug_2013.pdf; Colin Clark, "Chinese ASAT Test was 'Successful:' Lt. Gen. Raymond," last updated 14 April 2015, http://breakingdefense.com/2015/04/chinese-asat-test-was-successful-lt-gen-raymond/; Mike Gruss, "U.S. Official: China Turned to Debris-free ASAT Tests Following 2007 Outcry," last updated 11 January 2016, http://spacenews.com/u-s-official-china-turned-to-debris-free-asat-tests-following-2007-outcry/. China has conducted several known or suspected ASAT tests since 2005. The destruction of Fengyun-1C in 2007 created a significant amount of debris; however, the ASAT tests conducted in 2010, 2013, and 2014 did not create debris.

[85] United Nations Office for Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," last accessed 01 March 2017, http://www.unoosa.org/pdf/publications/st_space_49E.pdf.

harmful interference; however, the contested nature of the space environment and individual state practices appear to be impediments to international consultation or cessation of these activities.[86] Finally, any attempts to remove orbital debris from outer space are hindered by Article VIII, which asserts that any object, including its component parts, remains under the jurisdiction of the registering state whether it is in outer space, on a celestial body, or returns to Earth. In other words, only the state to which the object is registered can remove it.[87] Consequently, the orbital debris issue is not easily remedied due to the lack of an update to the Outer Space Treaty.

Overall, the Outer Space Treaty reflects the time during which it was created, and is therefore deficient when applied to contemporary activities. To further their interests, space actors can exploit the loopholes that exist, which in turn will intensify the congested, contested and competitive nature of the space environment. The mitigation measures that have attempted to rectify some of these gaps will be discussed later in this chapter.

Registration Convention

The "Convention on Registration of Objects Launched into Outer Space," or more simply known as the Registration Convention, builds on the three treaties that came before it: the Outer Space Treaty, the Rescue Agreement, and the Liability Convention.

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[86] Leonard David, "Russian Satellite Hit by Debris from Chinese Anti-Satellite Test," last updated 8 March 2013, http://www.space.com/20138-russian-satellite-chinese-space-junk.html; Warren Ferster, "Pentagon: Russian Satellite not Hit by ASAT Test Debris," last updated 21 March 2013, http://spacenews.com/pentagon-russian-satellite-not-hit-by-asat-test-debris/. It was suspected that debris from the destruction of Fengyun-1C in 2007 hit the Russian satellite BLITS on 22 January 2013, but JSpOC assessed that the debris cloud from the 2007 event was not the culprit. Nevertheless, there was a close approach of the orbital debris that day with the BLITS satellite and it underscores the potential harmful interference that the debris poses.

[87] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 4 April 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.

The Registration Convention sets out to establish a practice of registering space objects to assist with their identification, return, or assignment of liability in the case of accidents. It consists of 12 articles, and like the Outer Space Treaty it focuses on state actors and does not mention private companies, reflecting the time during which it was drafted.[88]

The Registration Convention begins by defining the terms “launching state,” “space object,” and “state of registry” in Article I.[89] Of these terms, the first is of most importance because it identifies two ways that a state can be classified as a launching state, which sets the conditions for the remainder of the treaty. These two ways include “a state which launches or procures the launching of a space object,” and “a state from whose territory or facility a space object is launched.”[90] Due to the increasing complexity of contemporary launches, this definition of launching state becomes more difficult to apply to scenarios where private subcontractors are involved. Additionally, the definition does not address the transfer of space objects from one state to another, as can occur within the commercial space sector. An example of this situation occurred when ownership of INTELSAT satellites were transferred to New Skies NV in the Netherlands in 1998. Following the transfer, the Netherlands disclaimed being subject to the Registration Convention, but took responsibility for their operation as the national state in accordance with Article VI of the Outer Space Treaty.[91]

The responsibilities of the launching state are listed throughout the remainder of the Registration Convention; however, the articles of particular importance to this paper

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[88] United Nations Office for Outer Space Affairs, “Convention on Registration of Objects Launched into Outer Space,” last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.
[89] *Ibid*.
[90] *Ibid*.
[91] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 92.

include Article II, III and IV. Article II outlines the requirement for launching states to maintain a registry where space objects are listed. In the case of two or more launching states, the states must identify which one will register the space object on its registry, thereby becoming the state of registry. This creates the chance of a weak connection between the state of registry and the actual operator of the space object.[92] Further, the contents of a state's registry and how it is maintained is left up to the individual states. Thus, the registry may not contain thorough or updated information on space objects.

Article III of the Registration Convention requires that the Secretary General of the United Nations maintain a register equipped with information provided by each state of registry. Established in November 1976, the UN Register is open access, allowing for states and the public to request information at any time to assist with planning launches or tracing space objects to their launching state for liability purposes.[93] However, the contents are only as accurate as the information provided by states.

The requisite information is detailed in Article IV of the treaty, but it is only required "as soon as practicable."[94] This provides leniency for the launching states to provide the information whenever it suits their purposes, and it is certainly not required prior to the launch of a space object. In fact, many states report well after they have launched their space object, in some cases six months or later.[95] The necessary information includes the space object's basic orbital parameters, its general function, its designator or registration number, and the name of the launching state(s). Over time,

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[92] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 94.

[93] *Ibid.*, 86.

[94] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

[95] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 93.

additional information can be provided to the Secretary General; however, it is not mandatory. Therefore, any maneouvres or changes to a space object's orbital position can be provided, but states are not obliged to provide these updates. The only additional information that the treaty stipulates is to notify the Secretary General when the object is no longer in Earth's orbit, but once again the timing associated with this requirements is "as soon as practicable."[96]

Consequently, the Registration Convention exhibits gaps in both its application to contemporary space activities and in its ability to produce timely and accurate registries. At the time of drafting of the treaty, the emergence of private space actors and a flourishing commercial space sector was not forecasted. The drafters also did not foresee the congestion that would come to exist in outer space. As a result, the registration process is not timely and the lack of available information renders the treaty irrelevant for COLA. To rectify the information voids, launching states have turned to informal routes to exchange data.[97]

Mechanisms Used to Address Space Law Deficiencies

As part of the overall space law framework, the Outer Space Treaty and the Registration Convention have proven to be insufficient in dealing with key issues such as the emergence of private space actors and a competitive commercial space industry; the congestion of outer space due to the amount of orbital debris and number of satellites; and the contested space environment created through activities like ASAT tests. These deficiencies have been identified; however, the member states of the UN COPUOS are

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[96] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

[97] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 96.

reluctant to change the current space law framework.[98] Instead, national agreements, international guidelines, and informal arrangements have been put in place in a piecemeal fashion as stopgap measures to attempt to address space law deficiencies.

To address the lack of regulation for commercial space actors and to encourage growth in the commercial space industry, the United States drafted the U.S. Commercial Space Launch Competitiveness Act.[99] Known more simply as the Commercial Space Act, it was signed into domestic law on 25 November 2015. It contains four titles dealing with various subjects such as licensing, space flight participants, orbital traffic management, space situational awareness (SSA), commercial launch facilities, commercial remote sensing, as well as exploration and utilization of space and asteroid resources. The latter topic has been a source of excitement for space mining companies like Planetary Resources, as the Commercial Space Act allows citizens of the United States to retain any space and asteroid resources, including water and minerals that are extracted from outer space.[100] Some in the space community have disagreed with the United States' domestic law, citing Article II of the Outer Space Treaty as international law that prohibits appropriation of outer space and celestial bodies.[101] However, lawyers from the United States have interpreted this article to mean that citizens have the right to claim the resources they extract from the Moon and other celestial bodies, but they do not have the

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[98] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 273.

[99] United States Congress, "U.S Commercial Space Launch Competitiveness Act," last accessed 10 April 2017, https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf.

[100] Planetary Resources, "President Obama Signs Bill Recognizing Asteroid Resource Property Rights into Law," last updated 25 November 2015, http://www.planetaryresources.com/2015/11/president-obama-signs-bill-recognizing-asteroid-resource-property-rights-into-law/.

[101] Peter B. de Selding, "New U.S. Space Mining Law's Treaty Compliance May Depend on Implementation," last updated 9 December 2015, http://spacenews.com/u-s-commercial-space-acts-treaty-compliance-may-depend-on-implementation/.

right to claim the bodies themselves.[102] Not all members of the space community agree with this logic, and there is fear that other states will adopt a similar stance in their domestic law and weaken Article II of the Outer Space Treaty.[103] The passing of the Commercial Space Act into United States domestic law has forced a national resolution to the subject of commercial space exploration, which has been debated in the international community for several years, but has yet to produce international regulations.

Orbital debris is another area where international regulations do not exist. There are no treaties or arrangements that directly bind states and private actors to practices that minimize the creation of further debris. Recognizing the severity of the problem, an inter-agency committee was formed in 1993, called the Inter-Agency Space Debris Coordination Committee (IADC). Currently, the IADC consists of 13 members: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (Russian Federal Space Agency), SSAU (State Space Agency of

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[102] Jennifer Hackett, “New Law Paves the Way for Asteroid Mining--but Will It Work?” last updated 4 December 2015, https://www.scientificamerican.com/article/new-law-paves-the-way-for-asteroid-mining-but-will-it-work/.

[103] Gbenga Oduntan, “Who owns space? US asteroid-mining act is dangerous and potentially illegal,” last updated 25 November 2015, https://theconversation.com/who-owns-space-us-asteroid-mining-act-is-dangerous-and-potentially-illegal-51073; Quinten Plummer, “New US Asteroid Mining Law Could Violate International Space Treaty,” last updated 30 November 2015, http://www.technewsworld.com/story/82806.html; Peter B. de Selding, “New U.S Space Mining Law’s Treaty Compliance May Depend on Implementation,” last updated 9 December 2015, http://spacenews.com/u-s-commercial-space-acts-treaty-compliance-may-depend-on-implementation/; Jeff Foust, “Staking a claim to space resources,” last updated 14 December 2015, http://www.thespacereview.com/article/2883/1.

Ukraine), and the UK Space Agency.[104] The number of major space agencies forming the IADC signifies the seriousness of the orbital debris issue. The purpose of the IADC is to exchange information, conduct space debris research and identify options for mitigating space debris.[105] In 2002, the IADC published their first debris mitigation guidelines. That same year, the IADC presented these guidelines to the Scientific and Technical Subcommittee of the UN COPUOS. The IADC's guidelines then served as the foundation for the UN Space Debris Mitigation Guidelines that were published in 2007.[106] Both of these guidelines are voluntary for states to abide by, but they represent stopgap measures to help fill the void that exists within the international space law framework.

