# INTERNATIONAL SECURITY AND THE SPACE DOMAIN:

# APPLYING TRADITIONAL THEORIES OF

# INTERNATIONAL RELATIONS

# TO THE ASTROPOLITICAL

# ENVIRONMENT

by

ALLEN ERIC ROTTER

KARL R. DEROUEN, COMMITTEE CHAIR
DERRICK V. FRAZIER, COMMITTEE CO-CHAIR
EVERETT C. DOLMAN
WENDY WHITMAN COBB
STEPHEN BORRELLI
DANIEL J. LEVINE
HOLGER ALBRECHT

A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Political Science
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2020

## ABSTRACT


Traditional theories of International Relations have long been used to describe the politics of space. The space security debate itself reflects the inter-paradigm debate of the 1970s and 1980s in which neorealist and neoliberal institutionalist scholars argued over the constitutive character of the anarchic international system. This disagreement is projected onto the space environment and thus contending theoretical assumptions are used to justify opposing propositions concerning the securitization of the domain. Neorealists assume that militarization is an effective method of securitization while neoliberals assume that subscription to international institutions is a more effective method.

The extant literature on space security appeals to or extends from military doctrine and political psychology to make prospective space behaviors intelligible. In this dissertation, I apply the theoretical assumptions that undergird traditional schools of thought to the space security environment and operationalize them in a manner conducive to quantitative statistical analysis. I propose that the security status of space can be operationalized by the frequency of non-military payloads placed in orbit every year. This represents the perceived precarity of the domain among civilian and commercial industrial leaders. I operationalize the neorealist explanatory variable as the frequency of military payloads placed in orbit every year and the neoliberal explanatory variable as the annual number of ratified international space treaties. These observations are regressed against the dependent variable and alternative explanatory variables in order to discover which of them accurately accounts for space security.

This project utilizes an original, longitudinal database consisting of 195 political actors observed over 63 years from 1957 to 2019. Two estimator models are used to empirically analyze the respective effects of military activity and international space treaty subscription on the security status of space: feasible generalized least squares (FGLS) and generalized least squares (GLS) with Huber-White sandwich estimators. The results strongly support the neorealist position that military activity has a positive influence on security. The results to do not support the neoliberal institutionalist position that subscription to space treaty organizations has a positive influence on security.

## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| AHCOPUOS | Ad Hoc Committee on the Peaceful Uses of Outer Space |
| ATOP | Alliance Treaty Obligations and Provisions |
| CINC | Composite Index of National Capability |
| COPUOS | Committee on the Peaceful Uses of Outer Space |
| COSPAR | Committee on Space Research |
| COW | Correlates of War |
| DARPA | Defense Advanced Research Projects Agency |
| FGLS | Feasible Generalized Least Squares |
| GLS | Generalized Least Squares |
| GNSS | Global Navigation Satellite System |
| ICBM | Intercontinental Ballistic Missile |
| IGO | Intergovernmental Organization |
| IGY | International Geophysical Year |
| IL | International Law |
| INSCR | International Network for Societal Conflict Research |
| IR | International Relations |
| IRBM | Intermediate Range Ballistic Missile |
| ISS | International Space Station |
| ISTS | International Space Treaty System |

| | |
|---|---|
| LEO | Lower Earth Orbit |
| MEO | Medium Earth Orbit |
| MNC | Multinational Corporation |
| NASA | National Aeronautics and Space Administration |
| NEO | Near Earth Object |
| NPT | Treaty on the Non-Proliferation of Nuclear Weapons |
| NSSDCA | NASA Space Science Data Coordinated Archive |
| OEDC | Organization for Economic Cooperation and Development |
| OST | Outer Space Treaty |
| SIPRI | Stockholm International Peace Research Institute |
| UNCLOS | United Nations Convention for the Law of the Sea |
| UNODA | United Nations Office for Disarmament Affairs |
| UNOOSA | United Nations Office for Outer Space Affairs |
| UNTC | United Nations Treaty Collection |
| WMD | Weapons of Mass Destruction |

# ACKNOWLEDGEMENTS

I could not have succeeded in this project without the stalwart aid of my advisor and friend, Derrick Frazier. Inundated with important work as a scholar, an administrator, and a family man, he always made time for me both before and after we began working together on this dissertation. I could not have asked for a better chair, though I am sure he often wished for a better student. I would like to thank Everett Dolman, Wendy Whitman Cobb, Karl DeRouen, and Stephen Borrelli for their grace in agreeing to be members of my committee. I can only imagine how busy they were on a daily basis, and I am grateful for the time they set aside to read and review my work. I am doubly grateful for how polite and constructive they were in their criticisms along the way. I took every note seriously, and to heart, and was made better by their insights. The faculty in the Department of Political Science at the University of Alabama deserves my gratitude as well. Joseph Smith, Dana Patton, and Richard Fording held leadership positions during my time as a graduate student, and each of them showed me patience and kindness over the years. I would be remiss if I failed to thank Daniel Levine for possessing one of the most penetrating intellects on the planet and for still being a congenial, hilarious person who made graduate seminars enjoyable as well as rewarding. My fellow graduate students and friends must be also acknowledged, as we shared the highs and lows of graduate school together: Wes Hutto, Erin Little, Matthew Millard, and Patrick Rickert.

Finally, I extend the most heartfelt thanks to my fiancé, Abbey Herringshaw, for her loving support and hopeless attempts at keeping me sane during the composition of this manuscript.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

# CHAPTER 1

# INTRODUCTION

This chapter serves as the introduction to the dissertation and contains five sections. The first section describes the pragmatic and political significance of space before articulating the international security concerns that are unique to this domain. The second section contextualizes the politics of space security through a brief historical discussion of the space race. The third section explains the research agenda for the dissertation. The fourth section describes the significance of the dissertation project. Finally, the fifth section provides a summary of the chapters that follow.

## 1.1. Introducing the Politics of Space Security

Most people likely never consider space to be a source of political consternation. Perhaps to them space is little more than a vast domain for scientific exploration and little less than the backdrop of popular science fiction stories. Not much thought is given to its pragmatic significance for daily human experiences and even less to the political significance that emanates from it. Modern life in the twenty-first century is tethered invariably to technological enterprises that operate in the space domain. Communication satellites provide high-speed internet access, high-definition television programming, email and facsimile exchanges, mobile and long-distance telephone calls, live videoconferencing, and civilian and commercial parcel tracking. Navigation satellites provide global positioning systems to facilitate travel and location guidance.

Observation and remote-sensing satellites provide meteorological, oceanic, and traffic monitoring systems to examine and forecast both natural and artificial planetary phenomena.[1]

Each of these satellite networks are endowed with cross-industrial utilities. Communication, navigation, and earth observation satellites serve civilian, commercial, and military purposes alike. The same type of technology that allows a civilian to access social media or send an email to a friend also aids in the communication of ground-based armed forces between each other or with command operation units located in distant places. The same type of technology that guides a family on a road trip vacation also helps military leaders locate troops deployed in remote regions of the world or find wayward vessels caught in storms among the high seas. For these reasons, space assets and architectures are considered "dual-use" technologies.[2]

In its simplest articulation, dual-use technology is that which can be used for both military and non-military purposes. The United States government's *Code of Federal Regulations* defines the category as "items that can be used both in military and other strategic uses…and commercial applications."[3] The United States Department of Defense expands the definition by adding a caveat concerning sustainable cross-market growth and a "sufficient commercial potential to support a viable industrial base."[4] A significant consequence of supporting dual-use technology is that the costs and revenues associated with it can be shared

---

[1] "What Are Satellites Used For?," Union of Concerned Scientists, accessed June 5, 2018, https://www.ucsusa.org/nuclear-weapons/space-weapons/what-are-satellites-used-for.
[2] For inexhaustive but notable discussions of dual-use technology, see: Elisa D Harris et al., *Governance of Dual-Use Technologies: Theory and Practice*, 2016; Steven J. Dick, *Societal Impact of Spaceflight* (Government Printing Office, 2007). Attend especially to Chapter 18: "Dual-Use as Unintended Policy Driver: The American Bubble," Roger Handberg, pgs. 353-368.
[3] "15 CFR 730.3 - 'Dual Use' and Other Types of Items Subject to the EAR.," LII / Legal Information Institute, accessed June 5, 2018, https://www.law.cornell.edu/cfr/text/15/730.3.
[4] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia University Press, 2007), 28. See also: Department of Defense, "Dual Use Science and Technology," available at http://www.acq.osd.mil/ott/dust/

across civilian, commercial, or military industrial sectors. Additionally, the horizons of research and development opportunities widen once other industrial sectors get involved, thereby increasing the extent to which one state may outpace foreign competitors in a technology race. Two issues illuminate the manner in which the pragmatic significance of dual-use technologies takes on a political character. The first issue is that major world powers have an incentive to suppress the diffusion of dual-use technologies in order to mitigate the effects of international uncertainty, particularly between rivals. Even the United States, a liberal democracy that promotes an agenda of globalization through transnational market expansions, exhibits circumspection at the prospect of other major powers gaining access to advanced military technologies and faces the challenge of controlling this access.[5] Dual-use space technology represents a compelling encapsulation of this challenge, as the history of its development is intertwined with the history of the US-Soviet Cold War and the technology races inherent to it.

The second issue is that dual-use technologies are often associated with the global commons and thereby operate in geographic theaters that represent an intersection between national and international interests. The global commons are a living relic and application of the ancient Roman principle of *res communis* which claims that certain domains, such as the high seas and international airspace, are held in shared ownership by all.[6] Modern international law reinterprets this principle as the "common heritage of mankind" which ostensibly mandates that these domains are beyond the purview of national sovereignty and appropriation.[7] International waters were included into the global commons as great powers began to master the high seas

[5] Johnson-Freese, 30.
[6] Charlotte Ku, "The Concept of Res Communis in International Law," *History of European Ideas* 12, no. 4 (January 1, 1990): 459–77, https://doi.org/10.1016/0191-6599(90)90002-V.
[7] Daniel A Porras, "The 'Common Heritage' of Outer Space: Equal Benefits For Most of Mankind," *California Western International Law Journal* 37, no. 1 (2006): 34.

with advanced naval technology. Upon the invention of the airplane and the ubiquity of air travel, international airspace was included as well. Finally, upon the advent of spaceflight, the space domain became a part of it also.

To say that the global commons represent a geographic intersection between national interests and international interests is to comment on the perceived extent of sovereign power within non-sovereign domains. There appears to be a potential conflict between the satisfaction of a state's interest in national defense and the satisfaction of the international interest of freedom of navigation and access. States found clever ways of resolving these issues in a proximal sense. For the maritime domain, international norms and eventually legal provisions were established for territorial seas, contiguous zones, and exclusive economic zones.[8] For the aeronautical domain, states adhered to a similar precept of "vertical sovereignty" derived from ancient Roman property law.[9] Over time, technological advancements and geostrategic incentives compelled states to realize that national security could not be fully satisfied through proximal sovereign claims. The so-called "hard shell" of the territorial state was an artifact of a bygone era and thus alternative tactics were required for national defense.[10]

Eventually, the global commons became theaters for the preservation of national and international security as much as they were conduits for civilian and commercial prosperity. Great powers with impressive navies and air forces patrol international waters and airspace in order to securitize and stabilize these domains, as well as the territories that border them, from potential threats. Securing freedom in the global commons through military activities has largely

---

[8] "Convention on the Law of the Sea" (UN General Assembly, December 10, 1982), Sections III & V. https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.
[9] Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York : Basic Books, [1985], 1985), 120.
[10] John H. Herz, "Rise and Demise of the Territorial State," *World Politics* 9, no. 4 (1957): 473–493.

been uncontroversial and remains so today in the high seas and international airspace. The space domain is an outlier in this regard, as the political discourse surrounding it has manifested a debate concerning the necessity for and permissibility of military operations. Rivalry between the United States and the Soviet Union during the Cold War was exacerbated by the very space race it precipitated. This competition ultimately augmented the traditional interpretation of the common heritage thesis, which was once a policy largely devoted to demarcating the beginnings and ends of national sovereignty and appropriation. When applied to the space domain, the common heritage thesis took on a new character that emphasized a pacific and disarmament-oriented perspective.

The political climate of the Cold War not only gave birth to the space race but also shaped its trajectory into the future by establishing norms of behavior based on geopolitical and ideological tensions. The rivalrous character of this era cannot be divorced from either the space race or the cooperative apparatus to which it gave rise. Viewed as an appendage of the nuclear arms race, the space race represented a geostrategic competition founded upon the national interests of advancing both material capabilities and international prestige. The United States and the Soviet Union continuously sought to out-compete each other towards technological supremacy. As this competition escalated, the logical connection between the advent of ballistic missile systems and the deployment of nuclear warheads created anxieties over an uncertain future. As the nuclear utility of the space domain became more apparent, the need for cooperation grew more profound.

A decade after the launch of Sputnik, international legislation was enacted to codify and regulate appropriate activities in space. The Outer Space Treaty (OST) of 1967 prohibited the placement of nuclear weapons in space and on celestial bodies, but it did not explicitly prohibit the militarization or weaponization of space.[11] This is a point of contention among military and policy officials who have been entrenched in an ongoing debate concerning the politics of space security. The debate is essentially a disagreement about the constitutive character of the space domain in its capacity as a global common. On one side of the debate are advocates of a position that I call “space internationalism” which is an analog of the International Relations (IR) theory of neoliberal institutionalism. This group argues that the common heritage thesis implies that the commons should be used for peaceful purposes, and therefore space ought to constitute a sanctuary from the weapons of modern warfare. On the other side of the debate are proponents of a position that I call “space statism” which is an analog of the IR theory of neorealism. This group argues that no domain of the global commons can be secure without a military presence to deter acts of aggression and disruption from potential enemies.

Again, this contention is unique to the space domain as a global common. The militarization and weaponization of international waters and airspace is widely accepted as a staple of the political character of those domains. This is likely attributed to the enduring military utility of these domains and its subsequent normative internalization over the centuries. Perhaps the relative recency of human spaceflight has given license for unconventional political discourse that is contrary to the norms associated with national behavior among the global commons. The complexity of contemporary international relations cannot be adequately understood without reference to the past. To establish a proper context for current space politics and space theory, an exploration into the early history of the space race is of paramount significance.

[11] “Outer Space Treaty” (UN General Assembly, January 27, 1967), https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

## 1.2. A Brief History of the Space Race

*The Cold War and the Origins of Spaceflight*

In the immediate aftermath of World War II, the United States had situated itself as the dominant military presence on Earth. With a clear lead in the development of atomic and nuclear technology, the procurement of a grand fleet of aerial bombers, and a strategic array of foreign military bases, the United States was outpacing the Soviet Union in the sprint to global hegemony. The extent to which the United States represented a nuclear threat was heavily contingent upon its ability to control airspace, to arm its bombers with nuclear payloads, and to infiltrate Soviet airspace from a neighboring outpost. To counteract the asymmetry of US military capabilities, the Soviet Union shifted its research and development sectors towards the advancement of ballistic missile technology.[12] This strategy attempted to circumvent the need to match the United States in aerospace defense ordinance and instead cultivate a more sophisticated delivery system for weapons of mass destruction (WMD). Intercontinental ballistic missiles (ICBMs) could traverse long distances quickly, could be deployed remotely, and did not require a human presence for payload detonation. The extent to which the Soviet Union represented a nuclear threat was contingent upon the establishment of a viable delivery system.

At the time, the United States had not devoted much attention to the development of advanced missile technology, but three key factors from the forthcoming decade reoriented its tactical interests.[13] First, by the early-1950s, US military officials realized that their erstwhile advantage in heavy bombers was gradually being attenuated by Soviet surface-to-air artillery defenses. This exacerbated the danger of airspace infiltration and ultimately reduced its strategic

[12] Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York : Basic Books, 1985), 6.
[13] Donald William Cox, *The Space Race: From Sputnik to Apollo, and Beyond* (Chilton Books, 1962), 40–41.

utility to relative obsolescence.[14] Second, by 1953, the US Atomic Energy Commission (AEC) successfully manufactured a hydrogen bomb that could be encased in a smaller, more compact shell than its atomic predecessor.[15] The advent of a smaller payload carried with it the prospect of a lighter, faster ballistic missile that could easily challenge the enormous rockets needed to deliver the heavier, bulkier payloads of the USSR. Third, by 1955, the Soviet Union had not only developed and tested a hydrogen bomb of its own but had also operationalized an intermediate range ballistic missile (IRBM) as a new delivery system.

These two events alarmed President Eisenhower and the Pentagon such that measures were immediately taken to assess the gravity of the situation. The Pentagon established the Strategic Missiles Evaluation Committee (SMEC) to explore the viability of a concerted technological shift towards the manufacture of ICBMs. The central thesis of the committee's research was that, if the United States did not initiate a full-scale reorientation of operations towards ICBM technology, then the USSR would likely gain military supremacy by the turn of the decade.[16] This news motivated Eisenhower and the National Security Council (NSC) to accelerate the Atlas, Titan, and Thor rocket programs of the United States Air Force (USAF) as well as the Jupiter rocket program of the United States Army.[17]

Until this point, the Eisenhower administration had promoted a foreign policy strategy of "Massive Retaliation" against the USSR which stipulated that any attack against US territories could result in a disproportionate nuclear response.[18] While the United States enjoyed its military dominance over the Soviet Union, this foreign policy agenda possessed the cachet of a strong

[14] Cass Schichtle, "The National Space Program from the Fifties into the Eighties" (NATIONAL DEFENSE UNIV WASHINGTON DC RESEARCH DIRECTORATE, 1983), 41.
[15] Schichtle, "The National Space Program from the Fifties into the Eighties." Ibid.
[16] Philip J. Klass, *Secret Sentries in Space* (New York: Random House, 1971), 16.
[17] Schichtle, "The National Space Program from the Fifties into the Eighties," 41.
[18] McDougall, *The Heavens and the Earth*, 326.

deterrence mechanism—no matter how artless and severe it was likely construed by foreign diplomats. Eisenhower was now confronted with the turning of the tide, however. If the USSR managed to operationalize an ICBM before the United States, then it would obtain a credible second-strike capability that would not only neuter the Massive Retaliation agenda and render it a dangerous precedent of international posturing but also—and far more importantly—supplant the United States in global military supremacy. The race to narrow the so-called "missile gap" by both superpowers endured well into the following decade.[19] By the mid-1960s, the Soviet Union had finally matched the United States in the production of WMDs and rocket delivery systems. By the late 1960s, the United States had fallen behind the USSR in the manufacture of both.[20]

This nuclear arms race between the US and the Soviet Union played a major role in the onset of the space race to come. While the development of advanced space technology did not include a nuclear component, the production of ICBMs constituted the foundation for future orbital launch vehicles.[21] Most contemporary space launch architecture is derivative of the very rocket that was originally designed to carry a warhead toward enemy territory. While the adaptation of this technology toward less bellicose pursuits is noteworthy, it neither absolved the space race of its inherently competitive tenor, nor did it mollify tensions and mitigate the existing arms race. In fact, the space race can invariably be viewed as contiguous with the existing arms race to the extent that the military competition from which it was born would eventually suffuse into the space domain.[22] This topic will be examined further below in the discussion of the

---

[19] Schichtle, "The National Space Program from the Fifties into the Eighties," 43; McDougall, *The Heavens and the Earth*, 217–27.
[20] Everett C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age*, 1 edition (London ; Portland, OR: Routledge, 2001), 79.
[21] McDougall, *The Heavens and the Earth*, 6.
[22] Donald G. Brennan, "Arms and Arms Control in Outer Space," *Outer Space: New Challenge to Law and Policy*, 1962, 124.

militarization of space. For the moment, it is enough to acknowledge the Cold War nuclear arms race as an antecedent to the space race. As will be articulated in the following section, the second major precursor to the space race was a civilian-scientific challenge that exacerbated the US-Soviet competition for prestige as opposed to geopolitical and military hegemony.

### *The International Geophysical Year and the Advent of the Artificial Satellite*

Most historical accounts of the space race begin with the groundbreaking orbital launch of the Soviet satellite Sputnik in 1957, but such an event does not happen in a vacuum. The motivation for the production of an artificial satellite must itself derive from the political climate of a preexisting space race. The International Geophysical Year (IGY) represented the source of this motivation. Founded in 1950 by a conglomeration of international physical scientists, the IGY sought to replicate the Polar Years of 1882 and 1932 in which national dignitaries convened under the banner of pacific, collaborative enterprises to explore the poles of the planet.[23] As opposed to studying terrestrial domains like its predecessors, the IGY promoted the scientific exploration of the Earth's thermosphere and exosphere. In its annual meeting in Rome in 1954, the organization officially issued a challenge to construct an artificial satellite to place in orbit for the purpose of analyzing these atmospheric regions.[24] In the summer of 1955, the only two nations then capable of perpetrating such a feat, the US and the USSR, accepted the challenge.

While the spirit of the IGY was truly international and scientific, the motives of the United States and the Soviet Union to engage with this challenge were nationalistic and geostrategic.[25] Prestige was a source of power both states wished to obtain in a perceived zero-

[23] Don E. Kash, *The Politics of Space Cooperation* (Purdue University Studies, 1967), 2.
[24] Hugh Odishaw, "The Challenges of Space," *American Journal of Physics* 31, no. 10 (1963): 110.
[25] McDougall, *The Heavens and the Earth*, 60.

sum game of technological advancement.[26] Even the nuclear arms race, despite the obvious deterrent utility of the WMD, was an artifact of a drive toward technological superiority—which itself was a totem of prestige. The United States was arguably ahead in this sphere of competition, as the destructive character of World War II had a far greater effect on the Soviet Union both in terms of economics and mortality. Moreover, as mentioned above, the United States enjoyed a considerable aeronautical and naval military advantage. Just as these factors contributed to the Soviet drive to outperform the United States in the development of ballistic missile technology, so too did they inspire the Soviet government to outcompete the United States in the advent of an orbital asset.

The United States, on the other hand, was less concerned with the acquisition of prestige as it related to the creation of an artificial satellite. The acquisition of information was its primary pursuit.[27] As the decade progressed, the Soviet's ground-based artillery defense systems were making US overflight surveillance endeavors more precarious—thereby diminishing the output of intelligence-gathering mechanisms not performed by traditional methods of covert espionage. Eisenhower's initial strategy was the so-called "open skies" policy whereby international air law would be augmented to allow all registered vessels, including those used for reconnaissance purposes, to navigate freely over sovereign airspace.[28] At the time, international air law was founded upon the precept of "vertical sovereignty" established in Roman property law (*cuius est solum eius est usque ad coelum et ad inferos*; "whoever owns the earth, owns everything above it to heaven and everything below it to hell").[29] This ostensibly gave a

[26] Dolman, *Astropolitik*, 93.
[27] Dolman, *Astropolitik*. Ibid.
[28] McDougall, *The Heavens and the Earth*, 127–28.
[29] McDougall, 120.

sovereign state the legal right to fire upon a potential belligerent invading its airspace with impunity equal to that of a belligerent's invasion by land.

Eisenhower wished to transpose a precept fundamental to international maritime law—the freedom of navigation and innocent passage—to international air law. While this would eventually become actualized in the United Nations Convention of the Law of the Sea (UNCLOS) roughly thirty years later, it was not a legal custom of the time. Therefore, US attempts at overflight surveillance were technically illegal. Eisenhower saw the artificial satellite as a means to evade this technicality. In the parlance of the Roman law mentioned above, Earth's orbit was "above heaven" and thereby immune from the extension of state sovereignty. Placing a reconnaissance satellite in orbit would satisfy both the United States' need for greater intelligence as well as its desire to avoid the stain of violating international law. The Soviet Union and other states, however, could still claim interpretive license and avow even Earth's orbit as congruent with "heaven," therefore maintaining the concurrent legal framework. Ultimately, Eisenhower's gambit worked, but perhaps not in the way he intended. The Soviets were the ones who won the space race by launching Sputnik first, and since it was their satellite in orbit trespassing over the aerospace of every nation, it was they who had to concede to the abjuration of vertical sovereignty.[30]

The launch of Sputnik was perceived by the international community, as well as by American media outlets, to be a staggering victory for the Soviet Union. After little more than a decade following the end of World War II, the USSR had finally usurped some semblance of prestige and authority from their former ally and concomitant rival. They legitimated the proposition, however superficially, that a socialist government and a communist economy could

[30] McDougall, 120; Dolman, *Astropolitik*, 94.

outperform its democratic, capitalist counterpart by developing ICBMs and satellites faster and more efficiently. The social and political narrative was demoralizing for the United States' reputation at home and abroad, but the defeat in getting to space first did not insinuate anything qualitatively about the actual space assets that the US was developing. The race to put a satellite into orbit would be but the first in a series of races that entailed human spaceflight, the continued development of more sophisticated architecture and assets, and ultimately the pursuit of soft-lunar landing capabilities. The momentous event that culminated the International Geophysical Year was the product of a decade-long arms competition that typified Cold War antipathies and anxieties. This competition would only grow fiercer in the forthcoming decades and its attendant set of existential anxieties would eventually lead to an unexpected cooperative apparatus.

### *Détente and the Aspiration of Cooperation*

The logic of the security dilemma paradoxically explains the necessity of both arms races and arms control treaties. In the context of the Cold War, contending superpowers vied for global supremacy by expanding the scope of their military capabilities respectively and relative to one another. Preparing for confrontation, however, is just as salient an endeavor as suppressing the activities that exacerbate the probability of said confrontation. The necessity of defense and the aspiration for peace are not mutually exclusive agendas—even between two mistrusting adversaries and especially between two rivals that intimately understand the cross-sector disadvantages of mutual assured destruction. Eventually, the satisfaction of security interests gives way to some expression of pacific diplomacy. The same era that experienced the onset of two multibillion-dollar arms proliferation industries also bore witness to a series of international arms control legislation aimed at curtailing the expansion of each industry. Each enterprise was successful in its own right.

For example, it was not until directly after the launch of Sputnik that the exponential growth of nuclear weapons occurred. Between 1958 and 1959, the United States expanded its arsenal of warheads by nearly five thousand units.[31] Less than a decade later, the US had manufactured over thirty-one thousand nuclear warheads compared to the Soviet Union's arsenal of over eight thousand. By 1978, the United States and the Soviet Union had reached near parity with roughly twenty-five thousand nuclear warheads each. While the total number of nuclear weapons in the world continued to rise for another eight years, powerful states in the international system came together on a number of occasions to find common ground in the face of prospective mutual annihilation. These treaties, agreements, and conventions focused not only on the proliferation of nuclear weapons but also on their use, the deployment of launch vehicles, the parameters of testing procedures, and pacification of certain geographic regions.[32]

Even before the fall of the Soviet Union, these treaties helped reduce the number of nuclear warheads globally. For example, at the apex in 1986, there were over sixty-four thousand nuclear warheads in the world. By the fall of the Berlin Wall three years later, this number had diminished to just over fifty-eight thousand units. By the fall of the Soviet Union two years after that, there were a total of just over forty-nine thousand warheads in the world. This narrative demonstrates that the securitization of two superpowers can coincide with pacific diplomatic relations—each of which generate from the same set of aspirations: the promotions of national defense and a stable world order.

[31] According to the Federation of American Scientists (FAS) Nuclear Notebook, the number of US warheads increased from 7345 to 12298 units while the USSR only expanded its arsenal from 863 to 1048 units. See: https://fas.org/issues/nuclear-weapons/nuclear-notebook/

[32] Anti-Ballistic Missile (ABM) Treaty of 1972; the Biological Weapons Convention of 1972; the Intermediate-Range Nuclear Forces Treaty of 1987; the Latin America Nuclear Weapons Free Zone Treaty (Tlatelolco) of 1967; the Limited Test Ban Treaty (LTBT) of 1963; the Missile Technology Control Regime of 1987; the Nuclear Proliferation Treaty (NPT) of 1968; the Peaceful Nuclear Explosions Treaty of 1976; the Seabed Arms Control Treaty of 1971; the South Pacific Nuclear Weapons Free Zone Treaty of 1985; the Strategic Arms Limitations Talks (SALT) of 1968 and 1979; and the Threshold Test Ban Treaty of 1974.

As the space race was imbricated with the nuclear arms race, the United States and the Soviet Union approached the expansion and utility of space technology much as they approached the analogous dimensions of nuclear weapons technology. Moreover, as the space domain was increasingly being considered a potential new arena of military engagement, these two superpowers engaged with it politically as they engaged with other similar domains.[33] The central objectives of each state were to prevent the other from obtaining an incontrovertible strategic advantage over the domain and to mitigate the onset of any future military campaign there. To achieve these ends, some agreement had to be made that set standards and expectations for future activities in space. Just as a series of bilateral and multilateral treaties were established to regulate the behavior of states in the nuclear, maritime, and aeronautical spheres, so too would a treaty system be erected to regulate behavior in space.

While the United States and the Soviet Union both had incentives to exploit the space domain for military purposes, they also had incentives to prevent the incipient transference of their nuclear rivalry to Earth's orbit. The specter of mutually assured destruction was no less ominous beyond the terrestrial realm, and the weaponization of space—particularly with nuclear weapons—became a central concern for both states. The sharing of this general concern, however, did little to impede the dynamism of realpolitik from entering in to diplomacy.[34] Just as these superpowers attempted to out maneuver each other geopolitically on the world stage, so too did they endeavor to out maneuver each other at the negotiating table. The first obstacle was the attempt to determine what constituted legitimate behavior in space. The prevailing issue that brought the US and the USSR together was the promotion of "peaceful" operations in Earth's

[33] Irvin L White, *Decision-Making for Space: Law and Politics in Air, Sea and Outer Space.* (Lafayette: Purdue University Studies, 1970).
[34] An observation made most forcefully in Dolman, *Astropolitik*, 164–69.

orbit and beyond, and yet neither state could agree on a definition of "peaceful." The Soviet Union claimed that the distinction should be drawn between the military and civilian uses of space where only the latter was deemed valid. The United States argued that the distinction should be made between peaceful and aggressive operations.[35] Ultimately, the United States capitulated to arguments over semantic clarity in which peaceful operations could still be construed as military in nature and thereby still problematic.

The next set of obstacles more acutely demonstrated the game of power politics at work in these negotiations, where each state attempted to imbue their own national interests into the regulatory framework. Essentially, Eisenhower and Krushchev exchanged proposals that neither could tenably accept. First, Eisenhower proposed that ICBMs should be banned because they could be used to destroy assets in space.[36] The argument was founded upon the savvy recognition that, if the Soviets were truly concerned with the military/non-military distinction of space operations, they should also be concerned about ground-based weapons that could be used to disrupt or destroy satellites. In earnest, the proposition was an attempt to neuter the Soviets' only viable military response to the imposing fleet of American bombers. In an equally savvy response, Krushchev claimed that the USSR would concede to the abolition of its ICBM projects if the US conceded to the removal of all nuclear weapons stationed in foreign bases.[37]

Eisenhower was in no position to accept these terms because foreign nuclear depots were the only true bridles to potential Soviet usurpations of East Asia and Europe. It became apparent that bilateral negotiations were not going to end with a mutually acceptable set of regulations, so the United States called upon the United Nations to contribute to the dialogue. In 1958, the Ad

---

[35] McDougall, *The Heavens and the Earth*, 181–82.
[36] "Letter from Eisenhower to Premier Bulganin" Department of State Bulletin (10 March, 1958), pg. 373; Dolman, *Astropolitik*, 126.
[37] "Soviet Memorandum of May 5, 1958," Department of State Bulletin (7 July 1958), pg. 19; Dolman, 127.

Hoc Committee on the Peaceful Uses of Outer Space (AHCOPUOS) was established to discover a viable vision for international space cooperation. This endeavor, however, could scarcely proceed before another disagreement ensued between the US and the USSR—this time over a clear bias in state representation. The committee was to be composed of nine member states based on their stated intentions of pursuing spacefaring projects.[38] The problem with this arrangement was that eight of the nine states were from the West, and the Soviet Union complained that its status as one of only two existing spacefaring powers ought to provide it greater representation in the committee. The US responded with a new proposal calling for a committee composed of eighteen states of which the Soviet Union would have three representatives and the rest would be Western and neutral states. While the UN General Assembly voted in favor of this new arrangement, the Soviet Union held fast to its demand for parity and took no part in the committee's discussions.

Without the participation of the USSR, the AHCOPUOS was ostensibly impotent. The committee attempted to put forth a small number of resolutions such as the injunction of a dedicated UN space agency and the establishment of a bureaucracy of space scientists. The only measure that was actually pursued was the call for the establishment of a permanent committee that could gain legitimacy through the satisfaction of Western and Eastern interests alike. Again, in the attempted formation of this new committee, the US and the USSR disagreed over membership. The Soviets demanded parity much to the chagrin of the Americans, and ultimately each side was accommodated. The new permanent committee would be composed of twenty-four states of which twelve represented the West and twelve represented a conglomeration of

[38] McDougall, *The Heavens and the Earth*, 258.

Eastern and neutral states.[39] By the end of 1959, the UN General Assembly voted in favor of the creation of the Committee on the Peaceful Uses of Outer Space (COPUOS) which represented the first tangible step towards international cooperation in space. It would take roughly the entirety of the following decade, however, for the COPUOS to issue mutually agreeable multilateral legislation.

Between 1966 and 1979, the COPUOS issued five treaties to the UN General Assembly for signature and ratification. The first and most notable was the Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (also known as the Outer Space Treaty, or OST).[40] The OST serves as a general guideline for national behavior in space under the auspices of promoting peace and stability. The second treaty was the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space of 1968 (also known as the Rescue Agreement) which outlined the processes by which endangered astronauts should be saved from distress and returned to their country of origin by their home state as well as other assisting spacefaring nations.[41] The third treaty was the Convention on International Liability for Damage Caused by Space Objects of 1972 (also known as the Liability Convention) which provided guidelines for state liability in the event that a space asset damages the property of another spacefaring nation in space or the property of any nation on Earth's surface.[42] The fourth treaty was the Convention on Registration of Objects Launched into Outer Space of 1972 (also known as the Registration Convention) which established a means of formal identification for space objects and a registration forum to be overseen by the United Nations Register of Objects

[39] McDougall, 258–59.
[40] http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html
[41] http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/rescueagreement.html
[42] http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/liability-convention.html

Launched into Outer Space.[43] The fifth treaty was the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies of 1979 (also known as the Moon Agreement) which added caveats to the OST provisions concerning the environmental integrity and property status of celestial bodies.[44]

### 1.3. Research Agenda

This dissertation identifies two corresponsive observations concerning contemporary international relations in space. The first observation is that the politics of space security still resembles behavior associated with the political climate of the Cold War. The second observation is that theorizing about the politics of space security still reflects the inter-paradigm debate of IR scholarship during the 1970s and 1980s. These observations are considered corresponsive because behavior and theory inform upon and augment each other. Changes in one sphere may be mirrored in or attributed to changes in the other. This dynamic is probabilistic and requires a causal link between two sets of actors. For space behavior and space theory to affect each other, a conduit of communication must exist between space policy officials and space theorists as well as a mutual sense of responsiveness.

The Cold War is over, however. In the decades that followed, alternative perspectives emerged in political theory that have not penetrated the theoretical discourse of space security. The traditional IR theories of neorealism and neoliberal institutionalism remain intractably entangled in a debate about the most efficient method of securitizing the space domain. While it may be tempting to interject alternative theories into the discourse, and while such an endeavor may yet be in the offing, one must first investigate the extent to which these traditional IR

[43] http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html
[44] http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/moon-agreement.html

theories accurately describe the space security environment. The primary objective of the dissertation's analytical project is to conduct a quantitative empirical analysis on the effects of neorealist and neoliberal assumptions, respectively, on the security status of the domain.

As is explained in greater detail in Chapter 3, I constitute the security status of the space domain as a mitigated state of external impediments to the freedom of navigation and access by potential spacefaring political actors. I argue that the operations of non-military space industrial sectors are the key to empirically capturing the relative security status of the domain as a whole. I identify two general non-military industrial sectors: civilian and commercial. I maintain that two general propositions: first, that stagnant, steady, or rising trends in non-military orbital payload operations indicate that the domain is relatively secure; and second, that sharp or downward trends in non-military payload operations indicate that the domain is relatively insecure. The logic supporting each claim rests on an assumption that industries will respond to fluctuations in the perceived precarity of the space environment. As a result, I propose that the number of non-military payloads placed in orbit per year represents an appropriate proxy variable for the security status of space.

The neorealist perspective on space security, embodied by the space statist position, argues that the militarization of space acts as a deterrence mechanism and thereby works to securitize the domain. I propose that the number of military payloads placed in orbit per year represents an appropriate explanatory variable for neorealist astropolitics. The neoliberal perspective, embodied by the space internationalist position, argues that regimes, treaty organizations, and international institutions signal commitments to non-aggression and thereby securitize the domain. I propose that the number of international space treaty ratifications per year represents an appropriate explanatory variable for neoliberal astropolitics.

After including control variables to represent alternative explanatory variables that may influence the dependent variable, and after testing for individual specific effects, I conduct two sets of regressions: feasible generalized least squares (FGLS) and generalized least squares (GLS) with Huber-White sandwich estimators. As is described in greater detail in Chapter 4, I choose these estimator models to account for a strongly balanced, non-autocorrelated, but heteroskedastic panel. The results strongly support the neorealist position and do not support the neoliberal position.

### 1.4. Significance of the Dissertation

This dissertation contributes to the study of international relations in space in four principal ways. First, it builds upon preexisting philosophical and qualitative scholarship that attempts to understand the politics of space security through the application of traditional IR theories to the space domain. Second, the dissertation advances earlier scholarship by examining the influence of neorealist and neoliberal assumptions on the space security environment through quantitative empirical analyses. Third, the analytical project required the construction of a database that provides valuable information for current and future research. The database offers detailed descriptive statistics on three general modes of national space behavior: orbital launches, orbital payloads, and space regime membership. Fourth, cataloging both national material space capabilities and international space treaty subscriptions allows me to construct typologies of political actors that contribute to the classification of space activities by relevant subpopulations. I establish three typologies germane to the topic that may be instrumental in future research: spacefarers, space powers, and space cooperators.

### 1.5. Chapter Summary

This dissertation is comprised of six total chapters. The first and present chapter introduces the pragmatic and political significance of the space domain and contextualizes the politics of space security through a brief history of the early space race. In this chapter, I also provide a cursory overview of the project's research agenda and a note on the dissertation's significance to the field.

In Chapter 2, I discuss the multifaceted nature of space politics across four broad issue areas: political history, international law, international cooperation, and the militarization and weaponization of space. The main thrust of this chapter is dedicated to the literature on space security which entails traditional schools of thought and ancillary typologies of political psychology for spacefaring actors.

In Chapter 3, I explain the relationship between traditional theories of International Relations and their respective analogs in the space security debate. This entails discussions of geopolitics as well as philosophical disagreements over ontological and epistemological perspectives pertaining to space security. This chapter also bridges the gap between the theoretical assumptions of neorealist and neoliberal astropolitics, respectively, and the operationalization of those assumptions for quantitative analysis.

Chapter 4 is dedicated to describing three central components of the dissertation's analytical project: the data collection process, research design, and methodology. In this chapter, I also explain my decision-making procedures for facilitating the descriptive statistics section of Chapter 5, such as the creation of typologies to establish subpopulations of the panel.

In Chapter 5, I provide extensive descriptive statistics to demonstrate the wide-ranging scope of orbital space activities from 1957 to 2019. The descriptive statistics pertain to four general categories: the population and temporal components of the panel data, the three typologies of political actors, orbital launches, and orbital payloads. The final section of the chapter describes the results of the two sets of regression models.

Chapter 6 is the final chapter of the dissertation and contains three sections. First, I recapitulate the trajectory of the dissertation to that point. Second, I discuss how the regression results described in Chapter 5 relate to the two hypotheses stated in Chapter 3. Finally, I outline the ways in which the dissertation may be utilized to advance the field of scholarship with avenues of future research.

# CHAPTER 2

# LITERATURE REVIEW

This chapter consists of four sections. In the first section, I provide a general overview of the literature pertaining to four space-related subjects: political history, international law, international cooperation, and militarization. In the second section, I review the literature on space security by focusing on important typologies concerning military doctrine and political psychology. In the third section, I categorize the typologies discussed in the second section into two general camps that constitute the two sides of the space security debate. I also introduce the parallels between these camps and the two camps engaged in the IR inter-paradigm debate of the 1970s and 1980s. The fourth section concludes the chapter.

## 2.1. Overview of the Literature on Space-Related Subjects

The politics of space is multidimensional and encourages a review of the literature that ramifies into the fields of history, international space law, international space cooperation, and the militarization and weaponization of space. It is important to note that most of the early historical literature on the space race did not engage in the subject necessarily out of an interest to discuss space as the focal point of the research. Rather, as is the case with Walter

McDougall's seminal text *The Heavens and the Earth*, the central subject was a diplomatic history of the Cold War that happened to intersect with competition over rocketry and other space-related technologies.[45]

Early historians of the space race were preoccupied with the role that technological innovation played in exacerbating tensions between the United States and the Soviet Union, tracking the manufacture of nuclear weapons to the development of ballistic missile systems that ultimately served as the precursor for later orbital launch vehicles.[46] More recent scholarship has carried on this tradition by revisiting the old rivalry through the prism of a post-Cold War perspective.[47] Meanwhile, others draw parallels between the competitive structure of the previous bipolar world order and current military competition among modern space powers.[48]

Space is not just an interest of IR scholars but also scholars of International Law (IL). The indoctrination of space as a global common is a key interest of legal scholars, many of whom draw spatial identity analogies between space and the high seas, international airspace, and Antarctica. Parallels are subsequently drawn between the international legislation associated

---

[45] McDougall, *The Heavens and the Earth*.

[46] Dodd L. Harvey and Linda C. Ciccoritti, "Us-Soviet Cooperation in Space.," *University of Miami Press*, 1974; Geoffrey Keith Charles Pardoe, *The Future for Space Technology* (Pinter London; Dover (NH), 1984); James Westwood, "Military Strategy and Space Warfare," *Journal of Defense and Diplomacy* 2, no. 11 (1984): 17–21; McDougall, *The Heavens and the Earth*; Colin S. Gray, "Space Arms Control: A Skeptical View," *Air University Review* 37 (1985): 73–86.

[47] Matthew J. Von Bencke, *The Politics of Space: A History of Us-Soviet/Russian Competition and Cooperation in Space* (Westview Pr, 1997); Stephen Lambakis, "On The Edge of Earth: The Future of American Space Power," *Kentucky: University Press of Kentucky*, 2001; Deborah Cadbury, *Space Race: The Epic Battle between America and the Soviet Union for Dominion of Space* (HarperCollins, 2006); Matthew Brzezinski, *Red Moon Rising: Sputnik and the Hidden Rivalries That Ignited the Space Age* (Macmillan, 2007); William E. Burrows, *This New Ocean: The Story of the First Space Age* (Modern library, 2010); Anne Millbrooke, "History of the Space Age," in *Handbook of Space Engineering, Archaeology, and Heritage*, ed. Ann Darrin and Beth O'Leary, vol. 8 (CRC Press, 2009), 195–207, https://doi.org/10.1201/9781420084320-c11.

[48] Dolman, *Astropolitik*; John J. Klein, *Space Warfare* (New York: Routledge, 2006); Joan Johnson-Freese, *Space as a Strategic Asset* (New York : Columbia University Press, [2007], 2007); James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford, Calif. : Stanford Security Studies, 2008., 2008); Roger Launius, "United States Space Cooperation and Competition: Historical Reflections," *Astropolitics* 7, no. 2 (May 2009): 89–100, https://doi.org/10.1080/14777620903073853.

with these domains and the international space treaty system.[49] International legislation on space activities has surpassed a myopic concern for security and now encompasses spheres of civilian-scientific and commercial enterprises. The increasing presence of non-military agencies and non-state actors in spacefaring operations carries with it an expanding curiosity about the role military affairs might play in stabilizing or destabilizing the space environment for these other actors. This is the primary locus of overlap between IR and IL scholarship on space, and thus it is appropriate to engage with the works of legal experts in order to edify the works of political scientists.[50]

International cooperation in space is an umbrella term for processes conforming to the subcategories of coordination and collaboration. Much of the general literature on this topic is descriptive in nature and focuses on the capacity for states to work together in space.[51] Many studies situate the prospect of cooperation within the context of a post-Cold War transitional political climate,[52] while others focus on the extent to which the domain itself represents an

---

49 Susan J. Buck, *The Global Commons: An Introduction* (Routledge, 2017); Scott Jasper, ed., *Securing Freedom in the Global Commons* (Stanford, Calif: Stanford Security Studies, 2010); Scott Jasper, *Conflict and Cooperation in the Global Commons: A Comprehensive Approach for International Security* (Georgetown University Press, 2012); Pranab K. Bardhan and Isha Ray, *The Contested Commons: Conversations Between Economists and Anthropologists* (Malden, MA ; Oxford : Blackwell Pub., 2008., 2008); John Vogler, *The Global Commons: Environmental and Technological Governance*, vol. 9 (John Wiley & Sons, 2000).

50 John Mcintyre and Daniel Papp, *International Space Policy: Legal, Economic, and Strategic Options for the Twentieth Century and Beyond* (New York: Praeger, 1987); MJ Peterson, "The Use of Analogies in Developing Outer Space Law," *International Organization* 51, no. 2 (1997): 245–74; Stephan Hobe, "Importance of the Rule of Law for Space Activities, The," *Proc. Int'l Inst. Space L.* 51 (2008): 351; Ram Jakhu and Steven Freeland, "The Sources of International Space Law," *Proceedings of the International Institute of Space Law 2013*, 2014, 461–478; Michael Sheehan, *The International Politics of Space* (Routledge, 2014).

51 Arnold Wolfe Frutkin, *International Cooperation in Space* (Englewood Cliffs, N.J. : Prentice-Hall, [1965], 1965); R.-M Bonnet and Vittorio Manno, *International Cooperation in Space: The Example of the European Space Agency.: Frontiers of Space.: Frontiers of Space*, Frontiers of Space (Cambridge, Mass. : Harvard University Press, 1994., 1994); James D. Rendleman and J. Walter Faulconer, "Improving International Space Cooperation: Considerations for the Usa," *Space Policy* 26, no. 3 (August 2010): 143–51, https://doi.org/10.1016/j.spacepol.2010.06.008.

