GOVERNING THE FINAL FRONTIER: A POLYCENTRIC APPROACH TO MANAGING SPACE WEAPONIZATION AND DEBRIS

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INTRODUCTION

In 2007, China performed a successful anti-satellite (ASAT) test and destroyed an aging weather satellite at an altitude of some 500 miles.[i] This event contributed more than 35,000 pieces of space debris,[ii] increasing in a stroke the amount of total orbital space debris by approximately twenty-five percent.[iii] The Chinese ASAT test continues to reverberate with resulting debris causing ongoing alerts for the International Space Station (ISS),[iv] as the larger problem of space debris threatens satellites, and potentially hinders "space commerce, space tourism, and the scientific exploration of space . . . ."[v] The 2007 ASAT test is only one in a string of incidents that has led to the proliferation of orbital debris.[vi] Unfortunately, governance regimes have thus far failed to manage the interrelated problems of space weaponization and debris. This raises concerns about a brewing tragedy of the space commons and underscores the need for sustainable development of the final frontier.[vii]

With the human population continuing to grow and resource scarcity increasing, space technology is an essential tool for promoting sustainable development.[viii] Indeed, in some ways "the key to the world's wealth and power has shifted to the heavens. . . ."[ix] This fact renders global cooperation in space, including the proactive development of appropriate legal frameworks, a primary imperative for policymakers. Thus far though, applicable governance regimes remain amorphous and outdated.[x] This Article analyzes how and why this is the case by investigating the impact of technology, politics, and resource scarcity on space law. The Article then examines the growth and effectiveness of "polycentric"[xi] networks in managing the collective action problems of space weaponization and junk, and argues for the application of sustainable development policies to better manage the space commons.[xii]

National and commercial interests are increasingly tied to space in political, economic, and military arenas. Beyond fanciful notions of solar energy satellites, fusion energy, and orbiting hotels, contemporary political issues such as nuclear non-proliferation, economic development, and human rights are also intimately tied to outer space.[xiii] Operating in space is now essential to global communications and trade, and to the world's leading militaries.[xiv] Space has become vital to every nation relying on everything from weather forecasting to satellite telecommunications.[xv] In 2006, the satellite telecommunications' market alone exceeded $100 billion.[xvi] By 2010, the global space industry was worth over $276 billion.[xvii] These figures demonstrate that the space industry enjoys has a tremendous degree of economic importance, by one estimate in 1999 already employing over one million people and growing at an annual rate of nine percent.[xviii] By 2008, private sector spending in space surpassed $250 billion.[xix] NASA officials have applauded this jump in private sector interest, with former NASA Administrator Michael Griffin stating, "Sooner rather than later, government space activity must become a lesser rather than a greater part of what it is that humans do in space."[xx] Yet even as the private sector emerges as a key player in space, nations around the world are reassessing, and in some cases reasserting, national space policies. This phenomenon is leading to an emerging polycentric system featuring greater national regulation and regionalization.

This Article investigates whether space is reminiscent of the other parts of the "global commons,"[xxi] such as the deep seabed,[xxii] in that it is transitioning from a multilateral system centered on the United Nations to a polycentric regime complex. A polycentric regime complex may be defined as "a collective of partially overlapping and non-hierarchical regimes" that vary in extent and purpose,[xxiii] but embrace polycentric principles.[xxiv] The "basic idea" of polycentric governance according to Professor Michael McGinnis is that a group facing a collective action

problem "should be able to address" it in "whatever way they [members of the group] best see fit."[xxv] This could include using existing governance structures or crafting new systems.[xxvi] At the international level, this includes overlapping multi-level regimes featuring numerous power centers. A watershed moment could occur if policymakers applied this bottom-up conceptual framework to mitigating outer space challenges. Polycentric governance regimes that are multi-level, multi-purpose, multi-type, and multi-sectoral in scope[xxvii] could complement the top-down governance model favored throughout much of the history of space governance.[xxviii]

This Article analyzes the evolution of space law and builds a contemporary picture of space governance by assessing how and why space law has developed in the way that it has. This involves an examination of the effectiveness of emerging polycentric regimes, which moves beyond the appeal of regime complexes in the abstract. This Article aims to offer what some scholars including Professor William Boyd have called for, namely a "more thick description[] of how these forms of governance are taking shape," and to pay more "attention to the connective tissues that bind and hold these forms together."[xxix] Polycentric regime complexes offer some advantages for the peaceful and sustainable use of space that could help break the relative legal logjam in space governance.[xxx] Significant scholarly attention has not been paid to the evolution of space law in this manner.[xxxi] This Article makes an original contribution to the field by appraising the role of polycentric governance of the space commons, including an analysis of national space laws. This investigation is critical given the importance of orbital space to economic and scientific development, as well as to geopolitics. Space could be thought of as the ultimate commons. Ensuring its sustainable development and peaceful use is a critical case study in commons management.[xxxii]

Part I of this Article investigates the impact of technology, scarcity, and multipolar politics on space governance, focusing on the problem of the tragedy of the space commons. Part II analyzes the evolution of space law and offers a short history of international cooperation and conflict in space to provide a framework for examining contemporary governance challenges. Finally, Part III examines whether the emerging governance system is mitigating the collective action problems of space weaponization and junk. This final Part concludes by discussing what more might be done to help avoid the tragedy of the space commons, as well as identifying further opportunities for research.

I. THE IMPACT OF TECHNOLOGY, RESOURCE SCARCITY, AND INTERNATIONAL RELATIONS ON THE GOVERNANCE OF OUTER SPACE

Three variables provide a useful analytical framework for investigating the evolution of space governance. First, technological advancements are allowing for increased commercialization,[xxxiii] as well as dual-use military activities.[xxxiv] Second, growing demand for space-based resources and services is driving intensified space operations.[xxxv] Third, the end of the so-called "golden age" of space law and the subsequent rise of multipolar international relations have made managing security and environmental issues difficult.[xxxvi] Each variable is introduced and analyzed in the context of the tragedy of the space commons.

A. Technological Advancements in Space Transportation

Technological advancements are driving interest in the global commons.[xxxvii] These spaces are situated "beyond the limits of national jurisdiction" and are "open to use by the [international] community but [are] closed to exclusive appropriation"[xxxviii] by treaty or custom. Private companies, such as SpaceX, are working to dramatically lower the cost of launching payloads into low Earth orbit, which currently stands at approximately $10,000/pound.[xxxix] At the same time, NASA is working to develop a series of next-generation launch vehicles to lower this cost to approximately $100/pound by 2025.[xl] Governments are also supporting the expanding space industry. For example, NASA's Commercial Crew and Cargo Program manages the Commercial Orbital Transportation Services' partnership with U.S. industry, investing over $800 million in commercial crew and cargo transportation[xli] and funding everything from launch vehicles to orbiting fuel depots.[xlii] Boeing, for example, is developing a commercial space taxi under this program.[xliii] Thus, space technology and industry are moving ahead rapidly, challenging space law to keep up.[xliv] Indeed, technological advancements have influenced space treaty making since the dawn of the Space Age.[xlv] And ultimately, technology may help address the collective action problems, such as space debris, that have resulted from governance gaps.[xlvi]

B. Demand for Services and Resource Scarcity

In addition to growing technological capabilities, space governance is also being influenced by increasing commercial demand for space-based services and resource scarcity. From now ubiquitous GPS-enabled devices,[xlvii] to the prevalence of telecommunications satellites,[xlviii] space-based services are a vast and fast growing business, with the overall market in Europe alone estimated to be €21 billion in 2005.[xlix] This business may be dwarfed by the demand for resources going forward assuming commodity prices continue to rise.[l] The global commons is increasingly a resource domain vital to the world economy. Securing access to this domain "may be the signal security challenge of the twenty-first century."[li] A U.K. Ministry of Defense think tank predicts, "The economic prosperity of many states *will* depend on functioning globalised markets and access to the global commons . . . [and that] access to the 'global commons' . . . *will* be a priority for virtually all states."[lii] Some studies have determined that three to five trillion barrels of oil remain on Earth, and contested estimates suggest production may peak by 2030.[liii] Other resources, such as silver, could be nearing exhaustion sooner depending on demand.[liv] Technology will likely revise these estimates, but not the fact that the Earth's resources are finite. Eventually then, as commodity costs rise, the public and private sectors will search for new resource domains to satiate demand—including outer space.[lv] Already, scientists in China have reportedly called for the development of a space-based infrastructure to tap such resources,[lvi] while private firms such as Planetary Resources are making plans for mining asteroids.[lvii] Developing space industry could also help alleviate ongoing concerns over climate change by moving polluting industries off planet, impacting atmospheric governance.[lviii] The governance regimes that the international community creates now will impact the manner and rate at which space develops. The key questions are whether ambiguities in space law are supporting or impeding development, and whether it is politically possible to address space law issues multilaterally given the multipolar state of international affairs.

C. *"From Geopolitics to Astropolitics"*[lix]

Both domestic politics and multipolar international relations play an important role in space policymaking. For example, initial U.S. rejection of and eventual support for a space weapons ban has been instrumental in the slow progress in regulating this area.[lx] The Cold War shaped space policymaking for decades, as is explored in Part III, while the failure of the Moon Treaty called into question the continued validity of the CHM concept in space law.[lxi] The rise of multipolar politics has made it increasingly difficult to reach consensus through the U.N. Office of Outer Space Affairs.[lxii] The U.K. Ministry of Defense sums up the situation succinctly: "Out to 2040, the locus of global power will move away from the United States (US) and Europe towards Asia, as the global system shifts from a uni-polar towards a multi-polar distribution of power."[lxiii] With the rise of multipolar politics and the "Rest,"[lxiv] distinctions between the West and the East, between developing and developed countries, and between the North and the South are impacting the development of international law generally, [lxv] and space law specifically.[lxvi]

D. *A Comparative Analysis of the Impact of Technology, Scarcity, and Multipolar Politics on Atmospheric Governance*

In order to understand how the forces of technological advancement, resource scarcity, and multipolar politics are shaping space governance, it is useful to compare and contrast how these variables are playing out in different areas of the global commons. Toward that end, consider atmospheric governance. During the 15th Conference of the Parties (COP15) to the United Nations Framework Convention on Climate Change (UNFCCC), held in Copenhagen in December 2009, delegations from 192 nations came together to address the mounting problem of global climate change.[lxvii] With weather patterns changing, global sea levels rising, and temperatures set to rise between 1.1 and 6.4 degrees Celsius by 2100, climate change is a problem affecting the entire world.[lxviii] It is also "a classic collective action problem" in which individual nations can be expected to free ride.[lxix] This behavior was on display at COP15, with the actions of a few nations able to slow progress, underscoring the difficulties of treaty making in a multipolar world.

