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Dividing Heaven: Investigating the Influence of the U.S. Ban on Cooperation with China on the Development of Global Outer Space Governance

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Declaration

I, Robert Jay Ronci, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature……..

Date……

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Abstract

This thesis investigates how the U.S. policy barring NASA's cooperation with China, colloquially known as the "Wolf amendment", is influencing the developing system of global space governance. As rapid technological advancements improve access to outer space, policymakers around the world are crafting institutions that will regulate humanity's access, participation, and activities in the final frontier. However, the rapid pace of technological advance is creating policy challenges much faster than policymakers can address them. With the two most significant spacefaring countries legally barred from working together in major space projects, the challenge international policymakers face becomes greater. This research utilizes a complex systems approach to identify how the Wolf amendment is influencing the evolutionary trajectory of global space governance. Congressional hearing transcripts, legal documents, personal letters, research reports, and public statements were investigated using a qualitative thematic analysis to identify the manner in which the Wolf amendment exerts influence, as well as the trends and patterns occurring in the political systems within which the amendment is embedded. Findings reveal that the persistence of the Wolf amendment's influence forces the U.S. - China relationship to remain primarily competitive, rather than cooperative, in space exploration activities. Global space policy development is trending toward the pursuit of less-rigid voluntary norms rather than firm international treaties. As international space policy-making becomes increasingly decentralized, the policies of perceived leaders will remain key drivers of norm and infrastructure development. With U.S. policymakers preventing participation in joint activities with China, the creation of multiple spheres of influence becomes inevitable. Such a division of influence will likely lead to a persistently fragmented and competitive environment in outer space. This outcome would exacerbate challenges for international policymakers working to secure the sustainable usage of outer space, but also create opportunities for a wider range of space actors.

List of Acronyms

ASAT - Anti-Satellite Weapon

CD – UN Conference on Disarmament

CMA - China Meteorological Administration

CNSA - China National Space Administration

COPUOS – UN Committee on the Peaceful Uses of Outer Space

DoD – U.S. Department of Defense

DoS - U.S. Department of State

ESA - European Space Agency

FAA - Federal Aviation Administration

FCC – U.S. Federal Communications Commission

GAO – U.S. Government Accountability Office

ISECG - International Space Exploration Coordination Group

ISS - International Space Station

ITAR - International Traffic in Arms Regulations

LOP-G - Lunar Orbital Platform – Gateway

NASA – U.S. National Aeronautics and Space Administration

NOAA – U.S. National Oceans and Atmospheric Administration

OECD - Organisation for Economic Co-operation and Development

OSC – U.S. Office of Space Commercialization

OST - Outer Space Treaty

PLA - Chinese People's Liberation Army

UN - United Nations

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1. Introduction

For centuries, people have imagined human civilization beyond the confines of our home planet. We have imagined colonies on other planets, giant city-like starships, and vast intergalactic civilizations. Science fiction writers have explored an equally inspired range of interplanetary governance structures ranging from Star Trek's peaceful and science driven utopia-like Federation, to the evil galactic Empire of Star Wars. As we develop the technology that takes us closer and closer to a reality of a true human presence in space, imagining space-based governance structures becomes less the domain of science fiction writers and increasingly occupies the minds of diplomats, legal experts, military leaders, and academics world-wide. How then will humanity's presence in space develop? How will extraterrestrial societies be governed, and what will the rules be? What will a space-based economy look like and how will it be regulated? Will it be peaceful, or will humanity's long history of war accompany us in space? There are many perspectives currently being debated and many possible answers to these questions. In space policy literature one idea appears to be universally agreed upon: the decisions we make in the next few decades will have significant impacts on our future. But what of the decisions we have already made?

The regulation and governance of outer space activities has been under development for over 60 years. Over 70 countries have space-based interests and the global space industry was valuated at over $300 billion in 2017, with estimates this valuation will top a trillion dollars annually within the next 2-3 decades (*Space: Investing*, 2017) While permanent colonies on the Moon or Mars may not yet exist, the process of developing the laws, norms, and standards that will influence human extraterrestrial settlement and societies has already begun. This decision-making process and the influences it may have, both known and unknown, on the future of humanity's next steps into outer space lie at the heart of this thesis. More specifically, what future outcomes have already been determined by today's outer space policies, and can a close evaluation of contemporary outer space governance offer better insight into what challenges and opportunities await? This thesis presents an investigation and analysis of one particular policy that lies between the United States and China, the two actors who are most likely to have a significant influence on the development of humanity's extraterrestrial future. That policy is known as the "Wolf amendment".

In 2011, the United States Congress voted to accept Public Law 112-55. Section 539 of that bill, commonly known as "the Wolf amendment", stipulated that the National Aeronautics and Space Administration (NASA) could not "develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company" (*Continuing Appropriations Act*, 2011). This law effectively created a legal barrier between the U.S. and China in their ability to cooperate on civil space projects. The Republican Representative from Virginia, Frank Wolf, who authored the amendment, had strong feelings about China's policies on human rights and religious freedom and had great concerns about giving the People's Liberation Army, the Chinese armed forces, opportunities to steal advanced technology (*Efforts to Transfer*, 2011, p.8). The United States has had a mistrusting relationship with China since the beginning of the Cold War, but the Obama administration had seen space exploration as an opportunity to foster cooperation between the two powerful nations. With his amendment, Congressman Wolf brought those cooperative efforts to an end.

The debate over whether the United States should cooperate with China in space activities has been hashed out in many forms for decades (Stone, 2013). This thesis is not intended to weigh in on the merits for or against such bilateral cooperation and therefore avoids a rehashing of the primary arguments of that debate except for offering necessary background context. Rather, this thesis explores how the institutionalized elimination of cooperation between two of the world's predominant space actors is likely to influence the ongoing development of the institutions that will guide humanity beyond Earth's cradle. Specifically, the research question posed in this thesis is: How is the Wolf amendment influencing the evolutionary trajectory of the system of global space governance?

Understanding this complex and multifaceted issue requires an understanding of the systemic patterns that make up global space governance. This research uses complexity theory to explore how altering patterns of interaction between actors can impact the evolution of complex social systems. Complexity theory tells us that social systems are path dependent and are therefore highly sensitive to initial conditions (Byrne & Callaghan, 2013). As human space capabilities are still in an early development stage, today's policymaking challenges form a "critical junction", where the decisions made by influential individuals may have especially significant impacts on the future trajectory of system development (Capoccia & Kelemen, 2007).

The Wolf amendment significantly influences U.S. policymakers and interactions between the U.S. and Chinese space programs. Due to China's rising influence in international space activities, changes in the U.S.-China space relationship have a direct impact on the greater global scale of space governance. By analyzing current trends in the complex social systems that are the U.S.-China space relationship and the greater system of global space governance, we can better understand how the Wolf amendment is influencing trends in these systems.

This thesis is organized into 6 Chapters, including this introduction. Chapter 2 will introduce the system of global space governance, including the actors, institutions and activities that make up humanity's presence in space. This chapter will demonstrate that the current system of global space governance does not sufficiently address the challenges emerging in the space domain. Thus, it will exemplify the need for investigating how this system is developing. Chapter 3 will describe the theoretical framework utilized in this thesis. It will introduce complexity theory's conceptualization of social systems and the concepts that guided this research, including path dependency and feedback loops. Chapter 4 presents the methodology utilized to conduct the research. Specifically, it will demonstrate how systemic patterns were identified in both primary and secondary data sources via thematic analysis. The challenges of conducting such research on space activities will also be discussed, as well as the methods of triangulation that were utilized to validate the findings herein.

Chapter 5 will present the findings and final analysis of this research and will be divided into four sub-sections. Sub-section 1 will focus on the Wolf amendment itself and will reveal how the amendment works both legally and in practice, where the amendment came from, and the likelihood of its continuation. Sub-section 2 expands the research focus to investigate systemic trends occurring in the U.S.-China space relationship. Investigating primarily from the U.S. perspective, it will present a historical view of the U.S.-China relationship's development and current discourses that indicate the direction in which this relationship is evolving. Sub-section 3 will expand the research focus further to identify systemic trends occurring at the global international level of space governance. Finally, sub-section 4 is a discussion that combines the patterns identified in sub-sections 2 and 3 with the systems understanding of the Wolf amendment identified in sub-section 1. This will present a final analysis of the overall findings uncovered in this research.

As with any research that explores theoretical outcomes, this thesis has some limitations. One of the core principles of complexity theory is that future outcomes are stubbornly impossible to predict (Byrne & Callaghan, 2013). Thus, this thesis does not offer conclusive answers or policy prescriptions. Rather, it is the intention of the author that the findings within will provide insights that will inform discussions between policymakers, both in the United States and internationally, who are working on the long-term sustainability of space activities. Existing policy debates about the Wolf amendment tend to focus solely on the security risks of allowing China to catch up to the U.S. technologically (*China's Space Programs*, 2015; *Efforts to Transfer*, 2011). By presenting a holistic understanding of this complex issue, this thesis can expand the scope of current debates. The findings in this thesis reveal the trends being influenced by the persistence of the Wolf amendment and demonstrate how global space governance may develop because of this influence.

2. Background: The System of Global Space Governance

Humanity's presence in outer space officially began on October 4th, 1957, when the Soviet Union launched Sputnik into low Earth orbit (NASA, 2007). That small satellite fundamentally changed the world as we know it. The overhead presence of this man-made spherical object ignited American Cold War fears and launched the Space Race. However, the fact that the U.S. government did not protest the satellite's ability to pass over its territory set the very first legal precedent in outer space (Brown, 2013, p.192). Thus, the governance of outer space was born.

Sixty years later much has changed. Humans have been to the moon, there is an international space station with full-time human residents, and billionaires have begun launching their personal vehicles towards Mars[1]. Outer space hosts a viable and rapidly developing commercial industry, with projections to grow exponentially (*Space: Investing*, 2017). Over 70 countries have adopted space regulations, and new national space programs emerge on a regular basis (Space Foundation, 2017). There have been 5 international treaties solely dedicated to outer space, and countless bilateral agreements between a growing number of states with celestial ambitions. Yet despite the progress made in developing governance mechanisms, technological

[1] Referring to the highly publicized launch of Elon Musk's personal Tesla Roadster as a demo for the inaugural flight of SpaceX's Falcon Heavy rocket.

and economic progress move at a much faster pace. New and complex policy challenges are calling attention to limitations in the current system of global space governance (Jakhu & Pelton, 2017).

This chapter will serve as a basic introduction to the system of global space governance. Within this research, this system is considered to be made up of the actors, institutions, and patterns of interactions that encompass humanity's access, participation, and regulation of outer space. In this thesis, "institutions" refers to the various norms, rules, laws, and frameworks that influence behavior within the system of global space governance. Technically the actors presented here, such as NASA and the Chinese government, can also be considered as institutions. However, to emphasize that individuals within these institutions have the agency to influence the creation of the institutions that fit the definition chosen in this thesis, the term actor has been adopted instead.

For readers less familiar with global space governance, this chapter will briefly introduce current and historical happenings in outer space activities. For readers more familiar with space policy, this chapter will be a quick summary of the history and current challenges in space governance relevant for the context of this study. It will begin with a brief introduction of the main participants in space-based activities. It will then introduce existing space governance institutions including the five UN space treaties. Finally, this chapter will introduce the major space activities and the challenges they pose for policymakers.

2.1 The Actors

Much has changed since the early days of space exploration, when there were only two significant actors in space. The Soviet Union and the United States rapidly developed a range of space technology with the Cold War as a key driver. The Soviet Union predominately led the "space race" with the first satellite, the first man in space, the first woman in space, the first space station, and the first successful landing on another planet[2]. The Soviets' remarkable success in space pushed the United States into investing unparalleled government funding into the NASA's development (Brown, 2013, p.141). Eventually the United States declared itself winner of the space race when Neil Armstrong and Buzz Aldrin placed an American flag on the

[2] First satellite: Sputnik (1957), first man: Yuri Gagarin (1961), first woman: Valentina Tereshkova (1963), first landing on other planet: Venera 7 landed on Venus (1970), first space station: Salyut 1 (1971)

Moon's surface. The United States has maintained its status as the preeminent actor in space ever since.

United States

The U.S. space program, like many other space programs, has a civil and a military component. The two main civil agencies are the National Aeronautics and Space Administration (NASA) and the National Oceans and Atmospheric Administration (NOAA). NASA is the lead U.S. space agency, and responsible for the development and creation of cutting edge space technology. The Department of Defense (DoD) oversees a variety of space security offices ranging from the operation of intelligence satellites to designing new military space strategies. While NASA has by far the largest budget of any global space agency, the DoD has a significantly larger space budget, though the exact numbers are classified[3] (Space Foundation, 2016). The United States also has an ambitious and rapidly growing commercial space sector. The U.S. government increasingly utilizes its private sector to deliver satellites and International Space Station (ISS) supplies into Earth's orbit.

To support this industry, the United States has multiple government agencies dedicated to the regulation and development of the commercial space industry (Space Foundation, 2017). The Federal Aviation Administration (FAA) has been responsible for regulating space vehicle launches and orbital re-entries. The Federal Communications Commission (FCC) has been responsible for assigning orbital slots for satellites. Finally, the Office of Space Commercialization (OSC), which has been an office within NOAA, is responsible for most other commercial space regulatory matters. It appears this commercial arrangement is about to change. In 2017, Vice President Mike Pence led the re-establishment of the National Space Council (Lightfoot, 2017). This council is a forum for each agency with space efforts, plus the military joint chiefs of staff, to share and discuss an overall space strategy for the country. At the second meeting of the council, a proposal was introduced to consolidate all commercial regulation to the OSC and to move that office to a higher independent position within the US government structure (Smith, 2018c). This proposal appeared to be met with great enthusiasm, showing the current drive to promote the U.S. commercial space sector.

[3] 2015 NASA budget was $18 billion vs estimated DoD budget of $23.572 billion

Russia

During the Cold War, the Soviet Union did not have a central space technology agency like NASA, instead it had multiple competing space programs spread throughout the Union (Brown, 2013, pp.151-164). With this model, the Soviet Union was able to achieve a wide range of technological feats. However, after the Soviet Union's collapse, the space sector was scattered between Russia, Ukraine and Kazakhstan. Russia's space agency, Roscosmos remains one of the lead space agencies worldwide, but has struggled with funding in the post-Cold War era. This has led to creative fundraising, primarily through space tourism, and some complicated realities with accessing the International Space Station. Today the United States is reliant on Roscosmos for sending astronauts to the ISS. Yet Russia does not have its own major spaceport, so it is reliant on Kazakhstan's Baikonur Cosmodrome to have the ability to send astronauts into space (Brown, 2013, p.152). Russia has been constructing a new cosmodrome to end its reliance on Kazakhstan but has yet to replace Baikonur as the main Russian launch site.

After the end of the Cold War, NASA and Roscosmos have had a notably successful cooperative relationship in space exploration (Brown, 2013, p.147). The ISS is the culmination of this relationship as the station is primarily made up of connected Russian and American modules. However, despite the famously friendly relationship that Astronauts and Cosmonauts share, the relationship often is subject to Earthly political challenges. The 2014 Russian annexation of Crimea heavily strained relations with the West. In response to sanctions imposed by the United States, Russian politicians have threatened to deny U.S. astronauts access to the ISS (Taylor, 2014), and have tried to disrupt Western space policy initiatives in protest of the sanctions (Johnson-Freese, 2016, p.153). However, despite the ongoing tension between these two major space players, their relationship continues in outer space.

European Space Agency

The European Space Agency (ESA) is an international organization with 22 European space program members. Each member country has its own space agency and the ESA is a platform for collaboration between them. This includes well established space programs, including the French and German Space agencies as well as less developed agencies such as the Romanian and Norwegian space programs. Collectively, the ESA has been a major participant in the ISS and projects exploring the far reaches of the solar system. The ESA is a separate body from the European Union (EU), but the EU does contribute significantly to ESA funding.

Currently, some major ESA projects including the Galileo and Copernicus satellite systems, are in doubt due to the United Kingdom's "Brexit" from the EU (Roux, 2018). The UK Space Agency will likely remain a member of the ESA, but it will be difficult to re-establish trade rules and policies that allow the various ESA members to trade components after the U.K. leaves the EU (Erwin, 2017).