The management of satellite orbital slots and frequencies by the ITU represents an additional mechanism that has been used to address deficiencies in the international space law framework. In 1959, the ITU appreciated the radio frequency requirements for space objects to operate and began including definitions such as "space station," "earth station," "space service," and "earth/space service" in their regulations. The UN General Assembly recognized the important role that the ITU could play in the peaceful uses of outer space in 1961, and by 1998 they granted the ITU formal jurisdiction over all Earth orbits for allocation of frequencies.[107] Although the ITU's focus was frequency assignment, the link between orbital positions and the risk of frequency interference

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[104] Inter-Agency Space Debris Coordination Committee, "Inter-Agency Space Debris Coordination Committee," last accessed 10 April 2017, http://www.iadc-online.org/.

[105] Inter-Agency Space Debris Coordination Committee, "Terms of Reference for the Inter-Agency Space Debris Coordination Committee," last accessed 10 April 2017, http://www.iadconline.org/ index.cgi?item=torp_pdf.

[106] European Space Agency, "Space Debris," last updated 19 April 2013, http://www.esa.int/Our_Activities/Operations/Space_Debris/Mitigating_space_debris_generation.

[107] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 200, 251.

meant that orbital slots had to be allocated through the same process, representing "competence creep."[108] Of note, the ITU views the allocation of an orbital slot not as the right to ownership or appropriation, but rather a temporary right to its use.

The ITU allots frequencies and orbital slots to "administrations," which are governmental departments or services that are responsible to uphold the obligations listed within the ITU Constitution, Convention and Administrative Regulations.[109] Consequently, private space actors and intergovernmental organizations are unable to request allocations directly from the ITU; they require a state to register on their behalf. Although the ITU has filled a vital role for space activities, there have been critics of the allocation process due to the allowance of "paper satellites," or speculative systems that have not or will never be launched into orbit.[110] These "paper satellites" and over-filing practices result in considerable backlogs and the denial of orbital slots to others, thereby restricting access to the "province of all mankind." Recently, the surge of constellation proposals that have been filed with the ITU has posed a new challenge. The ITU regulations currently allow for the state to declare that the constellation has been brought into regular operation with only one of the satellites launched, rather than requiring the entire constellation to be functioning in orbit.[111] Unfortunately, the ITU has no powers of enforcement to address this problem, and they must rely on states' good will.

The contested space environment has also exposed problems with the legal framework concerning the use of space weapons like ASATs. An informal international

[108] Frans von der Dunk, "International organizations in space law," in *Handbook of Space Law* (Cheltenham: Edward Elgar Publishing, Inc., 2015), 275-276.
[109] *Ibid*., 327.
[110] International Telecommunication Union, "Press Release," last updated 16 September 2002, http://www.itu.int/newsroom/press_releases/2002/21.html.
[111] Peter B. de Selding, "ITU, FCC: Satellite constellation surge requires new rules," last updated 16 March 2017, https://www.spaceintelreport.com/itu-fcc-satellite-constellation-surge-requires-new-rules/.

moratorium on ASAT testing was put in place following the United States' kinetic ASAT test conducted in 1985, but it was broken when China destroyed its Fengyun-1C defunct weather satellite with an ASAT in 2007.[112] As noted earlier, the Outer Space Treaty does not specifically prohibit ASATs; therefore, something more concrete is needed to address the ASAT issue. At the Conference on Disarmament in 2008, China and Russia presented a draft treaty, entitled "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space," aiming to prevent the weaponization of outer space.[113] The United States, however, felt that both this proposal and the updated draft treaty provided in 2014 were "fundamentally flawed."[114] One of the critical concerns raised was that the draft treaty does not ban terrestrially-based direct ascent ASATs. As a result, this treaty remains in draft form and is being debated at the UN.[115]

Alongside the draft treaty efforts being made by China and Russia, the European Union (EU) began drafting regulations. In 2008, the EU provided a draft of its "Code of Conduct for Outer Space Activities" to the international community and requested feedback on the instrument they had created to establish responsible behaviour in outer space.[116] The EU's intent is to allow states to sign onto this document voluntarily, but it

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[112] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York: Columbia University Press, 2014), 29-30.

[113] United Nations Office for Disarmament Affairs, "Russian Federation and China: draft PPWT," last updated 8 September 2014, https://documentsddsny.un.org/doc/UNDOC/GEN/G08/604/02/PDF/G0860402.pdf?OpenElement.

[114] Jeff Foust, "U.S. Dismisses Space Weapons Treaty Proposal As 'Fundamentally Flawed'," last updated 11 September 2014, http://spacenews.com/41842us-dismisses-space-weapons-treaty-proposal-as-fundamentally-flawed/.

[115] United Nations, "Debating Proposals on Common Principles to Ensure Outer Space Security, First Committee Delegates Call for Adoption of Legally Binding Treaty," last updated 19 October 2016, https://www.un.org/press/en/2016/gadis3557.doc.htm.

[116] Chris Johnson, "Draft International Code of Conduct for Outer Space Activities Fact Sheet," last updated February 2014, https://swfound.org/media/166384/swf_draft_international_code_of_conduct_for_outer_space_activities_fact_sheet_february_2014.pdf.

would not be legally binding. The draft document proposes measures to minimize collisions and harmful interference; requests that space actors refrain from intentional destruction of spacecraft, unless required to mitigate debris or for self-defence; and encourages adherence to ITU regulations and IADC Space Debris Mitigation Guidelines.[117] Essentially, it looks to incorporate some of the measures discussed above into one code of conduct to address gaps in the space law framework. However, once again this document would not be legally binding, and thus there is no enforcement mechanism to ensure state compliance. Discussions are ongoing concerning this proposal, and the United States, Japan and Australia have joined the EU in developing a code of conduct that in the future may be acceptable to all states.[118] In addition to the Commercial Space Act, the IADC Debris Mitigation Guidelines, the ITU processes, and the Chinese and Russian attempts at preventing the weaponization of outer space, the EU Code of Conduct represents a stopgap measure to address the deficiencies of international space law.

The Need for Space Traffic Management

The aim of the EU's Code of Conduct for Outer Space Activities is to set norms of behaviour in outer space, or rather to establish "rules of the road." What they are trying to establish is a voluntary, though non-binding, method of managing contemporary space activities that would allow the peaceful use of outer space. Yet, they are attempting to use the existing space law framework and band-aid solutions without resolving the underlying problem: increasing levels of traffic. In considering this dilemma, this

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[117] *Ibid.*
[118] *Ibid.*

research paper proposes that there is a pressing need for STM to enable safe scientific exploration, commercial space developments, and to avoid interference with defence capabilities. Space traffic management would require an overhaul of the space law framework, since it would necessitate a comprehensive approach to solve the core problem, rather than addressing individual issues that have been the focus of the past.[119] Furthermore, the space law treaties do not provide for a governing body to manage space activities.[120] Consequently, the creation of a STM system would be a shift in momentum for the international community, and would require cooperation from all states.

Conclusion

The aim of this chapter was to analyze the international space law framework that space actors must work within and demonstrate deficiencies in its application to contemporary space activities. It has highlighted several inadequate areas in the Outer Space Treaty and the Registration Convention, as well as overviewed mechanisms that have been put in place to attempt to mitigate them. The congested, contested and competitive space environment of today can be linked to these deficient areas of international space law, and it is argued that a more comprehensive approach is necessary to enable the peaceful use of outer space. The proposed course of action is to enact a STM system to manage the increasing traffic levels, which is the fundamental issue plaguing outer space. The organization that is to be created or selected to conduct STM must be able to operate internationally. This will ensure that regulatory mechanisms can be applied equally to all states, since there is no sovereignty in outer space.

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[119] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 274.

[120] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 18.

The following chapter will use the International Civil Aviation Organization (ICAO) as a case study to draw parallels between the international aviation industry and the space industry. It will also analyze whether ICAO's role could be expanded beyond ATM to include STM, or whether a different organization will be required to assume this new role. This analysis will focus on the types of tasks that any organization will be required to perform, such as COLA, minimization or elimination of RFI and laser interference, and provisions for safe launches and recovery of space objects and spacecraft.

CHAPTER 3 – ICAO: A CASE STUDY FOR SPACE TRAFFIC MANAGEMENT

Introduction

With the expanding utilization of outer space and a global dependence on space-based systems, there is a compelling need for regulations that set the "rules of the road" and a requirement to identify a management organization to establish and enforce these rules. Although management of outer space is not specifically theorized in space treaties, the contemporary reality of a congested, contested and competitive space environment indicates that a comprehensive approach to managing space activities is required. The selected approach must be based on cooperation from states to enable the safe and orderly conduct of space activities without harmful interference, as well as the equitable and peaceful use of outer space. It must also provide a framework through which the commercial space transport industry can develop to meet the world's social and economic needs.

The main argument of this study is that the regulations and desired oversight of space activities should be provided by an international organization assigned the managerial responsibility to enact and administer a global STM system. The aim of STM is to achieve a "common good" through cooperation amongst all space actors to guarantee the safe and continued use of outer space. Arguably, cooperation is in the best interests of both space operators and their consumers. As discussed in Chapter 2, there are piecemeal mechanisms that have been put in place that have begun the build up towards this more comprehensive, cooperative approach, but they are merely stopgap measures that do not address the rising number of space activities.

Drawing parallels from the international aviation industry's ATM system, this chapter will use ICAO as a case study to analyze its evolution since its creation in 1947 and evaluate whether its current mandate could be expanded to include STM. The chapter will first overview ICAO's role at its inception and how it has evolved its procedures to meet the needs of the international aviation industry. It will then explore ICAO's interests in outer space, highlighting its involvement in the regulation of the Global Navigation Satellite System (GNSS) for air navigation, and its potential role in regulating suborbital flights. Following, the chapter will examine the tasks that could be performed by a STM regime, before turning to the final section that will investigate whether ICAO's role in the international community could be expanded to include these new tasks.

ICAO and the International Aviation Industry

During the Second World War, it was recognized that military aviation would have a considerable impact on post-war commercial aviation. The pilots, aircraft, factories, and air routes established for the war effort would likely be transferred to the commercial industry following the war. It was also recognized that cooperation in international aviation would be required to manage key components such as the provision of air traffic control services, meteorology, the standards, training and licensing of pilots, the construction and maintenance of airports, and the establishment of an air law framework. International regulations would be necessary to deal not only with the competitive commercial aviation sector, but also with international rivalries and military disarmament in order to ensure aviation security.[121]

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[121] David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 5, 19.