The issues that COP15 underscored are not limited to the atmosphere but also apply to outer space, including: the changing role of the United Nations, the rise of multipolar politics and its effect on commons governance, and rapid technological advancements alongside growing scarcity. For example, COP15 demonstrated the difficulty of reaching consensus between major emerging markets, like the BASIC group (Brazil, South Africa, India, and China), and other power centers, including the United States, European Union, and the G77.[lxx] The struggle to reach agreement across such an array of interests has led to the development of more targeted forums, both in terms of membership and subject matter, in what could be considered a shift toward a polycentric approach to atmospheric management.[lxxi] Moreover, COP15 illustrated the extent to which negotiations over implementing the CHM concept have changed over time, according to Professor Michael Oppenheimer, lead author of the Third and Fourth Intergovernmental Panel on Climate Change assessments.[lxxii] "[P]ragmatism and efficiency has led to the uptake of emissions trading, which some view as privatization of the commons," argues Professor Oppenheimer.[lxxiii] "On the other hand, the other four principles

remain more or less embedded in current understanding. What has fallen by the wayside is that the principle of equity (for example, equal per capita emissions) is seen as a very distant objective."[lxxiv] COP15 is thus a microcosm both of what is at stake in the commons and how politically, economically, and legally difficult it is to create new governance structures to address collective action problems, including the tragedy of the space commons.[lxxv]

E. The Tragedy of the Space Commons

Technological advancements and resource scarcity are driving interest in the space commons, yet thus far governance has failed to keep pace. The classic tragedy of the commons model predicts the eventual overexploitation and degradation of all common pool resources. Garrett Hardin illustrated the tragedy of the commons scenario through a thought experiment involving a metaphorical village pasture.[lxxvi] Each herder in the village sought to maximize individual profits while only bearing a fraction of the cost of overgrazing, thus highlighting the divergence between individual and collective rationality.[lxxvii] The model is often theorized as a prisoner's dilemma in which it is more advantageous to defect than cooperate.[lxxviii] This means people acting in rational self-interest do not necessarily reach optimal results as a collective.[lxxix] For the purposes of this study, the key insight from Hardin's work is that absent coercion, "rational self-interested individuals will not act to achieve their common or group interests."[lxxx] Hence Hardin's famous idea that "freedom in a commons brings ruin to all."[lxxxi] Given that space is largely an open access system, the predictions of the tragedy of the commons are self-evident. Professor Robert Bird, for example, has argued that nations treat orbital space as a kind of communal pasture that may be overexploited and polluted through debris.[lxxxii] This model may also applies to space weaponization, since individual nations may "benefit by introducing space weapons while spreading the associated negative externalities among" spacefaring and non-spacefaring nations alike.[lxxxiii]

The model of "the tragedy of the commons has become a part of conventional wisdom in" such diverse fields as "economics, ecology, . . . political science"[lxxxiv], and, to an extent, international law.[lxxxv] More importantly, resource-management policies around the world have relied on this model, including in the Atlantic Canadian fisheries.[lxxxvi] But since its introduction more than forty years ago, the at times too simplistic theory has been critiqued and modified,[lxxxvii] resulting in important insights for management of the space commons. For example, some of Hardin's conclusions ring true for open access areas, but not common property systems.[lxxxviii] Hardin failed to recognize the potential for communication between participants and self-organization to avoid the tragedy from unfolding by instigating local rules for managing common resources.[lxxxix] These omissions caused other scholars, led by Nobel Laureate Elinor Ostrom, to modify the tragedy of the commons.

The more liberal reaction to the tragedy of the commons, which Hardin himself promoted, argued for the necessity of centralized control of the commons to avoid overexploitation,[xc] while the conservative reaction favored privatization—if everything is privately owned, then the commons falls away.[xci] Nations increasingly seem to be favoring the former approach to global commons management, with national regulation becoming more prevalent in the oceans,[xcii] as well as in outer space.[xciii] Government control can eventually lead to negative environmental consequences if states fail to internalize externalities generated by private sector actors given that the state is "both developer and protector of natural

resources."[xciv] What, then, of the middle ground pioneered by Professor Ostrom in *Governing the Commons*?[xcv] Part Two explores this middle ground of polycentric governance featuring self-organization, i.e., recognizing a role for bottom-up communal management as opposed to outright nationalization or privatization.

F. Summary

Technological progress, resource scarcity, and the rise of multipolar politics are all putting pressure on space governance. Regulatory change must keep pace with technical, political, and economic change if the tragedy of the space commons is to be avoided.[xcvi] In order to determine whether this is taking place, the evolution of space law to date must be reviewed to provide a foundation for analysis.

II. THE EVOLUTION OF SPACE LAW

This Part provides an overview of space law, with a particular emphasis on issues of sovereignty, peaceful use, property rights, and the regulation of space-based weapons and debris. Section A analyzes the birth of space law and its origins in the freedom of the seas concept through to the Outer Space Treaty (OST). Section B examines peaceful use and the contemporary position of the CHM concept in space law. Section C complements this legal analysis with an investigation into how international politics have shaped space governance. Section D then builds off this survey to critique the emerging space regime complex. Finally, Section E introduces the concept of polycentric governance with Section F then focusing on one aspect of this evolving system—the growth of national regulation.

A. Early Regulation and Sovereignty in Space

Space law is based on the principle that outer space, including celestial bodies, should remain open and freely accessible "for exploration and use by all States."[xcvii] This principle is even broader than the original Law of the Sea (LOS) concept of the freedom of the seas,[xcviii] which developed prior to resource discoveries and technological progress incentivizing layered jurisdiction in which coastal states began enjoying relatively more regulatory power further from shore.[xcix] Like the LOS, the fragmented nature of space law – based on multilateral treaties, bilateral accords, and national regulations – is due in part to the rapid pace at which technology has opened up space to exploration and exploitation; however, space law differs from the LOS given the relative lack of custom compared to the centuries of state practice in oceanic exploration.[c] As the proposed usages of outer space multiply, so too does the complexity of claims and challenges to existing laws and norms. Differing interpretations of the general principles that guide space law abound. A brief review of these principles undergirding space law provides a useful framework for analysis.

The first academic effort calling for a legal regime to govern outer space appeared as early as 1910.[ci] Yet it was not until just before the 1957 launch of *Sputnik* that the push for regulation commenced through the U.N. General Assembly (UNGA) as the international community began to realize the dangers of unregulated, open access space.[cii] The superpowers

were initially supportive of international space cooperation and sought to promote the peaceful use of space.[ciii] Beginning in 1957, the United Nations passed resolutions to the effect that outer space should be used for peaceful purposes, and moved to bar national appropriation.[civ] This was due in particular to the high cost of enforcing national sovereignty in space and the benefits of orbiting satellites, including reconnaissance and scientific data collection.[cv]
International lawmaking in space began with several UNGA Resolutions creating the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), which became the locus for the advancement of international space law.[cvi] COPUOS became a permanent U.N. committee in 1959 and boasted 71 Member States as of 2012, with Thailand, Azerbaijan, and Tunisia joining in 2010.[cvii] Throughout the 1960s and 1970s, COPUOS engendered cooperation and consensus building.[cviii] This may be seen in the five international treaties and numerous bilateral and multilateral agreements concerning outer space that were enacted between 1962 to 1979, many of which began life at COPUOS.[cix] Progress was made easy in part because technology for economical space travel had not yet been realized, thereby limiting the number of stakeholders interested in governance.[cx] The rapid evolution of space law was also facilitated by the fact that precedents already existed in the form of the Antarctic Treaty and customary air law.[cxi]

Today, the outer space legal regime is defined by five principle treaties: the OST, the Rescue Agreement, the Liability Convention, the Registration Convention, and the Moon Treaty.[cxii] None of these explicitly regulate orbital debris, effectively manage space weaponization, or define property rights. However, several of the treaties, such as the OST and the Moon Treaty, bear on these topics and are examined next.

B. Defining Occupation and "Peaceful Use"

Space law broke new ground beginning after the launch of *Sputnik* in 1957 by considering the welfare of humanity as a whole, flouting traditional notions of state-centric Westphalian sovereignty. Consider Articles II and IV of the OST.[cxiii] Article II bars national appropriation of the moon and other celestial bodies "by claim of sovereignty, by means of use or occupation or by any other means."[cxiv] This led to contrasting interpretations between commentators as to the sufficiency of property rights for commercial development.[cxv] The dispute was partially resolved by the OST, which proclaimed the "exploration and use of outer space" to be the vague "province of all mankind."[cxvi] However, space regulation still did not fully embrace the CHM concept, which would have required equitable benefit sharing, among other provisions discussed above.[cxvii] Indeed, the phrase "common heritage of mankind" is included only once in all of the U.N. treaties, General Assembly Resolutions, and principles that comprise the corpus of space law.[cxviii] Instead, nations including the United States have adopted resource distribution policies that bar the extension of national sovereignty to outer space but permit the reasonable exploitation of resources under certain conditions.[cxix] This diversity of approaches conflicts with the classic CHM approach, and may lead to growing tensions if the leading spacefaring powers of the United States, Russia, the European Space Agency, Japan, India, and China were to refuse to transfer technology or resources to assist developing states in accessing space.[cxx]

Analyzing the peaceful use of space may be broken down into two areas: orbital space and the moon and other celestial bodies.[cxxi] Article IV(1) of the OST allows for the

nonaggressive military use of orbital space,[cxxii] and prohibits the placement "in orbit around the earth [of] any objects carrying nuclear weapons or any other kinds of weapons of mass destruction."[cxxiii] In contrast, Article IV(2) preserves these areas "exclusively for peaceful purposes."[cxxiv] As applied to the issues of orbital debris and space weaponization, which may be described as placing weapons in space that target either space-based or terrestrial assets,[cxxv] OST Articles IX and III also come into play. Article IX addresses the "harmful contamination" of outer space, but it falls short of requiring action to mitigate debris and merely requires that the offending party undertake "international consultations."[cxxvi] This due regard standard as applied to orbital debris is both broad and vague, and thus controversial.[cxxvii] Article III is more generic but also is applicable to peaceful use since it calls member nations to carry out space exploration and activities "in accordance with international law."[cxxviii] This phrase brings in U.N. Charter Law including the prohibitions on aggression, which can help to promote international peace and security in space such as by regulating ASAT testing.[cxxix] Thus far, however, these OST provisions have not led to the sustainable, peaceful use of space, in part because of ambiguity in the treaty language.[cxxx] Nor has the CHM been a particularly useful vehicle to equitably develop space, other than laying out common but differentiated responsibilities.[cxxxi] Thus, given state practice and amorphous treaty language, the generation of space debris is likely not illegal under international law.[cxxxii]

As a result of persistent resistance, only "the moon and its natural resources[,]"[cxxxiii] as well as the deep seabed beyond national jurisdiction, are explicitly proclaimed as common heritage areas under international law.[cxxxiv] Thus, the international community has rejected the two most direct tests of the CHM concept.[cxxxv] This rejection has soured international support for further multilateral efforts in regulating the commons spaces through the classic CHM concept featuring supranational management and technology transfer in which developed nations were required to transfer intellectual property to developing states. Indeed, some have gone so far as to argue that the OST itself is destined to fail, and that the "benefit of all mankind" language in the OST has created a space anti-commons.[cxxxvi] The international community has proven unable to produce any new multilateral instruments regulating space since the Moon Treaty. Instead, states have preferred the development of a space regime complex that has important ramifications for the sustainable, peaceful use of outer space. Before that regime complex may be examined, though, it is first important to consider the history of international cooperation and conflict in space to illustrate how these forces have influenced space governance and investigate what that might portend for addressing environmental and security issues in the space commons.

C. International Cooperation and Conflict in Space

This section argues that international relations and technological advancements are shaping space policymaking more so than resource scarcity, which is unlike what is transpiring in the deep seabed.[cxxxvii] This conclusion is supported by historical examples, emphasizing the roles that the principal spacefaring powers of the United States, Russia, and China have had in developing space law. The goal is to provide historical context for the following discussion of contemporary efforts to regulate space weaponization and debris through polycentric action, and to demonstrate the utility of these factors as analytical tools to conceptualize space governance.

1. The U.S. Approach to International Space Cooperation and its Impact on Space Governance

Then-Senator Lyndon Johnson stated in 1959, "Men who have worked together to reach the stars are not likely to descend together into the depths of war and desolation."[cxxxviii] According to Professor John Krige, "the conviction that international space cooperation . . . would remove misunderstanding, project a positive image of the United States abroad . . . and advance the cause of world peace was a *leitmotif* of early arguments for an international component to the [U.S.] space program."[cxxxix] International space cooperation was seen by some then, as now, as a way of reducing tensions by cooperating in a visible, challenging arena for the benefit of all humanity.[cxl] Indeed, space has long been a powerful symbol of national prestige and international solidarity in divisive times.[cxli] From their inception, space cooperation and policymaking have been linked to broader foreign policy and national security objectives.[cxlii] This can be seen, notably, in the United States, which continues to wield significant power in influencing space policy.