52 Bhupendra Jasani, *Outer Space: A Source of Conflict or Co-Operation* (Tokyo : United Nations University Press, [1991], 1991); Michael E. O'Hanlon, *Neither Star Wars nor Sanctuary: Constraining the Military Uses of Space* (Washington, D.C. : Brookings Institution Press, [2004], 2004); Kenneth S. Pedersen, "Thoughts on International Space Cooperation and Interests in the Post-Cold War World," *Space Policy* 8, no. 3 (August 1992): 205–20, https://doi.org/10.1016/0265-9646(92)90050-6; Bertrand de Montluc, "Russia's Resurgence: Prospects for Space

environment conducive to cooperative practices.[53] A substantial amount of work is also dedicated to the role that regimes play in the securitization of the domain for military interests[54] as well as the stabilization of the domain for civilian and commercial interests.[55]

Coordination in space occurs when states agree to the establishment of certain standards of practice that streamline activity. It is the least problematic subcategory of cooperation because the processes that define it are innocuous methods of reducing the probability of environmental disruption, which compels states to mutually recognize the facility of making the same decisions in the face of a negligible incentive to defect. Spacefaring nations predominately coordinate through an adherence to the utility of established orbital planes and the radio spectrum. For example, different altitudes of Low Earth Orbit (LEO) are used for remote sensing, reconnaissance, navigation, and military satellites while Medium Earth Orbit (MEO) is used for telecommunications satellites.[56] The literature on orbital coordination focuses on the enduring

---

Policy and International Cooperation," *Space Policy* 26, no. 1 (February 2010): 15–24, https://doi.org/10.1016/j.spacepol.2009.12.002; Lynn M. Fountain, "Creating Momentum in Space: Ending the Paralysis Produced by the Common Heritage of Mankind Doctrine," *Conn. L. Rev.* 35 (2002): 1753.

53 David André Broniatowski et al., "A Framework for Evaluating International Cooperation in Space Exploration," *Space Policy* 24, no. 4 (November 2008): 181–89, https://doi.org/10.1016/j.spacepol.2008.09.012; Martin Machay and Vladimír Hajko, "Transatlantic Space Cooperation: An Empirical Evidence," *Space Policy* 32 (May 2015): 37–43, https://doi.org/10.1016/j.spacepol.2015.02.001; Cornelia Riess, "A New Setting for International Space Cooperation?," *Space Policy* 21, no. 1 (February 2005): 49–53, https://doi.org/10.1016/j.spacepol.2004.11.010.

54 Jose Monserrat Filho, "The Place of the Missile Technology Control Regime (MTCR) in International Space Law," *Space Policy* 10, no. 3 (1994): 223–228; David Tan, "Towards a New Regime for the Protection of Outer Space as the Province of All Mankind," *Yale J. Int'l L.* 25 (2000): 145; Mildred J. Peterson, *International Regimes for the Final Frontier* (SUNY Press, 2006).

55 Andrew J. Aldrin, "Technology Control Regimes and the Globalization of Space Industry," *Space Policy* 14, no. 2 (May 1998): 115–22, https://doi.org/10.1016/S0265-9646(98)00009-5; Wulf von Kries, "Towards a New Remote Sensing Order?," *Space Policy* 16, no. 3 (July 2000): 163–66, https://doi.org/10.1016/S0265-9646(00)00029-1; Dan St. John, "The Trouble with Westphalia in Space: The State-Centric Liability Regime," *Denver Journal of International Law and Policy* 40 (2012): 686–713; Joel A. Dennerley, "Emerging Space Nations and the Development of International Regulatory Regimes," *Space Policy* 35 (February 2016): 27–32, https://doi.org/10.1016/j.spacepol.2016.02.003.

56 Dolman, *Astropolitik*, 68–71.

viability of these practices[57] as well as the navigation of environmental contamination through high traffic and increasing levels of debris.[58]

Collaboration in space occurs when states agree to work through joint or shared activities. Unlike coordination, collaboration is problematic because even though states may mutually benefit by working together, they also perceive higher incentives to defect due to uncertainty and mistrust. This is reflected in both the realist critique of liberalism as well as the classic problem of collective action.[59] Much of the scholarship on space collaboration is dedicated to the utility of bilateral and multilateral agreements in both signifying and fostering trusting relationships among spacefaring nations.[60] Many studies focus on joint space activities as more tangible

---

[57] Harvey Joshua Levin, *Invisible Resource; Use and Regulation of the Radio Spectrum.* (PRESS, 1971); Stephen Gorove, "The Geostationary Orbit: Issues of Law and Policy," *The American Journal of International Law* 73, no. 3 (July 1979): 444, https://doi.org/10.2307/2201144; Carl Q. Christol, "Telecommunications, Outer Space, and the New International Information Order (NIIO)," *Syracuse J. Int'l L. & Com.* 8 (1980): 343; Marvin S. Soroos, "The Commons in the Sky: The Radio Spectrum and Geosynchronous Orbit as Issues in Global Policy," *International Organization* 36, no. 3 (1982): 665–677; Harvey Levin, "The Political Economy of Orbit Spectrum Leasing," *Mich. YBI Legal Stud.* 5 (1984): 41; Stephen E. Doyle, "Regulating the Geostationary Orbit: ITU's WARC-ORB-'85-'88," *J. Space L.* 15 (1987): 1; Harvey J. Levin, "Trading Orbit Spectrum Assignments in the Space Satellite Industry," *The American Economic Review* 81, no. 2 (1991): 42–45; Molly K. Macauley, "Allocation of Orbit and Spectrum Resources for Regional Communications: What's At Stake?," *The Journal of Law and Economics* 41, no. S2 (October 1998): 737–64, https://doi.org/10.1086/467411; Larry F. Martinez, "Satellite Communications and the Internet: Implications for the Outer Space Treaty," *Space Policy* 14, no. 2 (May 1998): 83–88, https://doi.org/10.1016/S0265-9646(98)00002-2; Christy Collis, "The Geostationary Orbit: A Critical Legal Geography of Space's Most Valuable Real Estate," *The Sociological Review* 57, no. 1_suppl (May 2009): 47–65, https://doi.org/10.1111/j.1467-954X.2009.01816.x; Lawrence D. Roberts, "A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union," *Berkeley Technology Law Journal* 15, no. 3 (2000): 1095–1144, https://doi.org/10.15779/z38dq1j; MJ Peterson, "Diverging Orbits: Situation Definitions in Creation of Regimes for Broadcast and Remote Sensing Satellites," *The American Political Science Review* 98, no. 2 (2004): 277–91.

[58] James Mason et al., "Orbital Debris-Debris Collision Avoidance," *Advances in Space Research* 48, no. 10 (November 2011): 1643–55, https://doi.org/10.1016/j.asr.2011.08.005; C. Pardini and L. Anselmo, "Assessing the Risk of Orbital Debris Impact," *Space Debris* 1, no. 1 (1999): 59–80; Serge Plattard, "Security in Space: Should Space Traffic Management Also Concern Payloads Management?," *Space Policy* 33 (August 2015): 56–62, https://doi.org/10.1016/j.spacepol.2015.02.005.

[59] Garrett Hardin, "The Tragedy of the Commons," *Science* 162, no. 3859 (1968): 1243–1248.

[60] Vladimír Kopal, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," *YB Air & Space L.*, 1966, 463; Brian Wessel, "The Rule of Law in Outer Space: The Effects of Treaties and Nonbinding Agreements on International Space Law," *Hastings Int'l & Comp. L. Rev.* 35 (2012): 289; Yun Zhao, "The Role of Bilateral and Multilateral Agreements in International Space Cooperation," *Space Policy* 36 (May 2016): 12–18, https://doi.org/10.1016/j.spacepol.2016.02.007; Leonardo P. Caselli, "Space Demilitarization Treaties in a New Era of Manned Nuclear Spaceflights," *J. Air L. & Com.* 77 (2012): 641; Porras, "The 'Common Heritage' of Outer Space: Equal Benefits For Most of Mankind."

manifestations of cooperation. States collaborate directly through enterprises such as the International Space Station (ISS)[61] and Sea Launch,[62] as well as indirectly through an openness of access to GNSS[63] and impact monitoring satellite systems.[64]

The militarization of space is the topic upon which most experts on international space relations are fixated. These processes gave birth to the space race and perpetuated its existence well into the twenty-first century by providing both opportunities for increased national intelligence and mechanisms for interstate deterrence. Most of the literature outlines the history

---

[61] Mary Catherine Devlin and William G. Schmidt, "Legal Issues Continue to Surround the International Space Station," *USAF Acad. J. Legal Stud.* 8 (1997): 237; Masahiko Fukushima, "Legal Analysis of the International Space Station (ISS) Programme Using the Concept of 'Legalisation,'" *Space Policy* 24, no. 1 (February 2008): 33–41, https://doi.org/10.1016/j.spacepol.2007.11.001; Alan D. Hemmings, "Why Did We Get an International Space Station Before an International Antarctic Station?," *The Polar Journal* 1, no. 1 (June 2011): 5–16, https://doi.org/10.1080/2154896X.2011.569377; John M. Logsdon, "International Cooperation in the Space Station Programme," *Space Policy* 7, no. 1 (February 1991): 35–45, https://doi.org/10.1016/0265-9646(91)90044-I; J. M Logsdon, "Commercializing the International Space Station: Current US Thinking," *SPACE POLICY* 14, no. 4 (1998): 239–46; Jie Long, "China's Space Station Project and International Cooperation: Potential Models of Jurisdiction and Selected Legal Issues," *Space Policy* 36 (May 2016): 28–37, https://doi.org/10.1016/j.spacepol.2016.05.002; Roger D. Launius, "Space Stations for the United States: An Idea Whose Time Has Come—and Gone?," *Acta Astronautica* 62, no. 10–11 (May 2008): 539–55, https://doi.org/10.1016/j.actaastro.2008.02.014; Lara L. Manzione, "Multinational Investment in the Space Station: An Outer Space Model for International Cooperation," *Am. U. Int'l L. Rev.* 18 (2002): 507; Rochus Moenter, "The International Space Station: Legal Framework and Current Status," *J. Air L. & Com.* 64 (1998): 1033; Eligar Sadeh, "Technical, Organizational and Political Dynamics of the International Space Station Program," *Space Policy* 20, no. 3 (August 2004): 171–88, https://doi.org/10.1016/j.spacepol.2004.06.007.

[62] Lina M. Cashin, "Lessons from Sea Launch:" (Fort Belvoir, VA: Defense Technical Information Center, April 1, 2001), https://doi.org/10.21236/ADA407104; Joosung J. Lee, "Legal Analysis of Sea Launch License: National Security and Environmental Concerns," *Space Policy* 24, no. 2 (May 2008): 104–12, https://doi.org/10.1016/j.spacepol.2008.02.002.

[63] J M Dow, R E Neilan, and C Rizos, "The International GNSS Service (IGS): Preparations for the Coming Decade," *20th Int. Tech. Meeting of the Satellite Division of the US Inst. of Navigation, Fort Worth, Texas*, 2007, 9; John M. Dow, R. E. Neilan, and C. Rizos, "The International Gnss Service in a Changing Landscape of Global Navigation Satellite Systems," *Journal of Geodesy* 83, no. 3–4 (March 2009): 191–98, https://doi.org/10.1007/s00190-008-0300-3; Chris Rizos, "The International GNSS Service: In the Service of Geoscience and the Geospatial Industry," in *International Global Navigation Satellite Systems Society IGNSS Symposium 2007* (Citeseer, 2007).

[64] Linda Billings, "Words Matter: A Call for Responsible Communication About Asteroid Impact Hazards and Plans for Planetary Defense," *Space Policy* 33 (August 2015): 8–12, https://doi.org/10.1016/j.spacepol.2015.07.001; Clark R. Chapman, "The Hazard of Near-Earth Asteroid Impacts on Earth," *Earth and Planetary Science Letters* 222, no. 1 (May 2004): 1–15, https://doi.org/10.1016/j.epsl.2004.03.004; A.F. Cheng et al., "Asteroid Impact and Deflection Assessment Mission," *Acta Astronautica* 115 (October 2015): 262–69, https://doi.org/10.1016/j.actaastro.2015.05.021; Jinyuan Su, "Measures Proposed for Planetary Defence: Obstacles in Existing International Law and Implications for Space Arms Control," *Space Policy* 34 (November 2015): 1–5, https://doi.org/10.1016/j.spacepol.2015.05.006.

of the militarization of space from its inception to the end of the Cold War, detailing how the earliest priority evolved from reconnaissance satellites to anti-satellite technology.[65] Other works focus on the geopolitical utility of space as either a new arena through which states can exploit new security measures or as an additional theater of potential combat.[66] As space capabilities become more advanced and more destructive throughout the twenty-first century, some scholars choose to provide comprehensive assessments of these new technologies[67] while others attend to the growing insecurity of the domain due to the ongoing arms race.[68]

### 2.2. The Space Security Literature

*Traditional Schools of Thought*

The traditional schools of thought that underlie the topic of space security were initially articulated in David Lupton's *On Space Warfare* as categories of preexisting military doctrine projected onto the space domain.[69] Lupton's work generated from the Air University's Airpower Symposium of 1981 in which criticisms were voiced concerning a dearth of space power doctrine in the United States Air Force. The prevailing doctrine at the time, the sanctuary thesis, was fundamentally non-military and thus unacceptable to a cohort of military luminaries. As a

---

[65] Jack Manno, *Arming the Heavens: The Hidden Military Agenda for Space, 1945-1995* (Dodd Mead, 1984); Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945-1984*, Cornell Studies in Security Affairs (Ithaca, N.Y. : Cornell University Press, 1985., 1985); Stephen Kirby and Gordon Robson, *The Militarisation of Space* (Brighton : Wheatsheaf, 1987., 1987); Matthew Mowthorpe, *The Militarization and Weaponization of Space* (Lanham, Md. : Lexington Books, [2004], 2004); Robert Preston et al., *Space Weapons Earth Wars* (Rand Corporation, 2002).

[66] Thomas Karas, *The New High Ground: Systems and Weapons of Space Age War* (Simon and Schuster, 1983); Colin S. Gray and John B. Sheldon, "Space Power and the Revolution in Military Affairs," *Air & Space Power Journal* 13, no. 3 (1999): 23; Benjamin S. Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space* (Santa Monica, CA: RAND, Project Air Force, 2003); Wilson Wong and James Gordon Fergusson, *Military Space Power: A Guide to the Issues* (ABC-CLIO, 2010).

[67] Bert Chapman, *Space Warfare and Defense: A Historical Encyclopedia and Research Guide* (ABC-CLIO, 2008); Carl Q. Christol, "Missile Launches, Militarization, Weaponization: Security in Space," *Proc. Int'l Inst. Space L.* 52 (2009): 99; Blair Stephenson Kuplic, "The Weaponization of Outer Space: Preventing an Extraterrestrial Arms Race," *NCJ Int'l L. & Com. Reg.* 39 (2013): 1123.

[68] Dolman, *Astropolitik*; Moltz, *The Politics of Space Security*; Johnson-Freese, *Space as a Strategic Asset*, 2007.

[69] David E. Lupton, "On Space Warfare: A Space Power Doctrine" (AIR UNIV PRESS MAXWELL AFB AL, 1988).

response to the symposium's conclusions, Lupton composed a text that classified four schools of thought for space power that reflected commonly held "belief structures."[70]

The first doctrine is the sanctuary thesis which defines the domain as a haven for peaceful space operations, free from weaponization.[71] The perspective emphasizes the national security benefits of an environment that is unencumbered by potential threats to satellites and other space assets. On a national level, this policy facilitates the extent to which early warning satellites can effectively monitor missile launches which strengthens the state's ability to safeguard tactical response mechanisms. On an international level, this policy facilitates the verification of arms limitation agreements through monitoring processes conducted by surveillance and reconnaissance satellites. The basic tenet of this school of thought is that the presence of conventional and antisatellite weapons in space would likely cause greater disruptions to the value of the aforementioned capabilities than if those weapons were absent.

The second school of thought is the survivability doctrine which deprioritizes the strategic advantages inherent to space assets.[72] This position does not imply that space assets are less valuable than is apparent or previously anticipated but that they are intrinsically less survivable than terrestrial or nautical assets. Satellites in orbit are more susceptible to damage or decay without the guaranteed benefit of remedy or remuneration for tremendously expensive technologies. The environment became particularly more dangerous during the late 1970s and early 1980s, when the Soviet Union began testing antisatellite capabilities with greater frequency. As a result, an absolute reliance on space assets for communication and reconnaissance during times of war might inadvertently undermine or cripple a state's chances of

---

[70] Lupton, 19.
[71] Lupton, 29–37.
[72] Lupton, 38–51.

success. For this reason, Lupton mentions that perhaps "the vulnerability school" would be a name more aligned with the position's meaning.[73]

The third school of thought is the high ground doctrine which claims that space is the ultimate high ground to ensure critical tactical outcomes during warfare or times in which deterrence is needed.[74] This position expands upon a long-standing terrestrial doctrine that predicts military success against foes in lower elevations if one dominates nearby elevations above them. The first expansion of this thesis was utilized with the advent of modern air forces, as the aircraft serves as a portable encapsulation of the high ground advantage. The strategic advantage of the space domain represents the natural next step in the doctrine's evolution.

The fourth and final school of thought is the control doctrine which is an extension of the geopolitical prescriptions attributed to sea power and air power.[75] The central idea behind this doctrine is that the value of a geospatial domain is only as good as its susceptibility to serve one's interests. In order to safeguard this outcome, complete control over the environment is necessary. Throughout history, the empires that established the largest armies and controlled the largest amounts of territory were considered masters of the known world. Similarly, empires that developed the largest navies were considered the rulers of the high seas. By the middle of the twentieth century, the state with the largest air force ostensibly ruled the skies. Controlling spatial domains all but guarantees a position of incontrovertible dominance. The same dynamic is speculated about space: whichever state can master Earth's orbit not only controls the domain but also controls the high ground in its entirety.

---

[73] Lupton, 20.
[74] Lupton, 52–59.
[75] Lupton, 60–70.

*Political Psychology and Space Security*

Peter Hays and Karl Mueller also categorize perspectives on space security, but their typologies are not necessarily doctrinal as is Lupton's four schools of thought. While military doctrine is undoubtedly a factor, as the literature on space security is invariably associated with militarization, these scholars classify the perspectives of spacefaring actors in ways that align more with political psychology. Each typology contains groups that exist on a spectrum between poles of support and opposition to the weaponization of space.

In *United States Military Space*, Hays categorizes political actors into four groups: space hawks, inevitable weaponizers, militarization realists, and space doves.[76] It is important to note that Hays's typology is directed mainly at US space strategy, but the tenets of this overall outlook could conceivably be implemented by any major space power. Space hawks contend that the space domain is an instrumental force multiplier for modern militaries and advocate for the immediate exploitation of the environment. This position hinges on the necessity to outcompete rivals who are likely employing the same strategy and is contingent upon the abject weaponization of the domain. As such, space hawks eschew recommendations for disarmament or arms control legislation.[77]

Inevitable weaponizers represent a mitigated version of space hawks. They agree with space hawks that the space domain is no different than any other spatial environment in its capacity to eventually succumb to weaponization. They disagree with space hawks insofar as "they are not convinced that space weaponization would be beneficial for U.S. or global security and they are unsure that space will prove to be the decisive theater of combat operations."[78]

[76] Peter L. Hays, *United States Military Space: Into the Twenty-First Century* (DIANE Publishing, 2002).
[77] Hays, 98.
[78] Ibid.

Inevitable weaponizers also differ from space hawks about arms control legislation, which they see as potentially helpful in suppressing the exponential expansion of space weapons, but they balk at the prospect of outright bans or moratoria.

Militarization realists do not support the weaponization of space, not because they adhere to the prescriptions of the sanctuary doctrine, but because they wish to maintain the status quo. The status quo is already beneficial to United States security interests both on Earth and in orbit. As the dominant military presence on Earth, the U.S. "has little to gain but much to lose by weaponizing space."[79] This group agrees with inevitable weaponizers to the extent that they agree that aeronautical combat will eventually bleed into space, but they argue that establishing weapons systems in orbit to fight battles there is ultimately inimical to national interests. Militarization realists support arms control legislation only if the policy diminishes the militarization of space by nations other than the United States.

Finally, space doves are basically the opposite of space hawks and align most closely with the sanctuary thesis. This group outrightly opposes the weaponization of space and, in some circumstances, the militarization of space as well. A common idea held among some members of this group is that military operations in space represent a "slippery slope" to weaponization and must therefore be resisted.[80] Many, however, perceive the virtues of early warning and nuclear detection satellites but rebuke even the use of military intelligence satellites for espionage. For obvious reasons, space doves embrace international arm control regulations for the space environment more than every other group mentioned above.

---

[79] Hays, *United States Military Space*, 99.
[80] Ibid.

Karl Mueller establishes a typology of six attitudes that are categorized into two camps of three.[81] The first camp involves three types of political psychology that agree with the sanctuary thesis: idealists, internationalists, and nationalists. Sanctuary idealists resemble the space doves from Hays's typology. This group outrightly opposes the weaponization of space with little to no regard for national defense concerns. Sanctuary idealists argue that the presence of space weapons encourages the advent of space warfare and the most desirable outcome for all is the absence of space warfare.[82]

Sanctuary internationalists are similar to idealists in that they oppose the use of space weapons, but their position is based more pragmatically on the logic of the security dilemma and the desire to prevent disruptions to the stability of the environment. Internationalists argue that orbital space weapons are largely offensive in orientation and difficult to securitize from attack, which makes their vulnerability attractive to rivals who would be compelled to engage in first-strike tactics.[83] The destabilizing effects generated from orbital military encounters are not only attributed to the bellicose climate but also the long-term dangers produced from the residual debris of the damaged asset.

Sanctuary nationalists align with Hays's militarization realist group. Nationalists believe that the United States, by virtue of its position as a dominant power on Earth and in space, benefits most by maintaining the status quo.[84] By exacerbating the weaponization of space, the U.S. can only work to diminish the already substantial benefits it obtains by being a global leader in space operations. Nationalists also contend that the weaponization of space by the United

[81] Karl Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (January 1, 2003): 4–28, https://doi.org/10.1080/1477-760391832499.
[82] Mueller, 10.
[83] Mueller, 11.
[84] Mueller, 12.

States only compels its rivals to enhance their military capabilities in the domain, driving forward the perpetual dynamic of the security dilemma. These continued military pursuits by the U.S., an already dominant world power, will be perceived by rivals as offensive machinations as opposed to defensive strategies.

Mueller's second camp involves three types of political psychology that promote the weaponization of space: racers, controllers, and hegemonists. Space racers align closely with Hays's category of inevitable weaponizers. This group is open to the promise of arms control and disarmament but skeptical about the extent to which such policies could ever be implemented successfully.[85] Space racers contend that the most important strategy a state can employ is preventing its rivals from exceeding its position in the hierarchy of military power. They also argue that the most advantageous time to weaponize space is contingent upon the weaponizing behavior of other states. For space racers, weaponization should be a defensive response to another state's attempt at an offensive advantage.

Space controllers fall somewhere between Hays's categories of inevitable weaponizers and space hawks. This group argues that space is no different than the sea and airspace in its capacity to be dominated by aspiring world powers. Space controllers believe that Earth's orbit is quickly becoming as important for non-military industrial sectors as it is for the military, and this significance will exacerbate the need for a state to utilize space weapons to safeguard its native civilian and commercial assets.[86] Less relaxed in its outlook than space racers, space controllers claim that the best time for a state to manufacture space weapons is whenever doing so will be most useful for the state's overall prospects.

---

[85] Mueller, 14.
[86] Mueller, 15.

Finally, space hegemonists are most similar to Hays's category of space hawks. This group steadfastly believes that space is not only an inevitable battlefield arena but it is also the last and most essential military theater associated with the planet.[87] This is the perspective where the high ground doctrine and control doctrine are espoused with the most vigor. Unlike space racers and space controllers, hegemonists propose no caveats or restrictions on their advocacy for weaponization. They argue that the most advantageous time to weaponize the domain is as soon as a state is capable of doing so and that the processes should continue unabated until the state has conquered the domain.[88] This perspective explains the name of this group. Their primary objective is to exploit the geopolitical domain for total global control.

## 2.3. The Space Security Debate

### *Generalizing Types*

The doctrinal typology of Lupton and the political psychology typologies of Hays and Mueller each situate space security perspectives on a spectrum between heightened militarism and relative pacificism. These typologies are important because they demonstrate that the politics of space security is nuanced. Nevertheless, it is commonplace to reduce these perspectives into two broader camps that are engaged in a debate about the constitutive nature of the space domain and the scope of appropriate behavior within it. In this dissertation, I refer to the two camps as space statists and space internationalists. Space statists are biased towards the militarism end of the spectrum, and space internationalists are biased towards the pacific end of the spectrum. It is important that I contextualize this reduction in order to avoid criticism for being too superficial

[87] Ibid.
[88] Mueller, "Totem and Taboo," 16.

or whimsical with what would otherwise be perceived as sophisticated and relevant distinctions. There is precedent for this conflation of views.

As the previous section reveals, there are several perspectives that can be established to describe various positions on the space security spectrum, but many experts in the field suggest that it is permissible to reduce them into two general groups. For example, in *The Politics of Space Security,* James Clay Moltz concedes that the field is dominated by a debate between promulgators of the "space defense" and "space sanctuary" theses, respectively.[89] In *Astropolitik*, Everett Dolman claims that the two classic schools of thought on the subject view the space domain as either a "strategic sanctuary" or "the ultimate high ground."[90] In "Totem and Taboo" discussed in the previous section, Mueller argues that his typology of six perspectives can be conceptually aggregated into two groups of three in which each larger camp promotes "space security" and "space sanctuary" respectively.[91] Similarly, in *United States Military Space,* Hays argues that three of the four categories in his typology reflect the "space defense" thesis and one reflects the "space sanctuary" thesis.[92]

Each of the typologies mentioned above includes a description of a particular group's position concerning two central topics: the militarization of space and international space treaties. This is significant because, in the next chapter, I draw parallels between the space security debate and the inter-paradigm debate among IR scholars in the 1970s and 1980s. Neorealism and neoliberal institutionalism are embodied by space statism and space internationalism, respectively. Neorealism and space statism interpret anarchy in the same manner and advocate for militarization as an effective method of achieving security in the

[89] Moltz, *The Politics of Space Security*, 23.
[90] Dolman, *Astropolitik*, 149.
[91] Mueller, "Totem and Taboo," 9.
[92] Hays, *United States Military Space*, 98.

international system. Neoliberal institutionalism and space internationalism also interpret anarchy in the same way but advocate for the utility of international treaty organizations as effective means of achieving security. The theoretical overlaps between these respective camps will be explained in greater detail in the following chapter.

*Advancing the Literature*

The literature reviewed in the previous section is important and contributes to the field by facilitating our understanding of prospective national space behaviors through the classification of geopolitical perspectives on space security. This scholarship has also greatly influenced the cross-section of academic work conducted by IR and IL specialists alike, precipitating deeper investigations into the concurrent militaristic or pacifistic predilections of spacefaring actors. As the social and political vitality of the space domain grows, these works will subsequently contribute to future scholarship intent on tracking the evolution of both national and international space activities.

Despite the obvious significance and influence of the extant literature, two key elements are missing. First, the prevailing typologies that help us understand the space security environment are doctrinal and dispositional. They reflect political perspectives about the domain that explains variation in space behavior. They do not account for the tangible differences in the capabilities and tendencies of political actors to perform the activities associated with a given perspective. Having an understanding of the capabilities and tendencies of states and non-state actors would help bridge the gap between real-world political players and the security outlook they purportedly occupy.

Second, much of the scholarship that emanates from these groundbreaking works either embrace and perpetuate the theoretical discourse or edify it through qualitative empirical analyses. While these methods are sound and certainly encourage the flourishing of the discipline, quantitative statistical analyses are noticeably rare—at least in civilian academic circles. Such analyses could invigorate both the application of political theory to the space domain and the qualitative case studies that relate theoretical assumptions to the behaviors of spacefaring actors.

This dissertation advances the literature by providing these missing elements. As is described in greater detail in Chapters 4 and 5, I establish three new typologies to categorize the space activities of political actors. The first two typologies are based on material space capabilities and organize actors into subpopulations of spacefarers and space powers. The spacefarer typology is contingent upon launch capabilities, and the space power typology is contingent upon spacefarer status and military payload operability. The third typology is based on a cataloging of international space treaty ratifications and organizes political actors into a subpopulation of space cooperators. These typologies contextualize the space security debate. The spacefarer typology provides a framework for understanding which political actors engage in orbital operations and when. The space power typology provides a framework for understanding which political actors engage in military orbital operations. This, in turn, may illuminate potential candidates for one of Hays's or Mueller's more militaristic perspectival types. Finally, the space cooperator typology provides a framework for understanding the propensity with which political actors subscribe to space treaty organizations. This, in turn, may highlight potential adherents to the space sanctuary thesis and their cognates in Hays's and Mueller's respective typologies.

I also conduct quantitative statistical analyses that regress the effects of militarization and regime membership on the security status of the space domain. Militarization and regime membership are broadly construed as the empirical objectifications of neorealist and neoliberal institutionalist assumptions, respectively. In Chapter 3, I provide the philosophical background that connects these positions to the research design articulated in the Chapter 4. In Chapter 4, I discuss the operationalization of the specific explanatory variables related to these broadly conceived objectifications as well as the methods used for the analyses. The analytical results are described in Chapter 5 and interpreted in Chapter 6. The analyses themselves represent a significant contribution to a growing field of interest concerning the character of the space security environment.

### 2.4. Conclusion

In this chapter, I reviewed much of the relevant literature that informs the theory that drives this dissertation project. The chapter is composed of three substantive parts. In the first section, I provide an overview of the literature pertaining to four space-related subjects: political history, international law, international cooperation, and militarization. More importantly, in the second section, I review the literature on space security by focusing on important typologies concerning military doctrine and political psychology. In the third section, I explain how the typologies discussed in the second section can be conflated into two camps that constitute the two sides of the space security debate. I also introduce the parallels between these camps and the two camps associated with the inter-paradigm debate among IR scholars in the 1970s and 1980s. The theoretical links between these respective camps pertain to the implementation of militarization and regime membership as effective means of securitization in the space domain. Chapter 3 provides an in-depth discussion of the ways in which the space security debate and the inter-paradigm debate are related.

# CHAPTER 3

# THEORY

This chapter is comprised of three sections. In the first section, I introduce the philosophical associations that bridge the gap between traditional theories of International Relations and the analogs of these theories in the space security debate. This includes discussions about the ontological and epistemological assumptions that differentiate how promulgators of each theory engage with space as a political environment. In the second section, I conceptualize space security and articulate hypotheses that will be operationalized in Chapter 4 and analyzed in Chapter 5. The third section concludes the chapter.

## 3.1. IR Theory and the Space Security Debate

A central problem of international relations concerns the navigation of anarchy, which is broadly defined as an environmental characteristic denoting an absence of overarching authority. The condition of anarchy is problematic because, without a legitimate supreme authority, individuals and states have no recourse beyond their own brute attributes to adjudicate disputes and to realize tangible affirmations of justice. For the individual, this is overcome by the social contract. For the state, this is never overcome because for states, unlike individuals, even under the auspices of alliances and treaties, there is little incentive to proffer sovereignty upon a global body politic. This observation has long reinforced the logic of political realism which prioritizes the independence, self-determination, and sovereignty of the state. To satisfy the integrity of these characteristics, states become preoccupied with the utility of relative power. Power, according to the realist, is both the mechanism and *telos* of politics. Its acquisition is the morality of politics.

While political realism is widely considered to be the predominant theory of international relations, it is not without peer. Moreover, its salience has waxed and waned with the ebb and flow of the conflictual and pacific episodes of modern world history. The fluctuation of these episodes has produced oscillating attributions of scholarly cachet to realism, in times of conflict, and, in times of peace, to its perennial rival: liberalism. The tension between these perspectives has its roots in ancient historiography, and perhaps the most poignant encapsulation of it resides in Thucydides's account of the so-called "Melian Dialogue" which took place at the height of the Peloponnesian War.[93] Over a millennium later, the first modern iteration of the same tension was generated by the social contract tradition of the European Enlightenment. The contending interpretations of anarchy by Thomas Hobbes and John Locke reflected the base assumptions of realism and liberalism respectively.[94]

More recently, after the establishment of International Relations as a *bona fide* academic discipline, this tension took the form of two major scholarly debates. The first debate took place from the 1920s to the 1950s between utopian liberals who espoused the ideals of Locke and Immanuel Kant and classical realists who embraced the shrewd views of Hobbes and Niccolo Machiavelli.[95] The second debate, often referred to as the inter-paradigm debate, took place in

[93] Thucydides, *History of the Peloponnesian War*, trans. Michael Finley (Penguin UK, 1974).
[94] Thomas Hobbes, *Leviathan: With Selected Variants from the Latin Edition of 1668*, ed. Edwin Curley, Underlined, Notations edition (Indianapolis: Hackett Publishing Company, 1994); John Locke, *Locke : Two Treatises of Government* (Cambridge England ; New York: Cambridge University Press, 1994).
[95] Joel Quirk and Darshan Vigneswaran, "The Construction of an Edifice: The Story of a First Great Debate," *Review of International Studies* 31, no. 1 (January 2005): 89–107, https://doi.org/10.1017/S0260210505006315.

the 1970s and 1980s between the scientifically reconceived versions of the old philosophies: structural realism and neoliberal institutionalism.[96]

In the time during and after these debates, alternative perspectives challenged the traditional theories. Marxism and its cognates played a catalytic role in the third great debate of IR, attempting to reorient the conceptualization of the international structure away from state-centric power politics and toward class-centric emancipatory politics.[97] From the 1990s onward, social constructivism gained popularity as an attempt to reconcile the seemingly incongruous ontological assumptions of structural realism and neoliberalism in favor of a less deterministic formulation of international anarchy.[98] Despite these alternative approaches, the realist and liberal traditions are still invariably embedded in the geopolitical dimensions of contemporary international relations. This is perhaps most profoundly attributed to the geostrategic concerns inherent to both national defense and international freedom of navigation among the global commons.

*Geopolitics, National Security, and Space*

The schools of thought that underlie the study of international relations in space can be reduced to two opposing camps: space statists and space internationalists. Since the middle of the Cold War, proponents of these perspectives have engaged in a debate that mirrors the inter-paradigm debate that took place among IR theorists in the 1970s and 1980s. This connection extends from the supposition that the same political actors that interact within the terrestrial

---

[96] Emilie M. Hafner-Burton et al., "The Behavioral Revolution and International Relations," *International Organization* 71, no. S1 (April 2017): S1–31, https://doi.org/10.1017/S0020818316000400.
[97] Robert Jackson and Georg Sørensen, *Introduction to International Relations: Theories and Approaches by Jackson, Robert, Sørensen, Georg 5th Edition (2013) Paperback*, 5 edition (Oxford University Press, 2013), 54.
[98] Alexander Wendt, "Anarchy Is What States Make of It: The Social Construction of Power Politics," *International Organization* 46, no. 2 (1992): 391–425.

domain of Earth also interact in the extraterrestrial domain. The location of the interaction is purported to be irrelevant because the factors that contribute to the behavior of the political actors are the same. In lieu of this premise, scholars, military officials, and policy officials alike have applied the tenets of structural realism and neoliberal institutionalism to the politics of space much in the same way that these doctrines were projected from the telluric realm to the nautical and aeronautical realms respectively.

IR theory has long wrestled with the geopolitical view that a new theater of interest—be it land, sea, or air—first reveals itself as a supplement for the securitization of the state and then eventually becomes a theater to be controlled *propter se*. Military strategists first interpreted airpower and sea power as means of appreciating land power.[99] This dynamic carries with it the need to perpetually develop more domain-specific assets as well as more advanced technologies in order to compete with other states who are likewise attempting to enhance their native capabilities. Ultimately, access to these domains becomes so diffuse that the orientation of national security interests shifts away from mere territorial defense and towards the pursuit of comprehensive domain control. Whether or not the politics of the space domain operate any differently is a principal question addressed by experts of international space relations.

Construed as an analog to sea power and airpower, one cannot deny the existence of space power. By and large, those states situated higher in the hierarchy of material capabilities are also those states with the technological infrastructure conducive to higher stations of material capabilities in all the theaters of international affairs. The United States, Russia, China, and the European Union are all major world powers and all exhibit substantive influence in matters

[99] See Alfred Thayer Mahan, *The Influence of Sea Power upon History, 1660-1783* (Read Books Ltd, 2013); Giulio Douhet, *The Command of the Air (1921)* (University of Alabama Press, 2009). Dolman, *Astropolitik*, 31–36.

related to the nautical and aeronautical realms. This is partly attributed to their respective propagations of local domain-specific assets, and it is partly attributed to their respective diplomatic standings as high-ranking members of global institutions. The former is an expression of hard power, and the latter is an expression of soft power.[100] States such as these have the power to exercise their material assets in the high seas or international airspace as well as the power to influence international policy for these domains through reputation and relative affluence. The political machinations of competition and cooperation are just as evident in the astronautical domain as they are in the nautical and aeronautical domains. Material capabilities, however, are the products of three principal industrial sectors: civilian, commercial, and military. The central tension in the space security debate concerns the militarization of the domain, which space statists view as a conventional byproduct of national security concerns and space internationalists view as a stepping-stone to outright weaponization.

On the one hand, it is seemingly impossible to divorce the concept of space power from the intention of a state to enhance its national security through a military presence in space. After all, as an analog to the sea and air, states have historically securitized their territories through the establishment of large naval and air fleets. In the same vein, a state can also securitize its territory through the stationing of military assets in orbit.[101] The incumbent danger of this scenario is that arms races increase the probability of conflict where it might not have otherwise existed. This is the fundamental conundrum of the security dilemma.

---

[100] Joseph S. Nye Jr, *Power in the Global Information Age: From Realism to Globalization* (Routledge, 2004), 9–18.
[101] To say nothing of the tactical advantage satellites offer to active military operations, as was made evident for the first time in the first Gulf War of 1991. See Peter Anson and Dennis Cummings, "The First Space War: The Contribution of Satellites to the Gulf War," *The RUSI Journal* 136, no. 4 (1991): 45–53; Larry Greenemeier, "GPS and the World's First 'Space War,'" Scientific American, accessed September 12, 2018, https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war/.

On the other hand, states have also historically mitigated their military activities through cooperative arrangements such as arms control agreements. The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is a famous example, but—in keeping with the analogies at hand—the Convention on the Law of the Sea is apropos. Governing activities in both international waters and international airspace, UNCLOS forbids unprovoked, belligerent military activities between and among state actors.[102] These are both domains that large navies and air fleets patrol with great regularity, armed with enough munitions to cause inordinate levels of destruction, yet the vast majority of aggression in these domains occurs by way of piracy on the high seas and not between state actors. The OST was established as an arms control treaty to mitigate the uncertainty experienced by Cold War rivals—ostensibly allowing for the militarization of the domain while intimating against its weaponization—all for the purpose of establishing an environment conducive to peace. The danger of this scenario, however, is that international regimes are established under the conceit of permanence and the aspiration of perpetuity. Unfortunately, the world of international politics is a world of fluctuating interests such that even the longest-standing treaty can be violated or abrogated with impunity given the right geopolitical climate. This is a fundamental problem of state sovereignty.

*Space Statism and the Realist Tradition*

It should come as no surprise that since the space race was a product of the Cold War, the prevailing political theory pertaining to the international relations of that era was also applied to the international relations between spacefaring actors. The preeminent space historian, Walter McDougall, claims that the technological advancements that gave rise to the space industry

[102] http://www.un.org/Depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm

would not have occurred if not for the anxiety and belligerence generated by Cold War antipathies.[103] Even contemporary scholars, such as James Clay Moltz and Everett Dolman, argue that the principles that governed the early politics of space were threefold: first, the competition between the great powers during the Cold War; second, the antagonism between the great powers during the Cold War; and third, the political theory of realism.[104]

The essential components to realism are statism, survival, and self-help.[105] Put simply, the state is the primary political actor in international relations and its chief function is to perpetuate its existence. Because the world is anarchic, each state must rely on itself –its own capabilities and the resolve of its own people—to ensure its survival. Classical realists believe that the will to power is a fundamental characteristic of nature, integral to both the human condition and the condition of the state—so long as each esteems survival and self-interest above all other aspirations.

The ancient historian Thucydides discusses this dynamic in his account of the Peloponnesian War, when Athenian commanders tell the Melian elders that "the standard of justice depends on the equality of power to compel and that in fact the strong do what they have the power to do and the weak accept what they have to accept."[106] This cold outlook may seem antithetical to the traditional tenets of justice espoused by contemporary liberal democratic philosophy, but these tenets are almost exclusively the products of domestic social justice systems and not associated with the international realm. The international realm is anarchic and thereby lawless. As Thomas Hobbes claimed, "where there is no common power, there is no law;

---

[103] McDougall, *The Heavens and the Earth*, 5–6.
[104] Moltz, *The Politics of Space Security*, 24; Dolman, *Astropolitik*, 168.
[105] John Baylis, Steve Smith, and Patricia Owens, eds., *The Globalization of World Politics: An Introduction to International Relations*, 7 edition (Oxford, Uinted Kingdom ; New York: Oxford University Press, 2017), 109–12.
[106] Thucydides, *History of the Peloponnesian War*, 406.

where no law, no injustice."[107] He considered anarchy to be a state of war wherein political actors contended with each other for survival, cultivating a pre-existing dynamic of suspicion and mistrust which was edified by the observation that "force and fraud are in war the two cardinal virtues."[108]

Structural realism, or neorealism, emerged in the twentieth century as a part of the rising tide of scientism that constituted the so-called "behavioral revolution."[109] Structural realism aligned with classical realism in its appraisal of the international system as anarchic as well as its evaluation of international politics as being driven by a struggle for power. Instead of founding the impetus for political activity within the essential nature of the political actor, neorealists viewed behavior as a conditional response to the anarchic structure of the system.[110] For Kenneth Waltz, the putative father of structural realism, a state's behavioral response to anarchy is directed towards a maximization of security.[111] This perspective is often referred to as defensive realism. Building from Waltz and borrowing from Hans Morgenthau's thesis of the *animus dominandi*, John Mearsheimer claimed that a state's survival is not guaranteed into perpetuity by simple virtue of maximizing its security.[112] The state can only ensure its long-term survival by maximizing its power and seeking hegemony.[113] This perspective is often referred to as offensive realism. While defensive and offensive neorealists disagree about the procedure for ensuring the

[107] Hobbes, *Leviathan*, 78.
[108] Hobbes, *Leviathan*. Ibid
[109] See Hafner-Burton et al., "The Behavioral Revolution and International Relations."
[110] A perspective famously established in Kenneth N. Waltz, *Theory of International Politics* (Long Grove, Ill. : Waveland Press, 2010., 1979).
[111] "In crucial situations…the ultimate concern of states is not for power but for security," Kenneth N. Waltz, "The Origins of War in Neorealist Theory," *The Journal of Interdisciplinary History* 18, no. 4 (1988): 616.
[112] Morgenthau's *animus dominandi*, referenced in Hans J. Morgenthau, *Politics Among Nations ; the Struggle for Power and Peace* (New York : A. A. Knopf, 1948., 1948)., reflects the Hobbesian perspective of the human lust for "power after power that ceaseth only in death," from Hobbes, *Leviathan*, 58.
[113] John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York : Norton, [2001], 2001), 33.

state's survival, they are united by a common belief that the uncertainty born from the condition of anarchy drives political behavior.

Most of the early historians of international relations in space viewed it through the lens of political realism and therefore occupied, at least descriptively if not prescriptively, the perspective of space statism.[114] Proponents of this perspective construe the space domain in terms of nationalistic geostrategic utility. They adhere closely to two analogies: the sea and air power analogy and the New World analogy.[115] As is mentioned above, states have sought to securitize their territory by controlling contiguous nautical and aeronautical realms. Later, these domains, conceived broadly as the high seas and international airspace, become sources for the pursuit of comprehensive control. The philosophy here aligns with Hobbes's claim that the acquisition of power is compounding and incessant.[116] Similarly, gaining access to space can serve a state's immediate national interests, but eventually the perpetuation of that access may require total control of the domain.

The New World analogy simply draws a parallel between the old mercantilist-imperialist interest of discovery and the newer industrialist-nationalist interest in discovery.[117] The Old World empires of the fifteenth and sixteenth centuries sought access to eastern trade routes that required advanced technological development and the concealment of intelligence. The space race required the same components for success as well as similar outcomes. Gaining access to

---

[114]See Donald Kash, *Cooperation in Space* (Lafayette: Purdue University Press, 1967); Harvey and Ciccoritti, "Us-Soviet Cooperation in Space."; Pardoe, *The Future for Space Technology*; Westwood, "Military Strategy and Space Warfare"; Gray, "Space Arms Control"; Von Bencke, *The Politics of Space*; Steven Lambakis, *On the Edge of Earth: The Future of American Space Power* (University Press of Kentucky, 2013); Dolman, *Astropolitik*; Klein, *Space Warfare*.
[115] Moltz, *The Politics of Space Security*, 15–20.
[116] "I put forth the general inclination of all mankind a perpetual and restless desire of power after power, that ceaseth only in death. And the cause of this is not always that a man hopes for a more intensive delight than he has already attainted to, or that he cannot be content with a moderate power, but because he cannot assure the power and means to live well, which he hath present, without the acquisition of more." Hobbes, *Leviathan*, 58.
[117] McDougall, *The Heavens and the Earth*, 225.

Earth's orbit could expand a state's commercial and military industrial sectors much in the same way that obtaining lucrative trade routes or conquering foreign lands would enhance an empire's mercantilist economy. In each case, discovery represents the promise of both material and reputational aggrandizement.

Space statists prioritize national interests and convey skepticism about the legitimacy of international cooperation in space. They abide by the Hobbesian maxim that defines anarchy as "a condition which is called war, and such a war as is of every man against every man."[118] As war is by definition the absence of peace, any proposal to curtail the proliferation of weapons during such a time would seem dubious at best. A state cannot be sure if another state is trustworthy and therefore must always be *en garde*. After all, the war in question involves every political actor against every political actor. In such a situation, a state would be loath to enter into a bilateral or multilateral agreement because there is little incentive for *any* participating state to not defect.[119] Space statists therefore perceive the prospect of an arms control treaty for space-related activities to be unviable. For example, Colin Gray claims that "much of what has been said and written in favor of various proposals for space arms control amounts, in truth, to little more than pious nonsense."[120]

Space statists vary somewhat in their prescriptions for maximizing the geostrategic utility of the space domain, occupying both the defensive and offensive flavors of neorealism. Military officials such as Commander John Klein argue that the weaponization of space ought to be pursued primarily for defensive purposes—as a deterrent against the bellicosity of both current

---

[118] Hobbes, *Leviathan*, 76.
[119] Moltz, *The Politics of Space Security*, 25.
[120] Gray, "Space Arms Control," 134. See also Max M. Mutschler, *Arms Control in Space* (London: Palgrave Macmillan UK, 2013), 37, https://doi.org/10.1057/9781137320643; Moltz, *The Politics of Space Security*, 25.

and incipient space powers.[121] Other experts argue that the weaponization of space ought to be pursued for offensive purposes. For example, Everett Dolman proposes a type of hegemonic stability theory[122] which encourages the United States government to dominate the domain in order to ensure that no politico-economic ideology other than liberal-democratic capitalism holds sway in space.[123] According to Dolman, the establishment of the US as a space hegemon does not merely satisfy national security interests, it also encourages stability in the domain by keeping at bay those rivals and adversaries that wish to satisfy interests that are inimical to the West.