Following the invasion of Normandy, the positive outlook of the war indicated that commercial aviation would resume in the near future, and precipitated the planning of an aviation conference involving non-Axis nations. Held in Chicago in November 1944, the attendees reached consensus that a permanent international organization should provide oversight on the development of international air travel.[122] To this end, two agreements were signed on the final day of the conference that provided the foundation for the creation of ICAO: the Convention on International Civil Aviation, also known as the Chicago Convention; and the Interim Agreement that established the Provisional International Civil Aviation Organization (PICAO) with advisory powers only.[123] The Chicago Convention would enter into force following ratification by at least 26 states, after which ICAO would change from provisional to full status.[124]

The preamble of the Chicago Convention lists the intent of the agreement, which is to develop international civil aviation in a "safe and orderly manner," and enable the equitable establishment of international air transport that is to be operated "soundly and economically."[125] Part I sets forth the principles and standards for air navigation, addressing subjects such as sovereignty, territory, customs and immigration procedures, aircraft in distress, licensing, and airworthiness. Part II describes ICAO's objectives, composition, powers and legal capacity. Part III outlines the requirements for international air transport, specifically the designation of routes and airports, the financing and improvement of air navigation facilities, and the acquisition or use of land.

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[122] *Ibid.*, 10-13.

[123] International Civil Aviation Organization, "The Postal History of ICAO," last accessed 19 April 2017, http://www.icao.int/secretariat/PostalHistory/from_picao_to_icao_organizational_similarities.htm.

[124] International Civil Aviation Organization, "Convention on International Civil Aviation – Doc 7300," last accessed 19 April 2017, http://www.icao.int/publications/Pages/doc7300.aspx.

[125] International Civil Aviation Organization, "Convention on International Civil Aviation – Original version. Signed at Chicago on 7 December 1944," last accessed 19 April 2017, http://www.icao.int/publications/Documents/7300_orig.pdf.

Part IV, titled "Final Provisions," states that the Chicago Convention supersedes the Paris and Habana Conventions, delineates the procedures for registering existing and new interstate agreements with the ICAO Council, the settlement of disputes, appeals, and addresses war and emergency situations.[126]

In accordance with Article 37 of the Chicago Convention, ICAO was given the task to prepare, adopt and amend Standards and Recommended Practices (SARPs) for international air travel in order to standardize and facilitate efficient and safe operations. SARPs are to be included as annexes to the Chicago Convention, which allows the ICAO Council the ability to update them in order to maintain their relevance, despite advancements in technology and within the civil aviation sector.[127] Draft annexes had been created during the conference in Chicago, but required further analysis and amendments before being adopted by ICAO. Technical committees worked on these draft annexes, resulting in the first six being released in 1948 and an additional nine released between 1949 and 1953. Today, there are 19 annexes to the Chicago Convention containing over 12,000 SARPs.[128]

Member states are expected to adhere to the SARPs "to the greatest extent possible" by implementing national legislation, to which their own aircraft as well as flights operating within their airspace are to obey.[129] Article 38 allows for deviations from the SARPs; however, member states must immediately notify ICAO of these

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[126] *Ibid*.

[127] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 8.

[128] David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 103-104; International Civil Aviation Organization, "How ICAO Develops Standards," last accessed 19 April 2017, http://www.icao.int/about-icao/AirNavigationCommission/Pages/how-icao-develops-standards.aspx.

[129] Peter van Fenema, "Legal aspects of launch services and space transportation," in *Handbook of Space Law* (Cheltenham: Edward Elgar Publishing, Inc., 2015), 409-410.

situations. With the exception of the airspace over the high seas, states are not legally obliged to implement and abide by them, but are encouraged to do so. While it was generally agreed at the time of the creation of the Chicago Convention that standardization was necessary for international civil aviation, the implementation of these standards by states was both costly and time-consuming. The post-Second World War period saw rapid growth and technological advancements within the aviation industry, which made it difficult to implement SARPs, particularly for smaller and developing states that did not have mature industries. Consequently, a Special Implementation Panel was established under ICAO in 1956 to investigate the situation, and offered suggestions to facilitate a smoother implementation process.[130]

Advancements in aircraft engine technology, coupled with the increasing number of aircraft in service led to concerns such as escalated demands on air traffic control, insufficient length and strength of runways, and noise pollution. This signaled a requirement for further stewardship in civil aviation. ICAO responded by establishing a Special Implementation Panel in 1958 to assess the impact of jet aircraft on air traffic services and aerodromes, resulting in suggestions for state implementation. ICAO also organized a Special Meeting on Aircraft Noise in the Vicinity of Aerodromes in 1969, which led to the creation of Annex 16 of the Chicago Convention in 1971, titled "Aircraft Noise." Shortly after the annex was adopted, it was recognized that it should also address environmental pollution from engine emissions, and it was revised to include provisions for emissions and renamed "Environmental Protection."[131]

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[130] David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 171, 175-176.

[131] International Civil Aviation Organization, "The Convention on International Civil Aviation: Annexes 1 to 18," last accessed 19 April 2017, http://www.icao.int/safety/airnavigation/

Security also became a concern for the aviation sector following a surge of violent crimes and hijackings affecting civil aviation in the late 1960s.[132] Multiple ICAO subcommittees, including the Committee on Unlawful Interference, developed SARPs to specifically address unlawful interference and unlawful seizure of aircraft. In 1974, these SARPs were incorporated into Annex 17 of the Chicago Convention, titled “Security – Safeguarding International Civil Aviation against Acts of Unlawful Interference.” An amendment added provisions dealing with sabotage, complementing the existing procedures safeguarding against hijacking. Following the horrific events of 11 September 2001, further amendments were made to Annex 17. New definitions and provisions enable states to apply the annex to domestic operations, and strengthen control and communication measures.[133]

Annex 18 and 19 to the Chicago Convention were added in 1983 and 2013, respectively. Annex 18 was created to ensure the safe transport of dangerous goods by air, which includes explosives, compressed and liquefied gases, flammable liquids and solids, oxidizing material, poisonous or toxic substances, radioactive materials, corrosive substances, and other items such as magnetized materials. Annex 19 is a consolidation of SARPs relating to safety management from other annexes and new provisions developed by the Safety Management Panel with the intent to assist states manage aviation safety risks.[134] Both annexes highlight ICAO’s concern with international civil aviation safety,

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NationalityMarks/annexes_booklet_en.pdf.

[132] Jeffrey C. Price and Jeffrey S. Forrest, *Practical Aviation Security: Predicting and Preventing Future Threats*, 3rd ed. (Oxford: Butterworth-Heinemann, 2016), 48-49.

[133] International Civil Aviation Organization, “The Convention on International Civil Aviation: Annexes 1 to 18,” last accessed 19 April 2017, http://www.icao.int/safety/airnavigation/NationalityMarks/annexes_booklet_en.pdf.

[134] Director General of Civil Aviation, “Annex 19 to the Convention on International Civil Aviation,” last accessed 23 April 2017, http://web.shgm.gov.tr/documents/sivilhavacilik/files/pdf/saglik_birimi/aneks_19eng.pdf.

and along with the preceding annexes, demonstrate the organization's commitment to develop SARPs "in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector."[135]

As civil aviation activities and technologies evolve, ICAO continues to remain relevant by amending the existing annexes of the Chicago Convention and creating new SARPs and annexes to meet the needs of the aviation industry. It has provided useful procedures that deal with every facet imaginable of international civil aviation.[136] Through its performance, ICAO has demonstrated considerable competence in the successful adoption of 19 annexes, and has gained widespread credibility within the international civil aviation community over its 70 years of existence.[137] It has established a global framework that has enabled the prosperous development of the commercial aviation sector and mitigated the risk of mid-air collisions. It is therefore an ideal organization to address STM.

ICAO's Outer Space Interests

ICAO's attention and management abilities are crossing over into the space community due to the aviation industry's growing interest and reliance on space-based assets. The ground-based communication, navigation and surveillance (CNS) system that had been in use globally since the late 1940s was becoming inadequate to meet the needs of the growing international aviation sector as it moved into the 21st century. It was accepted that a satellite-based CNS system would eventually replace it. Satellites could

[135] International Civil Aviation Organization, "About ICAO," last accessed 23 April 2017, http://www.icao.int/about-icao/Pages/default.aspx.

[136] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" *Journal of Space Law* 30, no. 2 (Fall 2004): 192.

[137] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 29.

provide coverage in areas, such as over oceans, which had previously been "blind spots" to the ground-based systems, but implementing a satellite-based system globally would be costly. Free use of the Russian Global Navigation Satellite System (GLONASS) and the United States GPS System was offered to ICAO member states; however, ICAO's intent was to establish a multinational satellite-based CNS system integrated with an automated air traffic management system (CNS/ATM).[138] The ICAO Council first endorsed a Global Air Navigation Plan for an integrated CNS/ATM system in 1998, and its development and implementation to date have been an incremental process.[139] To assure the orderly introduction of CNS/ATM systems, ICAO initially focused its energy on the creation of technical and operational standards.[140] This has allowed the seamless migration to CNS/ATM systems over time, which is bringing further credibility to the organization.

While developing the standards for navigation performance, ICAO realized that it was preferable not to specify the equipment required in order to avoid constant updates to the standards as new technology emerged.[141] Further, it recognized that GNSS would be an important component of the CNS/ATM systems, and would be legally compatible with the Chicago Convention.[142] Accordingly, in 1998 ICAO adopted the Charter on Rights and Obligations of States Relating to GNSS Services. Although the Charter is not

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[138] David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 375-376.

[139] International Civil Aviation Organization, "Global Air Traffic Management Operational Concept," last accessed 23 April 2017, http://www.icao.int/Meetings/anconf12/Document%20Archive/9854_cons_en[1].pdf.

[140] Jack Howell, "Evolutionary approach to transition now focused on detailed vision of how to exploit technologies," *ICAO Journal* 55, no. 7 (September 2000): 6.

[141] David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 377.