There have been three paradigm shifts in U.S. space policy. The first post-*Sputnik* U.S. space policy, NSC 5814, stated: "International cooperation agreements in which the United Sates participates could have the effect of . . . enhancing the position of the Unites States as a leader in advocating the use of outer space for peaceful purposes."[cxliii] Implicit in this statement is the belief that the United States should remain dominant in space technology, demonstrating how technology has influenced the course of space policymaking.[cxliv] This philosophy informed the first definitive shift in U.S. space policy that began in 1961 with President Kennedy's decision to go to the moon, transitioning the U.S. space agency from the National Advisory Committee on Aeronautics (NACA) to the mighty NASA of the *Apollo* years.[cxlv]

The second shift began with the dissolution of the Soviet Union in 1991. The Cold War had provided long-term continuity within which incremental change was possible,[cxlvi] allowing for a proxy arena of superpower competition to demonstrate technical prowess and national wherewithal. A new rationale for international space cooperation needed to be constructed when this competition ended, featuring increased partnership with strategic allies such as India. Both of these earlier shifts have been described in depth by commentators.[cxlvii]

The third shift in U.S. space policy arguably began with the terrorist attacks of September 11, 2001. This shift crystallized trends already underway post-1991 and was accelerated by the *Columbia* Space Shuttle accident that led to the NASA Vision for Space Exploration (VSE).[cxlviii] A new set of policy priorities brought security threats to the forefront and cemented the role of multipolar politics in space cooperation. Howard McCurdy sees the "internationalization of space as a dominant theme in the present century,"[cxlix] though this phrasing perhaps misses the extent to which the private sector along with the spacefaring powers will help shape space policymaking going forward. Indeed, new State and non-State actors are entering the arena of space policy formulation through the growth of multipolar politics, further diffusing power and creating opportunities for experimentation and new norms along with the potential for greater gridlock and regime complexes. In this third era, the private sector has become a far greater focus of space law and policy, shifting from scientific investigation and national prestige to considerations based on return on investment.[cl] As a result, international space cooperation has become increasingly political and market-driven.

Contemporary analyses of U.S. motives for space collaboration combine realpolitik with a tendency toward normative views about NASA's behavior.[cli] According to Professor Krige,

"technological sharing[] and foreign policy concerns, are the material substrates of international space collaboration."[cliii] When NASA was created in 1958, there was no need for it to collaborate with other nations.[cliii] From its inception, U.S.-led cooperation in space has been political in nature.[cliv] Legislation *ab initio* allowed this international cooperation out of self-interest and as a means of influencing the space programs of partner nations.[clv] NASA alone has negotiated approximately 4,000 agreements with more than 100 countries including both traditional U.S. allies and competitors.[clvi] As the third era in U.S. space policymaking unfolds, partnerships are evolving to an extent as more nations develop space programs rising from some 40 space agencies in 2000 to roughly 55 in 2009.[clvii] Agreements are now being deepened with both U.S. allies and major emerging markets, from Norway to India.[clviii] Although more prevalent since 9/11, this transition has its roots in the Cold War. As superpowers' competition ebbed and flowed with the geopolitical tides, so too have the motivations that have spurred space governance and development forward.

2. U.S.-Soviet Space Cooperation and the Role of Nuclear Non-Proliferation in Space Governance

As superpower rivalry was increasing by the end of the 1950s,[clix] the rise of Mutually Assured Destruction (MAD) underscored a frequent argument for international space cooperation: nuclear non-proliferation. Soviet Premier Nikita Khrushchev stated, "The scale of our [US-Soviet] cooperation in the peaceful conquest of space . . . is . . . related to the solution of the disarmament problem."[clx] President Kennedy attempted to bridge the superpower divide by stating in his inaugural address, "Let both sides seek to invoke the wonders of science instead of its terrors. Together let us explore the stars."[clxi] Such lofty rhetoric belied the Kennedy Administration's original political justification for space exploration.

A recording from the John F. Kennedy Library affirmed that politics, more than technology or scarcity, fuelled the first space race.[clxii] Evident in the recording was NASA Administrator James Webb's belief that landing on the moon should not be a top NASA priority. Administrator Webb said of the moon landings, "I think it is *one* of the top priority programs . . . ."[clxiii] In response, President Kennedy stated, "this is important for political reasons, *international political reasons*. This is, whether we like it or not, in a sense a race. . . . we hope to beat them and demonstrate that starting behind . . . by God, we passed them."[clxiv] In their discussion, President Kennedy reminds Administrator Webb of the "fantastic" amounts of money the federal government had spent on NASA and asserts that future funding should be directed toward the lunar landings.[clxv] According to President Kennedy, if the moon was not the priority, "we shouldn't be spending this kind of money because I'm not that interested in space."[clxvi] Although evidence is limited, it is likely that the Soviets similarly viewed space operations as a means of increasing legitimacy and prestige on the international stage.[clxvii]

The orbital flight of Yuri Gagarin on April 12, 1961 raised the issue of space cooperation to a new level of visibility and importance.[clxviii] Khrushchev stated in a letter to President Kennedy, "If our countries pooled their efforts . . . to master the universe, this would be very beneficial for the advance of science and would be joyfully acclaimed by all peoples."[clxix] In response, the Kennedy Administration proposed joint projects, including weather satellites, tracking services, and satellite communications. After signing the Nuclear Test Ban Treaty in August 1963, President Kennedy began seeking a broader détente with the

Soviet Union, including turning project *Apollo* into a joint U.S.-Soviet program.[clxx] Before the U.N. General Assembly, he stated, "Why . . . should man's first flight to the Moon be a matter of national competition?"[clxxi] The Soviets were silent, but President Kennedy was undaunted and proposed a new program to Webb that included a broad array of bilateral space initiatives.[clxxii] Before these proposals could bear fruit, though, President Kennedy was assassinated.[clxxiii]

Though President Johnson was also supportive of U.S.-Soviet collaboration, without the personal attention of President Kennedy the proposals died.[clxxiv] The Nixon Administration attempted a different tack, trying to attract a broader array of international participation in space exploration.[clxxv] NASA Administrator Thomas Paine visited Europe, Canada, Japan, and Australia for discussions of cooperative opportunities.[clxxvi] Progress was slow as countries were reluctant to devote the substantial resources required for space exploration. Instead of a truly international space program, U.S. space dominance convinced leading European countries to pool their resources into a multilateral alliance for economic development, the precursor to the European Space Agency.[clxxvii]

The 1975 *Apollo-Soyuz* handshake in space proved to be the high-water mark for U.S.-Soviet space cooperation. Relations deteriorated during the Carter Administration because of concerns over Soviet human rights abuses and further eroded during the Reagan Administration as part of the Evil Empire tilt.[clxxviii] It took until roughly 1994, more than thirty years after President Kennedy's proposals, for cooperation to replace competition in U.S.-Russian space relations.[clxxix] Indeed, the United States has pushed to integrate Russia into the ISS program partly to strengthen Russia's adherence to non-proliferation guidelines and to encourage "Russian scientists and engineers to work on 'peaceful projects' . . . ."[clxxx] This helps illustrate that international space cooperation from the U.S. viewpoint is "a politically driven means of linking the space programmes of other countries to US goals and activities . . . ."[clxxxi] Now, however, in this third era of space policymaking, an increasing number of space actors—including the People's Republic of China (PRC)[clxxxii] —are influencing the growth of the space regime complex.

3. The Potential for a Second Space Race and Chinese Space Policymaking in International Relations

The first space race began in October 1957 when the USSR launched *Sputnik I* and ended when Neil Armstrong set foot upon the Moon in July 1969.[clxxxiii] The total number of space launches helps to illustrate space activity during and after this period. For example, in 1957, two space vessels were launched; in 1984, the number had grown to 129, before dropping to 78 by 2009.[clxxxiv] This figure had rebounded slightly to 84 by 2011.[clxxxv] A list of contenders in a twenty-first century space race includes the spacefaring powers of the present and those burgeoning space programs. As of 2012, the six leading space powers are the United States, Russia, Japan, China, and Europe.[clxxxvi] Each spent over $1 billion on space programs in 2009.[clxxxvii] Even so, few of these space powers are contenders for a true second space race. Although Russia would be a likely candidate, the country's space program has only recently begun to receive stable funding[clxxxviii] and has been marred by setbacks, including the failure of its 2012 Mars probe.[clxxxix] European Space Agency efforts have long been restricted by a lack of coordination among the member states.[cxc] Japan's program is plagued with delays.[cxci] India

has fast evolving space program, but Indian politicians share the same concerns as their U.S. counterparts: "[I]n a democracy, space programs are positively viewed by the public but considered expendable relative to other spending concerns."[cxcii]

A telling example of U.S. views on space occurred when the House Appropriations Subcommittee that oversees NASA met to review the agency's 2007 budget request. Fiscal inquiries quickly gave way to alarmed rhetoric aimed at China's human spaceflight program. Former House Majority leader Tom Delay declared that the United States was engaged in a "space race" with China.[cxciii] Representative Frank Wolf added, "If China beats us [to the Moon]; we will have lost the space program. . . . They are basically, fundamentally in competition with us."[cxciv] Such sentiments are in response to polls finding that fifty-five percent of Americans consider China to either be an adversary or a serious threat as of 2004.[cxcv] However, more recently, in 2011 views of China have become somewhat more balanced with forty-nine percent of Americans viewing China favorably.[cxcvi] Still, these divisions play out in the U.S. Congress, which has been reluctant to seek out joint U.S.-Sino space cooperation,[cxcvii] going so far as to ban any NASA collaborations with China for the 2011 fiscal year.[cxcviii]

In only twenty-five years, China has gone from having no geosynchronous orbital satellites to advanced space systems including ASAT weapons. Indeed, the Chinese *Shenzhou* spacecraft, which is closely related to the Russian *Soyuz*, is technically capable of sending people to the moon.[cxcix] China's space program now reportedly aims to have an orbiting space station by 2020, a manned lunar landing by 2024, and a manned mission to Mars by 2050,[cc] though precise targets are malleable. Estimates place China's current space program budget at approximately $2.2 billion, roughly 12 percent of NASA's 2012 budget.[cci] Discovering China's true motivations for its increasingly robust space program is difficult in such a large and complex country. China's evolving space strategy, or "Project 921" as it is known to the People's Liberation Army (PLA), is deliberately opaque.[ccii] This makes it difficult to determine whether it is resources, military dominance, commercial opportunities, or all of the above that are motivating forces behind Chinese efforts. Untangling this web, however, is critical to developing partnerships that address collective action problems.

The U.S. response to Chinese space efforts has been varied but has followed political fault lines. This is reminiscent of the Carter and Reagan Administrations' stance toward international space cooperation with the Soviet Union. Then, as now, nuclear non-proliferation and human rights concerns were underscored as a hindrance toward bilateral cooperation. With debate over the veracity of the China threat thesis intensifying,[cciii] future bilateral space cooperation between the United States and China is similarly contentious.[cciv] In the first space race, space became "a Cold War battlefield, where scientists . . . were the frontline soldiers, fighting for prestige and global influence that would flow from technical prowess . . . ."[ccv] Now, economic development seems to be increasingly tied to the rationale for space exploration. The PRC is keenly aware of the relationships between space, technology, and economic growth, as it is due to surpass the United States as the world's largest economy as early as 2016.[ccvi] Ziyuan Ouyang, chief scientist of the Chinese lunar exploration program, has reportedly stated that China plans to mine lunar resources beginning with preliminary robotic missions slated for launch in 2013 and 2017.[ccvii] Yet China does not have to be an enemy of the United States as it seeks to utilize space-based resources; it could be at worst a competitor and at best a partner in certain sectors and issue areas. Since 1985, China has established cooperative relations with more than forty countries and international bodies.[ccviii] Assuming continued improving U.S. attitudes and political will in Congress, the United States and China could one day realize a

version of the Apollo-Soyuz handshake that would help lay the groundwork for a more robust and lasting partnership.