The ESA has a long and successful history of collaboration with NASA. Many of the more exciting space exploration missions in recent years have been joint efforts between the two countries[4]. However, the ESA's funding does not match that of NASA so when NASA programs prioritize partnering with the U.S. commercial sector, the ESA must look elsewhere for partners. China has become an attractive partner for the Europeans, and this has become somewhat troubling for U.S. policymakers (Johnson-Freese & S. Erickson, 2006).

China

China has been a rising star in the space community, and in 2003 China became the third country to launch a human being into space. The Chinse space program has also been steadily developing advanced space technologies and has plans to be the first country to land an object on the far side of the moon. The Chinese have made great strides in space technology, both domestically and with help from Russia and other countries. Though whether most of that technology is given, bought, or stolen is of serious debate within U.S. political circles (*China's Space Programs*, 2015; *Efforts to Transfer*, 2011; Pollpeter et al., 2015). Most Chinese space craft are based on Russian designs, though analysists note that they have largely been modified and upgraded by the Chinese (Stokes & Cheng, 2012). The China National Space Administration, CNSA maintains a close relationship with the Russian space program.

Publicly the Chinese have been very adamant about peaceful cooperation in space and have been very open about trying to engage in international cooperation (McKenzie, 2015; Xinhua, 2018). Due to their space program's opacity and often unpredictable behavior, cooperation has been a mixed experience for countries that partner with China (Pollpeter et al., 2015, pp.24-40). For reasons that will be explored later in this thesis, the United States has not allowed the Chinese to participate in the ISS project. However, the Chinese have successfully launched into orbit a test lab space station, with plans to have a permanent station in low earth

[4] The Cassini-Huygens mission that concluded in 2017 and revealed exciting new information about Saturn and its moon Titan was one such cooperative endeavor. https://www.jpl.nasa.gov/missions/cassini-huygens/

orbit open to international partners (UNOOSA, 2016). The Chinese see space as an opportunity to boost the image of the country, and gain prestige as a major world power (State Council Information Office, 2016). Because of this the Chinese space program has consistent and strong government support.

Mid-level National Actors and Regional Cooperatives

While the United States, Russia, China and ESA space programs are the four biggest players, there are many other mid to small level national space agencies with a variety of experience and skill sets. The Canadian and Japanese space agencies are the other participants on the ISS project. India, South Korea, Brazil, and Nigeria are all developing significant space programs. The increase in small and mid-level space agencies has led to an increase in both regional cooperation and regional competition (Jakhu & Pelton, 2017). Regional cooperatives such as the Asia-Pacific Space Cooperation Organization (APSCO) and the Asia-Pacific Regional Space Agency Forum (APRSAF) support the cooperation of regional state agencies with the goals of sharing information and coordinating activities. Interestingly, those two cooperatives highlight that China, Japan, India, and South Korea are in what is currently considered to be the "Asian space race" (Aliberti, 2013). China is the key contributor to the APSCO, while Japan is the key contributor to the APRSAF. Each cooperative is largely a soft power tool used to gain regional prestige and influence for whichever major space power is at the center of it (Du, 2014). China shares generous financial and technological support with its partner countries. While Japan uses its status as an ISS member to gain recognition and influence in its regional space block (Jakhu & Pelton, 2017). Regional cooperatives such as these are becoming increasingly prominent in developing parts of the world.

Commercial Actors

Perhaps the most disruptive shift in outer space governance has been the introduction of serious and capable commercial actors (Pelton, 2016). Companies such as SpaceX, Ariannespace, and United Launch Alliance are dedicated to making access to space affordable and commercially viable. These companies primarily generate income via commercial and government satellite launches but are aggressively working to open space to new industries. Then there are companies such as Bigelow Aerospace and Nanoracks which are dedicated to the creation and operation of space stations and human activities in space. Virgin Galactic and Blue Origin are looking to make space tourism a major commercial industry. Companies such as

Planetary Resources are working on developing space mining technology and starting a brand-new gold rush in outer space (Pelton, 2016).

These private sector actors are helping re-engage public excitement in space exploration and the potential for a booming space industry. However, they are also introducing new challenges to space policymakers. The existing international treaties for space governance were created at a time when no one imagined a viable commercial space sector would exist (Jakhu & Pelton, 2017; Pelton, 2016). All the major international laws pertain to states only, and predominantly have a focus on issues of security and cooperation. What to do about a prominent commercial space sector has become of the most pressing issues for space policymakers worldwide, though not in the same way. Countries such as the United States and Luxembourg are designing policies to encourage the development of a thriving space economy (Selding, 2016), while others are working hard to ensure there are firm regulations to prevent the endless bounty of space from belonging only to those rich enough to access it (Paikowsky et al., 2014). Many of these debates and discussions are held through the United Nations.

2.2 The Institutions

The UN

The United Nations (UN) has played a significant role in the development of outer space governance. Each of the five major space treaties emerged from the UN, and it continues to be the central arena for international space diplomacy. Within the UN there are two main forums that deal specifically with outer space issues, the Committee on the Peaceful Uses of Outer Space (COPUOS) and the Conference on Disarmament (CD). The CD is primarily focused on establishing transparency and confidence-building measures (TCBMs) between major space powers to prevent an arms race in outer space (Brown, 2013, pp.185-188). COPUOS focuses largely on the long-term sustainability of outer space activities (UNOOSA, n.d.). The original space treaty was negotiated through the UN General Assembly, while the next 4 treaties came from COPUOS (Brown, 2013, p.181).

5 Space Treaties

The Outer Space Treaty (OST) is the backbone of international space law (Jakhu & Pelton, 2017). Over 100 states have ratified the treaty since it entered into force in 1967. A key declaration in the treaty is that the exploration of outer space should be a peaceful endeavor that is available to all States for the collective benefit of mankind (*Outer Space Treaty*, 1967). The

OST also declares that no celestial objects can be appropriated by claims of national sovereignty or otherwise. This means that no government or individual can claim territory beyond Earth. However, it is unclear whether this article applies to resources pulled from celestial objects. Another provision is that that no weapons of mass destruction can be placed in orbit or on a celestial body. Significantly, it also declares that States are ultimately responsible for any activities conducted in space. If a private American satellite company accidently crashes its equipment into another country's satellite, the U.S. government can be held liable. The wording in much of the OST was vague and introductory, largely because the drafters at the time could not foresee how complex space governance would become, and this led to the drafting of four more treaties.

The following year saw the drafting of the Rescue Agreement Treaty (*Rescue Agreement*, 1968). This legally binding institution requires states to help and rescue astronauts that fall into danger and send them back to their state of origin without harm. Soviet Union cosmonauts always carried pistols with them in case they landed in hostile territory or for survival in the Siberian wilderness. A tradition that the Russians continued until recently. The Rescue Agreement also requires states to help recover any space objects that land back on Earth outside of the launching state's territory.

The Liability Convention further expands on who is responsible for damages caused by anything launched into space (*Liability Convention*, 1972). This covers damages that occur in space or back on Earth. The Liability Convention declares that the "launching state" is fully responsible for any damages caused by an object, regardless of who launched it. A launching state is any state that facilitates a launch, either by procuring the launch or by having the launch occur within the State's territory, or territory controlled by the State. If one State pays for the launch, but the launch occurs in another State, then both States are liable for damages. Many objects have multiple launching states. The Liability Convention also outlines the process for settling claims in the event of damages. According to the convention, only States may make claims against another State. If an individual has their property destroyed by a falling object, then that person must petition their State government to bring their claim against the launching State. This has only ever occurred one time, with the crash of a nuclear powered Soviet satellite over Canadian territory in 1978 (Brown, 2013, p.25). This convention and the liability provisions

of the OST are of particular concern for space policymakers today due to the rise of private industry in space endeavors.

The most recent successful space treaty was adopted in 1976. The Registration Convention requires states to register their space objects with the UN (*Registration Convention*, 1976). This registrar is held by the UN Office for Outer Space Affairs, the secretariat for COPUOS. This registrar contains an i.d. for each object, its orbit, launch date, launching State, and general explanation for its purpose. The Registration Convention was created to facilitate the previous treaties by making it easier to identify objects and facilitate transparency in outer space affairs. The convention also further elaborates on the definition of "launching state" and "space object" to help clarify certain legal questions, though many of those questions and more remain today. Which is largely why the fifth and final treaty was introduced in 1979, though it is largely considered a failed treaty.

The Moon Treaty tried to specifically tackle the issues of exploitation, militarization and the nature of outer space as a global common (*Moon Agreement*, 1984). Opened in 1979 and adopted in 1984, the Moon Treaty specifically banned using celestial bodies for military purposes of any kind. It banned resource exploitation without consent from other states and declared that an international regime must be put into place to ensure that resources gathered from outer space were regulated as the collective property of all mankind. Developing countries without space programs hoped the Moon Treaty would prevent outer space becoming the exclusive domain of wealthier nations (Leib, 2015).

In the end the treaty gained the required number of ratifications to come into effect, but no major spacefaring nation signed it. Therefore, the common understanding is that it is a failed treaty that does not apply to any nations that did not sign it (Kohler, 2015). Article 38 of the Statute of the International Court of Justice states that treaties signed between involved parties and customary international law, are the two main sources of international law (*I.C.J.*, 1946). The OST is largely considered to be customary international law, so it is possible that it could legally apply to nations that did not ratify it, though that would have to be tested in an international court. The Moon Treaty is not commonly recognized as customary international law, and therefore while it is in effect it does not apply to the countries who are likely to conduct activities outlined in it.

While the OST and the four other space treaties are the backbone of all global space governance, there are a variety of other mechanisms in place as well. The International Telecommunications Union is a UN backed organization responsible for allocating satellite orbits and radio frequency spectrum, as well as defining relevant technical standards (ITU, n.d.). The Inter-Agency Space Debris Coordination Committee serves as a forum for international coordination of space debris reduction projects and proposals. The committee has promoted non-binding, voluntary guidelines for coordinating and preventing the creation of space debris (IADC Coordination Committee, 2007). Recognized best-practice national laws can also serve as examples for other countries to follow, thus influencing international space behavior (Jakhu & Pelton, 2017). The U.S. Space Competitiveness Act is one such law that may influence the direction of global space governance. This law outlines that private entities are permitted to profit off resources pulled from celestial bodies, though they are not allowed to claim sovereignty over any territory. Luxembourg has also created a similar national legal framework, and other countries appear to be interested in following suit (Selding, 2016). Norm building through consensus built voluntary agreements can also influence national space practices in the absence of legally binding treaties (UNIDIR, 2015). These highly varied forms of regulation are made in response to challenges created by the increasing complexity of current outer space activities.

2.3 Space and Space Activities

In the broadest sense, outer space governance is the organization and regulation of human activities in the area that begins at Earth's upper-most atmospheric layers and stretches out infinitely beyond. Currently this primarily pertains to activities within Earth's orbit and around other celestial bodies. Outer space is considered one of the Earth's global commons, which include the polar regions and the deep seas (Pelton, 2016). These are areas that have been deemed as the collective property of mankind and cannot be claimed or made part of any single nation's territory. This includes on the Moon, Mars, or anywhere else beyond Earth.

Dictionary definitions suggest that outer space refers to everything beyond Earth's atmosphere. Outer space governance, however, includes the higher regions of our atmosphere as this is where the majority of space related activity actually occurs. The International Space Station and most commercial satellites reside in Low Earth Orbit (LEO), which exists within the thermosphere and exosphere portions of our atmosphere. The orbital zones outside of our

atmosphere include Medium Earth Orbit (MEO) and Geosynchronous Orbit (GEO). MEO is where most guidance systems satellites reside, including the U.S. based Global Positioning System, GPS. GEO is where more advanced spy and reconnaissance satellites orbit because at this distance, orbital velocity can match the rotation of the earth and therefore the satellite can be "fixed" above a specific location.

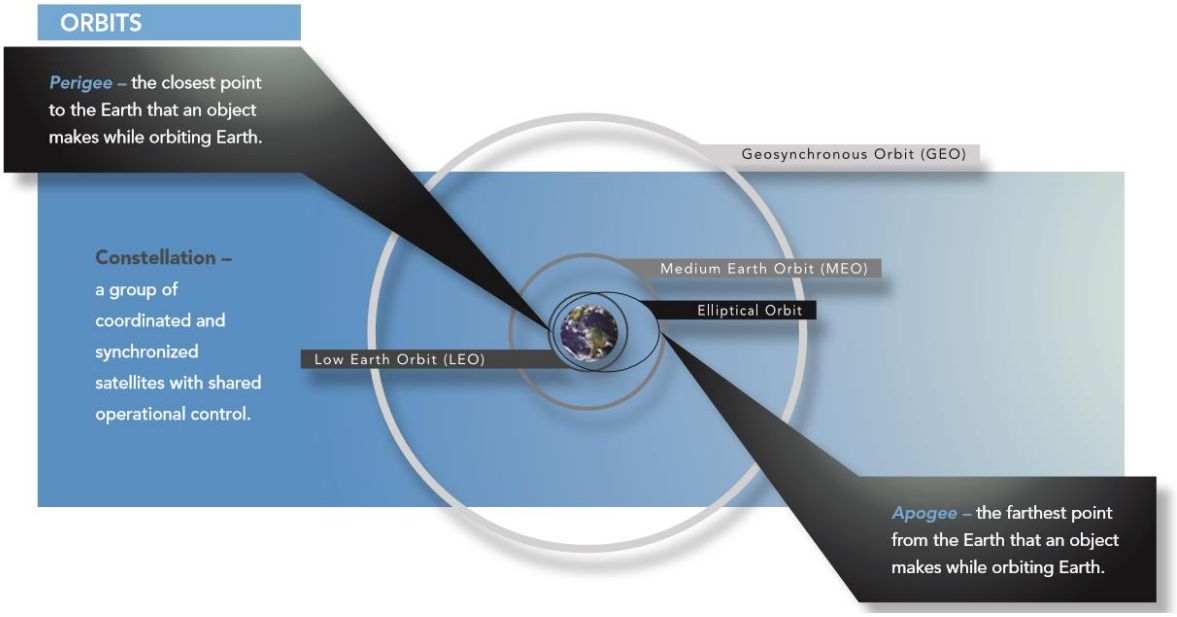

Figure 1 Intro to Space. (Space Foundation, 2017)

Today these orbital zones, particularly LEO and MEO are becoming increasingly congested as technology becomes more accessible and costs launching satellites decrease. Satellites the size of toasters have the same capabilities as satellites the size of school buses mere decades ago. Today satellites are so easy to make that an online radio podcast team was able to go through the entire process of acquiring a satellite and launching it into orbit without a clear purpose for what the satellite would even be used for (Kulas et al., 2017). This ease of access is contributing to an exponentially increasing number of users launching their own satellites into Earth's orbit. This is leading to a concern that these orbital regions will become unsustainably packed full of objects, potentially leading to a catastrophic event that will block humanity's access to outer space.

The problem is that there are not only satellites orbiting the Earth, but also a growing amount of space debris. Debris can be naturally occurring, or it can come from broken or unused man-made objects. There are thousands of pieces of space debris of trackable size, with an

unknown number of pieces too small to track. This is a considerable problem because the incredible speed objects are travelling at in space is so fast that even the smallest object can cause devastating damage to anything else in orbit. In 2015 a mere fleck of pain cracked a window on the ISS bad enough to require its replacement (ESA, 2016). There are over 20,000 substantially sized space debris objects currently being tracked by the U.S. Department of Defense, though over 500,000 smaller objects have also been identified so far (NASA, 2013). The great concern is that if one these objects directly hits a satellite in a congested orbital zone, it may set off a chain reaction of debris creation. This hypothetical scenario is referred to as the "Kessler syndrome", named after the physicist who first proposed the idea (Kessler & Cour-Palais, 1978).

Another concern is the possibility of debris generated from military conflict. In U.S. policy circles, space is referred to as being "congested, contested, and competitive" (Harrison, 2013). The contested component refers to the inherently military nature of outer space. As long as there have been activities in space, militaries have been involved. As satellite and communications technology have evolved, modern armed forces grow increasingly dependent on space-based infrastructure. The U.S. military in particular is heavily reliant on space assets for its military operations. The 1991 Persian Gulf War is often referred to as the first "Space War" because the United States greatly benefited from its GPS and communications satellite systems to dominate that conflict (Lang, 2016).