[142] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" *Journal of Space Law* 30, no. 2 (Fall 2004): 196.

legally binding, nor is it part of the Chicago Convention or its annexes, it is listed as ICAO General Assembly Resolution A32-19. Given the credibility that ICAO possesses, the resolution may hold importance worldwide.[143] Nevertheless, the ICAO Assembly felt that further standardization and procedures were required, and directed the ICAO Council to "consider the elaboration of an appropriate long-term legal framework to govern the operation of GNSS systems, including consideration of an international Convention for this purpose."[144] The ICAO Council responded by developing the first set of SARPs relating to GNSS, which were included in Annex 10 to the Chicago Convention in 2001.[145] Work on a legal framework in ongoing, and ICAO continues to be at the forefront of the development and use of GNSS.[146]

In addition to GNSS, ICAO may have a role to play in the regulation of suborbital aerospace transportation vehicles (SATVs). To be classified as a suborbital flight, a flight must reach a "very high altitude," but not enter into orbit around the Earth.[147] About 95 percent of the flight occurs within airspace, while the remainder of the flight reaches the lower edge of outer space. As a result, suborbital flights will undoubtedly interfere with aviation operating in the same three-dimensional airspace, which is of concern to ICAO.[148] The first of these flights took place in 2004 when Mojave Aerospace Ventures

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143 Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 407.

144 International Civil Aviation Organization, "ICAO Assembly Resolution A32-20: Development and Elaboration of an Appropriate Long-term Legal Framework to Govern the Implementation of GNSS," last accessed 23 April 2017, http://www.icao.int/Meetings/AMC/MA/Assembly%2032nd%20Session/resolutions.pdf.

145 David Mackenzie, *ICAO: A History of the International Civil Aviation Organization* (Toronto: University of Toronto Press, 2010), 377.

146 Francis Lyall and Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009), 408.

147 Committee on the Peaceful Uses of Outer Space, "Concept of Suborbital Flights: Information from the International Civil Aviation Organization," last accessed 24 April 2017, http://www.unoosa.org/pdf/limited/c2/AC105_C2_2010_CRP09E.pdf.

148 Frans von der Dunk, "Legal aspects of private manned spaceflight," in *Handbook of Space Law*

(MAV) successfully demonstrated that it could launch and recover its SpaceShipOne to an altitude of 100 km twice in one week, carrying the equivalent weight of three adults to win the Ansari XPRIZE.[149] Virgin Galactic licensed the technology from MAV and promised to provide suborbital flights commercially to customers willing to pay the ticket price by 2007, but has continued to delay its start date due to unfortunate events such as an explosion in 2007 and a flight test crash in 2014.[150]

UN COPUOS, ICAO, or a combination of the two could become the regulatory body for suborbital flights. Determining the appropriate organization will primarily depend on whether SATVs are considered "aircraft" or "space objects," and on the final decision of the delimitation of outer space. ICAO defines "aircraft" in Annex 7 of the Chicago Convention as "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface."[151] Additionally, "aeroplane" is found within the same annex and is defined as "a power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight."[152] Analyzing the flight profile of a suborbital flight, the initial ballistic portion does not meet the definition of aircraft or aeroplane; rather, the profile resembles that of a rocket. However, during atmospheric re-entry, the vehicle becomes more like an "unpowered aerodynamic (gliding) flight," and thus could be considered an aircraft in the final portion of its

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(Cheltenham: Edward Elgar Publishing, Inc., 2015), 672, 674.

[149] Ansari XPRIZE, "Mojave Aerospace Ventures Wins the Competition that Started it All," last accessed 24 April 2017, http://ansari.xprize.org/teams.

[150] Elizabeth Howell, "Virgin Galactic: Richard Branson's Space Tourism Company," last updated 17 February 2016, http://www.space.com/18993-virgin-galactic.html.

[151] Committee on the Peaceful Uses of Outer Space, "Concept of Suborbital Flights: Information from the International Civil Aviation Organization," last accessed 24 April 2017, http://www.unoosa.org/pdf/limited/c2/AC105_C2_2010_CRP09E.pdf.

[152] *Ibid*.

flight.[153] International space law does not offer a definition of "space object," but it does state in Article I of the Registration Convention that the term "includes component parts of a space object as well as its launch vehicle and parts thereof."[154] Further, Article II requires registration of space objects that are launched into Earth orbit or beyond. Perhaps this indicates that SATVs are more akin to aircraft than space objects, and air law would apply to suborbital flights.

In terms of the delimitation of outer space, UN COPUOS has been unable to define where outer space starts, despite much debate and it being an agenda item for its Legal Subcommittee for over 50 years.[155] Two principal schools of thought have emerged regarding the division of airspace and outer space: the functionalist approach that proposes to use the nature of an activity as a determinant for whether an object is operating in airspace or outer space; and the spatialist approach that proposes the use of a measurable, physical line as the defining factor.[156] The latter approach often uses the Von Karman line, or 100 km above sea level, as the accepted division between airspace and outer space[157]; companies like Virgin Galactic refer to the same altitude as the objective of suborbital flights.[158] If the spatialist approach is used, then suborbital flights may enter into the lower portion of outer space, triggering space law.

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[153] *Ibid*.

[154] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

[155] José Monserrat Filho, "Definition and Delimitation of Outer Space – a Deadlock Discussion?" last accessed 25 April 2017, http://www.icao.int/Meetings/SPACE2016/Presentations/2%20%20J.%20Filho%20-%20Chair%20of%20COPUOUS%20LSC%20WG%20on%20DefDel%20of%20Outer%20Space.pdf.

[156] Yaw Otu Mankata Nyampong, "The Definition and Delimitation of Outer Space: The Present Need to Determine Where 'Space Activities' Begin," last accessed 25 April 2017, http://www.unoosa.org/pdf/pres/lsc2014/tech-04E.pdf.

[157] The term "inner space" is often used to describe the area between 80 km and 100 km. It is also synonymous with "upper airspace."

[158] Frans von der Dunk, "Legal aspects of private manned spaceflight," in *Handbook of Space Law* (Cheltenham: Edward Elgar Publishing, Inc., 2015), 678.

The current definitions and understanding of "aircraft" and "space object," as well as the lack of a universally agreed upon delimitation of outer space, does not allow for a definitive answer as to who should regulate suborbital flights. In the past, ICAO has changed the definition of "aircraft" to exclude hovercraft, and could modify the definition again to suit its purposes. Additionally, ICAO could define the upper limit of airspace within the Chicago Convention instead of waiting for UN COPUOS to set the point where outer space begins; or the UN General Assembly could mediate the discussion to determine a solution acceptable to both.[159] For now, ICAO has made the decision to abstain from developing SARPs, despite the fact that many of the vehicles that are being designed for suborbital flight could be considered aircraft.[160]

Space Traffic Management Tasks

Before exploring whether or not ICAO could expand its mandate to include regulating suborbital flights and space activities through an international STM system, it is important to overview the tasks for which it would be required to develop SARPs. One of the primary responsibilities would be to devise and standardize a data management system for the collection of information from a multitude of sources to produce the SSA necessary for the management of space traffic. To optimize the amount and quality of data received, the system should be "open and accessible to all actors," but it will also need to manage the security concerns of both states and commercial companies.[161] It should be equipped with subordinate databases to store information regarding radio

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[159] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 5-6, 9.

[160] Frans von der Dunk, "Legal aspects of private manned spaceflight," in *Handbook of Space Law* (Cheltenham: Edward Elgar Publishing, Inc., 2015), 675.

[161] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 274.

frequencies and laser use, space vehicles, space debris, and space weather. Currently, the ITU allocates and manages satellite radio frequencies; however, a consequence of this database is that eventually the ITU would no longer have to perform these duties and an appropriate transition would be necessary.[162] Further, in order to collect information regarding space vehicles, the recommended method is to acquire it from the operators themselves since they would possess the most accurate information.[163] Space debris information can be obtained from the United States SSN, and the Russian Space Surveillance System (SSS), but they would have to begin tracking debris smaller than 4 inches (10 cm). Limited space weather information is available, and it would have to improve to meet the needs of a STM system.[164]

The second area that ICAO would have to develop SARPs for is a notification system that handles the information needs relating to the launch, in-orbit operation, and re-entry phases. Currently, there is a lack of pre-launch notification of space objects, since the Registration Convention only requires information concerning them "as soon as practicable."[165] The Hague Code of Conduct against Ballistic Missile Proliferation provides for pre-launch notifications; however, it is not a legally binding agreement.[166] This situation is insufficient for the purposes of STM, and it would need to be addressed by establishing a pre-launch notification system.[167] A similar circumstance is observed

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[162] Haydar Cukurtepe and Ilker Akgun, "Towards space traffic management system," *Acta Astronautica* 65 (2009): 876.

[163] William Ailor, "Collision Avoidance and Improving Space Surveillance," *Astropolitics* 2 (2004): 117.

[164] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 11.

[165] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

[166] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 39.

[167] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the

for the re-entry of space objects; the Registration Convention only requires the notification of an object that is no longer in orbit "as soon as practicable."[168] The IADC Space Debris Mitigation Guidelines state that operators should inform the appropriate air traffic control agency and maritime authorities of the re-entry time and trajectory in the case of a controlled re-entry; however, there is no legal requirement to notify them.[169] Thus, a re-entry notification system is required to be established in order to enable an effective traffic management system. Additionally, specific rules governing reusable launch vehicles may be required to deal with their launch and recovery, as they are sufficiently different from traditional space objects.[170] This will also require a final decision regarding the delimitation of outer space to enable the appropriate application of air and space laws. In terms of the in-orbit phase, standards would be required to address in-orbit maneouvre and operation notifications, since there is no requirement under the Registration Convention to update the UN Secretary General with additional information concerning a space object.[171]

The development and standardization of the "rules of the road" would be the third area that ICAO would have to focus its efforts. Some considerations include right of way rules, prioritization of maneouvres, zoning of restricted spaces for military assets, environmental standards that include space debris mitigation, safety provisions for

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use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 274.

[168] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

[169] Inter-Agency Space Debris Coordination Committee, "Inter-Agency Space Debris Coordination Committee," last accessed 10 April 2017, http://www.iadc-online.org/.

[170] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 43.