For the time being, the United States is not entering a space race with China. The United States continues to enjoy a massive superiority over China in space capabilities.[ccix] According to Dean Cheng of the Heritage Foundation, "If they [China] are racing with anyone, it's with Japan and India . . . [and it is] 'a marathon not a sprint.'"[ccx] But NASA is taking a cautious tone with China since the U.S. Congress has perceived the Chinese space program as a threat. A deeper partnership, however, holds the promise of better managing space weapons, enhancing cooperation on the related problem of orbital debris, and clarifying property rights in the space commons. Without such cooperation, history could repeat itself.

D. The Emerging Space Regime Complex

The increasing number of space powers, relative fragmentation of governance, and role of the private sector in space have led to the creation of a space regime complex. Regime complexes occur when several different regimes coexist "in the same issue area without clear hierarchy."[ccxi] Given the current state of international politics, "loosely coupled" regime complexes have significant advantages over unitary regimes, such as some U.N. consensus-driven multilateral treaties.[ccxii] In the context of climate change, for example, Professors Keohane and Victor argue, "[T]he structural and interest diversity inherent in contemporary world politics tends to generate the formation of regime complexes rather than a comprehensive, integrated regime."[ccxiii] Consequently, regime complexes are becoming more popular due to divergent interests and multipolar politics. This may have significant benefits. Futile negotiations of multilateral treaties can divert attention from more practical efforts to create flexible, loosely coupled regimes[ccxiv] that could successfully manage complex problems such as orbital debris. After a history of successful partnerships, international regimes may then emerge by "codifying informal rights and rules that have evolved over time through a process of converging expectations or tacit bargaining."[ccxv]

Yet there are downsides to regime complexes to consider. In the context of climate change, smaller forums may omit nations that are not major emitters, such as the least-developed nations most vulnerable to the effects of a changing climate.[ccxvi] The problems associated with foregoing multilateral negotiation in favor of more targeted initiatives are also troubling. One potential issue is incentivizing nations not to become free riders if they are not part of a global regime.[ccxvii] Regime complexes may also be laden with legal inconsistencies "because the rules in one regime are rarely coordinated closely with overlapping rules in related regimes."[ccxviii] This can cause negotiators to adopt broad rules that allow for multiple interpretations.

The corpus of space law to date represents a regime in terms of legal usage, but does not adhere to Professor Keohane's definition of international regimes. The scope of today's space laws does not correspond with issue areas that are "dealt with in common negotiations and by the same or closely coordinated bureaucracies."[ccxix] Instead of a single governing entity or system of tightly knit bureaucracies, a number of overlapping, often uncoordinated and sometimes competing regimes have emerged.[ccxx] In other words, we now have the beginnings of a polycentric regime complex.[ccxxi] Whether the different aspects of this system operate independently, collaboratively, or are in competition with one another is an empirical question

discussed in Part III. This argument may be introduced, though, by examining the evolving role of COPUOS in space governance.

U.N. space-lawmaking is a cumbersome process requiring COPUOS to approve a text by consensus and then send it to the UNGA.[ccxxii] Although useful for boosting acceptance of COPUOS positions, in recent years the COPUOS consensus required has become a straight jacket.[ccxxiii] This became apparent in 1982 when the UNGA bypassed COPUOS in adopting a resolution.[ccxxiv] COPUOS was largely silent in the early 1990s, as the end of the Cold War led to a realignment of interests.[ccxxv] But beginning with the UNISPACE III Conference in 1999,[ccxxvi] COPUOS has made significant progress in certain areas, such as endorsing the voluntary, non-binding 2007 Space Debris Mitigation Guidelines after the Chinese ASAT test.[ccxxvii] Some states were eager to convert this document into a binding treaty, but political resistance scuttled such talks. The Czech Republic, long a proactive leader in the arena of space debris, tried again for a binding treaty but was met with resistance from the European Union and other actors calling for more national regulation.

With the announcement of the NASA VSE and more recently the Obama Administration's space policy, space law has once again become a more pressing topic. This time, however, the focus is not on U.N. rulemaking but on more bottom-up approaches including national action plans, bilateral instruments, and regional agreements.[ccxxviii] However, this lack of multilateral cooperation is threatening core principles of space law. As a result, states have begun bypassing the U.N. consensus-driven system in favor of polycentric regulation. The curtailed scope of COPUOS is a phenomenon recognized by Steve Doyle, a member of the U.S. delegation to the OST, who argues:

> As COPUOS has grown, it has lost vigor and vitality. The initial problems dealt with were of broad scope and immediate concern. Over time, the issues became narrower . . . and with operational implications, which lead to real constraints on states . . . . Treaty writing gave way to principles drafting, which has now been reduced substantially to discussions and expressions of opinion for the record.[ccxxix]

The future of international cooperation in peacefully and sustainably managing space depends on the ability of stakeholders to both embrace best practices and understand the benefits and drawbacks of polycentric governance.

E. A Polycentric Approach to Space Governance

Professor Ostrom and others have argued for the adoption of polycentric solutions to collective action problems stemming from the global commons, particularly with regards to climate change. Among other lessons, this approach suggests that "a single governmental unit" is often incapable of managing global collective action problems in part because of free riding.[ccxxx] The central problem, as identified by Professor Ostrom, is that waiting too long could mean that solutions "negotiated at the global level, if not backed by a variety of efforts at national, regional, and local levels, are not guaranteed to work well."[ccxxxi] In other words, there does not necessarily need to be one comprehensive global solution to the global commons: as Professor Stephen Schneider stated, "You don't need big brother to step in to protect the

commons."[ccxxxii] Instead, local institutions, or even bilateral or regional regimes, may be created to promote good governance. Such a polycentric approach would be "mutually reinforcing"[ccxxxiii] at local, national, regional, and global levels. Thus, according to Professor Ostrom, "[P]olycentric regulation is useful when considering governance questions in the global commons as the complexity of these problems lends itself well to many small, issue-specific units working autonomously as part of a network . . . . It is an application of the maxim, think globally, but act locally."[ccxxxiv]

Proponents claim that top-down planning by national officials with extensive external resources is unnecessary to build efficient regimes to sustainably govern common pool resources.[ccxxxv] If done correctly, a polycentric management approach can lower transaction (rule enforcement) costs relative to a "monocentric hierarchy."[ccxxxvi] Polycentric governance thus arguably builds from the regime complex literature by recognizing both the benefits and drawbacks of multilevel regulation as well as the importance of multi-sector localized self-organization,[ccxxxvii] which is why this study uses the term "polycentric regime complex." While these principles were originally developed in other contexts, Professor Ostrom and others, including Professor Victor, have worked to extend them to the atmospheric commons. These scholars advocated targeted measures through small, issue-specific forums to help manage global collective action problems lest inaction hasten a worst-case scenario.[ccxxxviii] However, there are both moral and political problems with this approach, including an application of Garrett Hardin's "lifeboat ethics",[ccxxxix] and an unwillingness of some states to be politically pressured in the smaller forums as was described above. Nevertheless, there is a potential for more targeted treaties to emerge on the path to binding multilateral agreements.[ccxl] But there is no perfect forum in a multipolar world; both a more top-down multilateral approach and a bottom-up polycentric one have benefits and drawbacks. The most prominent example of polycentric regulation in the global commons relates to global climate change. Thus it is instructive to review this application of polycentric theory to determine what utility it may have for the space commons.

Although the atmosphere is by definition global, the causes and effects of climate change vary from region to region.[ccxli] "[A]ctions taken on a small scale" have an impact on the global climate change problem—insulating housing and buying more fuel-efficient cars could alone help reduce energy consumption worldwide by thirty percent.[ccxlii] As applied to space, this principle could mean that actions taken by individual firms or nations could help enable more sustainable management of the space commons. But "[t]rying to solve the problem of providing a public good is a classic collective action dilemma."[ccxliii] No single country or region acting alone can solve climate change.[ccxliv] Yet waiting for a consensus to emerge within the United Nations also has disadvantages since, at least for the near term, a "coherent, effective and legitimate comprehensive regime [for climate change] . . . is politically unobtainable."[ccxlv] Disagreements began during the Kyoto Protocol to the UNFCCC continue to this day.[ccxlvi] Given the decades-long delay at the global level in finding mechanisms for efficient, fair, and enforceable reductions of greenhouse gas emissions, waiting longer may lead to tragedy.[ccxlvii] Likewise with respect to the problems of space weaponization and orbital debris: inaction may hasten the worst-case scenario.

Professors Keohane and Victor have joined Professor Ostrom in investigating the benefits and drawbacks of smaller forums to manage global climate change that could reach an agreement more easily than is possible through the UNFCCC process.[ccxlviii] This approach has been tried in the Major Emitters Forum (MEF), and at COP15 when President Obama met with

the BASIC group.[ccxlix] However, the 17th Conference of the Parties (COP17) underscored the continuing importance and potential of multilateral engagement as well as the fluidity of multipolar politics as seen in the alliance between the European Union and less developed countries.[ccl] Still, such targeted efforts have lately met with some success, which is why Professor Ostrom has argued that polycentric regulation is "the best way to address transboundary problems, be it the overexploitation of fisheries, or climate change."[ccli] Part III analyzes whether the same holds true for addressing the linked challenges of space weaponization and orbital debris.[cclii]

In summary, according to Professor Ostrom "[t]he advantage of a polycentric approach is that it encourages experimental efforts at multiple levels, as well as the development of methods for assessing the benefits and costs of particular strategies adopted in one type of ecosystem and comparing these with results obtained in other ecosystems."[ccliii] This is an important lesson, in that "simply recommending a single governmental unit to solve global collective action problems—because of global impacts—needs to be seriously rethought and the important role of smaller-scale effects recognized."[ccliv] There is no central authority at the global level making authoritative decisions about payments for energy use and investments in clean technologies.[cclv] Nor is there such a central regulator of outer space, and only the beginnings of one for the deep seabed in the form of the International Seabed Authority (ISA).[cclvi] This is a fundamental problem across many open access regimes, which are unregulated areas that lack well-defined property rights and are open for everyone to use.[cclvii] Though umbrella organizations may exist, such as the UNFCCC or COPUOS, the importance of polycentric action incorporating multiple scales and sectors should not be ignored.[cclviii]

The move to polycentric space governance is a dramatic change of affairs from the U.N. system that has long encouraged the progressive development of international law and its codification by building consensus.[cclix] The fragmentation of this system could foreshadow what might occur in the governance regimes of other global commons spaces without concerted multilateral action. To help maintain the relevance of existing treaty systems in these domains, it is imperative that the traditional CHM concept give way to modern regimes that guarantee property rights and stimulate sustainable development while also promoting international peace and security. This, for example, could include infusing sustainable development policies at multiple regulatory levels, including nationally, as the Obama Administration has recently attempted in its 2010 National Space Policy.[cclx] Whether the existing space regime complex can foster such outcomes remains to be seen.

The 2010 COPUOS declaration is instructive as to the current state of space governance. There, the United States argued that "the international community must come together to measure and reduce the risks to space operation for all,"[cclxi] while also urging states to use national laws to implement needed reforms. Russia called for the implementation of existing agreements in the face of technological advancement and growing commercial interest lest a space arms race commence.[cclxii] The former Libyan government stressed the need to address space junk.[cclxiii] Pakistan argued that space was part of the CHM, and so all military activities should be forbidden.[cclxiv] In the end, Zimbabwe called for the resolution to be tabled, which it then was.[cclxv] This meeting underscores that COPUOS is now little more than a talking shop as maintained by Mr. Doyle,[cclxvi] but also that there is recognition that space law is incomplete, especially with regards to space weaponization and space junk. Many of the multilateral space treaties, including the OST, are more aspirational documents than binding accords with enforceable obligations. In part because of these governance gaps, new national regulations and

norms may be emerging in space to help clarify legal ambiguities through the influence of state and non-state actors, including the private sector. States in particular have become more active in regulating outer space activities, resulting in movements to increase commercialization and potentially make space law more state centric.