According to experts on the Chinese military's space program, China recognized the benefits that space assets offered the U.S. at the time and sees space as a key strategic domain (*China's Space Programs*, 2015). Recognition of the benefits of space technology on warfighting has brought concern over protecting those assets. According to military analysts, multiple countries are developing Earth-based and space-based anti-satellite technology (*Military Space*, 2017). No country has developed space-based weapons, at least publicly, but an arms race caused by fear of losing the technological advantage in space could quickly lead to their existence. With more countries pursuing robust space military assets, international policymakers fear an escalation of space debris caused by the use of spaced-based weaponry and anti-satellite technology (Johnson-Freese, 2016).

The issues of space debris and orbital allocation are some of the leading space policy issues being discussed today. There is no international regime that monitors all the objects

floating around in Earth's orbit (Jakhu & Pelton, 2017). Currently the U.S. DoD is the lead tracker of space debris and maintains a catalogue of all significantly sized objects orbiting the Earth (NASA, 2013). They send alerts to other nations, including China, when there are objects that may be in the way of any potential rocket launches. However, there are calls to create an international cooperative body that is responsible for monitoring all objects (Al-Rodhan, 2018). Additionally, there are talks over whether there should be a limit to the number of objects that can be in orbit at any given time. This is becoming a pressing issue because now there are multiple groups planning on launching "mega-constellations", groups of thousands of small satellites, that can deliver constant and worldwide internet coverage (Foust, 2016a). SpaceX has already launched test satellites for their own mega-constellation, so it may be only a few years before these orbital zones become incredibly dense.

The ease of sending satellites into space is calling significant attention to international liability laws because it is much harder to prevent people from launching satellites now. The incredibly small size of modern satellites makes it so that a single rocket launch can deliver multiple satellites from a variety of businesses, and not all of them from the same country. The OST declares that any liability for a given satellite resides with the state that owns the satellite or the state that launches it. This creates challenges for companies that do not reside in a spacefaring country, as launching countries may not want to be responsible for objects made countries they do not have regulatory authority over. Their home countries may also not want to risk such liabilities themselves when they do not have the skills and knowledge locally to effectively mitigate space-related risks.

While Earth's orbital regions are becoming increasingly congested and commercialized, the celestial bodies beyond Earth's atmosphere remain the targets of exploration and prestige. The Moon is particularly synonymous with mankind's achievements in space. For the United States in particular, landing on the moon has been a source of national identity and international prestige. Yet, in the years after the end of NASA's Apollo missions, the moon has been relatively ignored. However, international attention is returning to the moon as the potential for a new gold rush in space emerges (Pelton, 2016).

Helium-3 is very rare on Earth and has many potential industrial uses. It is the best known as the primary elemental candidate for developing sustainable fusion energy. The successful development of fusion technology would revolutionize energy use as we know it by

creating a safe, sustainable, and clean energy source that could easily power the globe (Pelton, 2016). The problem is that helium-3 is very rare on Earth. As it happens, helium-3 is expected to exist in vast abundance on the moon. The Sun constantly emits helium-3 through solar radiation, making it one of the most common elements in the solar system. This radiation is blocked by Earth's atmosphere, but because the moon does not have an atmosphere, helium-3 is able to blanket the surface. Current estimates suggest that there is likely a trillion-dollar industry in helium-3 on the moon, with an abundance of other rare-Earth minerals likely beneath the lunar surface (Pelton, 2016). The Chinese are particularly interested in potentially establishing lunar resource mining operations. In March 2018, the CNSA signed an agreement with Roscosmos to cooperate on lunar exploration and set up a joint lunar data center (Jones, 2018a).

The Moon is not the only celestial body attracting the attention of potential profiteers. Two large companies, Planetary Resources and Deep Space Industries, have been created specifically as asteroid mining companies. According to surveys of recent fly-by asteroids, one evaluated object in 2012 had an estimated total value of just under 200 billion dollars in water and various metals (Wall, 2013). A much larger asteroid that NASA is planning on sending a spacecraft to by 2030 is made of pure metal, and if it were mined it is estimated to contain 10,000 quadrillion dollars' worth[5] of Iron alone (Scotti, 2017). There are no plans to try to mine that specific asteroid, but there is clearly economic potential for whoever develops the capability to mine asteroids. Outside of the technical challenges however, there are also serious legal and economic hurdles to overcome.

There is serious debate over whether the OST forbids the mining and sale of anything taken from a celestial body (O'Brien, 2018). The OST specifically prohibits appropriation "by claim of sovereignty, by means of use or occupation, or by any other means" (*Outer Space Treaty*, 1967). The United States and Luxembourg have created legislation that would allow commercial entities to sell anything that was mined in space, while still not claiming sovereignty over the area the resource originated. However, Luxembourg's legal framework is already being contested as a potential breach of the treaty (Man, 2017). There are multiple reasons nations might be concerned about not regulating space mining rights internationally. Introducing hundreds of billions of dollars' worth of iron, copper, and nickel into the global economy would have devastating impacts on global economy, and there is currently no authority to prevent such

[5] Yes: ten thousand quadrillion dollars. $10,000,000,000,000,000,000.

a scenario from occurring. There is also the issue of space being the "common heritage of mankind". Only advanced spacefaring countries will be able to exploit space resources, thus widening the income gap between rich and developing countries. These developing countries see the OST and Moon treaty as explicitly ensuring that they should be included in the wealth of space even if they do not yet possess the capability to get it themselves (Paikowsky et al., 2014).

Beyond potential commercial exploitation, for advanced space faring countries space still holds the allure of international prestige by going where no one else has gone before. Mars is currently the next goal for human exploration. There are no perceived economic incentives to reach Mars, but even still space agencies around the world are focused on exploring the red planet. The United States is particularly keen on Mars exploration with both NASA and SpaceX planning to send humans to the surface of Mars within the next few decades (NASA, 2018a; SpaceX, n.d.). Other countries have plans to send humans to Mars, but they are less concrete, and most are far in the future[6]. Despite the uncertainty, scientists and engineers all over the world are working on the technology that will enable humans to live on another world. Policymakers face a great challenge in keeping up with the speed of technological development.

Collectively, the term "space activities" encompasses a wide range of projects, industries, and goals in the infinite expanse beyond Earth's surface. This chapter has only given a small glimpse of the complexity of human activity in outer space. It has served as an introduction to the system of outer space governance, including its main actors, institutions, historical moments, and current challenges. The current system of global space governance is evolving rapidly, but it is currently inadequate for addressing the various policy dilemmas that are emerging. Understanding how this system is developing will help policymakers identify areas to focus their efforts. This thesis will reveal how the Wolf amendment is influencing this development. The following chapter will present the theoretical and methodological framework utilized to investigate how this single law is impacting this highly complex system.

3. Conceptual Framework

The question put forth in this research is: How is the Wolf amendment influencing the evolutionary trajectory of the system of global space governance? Inherent to this question are three major theoretical assumptions. First, that outer space governance can be considered to as an

[6] The UAE plans on establishing a Mars colony in 2117 (Government of Dubai, 2017)

"evolving" system. Second, that the Wolf amendment, as an institution, is potentially capable of exerting influence on this system's evolutionary trajectory. Finally, that this influence is potentially significant because the system of outer space governance is at a crucial point in its development process. Each of these assumptions comes with unique implications that contribute to the direction of this research. Establishing a research method that accounts for the above assumptions allows academics, stakeholders, and policy makers to identify the consequences of specific policies within a dynamic context. A complexity theory approach is most suited to finding an answer to this research question. Complexity theory, or complex systems thinking, is particularly useful for understanding how social systems behave and how they develop over time (Byrne, 1998). Utilizing a complexity theory framework offers the tools to identify how the system of global space governance is developing and how the Wolf amendment exerts influence on this development.

3.1 Complexity Theory

Complexity theory is a blanket term for a collection of theoretical ideas and concepts that focus on the behavior of systems that display complex, chaotic, and dynamic qualities. Complex systems are open, embedded within other systems, and influenced by non-linear causality (Cudworth & Hobden, 2011, p. 65). They are "living" systems that evolve and are capable of adjusting to changes within the system. They are heavily path-dependent with particular influence coming from initial conditions (Byrne & Callaghan, 2013). Global climate patterns, living organisms, and socio-economic systems are all complex systems (Cudworth & Hobden, 2011). Each may function in different ways, but they all demonstrate the same complex traits and behaviors. The study of complexity stems from explorations in chaos theory, computer sciences and evolutionary studies (Cudworth & Hobden, 2011). It emerged from the simple recognition that outcomes in systems with high degrees of complexity are stubbornly difficult to predict.

Complexity systems thinking has found a wide range of applications in the social sciences (Byrne & Callaghan, 2013), but has only recently become a theoretical approach utilized by scholars of International Relations (Cudworth & Hobden, 2011; Root, 2013). There are two general approaches to trying to understand a complex system's behavior. The first and perhaps most common approach is to try to simplify the system and utilize computer-based modeling to conduct quantitative research. This approach recognizes the reality of complexity but does not fully accept the implications (Byrne & Callaghan, 2013). The second approach, and

the one used in this research accepts both the reality and the implications of complexity by utilizing holistic and qualitative methods. According to Byrne and Callaghan (2013), complexity thinking in the social sciences fits most appropriately within the critical realist paradigm. A researcher embracing this conceptualization of reality must utilize a non-positivistic approach and deny Newtonian concepts such as equilibrium.

Furthermore, complexity forces the researcher to accept limitations in their ability to predict future trends and challenges many long standing assumptions. For Example, Hilton Root (2013) utilized complexity thinking to effectively demonstrate that contrary to mainstream assumptions, globalization was not driving China toward a democratic model, but towards a unique autocratic model. In early 2018 Chinese President Xi Jinping shocked Western thinkers by successfully eliminating his own term limits (Economist, 2018). While this outcome was a surprise to many, it corresponded with Root's analysis, suggesting the potential validity of his approach. There are numerous concepts that make up complex systems thinking, but there a few that are particularly relevant for this research. Each of the concepts discussed here will directly influence the choice of methods utilized to conduct this research.

According to the complex sciences, complex systems have open and difficult to define borders, and are embedded within and amongst other complex systems (Bousquet & Curtis, 2011). These systems are multi-layered and are interconnected with other systems throughout these layers. The system of outer space governance, for example, is made up of a variety of political and commercial bodies including UN COPUOS, national space agencies such as NASA, and companies such as SpaceX. The interactions between these bodies make up the system's structure. These interaction patterns are influenced by previous interactions and on interactions within the various other systems they are connected to. For example, NASA's activities are dependent on the United States' national budget and policy directions, which are dependent on the recent election trends and the state of the American economy.

The implication of this is that it is inherently problematic to attempt to reduce or isolate a complex system in line with traditional scientific thought (Byrne & Callaghan, 2013). To address the challenge of investigating open and embedded systems, we must look holistically at not just the Wolf amendment, but the systems that it is embedded within. This means considering the greater geo-political context the Wolf amendment exists within. This is a challenging task on its

own, unfortunately, the open nature of complex systems is not the only thing that makes patterns in complex systems hard to predict.

The main reason that outcomes in complex systems are difficult to predict is because these systems demonstrate non-linear dynamics (Cudworth & Hobden, 2011, p. 65). Non-linearity was most famously introduced by Edward Lorenz (1972) when he asked if the flap of a butterfly's wings in Brazil could set off a Tornado in Texas. His research on the mathematics of weather patterns suggested that inputs can have disproportionate outputs in the right conditions. This concept directly challenged traditional Newtonian linear thinking. According to Newtonian physics, any input of force must have a predictable and equally proportioned output. Complex systems consistently display unpredictable behavior. Satellite launches today, for example, do not trigger the same massive response as Sputnik did 60 years ago. Conversely, when China conducted an anti-satellite weapons test in 2007, it received far greater international condemnation than did earlier tests conducted by the U.S. and Soviet Union. The conditions of the system had changed.

While outcomes in complex systems are difficult to predict, their behavior is by no means completely random. Research into complex systems has demonstrated that a system's initial conditions at the time of an input determines the output that occurs (Byrne, 1998). There are predictable patterns of behavior that every complex system displays. The challenge is then being able to understand the variable conditions that will determine the outcome at the time of input. In a social system this is effectively impossible before an outcome occurs, though it may be possible to recognize in hind-sight (Byrne & Callaghan, 2013). Human social systems have very high degrees of complexity and have too many constantly shifting variables. One would have to possess a god-like awareness to be able to predict outcomes in such a system. Instead of trying to predict outcomes based on inputs, it is more useful to identify that patterns occurring due a complex system's organizing mechanisms (Cudworth & Hobden, 2011, p. 66). These mechanisms are referred to as feedback loops and path dependency.

3.2 Understanding Complex Systems

Where the concepts of open systems and non-linear causality inform how this research *cannot* be conducted, feedback and path dependency guide how this research *can* be conducted. Complex systems are made up of the numerous interactions between their various components, and the patterns of these interactions make up the structure of the system. These patterns

accumulate into either negative or positive feedback. Negative feedback refers to patterns that maintain the current structure of the system. If an external input is introduced to the system, negative feedback patterns, referred to as "loops", will return the system to its pre-input state (Byrne & Callaghan, 2013). Traditional mainstream theorists would recognize this as a system moving toward equilibrium. The problem with social theories focused on equilibrium is that they do not recognize the equally powerful effects of positive feedback (Cudworth & Hobden, 2011, p. 28).

Positive feedback refers to patterns that enforce and promote the impacts of an external input within a system (Cudworth & Hobden, 2011 p. 35). If a new input is met by more positive feedback than negative feedback it will cause a change in the structure of the system. Well-established systems will generally have more negative feedback potential than positive at any given time. These systems are known to be "resilient", or able to resist change caused by external inputs known as "shocks". However, even in the most well-established systems, conditions are constantly shifting. If the conditions are just right, and the input receives enough positive feedback, the system will reach a "tipping point" where the input will become self-reinforcing and perpetuate the change introduced.

This can lead to sudden and dramatic shifts in a system. The collapse of the Soviet Union and the events of the Arab Spring are well recognized examples of tipping points within International Relations. Proponents of complexity theory in the political sciences argue that if one takes a long-term historical view of human society, not only are social systems equally prone to the effects of positive and negative feedback, but these systems generally move toward entropy rather than equilibrium (Byrne & Callaghan, 2013). This means that one should assume that social systems will become increasingly complex in the long term. However, while social systems are constantly moving toward new and unknown forms, the direction they take to get there will guided by what is known as path dependence.

Path dependence in social systems refers to the idea that potential decisions are limited by decisions made in the past (Byrne & Callaghan, 2013). According to this concept, the decisions that an actor can make within a system are influenced by the system's structure, the shape of which was influenced by the decisions of earlier actors, which was influenced by the structure at their time, and so on. Each pattern of interaction is sensitive to the history of interactions within the given system. But of all points in a system's history, complex systems are most sensitive to

their initial conditions (Root, 2013, p. 243). New complex systems emerge out of the positive feedback of other systems, and the manner in which they developed heavily influences how they will continue to develop.

The second assumption in the research question suggests that it is possible to measure the impact of an institution on the evolutionary trajectory of a complex system. Historical institutionalist scholars for example, utilize some complexity concepts to investigate the development of political institutions. They focus on the concepts of path dependence and feedback to see how decisions made throughout history have impacted the future by limiting potential outcomes. Acemoglu and Robinson's (2012) critically acclaimed book "Why Nation's Fail" utilized a historical institutionalist approach to highlight how the economic success of various nations throughout history has been determined by the designs of their institutional systems. Similarly to how these scholars utilize these concepts to investigate how historical events led to certain outcomes, it is possible to analyze the on-going evolution of global space governance in order to understand where it is going. We know that the principles of complexity theory tell us that we cannot reasonably make predictions of where we will go. Through a complexity understanding of feedback patterns and path dependence we can instead interpret what decisions have been made that limit potential future outcomes.