[171] United Nations Office for Outer Space Affairs, "Convention on Registration of Objects Launched into Outer Space," last accessed 8 April 2017, http://www.unoosa.org/pdf/gares/ARES_29_3235E.pdf.

launches and recoveries, and specific rules for LEO and GEO.[172] These rules would assist in the performance of COLA and in the minimization of RFI and laser interference, as well as alleviate the role of the ITU in orbital slot management. In addition to the rules, clarification of the terms “aircraft” and “space object” would be required to ensure the appropriate applicability of the Chicago Convention and space treaties. Further, the delimitation of outer space would also serve to clarify the rules, such as those relating to “launching states,” and would provide the requisite framework for licensing and insurance.[173]

The final area that ICAO would have to address is the implementation and control of STM. In the past, ICAO has established Special Implementation Panels to aid the implementation process for international civil aviation SARPs, and they could do the same for the implementation of international STM standards and procedures. Moreover, their experience with the migration to the CNS/ATM systems will serve as a foundation from which to draw lessons learned in order to successfully implement a global STM system. Finally, the provisions for control can be either formulated in an international treaty, or they can be incorporated as an annex to the Chicago Convention. Regardless of the legal framework selected, one organization should provide the oversight for STM in order to assure its effective implementation and ongoing control.

ICAO for Space Traffic Management

The concept of an international organization capable of overseeing space activities is not new. In fact, the idea of a World Space Organization has been circulated

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[172] Kai-Uwe Schrogl, “Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study,” *Acta Astronautica* 62 (2008): 274.

[173] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 14.

for several decades.[174] By examining ICAO's history and experience in the design of the regulatory framework for international civil aviation, a similar process can be envisioned for the development of an organization and framework for STM. Further, the ATM system created by ICAO is "highly sophisticated and effective" and can serve as an excellent example for a future STM system.[175] In September 2000, the President of the ICAO Council, Dr. Assad Kotaite, wrote in the *ICAO Journal* that "the idea of adopting ICAO as a model, or expanding the mandate of ICAO to encompass outer space…has merit."[176] There is an inextricable link between airspace and outer space, and an increasingly blurry distinction between aircraft and space vehicles; therefore, expanding ICAO's mandate is not out of the realm of possibility.[177]

Any expansion of ICAO's mandate would have to carefully consider institutional resistance that may emerge from various stakeholders. Within ICAO there may be resistance to incorporate tasks related to outer space, since their primary focus is international civil aviation. National ATM providers, such as NAV CANADA and the Federal Aviation Administration (FAA), may also resist this significant change, depending on their perceived role in the STM system. The UN COPUOS and its member states may object to ICAO regulating space activities, since the jurisdiction of outer space belongs to UN COPUOS.[178] Moreover, the expansion of ICAO's mandate may weaken UN COPUOS' legitimacy in the international arena. Additionally, there are other

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[174] Kai-Uwe Schrogl, "Space traffic management: The new comprehensive approach for regulating the use of outer space – Results from the 2006 IAA cosmic study," *Acta Astronautica* 62 (2008): 275.

[175] International Academy of Astronautics, *Cosmic Study on Space Traffic Management* (Paris: IAA, 2006), 12.

[176] Assad Kotaite, "Formal regulatory framework needed to govern expanding operations in outer space," *ICAO Journal* 55, no. 7 (September 2000): 5.

[177] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" *Journal of Space Law* 30, no. 2 (Fall 2004): 192.

[178] United Nations Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space," last accessed 4 May 2017, http://www.unoosa.org/oosa/en/ourwork/copuos/index.html.

international bodies that currently perform important functions in outer space affairs, such as the ITU and IADC, which would also require consideration.

Allowing ICAO to take on the oversight of STM poses several advantages. Firstly, ICAO possesses competency and authority that is well established within the international community. Its credibility has been developed over 70 years of existence and is a product of its regulatory structure, which has brought standardization to international civil aviation and led to safe and efficient operations.[179] To manage the international arena of space activities, ICAO's competence and legitimacy as an organization would be an asset to achieve consensus amongst a considerable number of states.[180] A second advantage is the expertise that ICAO has demonstrated in the mediation and settlement of disputes. Rather than being sidetracked by political issues and other distractions, it has maintained its focus, as well as refocused others, on the technical issues during disagreements.[181] Although ICAO is able to refocus these disputes, separating the political nature from the technical aspects of space activities may prove more difficult due to the strategic importance of space assets.[182] Nevertheless, it has an excellent record of handling delicate situations expeditiously, and it is expected that ICAO will rise to the challenge of handling space activity disputes.[183] Like other UN organizations, it uses concentrated cooperation and monitoring techniques, but it does not possess powers of enforcement comparable to a court, nor does it have mechanisms

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[179] José Monserrat Filho, "Which institutions for space traffic management?" *Space Policy* 18 (2002): 181.

[180] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 29.

[181] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" *Journal of Space Law* 30, no. 2 (Fall 2004): 200.

[182] José Monserrat Filho, "Which institutions for space traffic management?" *Space Policy* 18 (2002): 181.

[183] P. Paul Fitzgerald, "Inner Space: ICAO's New Frontier," *Journal of Air Law and Commerce* 78, no. 3 (2014): 34.

through which it can directly apply sanctions against non-compliant states.[184] If it were to add STM to its mandate, its lack of enforcement functions would need to be reassessed to determine if this is something it will need.

Being an agile organization is a third advantage of ICAO assuming oversight of a future STM system. Its agility is due in part to its ability to amend annexes to the Chicago Convention to meet the needs of the aviation industry. This allows its procedures to remain relevant regardless of changing technology. It also allows the organization to address state and non-state actors, which is a critical function that the international space law framework is currently lacking. The fourth advantage is that ICAO has demonstrated interest in outer space, particularly, in the regulation of suborbital flights, through its development of SARPs concerning GNSS, and in the implementation of the CNS/ATM integrated system. It has built up technical expertise in these areas, and demonstrated the capacity and desire to continue its growth to regulate other space activities. Moreover, the Chicago Convention and UN Resolution 1348 aim to meet the needs of the world by developing civil aviation and allowing the exploration of outer space for the benefit of humankind.[185] This highlights that ICAO's interests and goals are aligned with the underlying principles of the use of outer space.

One of the challenges of expanding ICAO's mandate is that the needs of a STM system may have to be tailored to fit ICAO's existing structure. Alternatively, if its organizational structure were to be altered, ICAO may find it difficult to continue to meet

[184] Jiefang Huang, *Aviation Safety through the Rule of Law: ICAO's Mechanisms and Practices* (The Netherlands: Kluwer Law International, 2009), 200.

[185] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" *Journal of Space Law* 30, no. 2 (Fall 2004): 188.

its original responsibilities.[186] The expansion would have to be carefully planned and managed to ensure that neither the ATM nor the STM systems are affected. A new organization would not have the same constraints, since its organizational structure can be built to suit the vision of a future STM system. However, the competency and credibility that ICAO enjoys would take a new organization a long time to acquire. The newly formed organization may not be able to inspire confidence quick enough in state and non-state actors, and thus would lack the consensus and compliance needed to implement a successful STM system. Consequently, ICAO may be the solution required; however, further investigation into this possibility is warranted before a definitive deduction can be made.

Conclusion

Space traffic management is necessary to assure the safe and equitable use of outer space, and to protect the launch, in-orbit operation and re-entry phases of space objects from harmful interference. By exploring ICAO's evolution from its creation to present day, this chapter has been able to draw parallels from international civil aviation to help envision how an international organization could be established to oversee the development, implementation and control of an international STM system. ICAO's competency, authority, and credibility achieved through its highly effective standards and procedures have provided a model that can be followed or expanded upon. Investigating its space interests and the STM tasks for which it would be required to develop SARPs has enabled this paper to cautiously deduce that ICAO could expand its mandate beyond

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[186] A.K. Anilkumar et al., "Space Traffic Management: Final Report" (Summer Session Program Report, International Space University, 2007), 45.

international civil aviation. Nevertheless, additional research is required before a final recommendation could be offered.

Implementing a STM system will inevitably limit the freedom of use of outer space and will require states to adjust their government and civil space programs. For better or for worse, the system will also place constraints on military space activities. Given the strategic importance of military space-based capabilities, the implementation of STM will have to consider and take the necessary steps to ensure national security is not affected. In Chapter 4, this paper will study the implications of STM for the CAF. It will analyze NORAD's operation in North American aviation to investigate how the CAF can achieve space effects within an international STM system. It will consider whether restricted zones would be necessary to safeguard military assets, and it will discuss the need for a robust space cadre.

CHAPTER 4 – IMPLICATIONS OF SPACE TRAFFIC MANAGEMENT FOR THE CAF

Introduction

The Outer Space Treaty declares that outer space shall be free for use by all states. Yet, the implementation of STM will limit the freedom of operation of space actors through the introduction of new rules and procedures. Viewed from a different angle, it can be seen that its implementation will provide the means for space activities to be accomplished without harmful interference. As a result, a "common good" will be achieved to allow the continued exploration and use of outer space. Reinforcing this theme amongst space actors will help overcome the political barriers to its implementation and facilitate cooperation, similar to what has been done for global ATM.

The key to implementing an international STM system is to achieve a safe and orderly environment through appropriate standardization without overly restricting state and non-state actors. Stakeholders will have to be engaged and technical committees established to develop rules and procedures that are economically feasible and can be adopted through consensus. Particularly, the various armed forces of the world will want their concerns addressed and restrictions minimized to allow them to accomplish the protection of their state sovereignty and people. The CAF is a fitting case study to identify how it can integrate its emerging military space operations within an international STM system, since in 2016 it declared outer space as an operational domain and designated the Comd RCAF as the military space authority. The growth of its space capability serves as an opportunity to proactively incorporate measures into its development initiatives. This chapter will focus on the CAF and some of the considerations it should investigate so that its ability to use space-based capabilities to project space power domestically and internationally is not compromised.

The chapter will begin by discussing how NORAD integrates with North American aviation through close coordination with the FAA, Transport Canada (TC), NAV CANADA and DND, and how established procedures such as Emergency Security Control of Air Traffic (ESCAT) Plans are used to avoid unnecessary interference with air defence missions. It will then overview restricted airspace in Canada and the United States to see how military operations can be conducted without concern of aircraft interfering in a defined area. This chapter will also discuss mechanisms employed on the high seas to create restricted zones to minimize vessel traffic. These sections will allow parallels to be drawn for how CAF space operations could be integrated into a STM system. The final section will discuss the development of a space cadre and its importance for the CAF.