F. The National Regulation of Space

This section investigates the extent to which national regulation is supplementing COPUOS and other multilateral fora in regulating the final frontier as one component of an emerging polycentric system. The section begins by briefly analyzing the current legal regime of property rights applicable in outer space before moving on to explore the growth in the national regulation of space.

1. Space, Inc.: Property Rights in Space Law

Commercial space ventures are increasing[cclxvii] even as regulatory frameworks lag behind. The United States has encouraged this activity: "In order to reach the space station, we will work with a growing array of private companies competing to make getting to space easier and more affordable," President Obama exclaimed in a speech on the future of NASA.[cclxviii] Indeed, President Obama referenced the importance of private companies in developing space three times in his approximately fifteen-minute address.[cclxix] This new space industry includes start-up companies like SpaceX and Planetary Resources, branches of established multinational corporations like Virgin Galactic, along with some of the biggest names in aerospace, including Boeing and Lockheed Martin. The United States is attempting to unleash the power of private enterprise to drive down the costs of accessing space.[cclxx] But are the legal regimes in space, most importantly the OST and the Moon Treaty, up to the challenge of a suddenly more crowded final frontier?

Sufficient property rights likely do exist in space law to support burgeoning industry.[cclxxi] Importantly, however, such rights are often ambiguous and are in need of clarification through polycentric regulation and multilateral collaboration to promote sustainable development and avoid collective action problems.[cclxxii] The Moon Treaty, for example, does not per se prohibit the commercial utilization of space resources,[cclxxiii] though it may conflict with OST provisions depending on the interpretation of the CHM concept.[cclxxiv] Indeed, existing space law establishes certain property rights in space.[cclxxv] The International Telecommunication Union (ITU) allocates available orbital resources, including spectra to satellites.[cclxxvi] Indirect property rights are created in this regard since satellite frequencies cannot be separated from orbits given that any change would alter the power of the frequency needed to reach the receiver on Earth. The market administered by the ITU is in some ways a model of effective polycentric governance, though problems of backlog among other issues continue to plague the organization.[cclxxvii] For example, some states, such as Tonga in 1990, have claimed orbital slots as bargaining chips for use in other policy arenas, rather than as efforts to pursue access, underscoring the influence of domestic politics on regulating the space commons.[cclxxviii] And the domestic situation can always change. This may be illustrated by comparing the importance of property rights in the Bush Administration's Commission on

Space Exploration with the Obama Administration's 2010 National Space Policy, which did not explicitly address the issue.[cclxxix] But it remains unclear whether commercial enterprises would be able to operate effectively within existing frameworks given confusion over the CHM concept found in Article XI of the Moon Treaty among other ambiguities.[cclxxx] The situation is further complicated by the widely differing geopolitical bents of the spacefaring powers.[cclxxxi] Examining differing national interpretations of property rights is thus an effective vehicle not only to weigh the relative merits of these arguments as applied to space governance, but also to help gauge the growth of this component of the space regime complex.

2. Analysis of National Space Laws

On July 21, 1969, humans first set foot upon the moon.[cclxxxii] This seminal moment in history was unique in more ways than one. The occasion marked one of the first times that a nation did not claim territory when making landfall on an uninhabited area.[cclxxxiii] The OST was already in place barring such appropriation.[cclxxxiv] This prohibibition, though, has not prevented states from regulating the final frontier. Analyzing national space laws helps develop a culturally relative theoretical framework to aid in explaining differing approaches toward space governance. Contrary perspectives are apparent when comparing developed and developing countries. East-West, and to an extent North-South, divides are also prevalent. This section categorizes the space powers into three camps in an effort to explain this divergence: liberal institutionalists, market rationalists, and communal neo-realists. This division is far from a perfect system, but it helps to illustrate how the varying legal cultures of these countries have influenced their national space policies. This categorization in turn also helps illuminate the difficulty in international law of providing a cohesive, uniform approach to space governance within an environment composed of such culturally diverse actors.[cclxxxv]

According to the U.N. Office of Outer Space Affairs (OOSA) Compilation of National Space Laws from the U.N. Nigeria Workshop on Space Law, eighteen countries have passed forty-five relevant space acts or executive orders since the beginning of the Space Age.[cclxxxvi] The most active governments, defined as those that have enacted three or more laws, resolutions, edicts, decrees, or other legal acts during this period, have been Australia (enacting four laws during this period), Brazil (three), France (three), Italy (four), Russia, (six), Ukraine (three), and the United States (seven).[cclxxxvii] The comprehensive mission statements on national space activity passed in Canada, Chile, and China are also relevant.[cclxxxviii] Together, the content of these instruments helps to reveal how these national governments approach the issue of managing global common pool resources. "Spacefaring countries such as France, Germany, Japan, Israel, India, Russia, China, and Brazil"[cclxxxix] have diverse economies and fall at varying points in the political-economic spectrum. This is reflected in how these governments approach regulating space activities. Through this lens, it is possible to gain new insights into how space might unfold as an astropolitical arena of international cooperation and conflict.[ccxc]

Space policies must fit within a State's laws, as well as within its political and economic interests.[ccxci] As these interests vary, so too do the content and style of space legislation. Belgium has passed a law on launching, flight operations, and the guidance of space objects,[ccxcii] while Germany has been more concerned with governing the transfer of responsibilities for space activities.[ccxciii] One common area of legislative action involves the promotion of international space cooperation. Canada, Chile, China, Russia, the Ukraine, and the United States have all included such provisions in bills and executive orders.[ccxciv] During the 1980s and

1990s, when the number of national space laws increased dramatically, several of these acts dealt with the ISS.[ccxcv] Nations such as Chile have also been codifying these provisions to advocate for peaceful use and to reinforce the channeling of international scientific, technological, and economic cooperation.[ccxcvi] This is consistent with the original OST,[ccxcvii] and may bode well for multilateral progress in managing common problems such as orbital debris.

Another common area of legislative of activity has been national bans on placing weapons of mass destruction in space or on celestial bodies.[ccxcviii] This topic is addressed in Part III.[ccxcix] But the most recent and prevalent phenomenon among these more than forty-five legal instruments, by far, are the number related to commercial activity: Nearly half, implicitly, and one-fifth, directly, address commercial activity.[ccc] This reflects the growing influence of the private sector in space as an important actor in this emerging polycentric system.

a) Commercial Space and the Market Rationalist Approach

The private sector has in part driven the proliferation of domestic space legislation designed to stimulate competition and commercialize government space operations. Although not universal, the list of countries with commercial space laws includes most of the major spacefaring powers such as the United States, United Kingdom, the Russian Federation, Japan, Australia, and China.[ccci] The U.S. Congress has been among the most proactive legislative bodies, as seen with the 1998 Commercial Space Act, which amended the 1984 Commercial Space Launch Act.[cccii] These acts include provisions dealing with the ISS and space development, stating: "[A] priority goal of constructing the International Space Station is the economic development of Earth orbital space. Congress further declares that free and competitive markets create the most efficient conditions for promoting economic development."[ccciii] Such laws have been helped by to some extent by lobbying efforts, showcasing the effect of domestic politics in space governance.[ccciv]

Japan is similar to the United States in that its long-range space program calls for promoting space access and helping other nations develop space resources. The Japanese Long Term Vision for Space Development sets out a basic philosophy regarding space exploration to: "enable access to the vastness of space and use the infinite potential of space as the common property of mankind . . . ."[cccv] Industry lobbying groups have been active in Japanese space policymaking.[cccvi] The impact of these efforts is evident in Article IV of the Japanese Aerospace Exploration Agency's (JAXA) 2025 Vision, which calls for "lunar utilization," and establishing "indigenous technologies" to develop the Japanese aerospace sector.[cccvii]

Both the United States and Japan may be termed *market rationalists* in that they recognize the value of international management, but are wary of imposing too many constraints on entrepreneurs operating in space. The CHM concept is thus viewed with some disfavor as applied to space governance.[cccviii] This fact could prove useful in forming a coalition if and when the issues of property rights, orbital debris, and weaponization reach the level of multilateral negotiations.

b) Liberal Institutionalists

According to Professor John Jackson, "In Europe, the Brussels institutions have expressed a strong desire for policy at the international level."[cccix] This has carried over to an extent in regulating outer space. In a joint ESA-EU statement, the ESA's Director General, Jean-Jacques Dordain, stated:

> [S]pace is an international field. A coherent European Space Policy does not make any sense if not grounded in the larger global context. Unlike in the days of the Cold War, getting to the Moon and Mars is not about proving one's superiority over a political enemy. It is about . . . working together for the common benefit.[cccx]

Much of Europe (with the potential exception of the United Kingdom)[cccxi] as well as many developing nations may be deemed *liberal institutionalist*. They favor establishing international regimes for the benefit of all humanity as a solution to managing the space commons. Australia, along with the twelve other signatory nations of the Moon Treaty, may also be considered liberal institutionalists.[cccxii]

c) Communal Neorealists

China, and to a lesser extent India and Brazil, are representative of a third group. These countries are major emerging markets that are naturally predisposed to supporting an international regime that promotes their own continued rapid economic development, but that in some cases do not share Western property rights traditions.[cccxiii] This special situation gives rise to their label as *communal neorealists* in that they are sympathetic to the equitable component of the CHM concept, but place economic development as their priority.[cccxiv] Given the rising power of communal neorealists, this group requires special analysis.

China's space policy, among the world's most active and robust, is an illustrative example. The Chinese government directs its space agency through a "socialist market economic mechanism" as part of a "comprehensive development strategy. . . ."[cccxv] Given that private property rights do not exist in mainland China except in specially designated enclaves,[cccxvi] it seems unlikely that China would choose to advance such rights in the commons. Yet, certain voices within China have indirectly criticized the CHM.[cccxvii] As China continues its own transformation, its conception of property rights might evolve alongside its stance on space weaponization that is described in Part III. China has participated in international space cooperation since the mid-1970s, and has since then joined numerous bilateral, regional, multilateral, and international agreements. Starting in 1983, China acceded to the OST and three other principal space treaties, but not to the Moon Treaty.[cccxviii]

China's situation is comparable to India as both countries have active space programs and are large emerging markets.[cccxix] The Indian Space Research Organization (ISRO) enjoys a deep relationship with NASA, unlike China's program, which is pursued on the U.S. side for political reasons. India, however, cannot yet match China's economic prowess or potential as a space power.[cccxx] Some assert that a space race is brewing between these Asian giants with an Indian general stating, "with time we will get sucked into a military race to protect our space assets and inevitably there will be a military contest in space."[cccxxi] Looking further afield in Asia, "South Korea is not far behind India and Japan, whilst Malaysia, Singapore and Taiwan also have impressive satellite capabilities."[cccxxii] Brazil, being an observer to the Bogotá

Declaration, has argued in favor of the CHM concept in the past while also maintaining its belief in the principle of national sovereignty over natural resources.[cccxxiii] Brazil also has a burgeoning commercial space sector, [cccxxiv] and being another large emerging market may cause it to fall into the communal neorealist camp.

G. Summary

The interplay between market rationalists, liberal institutionalists, and communal neorealists will do much to shape space governance in the twenty-first century. Loose coalitions could be formed between these and other camps. Multilateral cooperation is critical to avoid the tragedy of the space commons in an era of increasing national and private sector attention to space, even as the lack of consensus on new multilateral treaties will likely increase the importance of fashioning effective polycentric regulations. Beyond differences over national regulations, however, the overarching factors of resource scarcity, advancing technology, and multipolar politics are also influencing the ongoing debates over space weaponization and orbital debris. This is investigated in Part III.

III. AVOIDING THE ULTIMATE TRAGEDY OF THE COMMONS: MANAGING SPACE WEAPONIZATION AND DEBRIS WHILE PROMOTING PEACEFUL, SUSTAINABLE DEVELOPMENT

This Part examines the applicability of polycentricity to managing the issues of space weaponization and debris. To support this analysis, Section A focuses on space weaponization, and investigates whether the current legal framework is effectively managing this emerging problem. Section B then considers a central consequence of the unregulated status of space weaponry: the collective action problem of orbital debris. Section C explores the effectiveness of the space weaponization and orbital debris regimes. Section D finally offers a proposal, based on some principles of polycentric governance, to enhance sustainable management of space.