The system of outer space governance emerged from the introduction of a new technology into the existing system of the Cold War. The launch of sputnik triggered the space race that focused on getting spy satellites into orbit and people onto the moon. Chapter 2 introduced that the very first institution in outer space governance was the legal precedent that it was acceptable to have your satellite in orbit above another sovereign nation. This was a choice; if the United States had contested this, there would be no legal precedent allowing satellites to peacefully circumnavigate the globe. Path dependence, and the rules of international law, tell us that because this choice has been made it is now more difficult for any nation to choose not to allow foreign satellites to orbit over their terrestrial borders.

The period of time where the United States faced the choice to either accept or protest this reality is referred to by complexity researchers as a bifurcation point. Bifurcation points are historical junctures where multiple potential path trajectories exist. The path taken at any particular bifurcation point is heavily influenced by path dependence. Karl Marx (1852) eloquently described this reality by writing, "men make their own history, but they do not make

it as they please". This aptly characterizes the implications of path dependence on understanding how policy decisions are made today, and how those policy decisions can impact the future. In other theoretical disciplines, such as historical institutionalism, bifurcation points are commonly known as critical junctions (Capoccia & Kelemen, 2007). The third and final assumption in this research question is that the system of outer space governance is at one.

Critical junctions are periods in history where the actions taken by influential figures have a greater impact on future trajectories than at other points in that system's historical timeline (Capoccia & Kelemen, 2007). Based on this definition alone, identifying critical junctions is a challenging task and can typically only be done in hindsight. However, complexity theory demonstrates that tipping points occur within social systems when certain systemic conditions are met. This suggests that there are indeed points in time where conditions enable small inputs to create influential outcomes. Complexity thinking also tells us that complex systems are particularly influenced by initial conditions. Therefore, it is evident that any period of development considered to be an initial stage, is also a critical juncture.

3.3 Applying Complexity

60 years after the birth of outer space governance, this system is still at an initial stage. There are asteroid mining companies, but no asteroid miners. Each of the major space agencies has offered plans for sending humans to Mars, but none are close to doing so. Individual companies have proven capable of developing rockets powerful enough to go to Mars, but none have yet developed the technology to take people on the voyage. Humanity has not yet truly established a presence beyond Earth's orbit, so in reality the system we will use to govern our behavior in space has yet to be determined. However, the initial decisions of how we will begin our presence are being made today. Many of them have already been made. The question being asked in this thesis is whether one of those decisions appears to already be a guiding force determining the course of development that space governance will take.

To see why initial conditions will be important to the development of outer space, one need only compare two of our other global commons. The Arctic and Antarctic regions are in many ways very similar, but in other ways completely different. The Arctic is currently a highly militarized arena rife with efforts to claim resources as newly exposed resource potential reveals itself due to the melting sea ice (Duyck, 2011). The Antarctic, on the other hand, is relatively devoid of conflict, cannot be mined legally, and houses primarily scientific research outfits. It

has border disputes and military personnel conducting spy activities, but there are no strutting warships and no vocal threats between super powers. These are both harsh, isolated environments with fragile and poorly understood ecosystems that are expected to hide a vast wealth of natural resources (Koivurova, 2005). This begs the question, why is the political situation so different in each one?

A key difference is that one has a firm and comprehensive governance structure and the other does not (Koivurova, 2005). Both have been peacefully navigated for decades, but climate change has resulted in a free-for-all claiming of territory in the Arctic, but not in the Antarctic. Researchers note that Antarctica has firm treaties that clearly define responsibility, while the Arctic has a system focused on national laws and a non-binding regulatory regime (Weidemann, 2014, pp.207-211). Outer space governance is somewhere between the Arctic and Antarctic in terms of institutional development. There are a few binding treaties for outer space, but they do not cover nearly as much as the Antarctic treaty does. National laws and voluntary norms make up the rest of outer space governance, and many future issues remain unaddressed (Jakhu & Pelton, 2017). While climate change has opened new opportunities in the polar regions, technological advancements are having a similar effect on outer space. This thesis is interested in exploring whether we should expect a more Arctic style response to this new access, or an Antarctic version?

The theoretical framework presented in this chapter will enable this research to present a grounded and justifiable answer to this pressing question. Recognizing the complexity of outer space governance is relatively straightforward. However, acknowledging and accommodating for the methodological implications of complex systems is not quite so simple. The open and non-linear nature of complex systems force the researcher to accept that positivist methodologies utilizing reductionist or Newtonian concepts are inadequate for explaining patterns in highly complex social systems (Cudworth & Hobden, 2011). Research focusing on complex systems should instead take a holistic and historical approach to investigate feedback mechanisms and path dependent processes. The science of complexity helps understand the physics behind a given complex system, but the components included in the system are determined by other considerations. In chapter 2, the system of outer space governance was outlined as the various actors and institutions that influence humanity's access, participation, and regulation of outer space.

These system components match other studies of the system of global space governance, though different identifying terms may be used. One significant example is the research presented in the book "Global Space Governance: An International Study" (Jakhu & Pelton, 2017). This was a comprehensive and interdisciplinary study designed to illuminate the current state of outer space governance and identify the trends and challenges that currently exist. This study incorporated the perspectives and analyses of hundreds of academics, legal experts, government officials, business leaders, and other individuals with stakes in outer space activities. Led by McGill University, it is the most comprehensive study yet undertaken on the development of outer space governance.

In their study, Jakhu and Pelton define global space governance as, "a collection of international, regional, or national laws as well as regulatory institutions and actions/manners/processes of governing or regulating space-related affairs or activities". They further clarify that global space governance refers to, "the entirety of the agreements, laws, regulations and other mechanisms (mandatory and voluntary) in relation to outer space affairs or activities, and includes processes for their formulation, compliance monitoring, and/or enforcement by concerned international and or/national institutions" (Jakhu & Pelton, 2017). I present their description to emphasize that while we do not use the same terminology, we are investigating the same things; albeit in a different way.

This thesis has defined the system of global space governance as the actors, institutions, and patterns of interaction that encompass humanity's access, participation, and regulation of outer space. The key difference between this definition and the definition presented by Jakhu and Pelton, is that this definition explicitly identifies agency within the system and explores how actors interact with each other and outer space itself through the various developing institutions of outer space governance. This difference of definition does not mean that additional subjects are studied, Jakhu and Pelton's study is far more comprehensive than this thesis. Instead this alters the theoretical lens that informs the manner in which this research is conducted and allows this research to utilize the complexity framework outlined in this chapter.

To summarize, this theoretical framework is a qualitative complexity theory approach focusing on trend patterns, feedback loops, and path dependence to identify how the wolf amendment is influencing the development of global space governance. By identifying the historical and ongoing patterns of behavior between various actors within a system, it is possible

to illuminate that system's current trajectory. By identifying existing and potential feedback mechanisms and path dependent processes, such as the Wolf amendment, it is also possible to recognize where evolutionary trends are less likely to go. With this information combined it is possible to determine the direction that a system's evolution appears to be taking. In order to achieve this understanding this research utilizes a holistic, qualitative, and historical approach to analyze trends and patterns in the system of outer space governance.

4. Methodology

4.1 Research Design

The goal of this research was to identify the true nature of the Wolf amendment and to analyze how the amendment impacts trend patterns in the system of global space governance. Utilizing the theoretical framework outline in Chapter 3, the process for conducting this research was divided into two components. The first was analyzing the Wolf amendment itself by identifying how the amendment operates as a feedback modifying mechanism. The conditions that led to the establishment of the Wolf amendment, how it functions legally, practically, and through discourse, as well as its potential longevity were all investigated in this research component. The second component was identifying and analyzing the patterns and developments occurring within the social systems that the Wolf amendment is embedded within. These systems are primarily the U.S.-China space relationship and the system of global space governance. Other systems were considered during this process including the overall U.S.-China political relationship, however for practical purposes this analysis focused on the two primary systems.

This research utilized both primary and secondary data sources for analysis. Primary data sources included congressional hearing transcripts, legal documents, press releases, personal letters, and public statement transcripts. Secondary data sources included research documents, trend reports, journalistic pieces, podcast and video interviews, and books from well-known space policy scholars. These data sources have been analyzed via thematic analysis. Thematic analysis is a qualitative research approach intended to identify and analyze patterns and themes within data sets (Bryman, 2016, pp.584-589). Through this approach, data sources are scanned for repeating themes and sub-themes to identify significant patterns and ideas. Background interviews and conversations with persons involved in space policy development helped inform themes to investigate in these documents.

4.2 Data Collection

Collecting data on the relationship between two major super powers in the sensitive environment of space security is a challenging endeavor for a researcher on the outside of these internal debates. Very little information is available publicly and that which is available is often highly technical, classified, or hidden deep in outdated government websites. Fortunately, the niche element of this field has led to limited but high-quality information resources in the form of space policy journals and space news sites such as the journal Astropolitics[7], Space Policy Online[8], the Space Review[9], and Space News[10]. These resources often present information from the same limited number of experts, which makes it possible to identify the themes and debates of global space policy. Additionally, the United Nations Institute for Disarmament Research[11], the Space Foundation[12], and the European Space Policy Institute[13] draft high quality annual space trend and development reports. These resources were critical for the preliminary stages of this research and through them I was able to construct a general outline of trends and developments and identify preliminary themes for my analysis.

To fill in remaining gaps in information, I conducted background interviews and discussions. These conversations did not serve as primary data sources, but rather informative sessions to confirm or adjust the narrative already identified in the pre-interview process. In total, formal interviews were conducted with two Canadian COPUOS delegates, one space policy expert with observer status at COPUOS, and three individuals at one of the U.S. space-related agencies. Informal conversations were held with national space agency representatives, officials from the Organisation for Economic Co-operation and Development (OECD), U.S. military personnel, commercial space company owners and employees, space news journalists, and space policy advocates. Many of these informal conversations were held later in the research process and served to confirm findings rather than to collect new data.

After developing a working list of key themes, I began the analysis of primary and secondary data sources uncovered during the preliminary research process. These findings were

[7] Astropolitics: The International Journal of Space Politics and Policy. Available at tandfonline.com
[8] Available at spacepolicyonline.com
[9] Available at thespacereview.com
[10] Available at spacenews.com
[11] Available at unidir.org
[12] Available at thespacereport.org
[13] Available at espi.or.at

triangulated by comparing to research documents, expert analyses, and information uncovered in the interview process. Triangulation is a qualitative research method in which the researcher investigates the given subject from multiple sources of data. This supports a study's credibility by ensuring that findings did not come from misunderstanding the data (Bryman, 2016, p.386). This became a back and forth process of comparing my analysis to various expert testimonies and academic reports. Through this process I developed a narrative for how the system of global space governance operates, how it is evolving, and how the Wolf amendment is working within it.

4.3 Challenges and Reflections

Researching space-based issues has come with its own unique challenges and benefits. During the background interview stage, I reached out to a wide range of individuals involved in international space policy development. Unfortunately, because these topics are tied directly to both national security and international diplomacy, the willingness of many of those on the inside to discuss them in an official capacity was limited. However, the few who were willing to at least conduct interviews were also willing to share contact information with other insiders who were much more open to discussing these issues. Through snowball sampling I was able to acquire additional contacts and collect more informative interviews and personal conversations. Snowball sampling is a qualitative research method utilizing interviewee referrals to acquire new interview subjects (Bryman, 2016, p.415). Through these conversations I was exposed to an opportunity to attend the 34th Space Symposium in Colorado Springs, one of the largest space industry and security events globally (Space Foundation, n.d.). There I was able to conduct additional interviews and informal conversations that supported the findings in this thesis.

During these conversations it was very quickly apparent that while the Wolf amendment is recognized as a controversial political issue, not a single person I spoke to recognized the Wolf amendment as having significant influence on international space policy development. This was a surprising finding, and I had not adequately prepared myself for such an outcome[14]. Therefore, the interviews and conversations I conducted were only useful in informing the second component of the research design. However, this finding also revealed the novelty of the research presented in this thesis. The Wolf amendment's potential influence on international

[14] An example interview guide used in this research is shown in Appendix 3

space policy development has not been adequately recognized, and this research intends to remedy this lack of recognition.

To recapitulate, the analysis on the Wolf amendment is focused on identifying how it functions as a systemic feedback modifier, while the analysis of the two larger systems is focused on identifying existing systemic patterns that the Wolf amendment is embedded within. By creating this holistic understanding, it then becomes possible to analyze the Wolf amendment's potential for influencing the system of global space governance. The findings in this thesis are based on the collective information gathered from a wide-ranging search of documents, public statements, government hearings, and personal interviews. What follows is by no means an exhaustive presentation of what was found in this research, but a collection of the key findings.

5. Analysis

To organize the complexity uncovered in this thesis, the analysis is categorized into four sections. It begins with findings pertaining to the Wolf amendment itself: how, on what, and by whom the Wolf amendment exerts influence, a historical overview of how it has developed, and the likelihood of its persistence are covered in this section. In the second section the focus is expanded to present current and historical trend patterns of the larger U.S.-China relationship. The Wolf amendment is one of many components influencing this complex and dynamic relationship, so the findings will focus on which aspects of the U.S.-China relationship are most effected by the Wolf amendment, and how. This section introduces and describes the history of tension between the U.S. and China from the U.S. perspective, thereby giving context to the circumstances leading to the creation of the Wolf amendment. The third section expands the focus further and presents findings pertaining to the greater system of global space governance. As the make-up and history of this system was largely introduced in chapter two, this section examines current evolutionary trends to identify the context in which the Wolf amendment is exerting influence. Finally, the fourth section will be a discussion that utilizes complexity theory's concepts to combine the findings revealed in the prior sections. It will expand on the analysis and present the implications on what has been uncovered in this research.

5.1 The Wolf Amendment

In 2011, U.S. Congressman Frank Wolf inserted a small amendment into that year's appropriations bill. The appropriations bill is responsible for outlining the annual U.S. government budget and allocating funds for each of the various government agencies. Public Law 112-55, Section 539, or "the Wolf amendment", was only one paragraph in 150 pages of budget details affecting the many agencies that comprise the federal government. However, that one paragraph would prove to be a controversially influential piece of legislation for outer space affairs. At the time, Congressman Wolf was the chair of the United States House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies. A powerful position on the committee that is responsible for allocating finances for each of the civilian space agencies, including NASA. Congressman Wolf introduced language into the portion of the bill that outlined NASA's budget, effectively closing off the civil space relationship between the U.S. and China. The Wolf amendment stated:

> *"None of the funds made available by this Act may be used for the National Aeronautics and Space Administration (NASA) or the Office of Science and Technology Policy (OSTP) to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized by a law enacted after the date of enactment of this Act." (Continuing Appropriations Act, 2011)*

This effectively means that while this amendment is tied to NASA and the Office of Science and Technology Policy (OSTP) funding, neither agency can cooperate in any bilateral manner with actors representing the Chinese government, unless specifically granted congressional approval. Importantly, the amendment also adds that NASA cannot host any official Chinese visitors at its facilities[15]. In an interview published in Science magazine, Congressman Wolf explained his authorship of the amendment by saying about the Chinese:

> "We don't want to give them the opportunity to take advantage of our technology, and we have nothing to gain from dealing with them… And frankly, it boils down to a moral issue. ... Would you have a bilateral program with Stalin?" (Mervis, 2011).

[15] The entire draft of the original Wolf amendment can be seen in Appendix 1

Representative Wolf's feelings on China had been long-standing. His grievances were largely based on reports of wide-ranging espionage and data theft by the Chinese government, and his perception that the Chinese government was oppressive to the Chinese people and a malevolent force internationally (*Efforts to Transfer*, 2011, pp.10-15; Wolf, 2013). Additionally, Representative Wolf's personal staff's computers were hacked in 2006 and he reported to Congress that the Chinese government had accessed his case files on Chinese political dissidents (Wolf & Morse, 2011)

According to letters and congressional testimonies in which Wolf addressed his motivations for authoring the restriction, it appears that his goal was to halt the Obama administration from actively pursuing cooperation with China in space activities and deprive the Chinese government from accessing the prestige and technological benefits of space activity collaboration (Wolf, 2012; Wolf, 2013). NASA administrator Charles Bolden and his Office of Science and Technology Policy (OSTP) counterpart John Holdren were actively pursuing avenues of cooperation and dialogue with the Chinese just before the introduction of the Wolf amendment (Bolden, 2010; *Efforts to Transfer*, 2011, p.9). The OSTP represents the President in science and technology issues and was heavily relied upon by President Obama to organize and implement relevant policies both domestically and internationally. As the OSTP head, Holdren represented the White House in developing a bilateral space policy relationship with China. In an interview with Science magazine Wolf claims that his amendment blocks "the entire bilateral relationship on science and technology… the whole ball of wax" (Mervis, 2011).