The Integration of NORAD in North American Aviation

Established in 1957, NORAD is a bi-national organization that conducts three primary missions: aerospace warning for North America; aerospace control for North America; and maritime warning for North America.[187] The third mission relating to the maritime domain was only added in 2006 in the latest renewal of the NORAD Agreement. To accomplish these missions, NORAD employs ground-based and airborne

[187] Andrea Charron and James Fergusson, “NORAD in Perpetuity: Challenges and Opportunities for Canada” (Defence and Security Studies, University of Manitoba, 2014), 6; Agreement Between the Government of the United States of America and the Government of Canada on the North American Aerospace Defense Command, Canada-United States, April 2006. Aerospace warning is the term used to describe the activities of detection, validation, and warning of attacks by aircraft, missile, or space vehicle within North America. Aerospace control refers to the act of ensuring the air sovereignty and air defence of Canadian and American airspace. Maritime warning is the shared awareness and understanding of activities along the approaches to Canada and the United States, and their maritime areas and internal waterways.

radars, a network of satellites, and fighter aircraft in the detection, interception, and engagement of "air-breathing" threats to Canada and the United States.[188] To manage its vast area of responsibility, NORAD is split into three regions: the Alaskan NORAD Region (ANR), the Canadian NORAD Region (CANR), and the Continental United States NORAD Region (CONR). Within these regions, NORAD coordinates closely with multiple agencies, especially with the respective air traffic control agencies.[189]

In Canada, the Scramble, Intercept and Recovery (SIR) Agreement establishes the airspace control procedures between NAV CANADA Area Control Centres and CANR. The objective of the agreement is to ensure that military operations can be conducted "with maximum freedom while at the same time maintaining minimum interference and maximum safety for all other air traffic."[190] It allows CANR to control fighter aircraft within airspace that is normally controlled by NAV CANADA by specifying separation criteria for various air defence systems, aircraft transponder returns, types of air defence missions, and areas of operation such as within restricted airspace. The SIR agreement also lists the responsibilities of NAV CANADA and DND, and their respective operational control facilities, and specifies that each agency is responsible for creating their own procedures to meet the standards set in the agreement.[191]

The NORAD Terms of Reference (TOR) combines strategic guidance from the CAF Chief of Defence Staff (CDS) and the United States Chairman of the Joint Chiefs of Staff (CJCS) regarding the three primary missions tasked to the Commander NORAD

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[188] North American Aerospace Defense Command, "About NORAD," last accessed 27 April 2017, http://www.norad.mil/About-NORAD/. Air breathing refers to a vehicle with an engine that requires the intake of air for fuel combustion.

[189] *Ibid*.

[190] Agreement A-005 For Airspace Control Procedure, NAV CANADA-DND, April 2008.

[191] *Ibid*.

(CDRNORAD). It states that binational awareness is necessary for aerospace warning, which includes both air and space situational awareness, and is accomplished through the ISR capabilities of Canada and the United States.[192] The information is to be gathered and fused into one common operating picture that is then shared with command centres in Canada and the United States, and when required with other commands, departments, and agencies. With respect to aerospace control, the NORAD TOR stipulates that the authority of NORAD does not supersede or alter the authority of the FAA, TC, or NAV CANADA, or any other agencies or departments within Canada or the United States.[193] NORAD is expected to work with the agencies in order to support the safe and orderly control of air traffic. In response, the FAA and NAV CANADA provide NORAD with information regarding "questionable targets."[194] Any aircraft of interest will be monitored, and action will be taken against it, if it is deemed lawful to do so.

Complementing the SIR Agreement in Canada is the ESCAT Plan. It outlines the responsibilities and procedures for TC, NAV CANADA and DND when an air battle or contingency operation is occurring, or imminent. The ESCAT plan is employed to avoid the interference of non-essential air traffic during these situations, and it describes the actions that are to be taken by TC, NAV CANADA, and military authorities to control air traffic within a specified air defence area. For ease of implementation, Canadian airspace has been divided into seven zones, and one or more zones can be activated as required. There are three circumstances when the ESCAT Plan may be implemented: when an Air

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[192] Terms of Reference North American Aerospace Defense Command (NORAD), Canada-United States, August 2016.

[193] *Ibid*. It is also worth noting that the Deputy Commander of NORAD is always an RCAF three-star general.

[194] Tom Lawson and Michael Sawler, "NORAD in 2012 – Ever Evolving, Forever Relevant," *Canadian Military Journal* 12, no. 3 (Summer 2012): 10.

Defence Emergency or Air Defence Warning is declared; during a contingency operation or asymmetric attack; or at other times when airspace restrictions are critical for the conduct of air defence operations.[195] The implementation can be authorized by the CDS, the CDRNORAD, Commander CANR, or by the Commander Canadian Air Defence Sector (CADS). When implementation of ESCAT has occurred, all civilian and military aircraft movements are controlled in accordance with the ESCAT Air Traffic Priority List (EATPL) and/or Security Control Authorization (SCA) numbers. This allows the minimization of interference with normal air traffic and allows the prioritization of military operations that are vital to national defence.[196]

A similar ESCAT Plan has been developed for the United States. It provides direction, identifies responsibilities and describes procedures for the DoD, Department of Transportation, the Department of Homeland Security, and the FAA during air defence emergencies, defence emergencies, or national emergency conditions. Similar to the plan in Canada, the aim of ESCAT in the United States is to implement measures to control civilian and military air traffic within specified air defence areas in the interests of national security, while at the same time minimizing interference with normal air traffic. The ESCAT Plan may be implemented during the following three circumstances: an appropriate military authority declares an air defence emergency; an emergency has not been declared, but an adjacent combatant command in under attack; or emergency conditions exist that threaten national security or national interests.[197] There are specific authorities that can implement ESCAT in the United States. They are divided into three

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[195] Emergency Security Control of Air Traffic (ESCAT) Plan, TC-DND, October 2009.

[196] *Ibid*. The EATPL is outlined in Chapter 3 of the ESCAT Plan.

[197] Federal Aviation Administration, "Advisory Circular," last updated 18 January 2007, https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_99-1D.pdf.

areas: the CDRNORAD or NORAD region commanders can implement ESCAT within the 48 contiguous states; the Commander United States Pacific Command (USPACOM) or designed area air defence commander is responsible for implementation in the Pacific territories and oceanic airspace; and the CDRNORAD implements the plan in Puerto Rico and the U.S. Virgin Islands.[198] As in Canada, an EATPL and SCA numbers are used to control air traffic movements.

In its early years of existence, the integration of NORAD into civilian aviation and the achievement of its primary mission, brought credibility to the organization. With an emerging threat of intercontinental ballistic missiles (ICBM), NORAD expanded its missions from solely airspace threats to include space threats; its new role reflected by changing the "A" in NORAD from "air" to "aerospace."[199] In 2006, NORAD further expanded its mission to include the maritime domain; however, this mission is described as "information-based only," since NORAD does not possess maritime assets to conduct military operations. Its success is found not only in its ability to conduct its missions and evolve to meet new threats, but also in its cooperation with outside agencies and in the internal cooperation between Canada and the United States. Evidence of this is found in how NAV CANADA and the FAA share radar data with NORAD, and how Canada and the United States fuse their satellite data, allowing for a robust common operating picture.[200] This cooperation allows for enhanced situational awareness, including space situational awareness, and allows for the integration of air defence operations amongst civilian traffic in a safe and orderly manner.

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[198] *Ibid*.

[199] Jeffrey Rice, "NORAD: A History of Institutionalized Cooperation," *Policy Brief* 3, no. 1 (Winter 2017): 1.

[200] Tom Lawson and Michael Sawler, "NORAD in 2012 – Ever Evolving, Forever Relevant," *Canadian Military Journal* 12, no. 3 (Summer 2012): 7.

The effective integration of NORAD operations with civilian aviation, particularly during situations involving national security, demonstrates how an appropriate framework created through ESCAT Plans, agreements, and TORs can provide the necessary conduit for cooperation amongst agencies. Further, the agreements allow for the exercising of established procedures, permitting simulations of scenarios to better prepare for real world events.[201] This framework can serve as a model for the CAF to facilitate the smooth integration of military space operations into a STM system without compromising the classified nature of its operations. A similar framework could aid the CAF execute its space operations with maximum freedom while minimizing interference with other space traffic should a STM system be established.

In addition to considering the framework within which NORAD operates, the CAF may want to consider the possibility of capitalizing on its experience and success by working with the United States to expand NORAD's missions in order to deal with more than just "air breathing" threats. As has been identified in previous chapters, there are threats to CAF space-based assets in orbit from the risk of collision with other space objects and debris, as well as RFI, laser interference and ASATs. Since NORAD has proven capable of evolving its mission over the years, it could conceivably further the evolution of its aerospace mission. However, currently the Canadian Space Operations Centre (CANSpOC) and United States' JSpOC collaborate to detect, track, and catalogue man-made objects around the Earth through the SSN, and JSpOC also conducts laser clearing procedures for the United States.[202] Arguably, these operational units are in a

[201] *Ibid.*, 13.
[202] Royal Canadian Air Force, *Canadian Armed Forces Defence Space 5-Year Roadmap* (Ottawa: DG

better position to project space power for their respective militaries and to work in cooperation with a future STM organization. Nevertheless, regardless of the unit or organization chosen, a strong relationship will need to be fostered between the CAF and a STM regime.

Integrating military space operations into a STM system will be more challenging as compared to integrating military air defence operations with civilian aviation due to two fundamental differences between the air and outer space environment. First, sovereignty exists in the airspace immediately above a state's territory; thus, NORAD is able to project air power within North American airspace in order to protect the national interests of Canada and the United States.[203] In an international STM system, using sovereignty to attain priority and maximum freedom of movement will not be possible, since sovereignty does not exist in outer space.[204] A different rationale and associated procedures will need to be employed to protect military space assets and capabilities. Second, aircraft travel on relatively short duration flights that are often on predetermined routes and are manoeuverable. By contrast, space objects are on long duration orbits, whose movements are susceptible to space weather and solar activity. Additionally, only some space vehicles possess the ability and onboard fuel to conduct maneouvres in outer space. Consequently, it is difficult to minimize space traffic within a designated area on

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Space, 2016), 9; Robert J. Volio, "Laser tagged – how the JSpOC manages laser deconfliction," last updated 19 August 2016, http://www.vandenberg.af.mil/News/Features/Display/Article/920559/laser-tagged-how-the-jspoc-manages-laser-deconfliction.

[203] Ruwantissa I.R. Abeyratne, *Frontiers of Aerospace Law* (Burlington: Ashgate Publishing Company, 2002), 5.

[204] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," last accessed 20 March 2017, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.

short notice without impacting the safety of operations.[205] A possible solution is to establish restricted zones within outer space for military space activities.