To view space as a theater of geostrategic utility is to consider it also a theater of—at the very least—*potential* military engagement. As such, the tactical philosophy of the "high ground advantage" is applied to space just as it was once applied narrowly to terrestrial combat maneuvers and broadly to later advancements in air force technologies. Originally, ancient military tacticians recommended that armies seek out positions on elevated terrains in order to provide clearer overviews for reorienting ranks and opening up fields of fire for projectiles.[124] When advanced industrialized nations began establishing air forces to supplement their armies and navies, this philosophy was transferred to the skies. Fighter planes and bombers gained a strategic advantage by obtaining overview for surveillance and attack. Now, this advantage is extended upward yet another level, as space is commonly considered to be the *ultimate* high ground.[125] From Earth's orbit, states can not only continue to surveil rivals through

[121] Klein, *Space Warfare*.
[122] See Robert Gilpin, *The Political Economy of International Relations* (Princeton University Press, 1986), 86.
[123] Dolman, *Astropolitik*, 157–58.
[124] Sun Tzu, "The Art of War, Translated and with an Introduction by Samuel B. Griffith," *London, UK: Oxford,* 1971.
[125] Thomas Karras, *The New High Ground: Strategies and Weapons of Space Age Wars* (New York: Simon & Schuster, 1983).

reconnaissance satellites but also establish orbital defense systems to recognize, prevent, and/or undermine acts of aggression on Earth. Moreover, as military competition in space escalates, states may be increasingly more inclined to proliferate offensive weapons systems to deter aggression both on Earth and between assets in orbit. In all cases, the high-ground advantage serves as a force multiplier for associated military activities.

In addition to the high-ground thesis, space statists also adhere to the domain-control thesis. This position is grounded in the sea and air power analogy mentioned above. When states can avail themselves of new technologies to establish power asymmetries in new domains, they first pursue a course that satisfies immediate national defense needs and then afterwards pursue a course that satisfies a long-term need to dominate the domain. To achieve these ends, pragmatic tactical practices are employed based on the military theory of Alfred Thayer Mahan and Halford Mackinder.[126] Mahan's problematique concerned the dominance of the high seas and argued that despite the domain's vastness there existed tight, strategic locations that were ripe for exploitation.[127] He called these locations "chokepoints" and claimed that a state's dominance over them would assure its dominance over vital military and trade routes conducive to broad control over the domain itself.[128] Similarly, Mackinder argued that an incontrovertible dominance of world affairs could be attained if a state controlled integral sea and land routes.

These locations served to accelerate the trajectory of global domination as they are attained. His three-tiered worldview composed of a heartland and two peripheries has now been outmoded with the advent of airpower and the ballistic missile, as these technologies can easily

[126] Mahan, *The Influence of Sea Power upon History, 1660-1783*; Halford J. Mackinder, "The Geographical Pivot of History (1904)," *Geographical Journal* 170, no. 4 (2004): 298–321.
[127] Mahan, *The Influence of Sea Power upon History, 1660-1783*, 25.
[128] Mahan noted seven crucial nautical chokepoints: the Cape of Good Hope, Malta, the Suez Canal, the Saint Lawrence Seaway, and the straits of Dover, Gibraltar, and Malacca.

countervail the entrenchment of the heartland—what John Herz referred to as a state's "hard shell."[129] Yet Mackinder's basic supposition still holds: if a state cannot control these strategic locations and establish a position of global dominance, the only recourse is to prohibit their acquisition by any rival state.

Space statists apply the domain-control thesis to space as it has been applied to all the other realms of global transit. Ostensibly, the three general altitudinal orbits of Earth represent the new chokepoints, and the dominance of one or more of them will give rise to a dominance of the domain itself. This objective is certainly not beyond the purview of military officials in each of the major spacefaring nations, but it is especially pronounced in the works of hegemonic stability theorists such as Dolman, who endeavor to shape (or reshape) military doctrine. At the very least, following Mackinder, major space powers will employ a defensive strategy and attempt to suppress or deter the usurpation of these orbits through multilateral or unilateral processes. Regardless of the specific course of action, space statists apply the principle observations of neorealism to the space domain. In their view, competition over access to and action within Earth's orbit currently reflects a set of security concerns to which the only viable response is increased military activity.

*Space Internationalism and the Liberal Tradition*

As space statism projects the paradigmatic tenets of political realism and its cognates onto the space domain, space internationalism performs the same function with political liberalism. It should be noted that while liberalism is often construed as the optimistic opposition to realism's pessimistic appraisal of the global political environment, the perspectives agree on

[129] Herz, "Rise and Demise of the Territorial State."

two core assumptions. First, liberalism concedes that the international system is anarchic but defines anarchy and interprets its effects differently. Second, liberalism acknowledges that the sovereign state is the primary political actor but leaves open the possibility that non-state actors can obtain equal or greater influence in international affairs. The signature point of departure between the two philosophies is that liberalism is less skeptical about the propensity for cooperation among political actors. Liberals occupy a more communalistic or international approach to world politics, often advocating for utopian or cosmopolitan visions of the future, while realists tend to adhere to the values of individualism and the prescriptions of competition.

The liberal image of anarchy is based on John Locke's critical response to Hobbes.[130] Locke argued against Hobbes's vision of the state of nature defined as a war of all against all. In Locke's view, the state of nature *could become* a state of war, but its essential character was more peaceable and stable. He believed that anarchy was governed by a "natural law" of reason that conditions everyone towards irenic behavior.[131] Reason dictates to the individual that one possesses a right to one's "life, health, liberty, or possessions" and that this understanding is reciprocal.[132] If one person recognizes this right in oneself, then it stands to reason that one should recognize it in other persons as well. Only when this natural law is violated does the state of nature transmogrify into the Hobbesian state of war, and all manner of violence upon one's enemy becomes permissible.[133] Hobbes argued that there is no law in the state of nature, just an incessant will to power that extends from the recognition that anarchy is a state of pure liberty.

---

[130] Locke, *Locke*.
[131] Locke, 271.
[132] Ibid.
[133] "In transgressing the Law of Nature, the Offender declares himself to live by another Rule, than that of reason and common Equity, which is that measure God has set to the actions of Men, for their mutual security: and so he becomes dangerous to Mankind, the tye, which is to secure them from injury and violence, being slighted and broken by him." Locke, *Locke*, 272.

For Locke, the state of nature is "a State of Liberty, yet it is not a State of License, though Man in that State have an uncontroleable Liberty, to dispose of his Person or Possessions, yet he has not Liberty to destroy himself, or so much as any Creature in his Possession, but where some nobler use, than its bare Preservation calls for it."[134]

The liberal tradition also extends from the political philosophy of Immanuel Kant, who argued that a natural outcome of the Enlightenment would be the widespread acceptance of republicanism, natural rights, and citizenship.[135] Following the spirit of Locke's social contract theory, Kant believed that a "perpetual peace" could be made manifest in the world if states conformed to the dictates of reason which, on the one hand, persuades political actors to avoid violence and, on the other hand, compels political actors to work together. Kant recognized that an enduring peace could be realized if three conditions were met: first, every state had to adopt a republican constitution; second, every republic would conjoin to form a federation of states; and third, the social consciousness of every republic would become cosmopolitan in nature.[136] However daunting the actualization of Kant's prescription may appear, its logic is both simple and elegant.

Dovetailing with the popular twentieth century IR theory of the democratic peace, Kant believed that republics demonstrated more restraint concerning declarations of war because the people were forced to decide whether or not to place themselves in harm's way.[137] Once

[134] Locke, 270–71.
[135] "The Perpetual Peace, A Philosophical Sketch," from Immanuel Kant, *Political Writings,* ed. Hugh Barr Nisbet and Hans Reiss (Cambridge: Cambridge University Press, 1991), 93–115.
[136] Kant, 99–108.
[137] This is essentially an argument for the monadic democratic peace established in Rudolph J. Rummel, "Libertarianism and International Violence," *Journal of Conflict Resolution* 27, no. 1 (1983): 27–71; Kenneth Benoit, "Democracies Really Are More Pacific (in General) Reexamining Regime Type and War Involvement," *Journal of Conflict Resolution* 40, no. 4 (1996): 636–657. This position was ultimately disavowed by the findings in Melvin Small and J. David Singer, "The War-Proneness of Democratic Regimes, 1816-1965," *Jerusalem Journal of International Relations* 1, no. 4 (1976): 50–69.

republicanism became ubiquitous, states would naturally form a pacific international federation to conjure prohibitions to or abolitions of war.[138] As this federation perpetuates norms of unity and peace, the constituencies of all republics begin to identify less with their nation and more with humanity as a whole, and the out-of-sight-out-of-mind mentality of external events is replaced by an internalized recognition of empathy in the other.[139] Kant's philosophical problematique culminated in the recognition that the ethics of interpersonal relations must be rational, reciprocal, and universal.[140] If such is the case, then the moral prerogative of human beings is to treat each other according the same set of imperatives regardless of the parameters of one's self-identification. This means that ethics is blind to sex, race, class, sexual orientation, and all the other narrow examples of identity politics. Expanded to the realm of global politics, this also means that ethics is transnational. The moral prerogative of republics, according to Kant, is to consider the constituencies of other republics as coequal.

The Lockean image of anarchy, coupled with the Kantian prescription for confederated republicanism, were central features of the classical liberalism that preceded and followed the First World War. The central tension between political realism and liberalism arose from seemingly incommensurable explanations for the shifting world order in the early twentieth

---

For an excellent, early exploration of the Kantian peace and its relation to twentieth century liberal philosophy, see Michael W. Doyle, "Kant, Liberal Legacies, and Foreign Affairs," *Philosophy & Public Affairs*, 1983, 205–235.

[138] Here, Kant is not necessarily arguing for the creation of a world government or super-state political actor. While this might be all to the good, he is mainly arguing for the creation of an international league or collective security treaty organization that is founded upon the observation of what is now referred to as the dyadic democratic peace (see Small and Singer, "The War-Proneness of Democratic Regimes, 1816-1965"; Zeev Maoz and Nasrin Abdolali, "Regime Types and International Conflict, 1816-1976," *Journal of Conflict Resolution* 33, no. 1 (1989): 3–35.)

[139] This reflects a multifaceted explanation of shared norms among democratic dyads (see Zeev Maoz and Bruce Russett, "Normative and Structural Causes of Democratic Peace, 1946–1986," *American Political Science Review* 87, no. 3 (1993): 624–638.), an argument for a systemic democratic peace (see Bruce Bueno De Mesquita et al., "An Institutional Explanation of the Democratic Peace," *American Political Science Review* 93, no. 4 (1999): 791–807.), and a general philosophical perspective of cosmopolitanism (see Martha C. Nussbaum, "Kant and Stoic Cosmopolitanism," *Journal of Political Philosophy* 5, no. 1 (1997): 1–25.)

[140] Immanuel Kant, "Grounding for the Metaphysics of Morals, Trans," *J. Ellington, Indianapolis: Hackett*, 1981, 14.

century. Realists employed arguments based on the conditions that gave rise to the global conflicts that erupted in 1914 and 1939 respectively. Liberals pointed to the internationalist endeavors of normative unification that followed each of those conflicts, first with the League of Nations in 1920 and later with the United Nations Charter of 1945.

The terminology concerning the major focal points of the field have often been conflated over the years, sometimes permissibly and sometimes not. Scholars discuss international regimes, institutions, and organizations, but they are not always directing readers toward the same reference point. The early postwar studies were oriented toward the international organization—that corporeal political entity with an actual physical location—defined formally as an "arrangement transcending national boundaries that provides for the establishment of institutional machinery to facilitate cooperation among members in the security, economic, social, or related fields."[141] Later studies broadened the focus towards regimes, famously defined by Stephen Krasner as "principles, norms, rules and decision-making procedures around which actor expectations converge in a given issue-area."[142] More recent scholarship shifts the focus yet again, away from regimes and towards international institutions, which can in many cases permissibly be construed synonymously with regimes. Institutions are generally conceived of as "the rules of the game in society, or more formally, humanly devised constraints that shape human interaction."[143] The major point of conceptual departure among these terms is that regimes and institutions represent abstract conglomerates that are signified by tangible political artifacts. An international organization is an example of one of these artifacts.

---

[141] Jack C. Plano and Roy Olton, *The International Relation Dictionary. Western Michigan University* (California: ABC-CLIA, 1988), 288.
[142] Stephen D. Krasner, "Structural Causes and Regime Consequences: Regimes as Intervening Variables," *International Organization* 36, no. 2 (1982): 185.
[143] C. Douglass North, *Institutions, Institutional Change and Economic Performance* (Cambridge: Cambridge university press, 1990).

Much like the anti-essentialist, scientific reinterpretation of realism as neorealism in the late twentieth century, liberalism underwent a similar transition towards "neoliberal institutionalism" in the 1980s. Scholars in this tradition sought to explain the emergence of multilateral cooperative arrangements empirically by measuring state membership in regimes and institutions against the backdrop of problematic international issue areas.[144] This liberal transition paralleled the realist transition in another interesting way. Neorealism developed as a result of Waltz's appropriation of the structural model of relations among economic firms. Similarly, neoliberal institutionalism developed from economic explanations of firm integration.[145] Economists had long explained the discrepancies in firm size based on the relative growth of efficiency that was associated with the expansion of the firm itself. Over time, however, firms were growing beyond the scales commensurate with the produced efficiencies and thus a new theory was needed to explain why firms were internalizing market transactions across several properties.[146] Economists argued that a hierarchical corporate structure based on interdependence and cooperation was more conducive to the generation of efficiency than was the former model. As a result, neoliberal scholars such as Robert Keohane, David Lake, and Katja Weber appropriated a version of this argument to explain the expanding role international institutions were playing in the world affairs.[147]

---

[144] Stephen D. Krasner, "Regimes and the Limits of Realism: Regimes as Autonomous Variables," *International Organization* 36, no. 2, (1982), http://www.jstor.org/stable/2706531; Stephen D. Krasner, *International Regimes. : Cornell Studies in Political Economy*, Cornell Studies in Political Economy (Ithaca : Cornell University Press, 1983., 1983); Krasner, "Structural Causes and Regime Consequences"; Oran R. Young, "The Politics of International Regime Formation: Managing Natural Resources and the Environment," *International Organization* 43, no. 3 (1989): 349–75; Oran R. Young, "Regime Dynamics: The Rise and Fall of International Regimes," *International Organization* 36, no. 2, (1982), http://www.jstor.org/stable/2706523.
[145] Arthur A. Stein, "Neoliberal Institutionalism," in *The Oxford Handbook of International Relations*, 2008, 205.
[146] Ibid.
[147] Robert Keohane, *After Hegemony: Cooperation and Discord in the World Political Economy*, Revised edition edition (Princeton, N.J: Princeton University Press, 2005); David A. Lake, "Anarchy, Hierarchy, and the Variety of International Relations," *International Organization* 50, no. 1 (1996): 1–33; Katja Weber, "Hierarchy Amidst

Space internationalism prioritizes the role that international institutions play in safeguarding the environmental integrity of the domain in order to facilitate civilian, commercial, and peaceful military activities. Abiding by the ancient Roman principle of *res communis*, proponents of this perspective argue that space—like the high seas and international airspace—is to be considered a part of the global commons.[148] Implicit in the idea that a spatial domain can serve as a "common heritage of all mankind" is the assumption that such a domain is beyond the purview of national sovereignty and appropriation.[149] Space internationalists therefore follow the sanctuary thesis which stipulates that the domain must be kept free from interstate conflict and processes of weaponization.[150] They argue that national security is already ensured through networks of early warning satellites that can detect the deployment of ballistic missiles with enough time for target states to respond.[151] The prohibition of space weapons is therefore necessary to preserve the survivability of these assets from needless and costly external threats.[152]

*Ontological Assumptions*

Space statists and space internationalists disagree about the fundamental constitutive property of the space domain. Statists argue along neorealist lines, claiming that the uncertainty born by anarchy has manifested a security dilemma from which the only escape is full-scale securitization. Securitization, in this respect, can resemble either the defensive or offensive

Anarchy: A Transaction Costs Approach to International Security Cooperation," *International Studies Quarterly* 41, no. 2 (1997): 321–340.
[148] Ku, "The Concept of Res Communis in International Law."
[149] Porras, "The 'Common Heritage' of Outer Space: Equal Benefits For Most of Mankind."
[150] Moltz, *The Politics of Space Security*, 28.
[151] Mowthorpe, *The Militarization and Weaponization of Space*, 12.
[152] Peter L. Hays, "Struggling Towards Space Doctrine: Us Military Space Plans, Programs, and Perspectives During the Cold War" (AIR FORCE INSTITUTE OF TECHNOLOGY WRIGHT-PATTERSON AFB OH, 1994), 22.

dimensions of neorealism. Proponents of this perspective believe that the militarization and weaponization of space can best ensure either the state's survival as a status-quo power or its improvement towards domain hegemony. A state must construe space no differently than it construes the sea and the air: as a security threat and a potential arena for interstate conflict. Cooperative agreements may be entertained and accepted but never at the expense of national interests and never against the acquisition of relative gains.

Space internationalists argue along neoliberal institutionalist lines, claiming that space represents a sanctuary from interstate belligerence, as made evident by the international space treaty system. According to this view, space is a distant and fragile environment that should be construed as a domain of the global commons like the high seas, international airspace, and Antarctica. As a global common, space must be appraised by states as a province belonging to the "common heritage of mankind" and should only utilize it for peaceful purposes.[153] States may legitimately establish a military presence in space so long as that presence adheres to the agreed-upon tenets of non-aggression and the prohibition of property annexation.

Put simply, space statists and space internationalists disagree about what the space domain actually is. The former claims it is a security concern and the latter claims it is a sanctuary, free from the specter of threat. This ontological disagreement is profound because it illuminates the political environment of space as being nebulous which, in turn, further entrenches states in a species of uncertainty conducive to suspicion and mistrust. The problem of ontology also gives rise to two auxiliary issues: the acceptance of the space domain as a global common and the definition of the peaceful utility of space.

[153] For intellectual explorations of the global commons, see Buck, *The Global Commons*; Jasper, *Securing Freedom in the Global Commons*; Jasper, *Conflict and Cooperation in the Global Commons*.

States that have ratified the OST have ostensibly acquiesced to the definition of space as a global common, but this position has come under some scrutiny in recent years. For example, Scott Pace, the executive director of the US National Space Council, stated in late 2017 that "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." [154] If Pace's comments represent a form of political posturing implemented to strategically promote US interests in space, his position certainly dovetails nicely with the agenda of a space statist. If, on the contrary, Pace's comments articulate what he actually believes to be the case concerning international space law, then he is unfortunately misinformed. The second preamble of the OST, just prior to the first article, explicitly states that the nations party to the treaty recognize the peaceful exploration and use of space to be the "common interest of all mankind" and for "benefit of all peoples." [155] Moreover, Joanne Gabrynowicz, a professor emerita of space law from the University of Mississippi, argued that while states may not accept space as the common heritage of mankind—as articulated by the ancient precept of *res communis*—the text of the OST certainly adheres to this concept. [156] Even within the United States, the world's mightiest space power and ratifier of the OST, there is consternation concerning the definition of space as a global common.

---

[154] Tim Fernholz, "Space Is Not a 'Global Commons,' Top Trump Space Official Says," Quartz, 2017, https://qz.com/1159540/space-is-not-a-global-commons-top-trump-space-official-says/; Cory Doctrow, "Trump's Space Council Chief Says Space Is 'Not a Commons' and Promises That It Will Become Property of US Corporations," Boing Boing, 2017, https://boingboing.net/2017/12/21/the-man-who-sold-the-moon-2.html.
[155] OST, "Outer Space Treaty," 1966, http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html.
[156] Marcia Smith, "Pace Outlines Trump Administration's Approach to Space Development and Law," 2017, https://spacepolicyonline.com/news/pace-outlines-trump-administrations-approach-to-space-development-and-law/.

The second auxiliary issue concerns the definition of the peaceful use of space, which was unsurprisingly one of the earliest quibbles between the US and the USSR before the UN got involved in treaty negotiations. On the one hand, space internationalists want to define "peaceful purposes" as a moratorium on the weaponization of space because it complements their position that the domain is a sanctuary. On the other hand, space statists want to define "peaceful purposes" as a moratorium on aggression because it complements their position that the militarization of space—even through weaponization—can satisfy both the interest in national defense and the interest in establishing a deterrence mechanism that could ensure pacific relations in the domain. The OST is just vague enough to entertain doubt regarding these contending definitions. Article IV only explicitly prohibits the implementation of nuclear weapons or WMDs, the establishment of military outposts on celestial bodies, and the perpetration of military maneuvers on celestial bodies. [157] The implementation of non-nuclear weapons and non-WMDs, the establishment of military outposts in orbit, and the perpetration of military maneuvers in orbit are all prohibitions that are noticeably absent from the text. It is clear that the spirit of the OST is directed towards the cultivation of a peaceful environment. What is unclear, and what may simply be a product of shrewd negotiations conducted under a neorealist political climate, is whether or not states can legitimately use space weapons to foster peace.

### *Epistemological Assumptions*

Since the international system is anarchic, states are confronted with varying degrees of uncertainty. Uncertainty itself is a problem of epistemology, as states can only ever possess incomplete information about their counterparts—be they allies, rivals, or enemies. This

[157] OST, "Outer Space Treaty."

incomplete information concerns not only the material capabilities of another state but also the resolve of its people. As such, the manner in which a state interprets uncertainty will guide it towards favorable ends or otherwise. According to Brian Rathbun, realists and liberals interpret uncertainty quite differently. [158] Realists react to uncertainty with fear—fear of the interests, intentions, and potential actions of other states. [159] Fear is the primary motivator that gives credence to the security dilemma. Fear is what causes states to securitize and, in turn, compels their neighbors to do the same. Uncertainty, in both the Hobbesian and Waltzian contexts, represents the threat to which states must respond if they wish to ensure their own respective survivals.

Space statists react to uncertainty in the realist fashion: through fear. They view the domain as a potential arena for martial activity and act accordingly by advancing their material capabilities relative to the other. Depending on their adherence to the defensive or offensive iterations of realism, the goal of the space statist is to match the capabilities of its rivals, outpace and supersede the capabilities of its rivals, or dominate the domain altogether as a hegemon. For the space statist, as its primary concern is security, its greatest fear is what Bruce DeBlois calls the "space Pearl Harbor event." [160] The prevention of a surprise attack on native space assets is of the upmost significance. These assets perform functions integral to the sustainability of military, civilian, and commercial industries, and their preservation is a paramount interest of the state. In lieu of such a possibility, by virtue of the *fear* that such an event might take place, the

[158] Brian C. Rathbun, "Uncertain about Uncertainty: Understanding the Multiple Meanings of a Crucial Concept in International Relations Theory," *International Studies Quarterly* 51, no. 3 (September 2007): 533–57, https://doi.org/10.1111/j.1468-2478.2007.00463.x.
[159] Rathbun, 538–41.
[160] Bruce M. DeBlois et al., "Space Weapons: Crossing the Us Rubicon," *International Security* 29, no. 2 (2004): 52.

state is compelled to prioritize the militarization (and weaponization) of the space domain. The space statist *qua* the neorealist abides by the principles of survival and self-help.

Neoliberal institutionalists do not appraise the condition of anarchy in the same way as do neorealists. This is mainly attributed to the fact that those in the liberal tradition do not make the same kinds of assumptions about other political actors that realists are prone to make. Realists react to uncertainty with fear because the gravity of self-preservation is so profound. The most shrewd and viable lenses through which the intentions of others can be viewed is suspicion and mistrust. The safest course of action—that which is most conducive to survival—is to assume that one's counterpart would cheat or renege on a cooperative arrangement as soon as doing so would satisfy immediate interests. Concerning noncooperative arrangements, the safest course of action is to assume that one's counterpart is bluffing when employing a particular strategic posture. [161] This neatly encapsulates the pessimistic tenor of the realist tradition. Those in the liberal tradition obtain a much more optimistic worldview.

Neoliberal institutionalists refrain from making rash and drastic assumptions about the intentions of political actors. As Rathbun frames it, "they do not necessarily err on the side of caution," but they do not walk into strategic dilemmas with blind trust either. [162] Neoliberals react to uncertainty with ignorance—defined not in the pejorative sense connoting witlessness but in the rudimentary sense denoting agnosticism.[163] In this view, the most shrewd and viable lens through which the intentions of others can be viewed is simple, rational risk assessment. Whatever credible information the neoliberal possesses about its counterpart is used to make an informed determination of relative trustworthiness. If the situation is stable enough for two actors

[161] Rathbun, "Uncertain about Uncertainty," 541.
[162] Rathbun, 542.
[163] Ibid.

to engage in a cooperative arrangement, then the safest course of action is to assume each party will uphold its commitments. In noncooperative arrangements, the safest course of action is to assume that one's counterpart is sincere in its particular strategic posture. Neoliberal institutionalists argue that the skepticism of realism can be counterintuitive and actually bring about degenerative outcomes like deeper insecurities, arms races, or conflict.[164]

Rathbun aptly points out that *learning* is a major disjunction between realist and liberal behaviors. [165] The liberal seeks to employ what it knows—what it has *learned*—in order to make rational decisions in its political engagements. The whole point of mitigating uncertainty is to decrease the incompleteness of information in order to facilitate future decision-making processes. There exists in this view a contiguity of intentions and actions that can be construed as predicates to potential future actions. The outlook adheres to the promise of predictability and probabilistic speculation. The realist, however, has virtually no need for learning because the only critical article of knowledge is that which is already assumed in the framework: others ought not to be trusted. This does not mean that a state has no interest in decreasing the incompleteness of the information it possesses about its counterpart. It simply means that doing so neither attenuates the mistrust inherent to the model nor augments the type of behavior prescribed by the model. Uncertainty is mitigated by adding power and not by rational prediction or probabilistic speculation.[166] Decision-making processes have nothing to do with intentions and everything to do with capabilities.

Space internationalists react to uncertainty in the neoliberal fashion: through ignorance. Instead of cultivating suspicions about how and under what circumstances major space powers

---

[164] Charles L. Glaser, "Realists as Optimists: Cooperation as Self-Help," *International Security* 19, no. 3 (1994): 50–90; Andrew Kydd, "Game Theory and the Spiral Model," *World Politics* 49, no. 3 (1997): 371–400.
[165] Rathbun, "Uncertain about Uncertainty," 540.
[166] Ibid.

will endeavor to disrupt the stability of the space domain, space internationalists abide by the pragmatism of the status quo—by what they have learned hitherto. They make no assumptions about the intentions of spacefaring nations beyond what behavior has been exhibited, and the most seemingly indelible object of behavior thus far exhibited is the establishment of the international space regime. The near universal ratification of the OST ostensibly brought an end to the Cold War bellicosities that penetrated the space race. Even if rivalry and enmity continued between the US and the Soviet Union, circumstances became so untenable that an arms control treaty for space was required to cool tensions and stabilize the domain.

Unlike space statists who perpetuate the realist reaction of fear even within cooperative arrangements, space internationalists accepted the ratification of the OST as a legitimate articulation of the intentions of the ratifiers. In the proper neoliberal institutionalist manner, space internationalists construe the multilateral treaties that pertain to the space domain as binding legal documents. In the parlance of positivist international law, they abide by the principle of *pacta sunt servanda* as established in the 1969 and 1986 Vienna Conventions [167]. Space internationalists view the domain as a sanctuary and contend that the maintenance of peace therein can best be realized through the maintenance of the treaty system established to perform that very function. According to this perspective, the realist prescriptions of militarization and weaponization undermine the spirit of the institution and may work to reify what would otherwise be only conjectural dangers.

This epistemological problem also gives rise to an important auxiliary issue concerning the global commons: the seeming incompatibility between the national interest of defense and the international interest in the freedom of navigation and access. The global commons play an

[167] Hans Wehberg, "Pacta Sunt Servanda," *American Journal of International Law* 53, no. 4 (1959): 775–786.

interesting role in a world defined by state sovereignty and the scope of its attendant jurisdictions. Much of the content of contemporary discourses about international norms can in some measure be reduced to the stipulations of sovereignty as a concept. Traditionally, sovereignty is defined as a dual claim about the prerogative of the state signified by an internal and external dimension. The former refers to a state's capacity to establish a government that obtains absolute authority within the territory. The latter refers to a state's immunity from the interference of other states. Put simply, a state can act with impunity within its own borders and cannot infringe upon another state's liberty to do the same. This norm establishes a neat framework of political, social, and legal demarcations based superficially on existing geographic demarcations. Less neat, however, is the inclusion of the supra-sovereign domains of the global commons.

The high seas, airspace, and space are all media that exist beyond the legalistic purview of state sovereignty. As mentioned earlier, states have traditionally laid claim to parcels of these media that run adjacent to their borders, thus generating geopolitical terms such as "territorial waters" or "territorial airspace." Implicit to these terms is the realization that a state requires some sovereign authority over contiguous nautical and aeronautical spaces in order to adequately securitize itself. Beyond these zones, securitization becomes more difficult because sovereign claims cannot be made and yet threats may still abide. Enemies can exploit the global commons by using international waters and airspace as avenues of attack. Even in the presence of international treaties that declare the global commons to be mutually owned peaceful domains, and even when states have no formally declared enemies, they still safeguard themselves from such defection by patrolling the high seas and skies. No state wants to be denied the freedom of navigation in the global commons, and no state will abide the denial of its ability secure itself from prospective dangers. The result is a vast expanse of neutral territory populated with instruments of war.

### 3.2. Securitizing the Space Domain

This dissertation endeavors to apply the assumptions of neorealism and neoliberal institutionalism to the politics of space as they are characterized by each theory's analog in the space security debate: space statism and space internationalism, respectively. In order to establish an adequate research design for this project, two central research questions must be addressed:

- ❖ Research Question #1: *To what extent is the space domain secure?*
- ❖ Research Question #2: *To what extent do neorealism and neoliberal institutionalism respectively account for space security?*

The previous section describes the theoretical assumptions that ground neorealism and neoliberal institutionalism and relate them to the securitization of space. While each position prescribes a categorically different method for ensuring security, the envisioned outcome is the same. In the following sections, I discuss how this dissertation engages with the conceptualization of space security which will be operationalized in the next chapter. Afterwards, I describe how this dissertation engages with the conceptualization of the neorealist and neoliberal prescriptions, respectively.

*Conceptualizing Space Security*

The conceptualization of space security extends from a broader meditation on how one constitutes a stable geopolitical environment. I contend that a conservative definition constitutes such an environment as a mitigated state of external impediments to the freedom of navigation and access by potential spacefaring political actors.[168] The "external" caveat is important because a political actor's lack of technology, which would represent an internal factor, would also be an impediment to spacefaring operations but not one that disrupts the integrity of the environment. External impediments may include:

- Natural disasters, such as collisions with NEOs
- Artificial disasters, such as debris caused by payload damage/destruction
- Militarized disputes, such as acts of aggression or claims of sovereign appropriation by state actors
- Piracy, such as acts of aggression or claims of sovereign appropriation by non-state actors

Put simply, security is reflected by an undisrupted environment. The freedom of navigation and access is a hallmark of international legislation concerning spatial domains such as the high seas and international airspace in addition to space. It rests on an agreement that sovereign states enjoy the freedom to operate in the global commons because all states have a share in their purported ownership. To undermine or interfere with this freedom is condemnable for two general reasons: first, it is perceived to be a violation of the common heritage principle; and second, it is perceived to cause disruptions in civilian and commercial industrial sectors that are integral to society and economy.

I argue that the operations of non-military space industrial sectors are the key to empirically capturing the relative security status of the domain as a whole. After all, what is

[168] This contention is corroborated by others. For example, Moltz claims that "we can define 'space security' as *the ability to place and operate assets outside the Earth's atmosphere without external interference, damage, or destruction*." Moltz, *The Politics of Space Security*, 11. (italics belong to the author).

really meant by a claim that the high seas or international airspace is insecure? One implication is that those domains are *unsafe* for the use of civilian or commercial vessels. This insecurity may cause industry leaders to augment normal operations, perhaps markedly limiting or suspending activities in those respective domains. If one were actively cataloging all nautical and aeronautical activities every year, a substantive decrease in normal civilian and commercial operations could serve as a legitimate indicator of an insecure environment. Contrarily, if the trends remain average or rise, then that may indicate stability and security.

I maintain that space security can be understood in analogous terms. It stands to reason that one can capture the relative security of the space domain by referencing trends in cross-industrial space activities over time. I propose two general claims:

- Claim 1: stagnant, steady, or rising trends in civilian and/or commercial space operations indicate that the domain is relatively secure.
- Claim 2: sharp or downward trends in civilian and/or commercial space operations indicate that the domain is relatively insecure.

The logic supporting each claim rests on an assumption that industries associated with spatial domains respond positively or negatively to fluctuations in the perceived precarity of those environments. I propose that the number of non-military payloads placed in orbit per year represents an appropriate proxy variable for the security status of the space. It is important to note that I omit the military industrial sector in the claims above. I do not deny that military operations have both securitizing and destabilizing effects, but they ostensibly exist to offset the precarity of these domains. Militaries do not operate by the same set of protocols by which civilian and commercial organizations operate. They are not only compelled to take on risks that civilian and commercial organizations would avoid at all costs, but they are also often obliged to take them on. Excluding the military industrial sector is legitimized by this mandate, coupled with the fact that including them would manifest endogeneity issues with the neorealist position on securitization. As mentioned above, non-military operations are integral to society and economy in a way altogether different than military operations. I contend that defining security in this manner is permissible.

*Neorealist Astropolitics*

The neorealist perspective is associated with militarization and its utility as a deterrence mechanism. The space statist therefore takes on one of two positions concerning the politics of space security: either A) the space domain is insecure and thus requires militarization in order to manifest stability and security, or B) the space domain is secure, such as it is, by virtue of previous and ongoing militarization. As a result, the following hypothesis is attributed to the space statist *qua* neorealist:

- ❖ <u>Hypothesis #1:</u> *If the militarization of space increases, then the likelihood of space security increases.*

The militarization of space is the independent variable of interest which is conceptualized as the number of military payloads placed into orbit every year. Space security is the dependent variable which is measured by the number of non-military payloads placed into orbit every year.

*Neoliberal Astropolitics*

The neoliberal institutionalist perspective appeals to regimes, treaty organizations, and intergovernmental organizations to securitize the space domain for peaceful purposes. The space internationalist may take one of two positions concerning the politics of space security: either A) the space domain insecure and thus requires international cooperation in order to manifest stability and security, or B) the space domain is secure—such as it is—by virtue of previous and ongoing subscription to space-related international institutions. As a result, the following hypothesis is attributed to the space internationalist *qua* neoliberal:

- ❖ <u>Hypothesis #2:</u> *If cooperation in space increases, then the likelihood of space security increases.*

Cooperation in space is the independent variable of interest which is conceptualized as the number of international treaty ratifications every year. Space security is the dependent variable which is measured by the number of non-military payloads place into orbit every year.

### 3.3. Conclusion

In this chapter, I introduce the philosophical associations that bridge the gap between traditional theories of International Relations and the analogs of these theories in the space security debate. I discuss the ontological and epistemological assumptions that differentiate how these analogs engage with space as a political environment. Finally, I conceptualize space security and articulate hypotheses for neorealist and neoliberal positions that will be operationalized in the following chapter. Chapter 4 is dedicated entirely to the dissertation’s research design and methodology.

# CHAPTER 4

# RESEARCH DESIGN AND METHODOLOGY

In this chapter, I describe the three core features of this dissertation's analytical project. The first section is dedicated to the data collection process which involved the cataloging of orbital launches and payloads, the transposition of that data into a longitudinal database that comprises the entire international system, and the addition of data pertaining to international space-related treaties. The second section is dedicated to the research design and describes the operationalization of the dependent variable, the two independent variables, and the alternative explanatory variables for which the analysis controls. The final section is dedicated to methodology and describes the structure of the panel data, the process of testing for individual specific effects, and the process for choosing appropriate estimator models.

## 4.1. Data Collection

I compiled data for every orbital launch and payload for every spacefaring political actor from the launch of Sputnik in October 1957 to the end of the 2019 calendar year. I retrieved the information from six distinct sources and cross-referenced observations across each to ensure as satisfactory a level of accuracy as possible. In no order of priority, I used Gunter Krebs's GSP online compendium[169], John McDowell's JSR online collection[170], NASA's Space Science Data Coordinated Archive[171], Space-Track's online repository[172], the Union of Concerned Scientists UCS Satellite Database[173], and the United Nations' Online Index of Objects Launched into Outer Space.[174] All of these sources are recognized and condoned by the Center for Strategic and International Studies (CSIS)[175] which is among the preeminent policy institutes in the United States. It is reputed especially for its concentration on national defense and national security; therefore, it is permissible to assume that its avowal of online repositories—institutional or clandestine—administers the perception of academic legitimacy.[176]

While all the sources provided invaluable information, none of them had pre-existing databases that I could download or transpose in a way that would meet the structural requirements of my research project. Most of the data that I catalog had to be retrieved in different ways among the various sources and merged in different ways in order to form a coherent database. The GSP compendium is entirely web-based and structured as a series of webpages that contain tabulated information. There is a dedicated section to the chronology of

---

169 https://space.skyrocket.de/
170 https://planet4589.org/space/
171 https://nssdc.gsfc.nasa.gov/nmc/SpacecraftQuery.jsp
172 https://www.space-track.org/auth/login
173 https://www.ucsusa.org/resources/satellite-database#.WwMXcXovyUk
174 https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=
175 https://www.csis.org/topics/cybersecurity-and-technology/space
176 For credibility concerns, see James G McGann, "2017 Global Go To Think Tank Index Report," *University of Pennsylvania* TTCSP Special Report (2018).

orbital space activities, but it is individuated by year and not comprehensive. The information on launch vehicles and payloads is similarly divided by nation or type.

The data extraction and integration process for this source was extensive, requiring me to establish a full chronology of orbital launches by attending to sixty-three individual webpages. I then had to access individual webpages for 101 political actors in order to add payload information to the chronology. These data were then double-checked by referencing each of the political actors again, but this time across twelve general spacecraft types. Afterwards, I added launch vehicle information to the chronology by accessing individual webpages for each vehicle utilized by each political actor with orbital launch capabilities.

Unlike the GSP compendium, the JSR collection did provide comprehensive data on launches, vehicles, payloads, and organizations, but they were stored as text files. These files had to be opened, buffered, and transposed to spreadsheets which then had to be converted through text-to-column delimitation. This process had to be performed for each category of information and, since there was no direct overlap among the categories, the data required integration on my end. I combined the orbital launch list of 1957 to 1962 with the orbital launch list of 1963 to 2019. These were separated because launches were identified with Harvard designations during the first set of years and COSPAR designations during the second set of years. Since these lists only contained successful orbital launches, I added three additional lists so that full scope of orbital launch attempts could be captured. These three lists provided information on orbital launch failures, uncatalogued launches with orbital energy, and prelaunch pad explosions for orbital missions. Next, I matched the satellite and launch vehicle information with those listed in the chronology. Since these data provided operator and manufacturer information for both satellites and launch vehicles, I then added specific information pertaining to organizations from a separate spreadsheet.

NASA's NSSDCA website provides a master catalog search option which includes a spacecraft query. After cross-referencing, transposing, and merging the appropriate data from the GSP and JSR repositories, I utilized the NSSDCA for further refinement. I performed searches in the spacecraft query applet for the payloads listed in my comprehensive chronology. While the NSSDCA did not have all the information on every object, the information it did provide was still valuable. For example, detailed payload descriptions, launch specifics, and funding agency information was used to supplement the information I already possessed.

Space-Track's website requires login through a free personal account, and it provides information on the location of objects still in orbit or decayed. Since Space-Track is more interested in the orbital position of objects, there is less specific information relevant to my project than is provided by the GSP and JSR sources. Nevertheless, the repository proved to be instrumental in cross-referencing satellites with the organizations responsible for operation. The UCS Satellite Database was similarly helpful in a limited capacity. While this database includes information on country of origin, payload purposes, and other operational details, it is only comprised of objects that are still in orbit. Therefore, only about 28% of the objects I catalog could be cross-referenced with the UCS data. However, where overlap did exist, the information provided was contributory.

The United Nation's Online Index of Objects Launched into Outer Space contains data that I utilized primarily for refinement purposes. It catalogs all space objects across 64 years (1957-2020) and 91 organizations. Objects are further disaggregated based on location status, orbital status, and registration status. There is some perfunctory information on the object function, but it is sparse compared to data obtained from other sources. I mainly used the index to make sure launch dates and payloads were oriented correctly. For future projects, I will definitely use this index in conjunction with the Space-Track repository to add location and orbital information to the database I created for this dissertation.

*Cataloging Orbital Launch and Payload Data*

I catalog 9,686 observations of orbital payloads that are associated with 5, 913 orbital launches across a temporal range of 63 years (1957-2019). Since the focus of the analysis is international activity in space and since multiple payloads are often attached to a single orbital launch vehicle, the catalog is structured according to payloads. Of course, the appropriate details are provided for both payloads and the launch vehicles with which they are associated. While the launch year is the key temporal component of the analysis, I also account for specific launch dates in both Julian and Gregorian formulations.

For every payload, I catalog the political actor(s) responsible for its operation. These political actors are not necessarily the owner/operator of the payload itself but rather the entity that is liable for it. This is a manifestation of a long-standing international norm that holds states accountable for the actions of non-state actors within their territorial domain. In fact, liability rules were first enshrined in the Outer Space Treaty of 1967 and later expanded in the Space Liability Treaty of 1972. I refer to these entities as “political actors” as opposed to “states” for three reasons. First, I include Taiwan which is a spacefaring nation that is ostensibly a state but not recognized as sovereign by the United Nations. Second, I include non-state actors that are either intergovernmental organizations (e.g. European Space Agency) or multinational corporations that privatized after once being intergovernmental organizations (e.g. Intelsat). Third, even outside of intergovernmental organizations, many payloads are owned/operated by organizations that reside in one or more states. Payloads that are associated with political actors described in the second reason are labelled "international," and I provide an additional variable to account for the specific entity. Payloads that are associated with the third reason are labelled with backslashes separating the various political actors (e.g. Netherlands/United Kingdom).

I account for five payload classes that are organized according to the payload's stated purpose and the character of the payload's owner/operator. I establish both a narrow and a broad variable for classes. The narrow variable designates payloads as civilian, commercial, hybrid, military, and unknown. Civilian payloads are owned or operated by non-military governmental organizations, academic organizations, amateur organizations, or non-profit organizations. Commercial payloads are owned or operated by private or public business entities. Hybrid payloads are jointly owned/operated by civilian and commercial organizations. Unknown payloads are spacecrafts with no known expressed purpose. The broad variable collapses civilian, commercial, and hybrid payloads under the category "non-military" to be used in conjunction with the military class.

I catalog twenty-eight payload types that can be cross tabulated with the aforementioned classes. Payload type simply refers to the function that the space object performs. Some of these types are related to one particular class, but others are so common that they are suffused across all classes. For example, "early warning" satellites are strictly related to the military class while "communication" satellites are distributed across civilian, commercial, and military classes alike. Cross-referencing payload types between the repository sources allowed me to add three variables that relate to the primary variable. The first is “payload subtype” which serves mainly as a remark about the payload type’s character and varies in terms of content. For example, the payload type “science, technology, and education” can have attendant subtypes that specify which of those three purposes the spacecraft embodies. Others may specify a narrower focus such as “atmospheric research” or “space physics.” Interplanetary spacecrafts have subtypes that designate the scope of the interplanetary journey such as “lunar” or “Mars” or “deep space.” The other two variables are alternate subtypes and serve as ancillary remarks about the subtype categories. These descriptions may work to expand upon the content of the subtype variable or simply designate the manufacturer of the object.

The catalog contains information about the entities that own and/or operate the payloads. These are simply referred to as “payload organizations” and differ invariably from the launch organizations as well as the political actors responsible for either the launch or payload. For example, a payload may be operated by NASA but attached to a launch vehicle operated by the United States Air Force—both of which are subordinate to the United States as the liable political actor. The class of the payload organization is cataloged to cross-reference or clarify the class of the payload itself. This is important because there is not always an obvious class-relationship between payload operators and the payload class. For example, a military asset may be operated by a state-owned commercial enterprise in Russia or China. While the expressed purpose of the payload is military in nature, the operator might technically be considered a business entity. In this regard, it is important to make distinctions between and among the organizations responsible for payload and launch operations as well as the political actors from which these operations emerge.

There are nine variables that pertain to every payload owner/operator: an identification code, the political actor in which operator resides, the organization type, the organization class, the organization's short name, the organization's formal name, the organization's name translated to English, the organization's location, and the organization's parent entity. Most of these variables are self-explanatory. The identification code is typically the acronym for the organization. The political actor is typically a sovereign state. The organization type reflects one or more identifiers based on a set of sixteen (country, intergovernmental organization, astronomical polity, engine manufacturer, launch vehicle manufacturer, meteorological rocket launch agency, payload manufacturer, launch agency, suborbital launch agency, payload owner, parent organization, launch site, launch position, launch cruise, landing zone, and suborbital target area). The parent entity represents any organization to which the payload operator is subordinate. For example, DARPA's parent entity is the United States Department of Defense. Excluding unknown objects, there is at least one and at most eight organizations that own/operate a given payload. Consequently, eight sets of these variables are included in the catalog even if most payloads only have one or two owner/operators.

The catalog provides similar information for every launch vehicle associated with the payloads it carries. Every orbital launch attempt is endowed with an identification code that conforms to the COSPAR designations. These are generally comprised of the year, the launch rank for that year, and a letter to qualify the launch's success status. All orbital launch attempts are coded, including orbital launch failures and prelaunch explosions for orbital missions. The launch success status is coded across three outcomes: success, failure, or prelaunch explosion. I catalog the orbital launch year, Julian and Gregorian dates, the launch vehicle name, the base stage family name, the main stage family name, the launch vehicle manufacturer, and the launch organization. All of the variables that pertain to payload organizations mentioned above are also provided for the launch organizations. Launches are associated with at least one and at most two organizations, therefore two sets of these variables are included in the catalog even if most launches only have one organization conducting operations. Additionally, three variables are included for launch sites: launch site identification code, launch site location, and the political actor associated with the location.

*Transposing Orbital Launch and Payload Data*

I created the catalog discussed in the previous section in order to capture the scope of space behavior since the beginning of the space race. Unfortunately, the structure of the catalog is not conducive to a research project that endeavors to better understand the context of space-related activities against the backdrop of the broader international system. It only includes political actors that engage in spacefaring activities and excludes the rest of the system. As a result, I establish a database to reconcile this issue and transpose virtually all the catalog data into it.