However, Wolf's claim about the effects of the amendment was not entirely true at the time of his statement and remains an incorrect interpretation of the amendment today. As outlined in Chapter 2, there are many other government agencies that conduct space activities other than NASA and the OSTP, as well as the rapidly growing commercial sector. Furthermore, the amendment does not specify how cooperation occurring in multilateral settings should be regulated. Presumably the wording is quite clear that Wolf's amendment only pertains to bilateral activities. Yet, the reality of outer space relationships and activities is significantly more complicated than what the amendment's language contains. Thus, it is important to understand not only what the Wolf amendment was intended to do (as described above), but also what the amendment has effectively done – and continues to do – in reality.

The Wolf Amendment's Restrictions

The most straightforward and obvious restrictions emanating from the Wolf amendment pertain to scientific cooperation. As a result, much attention has been given to understanding the nuances of these restrictions. As an example, NASA has a dedicated frequently asked questions (FAQs) page dedicated to detailed explanations on what the amendment restricts for researchers working with Chinese colleagues or students (NASA, n.d.). In it is clear to see that there are very specific but complex boundaries in American-Chinese collaboration. For example, a NASA funded researcher may utilize Chinese published research, but only if it is publicly available online. If the researcher must request access to the published work, then they cannot use it (NASA, n.d.). Similarly, NASA-funded researchers may visit Beijing for scientific conferences, but only if the conference is clearly multi-national and "widely-attended".

As NASA's website is dedicated to FAQs, this suggests that researchers perceive the amendment to be highly restrictive and frequently seek clarification in interpreting its intent and the limit of its restrictions. One question asks whether researchers are even allowed to discuss general science topics with Chinese counterparts. In response, NASA's webpage states:

> "General scientific discussions do not constitute a bilateral policy, program, order, or contract and thus are permitted. However, these discussions must not involve discussions of bilateral collaboration between NASA and Chinese entities" (NASA, n.d.)

One of the reasons researchers express interest in clarifying the amendment's restrictions stems from confusion in the past. In 2013, organizers for the Second Kepler Science Conference at NASA Ames Research Center denied entry to several Chinese graduate students. The organizers claimed that the Wolf amendment barred Chinese citizens from stepping foot inside NASA facilities, and apologized for what that they considered to be a "deplorable" ban (Kepler Science Organizing Committee, 2013). In reality, the ban was a function of a temporary moratorium resulting from a security review that barred access to NASA facilities for citizens from certain countries, including China (*NASA Appropriations*, 2013). The conference organizers had believed the moratorium still stood and, mistakenly, that it was a requirement of the Wolf amendment rather than a separate and unrelated requirement.

Regardless of the restriction's origins, news of the event soon spread to academics across the U.S. and abroad that their Chinese colleagues and students were barred from attending the Kepler Conference, resulting in outrage and a public boycott of the event (Sample, 2013). This

outcry marked what was, for many, the first public introduction and large-scale awareness of the Wolf amendment. These events led to Congressman Wolf writing a public letter which chastised the head of NASA and explained that the conference was a multi-lateral event and thus not intended to be covered by his amendment (Wolf, 2013). Representative Wolf did however, include his view that the scientists who boycotted the event should redirect their "righteous outrage" for the Chinese government. In the end, the ban on Chinese participation was lifted for the event and Chinese participants were invited to reapply. However, the confusion surrounding the event cemented Wolf amendment's reputation for heavy restrictions.

Interestingly, Georgetown Law School researcher Hannah Kohler points out that while this exchange surrounding the Kepler Conference clarified that the Wolf amendment did not bar Chinese visitors from multi-lateral events at NASA facilities, the question nevertheless arose again later that year (Kohler, 2015). A new draft of Wolf's amendment was signed into law in January 2014 that included a slight adjustment in language. The subsection language changed from:

> 2011 Draft- *"[t]he limitation[s] in subsection (a) [precluding bilateral coordination] shall also apply to any funds used to effectuate the hosting of official Chinese visitors at facilities belonging to or utilized by NASA"*
>
> to,
>
> 2014 Draft- *"[n]one of the funds made available by this Act may be used to effectuate the hosting of official Chinese visitors at facilities belonging to or utilized by NASA".*

Kohler suggests that this change strengthens the previous restrictions and effectively bars visitors from the Chinese government or Chinese companies regulated by the Chinese government even at multi-lateral events held at facilities owned or paid for by NASA funds (Kohler, 2015). This change was an apparent reversal of Wolf's previous criticisms of NASA's interpretation of the amendment. A clarified approval mechanism was also added to the amendment detailing how NASA could request congressional permission to run bi-lateral projects or host certain events with Chinese participation in circumstances where no perceived risk of technology transfer exists. Consequently, this loophole in the Wolf amendment grants Congress the ability to terminate or restrict any space-related project with China deemed politically undesirable (Gibney, 2016). These seemingly contradictory changes make project planning difficult and disconcerting for any NASA science project managers who may want to

work with the Chinese. As a result, NASA scientists are likely incentivized by this regulatory climate to avoid partnership with the Chinese altogether rather than manage uncertainty of a politically challenging and/or volatile collaboration.

Beyond NASA, the Office of Science and Technology Policy has more directly confronted the limits and consequences of the Wolf amendment. The Obama administration originally took the stance that, constitutionally, the Wolf amendment should not apply to any action that could be considered the foreign policy imperative of the President (*Efforts to Transfer*, 2011). In a 2011 appropriations subcommittee hearing on President Obama's annual science budget request, John Holdren, head of the OSTP, made this position clear. The reply from Representative Culberson, a supporter of Wolf's amendment was equally clear:

> *"I note in your response to the chairman that the administration has decided that negotiations the president conducts are an exemption to the policy adopted by Congress… if anyone in your office, or at NASA, participates or collaborates or coordinates in any way with China, you're in violation of the statute. And frankly, you're endangering your funding and NASA's funding". (Efforts to Transfer, 2011)*

Despite this exchange, Holdren continued to conduct bi-lateral dialogue with China, an action that pointed to a Justice Department opinion suggesting that such actions were within President Obama's constitutional authority to permit. In response, Congressman Wolf petitioned the Government Accountability Office (GAO) to determine whether Holdren's dialogue with China violated his amendment and if the Justice Department's opinion was legally valid. The GAO found Holdren to be in violation of the amendment and the Justice Department opinion as not the proper authority to determine constitutionality (*Efforts to Transfer*, 2011). As a result, the Obama administration was forced to comply with the Wolf amendment by curbing OSTP led dialogues with the Chinese. One noteworthy point in this exchange was Congressman Culberson's explicit threat of endangering OSTP and NASA funding if cooperation was pursued. It is in the power of that threat that we can see how the Wolf amendment's power could reach beyond what is explicitly stated.

However, despite the Wolf amendment's ability to block certain forms of dialogue and projects, the United States and China still maintain a degree of civil space cooperation via the U.S. Department of State (DoS) and the National Oceanic and Atmospheric Administration (NOAA), both of which operate outside the scope of the Wolf amendment. In November 2017,

The Chinese National Space Administration and DoS hosted the third U.S.-China civil space dialogue in which recent successful cooperative projects were highlighted and future opportunities for cooperation were discussed. Cooperation between NOAA and the China Meteorological Administration (CMA) were emphasized as particularly successful (Jones, 2017). This collaboration is based on a bilateral cooperative agreement that has been in place since 1979 (NOAA, n.d.). NASA was also included in this agreement, and the OSTP had been designated as the U.S. executor of the agreement (*US-China Agreement*, 1979). Therefore, much of the space cooperation called for in the agreement has been cut off by the Wolf amendment. However, both NASA and the OSTP were invited to take part in each of the civil space dialogues. Charles Bolden himself was given congressional permission to attend the first two rounds of the dialogue (State, 2016). As very little about these meetings is made public, it is unclear if any NASA representatives were at the third dialogue.

The Space Station Dilemma

While the Wolf amendment does allow some room for conducting bilateral dialogue between the U.S. and China, cooperation on the largest projects in space remains firmly blocked. The implementation of the Wolf amendment coincided with the retirement of the U.S. Space Shuttle program. After the Space Shuttle was retired from service, Russian Soyuz vehicles became the only remaining option for sending astronauts to the International Space Station. This dynamic led to U.S. concerns that Russia would try to leverage this advantage in any tense political situations. These concerns were brought to fruition after the U.S. response to Russia's annexation of Crimea during which Russian politicians made suggestions that NASA should "use trampolines" to send astronauts to the ISS (Taylor, 2014). China was recognized as a possible alternative human launch supplier as they had proven that they could send people into space in 2003. But, this option became nonviable once the Wolf amendment eliminated the possibility of cooperating with China as an alternative source of transport.

With both Russian and Chinese cooperation under question, the only other alternatives for sending American astronauts into space were to encourage the U.S. commercial sector to develop human launch capabilities, a capacity which remained far in the future, or speeding up NASA's development of their next generation Space Launch System (SLS). To this day, neither of these options have come to fruition. Budget limitations and cuts slowed progress on the SLS,

which is still in development today[16] (Zimmerman, 2017). The commercial sector, with SpaceX as the current frontrunner in commercial launch capabilities, have made significant technological strides. However, while SpaceX sends regular payload deliveries to the ISS, no private company has yet developed human launch potential. Seven years after the Wolf amendment was introduced, Russia remains the world's sole provider of manned launches and retrievals from the ISS. Thus, finding a stable and secure method of sending American astronauts to the ISS remains a concern for NASA and U.S. policymakers. This concern has picked up renewed urgency as debates in the U.S. over when to retire the International Space Station have become contentious (*ISS After 2024*, 2017).

In 2018, President Trump instructed NASA to create plans to significantly reduce or end funding of the ISS by 2025 as part of an economic strategy for space project funding. Though it is "technically feasible" for the ISS to remain operational until at least 2028 (*ISS After 2024*, 2017, p.20), the White House wants to reallocate ISS designated funds to other future projects. The total cost of the ISS has been estimated around $100 billion dollars thus far (ESA, 2013), with NASA contributing by far the largest financial portion and continuing to pay between $3 to 4 billion annually. There are concerns that retiring the ISS prematurely will unnecessarily kill a major source of income for developing commercial space companies that rely on revenue derived from providing services to the ISS (Foust, 2018b; *ISS After 2024*, 2017, p.26). According to a 2017 testimony from NASA Associate Administrator William Gerstenmaier, 13% of all space launches globally have been associated with the ISS (*ISS After 2024*, 2017, p.14).

Currently the plan is to decommission the station in 2025, but there are hopes that a substantial portion of the $3 billion annually spent by NASA can be covered through opening the station to the commercial sector or to new partner countries. Space industry leaders however, are doubtful over whether a viable commercial market could be self-sustained without government support. Robert Bigelow, billionaire owner of Bigelow Aerospace, has suggested that he has concerns about the manner in which the commercial sector can fill the space station space (Smith, 2018a). Bigelow Aerospace builds and designs space stations and space habitats, so his company would be particularly prepared to benefit from the ISS coming to an earlier retirement. He suggests that demand for space-based science and tourism has not developed enough to support an independent commercial presence in LEO without substantial government support.

[16] The first unmanned SLS test flight will not occur before 2019.

In the absence of a viable private sector takeover of the ISS, adding new partner countries would seem a promising solution. This would also seem appropriate as the ISS has been recognized as one of the most successful international projects in modern history (SpaceSafety, n.d.). Here China would seem an ideal partner in terms of budget capability and desire to participate, but the continued restrictions put in place by the Wolf amendment suggests that invitation is unlikely to occur. Technically the Wolf amendment does not bar Chinese participation in the ISS project because it is a multi-lateral project. However, there is evidence to suggest that it has been an effective barrier preventing the steps for inclusion to be made.

While, the amendment itself does not explicitly mention any type of project that is particularly prohibited, it appears that the amendment's intent was to primarily block cooperation on projects such as the ISS. During a press conference at the 2014 International Astronautical Congress, NASA Administrator Charles Bolden explained that, "The prohibition is aimed mostly at human spaceflight, so we don't collaborate or cooperate with [the Chinese] there" (Foust, 2014). During his career, Bolden was openly opposed to this restriction and appeared to support the idea of including the Chinese in the space station (Selding, 2015b). This attracted the ire of Congressman Wolf, and in one particular exchange Wolf clearly expressed that the Chinese were not to be welcomed in the project.

In 2012, a Canadian newspaper reported that the ISS partner agency administrators held a meeting to discuss the potential of incorporate China into the ISS project. This article caught the attention of Representative Wolf, who responded with a letter to Bolden detailing his opinion that China was not welcome in the ISS project. In his letter he wrote:

> "As Charmain of the Appropriations subcommittee that funds NASA - and the author of the statute banning bilateral cooperation with the Chinese – I believe that any effort to involve the Chinese in the [ISS] program would be misguided, and not in the national interest" (Wolf, 2012).

This letter makes it evident that Wolf's influential position controlling NASA's funding was being used as a warning to enforce compliance with the intent of his amendment. Bolden and NASA could face threats to their funding if they continued to pursue a working ISS relationship with China. Therefore, while the Wolf amendment does not expressly prohibit Chinese inclusion, it does effectively achieve the same goal. This restriction likely applies both ways: while China

is effectively barred from joining the ISS, NASA will be barred from participating in any Chinese space station projects.

A few months after the U.S. shut down its Space Shuttle program, the Chinese launched their first prototype space station. Tiangong-1, or "Heavenly Palace-1", was a single module station that orbited the earth from 2011 to 2018. It hosted two separate crews of Chinese taikonauts[17] during this period and demonstrated that China was indeed a new major player in space. By 2016 they had launched an upgraded twin, the Tiangong-2 station. This station was the second in a planned series of prototypes to test space station technology before beginning the development of a larger, multi-module station more comparable to the ISS. The first module of the Tianhe, or "Harmony of the Heavens", station is planned to launch in 2020 (Jones, 2018b).

The station will be about a quarter of the size of the ISS but is expected to be open to astronauts from around the world. The Chinese have already begun agreements through the UN to make this larger station an international project (Selding, 2015a), and they have put particular emphasis on creating participation opportunities for developing nation space programs. "China is offering very attractive terms, conditions and features that [the] commercial sector is going to have a horrible time trying to compete with," said Robert Bigelow, during a press briefing, about the Chinese station's potential impacts on his company (Oberhaus, 2018). The ESA and Russian space programs have also expressed significant interest in participating in the project, with European astronauts already learning Mandarin in order to collaborate more closely with their potential Chinese counterparts (ESA, 2018).

The continued persistence of the Wolf amendment, and current U.S. congressional discourses, suggest that NASA will not be allowed to participate in any Chinese space station projects. Considering that the ISS is planned to be decommissioned in 2025 (pending further extensions), this could lead to a scenario where, perhaps temporarily, NASA will be the only major space agency without access to an orbital space station. This potential scenario is already a concern of U.S. policymakers. In a 2017 congressional hearing dedicated to investigating potential options for the ISS after 2024, NASA Associate Administrator for Human Exploration and Operations William Gerstenmaier explained:

> "I can see other countries interacting with China, and if we don't have a U.S. space station, then that would be the only space station available essentially to go to for

[17] Term for Chinese astronaut, similar concept to Russian "cosmonaut"

> these agreements, and that could pull away from America's leadership in space and technology towards China… I think there is a threat from the Chinese and their potential relationship with other governments and other countries that our international leadership role could be diminished unless we have a very strong human presence in space at that time" (*ISS After 2024*, 2017, p.70).

It is evident in this hearing that having NASA participate in the Chinese station is not being considered as a potential opportunity for post-ISS planning. The focus is instead on the next American led project.