Restricted Zones

Canadian airspace is managed by Transport Canada and is divided into seven classifications based on the type of air traffic services provided, the aircraft equipment and communications required, and operating rules. Class F is one of the classes of airspace and is designated as advisory, danger or restricted depending on the nature of activity taking place. Permission is required to enter a danger or restricted area, and therefore provides the user agency with freedom of movement without fear of interference within the defined dimensions for a specific period of time. There are several areas designated as restricted airspace for military operations within Canada's sovereign airspace, which are activated for the CAF in Canada's national interests.[206]

In the United States, the FAA controls the use of navigable airspace. It is divided into six classifications according to operating rules, aircraft equipment and communication requirements, and the type of air traffic services provided. Although not considered a class of airspace, the FAA designates portions of American airspace as special use airspace that are categorized as prohibited areas, restricted areas, warning areas, military operation areas, alert areas, or controlled firing areas.[207] Various levels of control are used to either completely restrict aircraft from entering special use airspace, or provide safe routings through the area. In addition, the FAA uses temporary flight

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[205] Ted Adam Newsome, "The Legality of Safety and Security Zones in Outer Space: A Look to Other Domains and Past Proposals" (Master's thesis, McGill University, 2016), 57.

[206] Transport Canada, *Designated Airspace Handbook* (Ottawa: NAV CANADA, 2017), 4.

[207] Federal Aviation Administration, "Pilot's Handbook of Aeronautical Knowledge, Chapter 15: Airspace," last updated 24 August 2016, https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/17_phak_ch15.pdf.

restrictions (TFRs) to temporarily restrict aircraft from entering or operating in a defined area. The purpose of TFRs is to protect people or property located on the ground or in the air, such as protecting the President of the United States or ensuring the safety of space flight operations.[208] TFRs and special use airspace are adopted to safeguard the American public's interests.

The previous discussions have highlighted restricted zones that have been established within Canadian and American sovereign airspace, but additional discussion is warranted of approaches used within a commons like the high seas, where sovereignty is absent. During peacetime, warning areas and warning zones are used by states to alert other states of military activities on the high seas; the first being a warning of the potential hazards to others' safety, and the second is a mechanism of self-defence to provide sufficient time to assess approaching vessels' hostile intent.[209] A warning zone signifies that the state operating within it is at a heightened defensive posture, but it cannot use force to remove another vessel unless a situation develops that warrants the state to respond in self-defence. Further, states are not authorized to deny access to these areas, nor can military operations be prioritized over others, since warning areas and warning zones are recognized by other states on a voluntary basis only and they do not provide any additional rights under international law.[210] During armed conflict or in anticipation of armed conflict, security and exclusion zones are typically used to exclude vessels from a designated area so that neutral states and companies are not affected;

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[208] Federal Aviation Administration, "Temporary Flight Restrictions (TFR) and Flight Limitations," last updated 12 September 2015, https://www.faa.gov/documentlibrary/media/advisory_circular/ac_91-63d.pdf.

[209] Ted Adam Newsome, "The Legality of Safety and Security Zones in Outer Space: A Look to Other Domains and Past Proposals" (Master's thesis, McGill University, 2016), 29-33.

[210] *Ibid*., 34.

however, it is unclear in international law whether the state establishing the security or exclusion zone possesses lawful enforcement powers to exclude vessels from an area.[211]

The mechanisms used in the air and maritime environments to restrict traffic within a specified area can provide an appropriate starting point for determining how CAF space assets could operate with some degree of freedom of movement and priority within a STM system. Within domestic airspace, Canada is able to use enforcement powers to legally restrict traffic to suit its national interests; however, on the high seas this is not the case. Lack of sovereignty and the underlying principle of freedom of use prevent the implementation of rules equivalent to those employed in restricted airspaces to commons like the high seas and outer space. To be considered acceptable to the international law community, any zone restrictions on the high seas generally rely on voluntary adherence, and it is assumed that outer space would require the same. Consequently, a point along this spectrum of solution sets should be chosen for military space activities in the outer space environment, and requires further study by the CAF.

There are many factors to consider in a future study of restricted zones in outer space. First, any restricted zone established will have to be communicated with sufficient notice to alert space users of restrictions. The appropriate time will have to be set in terms of the unique space parameters and weather, and if there is a need for operators to maneouvre space objects like satellites. Second, the zones will have to be transparent in their operation, so that they are not used, or perceived to be in use for “space race” purposes. They should be employed for the security of states’ space assets; however, these zones cannot be a mechanism to appropriate portions of outer space. Third, activation of restricted zones and the control of space activities within them will require a

[211] *Ibid.*, 35.

knowledgeable and professional cadre of space personnel. These three factors are valuable considerations for the CAF if a STM system is implemented in the future.

Force Generation of a Space Cadre

Comprised of less than 150 personnel, the CAF space cadre has been traditionally viewed as too small to justify a unique military occupation.[212] Accordingly, personnel that fill space positions often come from various occupations and services across the CAF. However, in July 2016 the authority for military space was transferred from the Vice Chief of Defence Staff (VCDS) to the Commander RCAF, who became the "overall lead for the CAF-related activities in the Space Domain."[213] This transition signified that outer space would no longer be viewed by the CAF as simply joint force enabling systems, but rather an operational environment.[214] With the focus turning to outer space as a domain within which to project space power, the RCAF will have to re-evaluate whether a unique military occupation is warranted.

CAF personnel that have worked in space positions in Canada and in the United States have completed on average 1-2 postings to a space unit in their career. Unfortunately, following their initial exposure to the space mission, some members' careers have taken paths that have not allowed them to return to a space billet.[215] As a result, there is limited net gain to the CAF space mission from the initial investment into their education and training. Further, this situation does not facilitate the force generation

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[212] Royal Canadian Air Force, *Canadian Armed Forces Defence Space 5-Year Roadmap* (Ottawa: DG Space, 2016), 12.

[213] Guy R. Thibault, *VCDS Initiating Directive – Transfer of Leadership Responsibilities for CAF Related Space Domain from VCDS to Commander RCAF* (Vice Chief of the Defence Staff: file 1000-1 (VCDS), 21 Mar 16), 5.

[214] Nathan Burgess, "Space Transitions to the RCAF," *INFORM*, no. 27 (January 2017).

[215] Royal Canadian Air Force, *Canadian Armed Forces Defence Space 5-Year Roadmap* (Ottawa: DG Space, 2016), 12.

of a professional cadre of space personnel. Although many personnel are exposed to space operations, few remain within the environment to advance the development of this emerging domain.[216] With the likely future expansion of CAF space missions, and the potential for the implementation of a STM system, a larger and more permanent collective of space personnel is required. This necessitates the creation of a military occupation for either officers or non-commissioned members, or both.

Drawing on Canada's strongest space ally for inspiration on what military space occupations could look like is the most logical approach. Indeed, the United States Air Force (USAF) employs enlisted members and officers in several different space occupations. Of particular interest to this study are the enlisted occupation of Space Systems Operations Specialist and the officer occupation of Space Operations Officer. Space Systems Operations Specialists are "highly trained experts" that detect ballistic missiles, track satellites, and assist rocket launches and space flight operations, requiring "an incredible amount of skill."[217] Space Operations Officers are responsible for the oversight of space surveillance, space warning, space lift and satellite command and control, as well as for developing plans to incorporate new technology into future space missions.[218] Both enlisted members and officers follow career paths that allow for progression within the space domain, thereby allowing the USAF to capitalize on their experience and expertise to produce a professional space cadre. The investment into these members produces considerable net gain for the United States' space mission.

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[216] *Ibid.*, 12

[217] United States Air Force, "Space Systems Operations," last accessed 4 May 2017, https://www.airforce.com/careers/detail/space-systems-operations.

[218] United States Air Force, "Space Operations Officer," last accessed 4 May 2017, https://www.airforce.com/careers/detail/space-operations-officer.

This study recommends that the RCAF follow the same occupation model as the USAF by creating non-commissioned member and officer space trades. The challenge is that this would require significant changes to the current occupational structure. One option for the RCAF is to expand the skill set of an existing occupation to include space control duties; however, it would necessitate an increase in size of the occupation to meet these new demands. Alternatively, new space occupations could be created and added to the RCAF career field. Since the size of the CAF is capped, the positions will have to come from other occupations. Both courses of action could be accomplished by either a reduction in the size of other occupations, or the elimination of one or more trades completely. In the publication, *Projecting Power: Canada's Air Force 2035,* occupations such as Flight Engineer (FLT ENGR) and Air Combat Systems Officer (ACSO) are forecasted to be replaced by technology, and Aerospace Control (AEC) Officers are predicted to assume the responsibility for space control duties.[219] The latter prediction is feasible, since AECs and Aerospace Control Operators (AC OP) have filled many of the space positions in the past and would provide a natural link to ATM and NORAD missions. However, the RCAF would have to investigate the possibility of reducing or eliminating trades, as well as other options to determine the appropriate course of action for creating space occupations, since there will be considerable institutional resistance from some occupational and operational communities within the RCAF.[220]

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[219] Andrew B. Godefroy, *Projecting Power: Canada's Air Force 2035* (Trenton: Canadian Forces Aerospace Warfare Centre, 2009), 76.

[220] Allan English and John Westrop, "Air Force Communities: Stovepipes and Subcultures," in *Canadian Air Force Leadership and Command: The Human Dimension of Expeditionary Air Force Operations* (Trenton: Canadian Forces Aerospace Warfare Centre, 2007), 158. The culture within occupational communities tends to drive the approach taken to address missions and it shapes the future organizational structure. Since there are multiple sub-cultures within the RCAF, careful consideration must be given to these heterogeneous cultures when implementing changes such as the reduction or elimination of occupations.

In addition to creating military space occupations, this study recommends that the RCAF reassess the quality of education and training provided to space personnel in order to meet the demands of future space missions and the potential implementation of an international STM system. There are only two courses currently provided through the RCAF that deliver a baseline understanding of space operations to CAF members: the Basic Space Applications Course and the Advanced Space Operations Course. To ensure that its space personnel are equipped with the skills necessary to meet its objectives, the RCAF has stated that in addition to these courses it will leverage other institutions such as government departments and universities, as well as international organizations, allies, and internal resources.[221] The complexity of space operations will only increase if a STM system is implemented; thus, education and training will become paramount to developing a knowledgeable and professional space cadre to project space power for the CAF.