The database is composed of 195 political actors across 63 years (1957-2019) and therefore accounts for 12,285 total observations. The unit of analysis is political actor-year. The political actors represent the 193 states that the United Nations recognizes as sovereign as well as Taiwan and the "international" component mentioned in the previous section. The observations that fall under this "international" label are predominately intergovernmental organizations and multinational corporations that represent the privatization of former IGOs. For example, the European Telecommunications Satellite Organization (EUTELSAT) was established as an IGO in 1977 but was privatized in 2001 as a commercial entity called Eutelsat S.A. Similarly, the International Telecommunications Satellite Organization (ITSO) was established as an IGO in 1964 but was privatized in 2001 as a commercial entity called Intelsat Corp. It is important to note that, in cases such as these, the class of payloads associated with these organizations changes from civilian to commercial upon the date of the transition.

Another notable augmentation in the data transference process concerns joint payload operation. In the catalog, I accounted for these observations by concatenating the political actors. Since the unit of analysis in the database is political actor-year, I have counted the same jointly operated payload once for each political actor that is party to the joint operation. For example, if the United States and New Zealand jointly operate one payload, then I count one payload for each state for that year. In order to offset any confusion that may arise from counting the same object multiple times, I created an additional variable that tracks how many jointly operated payloads each political actor operates per year. The only exception to this rule is when multiple political actors under the "international" designation take part in joint payload operations; these are only counted once. However, if a political actor under the "international" designation jointly operates a payload with another state, then rule applies.

I created four identifier variables for the database's unit of analysis: political actor, COW code, year, and political actor-year. The political actor variable is simply the name of the panel ID unit. The COW code refers to the Correlates of War country code, which is utilized in setting the panel parameters due to STATA rejecting textual string variables.[177] The year variable is a set of 63 repeated values of 1957 to 2019 for each political actor. The political actor-year variable is a concatenation of the first and third identifier variables.

[177] https://correlatesofwar.org/data-sets/cow-country-codes

I establish a set of six continuous launch variables: total launches, successful launches, failed launches, civilian launches, commercial launches, and military launches. The successful and failed launch variables are related to each other insofar as they together equal the number of total launches per political actor per year. The same goes for the civilian, commercial, and military launch variables.

There are seven general payload variables that are all continuous: total payloads, non-military payloads, military payloads, civilian payloads, commercial payloads, hybrid payloads, and unknown payloads. The non-military and military payloads are related to each other insofar as they together equal the number of total payloads per political actor per year. The same goes for the military, civilian, commercial, hybrid, and unknown payload variables. There are also twenty-eight specific payload variables that reflect the total number of "payload types" mentioned above for every political actor per year.

I include sixteen additional variables that reflect the material space capabilities of political actors. The first variable is coded dichotomously for whether a political actor has achieved satellite operability. I account for launch vehicle completion status across four types: orbital, suborbital, mesospheric, and atmospheric. These variables are coded dichotomously for completion. Once a political actor completes a launch vehicle type, it receives a code which then extends to the end of the temporal range. These variables allow me to establish a typology of four spacefarers: major spacefarers, minor spacefarers, emergent spacefarers, and spacefaring dependents.

Major spacefarers are political actors that have obtained orbital launch capabilities. The logic of this association is that these actors can choose to clandestinely launch orbital payloads with relative impunity. Minor spacefarers are political actors that have obtained suborbital launch capabilities. The logic of this association is that, while not yet able to place objects in orbit, these actors have the ability to launch powerful rockets up to the Karman Line—which often serves as the precursor to or testing framework for incipient orbital launches. Emergent spacefarers are political actors that have obtained mesospheric or atmospheric ballistic launch capabilities. The logic of this association is that these actors are at an entry-level position pertaining to space activity and the prospect of independent launch capabilities. Spacefaring dependents are political actors that operate at least one orbital payload without possessing any launch capabilities. The logic of this association is that these actors still have a modicum of spacefaring status due to their operation of an asset in orbit without actually being a spacefarer.

These typology variables are coded dichotomously but construed hierarchically. This means that a political actor is coded 1 for every year it embodies a spacefaring status and a 0 for the years prior. If a political actor advances up the capability hierarchy, it then receives a code of 0 for the years both prior to and after the advancement. For example, North Korea was a minor spacefarer from 1984 to 1997 and became a major spacefarer from 1998 to 2019. This means that it is coded 0 from 1957 to 1983 and from 1998 to 2019 in the minor spacefarer variable. This also means that it is coded 0 from 1957 to 1997 in the major spacefarer variable.

The spacefaring typology allows me to produce two additional variable that denote a general spacefaring status: spacefaring actors and non-spacefaring actors. Major and minor spacefarers are considered spacefaring actors because they each can reach space. Emergent spacefarers and spacefaring dependents are considered non-spacefaring actors because they cannot. These variables are coded dichotomously.

The spacefaring typology also allows me to produce a second typology that accounts for space power status. I establish three specific space power variables: primary space powers, secondary space powers, and tertiary space powers. Primary space powers are major spacefarers that operate military satellites. The logic of this association is that a political actor's capabilities are enhanced beyond spacefaring status by adding a military tactical advantage. Secondary space powers are major spacefarers that only operate non-military satellites. The logic of this association is that, despite a lack of military satellite operability, the orbital launch capability inherent to the major spacefaring status is still a form of power that carries with it the potential for future military activity. Tertiary space powers are political actors that operate military satellites regardless of their spacefaring status. The logic of this association is that the operation of a military satellite endows a political actor with a tactical advantage, regardless its launch capability status. I also establish two general space power variables: space powers and non-space powers. Space powers include all primary, secondary, and tertiary power types. Non-space powers are political actors that do not achieve any of the three space power types at any point in time.

Like the spacefaring typology, these variables are coded dichotomously but construed hierarchically. A political actor is coded 1 for every year it embodies a space power status and a 0 for the years prior. If a political actor advances up the power hierarchy, it then receives a code of 0 for the years both prior to and after the advancement. For example, China was a secondary space power from 1970 to 1972 and then a primary space power from 1973 to 2019. This means that it is coded 0 from 1957 to 1969 and from 1973 to 2019 in the secondary space power variable. This also means that it is coded 0 from 1957 to 1972 in the primary space power variable.

*Adding International Space Treaty Subscription Data*

The ratification status of international space-related treaties over time is the second major interest of this research project. To comprehensively capture the international system's propensity to subscribe to space-related treaties and organizations, I appealed to the United Nations Office of Outer Space Affairs.[178] This administration publishes an annual document detailing the subscription status of space-related agreements that includes bibliographical information as well as an index of ratification status.[179] While this document aided me in choosing the relevant treaties to include in my database, it only provided a snapshot of agreement statuses as of January 1st, 2020. Since my interest lay with cataloging the statuses on a yearly basis, I had to obtain ratification dates through the United Nations Treaty Collection (UNTC)[180] and the United Nations Office for Disarmament Affairs (UNODA).[181] If the UNTC or UNODA did not have ratification information on a particular treaty, I went back to the UNOOSA agreement status document to check for alternative sources. Since many of the agreements in which I was interested were submitted to American or British depositaries, I was able to retrieve ratification statuses from the United States Department of State[182] and United Kingdom Foreign and Commonwealth Office[183].

The data is comprised of three groups of international treaties that pertain to spacefaring operations. I provide twenty total variables to represent the international treaty subscription status of each political actor per year. The final variable is a total count of all treaty ratifications for every political actor-year across each of the three groups described below. There are five

[178] https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/status/index.html
[179] "STATUS OF INTERNATIONAL AGREEMENTS RELATING TO ACTIVITIES IN OUTER SPACE AS AT 1 JANUARY 2020" (United Nations Office of Outer Space Affairs (UNOOSA), January 1, 2020), https://www.unoosa.org/documents/pdf/spacelaw/treatystatus/TreatiesStatus-2020E.pdf.
[180] https://treaties.un.org/Pages/Home.aspx?clang=_en
[181] http://disarmament.un.org/treaties/
[182] https://www.state.gov/space-status-lists/ & https://www.state.gov/depositary-status-lists/
[183] https://treaties.fco.gov.uk/responsive/app/consolidatedSearch/

variables for each of the international space treaty system (ISTS) agreements: the Outer Space Treaty of 1967, the Rescue Agreement of 1968, the Liability Convention of 1972, the Registration Convention of 1975, and the Moon Agreement of 1979. Each of these variables is coded dichotomously for ratification or no ratification. I also provide a count variable to track how many of the ISTS treaties a political actor has ratified from zero to five. Cells are left empty for all years prior to a given treaty's existence and, in the case of the ISTS score variable, cells are left empty prior to the earliest treaty's existence.

I created five variables for peripheral space-related global agreements: the Nuclear Test Ban Treaty of 1963, the Convention Relating to Programme-Carrying Signals of 1974, the International Telecommunications Satellite Agreement of 1971, the International Mobile Satellite Convention of 1976, and the International Telecommunications Convention of 1994. Each of these variables is coded dichotomously for ratification or no ratification. I also provide a count variable to track how many of these global agreements a political actor has ratified from zero to five. Cells are left empty for all years prior to a given treaty's existence and, in the case of the global agreement score variable, cells are left empty prior to the earliest treaty's existence.

I established six variables for peripheral space-related regional agreements: the Intersputnik Agreement of 1971, the Intercosmos Agreement of 1976, the European Space Agency Convention of 1975, the Arab Corporation Agreement of 1976, the European Telecommunications Satellite Convention of 1982, and the European Meteorological Satellite Convention of 1983. Each of these variables is coded dichotomously for ratification or no ratification. I also provide a count variable to track how many of these regional agreements a political actor has ratified from zero to six. Cells are left empty for all years prior to a given treaty's existence and, in the case of the regional agreement score variable, cells begin filled at the earliest date if a given agreement came into effect prior to 1957.

## 4.2. Research Design

*Dependent Variable*

Non-military payloads are used as a proxy variable to indicate the relative security or stability status of the political environment at a given time. This variable represents the total number of civilian, commercial, and hybrid payloads launched per year. As mentioned above, civilian payloads are operated by non-military governmental organizations, academic organizations, amateur organizations, or non-profit organizations. Commercial payloads are operated by private or public business entities, and hybrid payloads are jointly operated by civilian and commercial organizations. Unknown payloads are omitted for obvious reasons. The variable is coded as continuous, representing a total count per political actor per year. While it serves as the only dependent variable of the analysis, I provide additional models in the appendix to demonstrate the effects on its three subcomponents.

*Independent Variable 1*

The neorealist hypothesis proposes that the militarization of space works to securitize the domain by acting as a deterrence mechanism against acts of international aggression. As a result, the presence of military payloads is the first explanatory variable of interest. This variable is coded as continuous and reflects the total number of payloads with expressed military purposes and operated by military branches of governmental entities per political actor per year.

*Independent Variable 2*

The neoliberal institutionalist hypothesis proposes that the subscription to international space treaties or institutions works to securitize the domain by acting as a credibility signal for promises made against acts of international aggression. As a result, the ratification status of space-related treaties is the second explanatory variable of interest. I operationalize this in three ways. First, I provide individual total ratification scores across three sets of treaties: the five core treaties that make up the ISTS, the five treaties that represent global space agreements, and the six treaties that represent the major regional space agreements. Each of these variables is coded on a scale from zero to the total number of treaties included in the set for every political actor per year. Second, I provide a total ratification score for all of the three sets mentioned above. This variable is coded on a scale from zero to sixteen for every political actor per year. Finally, I provide individual ratification scores for the five core ISTS treaties alone. Each of these variables are coded dichotomously for ratification per year for every political actor.

*Control Variables*

I include six control variables to account for alternative explanatory factors: polity score, log GDP, national material capability score, alliance score, annual military expenditures, and other domain agreement scores.

Polity data are used because government type is often argued by IR scholars to be an important factor in virtually all national activities. Polity data is obtained from the Polity Project of the Center for Systemic Peace's Integrated Network for Societal Conflict Research

(INSCR).[184] I utilized the Polity IV database which tracks the constitutive characteristics of national governments from 1800 to 2018.[185] I specifically used the POLITY2 Revised Combined Polity Score that codes a government on a scale of +10 (strongly democratic) to -10 (strongly autocratic). Cells are left blank for all observations in the year 2019.

Log of GDP is included because it stands to reason that a political actor's economy plays a role in its ability to engage in spacefaring operations. GDP data were obtained from The World Bank's Open DataBank of World Development Indicators and OECD National Accounts.[186] The variable is coded as a percentage of annual growth from the previous year's GDP. The World Bank indicators begin in 1960, therefore cells are left blank for years 1957-1959.

Material capability data are used because this status can serve as a determining factor in a political actor's ability to take part in the manufacture of spacefaring technologies. National material capability scores are obtained from the Correlates of War Project's National Material Capabilities Database.[187] I specifically use the Composite Index of National Capability[188] score which combines six independent measures of national material capabilities into an individual annual score for every government.[189] The CINC score is coded as a range between 0 and 1 reflecting a global percentage of material capabilities. This means that a score of 0 means that a state possessed 0% of the global material capabilities in a given year and 1 would indicate a

---

184 https://www.systemicpeace.org/polityproject.html

185 Monty G. Marshall, Ted Robert Gurr, and Keith Jaggers, "Polity IV Project: Political Regime Characteristics and Transitions, 1800–2018," *Center for Systemic Peace*, 2019.

186 https://data.worldbank.org/

187 https://correlatesofwar.org/data-sets/national-material-capabilities

188 J. David Singer, Stuart Bremer, and John Stuckey, "Capability Distribution, Uncertainty, and Major Power War, 1820-1965," *Peace, War, and Numbers* 19 (1972): 48.

189 Michael Greig and Andrew J. Enterline, "National Material Capabiltiies Data Documentation, Version 5.0.," *Correlates of War Project*, 2017, 7.

state's possession of 100% of the global material capabilities in a given year. The database only provides information from 1816 to 2012, so cells are left blank for years between 2013 and 2019.

Alliance data are included because a political actor's propensity to take part in alliance formation may indicate its willingness to take part in other international treaties, such as those pertaining to the space domain. Alliance scores are obtained from the Alliance Treaty Obligations and Provisions project which catalogs information pertaining to military alliance agreements between 1815 and 2016.[190] I use the ATOP 4.0 State-Year Dataset and impute the NUMBER variable into my database. This variable is coded continuously and accounts for the total number of alliances of which a political actor is a member per year.[191] Cells are left blank for years between 2017 and 2019.

Military expenditure data are used for similar reasons as government consumption of GDP data. The extent to which a political actor may be inclined to spend funds on general military purposes may influence its willingness to spend funds on military space operations. Military expenditure data is obtained from the Stockholm International Peace Research Institute (SIPRI).[192] Figures are provided from 1949 to 2019 in various formulations. I specifically use current United States dollars in order to maintain values that mirror the format of the World Bank GDP and GDP government consumption data.

Data pertaining to the ratification of other spatial domain treaties are used for similar reasons as the alliance data. A political actor's willingness to ratify space-related treaties may be indicated by its willingness to ratify treaties of other domains inherent to the global commons, such as international waters and international airspace. The data collection process for the

---

[190] http://www.atopdata.org/
[191] Brett Ashley Leeds, "Alliance Treaty Obligations and Provisions (atop) Codebook," *Houston: Rice University, Department of Political Science*, 2005, 50.
[192] https://www.sipri.org/databases/milex

ratification statuses of these treaties conformed to the process mentioned above concerning the international space-related treaties. The United Nations Treaty Collection was the primary resource.

This control variable is an indexed score variable like those used for the ISTS treaties, the global space agreements, and the regional space agreements. I account for seven spatial domain treaties: the Convention on the International Maritime Organization of 1948, the Convention on the Territorial Sea and the Contiguous Zone of 1958, the Convention on the High Seas of 1958, the United National Convention on the Law of the Sea of 1982, Annex XI on the World Meteorological Organization of 1951, Annex III on the International Civil Aviation Organization of 1948, and the Antarctic Treaty of 1961. These variables are coded dichotomously for ratification. Cells are left empty for years prior to a treaty's existence. The score variable is coded on a range from zero to seven.

I chose these six variables because they embody reasonable alternative explanations for variation in the dependent variable. I use the log of GDP because GDP itself is highly correlated with material capabilities. Government consumption of GDP was originally included to capture civilian budgets or market shares, but the variable is highly correlated with military expenditures. I decided that material capabilities and military expenditures were too important to drop, especially when the correlation issue could be resolved with the substitution of the log GDP variable

**4.3. Methodology**

The data are structured longitudinally across 195 political actors and 63 years (1957-2019) for a total of 12,285 observations. The panel is therefore considered *short* and *wide* because the cross-section is larger than the time-series.[193] The panel data is also considered *balanced* and *fixed* because every entity is measured over every unit of time and the same entities are measured for each unit of time.[194] The arrangement of the data is considered *long*, meaning that both the panel ID and temporal components are ordered, therefore no reshaping is required by the analysis software. I utilize STATA 14 for all descriptions, tabulations, graphs, and regression analyses.[195]

Since my data is longitudinal, I employ a time-series cross-sectional (TSCS) statistical analysis. There are three traditional estimator models for TSCS: pooled ordinary least squares (OLS), fixed effects (FE), and random effects (RE). Pooled OLS is no longer viewed as a particularly optimal model for panel data because it requires the acceptance of too many rigid assumptions, most notably the presence of spherical errors and homoscedastic variance.[196] Fixed effects and random effects models have endured for a long time as viable options, and a fair amount of debate currently exists around which is preferable to the other. Some argue that the fixed effects model is not only optimal[197] but also the "gold standard" for econometrics.[198] Others argue that the random effects model outperforms the fixed effects model in every way.[199] The

---

[193] Adrian Colin Cameron and Pravin K. Trivedi, *Microeconometrics Using Stata*, vol. 5 (Stata press College Station, TX, 2009), 230.
[194] Hun Myoung Park, "Practical Guides to Panel Data Modeling: A Step-by-Step Analysis Using Stata," *Public Management and Policy Analysis Program, Graduate School of International Relations, International University of Japan*, 2011, 3–4.
[195] https://www.stata.com/
[196] Nathaniel Beck and Jonathan N. Katz, "What to Do (and Not to Do) with Time-Series Cross-Section Data," *American Political Science Review* 89, no. 3 (1995): 636.
[197] Stephen Vaisey and Andrew Miles, "What You Can—and Can't—Do with Three-Wave Panel Data," *Sociological Methods & Research* 46, no. 1 (2017): 44–67.
[198] Stefanie Schurer and Jongsay Yong, "Personality, Well-Being and the Marginal Utility of Income: What Can We Learn from Random Coefficient Models?," 2012.
[199] Bruce Western, "Causal Heterogeneity in Comparative Research: A Bayesian Hierarchical Modelling Approach," *American Journal of Political Science* 42, no. 4 (1998): 1233–1259; Boris Shor et al., "A Bayesian Multilevel Modeling Approach to Time-Series Cross-Sectional Data," *Political Analysis* 15, no. 2 (2007): 165–181; Andrew Bell and Kelvyn Jones, "Explaining Fixed Effects: Random Effects Modeling of Time-Series Cross-Sectional and Panel Data," *Political Science Research and Methods* 3, no. 1 (2015): 133–153.

core difference between the two model types is how dummy variables are handled. The coefficient of a dummy variable is related to the intercept in a fixed effects model and an error component in a random effects model.[200] As a result, various statistical tests have become ubiquitous to determine which method is better for a give set of data.

*Testing for Individual Specific Effects*

Before any conducting any tests, I set the panel ID and time variables to ensure that STATA recognizes the panel data and confirms that the structure is strongly balanced. I regress a pooled OLS model and find that the results reject the null hypothesis. I then implement a Fisher (F) test and find that those results also reject the null hypothesis. This informs me that when compared to the pooled OLS, the fixed effects model is preferable. Next, I implement a Lagrange Multiplier (LM) test and find that the p-value is too high to reject the null hypothesis (Breusch and Pagan 1980).[201] This informs me that when compared to the pooled OLS, the random effects model is not preferable. I find this to be strange because my explanatory variables seem to conceptually conform to the assumptions made by the model. When regressing the random effects model, I find that no values are provided for either the Wald chi-square test or the p-value. STATA informs me that this does not necessarily mean that there is a problem with my data, only that values were not provided in order to prevent the conveyance of misleading results.

*Choosing an Estimator Model*

[200] Park, "Practical Guides to Panel Data Modeling," 8.

[201] Trevor S. Breusch and Adrian R. Pagan, "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics," *The Review of Economic Studies* 47, no. 1 (1980): 239–253.

The next step is to compare the applicability of the two models in question. I regress the fixed effects model as well as the random effects model and store each set of estimates respectively. Storing the estimates allows me to perform a Hausman test which checks for differences in the two parameter estimates.[202] Here, the null hypothesis states that there is no correlation between individual effects and a regressor. Since my Hausman test rejected the null hypothesis, it is permissible to assume that there is some correlation and that the random effects model may not be preferable. Unfortunately, in recent years, studies implementing Monte Carlo simulations have demonstrated the ineffectiveness of Hausman tests—particularly concerning trends in over-rejecting the null hypothesis.[203] A common recommendation is to choose an estimator model after first performing individual tests for heteroskedasticity and autocorrelation.[204]

I then implement a modified Wald test to check for heteroskedasticity and a Woolridge test to check for autocorrelation. The results convey that my data is heteroskedastic but not autocorrelated. In situations such as this, two models are recommended: the Feasible Generalized Least Squares model[205] and the Generalized Least Squares model with Huber-White sandwich estimators.[206] The first option estimates the structure of heteroskedasticity from the ordinary least

---

[202] Jerry A. Hausman, "Specification Tests in Econometrics," *Econometrica: Journal of the Econometric Society*, 1978, 1251–1271.

[203] Tom S. Clark and Drew A. Linzer, "Should I Use Fixed or Random Effects?," *Political Science Research and Methods* 3, no. 2 (2015): 399–408; Teodora Sheytanova, *The Accuracy of the Hausman Test in Panel Data: A Monte Carlo Study*, 2015; Justin Esarey and Jacob Jaffe, "A Direct Test for Consistency of Random Effects Models That Outperforms the Hausman Test," 2017.

[204] P. Kennedy, "A Guide to Econometrics, Oxford," *Willey Blackwell*, 2008, 286; Andrew Bell, Malcolm Fairbrother, and Kelvyn Jones, "Fixed and Random Effects Models: Making an Informed Choice," *Quality & Quantity* 53, no. 2 (2019): 1051–1074; Park, "Practical Guides to Panel Data Modeling," 17.

[205] Richard W. Parks, "Efficient Estimation of a System of Regression Equations When Disturbances Are Both Serially and Contemporaneously Correlated," *Journal of the American Statistical Association* 62, no. 318 (1967): 500–509; Jan Kmenta and Pietro Balestra, "Missing Measurements in a Regression Problem with No Auxiliary Relations," *Advances in Econometrics* 5 (1986): 289–300.

[206] Peter J. Huber, "The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions," in *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*, vol. 1 (University of

squares and the second option uses squared heteroskedastic residuals as an estimate of consistent variance.[207] Instead of choosing one option over the other, I decide to implement both approaches in order to maintain academic integrity and provide a more rigorous analysis.

## 4.4. Conclusion

In this chapter, I provide the requisite information concerning the research project's fundamental features. I discuss the data collection process in the first section which involves three phases: the cataloging of orbital launch and payload activities, the transposition of that information into a longitudinal database, and the addition of international space-related treaties into the newly constructed database. I discuss the research design in the second section which details the operationalization of the dependent variable, the two independent variables, and the control variables. I devote the final section to methodology and describe the structure of the panel data as well as the processes of testing for and choosing appropriate estimator models. In the following chapter, I provide descriptive statistics and results for the observations and analyses introduced here.

California Press, 1967), 221–233; Halbert White, "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," *Econometrica: Journal of the Econometric Society*, 1980, 817–838.
[207] William Rogers, "Quantile Regression Standard Errors," *Stata Technical Bulletin* 2, no. 9 (1993).

# CHAPTER 5

# DESCRIPTIVE STATISTICS AND RESULTS

In this chapter, I provide descriptive statistics across four sections and regression results in the fifth section. The first section is dedicated to describing the panel data's population component of the cross-section and temporal components of the time-series. The second section is dedicated to the three typologies constructed around material and behavioral capabilities: spacefarers, space powers, and space cooperators. The third section is dedicated to the descriptive statistics pertaining to orbital launches. The fourth section is dedicated to the descriptive statistics pertaining to orbital payloads. The final section is dedicated to describing the results of two sets of regression models: feasible generalized least squares and generalized least squares with Huber-White sandwich estimators.

## 5.1. Panel Data

*Population Data*

Table 5.1.1 describes the cross-sectional component of the database which is comprised of 195 political actors including 193 UN-recognized sovereign states, one non-sovereign state (Taiwan), and one set of international non-state actors. Almost all the panel falls under the sovereign state category which accounts for just under ninety-nine percent of the total population. Taiwan is included because it is the only state that takes part in space-related activities that is not considered sovereign by the UN.

**Table 5.1.1: Distribution of Political Actors by Type**

| Political Actor Type | Panel Entities | Percent of Panel | Actual Entities | Percent of Entities |
|---|---|---|---|---|
| Sovereign States | 193 | 98.97 | 193 | 93.24 |
| Non-Sovereign States | 1 | .51 | 1 | .48 |
| Non-State Actors | 1 | .51 | 13 | 6.28 |
| Total | 195 | 100.00 | 207 | 100.00 |

The non-state actor category falls under the solitary panel identifier "international" but represents thirteen multinational bodies including intergovernmental organizations and transnational corporations. These categories respectively account for roughly one-half a percent of the panel. When accounting for the actual entities included in the non-state actor category, the percentages are slightly augmented. Taiwan's proportion changes marginally while the sovereign state category drops by nearly six percent and the non-state actor category rises by nearly six percent.

Table 5.1.2 provides a list of organizations that represent non-state actors as well as the years of operation for each. Most of the non-state actors are IGOs, four of which still exist today while three transitioned to privatized multinational organizations. The European Launcher

Development Organization (ELDO) and the European Space Research Organization (ESRO) were merged with the ESA in 1975. Interkosmos launched its last flight in 1988 and dissolved with the USSR in 1991. The International Maritime Satellite Organization (INMAR) transitioned into the International Mobile Satellite Organization (IMSO) in 1999. All the transnational corporations are privatized iterations of former IGOs. Only two of the three IGOs that privatized exist today. The European Telecommunications Satellite Organization (EUTEL) became Eutelsat S.A. in 2001 and the Regional African Satellite Communications Organization (RASCOM) became RASCOMstar in 2002. The International Telecommunications Satellite Organization (ITSO) became Intelsat in 2001 and operated for nearly a decade before filing for bankruptcy in 2020.

**Table 5.1.2: Selection of Independent Satellite Operating Non-State Actors**

| Political Entity | IGO | Privatized Organizations |
|---|---|---|
| European Launcher Development Organization (ELDO) | 1964-1975 | |
| European Space Agency (ESA) | 1975-Present | |
| European Space Research Organization (ESRO) | 1964-1975 | |
| European Space and Research Technology Centre (ESTEC) | 1968-Present | |
| European Meteorological Satellite Organization (EUMET) | 1986-Present | |
| European Telecommunications Satellite Organization (EUTEL) | 1977-2001 | 2001-Present |
| Interkosmos (IK) | 1967-1991 | |
| International Mobile Satellite Organization (IMSO) | 1999-Present | |
| International Maritime Satellite Organization (INMAR) | 1976-1999 | |
| International Telecommunications Satellite Organization (ITSO) | 1964-2001 | 2001-2020 |
| Regional African Satellite Communications Organization (RASCOM) | 1993-2002 | 2002-Present |

I emphasize these transnational corporations not because they are the only ones taking part in spacefaring activities, rather they are the only ones that affiliate with a multinational conglomerate (e.g. the European Union) as opposed to a state. In Table 5.1.3, I provide a superficial list of these conglomerates. Most of the non-state actors are affiliated with the continent of Europe even before the establishment of the ESA in 1975, accounting for over sixty-one percent of NSAs and roughly four percent of the panel. Africa and Soviet Eurasia respectively account for just under eight percent of the group and one-half a percent of the panel.

Roughly twenty-three percent of the group is represented by transcontinental or global organizations that subsequently make up just over one and one-half percent of the panel.

**Table 5.1.3: Multinational Conglomerates Associated with Non-State Actors**

| Entity | NSA Count | Percent of Group | Percent of Panel |
|---|---|---|---|
| Africa | 1 | 7.7 | .51 |
| Europe | 8 | 61.54 | 4.10 |
| Eurasia (Soviet) | 1 | 7.7 | .51 |
| Transcontinental | 3 | 23.08 | 1.54 |
| Total | 13 | 100.00 | 6.66 |

*Temporal Data*

Table 5.1.4 describes the time-series component of the database which is comprised of 63 years from 1957 to 2019. The analyses regress observations across this full temporal range, but I also provide additional models for five segments of time within it. These additional ranges are included to demonstrate the variation of space behavior during specific eras. The first of these additional ranges isolates years from 1957 to 1979, which reflects the duration from the launch of Sputnik to the end of détente. Accounting for twenty-three years and over thirty-six percent of the full temporal scope, it is the largest range of the group. I originally intended to provide a range from 1957 to 1962 to represent the years of tension leading up to and through the Cuban Missile Crisis and another range from 1963 to 1979 to represent the traditional duration of détente. Since no observations were present for the treaty variables included for the second hypothesis, I concatenated the two ranges. In the results section below, I provide ancillary models excluding those variables in case the results are of interest to the reader.

**Table 5.1.4: Selection of Temporal Ranges**

| Range | Count | Percent of Total Range | Description |
|---|---|---|---|
| 1957-2019 | 63 | 100.00 | Full Temporal Range |
| 1957-1979 | 23 | 36.51 | From Sputnik to the End of Détente |
| 1980-1986 | 7 | 11.11 | The “Second” Cold War |
| 1987-1991 | 5 | 7.94 | The Fall of the USSR |
| 1992-2000 | 9 | 14.29 | The Early Post-Cold War Era |
| 2001-2019 | 19 | 30.16 | The Twenty-First Century |

The second additional range covers the so-called “second” Cold War from 1980 to 1986 and represents roughly eleven percent of the total range. The third range covers the five years leading up to the dissolution of the Soviet Union and only accounts for about eight percent of the entire series of time. The fourth range covers the immediate post-Cold War era leading up to the turn of the century. These nine years represent just over fourteen percent of the full temporal range. The fifth range covers the twenty-first century leading up to the end of the 2019 calendar year. As the second largest additional range, these nineteen years account for roughly thirty percent of all observed years.

## 5.2. Typologies of Political Actors and Space-Related Activities

*Typology of Spacefarers*

Material space capabilities are used to establish a typology of spacefarers. Major spacefarers have orbital launch capabilities, minor spacefarers have suborbital launch capabilities, emergent spacefarers have atmospheric and mesospheric launch capabilities, and spacefaring dependents operate satellites but rely on major spacefarers for launches. Despite the term being used in the emergent category, only members of the major and minor categories are technically spacefarers because they possess the launch capabilities required to enter space.

**Table 5.2.1: Typology of Spacefarers, by Number across Full Temporal Range**

| Spacefarer Type | Count | Percent of Group | Percent of Panel |
|---|---|---|---|
| Major Spacefarer | 15 | 13.39 | 7.69 |
| Minor Spacefarer | 35 | 31.25 | 17.95 |
| Emergent Spacefarer | 10 | 8.93 | 5.13 |
| Dependents | 52 | 46.43 | 26.67 |
| Total | 112 | 100.00 | 57.44 |

Table 5.2.1 provides general information for the typology of spacefarers. From 1957 to 2019, one hundred and twelve political actors achieve a ranking status in the typology of spacefarers which constitutes over fifty-seven percent of the panel. Of these, fifty are actual spacefarers while sixty-two take part in space-related activities despite lacking spaceflight technologies. Spacefarers make up roughly forty-five percent of the group and roughly one-quarter of the panel. Non-spacefaring actors represent about fifty-five percent of the group and nearly thirty-two percent of the panel.

Fifteen political actors achieve orbital launch capabilities which is just over thirteen percent of the group and just under eight percent of the panel. Thirty-five political actors achieve suborbital launch capabilities which makes up over thirty-one percent of the group and roughly five percent of the panel. Ten political actors develop mesospheric or atmospheric launch systems which constitutes nearly nine percent of the group and five percent of the panel. Finally, spacefaring dependents make up the largest group with fifty-two political actors that account for over forty-six percent of the group and nearly twenty-seven percent of the panel. It is important to note, however, that category representation is not always static because political actors advance their technological capabilities over time.

Table 5.2.2 conveys the active years for every state associated with at least one of the three types of the typology associated with rocket-launching capabilities. Eight of the ten political actors that achieve emergent spacefaring status move on to become minor spacefarers.

The Netherlands and Peru remain in the emergent category through the end of 2019. Twelve of the thirty-five minor spacefarers move on to become major spacefarers, which is roughly thirty-four percent of the group and six percent of the panel. Only Russia, the United States, and Ukraine began as major spacefarers, but Ukraine owes its status to its geographical location and allegiance to the USSR which manufactured and housed the launch vehicles there. As a result, eighty percent of major spacefarers developed orbital launch capabilities after first obtaining suborbital launch capabilities.

**Table 5.2.2: Spacefarer Typology, by Active Years**

| Political Actor | Major Spacefarer | Minor Spacefarer | Emergent Spacefarer |
|---|---|---|---|
| Argentina | | 1964-2019 | 1962-1963 |
| Australia | | 1957-2019 | |
| Brazil | 1997-2019 | 1965-1996 | |
| Canada | | 1958-2019 | 1957 |
| China | 1970-2019 | 1960-1969 | |
| Czech Republic | | 1970-2019 | |
| DPRK | 1998-2019 | 1984-1997 | |
| Denmark | | 1971-2019 | |
| Egypt | | 1973-2019 | 1962-1972 |
| Europe[208] | 1966-2019 | 1963-1965 | |
| France | 1965-2019 | 1957-1964 | |
| Germany | | 1957-2019 | |
| India | 1979-2019 | 1965-1978 | |
| Indonesia | | 2004-2019 | 1987-2003 |
| Iran | 2008-2019 | 1985-2007 | |
| Iraq | | 1977-2019 | |
| Israel | 1988-2019 | 1987 | |
| Italy | | 1961-2019 | |
| Japan | 1966-2019 | 1961-1965 | 1957-1959 |
| Lebanon | | 1962-2019 | |
| Libya | | 1986-2019 | |
| Netherlands | | | 2015-2019 |
| New Zealand | | 2009-2019 | |
| Norway | | 1962-2019 | |
| Pakistan | | 1962-2019 | |
| Peru | | | 2007-2019 |
| Poland | | 1970-2019 | 1963-1969 |
| Republic of Korea | 2009-2019 | 1997-2008 | 1978-1996 |
| Russia | 1957-2019 | | |

[208] Europe is included here as a component of the broader "international" panel identifier

| | | | |
|---|---|---|---|
| South Africa | | 1989-2019 | |
| Spain | | 1968-2019 | 1966-1967 |
| Sweden | | 1963-2019 | |
| Switzerland | | 1967-2019 | |
| Syria | | 1992-2019 | |
| Taiwan | | 1998-2019 | |
| Turkey | | 1962-2019 | |
| Ukraine | 1961-2019 | | |
| United Kingdom | 1970-2019 | 1958-1969 | |
| United States | 1957-2019 | | |
| Yemen | | 1994-2019 | |

By the end of 2019, there are ninety political actors that rank in the typology of spacefarers which represent about forty-six percent of the panel. Table 5.2.3 demonstrates the current number of spacefarers by type. Fifteen major spacefarers, including Europe via the ESA, make up nearly seventeen percent of the group and nearly eight percent of the panel. Twenty-three minor spacefarers represent just over one-quarter of the group and just under twelve percent of the panel. Two emergent spacefarers account for roughly two percent of the group and one percent of the panel. Finally, fifty spacefaring dependents make up over half of the group and roughly one-quarter of the panel.

**Table 5.2.3: Typology of Spacefarers, by Number as of 12/31/19**

| Spacefarer Type | Count | Percent of Group | Percent of Panel |
|---|---|---|---|
| Major Spacefarer | 15 | 16.67 | 7.69 |
| Minor Spacefarer | 23 | 25.56 | 11.79 |
| Emergent Spacefarer | 2 | 2.22 | 1.03 |
| Dependents | 50 | 55.56 | 25.64 |
| Total | 90 | 100.00 | 46.15 |

*Typology of Space Powers*

Space power types are determined by spacefaring status and military space capabilities. Primary space powers are major spacefarers that operate military satellites, secondary space powers are major spacefarers that do not operate military satellites, and tertiary space powers are political actors that operate military satellites without orbital launch capabilities. In Table 5.2.4, I provide general information concerning the typology of space powers.

**Table 5.2.4: Typology of Space Powers, by Number across Full Temporal Range**

| Space Power Type | Count | Percent of Group | Percent of Panel |
|---|---|---|---|
| Primary Space Powers | 9 | 22.50 | 4.62 |
| Secondary Space Powers | 12 | 30.00 | 6.15 |
| Tertiary Space Powers | 19 | 47.50 | 9.74 |
| Total | 40 | 100.00 | 20.51 |

From 1957 to 2019, forty political actors achieved space power status which constitutes over twenty percent of the panel. Nine primary space powers represent about twenty-three percent of the group and nearly five percent of the panel. Twelve secondary space powers make up thirty percent of the group and roughly six percent of the panel. Finally, nineteen tertiary space powers account for over forty-seven percent of the group and about ten percent of the panel. Like the spacefarer typology, space power status is not static because political actors advance in both launch capabilities and military satellite development over time.

**Table 5.2.5: Typology of Space Powers, By Active Years**

| Political Actors | Primary Space Powers | Secondary Space Powers | Tertiary Space Powers |
|---|---|---|---|
| Australia | | | 1967-2019 |
| Brazil | | 1997-2019 | |
| Canada | | | 2013-2019 |
| China | 1973-2019 | 1970-1972 | |
| Czech Republic | | | 1978-2019 |
| DPRK | | 1998-2019 | |
| Denmark | | | 2017-2019 |
| Egypt | | | 2019 |
| Europe | | 1966-2019 | |
| France | 1984-2019 | 1965-1983 | |

| | | | |
|---|---|---|---|
| Germany | | | 2006-2019 |
| India | 2019 | 1979-2018 | |
| Iran | | 2008-2019 | |
| Israel | 1988-2019 | | |
| Italy | | | 2001-2019 |
| Japan | 2003-2019 | 1966-2002 | |
| Luxembourg | | | 2017-2019 |
| Mexico | | | 2019 |
| Morocco | | | 2017-2019 |
| Netherlands | | | 2017-2019 |
| New Zealand | | | |
| Peru | | | 2016-2019 |
| Republic of Korea | | 2009-2019 | 2006-2008 |
| Russia | 1961-2019 | 1957-1960 | |
| South Africa | | | 2014-2019 |
| Sweden | | | 2019 |
| Taiwan | | | 2006-2019 |
| Turkey | | | 2012-2019 |
| Ukraine | | 1961-2019 | |
| UAE | | | 2019 |
| United Kingdom | 1970-2019 | | 1969 |
| United States | 1958-2019 | 1957 | |

Table 5.2.5 conveys the active years of every political actor that achieves at least one of the three space power statuses. Of the nineteen tertiary space powers, only two advanced on to a higher status. The Republic of Korea became a secondary power in 2009 after spending three years as a tertiary power, and the United Kingdom became a primary power in 1970 after spending only one year as a tertiary power. Roughly eighty-nine percent of tertiary space powers remain fixed in that station which, in turn, represents roughly forty-three percent of the group and nearly nine percent of the panel. Half of the twelve secondary space powers eventually become primary powers which accounts for fifteen percent of the group and three percent of the panel. Seven of the nine primary space powers advanced from a lower status which represents seventy-eight percent of category, roughly eighteen percent of the group, and nearly four percent of the panel. Six emerged from the secondary category and the United Kingdom, as mentioned above, rose from the tertiary category. The only outlier is Israel which entered the typology as

primary space powers in 1988. None of the political actors that obtained a space power status did so by traversing all three categories.

**Table 5.2.6: Space Power Typology, by Number as of 12/31/19**

| Space Power Type | Count | Percent of Group | Percent of Panel |
|---|---|---|---|
| Primary Space Powers | 9 | 28.13 | 4.62 |
| Secondary Space Powers | 6 | 18.75 | 3.08 |
| Tertiary Space Powers | 17 | 53.13 | 8.72 |
| Total | 32 | 100.00 | 16.42 |

By the end of 2019, there are thirty-two space powers which constitutes over sixteen percent of the panel. In Table 5.2.6, I provide the current count of political actors in each space power status. Nine primary space powers represent about twenty-eight percent of the group and nearly five percent of the panel. Six secondary space powers make up almost nineteen percent of the group and three percent of the panel. Finally, seventeen tertiary space powers represent over half of the group and nearly nine percent of the panel.

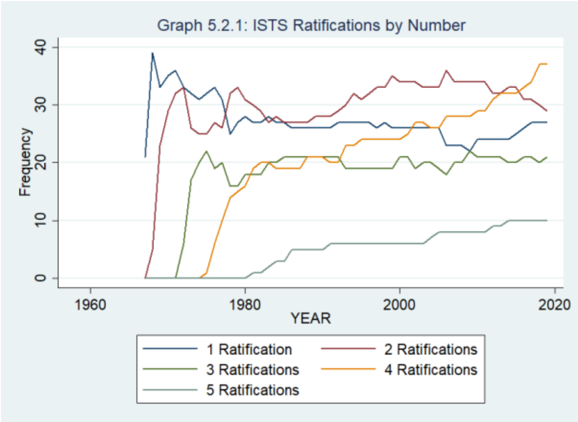
*Typologies of Space Cooperators*

Space cooperator types are based on the number of ratifications across four sets of treaties: the core ISTS agreements, global space-related agreements, regional space-related agreements, and a combination of all three sets. Each set of agreements contains the same four types: major cooperators, minor cooperators, base cooperators, and non-cooperators. In each set, non-cooperators are political actors that have not ratified any of the treaties contained within the set. The following conditions apply for the ISTS and global agreement sets which each contain five total agreements: base cooperators have ratified only one treaty, minor cooperators have ratified between two and three treaties, and major cooperators have ratified between four and five treaties. The regional set is comprised of six agreements, but no political actor has ratified more than four at a given time. As a result, the following conditions apply for this set: base cooperators have ratified one treaty, minor cooperators have ratified between two and three treaties, and major cooperators have ratified four treaties. The set of total space agreements is composed of all sixteen treaties, but no political actor has ratified more than thirteen at a given time. As a result, the following conditions apply for this set: base cooperators have ratified between one and four treaties, minor cooperators have ratified between five and nine treaties, and major cooperators have ratified between ten and thirteen treaties.

By the end of 2019, one hundred twenty-four political actors have ratified at least one ISTS agreement which is over sixty-three percent of the panel. Table 5.2.7 describes the current typology of ISTS space cooperators, and Graph 5.2.1 illustrates the frequency of ISTS ratifications by number over time. Forty-seven major cooperators make up thirty-eight percent of the group and twenty-four percent of the panel. Fifty minor cooperators represent forty percent of the group and one quarter of the panel. Twenty-seven base cooperators comprise nearly twenty-two percent of the group and roughly fourteen percent of the panel. Seventy-one political actors have not ratified any of the five treaties which is over a third of the total population.

**Table 5.2.7: Typology of ISTS Cooperators by 12/31/19**

| | Major | Minor | Base | Non | Total |
|---|---|---|---|---|---|
| Count | 47 | 50 | 27 | 71 | 195 |
| Group% | 37.90 | 40.32 | 21.77 | N/A | 100.00 |
| Panel% | 24.10 | 25.64 | 13.85 | 36.41 | 100.00 |




In Table 5.2.8, I provide the current number of political actors that are party to each ISTS agreement. Graph 5.2.2 illustrates the frequency of ISTS ratifications by treaty over time. The Outer Space Agreement is the most ratified treaty in the ISTS with nearly eighty-eight percent of the group and over half of the panel taking part. Conversely, the Moon Agreement is the least popular agreement with only eighteen ratifying parties which constitutes over fourteen percent of the group and less than ten percent of the panel. Seventy-nine political actors ratified the Liability Convention which is roughly sixty-four percent of the group and forty percent of the panel. Seventy-two cooperators ratified the Rescue Agreement which represents less than sixty percent of the group and over one third of the panel. Similar proportions describe the ratifications of the Registration Agreement: over half of the group and over one third of the panel.

**Table 5.2.8: Ratification of ISTS Agreements by 12/31/19**

| Treaties | Count | Group% | Panel% |
|---|---|---|---|
| Outer Space Treaty | 109 | 87.90 | 55.90 |
| Rescue Agreement | 72 | 58.06 | 36.92 |
| Liability Convention | 79 | 63.71 | 40.51 |
| Registration Agreement | 68 | 54.84 | 34.87 |
| Moon Treaty | 18 | 14.52 | 9.23 |

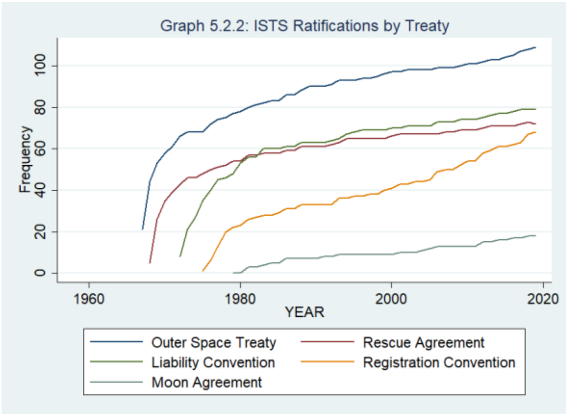



Table 5.2.9 describes the current number of ISTS ratifications by treaty, across each cooperator type. All the major cooperators ratified the Outer Space Treaty which accounts for forty-three percent of the treaty's total ratifications. Eighty-eight percent of minor cooperators and sixty-seven percent of base cooperators ratified it which represents forty percent and over sixteen percent of the treaty's total ratifications, respectively. All the major cooperators also ratified the Registration Agreement which accounts for sixty-nine percent of its total

ratifications. Thirty-six percent of minor cooperators and eleven percent of base cooperators ratified it which represents over twenty-six percent and over four percent of the treaty's total ratifications, respectively.