Currently in development is a NASA led mission currently known as the Lunar Orbital Platform – Gateway (LOP-G). The purpose of this project is to develop infrastructure for human deep space exploration (Nasa, 2018b). The Gateway will resemble a much smaller version of the ISS and will operate beyond the Earth's atmosphere in a cislunar[18] . Unlike the ISS, the LOP-G will not have a permanent human presence but will instead support astronauts for temporary re-supply and organization missions. The LOP-G will serve as a gathering point to launch missions to the Moon and, eventually, Mars. Like the ISS, the station will be constructed by putting together different segments over time, with the first component scheduled to launch in 2022 (Davis, 2018).

The ESA, China, and Russia have all presented plans for lunar bases or colonies in the past, but it was not until NASA's call for participation in the Gateway station that international enthusiasm around a shared project was apparent (Foust, 2018a; Jones, 2018c; Selding, 2015b). There have been several proposals from ISS partner agencies offering potential station components for the Gateway (Nasa, 2018b), and they have released proposed international guidelines for space habitat construction to be utilized for the first time on this project (ISS MCB, 2018). However, there remains a great deal of uncertainty of the level and type of cooperation that will occur on the LOP-G.

A full sharing of responsibility on projects of this size comes with increased debate over design plans, strategies, and sharing of resources (Zak, 2018). This been a source of contention on the ISS, where budget struggles between nations have led to seemingly petty divisions, such as when Russian Cosmonauts were not allowed to use toilets on the American side of the station (Harding, 2009). If the LOP-G functions as a U.S. station with other countries supplying parts,

[18] Cislunar space is the area between Earth and the Moon

then decision-making processes become simplified. However, this would come at the cost of reducing the incentives other agencies have to support the project. Sergei Krikalev, director of human spaceflight for Roscosmos, demonstrated at the 34th Space Symposium that this uncertain level of collaboration is likely to be a contentious topic. “We see this new international initiative as a sequel of the International Space Station program to be built under the same principles ... as an international project without the primacy or the priority of one of the participating partners,” he said of the Roscosmos position on the LOP-G. “I believe the most important issue today is establishing an international legal framework for cooperation on construction of a cislunar station, similar to the ISS program” (Klotz, 2018). With the proposed 2022 initial component launch date, there is not much time to develop extensive international negotiations on these issues. Thus, whether the LOP-G will genuinely become a “sequel” to the ISS remains to be seen.

It also remains to be seen if China will get to participate in the project. If NASA leads the project then it will likely need to make bilateral agreements with the various international partners that come on board. This type of parternship with China is expressly prohibited as long as the Wolf amendment remains in effect. However, even if the project was made into a multi-national forum it remains unlikely that this project would be more acceptable for Chinese participation. While NASA is primarily interested in using the station for missions to Mars, other international partners have expressed interest in primarily using the station as a launch point to the lunar surface. China’s interest in lunar resource extraction, primarily helium-3, could conceivably trigger a defensive response from U.S. policymakers who do not want to support Chinese access to a potentially lucrative industry. As a result, it is unlikely that the U.S. and China will cooperate in developing a cislunar station, or in any other, in the foreseeable future. Interestingly, the possibility of U.S. collaboration with China on a space station does still exist, but without the participation of NASA.

While the Wolf amendment does not put restrictions on the commercial sector, it does impact private companies who wish to utilize NASA projects with Chinese customers. The space logistics company Nanoracks offers access and support for customers wanting to conduct activities in LEO. One noteworthy customer was the Beijing Institute of Technology, who wanted to send a science project on board the ISS. Nanoracks CEO Jeff Manber was forced to work around the Wolf amendment by communicating with the White House and Congress to

assure that no sensitive technology transfer would take place (Cassell, n.d.). Though this effort by Manber was successful and the Chinese project was permitted to go to the ISS, it is remarkable that a CEO had to consult so extensively with the U.S. government to coordinate a science experiment. Manber told a reporter at space.com that he was pleased his company was able bring the first Chinese project on board the ISS. He added, "I also look forward to one day soon working on board the Chinese space station" (David, 2018). His comment suggests that there is a willingness in the U.S. commercial sector to pursue cooperation with China, even if there is not amongst U.S. policymakers. More recently, Nanoracks has signed an agreement with a Chinese company to partner in space tourism programs (GBTIMES, 2018), suggesting that the commercial sector does indeed have the capacity to make connections with Chinese space partners while NASA faces significant limitations in accomplishing the same collaborative partnerships.

The Wolf Amendment's Longevity

An interesting aspect of the Wolf amendment is that it must be renewed every year. Each annual budget requires new legislation to determine how each government program will be funded. However, due to the highly complex and politically challenging process of negotiating how government funding is disbursed, congress generally prefers to amend the previous year's bill rather than re-writing the spending bill entirely. In this process, previously passed amendments are carried over and renewed in the next year's budget if no congressman takes the initiative to remove them. NASA administrator Bolden stated that collaboration with China was inevitable (Selding, 2015b), indicating a tacit expectation that once the Wolf amendment's author and primary supporter had retired, the amendment would likely fail to be renewed in the next budget bill. However, this expectation was imperative on Congressman Wolf's successor holding different views.

Instead, his successor as Chair of the committee was, and continues to be, Representative John Culberson. Culberson not only shares Wolf's opinions on China, but he had also attempted to introduce a predecessor of Wolf's amendment in 2010 (Culberson, 2010). Regarding his stance on the Wolf amendment Culberson stated, "I intend to vigorously enforce the longstanding prohibitions designed to protect America's space program." (Smith, 2015). Thus, despite Wolf's departure, his amendment has continued to remain in effect as those Congressmen responsible for NASA's budget continue to support it. Rather than diminishing in influence as Bolden had

predicted, the most recent proposed draft of the amendment includes a major new restriction. Released on May 8th of 2018, this version adds the newly recommissioned National Space Council to the list of government bodies restricted from conducting bilateral dialogue without congressional approval (Committee on Appropriations, 2018). So instead of trending towards fading away, the amendment is trending towards increased restrictions. This suggests that without a major political shift, the Wolf amendment will remain in place for the foreseeable future.

However, such political change may be on the horizon. The mid-term election of November 2018 could usher a Democratic majority into congress for the first time since the Wolf amendment originally passed into law. This would cause a change in subcommittee leadership, and potentially install a Representative with fewer reservations about collaboration with China. Under these circumstances, the Wolf amendment could potentially be removed in the next appropriations bill cycle. However, it is unclear how much resistance to this change would persist even with a change in appropriations subcommittee leadership. Furthermore, even if the Wolf amendment were to be removed, its influence may continue for at least the remainder of the Trump administration.

In April 2018, congress narrowly voted to accept Representative Jim Bridenstine as the new NASA administrator. During his tenure in congress, Bridenstine expressed concerns over China's plans in space and his support of the Wolf amendment. In a 2016 congressional testimony, Bridenstine critiqued the Obama administration's policies toward China, and expressed support for Representative Wolf's legislation:

> *"Unfortunately, NASA under this Administration seems more focused on forcing partnership with China than in maintaining our leadership. Former Chairman Frank Wolf was a leader on, and our country is grateful for his work. He first codified restrictions on cooperation with China in space. On top of their belligerent space activity, China is run by a brutal regime that imprisons dissidents and persecutes minorities. State-sponsored cyber-crimes have robbed our companies of billions of dollars of intellectual property, doing untold damage to our economy. When does it stop is the question?" (Losing to China?, 2016)*

As NASA administrator, Bridenstine has vowed to compete, rather than cooperate, with China in space activities (Huang, 2017). If the principles of the Wolf amendment reside with the

administrator of NASA, then it is unlikely that an appeal of the amendment would do much to ignite a more cooperative relationship with China. Additionally, mistrust of China is common throughout congress (Allen-Ebrahimian, 2018b). A recent congressional proposal to label American university-based Confucius institutes as foreign operators shows that current misgivings toward the Chinese government remain strong in U.S. political circles (Allen-Ebrahimian, 2018a). Thus, it is unlikely that there exists strong congressional support to create new working ties between the U.S. and China in space activities.

Based on these findings, it is likely that the Wolf amendment's restrictions will continue at least through the Trump Presidency. A key point remains that the Wolf amendment is only a small part of a much larger relationship dynamic between the U.S. and Chinese space programs, much less the U.S.-China relationship as a whole. It is additionally not the only legislation that bars cooperation between U.S. and Chinese space entities. Thus, to better identify and understand how the Wolf amendment impacts the larger system of global space governance, it is necessary to evaluate the broader U.S. – China space relationship.

5.2 Trends in the US-China space relationship

To understand how the Wolf amendment might be impacting the system of global space governance, this section expands the focus to identify systemic patterns in the U.S.-China space relationship. These findings will come primarily from the U.S. perspective. This is for two reasons. First, because it is significantly challenging to find publicly available and authoritative documents and statements from the Chinese perspective due to the opacity of the Chinese space program - a central theme of this section. The second reason is that in conducting this research, it became evident that the Wolf amendment's primary influences are strictly on the U.S. side of the relationship. While attempts will be made to include the Chinese perspective within this section, the main focus will be from the U.S. perspective.

Within the U.S., cooperation with China is an often debated and highly controversial subject. The Chinese are considered by the U.S. military as the number one threat to U.S. space interests (Dr. Joan Johnson-Freese. (Hidden Forces, 2017, min. 43:30). Space-based information and communication technology has become a key component of U.S. military strategy, and it is U.S. security analysts suggest that the Chinese recognize this as a priority domain to target in the event of conflict between U.S. and Chinese forces (Pollpeter et al., 2015). While the Chinese continuously advocate a win-win cooperative approach to international space endeavors, U.S.

policy makers are generally skeptical of this rhetoric (*Losing to China?*, 2016; *China's Space Programs*, 2015) due to a combination of uncertainty and lingering Cold War era geopolitical fears

Opaque China problem

A key challenge to U.S. interactions with China is that the U.S. government does not genuinely understand the Chinese space program (Garretson & Goswami, 2017). China's space program is famously opaque in terms of organization and ambition. U.S.-based reports have suggested that the Chinese space program is largely run by the People's Liberation Army, and that there is no genuinely civilian component (*China's Space Programs*, 2015; Pollpeter et al., 2015). The U.S. military and intelligence communities closely follow relevant events and activities to determine Chinese space capabilities, but must make assumptions about the Chinese command structure and their intentions. The underlying problem is the "dual-use nature" of space technology. In space, nearly any technology can potentially be used for both civil and military purposes. Therefore, it is difficult to discern whether an unknown activity's intent is hostile or benign. This fundamental challenge was most explicitly highlighted in the 2015 U.S.-China Economic and Security Review Commission hearing on "China's Space and Counterspace Programs". One of the panelists, Dr. Joan Johnson-Freese of the U.S. Naval Academy, explained:

> "*Though policies, doctrines, and public statements can provide indications of intent, ultimately intent is revealed by actions. A co-orbital rendezvous and proximity operation satellite in space, for example, can be observed. Whether the satellite is intended for such benign operations as assessing damage to another satellite or whether for nefarious purposes, such as ramming into another satellite, or both, can rarely be determined based solely on the hardware*." (*China's Space Programs*, 2015, p.24)

The panel's question and answer session revealed a contentious debate over the correct response to the unknown element of Chinese intent. Of the four panelists, Dr. Johnson-Freese was the only person who argued that communication and dialogue through cooperation was the best solution for addressing this problem. The other panelists took a more defensive stance and suggested that the U.S. should be concerned about China's space ambitions and assume the worst. Based on transcripts of the hearing, this majority view was also held by the commissioners overseeing the panel. Commissioner Michael Wessel, notably a Democrat, directly addressed this discrepancy:

"Let me ask you, Dr. Johnson-Freese, I was a little surprised, I have to say, by your testimony... your testimony seems to be swimming against the tide… Help me understand why you're such an optimist about cooperation, and what it should yield, and why those who are cautious, as Mr. Wolf is, has been, and many others, why we should be… ignoring some of their most recent activities?"(China's Space Programs, 2015, p.53)

Representative Wolf previously claimed that his amendment had wide bi-partisan support (*Efforts to Transfer*, 2011, p.9) and Commissioner Wessel's question corroborates Wolf's claim. Wessel's reference to China's recent activities is another key aspect of that exchange. As Dr. Johnson-Freese indicated, due to the opacity of the Chinese space program, actions have become the measure of intent. Specifically, three key events are often referenced to illustrate concerns over China's behavior and intent in space: an alleged theft in the 1990's, a controversial display in 2007, and a rude awakening in 2013.

A history of mistrust

After the 1986 Challenger space shuttle disaster, the U.S. shuttle program temporarily suspended, leading U.S. satellite companies to look to Russia and China as alternative launch suppliers. In 1996, two American companies commissioned the launch of a broadcast satellite on a Chinese Long March rocket that exploded shortly after take-off. The two companies, Hughes Electronics and Loral Space and Communications, sent experts to improve the technological capacity of the Chinese company responsible for the failed launch (Kohler, 2015). In 1998, a congressional committee investigated the incident and released a report detailing how the Chinese company had stolen technology from the satellite wreckage and had utilized the technology shared by the U.S. companies to improve Chinese ballistic missile technology. Hughes and Loral were indicted in violating existing U.S. arms control export laws by sending experts to support Chinese rocket capabilities, and paid millions of dollars in fines. As a result, Congress voted to classify communication satellite technology as military technology. This reclassification dramatically increased regulations for private companies dealing with satellite technology by making them subject to the highly restrictive International Traffic in Arms Regulations (ITAR) system (*Yearbook on Space Policy*, 2015, pp.249-252).

The next and most commonly referenced event in the U.S.-Chinese relationship was a Chinese anti-satellite weapons (ASAT) test in 2007. During the test, the PRC fired a kinetic impact missile at a defunct Chinese weather satellite. The resulting impact created over 3,000

pieces of space debris, making it the greatest debris creation event to occur in human space activities. The test brought international condemnation to the Chinese and raised fundamental questions about the command structure of the Chinese space programs (*China's Space Programs*, 2015). It is still unclear if the Chinese military was unaware of the potential for space debris, or if they thought it was worth the risk. Regardless of the Chinese perspective, U.S. policymakers have labelled the incident as an irresponsible and hostile act. Gregory Kulacki of the Union for Concerned Scientists pointed out that the Chinese military had conducted multiple similar tests prior to and after the 2007 event. These had been tracked by the U.S. military without much alarm. However, the scale of the massive debris-creating event brought significant negative attention to the Chinese military space program (Kulacki, 2014). Toward the end of 2017, the Inter-Agency Space Debris Coordination Committee released a set of voluntary guidelines to prevent and mitigate the creation of space debris. These guidelines list China as a co-author via consensus (IADC Coordination Committee, 2007). This authorship suggests that either the backlash of the 2007 ASAT test made the Chinese more aware of the space debris problem, or that they decided that the statement originally intended by the missile test had been made.

However, while the 2007 incident caused consternation for U.S. policymakers, it pales in comparison to the alarm caused by later events. Rather, the 2013 "science" test, in which the Chinese military fired a rocket high into geo-stationary orbit, holds that distinction. Prior to this test, geo-stationary orbit had been known in U.S. defense circles as the "sanctuary" orbit where U.S. spy satellites could rest undisturbed and uncontested (Martin, 2015). This all changed when a Chinese missile was believed to have reached an altitude of 30,000km, effectively threatening the sanctuary orbit for U.S. spy satellites. For comparison, the International Space Station orbits the Earth at 408km. The Chinese claimed that this was a test to study energy particles at the outer reaches of Earth's atmosphere (Gruss, 2015). However, analysis conducted by Dr. Brian Weeden of the Secure World Foundation suggested that the flight pattern was inconsistent with such a mission, and instead was very similar a ballistic missile test. Another Chinese ASAT test conducted in 2014 seemed to further verify the Dr. Weeden's analysis of the 2013 test (Gruss, 2015). This test was seen by the U.S. security sector as a clear warning that the U.S. dominance of space was at risk.

The absence of greater understanding of these three events played a significant role in influencing the U.S.-China space relationship. Even the 2007 ASAT test could be viewed as a

mistake or an accident (Lewis et al., 2007), but due to the lack of in-depth U.S. understanding of Chinese priorities and perspectives, the U.S. assumed the worst, forcing these events to be viewed as dangerous threats to U.S. interests and security. Kulacki explains that the problem largely derives from Chinese military strategy.