A. The End of the Peaceful Use of Outer Space?: Weaponizing the Final Frontier and its Consequences

Military imperatives have long shaped space law.[cccxxv] The OST stresses the peaceful use and exploration of space.[cccxxvi] Yet, space law is becoming more similar to the LOS in that space is an arena in which the great powers want to preserve their freedom of access through buttressing national regulations. Additionally, "peaceful" has come to mean merely "non-aggressive."[cccxxvii] The United States, for example, interprets Article IV of the OST so as not to bar U.S. defense and intelligence-related activities in space.[cccxxviii] This section analyzes the debate over space weaponization in juxtaposition to the LOS in order to determine whether polycentric governance may help bring peace to the final frontier.

Unlike the LOS, the rules and prohibitions regulating military activity in space did not come from a multilateral forum like UNCLOS III. The rules regulating military activity in space were largely the result of bilateral agreements between the spacefaring powers. Many of

these agreements were part of larger arms control treaties, like the 1963 Atmospheric Test Ban Treaty prohibiting nuclear detonations in outer space,[cccxxix] and Article V of the 1972 SALT I agreement forbidding the testing or deployment of anti-ballistic missile systems (ABMs) in space.[cccxxx] But this agreement did not end interest in ABM or ASAT technology. Both superpowers had been experimenting with ABM technology since the 1960s, with the Soviet Union staging at least twenty ASAT tests from 1968-1982.[cccxxxi] The United States had a successful ASAT test in 1985, but development stopped after political issues and funding shortfalls.[cccxxxii]

One of the greatest challenges to the peaceful use of space was President Reagan's Strategic Defense Initiative (SDI), or "Star Wars." Critics argued that the policy violated the spirit of the OST, while supporters maintained that the program did not involve any WMDs.[cccxxxiii] This episode demonstrates the difficulty in framing the debate on space weaponry. The term "space weaponry" is so broad that it could include nearly anything from jammers to lasers and physical ASAT weapons.[cccxxxiv] This vague terminology frustrates policymaking. If a nation were to detonate a nuclear weapon in orbit, it would generate an electromagnetic pulse sufficient to knock out most orbiting satellites in violation of the OST.[cccxxxv] Such a test disabled all orbiting satellites in 1962, prior to the negotiation of the OST, and disrupted television signals in Hawaii for months.[cccxxxvi] Yet it does not take a nuclear detonation to negatively impact the space environment, as shown by the China 2007 ASAT test,[cccxxxvii] underscoring the fragility of the space commons and the complicated task faced by lawmakers.[cccxxxviii]

The Obama Administration has been more receptive than the Bush Administration to addressing space weaponization in a multilateral format. For example, the White House updated its website shortly after President Obama was inaugurated with a pledge to both ban weapons that interfere with satellite operations and restore U.S. leadership on space issues.[cccxxxix] But enacting a global ban space weapon is difficult. Confounding issues include defining a "space weapon," as well as associated international relations and security challenges.[cccxl] President Obama acknowledged these challenges during his election campaign, calling for "a code of conduct for responsible spacefaring nations" as a potential interim measure as multilateral negotiations proceed.[cccxli] Thus far, however, this policy shift has not generated much success. Encouragingly, however, the European Union drafted a code of conduct for spacefaring nations in 2010 that includes the need to reduce orbital debris,[cccxlii] potentially opening the door for further negotiations on norms.[cccxliii]

One of the reasons for this impasse is the divergence between realist and liberal views on space cooperation. Some realists view space as a zero-sum game in which the United States' ability to dominate space preserves the peace, while some liberals see space cooperation as a positive-sum game furthering mutual interests.[cccxliv] At the root of the problem is preserving access to the space commons by exerting space power, which the U.S. Joint Chiefs of Staff defines as "the total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives."[cccxlv] Defending this strategic high ground is imperative to U.S. national security, making multilateral cooperation problematic even as it is championed in the 2010 U.S. National Space Policy as one way "to mitigate orbital debris."[cccxlvi]

The legal regime on space weaponization now includes an allowance for overhead surveillance and a prohibition on the deployment of WMDs,[cccxlvii] as has been discussed. But space weapons are broader than just WMDs, and differentiating weapons from debris is legally

and technically daunting. Negotiations over the continued peaceful use of space have been ongoing at the U.N. Disarmament Committee's Ad Hoc Committee on the Prevention of an Arms Race in Outer Space, but without significant result.[cccxlviii] With the rise of the Chinese space program and a renewed interest in ASAT technology around the world, U.S. hegemony in space is being challenged.[cccxlix] This is in part due to the dual-use nature of outer space,[cccl] with some commercial satellites being equally capable of producing meteorological observations as monitoring troop movements. Consider China again as an illustrative example.

There is evidence that China views space weapons as a means to help achieve "information dominance" by 2050, [cccli] which would likely be used as part of "integrated network electronic warfare."[ccclii] Major General Liu Jixian, paraphrasing President John F. Kennedy, has observed, ". . . whoever controls space controls initiative in war."[ccliii] Overall, an analysis of Chinese sources on space warfare leads to two main conclusions: China views space warfare as likely during an armed conflict with the United States, and China must prepare for this eventuality by developing space weapons.[ccliv] A potential touchstone for such a conflict is the prospect of a U.S.-backed Taiwanese declaration of independence.[ccclv] China's burgeoning space weapon capabilities may foreshadow "what other countries with space programmes, such as Russia, Iran, and North Korea, could do in [the] future."[ccclvi] Yet despite its investment, China has also favored a ban on space weapons since 1985.[ccclvii] Some argue that its January 2007 ASAT test was to coerce "the United States into negotiating a space weapons treaty," but the "breadth and sophistication" of China's efforts undermine this notion.[ccclviii]

Despite several false starts, there have been renewed calls for a new multilateral push for a space weapons treaty, such as the Prevention of an Arms Race in Outer Space (PAROS) to better manage the growing problem of space weaponization.[ccclix] Russia and China proposed such a treaty in 2002 at the U.N. Conference on Disarmament, which included provisions banning "any kinds of weapons" in orbit, but omitted ground-based systems.[ccclx] This omission would enable Russia and China, both of which enjoy ASAT capabilities, to continue developing these systems unhindered.[ccclxi] It is therefore doubtful that this proposal, as it currently stands, would be acceptable to the United States and its allies, or prevent war in space. Professors Nancy Gallagher and John Steinbruner have proposed an alternative version of PAROS that prohibits all interference with space-based assets and includes a "'robust' verification, monitoring, and inspection regime."[ccclxii] While an improvement, this proposal still has a number of loopholes. It leaves out jamming and other technologies, for example, which makes U.S. support doubtful.[ccclxiii]

"[S]pace is already weaponized,"[ccclxiv] and existing international law is inadequate to address this reality.[ccclxv] So far, the emerging space regime complex has proven unable to arrest this trend because of both domestic and multipolar politics. Space systems include satellites, launch facilities, command and control facilities, and data downlink nodes.[ccclxvi] The most difficult way to interfere with these systems is by attacking satellites directly with ground-based missiles. An easier way would involve targeting ground-based command and control facilities or launching cyber attacks to gain control of either the satellites directly, or failing that vulnerable commercial satellites to crash them into military spy satellites.[ccclxvii] This technique would create a cloud of debris reminiscent of the 2007 Chinese ASAT test, destroying and damaging other satellites and further exacerbating the problem of space junk.

B. Space Junk as a Collective Action Problem

States are required under international law "to avoid activities that would be harmful to the environment of the earth or to celestial bodies . . . ."[cccLxviii] This provision is a key part of fostering sustainable development in space, but it is also left undefined, like so much of space law. Some progress was made during the 2002 World Summit on Sustainable Development, when the Group on Earth Observations (GEO) was created to coordinate "the work of researchers from 79 governments, the European Commission, and 56 intergovernmental, international and regional organizations" on the sustainable space habitat.[cccLxix] But the GEO has yet to deal with space junk. Given the relative lack of multilateral attention, the private sector has formed the Space Data Association to protect their multi-billion dollar investments in satellite hardware.[cccLxx] Such private sector leadership could become a common feature of norm development within this emerging regime complex, highlighting the limitations on progress without multilateral coordination. Recognizing the reality of governance gaps, there have been calls for "international regimes to contribute to the openness of the space commons" by battling "the common enemy of all spacefaring nations: orbital debris."[cccLxxi] This section argues that space junk is a collective action problem that may only be solved through concerted action embracing the sustainable development of orbital space at each regulatory level, including multilaterally.

Given that the space commons is a largely open access regime, it is prone to three well-studied issues in the economics literature: the collective action problem, the free rider problem, and the prisoner's dilemma. Collective action problems are a classic "social dilemma."[cccLxxii] People tend to maximize their short-term personal interests instead of the collective good. This is a dilemma, in economic terms, because there is "at least one outcome [that] yields higher returns for *all* who are involved, but participants . . . maximizing short-term benefits make independent decisions and are not predicated to achieve this outcome."[cccLxxiii] According to Professor Ostrom, "[t]he socially optimal outcome could be achieved if most of those involved 'cooperated.'"[cccLxxiv] But no one is motivated to change "[s]ince the suboptimal joint outcome is an equilibrium . . . given the predicted choices that others will make."[cccLxxv] The essence of social dilemmas is this "conflict between individual rationality and optimal outcomes for a group."[cccLxxvi] Just as rational individuals free ride, so too do states.

Closely connected with the concept of collective action problems is the problem of free riding and the prisoner's dilemma. According to Professor Ostrom, "[F]ree riders enjoy the benefit of others' restraint in using shared resources or others' contribution to collective action."[cccLxxvii] But if many individuals decide to free ride in this way, the "others" may stop contributing to the collective good, until "eventually no one contributes", a situation called "collective *in*action."[cccLxxviii] One illustration of free riding behavior is the classic prisoner's dilemma in which there are gains to be had from cooperation, but each player has an incentive to free ride.[cccLxxix] The prisoner's dilemma is important because it can be modeled on any instance in which two (or more) players have an incentive to free ride, even though cooperation is in their best interest.[cccLxxx] Such examples range from the arms race between the United States and the former Soviet Union discussed above to modern-day climate change negotiations.

Collective action "predicts that no one will change behavior . . . [without] an external authority impos[ing] enforceable rules that change the incentives faced by those involved."[cccLxxxi] It is this animating problem that causes many scholars to call for global regulation of the global commons.[cccLxxxii] But the classic theory of collective action should not be uncritically assumed. Professor Ostrom identifies two broad reasons why reliance on this conventional theory is unwise: (1) a lack of empirical support that exists because "a

surprisingly large number of individuals facing collective action problems do cooperate[,]"[cccliii] and (2) the existence of multiple externalities at all scales.[ccliv] Moreover, "[r]ational choice theory [is] used as a foundation for the conventional theory of collective action."[cclv] The theory works well in the context of private goods in competitive environments, but is less useful when participants know and trust one another.[clvi] As the number of space powers multiplies and multipolar politics continues to hamper consensus-building measures, orbital debris remains a collective action problem; it is in the best interest of all participants to cooperate and not defect.