**Table 5.2.9: Ratification of ISTS Agreements among Space Cooperators by 12/31/19**

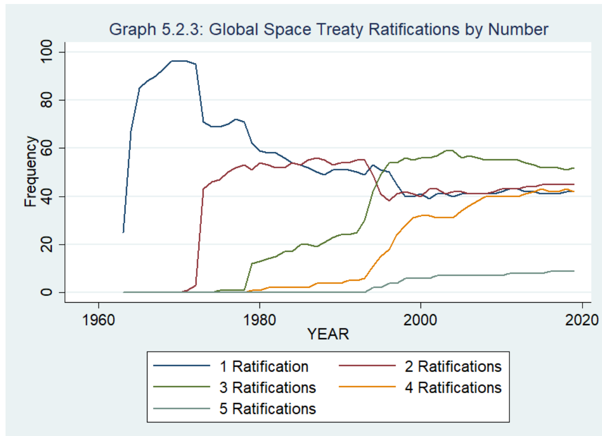
| Treaties | Major # | Major % | Rat% | Minor # | Minor % | Rat% | Base # | Base % | Rat% |
|---|---|---|---|---|---|---|---|---|---|
| Outer Space Treaty | 47 | 100.00 | 43.12 | 44 | 88.00 | 40.37 | 18 | 66.67 | 16.51 |
| Rescue Agreement | 44 | 93.62 | 61.11 | 26 | 52.00 | 36.11 | 2 | 7.41 | 2.78 |
| Liability Convention | 45 | 95.74 | 56.96 | 31 | 62.00 | 39.24 | 3 | 11.11 | 3.80 |
| Registration Agreement | 47 | 100.00 | 69.12 | 18 | 36.00 | 26.47 | 3 | 11.11 | 4.41 |
| Moon Treaty | 15 | 31.91 | 83.33 | 2 | 4.00 | 11.11 | 1 | 3.70 | 5.56 |

The Rescue Agreement was ratified by roughly ninety-four percent of major cooperators, fifty-two percent of minor cooperators, and seven percent of base cooperators. Respectively, this constitutes sixty-one percent, thirty-six percent, and nearly three percent of agreement's total ratifications. All but two major cooperators ratified the Liability Convention which accounts for about fifty-seven percent of its total ratifications. Sixty-two percent of minor cooperators and eleven percent of base cooperators ratified the convention which represents thirty-nine percent and nearly four percent of its total ratifications, respectively. Finally, while only thirty-two percent of major cooperators ratified the Moon Agreement, they account for eighty-three percent of its total ratifications. Four percent of both minor cooperators and base cooperators ratified the treaty. Respectively, this makes up for eleven percent and over five percent of its total ratifications.

Table 5.2.10 is dedicated to the distribution of other global space treaty ratifications by cooperator type. Graph 5.2.3 illustrates the frequency of these global treaty ratifications by number over time. All but five political actors ratified at least one of the five other global space-related agreements, constituting ninety-seven percent of the panel. Due to this proximity in group and panel totals, the proportions of cooperator representation are similar: major cooperators account for over one quarter of the group and panel alike, minor cooperators comprise roughly half of the group and panel, and base cooperators make up about twenty-two percent of the group and panel. Less than three percent of political actors choose not to ratify any of these treaties.

**Table 5.2.10: Typology of Global Space Treaty Cooperators by 12/31/19**

| | Major | Minor | Base | Non | Total |
|---|---|---|---|---|---|
| Count | 51 | 97 | 42 | 5 | 195 |
| Group% | 26.84 | 51.05 | 22.11 | N/A | 100.00 |
| Panel% | 26.15 | 49.74 | 21.54 | 2.56 | 100.00 |




In Table 5.2.11, I provide the current number of political actors that ratified each of the five other global space agreements. Graph 5.2.4 illustrates the frequency of global space treaty ratifications by treaty over time. The International Telecommunications Union Convention is the most widely ratified treaty in this collection with one hundred eighty-two parties representing over ninety-five percent of the group and ninety-three percent of the panel. The Convention Relating to Programme-Carrying Signals is the least ratified agreement with thirty-six participants comprising over eighteen percent of the group and panel. One hundred eight political actors ratified the Nuclear Test Ban Treaty which makes up over half of the group and panel. Similarly, about half of the group and panel ratified the International Mobile Satellite Convention with ninety-four parties. Finally, eighty-one political actors ratified the International Telecommunications Satellite Agreement which represents around forty-two percent of the group and panel.

**Table 5.2.11: Ratification of Global Space Agreements by 12/31/19**

| Treaties | Count | Group% | Panel% |
|---|---|---|---|
| Nuclear Test Ban Treaty | 108 | 56.84 | 55.38 |
| Satellite Signals Convention | 36 | 18.95 | 18.46 |
| ITSO Agreement | 81 | 42.63 | 41.54 |
| IMSO Convention | 94 | 49.47 | 48.21 |
| ITU Convention | 182 | 95.79 | 93.33 |

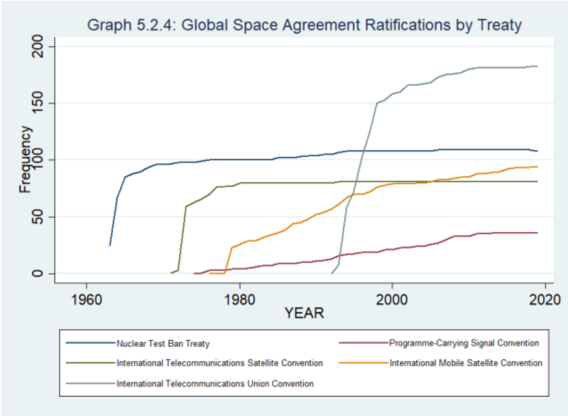



Table 5.2.12 shows the current number of ratifications for each global space agreement for cooperator type. Almost all the major cooperators in this treaty group ratified the NTB Treaty, ITSO Agreement, IMSO Convention, and ITU Convention (Table 5.16). Major cooperators accounted for forty-four percent, fifty-seven percent, fifty percent, and twenty-seven percent of each of the treaties' total ratifications, respectively. Forty-five percent of major cooperators ratified the Programme-Carrying Signals Convention which represents sixty-four percent of its total ratifications.

**Table 5.2.12: Ratification of Global Space Agreements among Space Cooperators by 12/31/19**

| Treaties | Major # | Major % | Rat% | Minor # | Minor % | Rat% | Base # | Base % | Rat% |
|---|---|---|---|---|---|---|---|---|---|
| NTB Treaty | 47 | 92.16 | 43.52 | 60 | 61.86 | 55.56 | 1 | 2.38 | .93 |
| Signals Convention | 23 | 45.10 | 63.89 | 12 | 12.37 | 33.33 | 1 | 2.38 | 2.78 |
| ITSO Agreement | 46 | 90.20 | 56.79 | 34 | 35.05 | 41.98 | 1 | 2.38 | 1.23 |
| IMSO Convention | 47 | 92.16 | 50.00 | 46 | 47.42 | 48.94 | 1 | 2.38 | 1.06 |
| ITU Convention | 50 | 98.04 | 27.47 | 94 | 96.91 | 51.65 | 38 | 90.48 | 20.88 |

Almost all the minor cooperators ratified the ITU Convention which constitutes over half of its total ratifications. Sixty-two percent ratified the NTB Treaty which makes up for over fifty-five percent of its total ratifications. Twelve percent and thirty-five percent of minor cooperators ratified the Programme-Carrying Signals Convention and the ITSO agreement which represents one third and forty-two percent of each agreement's total ratifications, respectively. Finally, forty-seven percent of minor cooperators ratified the IMSO Convention which accounts for nearly half of its total ratifications.

Base cooperators only marginally contribute to the ratifications of these global space related treaties. Only one political actor in this category ratified the NTB treaty, the Programme-Carrying Signals Convention, ITSO agreement, and IMSO Convention. This accounts for only two percent of the group and between one and three percent of these agreement's total ratifications. Nearly all base cooperators, however, ratified the ITU Convention which accounts for about twenty-one percent of its total ratifications.

Table 5.2.13 conveys the number of regional space treaty cooperators. Graph 5.2.5 illustrates the frequency of regional space treaty ratifications by number over time. By the end of 2019, seventy-three political actors ratified regional space related agreements which accounts for thirty-seven percent of the panel. Base cooperators are the largest subpopulation of the group with forty actors. They represent over half of the group and about twenty percent of the panel. Twenty-seven minor cooperators make up thirty-seven percent of the group and nearly fourteen percent of the panel. There are only six major cooperators which represents eight percent of the group and three percent of the panel. Over sixty-two percent of the panel chose not to ratify any of these agreements.

**Table 5.2.13: Typology of Regional Space Treaty Cooperators by 12/31/19**

| | Major | Minor | Base | Non | Total |
|---|---|---|---|---|---|
| Count | 6 | 27 | 40 | 122 | 195 |
| Group% | 8.22 | 36.99 | 54.79 | N/A | 100.00 |
| Panel% | 3.08 | 13.85 | 20.51 | 62.56 | 100.00 |

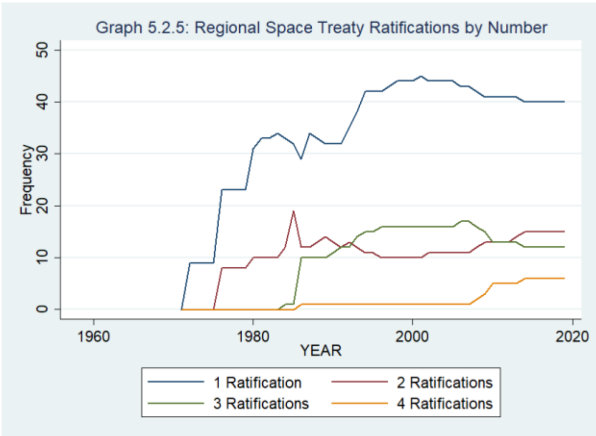


Table 5.2.14 shows the current number of ratifications for each of the regional space agreements. Graph 5.2.6 illustrates the frequency of regional space treaty ratifications by treaty over time. The European Telecommunications Satellite Convention is the most popular treaty in the regional collection with forty-six ratifications constituting sixty-three percent of cooperators and twenty-four percent of the panel. The least popular treaty is the Intercosmos Agreement with ten participants which accounts for fourteen percent of the group and over five percent of the panel. The ESA Convention is also ratified by over five percent of the panel with eleven participants and represents fifteen percent of cooperators. Thirty political actors ratified the European Meteorological Satellite Convention which accounts for forty-one percent of the group and fifteen percent of the panel. The Arab Corporation Agreement has twenty ratifications which represents twenty-seven percent of the group and ten percent of the panel. Finally, the Intersputnik Agreement is ratified by thirteen political actors constituting eighteen percent of the group and nearly seven percent of the panel.

**Table 5.2.14: Ratification of Regional Space Agreements by 12/31/19**

| Treaties | Count | Group% | Panel% |
|---|---|---|---|
| Intersputnik Agreement | 13 | 17.81 | 6.67 |
| Arab Corp Agreement | 20 | 27.40 | 10.25 |
| Intercosmos Agreement | 10 | 13.70 | 5.13 |
| ESA Convention | 11 | 15.07 | 5.64 |
| EUTL Convention | 46 | 63.01 | 23.59 |
| EUM Convention | 30 | 41.10 | 15.38 |

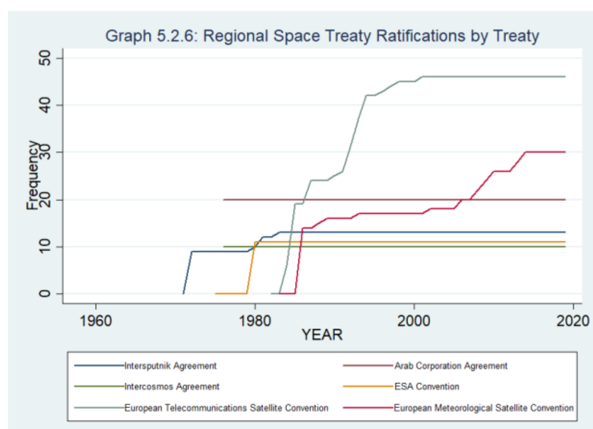



Table 5.2.15 describes the number of ratifications for each regional space agreement by cooperator type. All major cooperators ratified the Intersputnik Agreement, the European Telecommunications Satellite Convention, and the European Meteorological Satellite Convention which accounts for forty-six percent, thirteen percent, and twenty percent of each

treaty's total ratifications, respectively. None of the major cooperators ratified the Arab Corporation Agreement. Only one major cooperator ratified the ESA Agreement which represents seventeen percent of the group and nine percent the treaty's total ratifications. Eighty-three percent of the group ratified the Intercosmos Agreement which constitutes half of the treaty's total ratifications.

**Table 5.2.15: Ratification of Regional Space Agreements among Space Cooperators by 12/31/19**

| Treaties | Major # | Major % | Rat% | Minor # | Minor % | Rat% | Base # | Base % | Rat% |
|---|---|---|---|---|---|---|---|---|---|
| Intersputnik Agreement | 6 | 100.00 | 46.15 | 4 | 14.81 | 30.77 | 3 | 7.50 | 23.08 |
| Arab Corp Agreement | 0 | 0.00 | 0.00 | 1 | 3.70 | 5.00 | 19 | 47.50 | 95.00 |
| Intercosmos Agreement | 5 | 83.33 | 50.00 | 4 | 14.81 | 40.00 | 1 | 2.50 | 10.00 |
| ESA Convention | 1 | 16.67 | 9.09 | 10 | 37.04 | 90.90 | 0 | 0.00 | 0.00 |
| EUTL Convention | 6 | 100.00 | 13.04 | 24 | 88.89 | 52.17 | 16 | 40.00 | 34.78 |
| EUM Convention | 6 | 100.00 | 20.00 | 23 | 85.19 | 76.67 | 1 | 2.50 | 3.33 |

Over eighty-five percent of minor cooperators ratified both the European Telecommunications Satellite Convention and the European Meteorological Satellite Convention which makes up fifty-two percent and seventy-seven percent of each treaty's total ratifications, respectively. Fifteen percent are party to both the Intersputnik Agreement and Intercosmos Agreement which represents thirty-one percent and forty percent of each treaty's total ratifications, respectively. Ten minor cooperators ratified the ESA Convention which accounts for thirty-seven percent of the group and over ninety percent of the treaty's total ratifications. Finally, only one minor cooperator ratified the Arab Corporation Agreement which represents nearly four percent of the group and five percent of the treaty's total ratifications.

None of the base cooperators ratified the ESA Convention. Only one ratified both the Intercosmos Agreement and the European Meteorological Satellite Convention which accounts for over two percent of the group. Each ratification represents ten percent and three percent of each treaty's total ratifications, respectively. Three base cooperators ratified the Intersputnik

Agreement which makes up over seven percent of the group and twenty-three percent of the treaty's total ratifications. Sixteen base cooperators are party to the European Telecommunications Satellite Convention which constitutes forty percent of the group and thirty-five percent of the treaty's total ratifications. Finally, nineteen base cooperators ratified the Arab Corporation Agreement which accounts for over forty-seven percent of the group and ninety-five percent of the treaty's total ratifications.

Table 5.2.16 describes the typology of space cooperators for all the international space agreements considered together. Graph 5.2.7 illustrates the frequency of total ratifications by treaty group. The aggregation of these agreements into a comprehensive set indicates that all but five political actors fall into one of the three cooperator groups. Twenty-three major cooperators account for roughly twelve percent of the group and panel, respectively. Both minor and base cooperators represent about forty-four percent of the group and forty-three percent of the panel, respectively.

**Table 5.2.16: Typology of Space Treaty Cooperators by 12/31/19**

| | Major | Minor | Base | Non | Total |
|---|---|---|---|---|---|
| Count | 23 | 83 | 84 | 5 | 195 |
| Group% | 12.11 | 43.68 | 44.21 | N/A | 100.00 |
| Panel% | 11.79 | 42.56 | 43.08 | 2.56 | 100.00 |

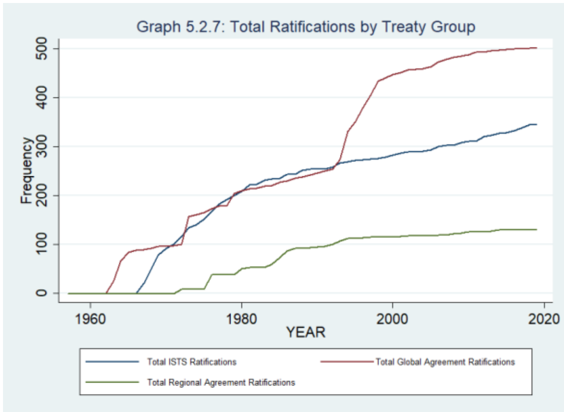



Table 5.2.17 shows the number of ratifications for every treaty by cooperator type. All major cooperators ratified the Outer Space Treaty and the ITU Convention. All but one major cooperator ratified the Rescue Agreement, Liability Convention, and Registration Agreement. All but two major cooperators ratified the Nuclear Test Ban Treaty and the IMSO Convention.

Roughly eighty percent of the group ratified the European Telecommunications Satellite Convention and the European Meteorological Satellite Convention. Seventy percent of major cooperators ratified the ITSO Agreement. Between thirty and forty percent are party to the Intersputnik Agreement, Moon Treaty, ESA Convention, and the Programme-Carrying Signals Convention. Over one quarter of the group participates in the Intercosmos Agreement and only eight percent participates in the Arab Corporation Agreement.

**Table 5.2.17: Ratification of Space Agreements among Space Cooperators by 12/31/19**

| Treaties | Major # | Major % | Rat% | Minor # | Minor % | Rat% | Base # | Base % | Rat% |
|---|---|---|---|---|---|---|---|---|---|
| Outer Space Treaty | 23 | 100.00 | 21.10 | 69 | 83.13 | 63.30 | 17 | 20.24 | 15.60 |
| Rescue Agreement | 22 | 95.65 | 30.56 | 46 | 55.42 | 63.89 | 4 | 4.76 | 5.56 |
| Liability Convention | 22 | 95.65 | 27.85 | 52 | 62.65 | 65.82 | 5 | 5.95 | 6.33 |
| Registration Agreement | 22 | 95.65 | 32.35 | 44 | 53.01 | 64.71 | 2 | 2.38 | 2.94 |
| Moon Treaty | 8 | 34.78 | 44.44 | 10 | 12.05 | 55.56 | 0 | 0.00 | 0.00 |
| Nuclear Test Ban Treaty | 21 | 91.30 | 19.44 | 62 | 74.70 | 57.41 | 25 | 29.76 | 23.15 |
| Signals Convention | 9 | 39.13 | 25.00 | 21 | 25.30 | 58.33 | 6 | 7.14 | 16.67 |
| ITSO Agreement | 16 | 69.57 | 19.75 | 46 | 55.42 | 56.79 | 19 | 22.62 | 23.46 |
| IMSO Convention | 21 | 91.30 | 22.34 | 56 | 67.47 | 59.57 | 17 | 20.24 | 18.09 |
| ITU Convention | 23 | 100.00 | 12.64 | 81 | 97.59 | 44.51 | 78 | 92.86 | 42.86 |
| Intersputnik Agreement | 7 | 30.43 | 53.85 | 6 | 7.23 | 46.15 | 0 | 0.00 | 0.00 |
| Arab Corp Agreement | 2 | 8.70 | 10.00 | 13 | 15.66 | 65.00 | 5 | 5.95 | 25.00 |
| Intercosmos Agreement | 6 | 26.09 | 60.00 | 4 | 4.82 | 40.00 | 0 | 0.00 | 0.00 |
| ESA Convention | 9 | 39.13 | 81.81 | 2 | 2.41 | 18.18 | 0 | 0.00 | 0.00 |
| EUTL Convention | 19 | 82.61 | 41.30 | 20 | 24.10 | 43.48 | 7 | 8.33 | 15.22 |
| EUM Convention | 18 | 78.26 | 60.00 | 10 | 12.05 | 33.33 | 2 | 2.38 | 6.67 |

The ITU Convention and the Outer Space Treaty are the most ratified agreements among minor cooperators with ninety-eight percent and eighty-three percent of the group taking part, respectively. Three-quarters of the group ratified the Nuclear Test Ban Treaty. Roughly one-third ratified the IMSO and Liability Conventions. Over half ratified the Rescue, Registration, and ITSO Agreements. About one quarter of the group ratified the European Telecommunications

Satellites Convention and Programme-Carrying Signals Convention. Twelve percent of minor cooperators ratified the Moon Treaty and the European Meteorological Satellites Convention. Less than ten percent of the group ratified the Intersputnik Agreement, Intercosmos Agreement, and ESA Convention.

None of the base cooperators ratified the Moon Treaty, Intersputnik Agreement, Intercosmos Agreement, and ESA Convention. Ninety-three percent of the group, however, ratified the ITU Convention. Between twenty and thirty percent of them ratified the IMSO Convention, ITSO Agreement, Outer Space Treaty, and Nuclear Test Ban Treaty. Less than ten percent of base cooperators ratified the Rescue Agreement, Liability Convention, Registration Agreement, Programme-Carrying Signals Convention, Arab Corporation Agreement, the European Telecommunications Satellite Convention, and the European Meteorological Satellites Convention.

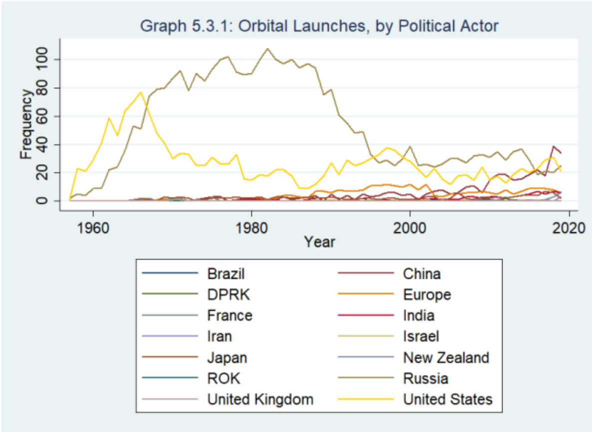
### 5.3. Orbital Launches

*Orbital Launches by Political Actor*

Table 5.3.1 describes the distribution of orbital launches by political actor, and Graph 5.3.1 illustrates the frequency of orbital launches by political actor over time. Fourteen political actors have conducted over fifty-nine hundred orbital launches from 1957 to the end of 2019. Russia is the most prolific in the group with over fifty-six percent of all orbital launch attempts. The United States is the second most frequent launcher with nearly thirty percent of all orbital launches. These two states are the only political actors with launch attempts that rank in the thousands. China, Europe, and Japan are the only political actors with attempts that rank in the hundreds. Respectively, they account for nearly six percent, five percent, and two percent of all orbital launches. India is responsible for seventy-four launches which represents one and one quarter percent of the total. Brazil, North Korea, France, Iran, Israel, New Zealand, South Korea, and the United Kingdom account respectively for less than one quarter of one percent of the total.

**Table 5.3.1: Distribution of Orbital Launches among Political Actors**

| Political Actor | Total | Percent |
|---|---|---|
| Brazil | 3 | .05 |
| China | 347 | 5.87 |
| DPRK | 5 | .09 |
| Europe | 269 | 4.55 |
| France | 12 | .20 |
| India | 74 | 1.25 |
| Iran | 11 | .19 |
| Israel | 10 | .17 |
| Japan | 124 | 2.10 |
| New Zealand | 10 | .17 |
| Republic of Korea | 3 | .05 |
| Russia | 3319 | 56.13 |
| United Kingdom | 2 | .03 |
| United States | 1724 | 29.16 |
| Total | 5913 | 100.00 |

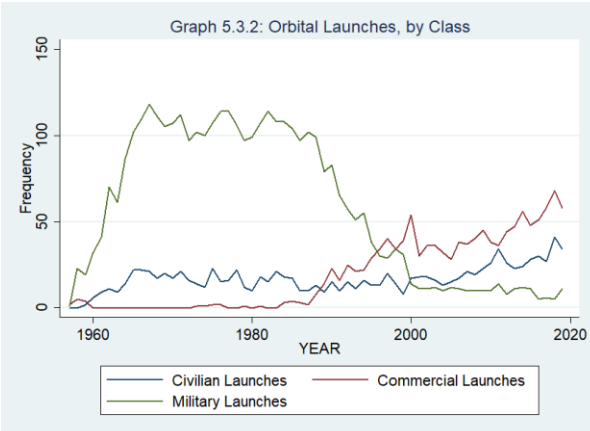



*Orbital Launches by Class*

Table 5.3.2 describes the distribution of orbital launches by class, and Graph 5.3.2 illustrates the frequency of orbital launches by class over time. One thousand and sixty-eight orbital launches are conducted by civilian organizations which represents eighteen percent of the total. Twelve hundred and sixteen launches are conducted by commercial organizations which constitutes twenty-one percent of the total. Thirty-six hundred and twenty-nine launches are conducted by military organizations which accounts for sixty-one percent of the total.

**Table 5.3.2: Orbital Launches, by Class**

| Launch Class | Frequency | Percent |
|---|---|---|
| Civilian | 1068 | 18.06 |
| Commercial | 1216 | 20.56 |
| Military | 3629 | 61.36 |
| Total | 5913 | 100.00 |



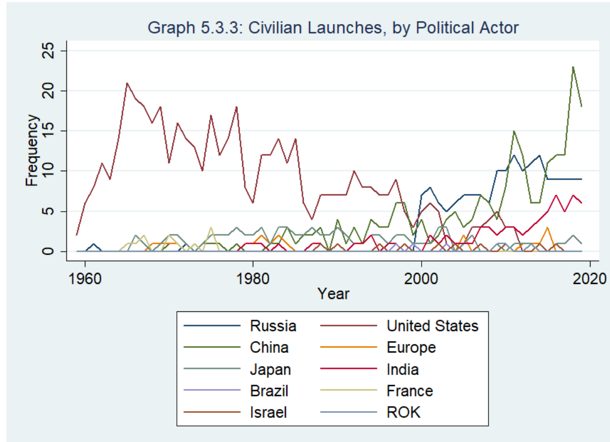

*Orbital Launches by Political Actors across Class*

Tables 5.3.3 through 5.3.5 describe the distribution of orbital launches by political actor and class with an additional emphasis on the percentage of total launches for the political actor as well as the percentage of total launches for the given class. Brazil, India, Israel, and South Korea have only launched civilian vehicles. They account respectively for one quarter of one percent, seven percent, one percent, and one third of one percent of all civilian launches. Ninety-two percent of France's launches are civilian and make up one percent of all launches in the class. Sixty-two percent of China's launches are civilian and represent twenty percent of all launches in the class. Sixty-five percent of Japan's launches are civilian and constitute nearly eight percent of all launches in the class. Twenty-eight percent of the United States' launches are civilian and make up forty-five percent of all launches in the class. Eight percent of Europe's launches are civilian and account for two percent of all launches in the class. Five percent of Russia's launches are civilian and represent sixteen percent of all launches in the class. North Korea, Iran, New Zealand, and the United Kingdom have taken part in no civilian launches. Graph 5.3.3 illustrates the frequency of civilian launches over time.

**Table 5.3.3: Civilian Launches among Political Actors**

| Political Actor | Count | Actor% | Class% |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Brazil | 3 | 100.00 | .28 |
| China | 215 | 61.96 | 20.13 |
| DPRK | 0 | 0.00 | 0.00 |
| Europe | 22 | 8.18 | 2.06 |
| France | 11 | 91.67 | 1.03 |
| India | 74 | 100.00 | 6.93 |
| Iran | 0 | 0.00 | 0.00 |
| Israel | 10 | 100.00 | .94 |
| Japan | 81 | 65.32 | 7.58 |
| New Zealand | 0 | 0.00 | 0.00 |
| Republic of Korea | 3 | 100.00 | .28 |
| Russia | 171 | 5.15 | 16.01 |
| United Kingdom | 0 | 0.00 | 0.00 |
| United States | 478 | 27.73 | 44.76 |
| Total | 1068 | | 100.00 |

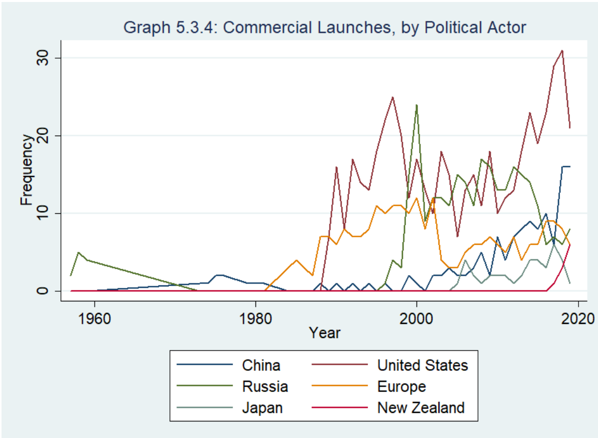


Graph 5.3.3: Civilian Launches, by Political Actor

New Zealand has only launched commercial vehicles which accounts for nearly one percent of all launches in the class. Ninety-one percent of Europe's launches are commercial which represents twenty percent of the class. Thirty-seven percent of China's launches are commercial which makes up roughly eleven percent of the class. Thirty-two percent of Japan's launches are commercial which constitutes three percent of the class. Thirty percent of the United States' launches are commercial which accounts for forty-two percent of the class. Nine percent of Russia's launches are commercial which represents twenty-three percent of the class. Brazil, North Korea, France, India, Iran, Israel, South Korea, and the United Kingdom have not launched any commercial vehicles. Graph 5.3.4 illustrates the frequency of commercial launches over time.

**Table 5.3.4: Commercial Launches among Political Actors**

| Political Actor | Count | Actor% | Class% |
|---|---|---|---|
| Brazil | 0 | 0.00 | 0.00 |
| China | 128 | 36.89 | 10.53 |
| DPRK | 0 | 0.00 | 0.00 |
| Europe | 247 | 91.82 | 20.31 |
| France | 0 | 0.00 | 0.00 |
| India | 0 | 0.00 | 0.00 |
| Iran | 0 | 0.00 | 0.00 |
| Israel | 0 | 0.00 | 0.00 |
| Japan | 39 | 31.45 | 3.21 |
| New Zealand | 10 | 100.00 | .82 |
| Republic of Korea | 0 | 0.00 | 0.00 |
| Russia | 284 | 8.56 | 23.36 |
| United Kingdom | 0 | 0.00 | 0.00 |
| United States | 508 | 29.47 | 41.78 |
| Total | 1216 | | 100.00 |

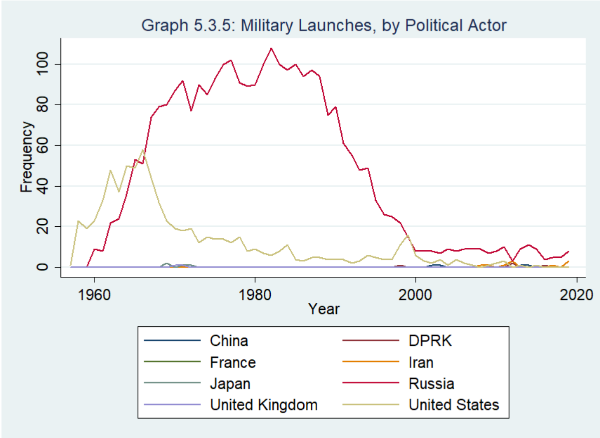



North Korea, Iran, and the United Kingdom have only launched military vehicles but each account for less than one third of one percent of all launches in the class. Eighty-six percent of Russia's launches are military which makes up seventy-nine percent of the class. Forty-three percent of the United States' launches are military which represents twenty percent of the class. Less than ten percent of the orbital launches from China, France, and Japan are military and each account for less than one quarter of one percent of the class. Brazil, Europe, India, Israel, New Zealand, and South Korea have never launched a military vehicle. Graph 5.3.5 illustrates the frequency of military launches over time.

**Table 5.3.5: Military Launches among Political Actors**

| Political Actor | Count | Actor% | Percent |
|---|---|---|---|
| Brazil | 0 | 0.00 | 0.00 |
| China | 4 | 1.15 | .11 |
| DPRK | 5 | 100.00 | .14 |
| Europe | 0 | 0.00 | 0.00 |
| France | 1 | 8.33 | .03 |
| India | 0 | 0.00 | 0.00 |
| Iran | 11 | 100.00 | .30 |
| Israel | 0 | 0.00 | 0.00 |
| Japan | 4 | 3.23 | .11 |
| New Zealand | 0 | 0.00 | 0.00 |
| Republic of Korea | 0 | 0.00 | 0.00 |
| Russia | 2864 | 86.29 | 78.92 |

| | | | |
|---|---|---|---|
| United Kingdom | 2 | 100.00 | .06 |
| United States | 738 | 42.81 | 20.34 |
| Total | 3629 | | 100.00 |




*Orbital Launches by Outcome Type*

Table 5.3.6 describes the distribution of orbital launches by outcome type, and Graph 5.3.6 illustrates the frequency of launch outcomes over time. Launches are considered successful if the launch vehicles successfully place payloads in orbit. Launches are considered failures if the launch vehicles malfunction, explode in transit, explode on the platform, or otherwise fail to place payloads in orbit due to mechanical errors. From 1957 to 2019, fifty-four hundred and fifty orbital vehicles were successfully launched which accounts for ninety-two percent of all launches. Four hundred and sixty-three launches failed which represents the remaining eight percent of the total.

**Table 5.3.6: Orbital Launches, by Outcome Type**

| Outcome Type | Frequency | Percent |
|---|---|---|
| Successful | 5450 | 92.17 |
| Failure | 463 | 7.83 |
| Total | 5913 | 100.00 |

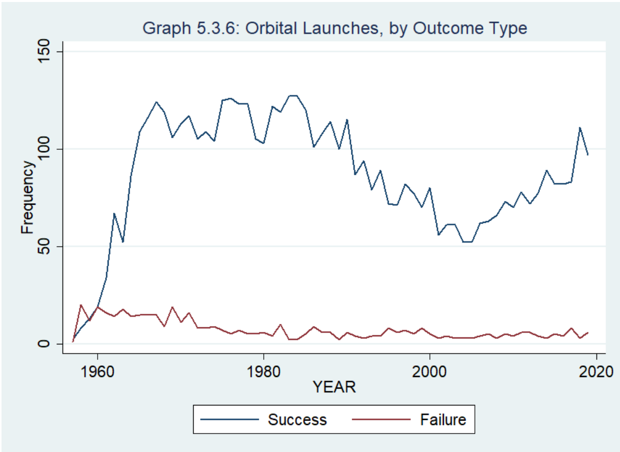


Table 5.3.7 breaks down orbital launch outcomes by political actor. China, Europe, France, New Zealand, Russia, and the United States successfully launched between ninety and one hundred percent of their orbital vehicles. Only the successes of Russia and the United States represent substantive proportions of the outcome total. Russia accounts for nearly fifty-seven percent of all successful launches and the United States accounts for twenty-nine percent. China and Europe make up six and five percent of all successful launches, respectively. Each of the remaining political actors make up less than two percent of all successful launches. India, Israel, and Japan successfully launched between eighty and eighty-nine percent of their orbital vehicles. The United Kingdom successfully launched half of its launch vehicles. North Korea successfully launched forty percent of its orbital vehicles. Iran and South Korea successfully launched about one third of their orbital vehicles. Brazil did not successfully launch any of its orbital vehicles.

**Table 5.3.7: Orbital Launch Outcomes, by Political Actor**

| Political Actor | Failure | Actor% | Outcome% | Success | Actor% | Outcome% | Total |
|---|---|---|---|---|---|---|---|
| Brazil | 3 | 100.00 | .65 | 0 | 0.00 | 0.00 | 3 |
| China | 21 | 6.05 | 4.54 | 326 | 93.95 | 5.98 | 347 |
| DPRK | 3 | 60.00 | .65 | 2 | 40.00 | .04 | 5 |
| Europe | 17 | 6.32 | 3.67 | 252 | 93.68 | 4.62 | 269 |
| France | 1 | 8.33 | .22 | 11 | 92.67 | .20 | 12 |
| India | 11 | 14.86 | 2.38 | 63 | 85.17 | 1.16 | 74 |
| Iran | 7 | 63.64 | 1.51 | 4 | 36.36 | .07 | 11 |
| Israel | 2 | 20.00 | .43 | 8 | 80.00 | .15 | 10 |
| Japan | 17 | 13.71 | 3.67 | 107 | 86.29 | 1.96 | 124 |
| New Zealand | 1 | 10.00 | .22 | 9 | 90.00 | .17 | 10 |
| Republic of Korea | 2 | 66.67 | .43 | 1 | 33.33 | .02 | 3 |
| Russia | 216 | 6.51 | 46.65 | 3103 | 93.49 | 56.94 | 3319 |
| United Kingdom | 1 | 50.00 | .22 | 1 | 50.00 | .02 | 2 |
| United States | 161 | 9.34 | 34.77 | 1563 | 90.66 | 28.68 | 1724 |
| Total | 463 | | 7.83 | 5450 | | 92.17 | 5913 |

Graph 5.3.7 illustrates the frequency of launch failures over time by political actor. Due to their proportion of overall launches, as it was also with successful launches, Russia and the

United States make up most of the failed orbital launches. Russia and the United States account for forty-seven percent and thirty-five percent of all failed launches, respectively. China, Europe, India, Iran, and Japan each represent less than five percent of all failed launches. Brazil, North Korea, France, Israel, New Zealand, South Korea, and the United Kingdom each make up less than one percent of all failed launches.

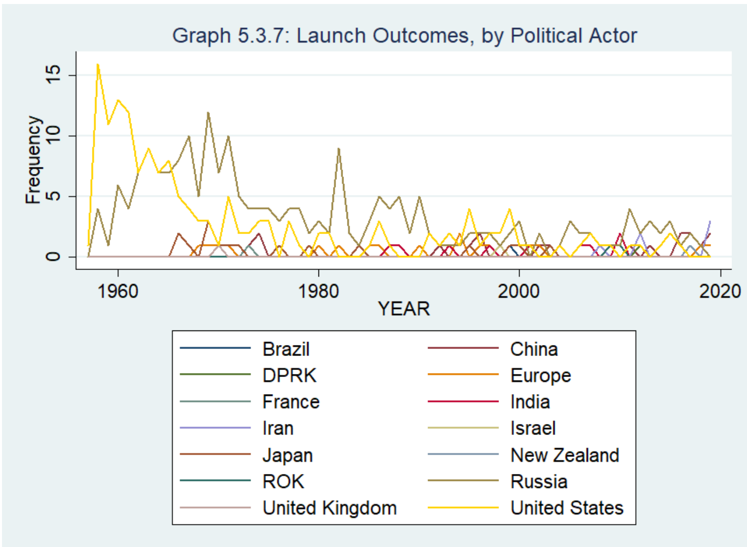
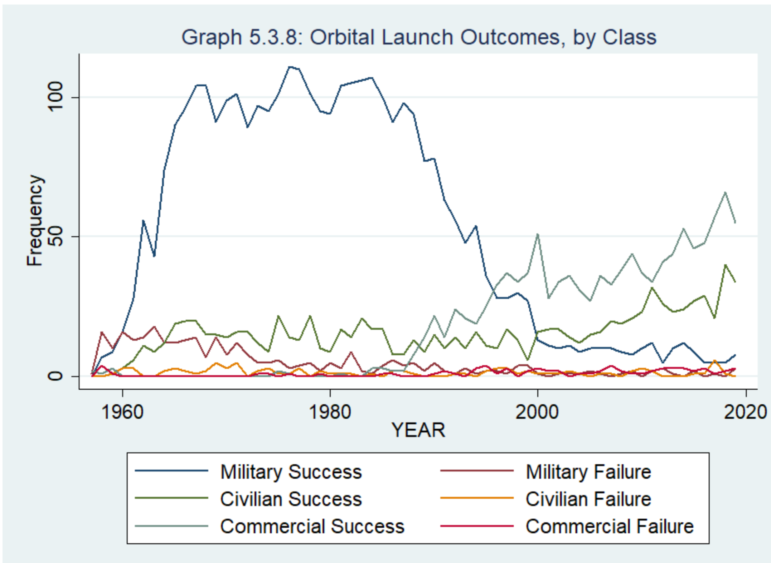



Table 5.3.8 describes orbital launch outcomes by class, and Graph 5.3.8 illustrates the frequency of orbital launch outcomes by class over time. Nine hundred and eighty civilian launches are successful which makes up ninety-two percent of the class and eighteen percent of the outcome type. Eighty-eight civilian launches are failures which constitutes eight percent of the class and nineteen percent of the outcome type. Eleven hundred and forty-seven commercial launches are successful which accounts for ninety-four percent of the class and twenty-one percent of the outcome type. Sixty-nine percent of commercial launches are failures which makes up six percent of the class and fifteen percent of the outcome type. Thirty-three hundred

and twenty-three military launches are successful which accounts for ninety-two percent of the class and sixty-one percent of the outcome type. Three hundred and six military launches are failures which accounts for eight percent of the class and sixty-six percent of the outcome type.

**Table 5.3.8: Orbital Launch Outcomes, by Class**

| Outcome | Civilian | Class% | Group% | Commercial | Class% | Group% | Military | Class% | Group% | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Failure | 88 | 8.24 | 19.01 | 69 | 5.67 | 14.90 | 306 | 8.43 | 66.09 | 463 |
| Success | 980 | 91.76 | 17.98 | 1147 | 94.33 | 21.05 | 3323 | 91.57 | 60.97 | 5450 |
| Total | 1068 | 100.00 | | 1216 | 100.00 | | 3629 | 100.00 | | 5913 |




*Orbital Launches by Space Power Type*

Table 5.3.9 describes the distribution of orbital launches by space power type, and Graph 5.3.9 illustrates the frequency of orbital launches by space power type over time. Primary space powers launched fifty-four hundred and forty-nine vehicles which represents ninety-two percent of all orbital launches. Secondary space powers launched one hundred and ninety-five vehicles which is roughly three percent of all launches. Two hundred and sixty-nine launches were conducted by non-space powers which constitutes about five percent of all launches.

**Table 5.3.9: Orbital Launches, by Space Power Type**

| Space Power Type | Frequency | Percent |
|---|---|---|
| Primary | 5449 | 92.15 |
| Secondary | 195 | 3.30 |
| Tertiary | 0 | 0.00 |
| Non-Space Power | 269 | 4.55 |
| Total | 5913 | 100.00 |

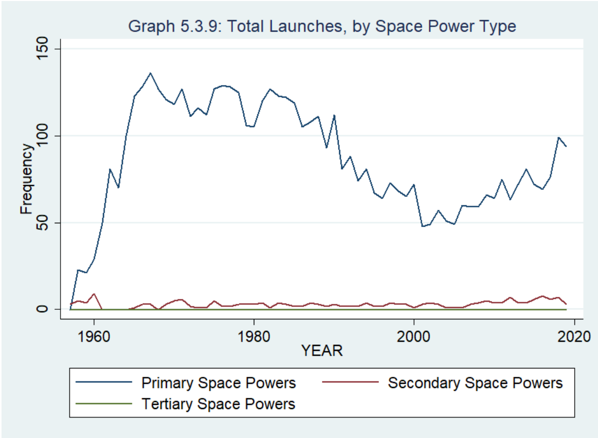



Table 5.3.10 describes the distribution of civilian orbital launches by space power type, and Graph 5.3.10 illustrates the frequency of civilian launches by space power type over time. Primary space powers launched eight hundred and ninety-four civilian vehicles which accounts for eighty-four percent of the group and fifteen percent of all orbital launches. Secondary space powers launched one hundred and fifty-two civilian vehicles which represents fourteen percent of the group and three percent of all launches. Twenty-two civilian launches were conducted by non-space powers which accounts for roughly one third of one percent of all launches. While all civilian launches constitute eighteen percent of all orbital launches, civilian launches among space powers represent seventeen and three quarters percent of them.

**Table 5.3.10: Civilian Launches by Space Power Type**

| Space Power Type | Frequency | Class% | Total% |
|---|---|---|---|
| Primary | 894 | 83.71 | 15.12 |
| Secondary | 152 | 14.23 | 2.57 |
| Tertiary | 0 | 0.00 | 0.00 |
| Non-Space Power | 22 | | .37 |
| Total | 1068 | 100.00 | 18.06 |

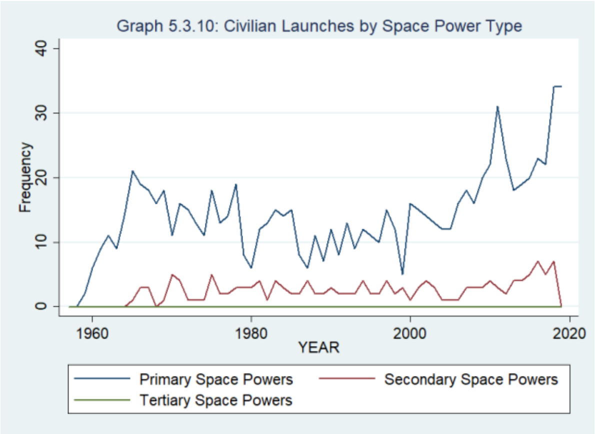



Table 5.3.11 describes the distribution of commercial launches by space power type, and Graph 5.3.11 illustrates the frequency of commercial launches over time. Primary space powers launched nine hundred and fifty-nine commercial vehicles which makes up seventy-nine percent of the class and sixteen percent of the total. Secondary space powers launched eleven commercial vehicles which accounts for one percent of the class and one fifth of one percent of the total. Non-space powers launched two hundred and forty-six commercial vehicles which represents twenty percent of the class and four percent of the total. While commercial launches constitute twenty-one percent of all orbital launches, space powers are responsible for sixteen percent of them.

**Table 5.3.11: Commercial Launches by Space Power Type**

| Space Power Type | Frequency | Class% | Total% |
|---|---|---|---|
| Primary | 959 | 78.87 | 16.22 |
| Secondary | 11 | .90 | .19 |
| Tertiary | 0.00 | 0.00 | 0.00 |
| Non-Space Power | 246 | 20.23 | 4.16 |
| Total | 1216 | 100.00 | 20.57 |

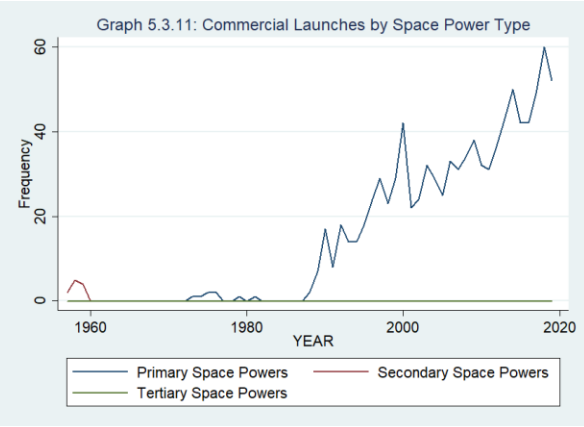
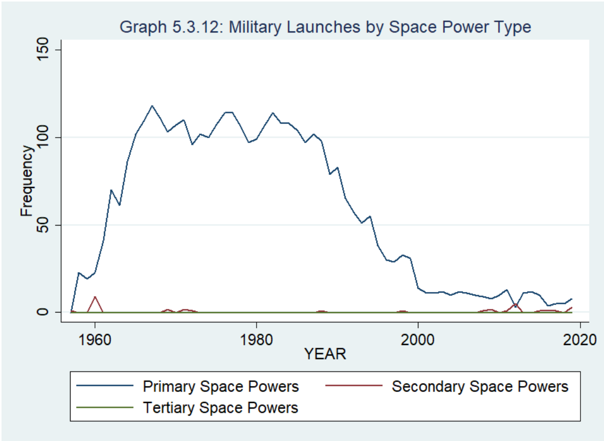


Table 5.3.12 describes the distribution of military launches by space powers, and Graph 5.3.12 illustrates the frequency of military launches by space power type over time. Primary space powers launched thirty-five hundred and ninety-six military vehicles which represents ninety-nine percent of the class and sixty-one percent of the total. Secondary space powers launched thirty-two military vehicles which accounts for one percent of the class and half of one percent of the total. Space powers are responsible for sixty-one percent of all orbital launches.