> *"China's pronounced reliance on deception requires a lack of transparency about its military capabilities that makes it very difficult for U.S. analysts to assess how China intends to use space for military purposes. This lack of information has led U.S. analysts frequently to rely on speculation—much of it based on sources that are not credible or authoritative, and some of which may be intentionally misleading." (Kulacki, 2014)*

Another key barrier of understanding between the two countries is rooted in language. Many words do not translate well between Mandarin and English. Some of the key trust building concepts used by the U.S., such as the idea of "transparency", have a negative connotation when translated into Mandarin (Sadeh, 2010). Thus, even at the most basic levels of communication there are challenges to bridging connections and understanding through dialogue alone. These conceptual translation challenges are compounded when incorporating the highly specialized and technical language of space technology. Thus, active cooperation could conceivably be a more effective method than language-based communication for establishing an effective U.S.-China dialogue. In pre-Wolf amendment U.S.-China dialogue workships, human spaceflight was identified as a key area where cooperation could be achieved successfully, though a challenging avenue to pursue politically (Sadeh, 2010, p.12). Today, these challenges are perhaps even greater. As Commissioner Jeffrey Fielder said in 2015:

> "I think we've dealt with cooperation. The place is pretty opaque on every level decision-making wise, and I don't particularly see why dialogue on space will give us any more insight into their decision-making process." (2015 transcript, p57).

A key theme in the U.S. unwillingness to engage is a fear of losing its lead status in outer space activities.

Escalating US Rhetoric

The idea that the U.S. is at risk of losing its leadership role in space activities is becoming increasingly pervasive throughout U.S. space decision making processes (*Losing to China?*, 2016). Politicians, CEO's, space analysts, and research program managers in the U.S. all agree that while the U.S. space program remains in the lead in terms of capability, the Chinese space

program is accelerating consistently and rapidly (*Losing to China?*, 2016; *China's Space Programs*, 2015). With this in mind, they suggest that the Chinese will be able to reap rewards from space the U.S. should have already been collecting (Smith, 2018b). One of the driving themes is that China's space sector has steady and strong support from the Chinese government, a strength that the U.S. space program lacks (*Losing to China?*, 2016; Smith, 2018c). This rhetoric can heavily influence which types of programs get funding and how both Congress and the public view the potential for cooperation with China. Within this dialogue, increasing military capability and reducing commercial sector barriers take priority over science projects with an international cooperation angle.

As a result, the U.S. military budget for developing new technologies and space-based military capabilities is increasing (Erwin, 2018b). These budgets are growing as part of a shift in military focus from combatting terrorism to Cold War style power balancing. Russia and China are seen as the primary "enemies" of the United States, and space is regarded as a key strategic domain that will play a part in any confrontations between these states (Coats, 2018, p.13). Space policy academics have pointed to increased conflictual rhetoric in the U.S.-China relationship (Johnson-Freese, 2015).

U.S. military leaders have appeared on public broadcasts such as 60 Minutes to discuss the Chinese threat that Americans face in outer space (Martin, 2015). In early 2018, President Donald Trump advocated for the creation of a new "Space Force" branch of the military (Erwin, 2018c), though Congress rejected the concept as recently as 2017 (Cohen, 2017). The President echoed space security advocates who have suggested that current geopolitical realities necessitate such a development. Discourses that suggest America's enemies threaten the U.S. in space with potentially long-term and far-reaching international consequences are becoming accepted fact within certain political circles (*China's Space Programs*, 2015; Coats, 2018; *Military Space*, 2017). As a result, U.S. military leadership have already declared that space is a present and future warfighting domain (Smith, 2017).

Chinese military authors claim that war in space is inevitable and that in preparation China must develop a strong military space capability, a discourse creating much concern among U.S. space security analysists who argue that the only way to keep outer space safe is establish a completely dominating military presence (*Military Space*, 2017; Pollpeter et al., 2015). Defense leaders have warned of the potential for a "space Pearl Harbor", or a surprise attack on U.S.

assets (*Commission on Space Security*, 2001). This rhetoric has also taken hold amongst congressional leadership. For example, in a May 2018 House Armed Services Committee budget debate, Representative Jim Cooper mentioned, "I think that any member of this committee who wants to make sure that we avoid a space Pearl Harbor will support the subcommittees' work…" (McLeary, 2018)). Even though current Defense Secretary Jim Mattis expressed optimism that eventually diplomacy would prevail, he too agreed that this would only be possible once the U.S. military could guarantee an uncontestable position of power in space. During an address at Johns Hopkins School of Advanced International Studies he explained,

> "We'll come up, I'm sure, with arms control agreements at some point, and we'll start getting this under control. But, for right now, it's sizing up the problem and making certain, again, that our diplomats will be negotiating from a position of strength" (Mattis, 2018).

A key problem in preventing conflict in space is that there is no mechanism that can effectively police or prevent aggressive behavior in space. Though efforts have been made to prevent an arms race in space, they have largely been unsuccessful at producing tangible results (Weeden & Samson, 2018). Specifically, Russia and China have repeatedly proposed a space weapons ban treaty at the UN Conference of Disarmament (NTI, 2017). The United States has refused to participate or negotiate on this treaty due to concerns that it would only apply to weapons placed in space, not Earth-based ASAT weapon systems. In a similar effort, the European Union introduced a voluntary international code of conduct that would establish trust-building norms to reduce the potential for conflict in space, but that effort was also unsuccessful (Listner, 2015) when Russia and China refused to accept this code as an alternative to their proposed treaty.

With the absence of a compelling mechanism to prevent conflict in space, the security-focused rhetoric is becoming embedded in the commercial sector as well. During the 34th Space Symposium in Colorado Springs, Tony Bruno, CEO of United Launch Alliance told interviewers at Politico:

> *"[Military officials] talk about space moving from an uncontested environment to one that is contested, and now they are even using language around it becoming a warfighting domain like air, land and sea… So one of the places we feel we can*

contribute to that and do right by the country is, as long as we're designing a new rocket, we're going to give it more capability" (Klimas, 2018).

Efforts are also being made by various defense, civil, and commercial U.S. space actors to increase collaboration, reduce redundancy in technological development, and improve military space innovation. A report requested by the Trump administration called for the various branches of the U.S. military to collect information on the "state of the defense industrial base" (Trump, 2017). Within the effort to conduct this information gathering exists a space industrial base working group which includes DoD, FAA, NRO, and NASA. Brennan Hogan Grignon, director of industry outreach for the secretary of defense, who oversaw the study described one of the main goals as determining, *"how we use commercial technology, how we leverage that technology and break down the barriers from an acquisition perspective to get that technology to our war fighters."(Erwin, 2018a)* While the U.S. defense sector is actively pursuing strategies to utilize commercial sector capability in developing new space technology, the commercial sector has its own set of concerns in regard to China.

ITAR and the Commercial Sector

As mentioned in Chapter 4, many within the space community did not consider the Wolf amendment to be a significant space policy issue. Rather, they view the amendment as a highly controversial political decision, but one without meaningful consequences for the development of space policy and infrastructure. Two of the major space trend reports, the European Space Policy Institute trends report[19] and the Space Report[20], never even mentioned its passing[21]. According to an interview with a space policy expert who holds observer status at COPUOS and is familiar with the Wolf amendment, the amendment is simply not discussed within international policymaking proceedings. This is largely because when it comes to the U.S.-China relationship, the International Traffic in Arms Regulations (ITAR) poses a far more immediate concern.

As mentioned, ITAR became more strict after the 1990's Cox report incident and the U.S. commercial space sector has been lobbying to ease those restrictions ever since. China has become one of, if not *the* biggest markets of space technology worldwide. However, selling any

[19] espi.or.at
[20] thespacereport.org
[21] Based on Wolf amendment title word searches in the entire Space Report online database and the 2011, 2012 and 2013 ESPI trends reports.

equipment with technology on the ITAR regulated United States Munitions List to China can have serious legal and financial consequences (State, n.d.). Indeed, ITAR's strict restrictions are so well known that other countries will advertise equipment they sell as "ITAR-free", indicating that even non-U.S. companies can be restricted by the legal regime (Hertzfeld & Jones, 2011, pp.645-657). For example, if a German manufacturer of satellite equipment uses a U.S.-produced part that is on the ITAR list in the manufacture of that equipment, then the German company is not allowed to sell their product to China. The number of space related technologies on the ITAR list have been reduced over time, notably under the Obama administration (Brown, 2013, pp.167-168), however this far-reaching impact remains a major issue today.

The opportunity to lobby for changes, and who may do such lobbying, is a key difference between ITAR and the Wolf amendment. While companies who are impacted by ITAR's regulations are free to petition and lobby congress, NASA is not allowed to lobby, advertise, or otherwise actively try to influence policy direction that pertains to the agency's funding. Nanoracks CEO Jeff Manber has perhaps most notably advocated for allowing businesses to cooperate with China in space enterprises. At the early 2018 session of the National Space Council Manber testified that U.S. businesses should be allowed to take advantage of the Chinese marketplace (Smith, 2018c). When former NASA administrator Charles Bolden was asked what was being doing to remove the Wolf amendment, his reply was "nothing" (Foust, 2016b). Paradoxically, however, there may be reason to believe that the Wolf amendment is quietly assisting NASA in acquiring more financial and political support.

Competition as Rocket Fuel

In Dr. Johnson-Freese's 2017 book Space Warefare in the 21st Century she describes a series of polls concerning American perspectives on NASA funding. One 2007 poll showed the average American believed NASA received 25% of the U.S. tax budget, a dramatic misperception as in 2007 NASA received just 0.58 percent of the U.S. tax budget (Dittmar, 2007). In 2013, Explore Mars and Boeing asked the public if they would support 1 percent of the U.S. budget going to a Mars mission (effectively doubling the NASA budget). 76% of respondants agreed. Yet in polls that ask whether theU.S. should spend more or less on space, the majority of respondants say less. Thus, there is a clear indication that the American people are largely unaware of what resources the U.S. is spending on space activities. Educating the public on the benefits and necessity of space activities is important, though often challenging.

Dr. Neil DeGrasse Tyson, astrophysicist and Director of the Hayden Planetarium, famously educates the public about space, though he has a more difficult time advocating for space science missions compared to the relevative ease experienced by space security advocates in selling the urgency of preparing for a "space Pearl Harbor" (Johnson-Freese, 2016, p.172).

In an episode of Dr. Neil deGrasse Tyson's podcast StarTalk Radio, he has a particularly revealing conversation about whether the U.S. needs competition to develop space technology. In the episode "Let's make America smart again: the future of NASA" (Matsos & Tyson, 2017, min 15:22), Dr. Ellen Stofan, former chief scientist at NASA, suggests that perceived competition with China is indeed maintaining political support and drive that encourages more space projects. They both agreed that the public drive to explore the cosmos is not as strong without such a clear challenge, and that a perceived rivalry with China can encourage increases in space program funding. This would correlate with an increasing U.S. national space budget and a return of interest for space issues in the American public discourse.

Increased public interest in space exploration appears to be coming from two fronts. On one hand, private companies such as SpaceX have been a huge source of public interest in space development. The recent successful launch of the massive SpaceX falcon heavy rocket, complete with live footage of Elon Musk's personal vehicle being fired off into an orbit in the direction of Mars, captivated audiences like few space events have in recent decades. History may remember the falcon heavy launch as equivalent to a second moon landing in terms of its ability to inspire the American public. Simultaneously, the launch marked a turning point where the private sector proved it could compete with national governments in space development. The other factor is increasing rhetoric of protecting American space dominance, which has been discussed in this section. Therefore, it can be recognized that trends from the U.S. side of the U.S.-China relationship are developing competitive and conflictual patterns of interaction, while the Wolf amendment is restricting cooperative patterns. These systemic patterns are embedded within the larger system of global space governance. The patterns occurring in this larger system suggest that conditions will be sensitive to these developments in the U.S.-China relationship.

5.3 Trends in Global Space Governance

Space 2.0: Increasing Complexity

Expanding the focus once more, the main overarching trend in the system of global space governance is an increase in overall complexity. There is an ongoing introduction of new and

diverse actors with space based interests, combined with new space activities and patterns of interaction between actors. The emergence of the private sector as a serious contributor to space based activities has caused many to consider this a new era of space exploration. Space enthusiasts use the terms “Space 2.0” and “New Space” to declare that space is no longer a government only domain (Pelton, 2016). Developing countries are also becoming active in space with their own burgeoning space programs or, lacking this, increasing investments in space-oriented technologies. For example, mobile phone usage in Africa is rapidly increasing and without widespread land based infrastructure in many countries, space-based satellite networks are becoming increasingly important for African mobile network development (UNIDIR, 2012). While this new stage of space history is celebrated by many space enthusiasts, a larger field of actors comes with new challenges such as the long-term sustainability of activities in outer space. As more and more players add objects into Earth’s orbit, there is increased pressure to address the risks posed by lacking situational awareness, space debris, and in-space military conflicts. Additionally, more voices at the table also makes it more difficultto reach consensus on international agreements.

Fall of Hard Treaties, Rise of Soft Norms

Space policy trend reports, including the McGill study, suggest that global space governance is trending toward a decentralized and less rigid policy making structure (Jakhu & Pelton, 2017; *Yearbook on Space Policy*, 2015). Interviews with officials from Canada’s COPUOS delegation confirmed that most space policymakers are not actively pursuing legally binding treaties as was done in the early decades of space exploration. Some nations continue to call for such treaties, particularly developing nations who fear being left behind in space activites in which they are not yet capable of participating (O'Brien, 2018). However, most major space-faring countries, particularly the U.S., specifically refuse to pursue any new legally binding treaties as the current policy focus is on easing restrictions rather than creating new ones. Scott Pace, executive secretary of the U.S. National Space Council, explained that the current administration,

> *“seeks to develop non-binding international norms that are complementary to the existing legal regime through both ‘bottom-up’ best practices developed cooperatively with other space actors, and ‘top-down’ non-legally binding confidence-building measures.”* (Pace, 2017).

If they refuse to participate then, as was the case with the Moon treaty, any new treaty becomes essentially meaningless. As a result, space policymakers are focusing on establishing norms through a combination of non-binding "soft" agreements and national level best practice laws (UNIDIR, 2015).

Non-binding agreements are essentially declarations of internationally agreed-upon norms and practices. These soft agreements can be established through UN committees such as COPUOS or through more focused forums such as the ISS working group. These types of agreements are easier to agree upon due to their non-binding nature, and can be effective at establishing definitions of unacceptable behavior. This has become the main regulatory approach for efforts in COPUOS, and some of the successes from this approach include the 2007 Space Debris Mitigation Guidelines (IADC Coordination Committee, 2007) However, even with not pursuing legally-binding agreements, the process is slow and challenging because COPUOS functions through consensus to prevent problems like that of the Moon treaty (Lyall & Larsen, 2017, pp.14-18). With 84 current members, each in a different economic position and with different interests, the scope of the challenge becomes evident. As international negotiation becomes increasingly difficult, the global space community has increasingly turned to best practice national policies (Foust, 2018c; Jakhu & Pelton, 2017).

Best practice national policies are legal regimes in individual countries that are recognized as successful by the international community (Jakhu & Pelton, 2017, p.50). Countries such as Luxembourg, the United Arab Emirates, New Zealand, and the U.S. have established national legal frameworks designed to both promote their individual space industries and encourage local adoption of international norms. Such regulations can be displayed as "best practice" models to encourage other countries to adopt similar regulations. However, these models certainly do not result in universal acceptance and are only partially effective for fully addressing the various challenges outlined above.

Decline of the Global Commons Concept?