As with the number of space actors, the number of space objects is increasing as well. The U.S. Congress Office of Technology Assessment estimates that in total, as many as 4,500 spacecraft have been launched since the dawn of the Space Age in 1957; approximately 2,200 of which remain in orbit, whereas 450 remain functional with the rest considered debris.[clvii] But these non-functional spacecraft constitute only a small fraction of the "junk" orbiting the Earth. According to Professor Susan Buck, "At least 50,000 objects one-inch or more in diameter"—ranging from spent rocket boosters to nuts and bolts—"are in orbit."[clviii] The sheer number of objects makes attribution and dispute settlement key components of international space law.[clix] But the applicable international space law offers no formal dispute resolution authority.[clx] Orbital debris can cause substantial damage to spacecraft. The Space Shuttle was struck with a fleck of paint in 1983, cracking its windscreen.[clxi] Nor does this problem effect only the United States. For example, "[i]n 2008 . . . U.S. and French officials admitted moving spacecraft eight times to avoid debris.[clxii] This debris can be a weapon in its own right, clogging the arteries of geosynchronous orbit slots and decreasing the effectiveness of space-based assets. But as with space weaponry generally, little progress has been made on addressing the problem of space junk due in part to the multipolar state of international relations. This is demonstrated by examining the aftermath of China's 2007 ASAT test.

As mentioned in the Introduction, China performed a successful ASAT test in January 2007 that destroyed an aging Chinese weather satellite and resulted in at least 900 objects large enough to be tracked.[clxiii] NASA's Orbital Debris Program Office is estimating more than 35,000 pieces larger than one centimeter,[clxiv] making this the largest debris-generating event in history and increasing total orbital debris by as much as twenty-five percent in a single stroke.[clxv] Estimates show that the strike has increased the chances of catastrophic collisions from once every nineteen years to once every twelve to fourteen years.[clxvi] The ISS is already regularly dodging fragments.[clxvii] The Chinese took this act after years of protestations about the destabilizing effects of ASAT technology. Yet this was a single ASAT test on a non-nuclear satellite. The open question is what the security and environmental results would be in a conflict in which multiple satellites, some of which may be nuclear, are destroyed. The breakup of a single large satellite of ten tons could roughly double the amount of orbital debris now in low-earth orbit.[clxviii]

The problems associated with satellites that possess nuclear or radioactive components exacerbate the problem of space debris. In total, "[m]ore than fifty satellites with radioactive components have been launched; [and] at least six nuclear-powered satellites have had uncontrolled re-entries . . . ."[clxix] An early problem with radioactive space debris occurred in January 1978, when the Soviet nuclear-powered satellite *Cosmos 954* disintegrated over Canada.[cd] Estimates of the total amount of radioactive material now in orbit range are as high as one metric ton.[cdi]

Nor is all space junk accidental; some debris has been placed into orbit purposefully.[cdii] For example, in 1961, Project West Ford launched a payload of small copper filaments that reflect radio waves to test the usefulness of passive reflectors. The experiment was a failure, but "350 million copper filaments continue to orbit the Earth."[cdiii] Even though space is immense, the sheer amount of junk now in orbit makes close calls nearly a daily occurrence. In February 2009 alone, a Iridium communications satellite collided with a dead Russian military satellite,[cdiv] an event that went largely unreported. Such instances have prompted a retired NASA scientist to comment, "We've lost control of the environment."[cdv]

The 1972 Liability Convention offers several legal avenues to address space debris. First, the Convention provides a process for presenting claims against launching states.[cdvi] Second, it defines the rights and obligations of launching and victim states. The major difficulty is determining the origin of the space debris at issue.[cdvii] Identifying the nationality of a screw travelling nearly 18,000 mph is no easy matter. Attribution, then, is a key problem in managing space junk. This issue is addressed in part by the 1974 Registration Convention, which elaborates on Article XI of the OST and requires States Parties to report the nature, conduct, locations, and results of launched "space objects."[cdviii] But given the minimal size needed to damage spacecraft, and the fact that debris are not individually readily identifiable, the Registration Convention helps the problem more in theory than in practice. There is also the problem that the Liability Convention covers only states and some intergovernmental organizations like the ITU, but does not explicitly include private corporations.[cdix] Given these governance gaps, it is worth exploring how well the space regime complex has performed to date.

C. Regime Effectiveness of Space Governance

The literature on international regime effectiveness has not yet dealt extensively with space governance as applied to orbital debris and space weaponization.[cdx] Thus, an examination of the interdisciplinary literature on regime effectiveness, drawing from the international environmental and human rights literatures, is needed to help gauge how effective evolving regimes have been in managing collective action problems arising in the space commons.[cdxi] Measuring the effectiveness of regime complexes is a difficult proposition, however, since the governance structures at work are diverse and not easily amenable to quantifiable comparison, unlike, for example, the impact of environmental treaties on emissions reductions.[cdxii] At best, correlations may be highlighted. Ultimately the success or failure of the space regime complex cannot be adequately measured solely in terms of the volume of space debris. Nevertheless, some qualitative and quantitative analysis of the performance of legal regimes governing the space commons is possible by comparing the performance of that regime to an ideal type as well as to a no regime counterfactual. Creating such an ideal type is difficult, but one candidate would be a system in which collective action problems are mitigated such as by debris no longer threatening space exploration or infrastructure, future development made more sustainable, and the risk of international conflict is minimized through effective dispute resolution.[cdxiii]

Regime effectiveness has become a "driving force in the analysis of international relations."[cdxiv] Empirical studies have concluded that there is modest support for the proposition that international agreements improve on the status quo.[cdxv] This research is also relevant to the debate between neorealist and neoliberal institutionalist scholars.[cdxvi] Neorealist scholars are

generally "pessimistic about the effect of institutions" and would expect that institutions do not matter, while institutionalists assert that they do in fact matter.[cdxvii] The fact that scores typically fall somewhere in between suggests that neither extreme is accurate,[cdxviii] and instead a nuanced view of the benefits of institutions is more appropriate.

Given the above caveats, the literature on international environmental regime effectiveness presents a prescient comparison to space law. Professor Oran Young has been among the most prolific scholars in this area, positing five main approaches for measuring effectiveness: the problem-solving, legal, economic, normative, and political approaches.[cdxix] A combination of the legal and political approaches is used here to analyze the regime performance of space governance relating to space weaponization and junk.

Analyzing the primary treaties relating to space weapons and orbital debris illustrates several important trends in space governance. Most notable is the decline in multilateral efforts to manage the space commons, which may be exemplified by the increase in the amount of time it took treaties to enter into force, going from eight months for the OST to 55 months for the Moon Treaty.[cdxx] This trend is also exemplified by the decrease in both the number of ratifying and signatory states to the principal space law treaties from 1967 to 1984,[cdxxi] and by the fact that there has not been a major multilateral treaty related to space governance negotiated since the end of the golden age of space law in 1982.[cdxxii] Given these data, there seems to be empirically little apparent international support for a new round of international space policymaking. However, the growing prevalence of orbital debris may change the suboptimal status quo. How have these existing treaties managed the problems of space weapons and junk since their ratifications?

Measuring the extent of space weapons is difficult given the definitional problems stated above. Focusing solely on launched spacecraft helps illustrate one facet of the overall picture. Of the spacecraft that have been launched worldwide since the dawn of the space age in 1957, approximately fifty-four percent have been military in nature.[cdxxiii] In 2011, for example, out of the eighty-four worldwide launch attempts, only "18(21 percent) were commercial in nature," fifty-six percent of which originiated in Russia, twenty-two percent in Europe, and eleven percent in China.[cdxxiv] There was a decline in military satellite launches beginning in the late 1980s when the United States and the Soviet Union halted ASAT testing, fuelled by congressional bans and voluntary Russian moratoria.[cdxxv] More recently, however, there has been an uptick, with emerging powers such as China and India alone launching more than forty spacecraft since 2007.[cdxxvi] In some ways this is nothing new. According to Professor Joan Johnson-Freese, a space policy analyst at the U.S. Naval War College, "Space has been militarized since before NASA was even created."[cdxxvii] However, some argue that these figures allude to a new space weapons race heating up.[cdxxviii] Due to the often-covert nature of ASAT capabilities, it is difficult to ascertain a clear picture as to current levels of ASAT testing. Beginning with the Chinese ASAT test in 2007 however, the United States, China, Russia, and India in January 2010, have all either begun or reinvigorated their ASAT programs.[cdxxix] The Missile Technology Control Regime has helped spur some progress in discussions between like-mind countries in managing this growing problem,[cdxxx] but it is focused on nuclear weapon delivery[cdxxxi] meaning that so far the specter of a space arms race has not been arrested.[cdxxxii]

These data may be compared to the rate of orbital debris proliferation since the golden age of space law ended in 1982. Unlike the rapid decline and recent uptick in military spacecraft, orbital debris has shown a dramatic increase, rougly quadrupling over the past thirty

years.[cdxxxiii] Now with over fifty nations participating in the space commons, the amount of debris is expected to triple again if current trends continue.[cdxxxiv] Neither the Registration nor the Liability Conventions have proven effective in mitigating this risk. With the growing risk of ASAT attacks in future international conflicts, the space environment is ripe for a tragedy of the unmanaged commons scenario to unfold. Without concerted multilateral action, Marshall Kaplan, an orbital debris expert within the Space Policy Department at the Johns Hopkins University, argues, "There is a good chance that we may have to eventually abandon all active satellites in currently used orbits."[cdxxxv] There has been a recent move towards bilateral and regional partnerships to address orbital debris, such as the Space Situational Awareness Partnership between the United States, France, and Australia. This partnership might "include development of a joint tracking facility . . . ."[cdxxxvi] It remains to be seen whether these partnerships, in conjunction with the public and private sector initiatives mentioned above, prove sufficient to mitigate orbital debris and weaponization. Technological advancements will surely help. But as with the LOS, the regime effectiveness of space law cannot be measured in reference to debris and weaponization alone. At best these are useful assessment tools that should be supplemented with additional research and data to move beyond correlations and begin to get clearer answers about space governance best practices.

Regarding the no regime counterfactual, how would the space commons look today if the space and test ban treaties would not have been ratified? In other words, have these legal regimes enhanced cooperation consistent with OST Article IX?[cdxxxvii] Although there are gaps in current space law, the space law treaties have provided a framework for governance that has proven at least partially effective. There has not yet been a genuine war in space. Nor has any nation claimed the moon or any other celestial body. Given the true free-for-all that would be possible in the absence of any regulation, it is clear that current space laws are preferable to none at all. Moreover, despite the lack of multilateral progress to manage space weaponization and orbital debris, it is encouraging that non-State actors and Member States are negotiating in small groupings, as well as through forums like COPUOS and the ITU.[cdxxxviii] This polycentric interaction may help speed progress. Hugh Ward has argued, "[W]hen nations participate in particular regimes they also become part of a wider network. This network links nations and also individual regimes. It embodies social capital that may be used to encourage nations to behave sustainably."[cdxxxix] This creates a synergistic effect, a virtuous cycle whereby nations and institutions involved in an international regime like space law have strong social influences within that regime to abide by its stipulations and create common codes of conduct. Creating a Space Forum of like-minded, spacefaring nations in the mold of the Major Emitters Forum or the Missile Technology Control Regime, could begin to address issues of common concern such as orbital debris and weaponization by drafting codes of conduct and norms for space operations.

D. The Future of the Final Frontier

What is the future of space governance? At least two approaches seem evident. The first is to proceed with building polycentric governance structures featuring more national regulations, bilateral accords, and norm building. This appears to be the most politically viable option at present.[cdxl] The second would be to treat outer space comprehensively as part of the global commons through new protocols and multilateral accords on weaponization, debris, and

property rights designed to incentivize sustainable development.[cdxli] Space constraints prohibit a comprehensive discussion of the myriad outstanding issues related to these policy choices.[cdxlii] Instead, various approaches are briefly considered aimed at managing these issues more effectively.