**Table 5.3.12: Military Launches, by Space Power Type**

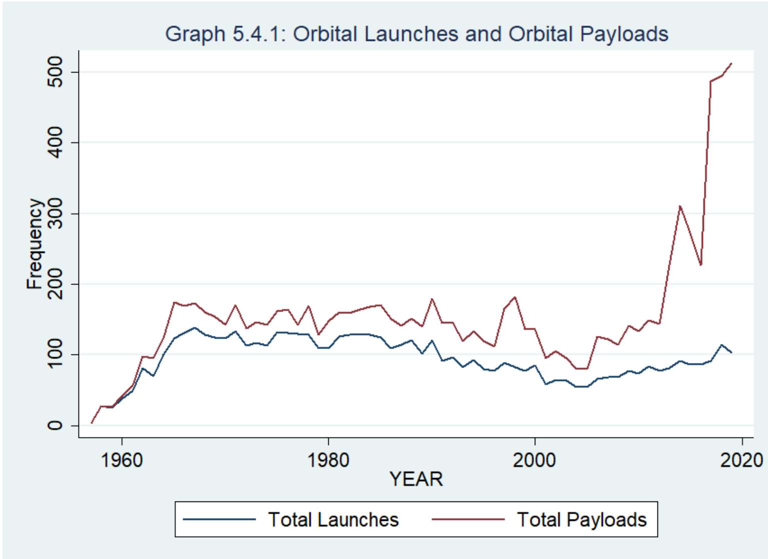
| Space Power Type | Frequency | Group% | Total% |
|---|---|---|---|
| Primary | 3596 | 99.12 | 60.82 |
| Secondary | 32 | .88 | .54 |
| Tertiary | 0 | 0.00 | 0.00 |
| Non-Space Power | 0 | 0.00 | 0.00 |
| Total | 3628 | 100.00 | 61.36 |




## 5.4. Orbital Payloads

*Orbital Payloads by Orbital Launches*

Graph 5.4.1 illustrates the frequency of orbital launches and orbital payloads over time. Three trends in the relationship between launches and payloads are apparent across three temporal waves. The first wave is a seven-year period between 1957 and 1963, the second wave is a twenty-seven-year period between 1964 and 1990, and the third wave is a twenty-nine-year period between 1991 and 2019.




Between 1957 and 1963, the ratios of payloads to launches were relatively close with the total numbers of each gradually increasing to high double-digit figures. Orbital launches peak at eighty-one in 1962 and drop to seventy in 1963 while orbital payloads peak at ninety-eight in 1962 and drop to ninety-five in 1963. From 1964 to 1990, the total numbers of launches and payloads remain consistently in triple-digit figures with launches averaging one hundred and twenty-two per year and payloads averaging one hundred and fifty-five per year. Launches peak in 1967 at one hundred and thirty-nine while payloads peak in 1990 at one hundred and seventy-nine. From 1991 to 2019, launches drop back to double-digit figures for all but the final two years while payloads remain in triple-digit figures for all but four years in the early 2000s. The major difference in this final wave is that the number of payloads begin to drastically exceed the number of launches around 2013. Launches average eighty per year and peak at one hundred and fourteen in 2018 before dropping to one hundred and three in 2019. Payloads average one hundred and eighty-three and peak at five hundred and thirteen in 2019 after a surge beginning in 2017.

*Orbital Payloads by Type*

Table 5.4.1 describes the number of orbital payloads by type. Communication satellites are the most launched payload type with twenty-seven percent of the total. Science, technology, and education satellites are the second most common payload type with eighteen percent of the total, followed by optical reconnaissance satellites with thirteen percent of the total. The only other payload type with a substantive proportion of the total is the earth observation category which accounts for ten percent of all orbital payloads. Navigation satellites and crewed spaceflight support satellites each make up roughly five percent of the total. Signal, communication, and electronic intelligence satellites represent four percent of the total. Space station supply satellites, meteorology satellites, interplanetary spacecrafts, and calibration satellites account for roughly three percent of the total. The rest of the satellites represent minor proportions of all payload types.

**Table 5.4.1: Orbital Payload Types, 1957-2019**

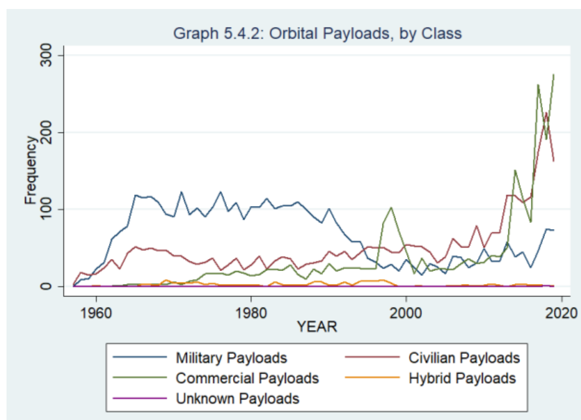
| Payload Type | Total | Percent |
|---|---|---|
| ASAT | 28 | .29 |
| ASAT Target | 19 | .20 |
| Art | 7 | .07 |
| Burial/Memorial | 9 | .09 |
| Calibration | 240 | 2.48 |
| Communication | 2614 | 26.99 |
| Crewed Spaceflight and Support | 440 | 4.54 |
| Early Warning | 149 | 1.54 |
| Earth Observation | 971 | 10.02 |
| Experimental | 168 | 1.73 |
| Geodesy | 76 | .78 |
| Interplanetary Spacecraft | 256 | 2.64 |
| Meteorology | 260 | 2.68 |
| Navigation | 533 | 5.50 |
| Nuclear Detection | 13 | .13 |
| Ocean Surveillance | 123 | 1.27 |
| Orbital Weapons | 19 | .20 |
| Reconnaissance, optical | 1252 | 12.93 |
| Reconnaissance, radar | 40 | .41 |
| SDIO/BMDO/MDA | 13 | .13 |
| SIGINT/COMINT/ELINT | 379 | 3.91 |
| Science, Technology, and Education | 1721 | 17.77 |
| Space Station Supply/Logistics | 262 | 2.70 |
| Space Surveillance | 9 | .09 |
| Traffic Monitoring | 28 | .29 |
| Uncrewed Spacecraft | 5 | .05 |
| Unknown | 12 | .12 |
| Vehicle Evaluation | 40 | .41 |
| Total | 9686 | 100.00 |

*Orbital Payloads by Class*

Table 5.4.2 describes the number of orbital payloads by class, and Graph 5.4.2 illustrates the frequency of orbital payloads by class over time. Thirty-one hundred and fifty-nine satellites are operated by civilian organizations which accounts for nearly thirty-three percent of all payloads. Twenty-two hundred and fifty-nine payloads are operated by commercial organizations which represents twenty-three percent of the total. Forty-one hundred and twenty-five payloads are operated by military organizations which constitutes forty-three percent of the total. One hundred and forty-one payloads are operated by hybrid civilian-commercial organizations which makes up roughly one and a half percent of the total. Finally, two unknown payloads only represent two-hundredths of one percent of the total.

**Table 5.4.2: Orbital Payloads, by Class**

| Payload Class | Frequency | Percent |
|---|---|---|
| Civilian | 3159 | 32.62 |
| Commercial | 2259 | 23.32 |
| Hybrid | 141 | 1.46 |
| Military | 4125 | 42.58 |
| Unknown | 2 | 0.02 |
| Total | 9686 | 100.00 |




*Orbital Payloads by Type and Class*

Table 5.4.3 describes the distribution of payloads by type. Eleven payload types are exclusively military: ASAT, ASAT target, early warning, nuclear detection, orbital weapons, optical reconnaissance, radar reconnaissance, SDIO/BMDO/MDA, SIGINT/COMINT/ELINT, space surveillance, and uncrewed spacecraft support. This is the only class to which payload types are exclusive. Optical reconnaissance satellites are the most launched payload type of the military class at twelve-hundred and fifty-two which represents thirty percent of the class. Science, technology, and education satellites are the most launched payload type of the civilian class at twelve hundred and five which accounts for thirty-eight percent of the class. Communication satellites are the most launched payload type of the commercial class at thirteen hundred and twenty-two which makes up fifty-nine percent of the class. Finally, interplanetary spacecrafts are the most launched payload type of the hybrid class at fifty-seven which constitutes forty percent of the class.

**Table 5.4.3: Payload Type, by Class**

| Payload Type | Civilian | Commercial | Hybrid | Military | Unknown | Total |
|---|---|---|---|---|---|---|
| ASAT | 0 | 0 | 0 | 28 | 0 | 28 |
| ASAT Target | 0 | 0 | 0 | 19 | 0 | 19 |
| Art | 4 | 3 | 0 | 0 | 0 | 7 |
| Burial/Memorial | 8 | 1 | 0 | 0 | 0 | 9 |
| Calibration | 18 | 0 | 0 | 222 | 0 | 240 |
| Communication | 381 | 1322 | 24 | 887 | 0 | 2614 |
| Crewed Spaceflight and Support | 351 | 86 | 2 | 1 | 0 | 440 |
| Early Warning | 0 | 0 | 0 | 149 | 0 | 149 |
| Earth Observation | 448 | 498 | 6 | 19 | 0 | 971 |
| Experimental | 6 | 8 | 0 | 154 | 0 | 168 |
| Geodesy | 18 | 1 | 0 | 57 | 0 | 76 |
| Interplanetary Spacecraft | 185 | 12 | 57 | 2 | 0 | 256 |
| Meteorology | 196 | 0 | 3 | 61 | 0 | 260 |
| Navigation | 56 | 0 | 0 | 477 | 0 | 533 |
| Nuclear Detection | 0 | 0 | 0 | 13 | 0 | 13 |
| Ocean Surveillance | 5 | 1 | 11 | 106 | 0 | 123 |
| Orbital Weapons | 0 | 0 | 0 | 19 | 0 | 19 |
| Reconnaissance, optical | 0 | 0 | 0 | 1252 | 0 | 1252 |
| Reconnaissance, radar | 0 | 0 | 0 | 40 | 0 | 40 |
| SDIO/BMDO/MDA | 0 | 0 | 0 | 13 | 0 | 13 |
| SIGINT/COMINT/ELINT | 0 | 0 | 0 | 379 | 0 | 379 |
| Science, Technology, and Education | 1205 | 271 | 36 | 208 | 1 | 1721 |
| Space Station Supply/Logistics | 237 | 23 | 2 | 0 | 0 | 262 |
| Space Surveillance | 0 | 0 | 0 | 9 | 0 | 9 |
| Traffic Monitoring | 10 | 18 | 0 | 0 | 0 | 28 |
| Uncrewed Spacecraft | 0 | 0 | 0 | 5 | 0 | 5 |
| Unknown | 3 | 6 | 0 | 2 | 1 | 12 |
| Vehicle Evaluation | 28 | 9 | 0 | 3 | 0 | 40 |
| Total | 3159 | 2259 | 141 | 4125 | 2 | 9686 |

To facilitate the tabulation and graphing process, I have divided the eleven exclusively military payloads into two camps: general defense satellites and intelligence satellites. Table

5.4.4 describes the distribution of military defense satellites by type, and Graph 5.4.3 illustrates the frequency of military defense satellites over time. There are eighty-four total payloads in this group which account for two percent of the class and nearly one percent of all orbital payloads. Twenty-eight ASATs represent one third of the group, nearly one percent of the class, and nearly one third of one percent of the total. There are nineteen ASAT target crafts and orbital weapons crafts that each make up twenty-three percent of the group, nearly half of one percent of the class, and two-tenths of one percent of the total. Thirteen SDIO/BMDO/MDA crafts account for fifteen percent of the group and one third of one percent of the class. Finally, five uncrewed spacecrafts and support satellites make up six percent of the group and negligible proportions of the other categories.

**Table 5.4.4: Military Defense Satellites**

| Payload Type | Frequency | Class% | Group% | Total% |
|---|---|---|---|---|
| ASAT | 28 | .68 | 33.33 | .29 |
| ASAT Target | 19 | .46 | 22.62 | .20 |
| Orbital Weapons | 19 | .46 | 22.62 | .20 |
| SDIO/BMDO/MDA | 13 | .32 | 15.48 | .13 |
| Uncrewed Spacecraft | 5 | .12 | 5.95 | .05 |
| Total | 84 | 2.04 | 100.00 | .87 |

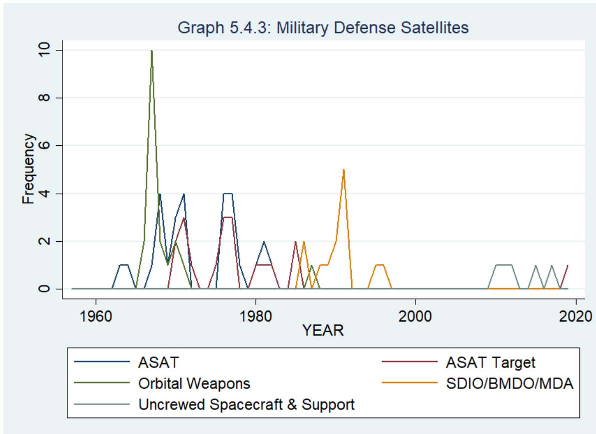



Table 5.4.5 describes the distribution of military intelligence satellites by type, and Graph 5.4.4 illustrations the frequency of military intelligence satellites by type over type. There are over eighteen hundred payloads in this group which constitutes forty-five percent of the class and nineteen percent of all orbital payloads. Twelve hundred and fifty-three optical reconnaissance satellites make up sixty-eight percent of the group, thirty percent of the class, and thirteen percent of the total. Three hundred and seventy-nine SIGINT/COMINT/ELINT satellites represent twenty-one percent of the group, nine percent of the class, and four percent of the total.

One hundred and forty-nine early warning satellites account for eight percent of the group, four percent of the class, and nearly two percent of the total. Thirty-nine radar reconnaissance satellites represent two percent of the group, one percent of the class, and nearly half of one percent of the total. Thirteen nuclear detection satellites make up nearly one percent of the group and one third of one percent of the class. Finally, nine space surveillance satellites represent half of one percent of the group and nearly one quarter of one percent of the class.

**Table 5.4.5: Military Intelligence Satellites by Class**

| Payload Type | Frequency | Class% | Group% | Total% |
|---|---|---|---|---|
| Recon, optical | 1253 | 30.38 | 68.02 | 12.94 |
| Recon, radar | 39 | .95 | 2.12 | .40 |
| Early Warning | 149 | 3.61 | 8.09 | 1.54 |
| Nuclear Detection | 13 | .32 | .71 | .13 |
| SIG/COM/ELINT | 379 | 9.19 | 20.58 | 3.91 |
| Space Surveillance | 9 | .22 | .49 | .09 |
| Total | 1842 | 44.67 | 100.00 | 19.01 |

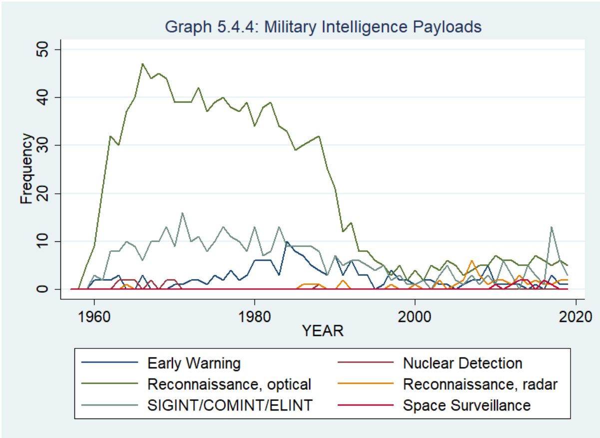



Table 5.4.6 describes the distribution of military payloads that are not exclusive to the class, and Graph 5.4.5 illustrates the frequency of these payloads by type over time. There are twenty-one hundred and ninety-nine payloads in this group across thirteen types which makes up twenty-three percent of all orbital payloads. Military communication satellites account for twenty-two percent of the class and thirty-four percent of the type. Military navigation satellites represent twelve percent of the class and eighty-nine percent of the type. Military calibration payloads make up five percent of the class and ninety-three percent of the type. Military science, technology, and education payloads constitute five percent of the class and twelve percent of the type. Military experimental payloads account for four percent of the class and ninety-two percent

of the type. Military ocean surveillance payloads represent three percent of the class and eighty-six percent of the type. Military geodesy and meteorology payloads make up seventy-five percent and twenty-three percent of the type, respectively.

**Table 5.4.6: Non-exclusively Military Payloads, by Type**

| Payload Type | Count | Class% | Type% | Total% |
|---|---|---|---|---|
| Calibration | 222 | 5.38 | 92.50 | 2.29 |
| Communication | 887 | 21.50 | 33.93 | 9.16 |
| Crewed Flight and Support | 1 | .02 | .23 | .01 |
| Earth Observation | 19 | .46 | 1.96 | .20 |
| Experimental | 154 | 3.73 | 91.67 | 1.59 |
| Geodesy | 57 | 1.38 | 75.00 | .59 |
| Interplanetary Spacecraft | 2 | .05 | .78 | .02 |
| Meteorology | 61 | 1.48 | 23.46 | .63 |
| Navigation | 477 | 11.56 | 89.49 | 4.92 |
| Ocean Surveillance | 106 | 2.57 | 86.18 | 1.09 |
| Science/Tech/Education | 208 | 5.04 | 12.09 | 2.15 |
| Unknown | 2 | .05 | 16.67 | .02 |
| Vehicle Evaluation | 3 | .07 | 7.50 | .03 |
| Total | 2199 | 53.41 | | 22.75 |

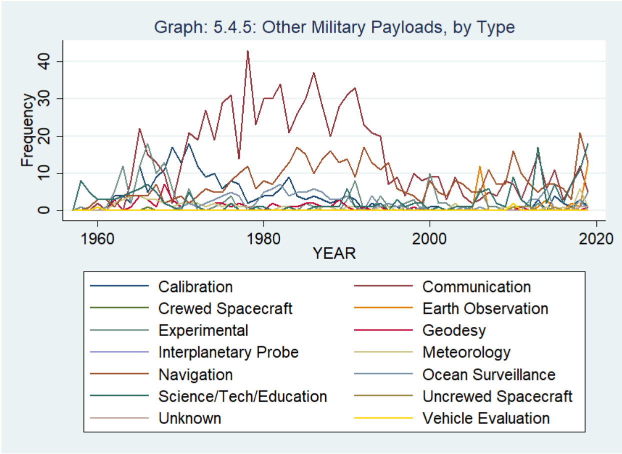



Table 5.4.7 describes the distribution of civilian payloads by type, and Graph 5.4.6 illustrates the frequency of civilian payloads by type over time. There are thirty-one hundred and fifty-nine payloads in this group across seventeen types which represents thirty-three percent of all orbital payloads. Civilian science, technology, and education payloads account for thirty-eight percent of the class, seventy percent of the type, and twelve percent of all orbital payloads. Civilian earth observation payloads make up fourteen percent of the class, forty-six percent of the type, and five percent of the total. Civilian communication satellites represent twelve percent of the class, fifteen percent of the type, and four percent of the total. Civilian crewed support payloads constitute eleven percent of the class, eighty percent of the type, and four percent of the

total. Civilian space station supply payloads account for eight percent of the class, ninety percent of the type, and two percent of the total. Civilian meteorology payloads represent six percent of the class, seventy-five percent of the type, and two percent of the total. Civilian interplanetary probes make up six percent of the class, seventy-two percent of the type, and two percent of the total. The rest of the civilian payload types constitute less than one percent of the class.

**Table 5.4.7: Civilian Payloads, by Type**

| Payload Type | Count | Class% | Type% | Total% |
|---|---|---|---|---|
| Art | 4 | .13 | 57.14 | .04 |
| Burial/Memorial | 8 | .25 | 88.89 | .08 |
| Calibration | 18 | .57 | 7.50 | .19 |
| Communication | 381 | 12.06 | 14.58 | 3.93 |
| Crewed Flight and Support | 351 | 11.11 | 79.78 | 3.62 |
| Earth Observation | 448 | 14.18 | 46.25 | 4.63 |
| Experimental | 6 | .19 | 3.57 | .06 |
| Geodesy | 18 | .57 | 23.68 | .19 |
| Interplanetary Spacecraft | 185 | 5.86 | 72.27 | 1.91 |
| Meteorology | 196 | 6.20 | 75.38 | 2.02 |
| Navigation | 56 | 1.77 | 10.51 | .58 |
| Ocean Surveillance | 5 | .16 | 4.07 | .05 |
| Science/Tech/Education | 1205 | 38.15 | 70.02 | 12.44 |
| Space Station Supply | 237 | 7.50 | 90.46 | 2.45 |
| Traffic Monitoring | 10 | .32 | 35.71 | .10 |
| Unknown | 3 | .10 | 25.00 | .03 |
| Vehicle Evaluation | 28 | .89 | 70.00 | .29 |
| Total | 3159 | 100.00 | | 32.61 |

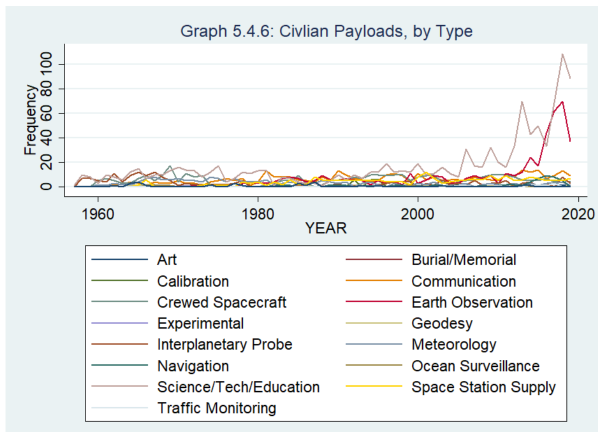



Table 5.4.8 describes the distribution of commercial payloads by type, and Graph 5.4.7 illustrates the frequency of commercial payloads by type over time. There are twenty-two hundred and fifty-nine commercial payloads in this group which makes up twenty-three percent of all orbital payloads. Commercial communication payloads account for fifty-nine percent of the class, fifty-one percent of the type, and fourteen percent of the total. Commercial earth observation payloads represent twenty-two percent of the class, fifty-one percent of the type, and five percent of the total. Commercial science, technology, and education payloads constitute

twelve percent of the class, sixteen percent of the type, and three percent of the total. Commercial crewed support payloads accounts for four percent of the class, twenty percent of the type, and one percent of the total. Commercial space station supply payloads represent one percent of the class and nine percent of the type. The remaining commercial payloads make up less than one percent of the class.

**Table 5.4.8: Commercial Payloads, by Type**

| Payload Type | Count | Class% | Type% | Total% |
|---|---|---|---|---|
| Art | 3 | .13 | 42.86 | .03 |
| Burial/Memorial | 1 | .04 | 11.11 | .01 |
| Communication | 1322 | 58.52 | 50.57 | 13.65 |
| Crewed Flight and Support | 86 | 3.81 | 19.55 | .89 |
| Earth Observation | 498 | 22.05 | 51.29 | 5.14 |
| Experimental | 8 | .35 | 4.76 | .08 |
| Geodesy | 1 | .04 | 1.32 | .01 |
| Interplanetary Spacecraft | 12 | .53 | 4.69 | .12 |
| Ocean Surveillance | 1 | .04 | .81 | .01 |
| Science/Tech/Education | 271 | 12.00 | 15.75 | 2.80 |
| Space Station Supply | 23 | 1.02 | 8.78 | .24 |
| Traffic Monitoring | 18 | .80 | 64.29 | .19 |
| Unknown | 6 | .27 | 50.00 | .06 |
| Vehicle Evaluation | 9 | .40 | 22.50 | .09 |
| Total | 2259 | 100.00 | | 23.32 |

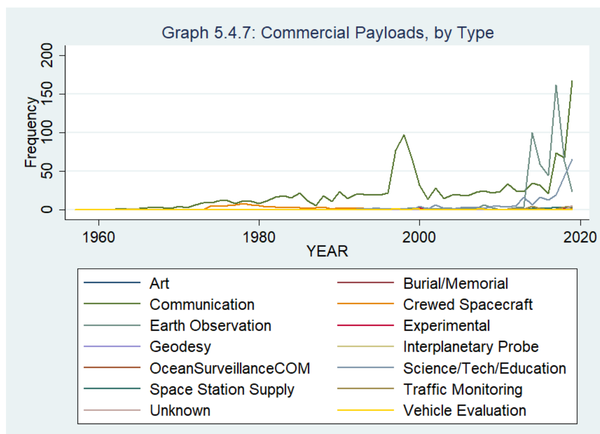
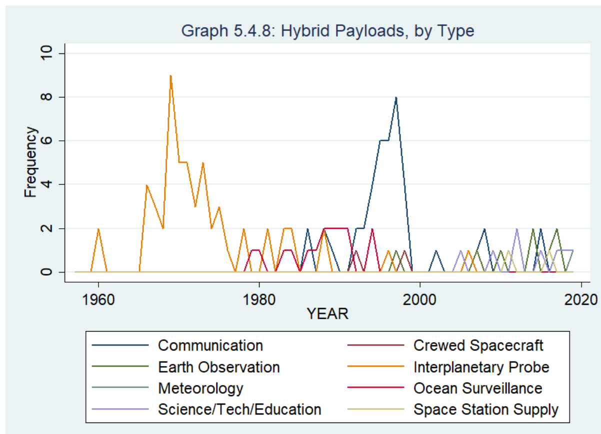



Table 5.4.9 describes the distribution of hybrid payloads by type, and Graph 5.4.8 illustrates the frequency of hybrid payloads by type over time. There are one hundred and forty-one payloads in this group across eight types which constitutes over one percent of all orbital payloads. Hybrid interplanetary probes make up forty percent of the class and twenty-two percent of the type. Hybrid science, technology, and education payloads represent twenty-six percent of the class and two percent of the type. Hybrid communication payloads account for seventeen percent of the class and one percent of the type. Hybrid ocean surveillance payloads make up eight percent of the class and nine percent of the type. Hybrid earth observation

payloads represent four percent of the class and nearly one percent of the type. Hybrid meteorology payloads constitute two percent of the class and one percent of the type. Crewed support payloads and space station supply payloads each account for over one percent of the class and less than one percent of each type, respectively.

**Table 5.4.9: Hybrid Payloads, by Type**

| Payload Type | Count | Class% | Type% | Total% |
|---|---|---|---|---|
| Communication | 24 | 17.02 | .92 | .25 |
| Crewed Flight and Support | 2 | 1.42 | .45 | .02 |
| Earth Observation | 6 | 4.26 | .62 | .06 |
| Interplanetary Spacecraft | 57 | 40.43 | 22.27 | .59 |
| Meteorology | 3 | 2.13 | 1.15 | .03 |
| Ocean Surveillance | 11 | 7.80 | 8.94 | .11 |
| Science/Tech/Education | 36 | 25.53 | 2.09 | .37 |
| Space Station Supply | 2 | 1.42 | .76 | .02 |
| Total | 141 | 100.00 | | 1.45 |




*Orbital Payloads by Class and Spacefarer Type*[209]

Table 5.4.10 describes the distribution of military payloads by spacefarer type across the full temporal range, and Graph 5.4.9 illustrates the frequency of military payloads by spacefarer type over time. There are forty-one hundred and forty-seven military payloads that represent forty-two percent of all orbital payloads. Major spacefarers operate ninety-nine percent of military payloads which represents forty-two percent of the total. Minor spacefarers operate one percent

[209] Totals for payload types are greater than true totals because the spacefarer typology accounts for the full temporal range, thus the same political actor is counted multiple times if it achieve more than one status.

of military payloads which represents roughly half of one percent of the total. Emergent spacefarers and spacefaring dependents operate two and six military payloads, respectively, which represents negligible percentages of type and total.

**Table 5.4.10: Military Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 4095 | 98.75 | 41.53 |
| Minor | 44 | 1.06 | .45 |
| Emergent | 2 | .05 | .02 |
| Dependent | 6 | .14 | .06 |
| Total | 4147 | 100.00 | 42.06 |

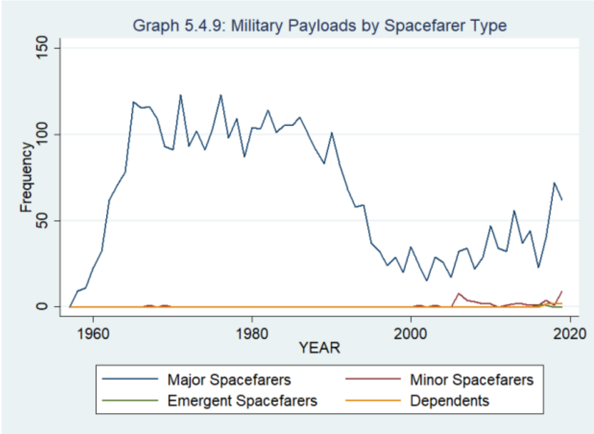



Table 5.4.11 describes the distribution of civilian payloads by spacefarer type across the full temporal range, and Graph 5.4.10 illustrates the frequency of civilian payloads by spacefarer types over time. There are thirty-two hundred and fifty-one civilian payloads that represent thirty-three percent of all orbital payloads. Major spacefarers operate eighty-seven percent of civilian payloads and twenty-nine percent of the total. Minor spacefarers operate nine percent of civilian payloads and three percent of the total. Spacefaring dependents operate four percent of civilian payloads and over one percent of the total. Emergent spacefarers operate six civilian payloads which accounts for negligible proportions of the type and total.

**Table 5.4.11: Civilian Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 2833 | 87.14 | 28.73 |
| Minor | 282 | 8.67 | 2.86 |
| Emergent | 6 | .18 | .06 |
| Dependent | 130 | 4.00 | 1.32 |
| Total | 3251 | 100.00 | 32.97 |

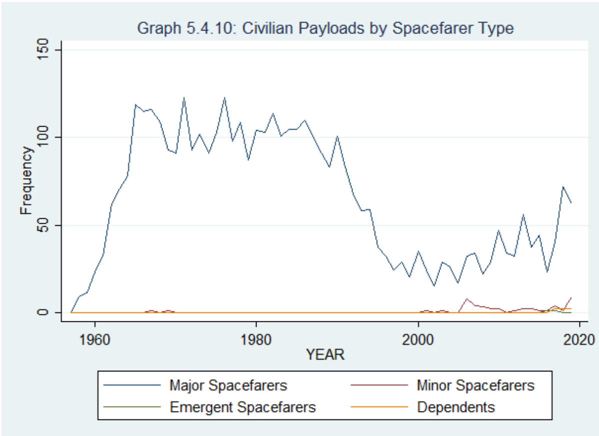



Table 5.4.12 describes the distribution of commercial payloads by spacefarer type across the full temporal range, and Graph 5.4.11 illustrates the frequency of commercial payloads by spacefarer type over time. There are twenty-two hundred and ninety-one commercial payloads that make up twenty-three percent of all orbital launches. Major spacefarers operate eighty-seven percent of commercial payloads which accounts for twenty percent of the total. Minor spacefarers operate seven percent of commercial payloads which represents nearly two percent of the total. Spacefaring dependents operate five percent of commercial payloads which constitutes over one percent of the total. Emergent spacefarers operate roughly one half of a percent of commercial payloads which makes up a negligible proportion of the total.

**Table 5.4.12: Commercial Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 1993 | 86.99 | 20.21 |
| Minor | 165 | 7.20 | 1.67 |
| Emergent | 13 | .57 | .13 |
| Dependent | 120 | 5.24 | 1.22 |
| Total | 2291 | 100.00 | 23.23 |

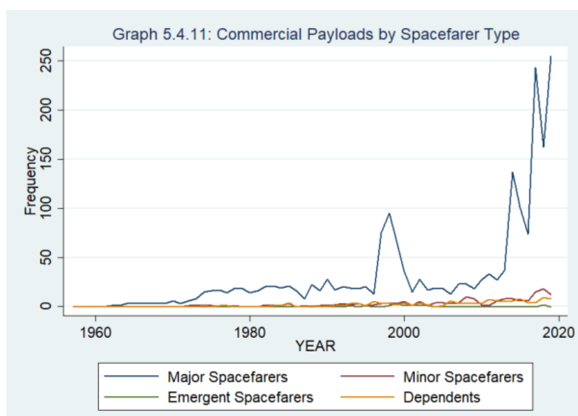
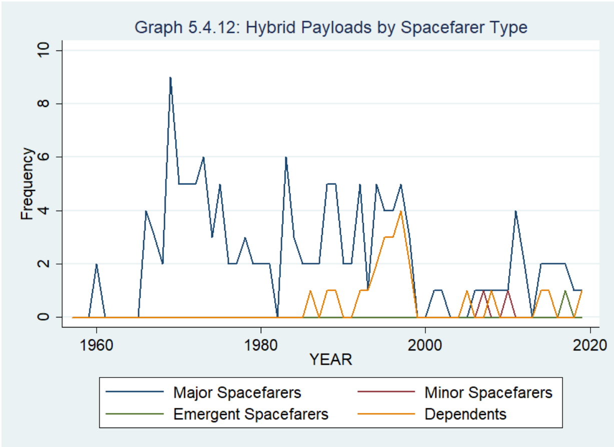



Table 5.4.13 describes the distribution of hybrid payloads by spacefarer type across the full temporal range, and Graph 5.4.12 illustrates the frequency of hybrid payloads by spacefarer

type over time. There are one hundred and sixty-nine hybrid payloads that represent nearly two percent of all orbital payloads. Major spacefarers operate eighty-three percent of hybrid payloads which constitutes over one percent of the total. Spacefaring dependents operate fifteen percent of hybrid payloads which represents one quarter of one percent of the total. Minor spacefarers and emergent spacefarers two and one hybrid payloads, respectively, which accounts for negligible proportions of the type and total.

**Table 5.4.13: Hybrid Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 141 | 83.43 | 1.43 |
| Minor | 2 | 1.18 | .02 |
| Emergent | 1 | .59 | .01 |
| Dependent | 25 | 14.79 | .25 |
| Total | 169 | 100.00 | 1.71 |




*Orbital Payloads by Class and Space Power Type*[210]

Table 5.4.14 describes the distribution of military payloads by space power type across the full temporal range, and Graph 5.4.13 illustrates the frequency of military payloads by space power type over time. Forty-one hundred and forty-seven military payloads make up forty-two percent of all orbital payloads. Primary space powers operate ninety-nine percent of military payloads which is forty-two percent of the total. Tertiary space powers operate one percent of military payloads which his one half of a percent of the total. Secondary space powers and non-space powers do not operate military payloads.

[210] Totals for payload types are greater than true totals because the space power typology accounts for the full temporal range, thus the same political actor is counted multiple times if it achieved more than one status.

**Table 5.4.14: Military Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 4095 | 98.75 | 41.53 |
| Secondary | 0 | 0.00 | 0.00 |
| Tertiary | 52 | 1.25 | .53 |
| Non-Space Power | 0 | 0.00 | 0.00 |
| Total | 4147 | 100.00 | 42.06 |

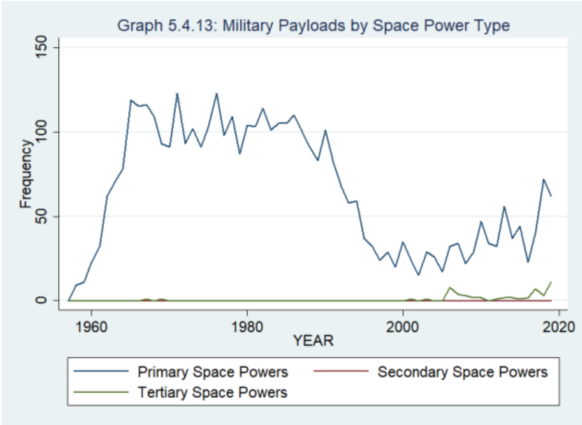



Table 5.4.15 describes the distribution of civilian payloads by space power type across the full temporal range, and Graph 5.4.14 illustrates the frequency of civilian payloads by space power type over time. There are thirty-two hundred and fifty-one civilian payloads which represents thirty-three percent of all orbital payloads. Primary space powers operate seventy percent civilian payloads which represents twenty-three percent of the total. Secondary space powers operate ten percent of civilian payloads which makes up three percent of the total. Tertiary space powers operate three percent of civilian payloads which accounts for one percent of the total. Non-space powers operate eighteen percent of civilian payloads which represents six percent of the total.

**Table 5.4.15: Civilian Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 2267 | 69.73 | 22.99 |
| Secondary | 312 | 9.60 | 3.16 |
| Tertiary | 95 | 2.92 | .96 |
| Non-Space Power | 577 | 17.75 | 5.85 |
| Total | 3251 | 100.00 | 32.96 |

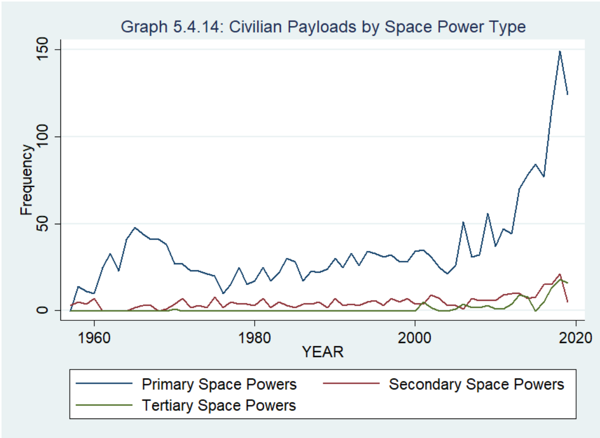


Table 5.4.16 describes the distribution of commercial payloads by space power type across the full temporal range, and Graph 5.4.15 illustrates the frequency of commercial payloads by space power type over time. There are twenty-two hundred and ninety-one commercial payloads which makes up twenty-three percent of all orbital payloads. Primary space powers operate eighty-three percent of commercial payloads which represents nineteen percent of the total. Secondary space powers operate two percent of commercial payloads which accounts for less than half of one percent of the total. Tertiary space powers operate three percent of commercial payloads which constitutes nearly three quarters of one percent of the total. Non-space powers operate twelve percent of commercial payloads which makes up three percent of the total.

**Table 5.4.16: Commercial Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 1900 | 82.93 | 19.27 |
| Secondary | 38 | 1.66 | .39 |
| Tertiary | 70 | 3.06 | .71 |
| Non-Space Power | 283 | 12.35 | 2.87 |
| Total | 2291 | 100.00 | 23.24 |

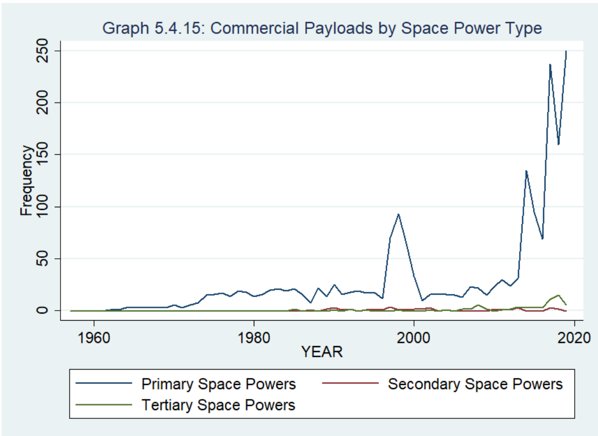
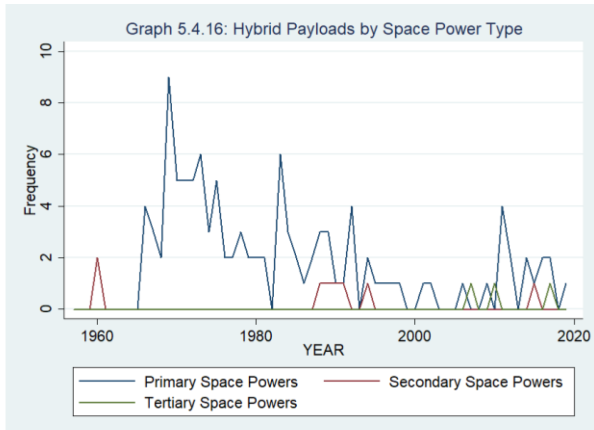



Table 5.4.17 describes the distribution of hybrid payloads by space power type across the full temporal range, and Graph 5.4.16 illustrates the frequency of hybrid payloads by space power type over time. There are one hundred and sixty-nine hybrid payloads which makes up

nearly two percent of all orbital payloads. Primary space powers operate sixty-five percent of hybrid payloads which represents one percent of the total. Secondary space powers and tertiary space powers operate five percent and two percent of hybrid payloads, respectively. Non-space powers operate twenty-eight percent of hybrid payloads which is one half of a percent of the total.

**Table 5.4.17: Hybrid Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 110 | 65.09 | 1.12 |
| Secondary | 8 | 4.73 | .08 |
| Tertiary | 3 | 1.78 | .03 |
| Non-Space Power | 48 | 28.40 | .49 |
| Total | 169 | 100.00 | 1.72 |




*Orbital Payload Operation Structures*

Payload operability is categorized across three structure types: unilateral, bilateral, and multilateral. The multilateral structure consists not only of joint operations among three or more political actors but also joint operations between state actors and transnational non-state actors. Table 5.4.18 describes the distribution of the payloads by structure type, and Graph 5.4.17 illustrates the frequency of payloads by structure type over time. Ninety-two hundred and thirty-two payloads are associated with the unilateral structure which makes up ninety-five percent of all orbital payloads. Three hundred and forty-six payloads are associated with the multilateral structure which accounts for three and a half percent of the total. One hundred and eight payloads are associated with the bilateral structure which represents one percent of the total.

**Table 5.4.18: Payload Operation Structures**

| Spacefarer Type | Frequency | Total% |
|---|---|---|
| Unilateral | 9232 | 95.31 |
| Bilateral | 108 | 1.12 |
| Multilateral | 346 | 3.57 |
| Total | 9686 | 100.00 |

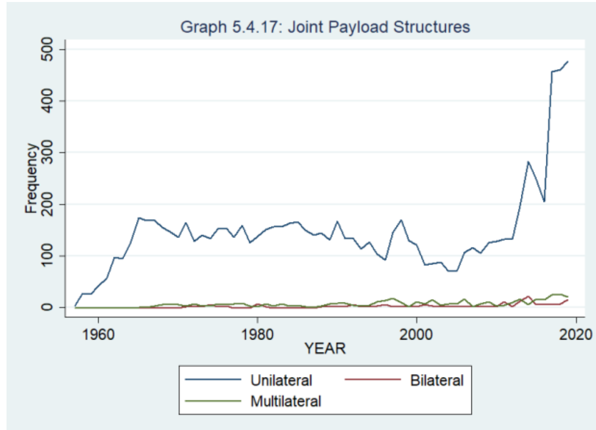



Table 5.4.19 describes the distribution of payloads by bilateral groupings. There are one hundred and eight payloads across forty-one groupings and thirty-five total state actors. Five states are a part of the greatest number of groupings. The United States is a part of thirteen groupings involving sixty total payloads. Russia is a part of nine groupings involving eighteen total payloads. France is a part of eight groupings involving nineteen total payloads. Germany is a part of six groupings involving twenty total payloads. China is a part of four groupings involving nine total payloads.

**Table 5.4.19: Bilateral Payload Operations**

| Groupings | Count | Structure% | Groupings | Count | Structure% |
|---|---|---|---|---|---|
| Algeria/United Kingdom | 1 | .93 | Germany/Morocco | 1 | .93 |
| Argentina/United States | 9 | 8.33 | Germany/Russia | 1 | .93 |
| Australia/Russia | 1 | .93 | Germany/United States | 14 | 12.96 |
| Australia/United States | 1 | .93 | Greece/Saudi Arabia | 1 | .93 |
| Austria/Canada | 1 | .93 | India/Russia | 1 | .93 |
| Azerbaijan/France | 2 | 1.85 | Iraq/Italy | 1 | .93 |
| Brazil/China | 6 | 5.56 | Israel/Switzerland | 1 | .93 |
| Brazil/Spain | 2 | 1.85 | Italy/United States | 4 | 3.70 |
| Canada/United States | 3 | 2.78 | Japan/Singapore | 4 | 3.70 |
| China/France | 1 | .93 | Japan/United States | 3 | 2.78 |
| China/Indonesia | 1 | .93 | Mexico/United States | 1 | .93 |
| China/United States | 1 | .93 | Monaco/Turkmenistan | 1 | .93 |
| Ecuador/Russia | 1 | .93 | Netherlands/United Kingdom | 1 | .93 |
| France/Germany | 2 | 1.85 | Peru/Russia | 1 | .93 |
| France/India | 2 | 1.85 | Russia/South Africa | 1 | .93 |
| France/Israel | 1 | .93 | Russia/Ukraine | 6 | 5.56 |
| France/Italy | 2 | 1.85 | Russia/United States | 3 | 2.78 |
| France/Russia | 3 | 2.78 | Spain/United States | 1 | .93 |
| France/United States | 6 | 5.56 | Sweden/United States | 1 | .93 |

| | | | | | |
|---|---|---|---|---|---|
| Germany/Indonesia | 1 | .93 | Taiwan/United States | 13 | 12.03 |
| Germany/Japan | 1 | .93 | | | |
| **Total** | **48** | | | **60** | **(108)** |

Table 5.4.20 describes the distribution of payloads by multilateral structure subtypes. There are three hundred and forty-six payloads associated with multilateral structures which represents three and a half percent of all orbital payloads. Thirteen interstate groupings account for four percent of the structure type. Thirty-seven groupings of states with non-state actors make up eleven percent of the structure type and one third of a percent of the total. Two hundred and ninety-six groupings of non-state actors represent eighty-six percent of the structure type and three percent of the total.

**Table 5.4.20: Orbital Payloads, by Multilateral Structure Type**

| Multilateral Type | Frequency | Percent of Structure | Percent of Total |
|---|---|---|---|
| Interstate | 13 | 3.76 | .13 |
| State-NSA | 37 | 10.69 | .38 |
| NSA | 296 | 85.55 | 3.06 |
| **Total** | **346** | **100.00** | **3.57** |

Table 5.4.21 describes the distribution of payloads among multilateral interstate groupings. There are seven groupings in this structure subtype consisting of fourteen state actors and thirteen total payloads. Five groupings consist of three state actors, one grouping consists of four state actors, and one grouping consists of five state actors. Two states take part in the greatest number of groupings. The United Kingdom is a part of five groupings involving eleven payloads, and the United States is a part of four groupings involving eight payloads.