Conclusion

With the implementation of an international STM system, the restrictions imposed on space actors will produce a "common good" that will enable the continued exploration and use of outer space in the future. If states are to agree to this new system, the procedures and regulations adopted cannot be overly restrictive, especially with respect to military space activities. The CAF relies heavily on space-based capabilities for domestic and international operations; therefore, it would be prudent to consider the implications that a STM system would have on its ability to conduct its missions. To this end, the preceding chapter has drawn parallels from the successful integration of NORAD into

[221] Royal Canadian Air Force, *Canadian Armed Forces Defence Space 5-Year Roadmap* (Ottawa: DG Space, 2016), 12.

North American aviation for how the CAF could execute military space operations with some degree of freedom of movement while minimizing interference with other space actors. The chapter also overviewed the classification and use of restricted airspace by the FAA and NAV CANADA, as well as restricted zones on the high seas to provide considerations for a future study of restricted zones in outer space to safeguard CAF space assets.

Not only must the RCAF and CAF protect its space assets and interests in outer space, they must also secure a future space cadre capable of carrying out space missions to achieve its objectives. Consequently, this paper recommends that space occupations should be established within the RCAF in order to develop and maintain a space cadre of knowledgeable and professional individuals. This paper also recommends that the quality of education and training provided to space personnel be reassessed to ensure that they are capable of meeting the demands of new space missions and the complexity of STM. These recommendations, coupled with the considerations proposed for the execution of military space activities and restricted zones, will support the CAF in discussions it may enter into with allies and other government departments to ensure that its interests are captured in proposed procedures and regulations of a future STM system.

CONCLUSION

Outer space is a vast commons that both intrigues and challenges humanity due to its mystique and harsh environment. The desire to place satellites in orbit and conduct human spaceflight has driven the development of innovative space technology and continues to push humanity to explore deeper into the universe. Now, after almost 60 years of exploration, modern society has become dependent on outer space for its quality of life and security. Space-based assets provide entertainment, communications, navigation, weather and agriculture information, drive financial and energy sectors, and enable military operations. Any interruption in these services would not only affect society's way of life, but also would significantly inhibit the achievement of military objectives and mission success. The likelihood of a disruption in service occurring is increasing, since the space environment can be described as congested, contested and competitive. Correspondingly, this study has shown that a STM system is necessary to provide the regulatory framework, organization and mechanisms to protect space objects against harmful interference during the launch, in orbit and recovery phases of operation.

Although many believe that outer space is an enormous expanse to use and explore, this study has shown that the primary useful orbits for human space activities, LEO and GEO, are congested with orbital debris, satellites and spacecraft. As a result, concerns of collisions with other orbiting objects, RFI, and laser interference persist amongst space operators. China's intentional destruction of satellite Fengyun-1C in 2007 and the collision between Iridium 33 and Cosmos 2251 in 2009 are examples of situations that generated large quantities of orbital debris and created negative consequences for the future utilization of outer space. The close proximity of satellites not only increases the risk of collision; it also raises the chances of RFI. The ITU manages orbital slots and the radio frequency spectrum for satellites in an attempt to minimize interference; however, the radio frequency spectrum and GEO are considered limited natural resources.

The study also examined the intentional use of ground-based lasers by China in 2006, which degraded the performance of United States' satellites. Drawing attention to intentional frequency jamming and the disruption or destruction of satellites and other space objects through lasers and ASATs has demonstrated that the space environment is progressively becoming contested. Discussions concerning the increased investment in military space and assertive actions by countries like Japan, India, China, Russia and North Korea directly support this conclusion. The contested space environment provides significant challenges to the commercialization of outer space. Furthermore, the competitive nature of state and non-state actors poses a threat to outer space and may constrain the cooperation necessary to permit its continued use.

Cooperation in debris mitigation, collision avoidance, and the peaceful use of outer space is imperative, and it will need to be achieved through an appropriate legal framework. Examination of relevant articles of the Outer Space Treaty and the Registration Convention provide an understanding of the current framework pertinent to STM. Because both documents reflect the Cold War era in which they were created, they are insufficient to address contemporary space issues and outer space utilization. Specifically, this study has shown that the Outer Space Treaty does not directly address non-state actors; it inadvertently allows exploitation of outer space and orbital debris proliferation; and it does not prohibit the use of ASATs or similar weapons. Furthermore, we have seen that the Registration Convention lacks direct regulation for private companies; does not adequately address the contemporary reality of launching states and transfers of space objects from one state's registry to another; and the registration process is inadequate to support COLA. Although the UN COPUOS has recognized deficiencies in space law, member states are reluctant to make any changes to the regulating instruments. Instead, stopgap measures have been put in place to address space law deficiencies; and they include national regulations like the United States' Commercial Space Act, international voluntary agreements such as the IADC Space Debris Mitigation Guidelines, and attempts at regulating the conduct of space actors through the "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space" and the "Code of Conduct for Outer Space Activities." This study has demonstrated that these stopgap measures do not resolve the underlying issue in outer space of increasing traffic levels. Space traffic management is necessary to address this fundamental issue. However, an overhaul of the space law framework is required, since it is not theorized in the treaties. Moreover, proper STM also requires a comprehensive approach to regulation rather than the piecemeal fashion that has been executed in the past.

ICAO is an ideal case study to draw parallels between the international aviation industry and the space industry to envision how a STM system could be implemented. The organization achieved its competency, authority, and credibility through the creation and adoption of effective SARPs, the implementation of a global CNS/ATM system, and its involvement in the regulation of GNSS. ICAO's interests and position in outer space affairs have strengthened over the years, exemplified by its potential role in the regulation of suborbital flights in the near future. However, one of the key issues that will need to be addressed in order to adequately regulate these flights is a universally agreed upon delimitation of outer space. Tasks that a STM organization would have to develop standards and procedures for include the establishment of a data management system, a notification system, and the development and standardization of “rules of the road.” Based on such parameters, one could cautiously deduce that ICAO could expand its current mandate to include STM. ICAO would offer the space community several advantages, such as international credibility, technical competency, expertise in the mediation and settlement of disputes, and agility due to its ability to amend annexes to the Chicago Convention. Nevertheless, it may be difficult for ICAO to adjust its organizational structure and practices to meet both its new mandate and its original responsibilities; therefore, further study is warranted before a definitive deduction can be made.

It is recognized that the implementation of STM will inevitably limit the freedom of use of outer space; however, it will also provide the means for space activities to be accomplished without harmful interference. The benefits outweigh the drawbacks, as STM would achieve a “common good” by allowing the continued exploration and use of outer space. To achieve a safe and orderly environment, new rules and procedures will have to be devised, but they should not overly restrict state and non-state actors, especially armed forces. Given the CAF’s recognition of outer space as an operational environment and the designation of the Comd RCAF as the military space authority in 2016, the CAF serves as an excellent case study for how to proactively incorporate measures into development initiatives for emerging military space operations. This paper reflected on how it can achieve space effects within an international STM system.

Analysis of NORAD's successful integration within North American aviation provides examples that have utility for the development of a STM system.

Cooperation amongst agencies such as the FAA and NAV CANADA is facilitated through ESCAT Plans, agreements and TORs, which provides NORAD with the ability to integrate military operations without compromising the classified nature of its missions and limiting interference from non-players. A similar framework could be used for the CAF's operations within a STM system; however, it will be more challenging to implement due to the lack of sovereignty and the way that space objects travel in outer space. Considerations for the establishment of restricted zones to safeguard CAF space assets highlight the way the FAA and TC classify and use restricted airspace, and the way that restricted zones are employed on the high seas. Further study should be conducted on the use of restricted zones for military space activities. In addition to considerations for safeguarding CAF assets, the RCAF and CAF should secure a future space cadre capable of carrying out new space missions and meeting the demands of a future STM system. To this end, it is recommended that military occupations be established for either officers or non-commissioned members, or both. Additionally, it is recommended that the quality of education and training provided to space personnel be reassessed to ensure their skill level is adequate to meet the rising complexity of space operations. The recommendations put forth for the CAF have been made to support any future discussions that it may enter into with allies and other government departments, enabling its interests to be captured in proposed procedures and regulations.

Increasingly, the subject of STM is being discussed at national and international levels. Through its Commercial Space Act in 2015, the United States Congress mandated that recommendations be made regarding an improved framework for STM to protect United States Government and private sector assets.[222] In response, Science Applications International Corporation produced a "Report on Space Traffic Management Assessment, Frameworks and Recommendations" in November 2016 for NASA, which recommends that a framework led by a civil agency would provide the best balance for the "needs for safety, national security, and economic interest."[223] Although encouraging, this approach is nationally focused; outer space requires an international solution. UN COPUOS and ICAO have separately and jointly discussed international STM, particularly during the 2015 Aerospace Symposium in Montreal, and it continues to be an agenda item for both agencies.[224] Nevertheless, available literature on the subject is minimal and the impetus to devise a concrete solution has not reached a critical level.[225] To protect its interests in outer space, Canada can take a leading role in crafting such a solution.

Will it take a major collision or interference to trigger states to cooperate on the formalization of a STM system, or will commercial space operators demand it? Before a catastrophic collision occurs, it is prudent to intensify the discussion of STM within Canada and the rest of the world. Since Canada is home to ICAO headquarters, and for the first time a Canadian is the chair of UN COPUOS, Canada is in a position of influence to act as a steward of international STM.[226] Through its leadership, Canada can

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[222] United States Congress, "U.S Commercial Space Launch Competitiveness Act," last accessed 10 April 2017, https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf.

[223] Science Applications International Corporation, "Orbital Traffic Management Study: Final Report," last updated 21 November 2016, http://www.spacepolicyonline.com/pages/images/stories/Orbital%20Traffic%20Mgmt%20report%20from%20SAIC.pdf

[224] United Nations Office for Outer Space Affairs, "Space traffic management and small satellites: new topics to be included in United Nations international space law discussions," last updated 24 April 2015, http://www.unoosa.org/oosa/en/informationfor/media/2015-unis-os-449.html.

[225] Haydar Cukurtepe and Ilker Akgun, "Towards space traffic management system," *Acta Astronautica* 65 (2009): 870.

[226] Government of Canada, "Canadian becomes Chair of the United Nations Committee on the

make an important step towards securing the future of outer space exploration. Perhaps that step is the expansion of ICAO's mandate from airspace to aerospace; evolving one "A" into another.

Peaceful Uses of Outer Space (COPUOS)," last updated 8 June 2016, http://news.gc.ca/web/article-en.do?nid=1081509.

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