In fact, this trend towards emphasizing international norms and national laws as the core of future regulations suggests that identifying space as the common heritage of mankind is a losing battle. Both the U.S. and Luxembourg have passed laws allowing for private industries to profit off the sale of resources originating from space. These laws are intended to create enticing business environments for companies working on developing asteroid and other extraterrestrial

mining operations (Selding, 2016). These laws represent national level decisions to ignore the debate on whether existing space treaties ban individual ownership of materials originating in space. The United States appears to have taken a clear stance on this issue, evidenced not only by the U.S. refusal to sign the Moon Treaty, but also in more explicit language. Scott Pace, Executive Secretary of the National Space Council made the following statement as a keynote speaker during the 12th Eilene Galloway Symposium on Critical Issues of Space Law:

> *"Finally, many of you have heard me say this before, but it bears repeating: outer space is not a "global commons," not the "common heritage of mankind," not "res communis," nor is it a public good. These concepts are not part of the Outer Space Treaty, and the United States has consistently taken the position that these ideas do not describe the legal status of outer space. To quote again from a U.S. statement at the 2017 COPUOS Legal Subcommittee, reference to these concepts is more distracting than it is helpful."* (Pace, 2017)

More firmly, the working draft of the American Space Commerce Free Enterprise Act being worked through congress right now includes the line: "Notwithstanding any other provision of law, outer space shall not be considered a global commons" (*Space Commerce Act*, 2018). If this bill continues its current course toward passage, this principle will be legally enshrined in the U.S. approach to space. This would be a highly controversial stance internationally, and has already triggered heated debates (O'Brien, 2018). Other space faring countries, including China, appear to be in support of establishing profitable space resource industries but would favor having an international body regulate it (Garretson & Goswami, 2017). However, as it is already difficult to come to agreements over norms of best practice, it is unlikely that negotiating the creation of an international regulatory regime would be successful in the foreseeable future. Thus, it seems that the current trends toward national regulatory regimes for space-based industries will continue and it is unlikely that space-based resources will be shared across humanity as the authors of the Moon Treaty had hoped. Interestingly, while the reality of space commercialization is causing trends toward decentralized policymaking, the coordination of human and deep space exploration is trending the opposite way.

Space Exploration's Role in Policy Development

According to members of the Canadian Space Agency's COPUOS delegation, the one aspect of space that is becoming more cooperative is that of exploration. Deep space and human

exploration projects usually attract the most public attention and are therefore associated with the greatest prestige. Playing an active role in space exploration can grant soft power to those capable of doing so (Brown, 2013). These projects are also often the most difficult and can be prohibitively expensive, so the momentum to work together is strongest toward this goal as more partners can contribute more resources. While spacefaring countries are expressing more interest in pursuing cooperative exploration projects, the institutions to coordinate such cooperation are yet to be fully established. Human spaceflight missions have been, and will continue to be, key drivers in influencing the further development of space infrastructure and political framing of space. Whoever has influence over these projects will influence future space developments. In an environment where it is becoming increasingly difficult to come to international consensus over many space policy issues, international decisions can be made more quickly through agreements between key elite actors. The political decisions made around human space flight programs will determine if there remains a unitary collection of elites, or if the elites will fragment into factions.

Determining who these elite players are and how the are organized will determine this outcome. The ISS MCB agency partners have demonstrated their capacity for policy leadership by designing and proposing international space exploration guidelines. For example, in 2018 the MCB partners, led by NASA, released a comprehensive draft of technological standards meant to guide best practices in human space exploration and to promote interoperability between space players (ISS MCB, 2018). These standards were released publicly to gain feedback and participation from other national and commercial space players actors. These standards are likely to be utilized in developing the LOP-G, which is expected to become a key component of the infrastructure that will enable humanity to leave Earth's atmosphere (Nasa, 2018b). As the LOP-G develops, it appears likely that the MCB will be the main decision-making body for the cislunar station (Klotz, 2018). Therefore, it seems reasonable to consider the MCB as the main gathering of elite space actors, comparable to a UN Security Council of space. But, as this thesis has established, one of the problems with the long-term credibility of the ISS MCB is that it does not include China.

China is widely recognized as the second most important space power following the U.S., and its absence in the ISS MCB leaves a key influencer out of the process. Outside of space issues, the Chinese have demonstrated that when they not allowed to equally participate, they

will create parallel competing institutions (Hellmann et al., 2014). With interest from other countries to participate, the Chinese space station could become a parallel sphere of influence with the Chinese at the center. If the Chinese are blocked from the MCB and the LOP-G project via the Wolf amendment and its supporters, then there will exist two competing "orbits" of elite influence. Due to the prohibitively expensive nature of these projects, most countries will not be able to participate in both. Therefore, there is likely to be competition between the two to incorporate more partners and get more funding.

One potential alternative to a two-power dichotomy is the International Space Exploration Coordination Group (ISECG). The ISECG is a voluntary cooperation mechanism for sharing information between agencies with goals of human and robotic space exploration (ISECG, n.d.). It is most notably responsible for creating the global exploration road map, which is the collective space exploration plan for all participating space agencies. The cislunar orbital station concept was originally introduced as one of two potential space exploration trajectories outlined in the original Global Exploration Roadmap (*First Roadmap*, 2011). China was not an original participant, though the Chinese said they would happily join the ISECG if offered an invitation (Selding, 2013). Therefore, the first two versions of the roadmap in 2011 and 2013 did not include Chinese input or projects. However, the Chinese did eventually join the group as the 2018 version of the roadmap includes the CNSA as a participating member and heavily emphasizes Chinese projects (*Third Roadmap*, 2018).

Currently, the ISECG is made up of 14 space agencies including the ISS partners plus China, India, Ukraine, Korea and Australia. There is potential for this body to become the defining forum for the elite government actors in space. However, it is unclear whether it will simply serve as a communication channel or eventually become a source of international standards in the same way that functioning project groups such as the MCB have been. Additionally, there are no ISECG projects that will drive the development of space technology in the same way that a space station or moon base project would. Furthermore, countries with developing space programs such as South Africa, Brazil, and Iran have voiced complaints that they are not treated as equal participants when planning international space policy (Paikowsky et al., 2014). Countries without space programs at all fear being left further behind as wealthy countries develop space policy without their input (Leib, 2015). As more States develop space capabilities, maintaining a centralized forum that does not include all interested parties is likely

to become politically challenging. The ISS MCB agencies are incentivized to work together on shared projects, and agreements between them are necessary, so cooperation is both practical as well as political. Without the development of ISECG led projects or the inclusion of China in the MCB, it is unlikely that either of these organizations will be able to maintain a centralized decision-making body of elite actors.

While it is unpredictable what form the future system of global space governance will take, complex systems thinking tells us that the early steps taken today will influence those forms. Though current trends suggest a decentralizing and increasingly flexible form of global space governance, human space exploration is moving in the opposite direction toward collaborative and cooperative development. Political initiatives around these exploratory endeavors are likely to remain influential on the development of international space policy and infrastructure. Due to the Wolf amendment's persistence, there is a strong possibility that cooperative space projects will fragment into at least two different blocks of political influence. In an environment where international treaties are becoming non-operative, the U.S.-China divide in space projects may indicate a persistent, bi-polar order in global space governance. In the context of these evolving systemic trends, Wolf amendment remains only a driver, rather than a root cause. By applying a complexity understanding of the Wolf amendment and the systemic trends revealed in this chapter, it is possible to recognize how the amendment exerts influence upon these systems.

5.4 Discussion: Complexity of the Wolf Amendment

Within complexity thinking, the Wolf amendment can be understood as a mechanism that modifies feedback patterns within the U.S. space governance system. These feedback patterns interact with the patterns of the larger systems within which the U.S. space governance system is embedded. These systems include the comprehensive U.S.-China space relationship and the system of global space governance. As a feedback mechanism, the Wolf amendment effectively restricts certain patterns of behavior while reinforcing others. Within the U.S.-China space relationship system, the Wolf amendment provides positive feedback to patterns of defensive posturing and provides negative feedback to patterns of cooperation. As these patterns develop over time, they create path dependent trajectories that are heavily influenced by their initial conditions (Cudworth & Hobden, 2011).

There are three categories of systemic patterns that characterize the relationship between the U.S. and China in space: one of cooperation, one of competition, and one of conflict. These patterns would likely occur without the Wolf amendment, but the Wolf amendment's influence upon them has been significant. By significantly reducing opportunity and ability for visible U.S.-Chinese cooperation, the Wolf amendment has strengthened the patterns of competition and conflict. The dominance of these patterns suggests that it is significantly less likely that the U.S. and China will be able to develop an openly cooperative space relationship without a pattern-disrupting intervention. As discussed, the U.S. and China do already have many agencies and private sector entities that cooperate. However, this cooperation is less visible to the public and to the U.S. policymakers who fund the U.S. space program. Thus, the perception of China as an opponent rather than a collaborator becomes self-perpetuating as the alternative view is rendered invisible. At the very least, the existence of the Wolf amendment turns any conversation about including China in projects like the ISS into a discussion about the potential threat that China's military poses to the United States.

As U.S. policymakers feared losing their leadership and dominance in space, the Wolf amendment emerged as a tool to help maintain a sense of security against a rising China. This created a positively reinforcing feedback loop: policymakers created the Wolf amendment to protect from an opposing China, which then reinforces the idea of an opposing China by not allowing China to become a cooperative or collaborative partner to the U.S., thereby pushing China to create its own competing projects, which in turn perpetuated the fear of a rising opponent and thus the cycle as a whole. This divide created the possibility of a long-term division in the spheres of influence in major space projects. As the system of global space governance is decentralizing and international guidelines are becoming more difficult to agree on, this division is likely to become influential in the development of future international norms and infrastructure. In such a scenario, the U.S. will have legitimized an external sphere of influence where it has little to no authority, thus risking the very leadership U.S. policymakers have feared losing.

6. Conclusion

In this thesis I have discussed the various trends that are occurring within the system of global space governance and how the Wolf amendment fits within them. The Wolf amendment

was created, as Rep. John Culberson put it, to "keep the Red Chinese out of [the U.S.] space program" (Leone, 2015). Despite expectations that this piece of legislation would eventually fade away (Selding, 2015b), it has remained influential and is likely to persist for the foreseeable future. The Wolf amendment is a small piece of the U.S.-China space relationship, but viewing this issue through a complexity lens reveals that it exerts significant influence over this relationship's development. By acting as a feedback pattern modifier, it manipulates the various systems in which it is embedded.

Primarily, the Wolf amendment prevents Chinese participation in major U.S. civil space projects. By doing so, it does not prevent most cooperation in space between the two countries, but rather it perpetuates an effective perception that the two nations do not, and should not, work together. This lack of potential cooperation in space activities perpetuates the perception of China as an opponent to the U.S. in space, and encourages the discourse that the U.S. should fear losing its outer space dominance. This self-reinforcing divide between the U.S. and China in space activities is particularly significant given current trends in global space governance. As international space policy trends towards decentralized and voluntary norm building rather than firm laws, the roles and actions of perceived leaders will become more influential. As major space exploration projects develop without the U.S. and China participating in joint endeavors, it is increasingly likely that a divide in space projects will occur. As these projects are likely to be particularly influential in both soft-power norm building and space infrastructure development, this divide will likely become a significant influence on the future development of space governance.

A major question that remains, which will surely be fascinating for scholars of International Relations to watch unfold, is how significant of a role will the commercial sector play in determining our destiny in outer space? In the New Space community of space entrepreneurs, it is commonly suggested that this is the age of private space enterprise, and the Elon Musk's and Jeff Bezos's of the world are going to chart humanity's course in space (Pelton, 2016). While it is true that they will influence the trajectory, both the Outer Space Treaty and the majority of IR scholars would argue that nation states will, and must, play the most significant role in international affairs. Therefore even if the commercial sector will exert significant influence on the future international space policy, it remains likely that the U.S.-Chinese civil relationship be key source of influence on the developing system of global space governance.

The trajectory outlined in this thesis can be construed as both a negative and positive result depending on one's perspective. On one hand the trends outlined here suggest that the United States and China will maintain a competitive and potentially conflictual relationship in space, meaning international policymakers working to maintain the peace and long-term sustainability of outer space activities have a challenging task ahead of them. With international space policy becoming more complex and decentralized, developing countries with less space capabilities will likely have little influence over the direction that humanity takes in space. However, in such a scenario developing countries may stand to benefit from a division in international space leadership. If the U.S. and China are forced to work separately, the possibility of the two sides competing for partners and resources will likely create more opportunities for other actors to get involved in the long-term.

Instead of a single hegemonic center with the major players at the center, there could a bi-polar, or multi-polar, space order with a wider potential spread of the benefits of space. Such an outcome would seem negative for those in the U.S. who want to see America maintain its leadership status and dominance in space. However, there is an argument to be made that such competition or conflict is a catalyst of technological development that the U.S. space industry needs to more rapidly explore the cosmos. For those who desire to see NASA develop the technology to send humans to Mars, perhaps the boost in funding and urgency created by a perception of competition with China is a positive outcome.

Regardless, the immediate value of this thesis is in addressing the gap in the international policy dialogue surrounding the existence of the Wolf amendment. This thesis is meant to fill that gap and bring attention to the big picture implications of the decisions being made in space policy circles today. It is clear that very few of the indviduals involved in international space policy-making have concerns over the Wolf amendment and its potential influence on the future of global space governance. Those that do openly debate the Wolf amendment tend to have a security focus that investigates the risk that cooperation with China could pose to the United States. While this is a crucial aspect of discussing the Wolf amendment, using a complex systems approach to create a more holistic perspective suggests that there is much more to discuss. It may be impossible to say where humanity will end up with its political structures when we become an interplanetary species, but the relationship between the United States and China in outer space will likely have significant influence on that outcome. The early decisions

that will determine our future are being made today, therefore it is a worthy endeavor to investigate the path we have chosen.

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Appendices

Appendix 1 – 2011 Wolf Amendment

U.S. Public Law 112-55, Section 539

(a) None of the funds made available by this Act may be used for the National Aeronautics and Space Administration (NASA) or the Office of Science and Technology Policy (OSTP) to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized by a law enacted after the date of enactment of this Act.

(b) The limitation in subsection (a) shall also apply to any funds used to effectuate the hosting of official Chinese visitors at facilities belonging to or utilized by NASA.

(c) The limitations described in subsections (a) and (b) shall not apply to activities which NASA or OSTP have certified pose no risk of resulting in the transfer of technology, data, or other information with national security or economic security implications to China or a Chinese-owned company.

(d) Any certification made under subsection (c) shall be submitted to the Committees on Appropriations of the House of Representatives and the Senate no later than 14 days prior to the activity in question and shall include a description of the purpose of the activity, its major participants, and its location and timing.

Appendix 2 – 2018 Wolf Amendment

U.S. Public Law 115-141, Section 530.

(a) None of the funds made available by this Act may be used for the National Aeronautics and Space Administration (NASA) or the Office of Science and Technology Policy (OSTP) to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized by a law enacted after the date of enactment of this Act.

(b) None of the funds made available by this Act may be used to effectuate the hosting of official Chinese visitors at facilities belonging to or utilized by NASA.

(c) The limitations described in subsections (a) and (b) shall not apply to activities which NASA or OSTP, after consultation with the Federal Bureau of Investigation, have certified— (1) pose no risk of resulting in the transfer of technology, data, or other information with national security or economic security implications to China or a Chinese-owned company; and (2) will not involve knowing interactions with officials who have been determined by the United States to have direct involvement with violations of human rights.

(d) Any certification made under subsection (c) shall be submitted to the Committees on Appropriations of the House of Representatives and the Senate, and the Federal Bureau of Investigation, no later than 30 days prior to the activity in question and shall include a description of the purpose of the activity, its agenda, its major participants, and its location and timing.

Appendix 3 – Example Interview Guide

1. The most recent [agency] departmental plan suggests that international cooperation is critical for implementing the agency's goals. Can you briefly describe some the projects and goals the [agency] pursues with international partners?
2. What role do politics, and more so international politics, play in regard to your agency's ability to achieve these projects and goals?
3. Can you briefly describe the [agency] role in international governance forums such as COPUOS, and the political outcomes that the [agency] currently sets as priorities?
4. What are the major challenges and hurdles facing the international governance of outer space as you see them now? What challenges do you see in the future?
5. Are you familiar with the so-called "Wolf amendment" and other U.S. policies to restrict U.S. space interests from cooperating in any way with China?
6. Do you feel that policies that limit cooperation between major space players, such as the Wolf amendment, will impact how the challenges you mentioned are met? Why or why not?
7. Do policies such as the Wolf amendment affect how the [agency] pursues some international projects?
8. Does the [agency] see itself as a potential negotiator/ intermediary between the U.S. and China in space issues? If so, in what capacity?
9. As may be clear, my research is focused on determining the impacts, if any, of the Wolf amendment and similar policies on the international development of outer space governance. Do you have any thoughts or ideas that I should be aware of that have not already been discussed in previous questions?

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