**Table 5.4.21: Multilateral Interstate Payload Operations**

| Political Actor Groupings | Frequency | Subtype% | Structure% |
|---|---|---|---|
| Australia/Canada/United Kingdom/United States | 3 | 23.08 | .87 |
| Australia/Israel/United Kingdom | 3 | 23.08 | .87 |
| Canada/Denmark/Luxembourg/Netherlands/New Zealand | 1 | 7.69 | .29 |
| China/Japan/South Korea | 1 | 7.69 | .29 |
| Germany/United Kingdom/United States | 1 | 7.69 | .29 |
| Netherlands/United Kingdom/United States | 1 | 7.69 | .29 |
| South Korea/United Kingdom/United States | 3 | 7.69 | .29 |
| **Total** | **13** | **100.00** | **3.76** |

Table 5.4.22 describes the distribution of payloads among multilateral state-NSA groupings with additional information regarding the international entity involved. There are ten groupings in this structure subtype including nine states and four non-state actors. Thirty-seven total payloads in the subtype account for nearly eleven percent of all multilateral payloads. Over half of the payloads included in this structure subtype are associated with Intelsat and the Netherlands which constitutes five and a half percent of all multilateral payloads. The European Space Agency is a part of six groupings involving fourteen total payloads. The United States and Russia are each associated with two groupings and are the only states involved with a grouping consisting of three political entities. The other nine groupings consist only of two entities.

**Table 5.4.22: Multilateral State-NSA Payload Operations**

| Grouping | Entity | Frequency | Subtype% | Structure% |
|---|---|---|---|---|
| Afghanistan/International | Eutelsat SA | 1 | 2.70 | .29 |
| France/International | ESA | 1 | 2.70 | .29 |
| International/Japan | ESA | 2 | 5.41 | .58 |
| International/Mexico | Eutelsat SA | 2 | 5.41 | .58 |
| International/Netherlands | Intelsat | 19 | 51.35 | 5.49 |
| International/Qatar | Eutelsat | 1 | 2.70 | .29 |
| International/Russia | ESA | 3 | 8.11 | .87 |
| International/Russia/United States | ESA | 1 | 2.70 | .29 |
| International/Switzerland | ESA | 1 | 2.70 | .29 |
| International/United States | ESA | 6 | 16.22 | 1.73 |
| **Total** | | **37** | **100.00** | **10.69** |

Table 5.4.23 describes the distribution of payloads among multilateral NSA groupings with additional information regarding the international entity involved. The structure subtype includes twenty-three entities including nine intergovernmental organizations and eight

multinational corporations. Sixteen entities operate alone while seven take part in groupings of two entities. Two hundred and ninety-six payloads in this structure subtype account for eighty-six percent of all multilateral payloads. The European Space Agency operates one hundred and seven payloads on their own which represents thirty-six percent of the subtype and thirty-one percent of all multilateral payloads. It is associated with twelve additional jointly operated payloads with other European civilian and commercial entities. Intelsat operates forty-five payloads as an IGO which is fifteen percent of the subtype and thirteen percent of all multilateral payloads. It operates thirteen payloads as a privatized corporation which represents roughly four percent of the subtype. Eutelsat operates twenty-two payloads as an IGO which is seven percent of the subtype and six percent of all multilateral payloads. It operates roughly the same proportions of the subtype and structure as a privatized corporation.

**Table 5.4.23: Multilateral NSA Payload Operations**

| Grouping | Entities | Frequency | Subtype% | Structure% |
|---|---|---|---|---|
| International | Arianespace | 1 | .34 | .29 |
| International | ELDO | 1 | .34 | .29 |
| International | ESA | 107 | 36.15 | 30.92 |
| International | ESA/ESRO | 1 | .34 | .29 |
| International | ESA/ESTEC | 3 | 1.01 | .87 |
| International | ESA/Eumetsat | 1 | .34 | .29 |
| International | ESA/Eutelsat | 5 | 1.69 | 1.45 |
| International | ESA/Inmarsat | 1 | .34 | .29 |
| International | ESA/GOMSpace | 1 | .34 | .29 |
| International | ESRO | 12 | 4.05 | 3.47 |
| International | Eumetsat | 11 | 3.72 | 3.18 |
| International | Eutelsat | 22 | 7.43 | 6.36 |
| International | Eutelsat SA | 21 | 7.09 | 6.07 |
| International | ICO GlobalComm | 2 | .68 | .58 |
| International | Inmarsat | 12 | 4.05 | 3.47 |
| International | Inmarsat Ltd. | 8 | 2.70 | 2.31 |
| International | Intelsat | 45 | 15.20 | 13.01 |
| International | Intelsat Ltd. | 7 | 2.36 | 2.02 |
| International | Intelsat SA | 3 | 1.01 | .87 |
| International | Intelsat SA/DirecTV | 3 | 1.01 | .87 |
| International | Interkosmos | 24 | 8.11 | 6.94 |
| International | Marisat-Inmarsat | 3 | 1.01 | .87 |
| International | RASCOM | 2 | .68 | .58 |
| Total | | 296 | 100.00 | 85.55 |

*Orbital Payload Structures by Spacefarer Type*[211]

Table 5.4.24 describes the distribution of unilateral payloads by spacefarer type, and Graph 5.4.18 illustrates the frequency of unilateral payloads by spacefarer type over time. Ninety-two hundred and thirty-three unilateral payloads which accounts for ninety-four percent of all orbital payloads. Major spacefarers operate eighty-five hundred and fifty-six unilateral payloads which represents ninety-three percent of the type and eighty-seven percent of the total. Minor spacefarers operate four hundred and sixteen unilateral payloads which makes up five percent of the type and four percent of the total. Spacefaring dependents operate two hundred and forty-one unilateral payloads which constitutes three percent of the type and two percent of the total. Emergent spacefarers operate twenty payloads which account for negligible proportions of the type and total.

**Table 5.4.24: Unilateral Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 8556 | 92.67 | 86.77 |
| Minor | 416 | 4.51 | 4.22 |
| Emergent | 20 | .22 | .20 |
| Dependent | 241 | 2.61 | 2.44 |
| Total | 9233 | 100.00 | 93.63 |

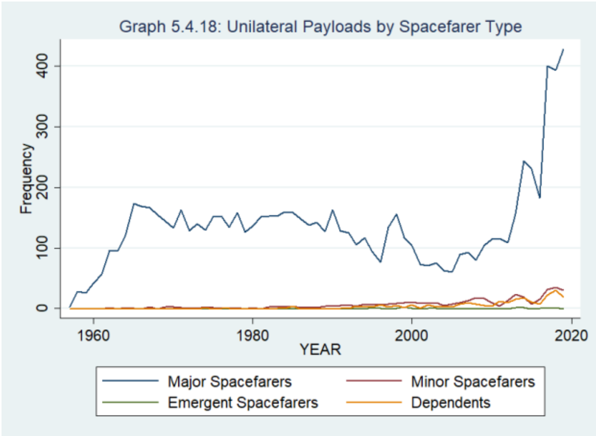


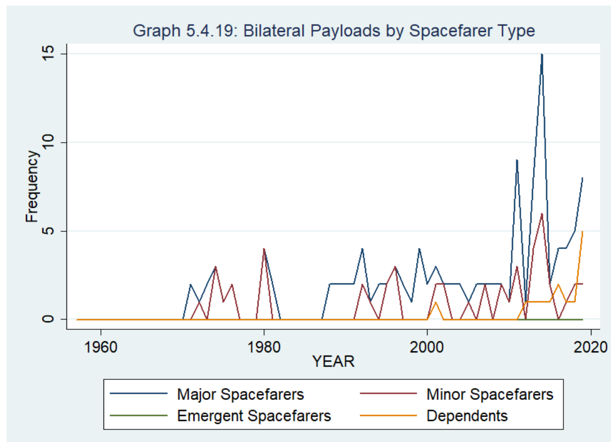

Table 5.4.25 describes the distribution of bilateral payloads by spacefarer type, and Graph 5.4.19 illustrates the frequency of bilateral payloads by spacefarer type over time. One hundred and eighty-six bilateral payloads account for two percent of all orbital payloads. Major

[211] Totals for payloads are greater than true totals because the spacefarer typology accounts for the full temporal range, thus the same political actor is counted multiple times if it achieved more than one status.

spacefarers operate one hundred and twenty-one bilateral payloads which represents sixty-five percent of the type and one percent of the total. Minor spacefarers operate forty-nine bilateral payloads which make up twenty-six percent of the type and half of one percent of the total. Spacefaring dependents operate fourteen bilateral payloads which constitutes eight percent of the type. Emergent spacefarers only operate one bilateral payload.

**Table 5.4.25: Bilateral Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 121 | 65.05 | 1.23 |
| Minor | 49 | 26.34 | .50 |
| Emergent | 1 | .54 | .01 |
| Dependent | 14 | 7.53 | .14 |
| Total | 186 | 100.00 | 1.88 |



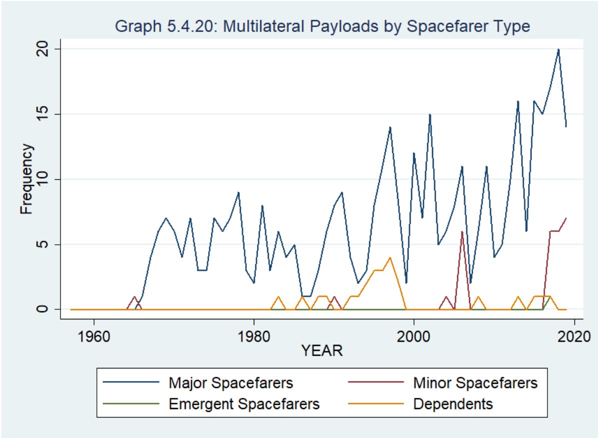
Graph 5.4.19: Bilateral Payloads by Spacefarer Type

Table 5.4.26 describes the distribution of multilateral payloads by spacefarer type, and Graph 5.4.20 illustrates the frequency of multilateral payloads by spacefarer type over time. Four hundred and forty-one multilateral payloads represent four percent of all orbital payloads. Major spacefarers operate three hundred and eighty-seven multilateral payloads which accounts for eighty-eight percent of the type and four percent of the total. Minor spacefarers and spacefaring dependents operate six percent of the type and roughly one quarter of one percent of the total, respectively. Emergent spacefarers only operate one multilateral payload which makes up negligible percentages of the type and total.

**Table 5.4.26: Multilateral Payloads by Spacefarer Type**

| Spacefarer Type | Frequency | Type% | Total% |
|---|---|---|---|
| Major | 387 | 87.76 | 3.92 |
| Minor | 28 | 6.35 | .28 |
| Emergent | 1 | .23 | .01 |
| Dependent | 25 | 5.67 | .25 |

| | | | |
|---|---|---|---|
| Total | 441 | 100.00 | 4.46 |




*Orbital Payload Structures by Space Power Type*[212]

Table 5.4.27 describes the distribution of unilateral payloads by space power type, and Graph 5.4.21 illustrates the frequency of unilateral payloads by space power type over time. Ninety-two hundred and thirty-three unilateral payloads make up ninety-four percent of all orbital payloads. Primary space powers operate eighty-two hundred and twenty-five unilateral payloads which accounts for eighty-nine percent of the type and eighty-three percent of the total. Secondary space powers operate three hundred and thirty-one payloads which represents four percent of the type and three percent of the total. Tertiary space powers operate one hundred and eighty-one payloads which constitutes two percent of both the type and the total. Non-space powers operate four hundred and ninety-six payloads which accounts for five percent of both the type and total.

**Table 5.4.27: Unilateral Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 8225 | 89.08 | 83.42 |
| Secondary | 331 | 3.58 | 3.36 |
| Tertiary | 181 | 1.96 | 1.84 |
| Non-Space Power | 496 | 5.37 | 5.03 |
| Total | 9233 | 100.00 | 93.65 |

[212] Totals for payloads are greater than true totals because the space power typology accounts for the full temporal range, thus the same political actor is counted multiple times if it achieved more than one status.

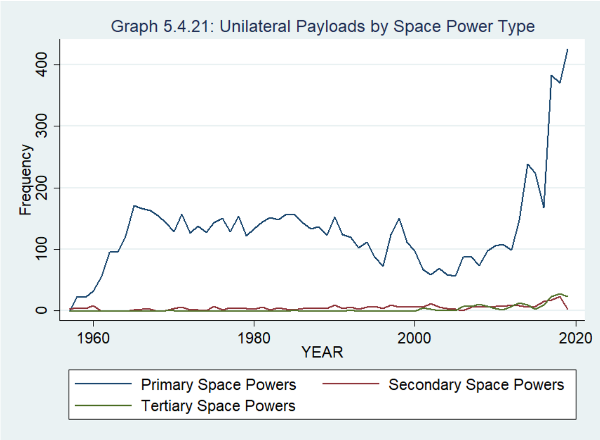



Table 5.4.28 describes the distribution of bilateral payloads by space power type, and Graph 5.4.22 illustrates the frequency of bilateral payloads by space power type over time. One hundred and eighty-six bilateral payloads make up nearly two percent of all orbital payloads. Primary space powers operate ninety-seven payloads which accounts for fifty-two percent of the type and one percent of the total. Secondary space powers operate twenty-four payloads which represents thirteen percent of the type and one quarter of a percent of the total. Tertiary space powers operate thirteen payloads which constitutes seven percent of the type and a negligible proportion of the total. Non-space powers operate fifty-two payloads which accounts for twenty-eight percent of the type and half of a percent of the total.

**Table 5.4.28: Bilateral Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 97 | 52.15 | .98 |
| Secondary | 24 | 12.90 | .24 |
| Tertiary | 13 | 6.99 | .13 |
| Non-Space Power | 52 | 27.96 | .53 |
| Total | 186 | 100.00 | 1.88 |

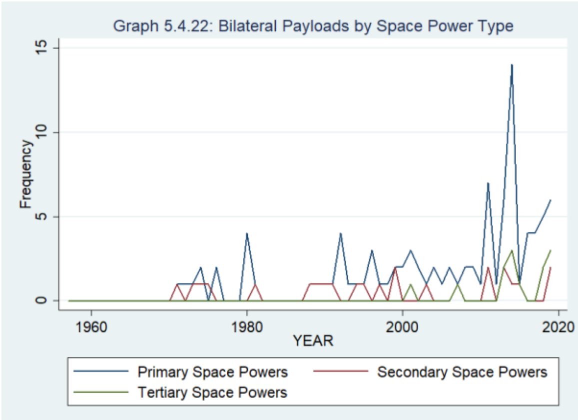
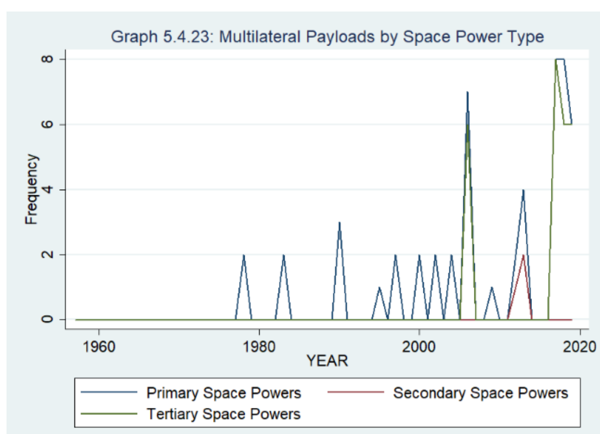



Table 5.4.29 describes the distribution of multilateral payloads by space power type, and Graph 5.4.23 illustrates the frequency of multilateral payloads by space power type over time. Four hundred and forty-one multilateral payloads make up nearly four and a half percent of all orbital payloads. Primary space powers operate fifty-two payloads which accounts for twelve percent of the type and half of a percent of the total. Secondary space powers only operate three payloads which represents nearly one percent of the type and a negligible proportion of the total. Tertiary space powers operate twenty-six payloads which constitutes six percent of the type and one quarter of a percent of the total. Non-space powers operate three hundred and sixty payloads which makes up eighty-two percent of the type and four percent of the total.

**Table 5.4.29: Multilateral Payloads by Space Power Type**

| Space Power Type | Frequency | Type% | Total% |
|---|---|---|---|
| Primary | 52 | 11.79 | .53 |
| Secondary | 3 | .68 | .03 |
| Tertiary | 26 | 5.90 | .26 |
| Non-Space Power | 360 | 81.63 | 3.65 |
| Total | 441 | 100.00 | 4.47 |



## 5.5. Results

*Feasible Generalized Least Squares Regressions*

This section contains three sets of FGLS models that test the effects of militarization and international space treaty subscription on the security status of the space domain. Differentiation in the sets is attributed to the operationalization of treaty ratification structures. The first set operationalizes treaty subscription across three groupings: the core ISTS grouping of ratifications, the ancillary global space treaty grouping of ratifications, and the regional space treaty grouping of ratifications. The second set operationalizes treaty subscription as the aggregate ratifications of all treaties included in the three groupings. Finally, the third set operationalizes treaty subscription by focusing solely on the ratifications of the five core treaties included in the ISTS grouping.

Table 5.5.1 describes the FGLS regression results of the first set. It includes six models that regress observations across specific time periods. The first model pertains to the full temporal. The second model covers the range of 1957 to 1979 which encapsulates global space activities from the launch of Sputnik to the end of détente. The third model covers the range of 1980 to 1986 which represents the so-called “second” Cold War. The fourth model covers the range of 1987 to 1991 which characterizes the fall of the Soviet Union and thus the waning years of the Cold War. The fifth model covers the range of 1992 to 2000 which exemplifies the immediate post-Cold War era and the turn of the twentieth century. Finally, the sixth model covers the range of 2001 to 2019 which signifies the twenty-first century.

**Table 5.5.1 : Feasible Generalized Least Squares Regression, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .48*** | .175*** | .403*** | .594*** | .529*** | .663*** |
| | (.022) | (.02) | (.029) | (.04) | (.046) | (.034) |
| ISTS Ratifications | -.009 | -.028 | -.017 | -.001 | -.06 | .027 |
| | (.024) | (.021) | (.014) | (.022) | (.072) | (.024) |
| GA Ratifications | .003 | -.043 | -.01 | .015 | -.021 | -.002 |
| | (.029) | (.035) | (.024) | (.033) | (.082) | (.03) |
| RA Ratifications | -.098** | -.055 | -.041 | .036 | -.25** | -.12*** |
| | (.04) | (.099) | (.031) | (.031) | (.107) | (.037) |
| Polity IV | .003 | .001 | .003 | .005 | -.001 | .002 |
| | (.005) | (.003) | (.003) | (.004) | (.015) | (.006) |
| Log GDP | -.001 | -.001 | .002 | -.002 | .008 | -.011** |
| | (.005) | (.004) | (.003) | (.006) | (.015) | (.006) |
| Material Capabilities | 19.294*** | 26.104*** | 22.154*** | 28.735*** | 2.138 | 15.431*** |
| | (2.425) | (2.686) | (2.303) | (2.773) | (7.241) | (2.232) |
| Alliances | .028*** | .004 | -.031*** | -.026** | .029 | .026*** |
| | (.006) | (.013) | (.01) | (.013) | (.018) | (.006) |
| Military Expenditures | .00004*** | .00003*** | .00001*** | -.00001*** | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .038* | -.007 | .01 | .027 | .062 | .051** |
| | (.02) | (.015) | (.012) | (.017) | (.057) | (.02) |
| Constant | -.22*** | .012 | .028 | -.071 | -.221 | -.227** |
| | (.077) | (.056) | (.048) | (.078) | (.224) | (.1) |
| Observations | 4827 | 779 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

Across the full temporal range, military payloads have a positive effect on the dependent variable and this effect is statistically significant at a ninety-nine percent confidence interval. Among the treaty ratification groupings, only global agreements have positive effects on the dependent variable and only regional agreements have significant effects. All of the control variables except for log GDP have positive effects on the dependent variable. Only log GDP and polity have insignificant effects.

From the launch of Sputnik through the end of détente, military payloads have a positive effect on the dependent variable and this effect is statistically significant at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has negative and insignificant effects on the dependent variable. Material capabilities and military expenditures have positive effects on the dependent variable at ninety-nine percent confidence intervals.

During the “second” Cold War, military payloads have a positive effect on the dependent variable and this effect is statistically significant at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a negative and insignificant effect on the dependent variable. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety-nine percent confidence intervals. Alliances have a negative and significant effect on the dependent variable at a ninety-nine percent confidence interval.

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has an insignificant effect on the dependent variable, and only the ISTS agreement grouping effect is negative. Military expenditures and alliances have negative and significant effects on the dependent variable at ninety-nine and ninety-five percent confidence intervals, respectively. Material capabilities have a positive and significant effect at a ninety-nine percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping international space treaty ratifications has a negative effect on the dependent variable, but only the regional agreement grouping effect is statistically significant at a ninety-five percent confidence interval. Among the control variables, only military expenditures have a significant effect on the dependent variable.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The ISTS grouping of treaty ratifications has a positive but insignificant effect on the dependent variable. The global agreement grouping has a negative and insignificant effect on the dependent variable, and the regional agreement grouping has a negative statistically significant effect at a ninety-nine percent confidence interval. Log GDP has a negative and significant effect at the ninety-five percent confidence interval. All of the remaining control variables have positive and significant effects except for polity.

Table 5.5.2 describes the FGLS results of the second set mentioned above. The same six models included in the first set are also present here. Across the full temporal range, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval and the aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. All of the control variables except for polity and log GDP have positive and significant effects on the dependent variable.

**Table 5.5.2 : Feasible Generalized Least Squares Regression, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .315*** | .282*** | .405*** | .59*** | .533*** | .67*** |
| | (.012) | (.006) | (.029) | (.04) | (.046) | (.034) |
| Total Ratifications | -.025** | -.01 | -.019** | .013 | -.088** | -.013 |
| | (.012) | (.013) | (.009) | (.013) | (.036) | (.012) |
| Polity IV | .001 | .001 | .003 | .005 | 0 | .003 |
| | (.004) | (.002) | (.003) | (.004) | (.015) | (.006) |
| Log GDP | -.002 | -.001 | .002 | -.002 | .008 | -.011* |
| | (.005) | (.003) | (.003) | (.006) | (.015) | (.006) |
| Material Capabilities | 19.649*** | 16.247*** | 22.532*** | 27.913*** | 5.762 | 17.827*** |
| | (2.125) | (2.087) | (2.253) | (2.62) | (6.668) | (2.081) |
| Alliances | .035*** | .003 | -.032*** | -.023* | .015 | .018*** |
| | (.005) | (.01) | (.01) | (.012) | (.016) | (.005) |
| Military Expenditures | .00003*** | .00001*** | -.00001*** | 0*** | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .038** | -.004 | .011 | .027 | .063 | .045** |
| | (.018) | (.012) | (.012) | (.017) | (.056) | (.02) |
| Constant | -.203*** | -.023 | .038 | -.081 | -.086 | -.152* |
| | (.064) | (.042) | (.046) | (.072) | (.204) | (.084) |
| Observations | 5343 | 1295 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

From the launch of Sputnik to the end of détente, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval and the aggregation of all international space treaty ratifications has a negative and insignificant effect on the dependent variable. Material capabilities and military expenditures have positive and significant effects at a ninety-nine percent confidence interval.

During the "second" Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval and the aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. Material capabilities positive and significant effects on the dependent variable at ninety-nine percent confidence intervals. Alliances and military expenditures have negative and significant effects at a ninety-nine percent confidence interval.

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval, and the aggregation of all international space treaty ratifications has a positive and insignificant effect on the dependent variable. Material capabilities and military expenditures have positive and significant effects at a ninety-nine percent confidence interval while alliances have a negative and significant effect at a ninety percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval, and the aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. Military expenditures have positive and significant effects at a ninety-nine percent confidence interval.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval, and the aggregation of all international space treaty ratifications has a negative and insignificant effect on the dependent variable. Log GDP has a negative and significant effect at a ninety percent confidence interval. Material capabilities, alliances, military expenditures, and other spatial domain treaties have positive and significant effects on the dependent variable.

Table 5.5.3 describes the FGLS results of the third set mentioned above. The same six models included in the first and second sets are also present here. Across the full temporal range, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the core ISTS treaties have negative effects on the dependent variable except for the Liability Convention, but none of these effects are statistically significant. Material capabilities, alliances, and military expenditures have positive and significant effects on the dependent variable.

**Table 5.5.3: Feasible Generalized Least Squares Regression, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .593*** | .298*** | .409*** | .602*** | .536*** | .675*** |
| | (.027) | (.051) | (.028) | (.04) | (.046) | (.035) |
| OST67 | -.094 | -.075* | -.058 | -.126* | -.161 | -.051 |
| | (.091) | (.039) | (.045) | (.069) | (.228) | (.083) |
| ARRA68 | -.05 | -.039 | -.047 | -.031 | -.115 | -.026 |
| | (.095) | (.038) | (.045) | (.073) | (.249) | (.087) |
| LIAB72 | .023 | .035 | -.011 | .063 | -.117 | .092 |
| | (.091) | (.035) | (.041) | (.068) | (.237) | (.084) |
| REG75 | -.026 | -.011 | .011 | .261*** | -.335 | .069 |
| | (.11) | (.052) | (.057) | (.092) | (.28) | (.094) |
| MOON79 | -.019 | | .087 | -.191 | .439 | -.192 |
| | (.145) | | (.093) | (.117) | (.37) | (.118) |
| Polity IV | .005 | .001 | .003 | .006 | -.001 | .001 |
| | (.006) | (.002) | (.003) | (.004) | (.015) | (.006) |
| Log GDP | -.001 | -.002 | .002 | -.001 | .006 | -.01* |
| | (.006) | (.003) | (.003) | (.006) | (.015) | (.006) |
| Material Capabilities | 24.894*** | 33.868*** | 22.72*** | 26.272*** | 9.024 | 17.183*** |
| | (2.698) | (2.128) | (2.294) | (2.765) | (6.958) | (2.155) |
| Alliances | .011* | -.019** | -.038*** | -.026** | .013 | .016*** |
| | (.006) | (.009) | (.01) | (.012) | (.016) | (.005) |
| Military Expenditures | .00004*** | -.00001** | .00001*** | -.00001*** | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .036 | .009 | .009 | .036** | .037 | .035* |
| | (.022) | (.01) | (.011) | (.016) | (.054) | (.02) |
| Constant | -.167** | -.013 | .044 | -.025 | -.174 | -.167** |
| | (.084) | (.037) | (.046) | (.071) | (.206) | (.084) |
| Observations | 4141 | 93 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

From the launch of Sputnik to the end of détente, Military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Among the ISTS treaties, only the OST has negative and significant effects on the dependent variable at a ninety percent confidence interval. Only the Liability Convention has a positive effect and the

Moon Treaty is omitted due to the year of its inception. Material capabilities have positive and significant effects on the dependent variable at a ninety-nine percent confidence interval. Alliances and military expenditures have negative and significant effects on the dependent variable at a ninety-five percent confidence interval.

During the “second” Cold War, military payloads have a postive and significant effect on the dependent variable at a ninety-nine percent confidence interval. None of the ISTS treaties have significant effects on the dependent variable. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety-nine percent confidence intervals. Alliances have negative and significant effects on the dependent variable at a ninety-nine percent confidence interval.

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The OST has a negative and significant effect on the dependent variable at a ninety percent confidence interval, and the Registration Convention has a positive and significant effect at a ninety-nine percent confidence interval. Alliances and military expenditures have negative and significant effects on the dependent variable at ninety-five percent and ninety-nine percent confidence intervals, respectively. Material capabilities have positive and significant effects on the dependent variable at a ninety-nine percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the core ISTS treaties have negative effects on the dependent variable except for the Moon Treaty, but none of these effects are statistically significant. Military expenditures have positive and significant effects at a ninety-nine percent confidence interval.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the core ISTS treaties have negative effects on the dependent variable except for the Liability Convention and the Registration Convention, but none of these effects are statistically significant. Material capabilities, alliances, military expenditures, and other spatial domain treaties have positive and significant effects on the dependent variable.

*Generalized Least Squares Regressions with Huber-White Estimators*

This section is structured in the same manner as the previous section: three sets of models are presented that reflect different operationalizations of international space treaty subscription status. The same six time periods are included in the first two sets of models. In the third set, the sandwich estimator of variance constrains the regression of the second model due to insufficient observations. As a result, the first two temporal ranges are conjoined in to one range spanning from 1957 to 1986.

Table 5.5.4 describes the results for the first set of models of the GLS regression with Huber-White sandwich estimators. Across the full temporal range, military payloads have a positive effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a negative effect on the dependent variable, but only the regional agreement grouping is statistically significant at a ninety percent confidence interval. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety percent and ninety-nine percent confidence intervals, respectively.

**Table 5.5.4: Generalized Least Squares Regression with Huber-White sandwich estimators, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .48*** | .175*** | .403*** | .623*** | .529*** | .382*** |
| | (.113) | (.044) | (.034) | (.144) | (.125) | (.064) |
| ISTS Ratifications | -.009 | -.028 | -.017 | 0 | -.06 | .019 |
| | (.021) | (.019) | (.015) | (.017) | (.047) | (.028) |
| GA Ratifications | .003 | -.043 | -.01 | .019 | -.021 | -.004 |
| | (.02) | (.036) | (.024) | (.03) | (.07) | (.024) |
| RA Ratifications | -.098* | -.055 | -.041 | .041 | -.25** | -.129 |
| | (.054) | (.062) | (.029) | (.043) | (.119) | (.091) |
| Polity IV | .003 | .001 | .003 | .005 | -.001 | .002 |
| | (.004) | (.003) | (.002) | (.004) | (.006) | (.006) |
| Log GDP | -.001 | -.001 | .002 | -.002 | .008 | -.011* |
| | (.002) | (.002) | (.002) | (.004) | (.007) | (.006) |
| Material Capabilities | 19.294* | 26.104** | 22.154** | 28.465*** | 2.138 | 21.028* |
| | (11.207) | (12.711) | (9.253) | (10.954) | (8.196) | (11.511) |
| Alliances | .028 | .004 | -.031* | -.026 | .029 | .039 |
| | (.029) | (.024) | (.017) | (.032) | (.045) | (.037) |
| Military Expenditures | .00004*** | .00003*** | .00001*** | -.00001 | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .038 | -.007 | .01 | .026 | .062 | .058 |
| | (.026) | (.012) | (.01) | (.022) | (.045) | (.044) |
| Constant | -.22 | .012 | .028 | -.078 | -.221 | -.312 |
| | (.145) | (.041) | (.035) | (.049) | (.258) | (.28) |
| Observations | 4827 | 779 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

From the launch of Sputnik to the end of détente, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a negative and insignificant effect on the dependent variable. Material capabilities and military expenditures have positive and significant effects at ninety-five and ninety-nine percent confidence intervals, respectively.

During the "second" Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a negative effect on the dependent variable, but none of them are statistically significant. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety-five percent and ninety-nine percent confidence intervals, respectively. Alliances have negative and significant effects at a ninety percent confidence interval.

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a positive effect on the dependent variable, but none of them are statistically significant. Material capabilities have positive and significant effects on the dependent variable at a ninety-nine percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. Each grouping of international space treaty ratifications has a negative effect on the dependent variable, but only regional agreements are significant at a ninety-five percent confidence interval. Military expenditures have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The ISTS agreement grouping has a positive but insignificant effect on the dependent variable. The global and regional agreement groupings have negative but insignificant effects on the dependent variable. Log GDP has a negative and significant effect at a ninety percent confidence interval. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety percent and ninety-nine percent confidence intervals, respectively.

Table 5.5.5 describes the results for the second set of models of the GLS regression with Huber-White sandwich estimators. Across the full temporal range, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety percent and ninety-nine percent confidence intervals, respectively.

**Table 5.5.5: Generalized Least Squares Regression with Huber-White sandwich estimator, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .315*** | .282*** | .405*** | .619*** | .533*** | .385*** |
| | (.082) | (.015) | (.034) | (.144) | (.124) | (.066) |
| Total Ratifications | -.025** | -.01 | -.019** | .016 | -.088*** | -.02* |
| | (.01) | (.007) | (.009) | (.016) | (.026) | (.012) |
| Polity IV | .001 | .001 | .003 | .005 | 0 | .003 |
| | (.005) | (.002) | (.002) | (.004) | (.006) | (.005) |
| Log GDP | -.002 | -.001 | .002 | -.002 | .008 | -.01* |
| | (.002) | (.001) | (.002) | (.004) | (.007) | (.005) |
| Material Capabilities | 19.649* | 16.247** | 22.532** | 27.56** | 5.762 | 23.317** |
| | (11.537) | (7.883) | (9.287) | (11.157) | (7.646) | (11.225) |
| Alliances | .035 | .003 | -.032** | -.023 | .015 | .032 |
| | (.037) | (.018) | (.016) | (.033) | (.04) | (.033) |
| Military Expenditures | .00005*** | .00003*** | .00001*** | -.00001 | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .038 | -.004 | .011 | .026 | .063 | .053 |
| | (.029) | (.01) | (.011) | (.023) | (.045) | (.042) |
| Constant | -.203 | -.023 | .038 | -.088 | -.086 | -.232 |
| | (.148) | (.025) | (.035) | (.057) | (.214) | (.22) |
| Observations | 5343 | 1295 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

From the launch of Sputnik to the end of détente, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The aggregation of all international space treaty ratifications has a negative and insignificant effect on the dependent variable. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety-five percent and ninety-nine percent confidence intervals, respectively.

During the “second” Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent. The aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety-five percent and ninety-nine percent confidence intervals, respectively. Alliances have a negative and significant effect on the dependent variable at a ninety-five percent confidence interval.

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The aggregation of all international space treaty ratifications has a positive and insignificant effect on the dependent variable. Material capabilities have a positive and significant effect on the dependent variable at a ninety-five percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The aggregation of all international space treaty ratifications has a negative and significant effect on the dependent variable at a ninety-nine percent confidence interval. Military expenditures have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The aggregation of all international space treaty ratifications has a negative and significant effect at a ninety percent confidence interval. Military expenditures and material capabilities have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval and ninety-five percent confidence interval, respectively. Log GDP has a negative and significant effect at a ninety percent confidence interval.

Table 5.5.6 describes the results for the third set of models of the GLS regression with Huber-White sandwich estimators. Across the full temporal range, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the ISTS treaties have negative effects on the dependent variable except for the Liability Convention. Among the treaties with negative effects, only the OST is statistically significant at a ninety-five percent confidence interval. Material capabilities and military expenditures have positive and significant effects on the dependent variable at ninety percent and ninety-nine percent confidence intervals, respectively.

From the launch of Sputnik to the end of the "second" Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The Outer Space Treaty, Rescue Agreement, and Registration Convention have negative and insignificant effects on the dependent variable. The Liability Convention and the Moon Treaty have positive and insignificant effects on the dependent variable. Material capabilities and military expenditures have a positive and significant effect on the dependent variable at a ninety-five percent confidence interval and ninety-nine percent confidence interval, respectively. Alliances have a negative and significant effect on the dependent variable at a ninety-five percent confidence interval.

**Table 5.5.6: Generalized Least Squares Regression with Huber-White sandwich estimator, Effects on Non-Military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1986 | (3)<br>1987-1991 | (4)<br>1992-2000 | (5)<br>2001-2019 |
|---|---|---|---|---|---|
| Military Payloads | .593*** | .365*** | .637*** | .536*** | .388*** |
| | (.045) | (.038) | (.127) | (.126) | (.063) |
| OST67 | -.094** | -.067 | -.124** | -.161 | -.041 |
| | (.046) | (.044) | (.054) | (.098) | (.059) |
| ARRA68 | -.05 | -.043 | -.029 | -.115 | -.002 |
| | (.067) | (.049) | (.062) | (.152) | (.078) |
| LIAB72 | .023 | -.006 | .065* | -.117 | .116 |
| | (.051) | (.032) | (.04) | (.11) | (.089) |
| REG75 | -.026 | .005 | .275* | -.335 | -.052 |
| | (.141) | (.07) | (.146) | (.232) | (.167) |
| MOON79 | -.019 | .098 | -.202 | .439* | -.187 |
| | (.127) | (.069) | (.143) | (.243) | (.138) |
| Polity IV | .005 | .003 | .006 | -.001 | .001 |
| | (.005) | (.002) | (.004) | (.006) | (.005) |
| Log GDP | -.001 | .001 | -.001 | .006 | -.01* |
| | (.002) | (.002) | (.003) | (.007) | (.005) |
| Material Capabilities | 24.894* | 20.046** | 25.695** | 9.024 | 22.902** |
| | (15.059) | (9.816) | (10.569) | (8.294) | (11.318) |
| Alliances | .011 | -.045** | -.026 | .013 | .031 |
| | (.026) | (.019) | (.035) | (.043) | (.035) |
| Military Expenditures | .00003*** | .00002*** | -.00001* | .0001*** | .00003*** |
| | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .036 | .01 | .037 | .037 | .039 |
| | (.027) | (.011) | (.024) | (.048) | (.038) |
| Constant | -.167 | .061 | -.028 | -.174 | -.272 |
| | (.141) | (.039) | (.047) | (.206) | (.228) |
| Observations | 4141 | 771 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

During the waning years of the Cold War, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. The OST has a negative and significant effect on the dependent variable at a ninety-five percent confidence interval. The Liability Convention and the Registration Convention have positive and significant effects on the dependent variable at ninety percent confidence intervals. Material capabilities have positive and significant effects at a ninety-five percent confidence interval, and military expenditures have negative and significant effects at a ninety percent confidence interval.

From the end of the Cold War to the turn of the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the ISTS treaties have negative effects on the dependent variable except for the Moon Treaty, which has positive and significant effects at a ninety percent confidence interval. Military expenditures have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval.

During the twenty-first century, military payloads have a positive and significant effect on the dependent variable at a ninety-nine percent confidence interval. All the ISTS treaties have negative effects on the dependent variable except for the Liability Convention. Military expenditures and material capabilities have positive and significant effects on the dependent variable at a ninety-nine percent confidence interval and ninety-five percent confidence interval, respectively. Log GDP has a negative and significant effect at a ninety percent confidence interval.

### 5.6. Conclusion

In this chapter, I provide the descriptive statistics and regression results germane to the analytical project of the dissertation. The first section describes the panel data. The second section describes the typologies of spacefarers, space powers, and space cooperators. The third section describes the orbital launch data. The fourth section describes the orbital payload data. The fifth section describes the regression results. Concerning to the regression results specifically, I describe the findings objectively and without interpretation or comment. The following and final concluding chapter is dedicated to the task of interpreting the results as they relate to the theories that ground the research project.

CHAPTER 6

# DISCUSSION AND CONCLUSION

## 6.1. Recapitulation

The purpose of this dissertation is to analyze the extent to which traditional theories of international relations accurately account for the security status of the space domain. I introduce the project by discussing the pragmatic and political significance of space by appealing to both the dual-use character of space technologies and the geospatial character of the domain as a global common. Dual-use technology is often a source of interstate competition because, due to the military component, major world powers have an incentive to suppress its diffusion in order to mitigate the effects of international uncertainty, especially between rivals. Such competition often takes place among the global commons, which is problematic because they represent non-sovereign domains where the international interest of freedom of navigation intersects with national security interests. Relative to the other global commons, this issue is most salient in the space domain because the utility of weapons there have become uniquely controversial. Support for the view that the commons ought to be a sanctuary from weapons is neither as mobilized nor as profound regarding the high seas or international airspace.

I provide a brief history of the early space race in order to not only demonstrate the overlap between technology races and the global commons but also contextualize why the space security debate became so polarized. The rivalrous character of the Cold War gave rise to an intense interstate competition as well as a cooperative security apparatus. The space race is viewed as an appendage of the nuclear arms race between the United States and the Soviet Union, each of whom viewed the rocket as an effective vehicle to deploy a nuclear warhead and space itself as a geostrategic arena to be exploited. As competition escalated and the nuclear utility of space became more apparent, both anxieties over an uncertain future and the need for cooperation grew more profound. The result was the Outer Space Treaty of 1967 which prohibited the placement of nuclear weapons in space but did not explicitly prohibit the weaponization of space. This, coupled with the existing view that the common heritage thesis implied peaceful purposes, further entrenched military and policy officials in the debate concerning the politics of space security.

In Chapter 2, I provide a general overview of the literature pertaining to four important subjects: political history, international law, international cooperation, and militarization. I go on to provide a more in-depth review of the space security literature by focusing on the traditional schools of thought articulated by David Lupton and the political psychology perspectives expressed by Peter Hays and Karl Mueller. These are essentially discussions of three typologies that characterize the scope of national space intentions and their attendant behaviors. Each typology situates the groups within them on a spectrum of space security perspectives between heightened militarism and relative pacificism. As a result, and with noted precedent, I conflate these space security perspectives into two core camps: space statists and space internationalists. Space statists embody the schools of thought that align with the realist tradition: the high-ground doctrine and the control doctrine. Space internationalists embody the school of thought that aligns with the liberal tradition: the sanctuary doctrine.

In Chapter 3, I describe the philosophical associations that bridge the gap between traditional theories of International Relations and their analogs in the space security debate. I focus on how the space security debate mirrors the inter-paradigm debate among IR scholars in the 1970s and 1980s and how the political climate of the Cold War affected each. I then go on to discuss the ontological and epistemological assumptions that differentiate how promulgators of each position engage with space as a political environment. One function of this chapter is to relate the debates so closely that the positions of space statism and space internationalism virtually represent neorealist and neoliberal astropolitics, respectively.

The other function of this chapter is to provide the theoretical foundations for the research design established in the following chapter. I define space security as a mitigated state of external impediments to the freedom of navigation and access, and I conceptualize it as the frequency of non-military payloads placed in orbit every year. I then manufacture hypotheses for the opposing theories in which militarization and cooperation are posited as positive influences on security, respectively. I conceptualize the neorealist explanatory variable as the number of military payloads placed into orbit every year, and I conceptualize the neoliberal explanatory variable as the number of ratified international space treaties every year.

In Chapter 4, I describe the three central features of this dissertation's analytical project: the data collection process, the research design, and the methodology. The data collection process involved three phases: the cataloging of orbital launches and orbital payloads by year along with their intrinsic characteristics, the transposition of that data into a longitudinal database that comprises the entire international system, and the addition of data pertaining to the ratification of international space-related treaties. The research design accounts for the operationalization of three sets of variables analyzed in the estimator models: the dependent variable, the two independent variables, and the alternative explanatory (or control) variables. The methodology section describes the structure of the panel data, the process of testing for individual specific effects, and the decision-making process for choosing appropriate estimator models due to the individual specific effects tests.

In Chapter 5, I describe the data across four sections: the cross-sectional and time-series components of the panel data, the three typologies constructed around material capabilities and cooperative tendencies, the orbital launch data, and the orbital payload data. The final section of the chapter is dedicated to describing the regression results of the FGLS and GLS estimator models which are interpreted below.

## 6.2. Discussion of Results

The three sets of models for both the FGLS and GLS estimator types are structured according to different articulations of the neoliberal explanatory variable. The first set breaks down international space treaty subscription to total ratifications across three groups of agreements: the core ISTS, other global space agreements, and regional space agreements. The second set involves a solitary variable for all space treaty ratifications. The third set includes total ratifications for each of the core ISTS agreements. The results support the neorealist hypothesis that military activities have positive effects on the security status of the space domain. The results do not support the neoliberal hypothesis that international space treaty subscriptions have positive effects on the security status of the space domain.

### *Neorealism and the Effects of Military Orbital Payloads*

The results strongly support for the neorealist hypothesis in both sets of regressions. In all three FGLS sets, military payloads have positive and statistically significant effects on the dependent variable across the full temporal range and all time periods within it. The results are the same for the three GLS sets with Huber-White sandwich estimators. Military payloads have positive and statistically significant effects on the dependent variable across the full temporal range in all three sets, as well as the individual time periods within it.

*Neoliberal Institutionalism and the Effects of International Space Treaty Ratifications*

The results do not support the neoliberal hypothesis in either the FGLS or GLS regressions. In the first FGLS set, two of the three ratification groups have negative effects on the dependent variable across the full temporal range, and among them only the regional agreement group is statistically significant. Across the five temporal intervals within the full range, each treaty grouping has largely negative effects on the dependent variable. The ISTS and global ratifications are never statistically significant. The influence of regional ratifications is statistically significant during the post-Cold War era leading up to the turn of the century and the first two decades of the twenty-first century.

In the second FGLS set, total space treaty ratifications have negative effects on the dependent variable across the full temporal range and are statistically significant. The aggregation of ratifications is negative associated with the dependent variable in all time periods except the waning years of the Cold War. They are significant only during the “second” Cold War and the turn of the century.

In the third FGLS set, only the Registration Convention during the waning years of the Cold War corroborates the neoliberal perspective. Most of the ISTS treaty ratifications have negative and insignificant effects on the dependent variable. The OST has negative and significant effects during détente and the waning years of the Cold War. None of the other treaties have significant effects.

The results are similar in the GLS regressions with Huber-White sandwich estimators. In the first GLS set, none of the ratification groupings corroborate the neoliberal perspective.

Across the full temporal range, only regional agreements have significant effects, but they are negative. Across the individual time periods, the influence of regional ratifications is only statistically significant during the turn of the century.

In the second GLS set, total space treaty ratifications have negative effects on the dependent variable across the full temporal range and are statistically significant. Total ratifications have negative effects on the dependent variable in every time period except for the waning years of the Cold War and are statistically significant during the "second" Cold War, the turn of the century, and the first two decades of the twenty-first century.

In the third GLS set, there is no corroboration of the neoliberal perspective across the full temporal range. In fact, the OST has negative and significant effects on the dependent variable. Among the individual time periods, the neoliberal perspective is only corroborated three times. The Liability Convention and the Registration Convention have positive and significant effects during the waning years of the Cold War, and the Moon Treaty has positive and significant effects during the turn of the century.

*Significance of the Results*

The results of this dissertation's analytical project are somewhat surprising considering the long-standing conformity to the sanctuary thesis throughout the history of the space race. That the presence of military payloads have such profound positive effects on space security in every individual time period is fascinating, especially when juxtaposed with the negative effects associated with major space treaty ratifications. One of the major implications of the study is that perhaps regime membership and treaty subscription play a more diminished role in the securitization of the space domain than previously thought. Alternatively, another major implication is that perhaps military assets in space play a more diminished role in the destabilization of the space domain than previously thought.

*Marginal Effects*

I examined the marginal effects of polity and region across each set of models. Polity is determined based on the previously operationalized Polity IV condensed score. Regions are dichotomously coded across eight variables: South Asia, Europe and Central Asia, Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific, North America, and International. The first seven regions are codified based on common World Bank distinctions, and the final "international" category is added due to the database's preexisting political actor group. Polity has no statistically significant marginal effects, and each region has negative and statistically significant marginal effects at a ninety-nine percent confidence interval. North America and International regions were omitted due to collinearity.

*Lagging Variables*

I ran additional regressions with lagged military payload variables for three and five years because it may accommodate the time-intensive nature of asset manufacturing and launch window viability. When lagging for three years, military payloads still have positive and significant effects on the dependent variable across the full temporal range in both sets of models. In the FGLS models, regional agreement ratifications have negative and significant effects, total ratifications have negative and significant effects, and none of the core ISTS treaty ratifications have significant effects. The same true for the GLS models except for the core ISTS treaties. The OST has negative and significant effects on the dependent variable.

When lagging for five years, military payloads still have positive and significant effects on the dependent variable across the full temporal range in both sets of models. In the FGLS models, regional agreement ratifications have negative and significant effects, total ratifications have negative and significant effects, and none of the core ISTS treaty ratifications have significant effects. The same true for the GLS models except for the core ISTS treaties. The OST has negative and significant effects on the dependent variable. Ultimately, lagging the first key independent variable scarcely changed the results of the analyses.

*Alternative Methodology*

While the TSCS GLS regressions are certainly permissible for both static and dynamic panel count variables, negative binomial regressions are also commonly associated with count variables and were thereby also implemented in subsequent analyses.[213] Negative binomial regressions are often used when count variables are overdispersed, meaning that the variation is exponentially greater than the mean. Table 6.2.1 describes the negative binomial regression involving the three treaty ratification groupings. Across the full temporal range, ISTS and global agreement ratifications have positive and significant effects on the dependent variable which primarily occur during the turn of the century and the first two decades of the twenty-first century. Regional agreement ratifications are never statistically significant. Military payloads have positive and insignificant effects across the full temporal range but are significant during the waning years of the Cold War.

---

[213] Adrian Colin Cameron and Pravin K. Trivedi, "Count Panel Data," *Paper Prepared for Badi H. Baltagi Ed., Oxford Handbook of Panel Data Econometrics*, 2013, 6, https://pdfs.semanticscholar.org/b8f5/d0d74c7d8846066fe0e9f9a516b15dae6ad3.pdf.

**Table 6.2.1: Negative Binomial Random Effects Regression, Effects on Non-military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .012 | -.021 | .027 | .078** | .016 | .001 |
| | (.008) | (.016) | (.032) | (.033) | (.012) | (.012) |
| ISTS Ratifications | .114* | -.125 | .193 | .252 | .516*** | .557*** |
| | (.06) | (.16) | (.142) | (.181) | (.165) | (.114) |
| GA Ratifications | .618*** | -.103 | .247 | .407 | .481*** | .443** |
| | (.08) | (.299) | (.38) | (.262) | (.139) | (.187) |
| RA Ratifications | -.025 | -17.561 | .31 | .012 | -.026 | .081 |
| | (.087) | (13631.978) | (.3) | (.17) | (.185) | (.168) |
| Polity IV | .017 | .126** | .083* | .191*** | .028 | -.021 |
| | (.015) | (.052) | (.044) | (.071) | (.032) | (.025) |
| Log GDP | -.022** | -.019 | .023 | .029 | .008 | -.046*** |
| | (.01) | (.036) | (.042) | (.052) | (.018) | (.012) |
| Material Capabilities | 10.139*** | 40.61*** | 69.639*** | 55.381*** | 43.763*** | 16.245*** |
| | (2.489) | (14.542) | (17.769) | (9.331) | (13.589) | (3.646) |
| Alliances | .017* | .086 | -.13 | .055 | .026 | .038** |
| | (.01) | (.101) | (.124) | (.083) | (.029) | (.017) |
| Military Expenditures | 0 | 0 | 0 | -.00002*** | -.00002*** | 0* |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .061 | .069 | -.086 | .293** | .013 | 0 |
| | (.068) | (.187) | (.196) | (.138) | (.114) | (.1) |
| Constant | -1.944*** | -1.716 | -2.748** | -6.464*** | -2.432*** | -2.707*** |
| | (.321) | (1.117) | (1.168) | (1.207) | (.607) | (.65) |
| Constant (ln_r) | .987*** | 1.479** | 1.923** | 17.349 | 1.449*** | 1.611*** |
| | (.238) | (.744) | (.822) | (0) | (.348) | (.332) |
| Constant (ln_s) | -1.718*** | -1.236* | -.031 | 16.37*** | -1.341*** | -.791*** |
| | (.2) | (.681) | (.976) | (.674) | (.282) | (.25) |
| Observations | 4827 | 779 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

Table 6.2.2 describes the negative binomial regression involving the aggregation of all space treaty ratifications. Across the full temporal range, both military payloads and treaty ratifications have positive and significant effects on the dependent variable at ninety and ninety-nine percent confidence intervals, respectively. Again, military payloads are primary significant during the waning years of the Cold War while total ratifications are significant from 1980 onward.

**Table 6.2.2: Negative Binomial Random Effects Regression, Effects on Non-military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .009* | .005 | .026 | .078** | .018 | 0 |
| | (.005) | (.007) | (.032) | (.034) | (.012) | (.012) |
| Total Ratifications | .227*** | .043 | .221* | .177* | .36*** | .428*** |
| | (.028) | (.087) | (.119) | (.094) | (.079) | (.078) |
| Polity IV | .019 | .105** | .083* | .195*** | .033 | -.017 |
| | (.014) | (.05) | (.044) | (.072) | (.031) | (.025) |
| Log GDP | -.017* | -.017 | .024 | .03 | .013 | -.046*** |
| | (.009) | (.03) | (.042) | (.053) | (.018) | (.012) |
| Material Capabilities | 8.805*** | 14.435** | 67.463*** | 61.098*** | 46.126*** | 18.454*** |
| | (2.199) | (6.119) | (16.122) | (7.698) | (13.224) | (3.413) |
| Alliances | -.001 | -.012 | -.118 | .011 | -.001 | .022 |
| | (.009) | (.062) | (.121) | (.077) | (.027) | (.016) |
| Military Expenditures | 0 | 0 | 0 | -.00002*** | -.00002*** | 0** |
| | (0) | (0) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .201*** | .342* | -.064 | .314** | .071 | .002 |
| | (.061) | (.207) | (.171) | (.138) | (.106) | (.098) |
| Constant | -1.992*** | -1.326 | -2.811** | -5.943*** | -2.267*** | -2.431*** |
| | (.271) | (.958) | (1.095) | (1.078) | (.581) | (.594) |
| Constant (ln_r) | .932*** | 1.289* | 1.939** | 19.607 | 1.344*** | 1.549*** |
| | (.232) | (.66) | (.824) | (0) | (.315) | (.329) |
| Constant (ln_s) | -1.662*** | -2.346*** | -.013 | 18.678*** | -1.372*** | -.963*** |
| | (.198) | (.529) | (.987) | (.663) | (.278) | (.233) |
| Observations | 5343 | 1295 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

Table 6.2.3 describes the negative binomial regression involving the core ISTS treaties. Across the full temporal range, only the Liability Convention has positive and significant effects on the dependent variable at a ninety-nine percent confidence interval. Again, military payloads are positive and significant during the waning years of the Cold War. The OST is negative and significant during that time but positive and significant during the twenty-first century. The Registration Convention is positive and significant during the waning years of the Cold War.

**Table 6.2.3: Negative Binomial Random Effects Regression, Effects on Non-military Payloads**

| | (1)<br>1957-2019 | (2)<br>1957-1979 | (3)<br>1980-1986 | (4)<br>1987-1991 | (5)<br>1992-2000 | (6)<br>2001-2019 |
|---|---|---|---|---|---|---|
| Military Payloads | .009 | -6.583 | .036 | .074** | .006 | .003 |
| | (.008) | (121.684) | (.032) | (.032) | (.011) | (.011) |
| OST67 | .225 | -6.17 | -.507 | -2.701*** | .423 | 1.385*** |
| | (.3) | (213.209) | (.667) | (.979) | (.593) | (.454) |
| ARRA68 | -.247 | 1.357 | .113 | .766 | -.321 | .553 |
| | (.286) | (261.219) | (.71) | (.68) | (.598) | (.41) |
| LIAB72 | 1.276*** | 1.29 | .635 | 1.725* | 1.831*** | 1.188*** |
| | (.322) | (244.784) | (.709) | (.928) | (.532) | (.402) |
| REG75 | .21 | 3.897 | .039 | 1.363** | .585 | .415 |
| | (.223) | (333.861) | (.624) | (.668) | (.538) | (.331) |
| MOON79 | .427 | | .903 | -.317 | .027 | -.729 |
| | (.386) | | (1) | (.529) | (.828) | (.472) |
| Polity IV | .009 | .038 | .099** | .199*** | .037 | -.032 |
| | (.016) | (17.09) | (.046) | (.064) | (.034) | (.026) |
| Log GDP | -.026*** | .123 | .011 | .02 | .008 | -.045*** |
| | (.009) | (14.938) | (.043) | (.051) | (.017) | (.012) |
| Material Capabilities | 2.247 | 282.176 | 78.518*** | 48.606*** | 46.655*** | 13.184*** |
| | (2.543) | (4568.068) | (24.397) | (8.694) | (14.917) | (3.705) |
| Alliances | .026*** | -1.127 | -.058 | .053 | .02 | .036** |
| | (.009) | (39.356) | (.12) | (.062) | (.027) | (.016) |
| Military Expenditures | 0 | .001 | 0 | -.00002*** | -.00002*** | 0* |
| | (0) | (.015) | (0) | (0) | (0) | (0) |
| OSD Ratifications | .328*** | .77 | -.011 | .394*** | .209** | .073 |
| | (.063) | (47.639) | (.185) | (.122) | (.105) | (.092) |
| Constant | -2.245*** | -11.174 | -2.153* | -5.384*** | -2.471*** | -2.266*** |
| | (.401) | (305.64) | (1.132) | (1.325) | (.63) | (.594) |
| Constant (ln_r) | .877*** | 12.464 | 1.695** | 17.76 | 1.12*** | 1.763*** |
| | (.229) | (17.452) | (.771) | (686.416) | (.303) | (.38) |
| Constant (ln_s) | -1.586*** | 6.705 | -.579 | 16.561 | -1.414*** | -.711*** |
| | (.21) | (12.285) | (.62) | (686.417) | (.274) | (.26) |
| Observations | 4141 | 93 | 678 | 519 | 1168 | 1683 |

*Standard errors are in parentheses*
**** p<.01, ** p<.05, * p<.1*

Ultimately, the negative binomial regression models lend more support for the neoliberal perspective than the previous two regression sets without completely subverting the findings that support the neorealist perspective.

## 6.3. Significance

This dissertation contributes to the study of international relations in space in four principal ways. First, it builds upon preexisting philosophical and qualitative scholarship that attempts to understand the politics of space security through the application of traditional IR theories to the space domain. This involves two central elements: first, an exegesis of the extant literature to deconstruct the space security debate in a manner that facilitates a relation to the broader IR inter-paradigm debate; and second, the conceptualization of space security in a manner that facilitates its operationalization for quantitative statistical analysis.

Second, the quantitative analyses conducted in this dissertation provide a rare addition to the scope of scientific inquiry concerning the politics of space security. The philosophical and qualitative works on the topic are valuable, and I contend that statistical analyses can supplement or strengthen existing scholarship. Third, this project required the construction of a database that provides extensive information that may prove instrumental for current and future research. The database offers detailed accounts of orbital launch behavior, orbital payloads, and space treaty subscriptions. It is also ripe for expansion in order to cater to future pursuits of empirical investigations.

Finally, the fourth contribution pertains to a byproduct of the data collection process: the establishment of three new typologies. Cataloging both material space capabilities and international space treaty subscriptions allowed me to construct new typologies of political actors that can be used to break down various space activities by relevant subpopulations. The typologies of spacefarers, space powers, and space cooperators depart from the tradition of constructing space-related typologies based on doctrinal preferences or states of political psychology.

### 6.4. Future Research

This dissertation paves the way for future research that not only represents an extension of the present work but also other projects that are indirectly related. Since the focus of this project is to apply the assumptions of traditional IR theories to the space security environment, one potential avenue of future research is to expand the scope by including an additional theory. I have already begun a new data collection project that will allow me to operationalize variables associated with social constructivist theory and perform new analyses. The project focuses on the policy convergence literature and explores the extent to which norm internalization by way of cross-policy harmonization may affect behavior. Studying policy harmonization requires an inclusion of national space policy data to the international space policy data that I already possess. The project also requires a content analysis component to examine the consonance of language between national space policies and international space treaties ratified by those political actors with published national policies. The core idea to this facet of broader social constructivist thought is that a high level of language consonance between national and international policies may reflect costly signals of reassurance. The signals may, in turn, have effects on international relations in space.

The data collection process for national space policies also provides an opportunity to explore comparative relationships between and among spacefaring political actors. While the project mentioned above focuses on systemic language consonance between an actor's national policy and the international policy to which it subscribes, this project could focus on dyadic language consonance between the national space policy of one actor and another. The major space powers classified in my space power typology would be of particular interest if such a project were pursued. For example, comparisons could be made between multiple dyads including the United States, Russia, China, and the European Union. I would also need to account for a temporal element, as these political actors have published multiple national space policies over recent decades.

Other opportunities are indirectly associated with the dissertation's specific research agenda. The data collection process provided a bounty of valuable observations that can utilized for other projects. A formal articulation of the typologies established in this dissertation is one project that I would like to pursue immediately. Most of the recent space-related typologies classify either doctrines of space activity or political psychologies attributed to space-oriented political actors. My spacefarer typology and space power typology each classify political actors based on material space capabilities, and my space cooperator typology categorizes actors based on their subscription status to international treaty organizations. As these relationships appear to be underrepresented in the literature, I believe a project dedicated to these typologies would be valuable to the field.

The categorization of orbital launches and orbital payloads, respectively, by industrial sector is another gift of the data collection process. I believe that a project dedicated to tracking cross-industrial trends over time would have value for intellectual pursuits that are not necessarily related to the space security topic. I would be interested in examining these trends as well as investigating their relationships to each other. Furthermore, the categorization of orbital payloads by unilateral, bilateral, and multilateral structures also seems like fertile ground for future research. I am interested digging deeper into the nature of cooperative payload operations and cross reference the structures with the industrial sectors. Being able to distinguish the extent to which civilian, commercial, or military payloads are associated with bilateral or multilateral structures may prove valuable to our understanding of contemporary international relations in space.

### 6.5. Conclusion

The purpose of this dissertation is to clarify our understanding of the politics of space security by applying the assumptions of traditional IR theories to the space environment. The quantitative analyses used to ascertain the extent to which neorealist astropolitics or neoliberal astropolitics accurately account for security represents a novel and valuable addition to a growing field of literature. My enduring hope is that the continued updates to the database utilized in this dissertation will benefit future research conducted by not only myself but also others with whom I would be most grateful to work.

## REFERENCES


LII / Legal Information Institute. “15 CFR 730.3 - ‘Dual Use’ and Other Types of Items Subject to the EAR.” Accessed June 5, 2018. https://www.law.cornell.edu/cfr/text/15/730.3.

Aldrin, Andrew J. “Technology Control Regimes and the Globalization of Space Industry.” *Space Policy* 14, no. 2 (May 1998): 115–22. https://doi.org/10.1016/S0265-9646(98)00009-5.

Anson, Peter, and Dennis Cummings. “The First Space War: The Contribution of Satellites to the Gulf War.” *The RUSI Journal* 136, no. 4 (1991): 45–53.

Bardhan, Pranab K., and Isha Ray. *The Contested Commons: Conversations Between Economists and Anthropologists*. Malden, MA ; Oxford : Blackwell Pub., 2008., 2008.

Baylis, John, Steve Smith, and Patricia Owens, eds. *The Globalization of World Politics: An Introduction to International Relations*. 7 edition. Oxford, Uinted Kingdom ; New York: Oxford University Press, 2017.

Beck, Nathaniel, and Jonathan N. Katz. “What to Do (and Not to Do) with Time-Series Cross-Section Data.” *American Political Science Review* 89, no. 3 (1995): 634–647.

Bell, Andrew, Malcolm Fairbrother, and Kelvyn Jones. “Fixed and Random Effects Models: Making an Informed Choice.” *Quality & Quantity* 53, no. 2 (2019): 1051–1074.

Bell, Andrew, and Kelvyn Jones. “Explaining Fixed Effects: Random Effects Modeling of Time-Series Cross-Sectional and Panel Data.” *Political Science Research and Methods* 3, no. 1 (2015): 133–153.

Benoit, Kenneth. “Democracies Really Are More Pacific (in General) Reexamining Regime Type and War Involvement.” *Journal of Conflict Resolution* 40, no. 4 (1996): 636–657.

Billings, Linda. “Words Matter: A Call for Responsible Communication About Asteroid Impact Hazards and Plans for Planetary Defense.” *Space Policy* 33 (August 2015): 8–12. https://doi.org/10.1016/j.spacepol.2015.07.001.

Bonnet, R.-M, and Vittorio Manno. *International Cooperation in Space: The Example of the European Space Agency.: Frontiers of Space.: Frontiers of Space*. Frontiers of Space. Cambridge, Mass. : Harvard University Press, 1994., 1994.

Brennan, Donald G. “Arms and Arms Control in Outer Space.” *Outer Space: New Challenge to Law and Policy*, 1962, 120–34.

Breusch, Trevor S., and Adrian R. Pagan. “The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics.” *The Review of Economic Studies* 47, no. 1 (1980): 239–253.

Broniatowski, David André, Michel-Alexandre Cardin, Shuonan Dong, Matthew J. Hale, Nicole C. Jordan, Deanna R. Laufer, Charlotte Mathieu, Brandon D. Owens, Matthew G. Richards, and Annalisa L. Weigel. “A Framework for Evaluating International Cooperation in Space Exploration.” *Space Policy* 24, no. 4 (November 2008): 181–89. https://doi.org/10.1016/j.spacepol.2008.09.012.

Brzezinski, Matthew. *Red Moon Rising: Sputnik and the Hidden Rivalries That Ignited the Space Age*. Macmillan, 2007.

Buck, Susan J. *The Global Commons: An Introduction*. Routledge, 2017.

Burrows, William E. *This New Ocean: The Story of the First Space Age*. Modern library, 2010.

Cadbury, Deborah. *Space Race: The Epic Battle between America and the Soviet Union for Dominion of Space*. HarperCollins, 2006.

Cameron, Adrian Colin, and Pravin K. Trivedi. “Count Panel Data.” *Paper Prepared for Badi H. Baltagi Ed., Oxford Handbook of Panel Data Econometrics*, 2013. https://pdfs.semanticscholar.org/b8f5/d0d74c7d8846066fe0e9f9a516b15dae6ad3.pdf.

———. *Microeconometrics Using Stata*. Vol. 5. Stata press College Station, TX, 2009.

Caselli, Leonardo P. “Space Demilitarization Treaties in a New Era of Manned Nuclear Spaceflights.” *J. Air L. & Com.* 77 (2012): 641.

Cashin, Lina M. “Lessons from Sea Launch:” Fort Belvoir, VA: Defense Technical Information Center, April 1, 2001. https://doi.org/10.21236/ADA407104.

Chapman, Bert. *Space Warfare and Defense: A Historical Encyclopedia and Research Guide*. ABC-CLIO, 2008.

Chapman, Clark R. “The Hazard of Near-Earth Asteroid Impacts on Earth.” *Earth and Planetary Science Letters* 222, no. 1 (May 2004): 1–15. https://doi.org/10.1016/j.epsl.2004.03.004.

Cheng, A.F., J. Atchison, B. Kantsiper, A.S. Rivkin, A. Stickle, C. Reed, A. Galvez, I. Carnelli, P. Michel, and S. Ulamec. “Asteroid Impact and Deflection Assessment Mission.” *Acta Astronautica* 115 (October 2015): 262–69. https://doi.org/10.1016/j.actaastro.2015.05.021.

Christol, Carl Q. “Missile Launches, Militarization, Weaponization: Security in Space.” *Proc. Int’l Inst. Space L.* 52 (2009): 99.

———. "Telecommunications, Outer Space, and the New International Information Order (NIIO)." *Syracuse J. Int'l L. & Com.* 8 (1980): 343.

Clark, Tom S., and Drew A. Linzer. "Should I Use Fixed or Random Effects?" *Political Science Research and Methods* 3, no. 2 (2015): 399–408.

Collis, Christy. "The Geostationary Orbit: A Critical Legal Geography of Space's Most Valuable Real Estate." *The Sociological Review* 57, no. 1_suppl (May 2009): 47–65. https://doi.org/10.1111/j.1467-954X.2009.01816.x.

"Convention on the Law of the Sea." UN General Assembly, December 10, 1982. https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

Cox, Donald William. *The Space Race: From Sputnik to Apollo, and Beyond*. Chilton Books, 1962.

De Mesquita, Bruce Bueno, James D. Morrow, Randolph M. Siverson, and Alastair Smith. "An Institutional Explanation of the Democratic Peace." *American Political Science Review* 93, no. 4 (1999): 791–807.

DeBlois, Bruce M., Richard L. Garwin, R. Scott Kemp, and Jeremy C. Marwell. "Space Weapons: Crossing the Us Rubicon." *International Security* 29, no. 2 (2004): 50–84.

Dennerley, Joel A. "Emerging Space Nations and the Development of International Regulatory Regimes." *Space Policy* 35 (February 2016): 27–32. https://doi.org/10.1016/j.spacepol.2016.02.003.

Devlin, Mary Catherine, and William G. Schmidt. "Legal Issues Continue to Surround the International Space Station." *USAF Acad. J. Legal Stud.* 8 (1997): 237.

Dick, Steven J. *Societal Impact of Spaceflight*. Government Printing Office, 2007.

Doctrow, Cory. "Trump's Space Council Chief Says Space Is 'Not a Commons' and Promises That It Will Become Property of US Corporations." Boing Boing, 2017. https://boingboing.net/2017/12/21/the-man-who-sold-the-moon-2.html.

Dolman, Everett C. *Astropolitik: Classical Geopolitics in the Space Age*. 1 edition. London ; Portland, OR: Routledge, 2001.

Douhet, Giulio. *The Command of the Air (1921)*. University of Alabama Press, 2009.

Dow, J M, R E Neilan, and C Rizos. "The International GNSS Service (IGS): Preparations for the Coming Decade." *20th Int. Tech. Meeting of the Satellite Division of the US Inst. of Navigation, Fort Worth, Texas*, 2007, 9.

Dow, John M., R. E. Neilan, and C. Rizos. "The International Gnss Service in a Changing Landscape of Global Navigation Satellite Systems." *Journal of Geodesy* 83, no. 3–4 (March 2009): 191–98. https://doi.org/10.1007/s00190-008-0300-3.

Doyle, Michael W. “Kant, Liberal Legacies, and Foreign Affairs.” *Philosophy & Public Affairs*, 1983, 205–235.

Doyle, Stephen E. “Regulating the Geostationary Orbit: ITU’s WARC-ORB-’85-’88.” *J. Space L.* 15 (1987): 1.

Esarey, Justin, and Jacob Jaffe. “A Direct Test for Consistency of Random Effects Models That Outperforms the Hausman Test,” 2017.

Fernholz, Tim. “Space Is Not a ‘Global Commons,’ Top Trump Space Official Says.” Quartz, 2017. https://qz.com/1159540/space-is-not-a-global-commons-top-trump-space-official-says/.

Filho, Jose Monserrat. “The Place of the Missile Technology Control Regime (MTCR) in International Space Law.” *Space Policy* 10, no. 3 (1994): 223–228.

Fountain, Lynn M. “Creating Momentum in Space: Ending the Paralysis Produced by the Common Heritage of Mankind Doctrine.” *Conn. L. Rev.* 35 (2002): 1753.

Frutkin, Arnold Wolfe. *International Cooperation in Space*. Englewood Cliffs, N.J. : Prentice-Hall, [1965], 1965.

Fukushima, Masahiko. “Legal Analysis of the International Space Station (ISS) Programme Using the Concept of ‘Legalisation.’” *Space Policy* 24, no. 1 (February 2008): 33–41. https://doi.org/10.1016/j.spacepol.2007.11.001.

Gilpin, Robert. *The Political Economy of International Relations*. Princeton University Press, 1986.

Glaser, Charles L. “Realists as Optimists: Cooperation as Self-Help.” *International Security* 19, no. 3 (1994): 50–90.

Gorove, Stephen. “The Geostationary Orbit: Issues of Law and Policy.” *The American Journal of International Law* 73, no. 3 (July 1979): 444. https://doi.org/10.2307/2201144.

Gray, Colin S. “Space Arms Control: A Skeptical View.” *Air University Review* 37 (1985): 73–86.

Gray, Colin S., and John B. Sheldon. “Space Power and the Revolution in Military Affairs.” *Air & Space Power Journal* 13, no. 3 (1999): 23.

Greenemeier, Larry. “GPS and the World’s First ‘Space War.’” Scientific American. Accessed September 12, 2018. https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war/.

Greig, Michael, and Andrew J. Enterline. “National Material Capabiltiies Data Documentation, Version 5.0.” *Correlates of War Project*, 2017.

Hafner-Burton, Emilie M., Stephan Haggard, David A. Lake, and David G. Victor. "The Behavioral Revolution and International Relations." *International Organization* 71, no. S1 (April 2017): S1–31. https://doi.org/10.1017/S0020818316000400.

Hardin, Garrett. "The Tragedy of the Commons." *Science* 162, no. 3859 (1968): 1243–1248.

Harris, Elisa D, Robert Rosner, James M Acton, and Herbert Lin. *Governance of Dual-Use Technologies: Theory and Practice*, 2016.

Harvey, Dodd L., and Linda C. Ciccoritti. "Us-Soviet Cooperation in Space." *University of Miami Press*, 1974.

Hausman, Jerry A. "Specification Tests in Econometrics." *Econometrica: Journal of the Econometric Society*, 1978, 1251–1271.

Hays, Peter L. "Struggling Towards Space Doctrine: Us Military Space Plans, Programs, and Perspectives During the Cold War." AIR FORCE INSTITUTE OF TECHNOLOGY WRIGHT-PATTERSON AFB OH, 1994.

———. *United States Military Space: Into the Twenty-First Century*. DIANE Publishing, 2002.

Hemmings, Alan D. "Why Did We Get an International Space Station Before an International Antarctic Station?" *The Polar Journal* 1, no. 1 (June 2011): 5–16. https://doi.org/10.1080/2154896X.2011.569377.

Herz, John H. "Rise and Demise of the Territorial State." *World Politics* 9, no. 4 (1957): 473–493.

Hobbes, Thomas. *Leviathan: With Selected Variants from the Latin Edition of 1668*. Edited by Edwin Curley. Underlined, Notations edition. Indianapolis: Hackett Publishing Company, 1994.

Hobe, Stephan. "Importance of the Rule of Law for Space Activities, The." *Proc. Int'l Inst. Space L.* 51 (2008): 351.

Huber, Peter J. "The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions." In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*, 1:221–233. University of California Press, 1967.

Jackson, Robert, and Georg Sørensen. *Introduction to International Relations: Theories and Approaches by Jackson, Robert, Sørensen, Georg 5th Edition (2013) Paperback*. 5 edition. Oxford University Press, 2013.

Jakhu, Ram, and Steven Freeland. "The Sources of International Space Law." *Proceedings of the International Institute of Space Law 2013*, 2014, 461–478.

Jasani, Bhupendra. *Outer Space: A Source of Conflict or Co-Operation*. Tokyo : United Nations University Press, [1991], 1991.

Jasper, Scott. *Conflict and Cooperation in the Global Commons: A Comprehensive Approach for International Security*. Georgetown University Press, 2012.

———, ed. *Securing Freedom in the Global Commons*. Stanford, Calif: Stanford Security Studies, 2010.

Johnson-Freese, Joan. *Space as a Strategic Asset*. New York : Columbia University Press, [2007], 2007.

———. *Space as a Strategic Asset*. New York: Columbia University Press, 2007.

Kant, Immanuel. "Grounding for the Metaphysics of Morals, Trans." *J. Ellington, Indianapolis: Hackett*, 1981.

———. *Political Writings*. Edited by Hugh Barr Nisbet and Hans Reiss. Cambridge: Cambridge University Press, 1991.

Karas, Thomas. *The New High Ground: Systems and Weapons of Space Age War*. Simon and Schuster, 1983.

Karras, Thomas. *The New High Ground: Strategies and Weapons of Space Age Wars*. New York: Simon & Schuster, 1983.

Kash, Don E. *The Politics of Space Cooperation*. Purdue University Studies, 1967.

Kash, Donald. *Cooperation in Space*. Lafayette: Purdue University Press, 1967.

Kennedy, P. "A Guide to Econometrics, Oxford." *Willey Blackwell*, 2008.

Keohane, Robert. *After Hegemony: Cooperation and Discord in the World Political Economy*. Revised edition edition. Princeton, N.J: Princeton University Press, 2005.

Kirby, Stephen, and Gordon Robson. *The Militarisation of Space*. Brighton : Wheatsheaf, 1987., 1987.

Klass, Philip J. *Secret Sentries in Space*. New York: Random House, 1971.

Klein, John J. *Space Warfare*. New York: Routledge, 2006.

Kmenta, Jan, and Pietro Balestra. "Missing Measurements in a Regression Problem with No Auxiliary Relations." *Advances in Econometrics* 5 (1986): 289–300.

Kopal, Vladimír. "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies." *YB Air & Space L.*, 1966, 463.

Krasner, Stephen D. *International Regimes. : Cornell Studies in Political Economy*. Cornell Studies in Political Economy. Ithaca : Cornell University Press, 1983., 1983.

———. “Regimes and the Limits of Realism: Regimes as Autonomous Variables.” *International Organization* 36, no. 2, (1982). http://www.jstor.org/stable/2706531.

———. “Structural Causes and Regime Consequences: Regimes as Intervening Variables.” *International Organization* 36, no. 2 (1982): 185–205.

Kries, Wulf von. “Towards a New Remote Sensing Order?” *Space Policy* 16, no. 3 (July 2000): 163–66. https://doi.org/10.1016/S0265-9646(00)00029-1.

Ku, Charlotte. “The Concept of Res Communis in International Law.” *History of European Ideas* 12, no. 4 (January 1, 1990): 459–77. https://doi.org/10.1016/0191-6599(90)90002-V.

Kuplic, Blair Stephenson. “The Weaponization of Outer Space: Preventing an Extraterrestrial Arms Race.” *NCJ Int'l L. & Com. Reg.* 39 (2013): 1123.

Kydd, Andrew. “Game Theory and the Spiral Model.” *World Politics* 49, no. 3 (1997): 371–400.

Lake, David A. “Anarchy, Hierarchy, and the Variety of International Relations.” *International Organization* 50, no. 1 (1996): 1–33.

Lambakis, Stephen. “On The Edge of Earth: The Future of American Space Power.” *Kentucky: University Press of Kentucky*, 2001.

Lambakis, Steven. *On the Edge of Earth: The Future of American Space Power*. University Press of Kentucky, 2013.

Lambeth, Benjamin S. *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space*. Santa Monica, CA: RAND, Project Air Force, 2003.

Launius, Roger. “United States Space Cooperation and Competition: Historical Reflections.” *Astropolitics* 7, no. 2 (May 2009): 89–100. https://doi.org/10.1080/14777620903073853.

Launius, Roger D. “Space Stations for the United States: An Idea Whose Time Has Come—and Gone?” *Acta Astronautica* 62, no. 10–11 (May 2008): 539–55. https://doi.org/10.1016/j.actaastro.2008.02.014.

Lee, Joosung J. “Legal Analysis of Sea Launch License: National Security and Environmental Concerns.” *Space Policy* 24, no. 2 (May 2008): 104–12. https://doi.org/10.1016/j.spacepol.2008.02.002.

Leeds, Brett Ashley. “Alliance Treaty Obligations and Provisions (atop) Codebook.” *Houston: Rice University, Department of Political Science*, 2005.

Levin, Harvey. “The Political Economy of Orbit Spectrum Leasing.” *Mich. YBI Legal Stud.* 5 (1984): 41.

Levin, Harvey J. “Trading Orbit Spectrum Assignments in the Space Satellite Industry.” *The American Economic Review* 81, no. 2 (1991): 42–45.

Levin, Harvey Joshua. *Invisible Resource; Use and Regulation of the Radio Spectrum.* PRESS, 1971.

Locke, John. *Locke : Two Treatises of Government*. Cambridge England ; New York: Cambridge University Press, 1994.

Logsdon, J. M. “Commercializing the International Space Station: Current US Thinking.” *SPACE POLICY* 14, no. 4 (1998): 239–46.

Logsdon, John M. “International Cooperation in the Space Station Programme.” *Space Policy* 7, no. 1 (February 1991): 35–45. https://doi.org/10.1016/0265-9646(91)90044-I.

Long, Jie. “China’s Space Station Project and International Cooperation: Potential Models of Jurisdiction and Selected Legal Issues.” *Space Policy* 36 (May 2016): 28–37. https://doi.org/10.1016/j.spacepol.2016.05.002.

Lupton, David E. “On Space Warfare: A Space Power Doctrine.” AIR UNIV PRESS MAXWELL AFB AL, 1988.

Macauley, Molly K. “Allocation of Orbit and Spectrum Resources for Regional Communications: What’s At Stake?” *The Journal of Law and Economics* 41, no. S2 (October 1998): 737–64. https://doi.org/10.1086/467411.

Machay, Martin, and Vladimír Hajko. “Transatlantic Space Cooperation: An Empirical Evidence.” *Space Policy* 32 (May 2015): 37–43. https://doi.org/10.1016/j.spacepol.2015.02.001.

Mackinder, Halford J. “The Geographical Pivot of History (1904).” *Geographical Journal* 170, no. 4 (2004): 298–321.

Mahan, Alfred Thayer. *The Influence of Sea Power upon History, 1660-1783*. Read Books Ltd, 2013.

Manno, Jack. *Arming the Heavens: The Hidden Military Agenda for Space, 1945-1995*. Dodd Mead, 1984.

Manzione, Lara L. “Multinational Investment in the Space Station: An Outer Space Model for International Cooperation.” *Am. U. Int’l L. Rev.* 18 (2002): 507.

Maoz, Zeev, and Nasrin Abdolali. “Regime Types and International Conflict, 1816-1976.” *Journal of Conflict Resolution* 33, no. 1 (1989): 3–35.

Maoz, Zeev, and Bruce Russett. “Normative and Structural Causes of Democratic Peace, 1946–1986.” *American Political Science Review* 87, no. 3 (1993): 624–638.

Marshall, Monty G., Ted Robert Gurr, and Keith Jaggers. “Polity IV Project: Political Regime Characteristics and Transitions, 1800–2018.” *Center for Systemic Peace*, 2019.

Martinez, Larry F. “Satellite Communications and the Internet: Implications for the Outer Space Treaty.” *Space Policy* 14, no. 2 (May 1998): 83–88. https://doi.org/10.1016/S0265-9646(98)00002-2.

Mason, James, Jan Stupl, William Marshall, and Creon Levit. “Orbital Debris-Debris Collision Avoidance.” *Advances in Space Research* 48, no. 10 (November 2011): 1643–55. https://doi.org/10.1016/j.asr.2011.08.005.

McDougall, Walter A. *The Heavens and the Earth: A Political History of the Space Age*. New York : Basic Books, [1985], 1985.

McGann, James G. “2017 Global Go To Think Tank Index Report.” *University of Pennsylvania* TTCSP Special Report (2018).

Mcintyre, John, and Daniel Papp. *International Space Policy: Legal, Economic, and Strategic Options for the Twentieth Century and Beyond*. New York: Praeger, 1987.

Mearsheimer, John J. *The Tragedy of Great Power Politics*. New York : Norton, [2001], 2001.

Millbrooke, Anne. “History of the Space Age.” In *Handbook of Space Engineering, Archaeology, and Heritage*, edited by Ann Darrin and Beth O’Leary, 8:195–207. CRC Press, 2009. https://doi.org/10.1201/9781420084320-c11.

Moenter, Rochus. “The International Space Station: Legal Framework and Current Status.” *J. Air L. & Com.* 64 (1998): 1033.

Moltz, James Clay. *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*. Stanford, Calif. : Stanford Security Studies, 2008., 2008.

Montluc, Bertrand de. “Russia’s Resurgence: Prospects for Space Policy and International Cooperation.” *Space Policy* 26, no. 1 (February 2010): 15–24. https://doi.org/10.1016/j.spacepol.2009.12.002.

Morgenthau, Hans J. *Politics Among Nations ; the Struggle for Power and Peace*. New York : A. A. Knopf, 1948., 1948.

Mowthorpe, Matthew. *The Militarization and Weaponization of Space*. Lanham, Md. : Lexington Books, [2004], 2004.

Mueller, Karl. “Totem and Taboo: Depolarizing the Space Weaponization Debate.” *Astropolitics* 1, no. 1 (January 1, 2003): 4–28. https://doi.org/10.1080/1477-760391832499.

Mutschler, Max M. *Arms Control in Space*. London: Palgrave Macmillan UK, 2013. https://doi.org/10.1057/9781137320643.

North, C. Douglass. *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge university press, 1990.

Nussbaum, Martha C. “Kant and Stoic Cosmopolitanism.” *Journal of Political Philosophy* 5, no. 1 (1997): 1–25.

Nye Jr, Joseph S. *Power in the Global Information Age: From Realism to Globalization*. Routledge, 2004.

Odishaw, Hugh. “The Challenges of Space.” *American Journal of Physics* 31, no. 10 (1963): 811–812.

O’Hanlon, Michael E. *Neither Star Wars nor Sanctuary: Constraining the Military Uses of Space*. Washington, D.C. : Brookings Institution Press, [2004], 2004.

OST. “Outer Space Treaty,” 1966. http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html.

“Outer Space Treaty.” UN General Assembly, January 27, 1967. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

Pardini, C., and L. Anselmo. “Assessing the Risk of Orbital Debris Impact.” *Space Debris* 1, no. 1 (1999): 59–80.

Pardoe, Geoffrey Keith Charles. *The Future for Space Technology*. Pinter London; Dover (NH), 1984.

Park, Hun Myoung. “Practical Guides to Panel Data Modeling: A Step-by-Step Analysis Using Stata.” *Public Management and Policy Analysis Program, Graduate School of International Relations, International University of Japan*, 2011, 1–52.

Parks, Richard W. “Efficient Estimation of a System of Regression Equations When Disturbances Are Both Serially and Contemporaneously Correlated.” *Journal of the American Statistical Association* 62, no. 318 (1967): 500–509.

Pedersen, Kenneth S. “Thoughts on International Space Cooperation and Interests in the Post-Cold War World.” *Space Policy* 8, no. 3 (August 1992): 205–20. https://doi.org/10.1016/0265-9646(92)90050-6.

Peterson, Mildred J. *International Regimes for the Final Frontier*. SUNY Press, 2006.

Peterson, MJ. “Diverging Orbits: Situation Definitions in Creation of Regimes for Broadcast and Remote Sensing Satellites.” *The American Political Science Review* 98, no. 2 (2004): 277–91.

———. “The Use of Analogies in Developing Outer Space Law.” *International Organization* 51, no. 2 (1997): 245–74.

Plano, Jack C., and Roy Olton. *The International Relation Dictionary. Western Michigan University*. California: ABC-CLIA, 1988.

Plattard, Serge. "Security in Space: Should Space Traffic Management Also Concern Payloads Management?" *Space Policy* 33 (August 2015): 56–62. https://doi.org/10.1016/j.spacepol.2015.02.005.

Porras, Daniel A. "The 'Common Heritage' of Outer Space: Equal Benefits For Most of Mankind." *California Western International Law Journal* 37, no. 1 (2006): 34.

Preston, Robert, Dana J. Johnson, Sean JA Edwards, Michael D. Miller, and Calvin Shipbaugh. *Space Weapons Earth Wars*. Rand Corporation, 2002.

Quirk, Joel, and Darshan Vigneswaran. "The Construction of an Edifice: The Story of a First Great Debate." *Review of International Studies* 31, no. 1 (January 2005): 89–107. https://doi.org/10.1017/S0260210505006315.

Rathbun, Brian C. "Uncertain about Uncertainty: Understanding the Multiple Meanings of a Crucial Concept in International Relations Theory." *International Studies Quarterly* 51, no. 3 (September 2007): 533–57. https://doi.org/10.1111/j.1468-2478.2007.00463.x.

Rendleman, James D., and J. Walter Faulconer. "Improving International Space Cooperation: Considerations for the Usa." *Space Policy* 26, no. 3 (August 2010): 143–51. https://doi.org/10.1016/j.spacepol.2010.06.008.

Riess, Cornelia. "A New Setting for International Space Cooperation?" *Space Policy* 21, no. 1 (February 2005): 49–53. https://doi.org/10.1016/j.spacepol.2004.11.010.

Rizos, Chris. "The International GNSS Service: In the Service of Geoscience and the Geospatial Industry." In *International Global Navigation Satellite Systems Society IGNSS Symposium 2007*. Citeseer, 2007.

Roberts, Lawrence D. "A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union." *Berkeley Technology Law Journal* 15, no. 3 (2000): 1095–1144. https://doi.org/10.15779/z38dq1j.

Rogers, William. "Quantile Regression Standard Errors." *Stata Technical Bulletin* 2, no. 9 (1993).

Rummel, Rudolph J. "Libertarianism and International Violence." *Journal of Conflict Resolution* 27, no. 1 (1983): 27–71.

Sadeh, Eligar. "Technical, Organizational and Political Dynamics of the International Space Station Program." *Space Policy* 20, no. 3 (August 2004): 171–88. https://doi.org/10.1016/j.spacepol.2004.06.007.

Schichtle, Cass. "The National Space Program from the Fifties into the Eighties." NATIONAL DEFENSE UNIV WASHINGTON DC RESEARCH DIRECTORATE, 1983.

Schurer, Stefanie, and Jongsay Yong. "Personality, Well-Being and the Marginal Utility of Income: What Can We Learn from Random Coefficient Models?," 2012.

Sheehan, Michael. *The International Politics of Space*. Routledge, 2014.

Sheytanova, Teodora. *The Accuracy of the Hausman Test in Panel Data: A Monte Carlo Study*, 2015.

Shor, Boris, Joseph Bafumi, Luke Keele, and David Park. "A Bayesian Multilevel Modeling Approach to Time-Series Cross-Sectional Data." *Political Analysis* 15, no. 2 (2007): 165–181.

Singer, J. David, Stuart Bremer, and John Stuckey. "Capability Distribution, Uncertainty, and Major Power War, 1820-1965." *Peace, War, and Numbers* 19 (1972): 48.

Small, Melvin, and J. David Singer. "The War-Proneness of Democratic Regimes, 1816-1965." *Jerusalem Journal of International Relations* 1, no. 4 (1976): 50–69.

Smith, Marcia. "Pace Outlines Trump Administration's Approach to Space Development and Law," 2017. https://spacepolicyonline.com/news/pace-outlines-trump-administrations-approach-to-space-development-and-law/.

Soroos, Marvin S. "The Commons in the Sky: The Radio Spectrum and Geosynchronous Orbit as Issues in Global Policy." *International Organization* 36, no. 3 (1982): 665–677.

St. John, Dan. "The Trouble with Westphalia in Space: The State-Centric Liability Regime." *Denver Journal of International Law and Policy* 40 (2012): 686–713.

Stares, Paul B. *The Militarization of Space: U.S. Policy, 1945-1984*. Cornell Studies in Security Affairs. Ithaca, N.Y. : Cornell University Press, 1985., 1985.

"STATUS OF INTERNATIONAL AGREEMENTS RELATING TO ACTIVITIES IN OUTER SPACE AS AT 1 JANUARY 2020." United Nations Office of Outer Space Affairs (UNOOSA), January 1, 2020. https://www.unoosa.org/documents/pdf/spacelaw/treatystatus/TreatiesStatus-2020E.pdf.

Stein, Arthur A. "Neoliberal Institutionalism." In *The Oxford Handbook of International Relations*, 201–221, 2008.

Su, Jinyuan. "Measures Proposed for Planetary Defence: Obstacles in Existing International Law and Implications for Space Arms Control." *Space Policy* 34 (November 2015): 1–5. https://doi.org/10.1016/j.spacepol.2015.05.006.

Tan, David. "Towards a New Regime for the Protection of Outer Space as the Province of All Mankind." *Yale J. Int'l L.* 25 (2000): 145.

Thucydides. *History of the Peloponnesian War*. Translated by Michael Finley. Penguin UK, 1974.

Tzu, Sun. "The Art of War, Translated and with an Introduction by Samuel B. Griffith." *London, UK: Oxford*, 1971.

Vaisey, Stephen, and Andrew Miles. "What You Can—and Can't—Do with Three-Wave Panel Data." *Sociological Methods & Research* 46, no. 1 (2017): 44–67.

Vogler, John. *The Global Commons: Environmental and Technological Governance*. Vol. 9. John Wiley & Sons, 2000.

Von Bencke, Matthew J. *The Politics of Space: A History of Us-Soviet/Russian Competition and Cooperation in Space*. Westview Pr, 1997.

Waltz, Kenneth N. "The Origins of War in Neorealist Theory." *The Journal of Interdisciplinary History* 18, no. 4 (1988): 615–628.

———. *Theory of International Politics*. Long Grove, Ill. : Waveland Press, 2010., 1979.

Weber, Katja. "Hierarchy Amidst Anarchy: A Transaction Costs Approach to International Security Cooperation." *International Studies Quarterly* 41, no. 2 (1997): 321–340.

Wehberg, Hans. "Pacta Sunt Servanda." *American Journal of International Law* 53, no. 4 (1959): 775–786.

Wendt, Alexander. "Anarchy Is What States Make of It: The Social Construction of Power Politics." *International Organization* 46, no. 2 (1992): 391–425.

Wessel, Brian. "The Rule of Law in Outer Space: The Effects of Treaties and Nonbinding Agreements on International Space Law." *Hastings Int'l & Comp. L. Rev.* 35 (2012): 289.

Western, Bruce. "Causal Heterogeneity in Comparative Research: A Bayesian Hierarchical Modelling Approach." *American Journal of Political Science* 42, no. 4 (1998): 1233–1259.

Westwood, James. "Military Strategy and Space Warfare." *Journal of Defense and Diplomacy* 2, no. 11 (1984): 17–21.

Union of Concerned Scientists. "What Are Satellites Used For?" Accessed June 5, 2018. https://www.ucsusa.org/nuclear-weapons/space-weapons/what-are-satellites-used-for.

White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica: Journal of the Econometric Society*, 1980, 817–838.

White, Irvin L. *Decision-Making for Space: Law and Politics in Air, Sea and Outer Space.* Lafayette: Purdue University Studies, 1970.

Wong, Wilson, and James Gordon Fergusson. *Military Space Power: A Guide to the Issues*. ABC-CLIO, 2010.

Young, Oran R. "Regime Dynamics: The Rise and Fall of International Regimes." *International Organization* 36, no. 2, (1982). http://www.jstor.org/stable/2706523.

———. “The Politics of International Regime Formation: Managing Natural Resources and the Environment.” *International Organization* 43, no. 3 (1989): 349–75.

Zhao, Yun. “The Role of Bilateral and Multilateral Agreements in International Space Cooperation.” *Space Policy* 36 (May 2016): 12–18. https://doi.org/10.1016/j.spacepol.2016.02.007.