Currently, the international legal framework is not in place to effectively manage orbital debris. Individual spacefaring states are subject to a modified prisoner's dilemma in which they need to safeguard their assets. In doing so, some states are exacerbating the chance of future conflicts through a destabilizing space weapons race. How might space weapons and orbital debris be better managed within a polycentric framework? The leading space agencies of the world have formed the Inter-Agency Space Debris Coordination Committee (IADC) to address orbital debris issues and to encourage operations in Earth's orbit that limit the growth of orbital debris.[cdxliii] In addition, orbital debris has been a topic of assessment and discussion at COPUOS since the late 1970s. Both IADC and COPUOS have published space debris mitigation guidelines, which are multi-year work plans on the long-term sustainability of space.[cdxliv] Multilateral meetings are planned to build upon these guidelines,[cdxlv] which could be used as an opportunity to include other stakeholders including private sector representatives as well as civil society groups. The status quo would be greatly improved by working to make these guidelines binding on participants – an initiative that seems to enjoy the support of the Obama Administration[cdxlvi] – as well as having spacefaring powers incentivize states to adopt them through national legislation to limit free riders, and including verification mechanisms to ensure compliance.[cdxlvii] Given the difficulties in reaching multilateral consensus, such multilevel and multi-sector initiatives are in keeping with a polycentric analysis.[cdxlviii] Other top-down proposals, such as a limited test-ban treaty for ASAT weapons, have not yet garnered significant political support.[cdxlix] At present there is insufficient political will to push for globally binding multilateral treaties to manage the related problems of space junk and weaponization, bringing into sharp relief the inadequacies of consensual space governance in a multipolar world. Perhaps recognizing the political infeasibility of negotiating such accords, the OOSA called upon all states in 2011 "to take measures at the national, regional, interregional and global levels" to preserve the space environment for future generations.[cdl] The UNGA has similarly added the objective of sustainable development in 2010 alongside international cooperation to foster the peaceful use of space.[cdli] Such action serve to reinforce efforts by the United States, the EU, Japan, Australia and other nations to begin negotiating to establish best practices while undertaking action at each regulatory level. Eventually, such a group of like-minded nations could expand to include the other spacefaring powers, including Russia and China, as well as non-state groups, creating a Space Forum as was described above.[cdlii] As with the Arctic Council, a body composed of the Arctic States, could undertake measures designed to enhance sustainability in order to build goodwill before negotiating over thorny security matters such as space weaponization.[cdliii] As with climate change, there is no time to waste to avoid the tragedy of the space commons.

What hope is there then for the CHM concept in an increasingly polycentric regime complex? Given the decreasing importance of the CHM in negotiations over global common pool resources, the open question is whether sustainable development offers an alternative legal concept that might better manage orbital space.[cdliv] Sustainable development is defined in the Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[cdlv] The term has found expression in numerous contexts.[cdlvi] In the CHM context, sustainable development marks the integration of

the development and environmental dimensions of the CHM concept.[cdlvii] Sustainable development also has relevance for environmental protection in the economic exploitation of natural resources generally.[cdlviii] The International Law Association's New Delhi Declaration on Principles of International Law Relating to Sustainable Development bears a striking resemblance to those principles comprising the CHM concept. Both endorse non-appropriation, common management, equitable benefit sharing, peaceful use, and preservation.[cdlix] This underscores the degree to which the core features of the CHM are alive and well in the sustainable development movement.[cdlx] Combining the ILA iteration of sustainable development with common but differentiated responsibility and the precautionary principle would help foster the sustainable development of the space commons.[cdlxi] Instead of waiting to do so in a future treaty, however, these principles may be infused in the growing network of private, national, bilateral, regional, and multilateral regulations without delay.[cdlxii]

The future of the final frontier is at a crossroads. The most comprehensive approach to securing outer space is a new multilateral accord designed to mitigate space debris and weaponization.[cdlxiii] COPUOS remains the best forum in which to negotiate such an accord, and the role of the United Nations is central to continued multilateral progress in space lawmaking. But reaching consensus on multilateral space initiatives is becoming increasingly difficult in a multipolar world. The OOSA's call for polycentric regulation and sustainable development is a necessary step to curtail the collective action problems of orbital debris and complement stalled multilateral efforts. Responsible spacefaring powers should welcome such a dialogue and make every effort to reduce risk and gain consensus on crafting new regulatory frameworks for outer space that are as equitable, secure, and sustainable as possible. The international community will lurch from crisis to crisis without action, challenging the continuation of a relatively peaceful final frontier.

Conclusion

This Article has shown that multipolar international relations, interrelated national security considerations, advancing technology, and scarcity have collectively shaped space governance both during and after the golden age of space law. The evolution of space law has also illustrated the growth of a space regime complex featuring a greater role for the private sector and national governments going forward. Instead of multilateral treaties negotiated through COPUOS, many nations are negotiating bilateral and regional agreements to regulate space. Where recent multilateral action has been taken, such as the space debris mitigation guidelines, so far it is has non-binding.[cdlxiv] Though the private sector has played an important role in tracking space debris, the problem cannot be solved without multilevel and multi-stakeholder cooperation. The lack of legally binding regulation has made addressing the pressing and interrelated problems of space weaponization and orbital debris difficult. This has exacerbated these collective action problems and underscores the need for instilling sustainable development policies at all regulatory levels.

This Article has demonstrated some of the benefits and drawbacks of a polycentric approach to global collective action problems. Nations and the private sector working separately cannot effectively address global collective action problems, like space junk, weaponization, or piracy, without the support of the international community.[cdlxv] The results of this study highlight the gridlock that can result from certain regime complexes. The United States, being the dominant space power, should do more to engage other responsible spacefaring

nations in a multilateral dialogue to sustainably develop the space commons and to increase organizational coordination.[cdlxvi] Efforts should also continue to negotiate an Agreement on Long-term Sustainability of Outer Space Activities, given that space debris is a common problem and thus a better entry point than space weapons, which must overcome formidable national security concerns. On the whole, policymakers should consider moving toward a polycentric framework in addressing space weaponization and debris given current international geopolitical divides, while continuing complementary multilateral efforts.[cdlxvii]

As Part III made clear, the ultimate redefinition of sovereignty in outer space will depend in part on relations between the main space powers, including the United States and China. Depending on future developments, this could either help usher in a second golden age of space law, a gilded age of serious problems such as proliferating weapons and debris hidden beneath a veneer of cooperation, or even eventually begin a second space race. The only question is whether new initiatives will occur proactively with the international community laying out effective legal regimes, or retroactively by formalizing a sub-optimal status quo. The answer to this question turns on international politics and the changing conceptions of sovereignty over the global commons in the twenty-first century.

For an international regime to be effective, it must benefit from the political goodwill of the spacefaring powers and satisfy both private industry and developing countries. Proposing a regime that clarifies the CHM concept, such as by rebranding sustainable development policies, and defines property rights, could create stability. This may be done through ratifying the Moon Treaty and then subsequently negotiating a new protocol in the tradition of the 1994 New York Amendments that modified UNCLOS III.[cdlxviii] It is still the cost of accessing space, as well as the interrelated lack of adequate demand, and not legal issues that remains the primary hurdle to development.[cdlxix] If the sustainable development of space is to be achieved, public and private funds need to be spent on lowering prohibitive costs and thereby increase the demand for space-based services.[cdlxx] It is necessary to recognize the private sector as a partner in future space activities and to encourage its participation in relevant projects. The next space race could be among private sector interests seeking to exploit resources, launch tourists, or service the ISS,[cdlxxi] rather than between states.

As the exploration of the solar system continues, the special conditions that operate in space will come into starker relief. If resource competition intensifies, an ideological battle may emerge between liberal institutionalists favoring a formalized suprnational regime, market rationalists preferring national management, and communal neo-realists seeking rapid economic development above all. These divisions will likely impact how disputes are resolved and governance is codified. To promote viability and good governance in the space commons, COPUOS needs either coercive power or, as is more likely, needs to offer incentives for member nations to cooperate in solving collective action problems.[cdlxxii] A parallel Space Forum should be created to resolve shared issues in space governance such as orbital debris.

Resolving disputes surrounding international regimes in order to enable effective management of the space commons, and avoid its tragic overexploitation, requires negotiations comprising myriad contemporary political issues. Emerging markets and diverse power centers will increasingly influence the trajectory and pace of these talks. With a legal foundation that is now more than forty years old, space governance is in need of an overhaul that reflects contemporary international relations as well as the role that space plays in today's international system.[cdlxxiii] With the adoption of polycentric principles to better govern space, humanity's development of space could be less a race than a peaceful march—not a flags and footprints

mission for one nation, but a destination serving the development of science, the economy, and the betterment of international relations.

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[i] *See* David Kestenbaum, *Chinese Missile Destroys Satellite in 500-Mile Orbit*, NAT'L PUBLIC RADIO (NPR) (Jan. 19, 2007, 4:00 PM), http://www.npr.org/templates/story/story.php?storyId=6923805.

[ii] *United Nations Adopts Space Debris Mitigation Guidelines*, NASA ORBITAL DEBRIS Q. NEWS, Apr. 2007, at 2 [hereinafter *NASA Orbital Debris*].

[iii] *See* Leonard David, *Ugly Truth of Space Junk: Orbital Debris Problem to Triple by 2030*, SPACE.COM (May 9, 2011, 08:17 AM), http://www.space.com/11607-space-junk-rising-orbital-debris-levels-2030.html.

[iv] Clara Moskowitz, *Space Junk Alert Called Off for Space Station Crew*, MSNBC (Nov. 23, 2011, 10:29 AM), http://www.msnbc.msn.com/id/45407947/ns/technology_and_science-space/.

[v] Thierry Sénéchal, Orbital Debris: Drafting, Negotiating, Implementing a Convention, at 99 (2007) (unpublished M.B.A. Thesis, MIT) (on file with Sloan School of Management, MIT), *available at* http://hdl.handle.net/1721.1/39519.

[vi] Space debris is becoming so commonplace that it may even be crashing through rooftops in Massachusetts. *See* Natalie Wolchover, *Space Junk? Mysterious Object Crashes Into Warehouse Roof*, MSNBC, (Dec. 2, 2011), http://www.msnbc.msn.com/id/45529518/ns/technology_and_science-science/.

[vii] The "commons" may be defined as resource domains in which common pool resources are found, which may be overexploited and degraded unlike public goods. *See, e.g.*, Paul A. Samuelson, *The Pure Theory of Public Expenditure*, 36(4) REV. ECON. & STAT. 387 (1954).

[viii] Space technology has myriad applications in health, education, disaster management, communication, and energy. *See* Joseph Bosco, *International Law Regarding Outer Space: An Overview*, 55 J. AIR L. & COMM. 609, 610-12

[ix] Stephen Jones, *Can the UK remain a First Division Player in Military Operations Without Significant Additional Investment in Space-Based Capability?*, RAF AIR POWER REV., Summer 2009, at 17.

[x] *See* Eric Sterner, *Beyond the Stalemate in the Space Commons*, *in* THE CONTESTED COMMONS 116 (Abraham M. Denmark & James Mulvenon eds., 2010).

[xi] Elinor Ostrom, *A Polycentric Approach for Coping with Climate Change* at 32-33 (World Bank Policy Research, Working Paper No. 5095, 2009).

[xii] *See* Scott J. Shackelford, *Was Selden Right? The Expansion of Closed Seas and its Consequences*, 47 STAN. J. INT'L L. 1 (2011) [hereinafter *Closed Seas*] (taking a similar approach to analyze the expansion of closed seas and its consequences).

[xiii] *See* Ty S. Twibell, *Space Law: Legal Restraints on Commercialization and Development of Outer Space*, 65 UMKC L. REV. 589, 591-92 & 636 (1996-1997).

[xiv] *See* James Kraska, *Indistinct Legal Regimes*, *in* SECURING FREEDOM IN THE GLOBAL COMMONS 58-60 (Scott Jasper ed., 2010). Outer space is defined as the area above airspace. Since the composition of the atmosphere changes gradually as elevation increases, defining exactly where airspace ends and outer space begins has proven problematic. Proposals have ranged from eighty to one-hundred kilometers; other proposed definitions rely on a more functionalist perspective, such as the point at which artificial satellites may be placed into orbit. *See* Leo B. Malagar & Mario Apalisok Magdoza-Malagar, *International Law of Outer Space and the Protection of Intellectual Property Rights*, 17 B.U. INT'L L.J. 311, 315-17 (1999).

[xv] *See The Space Economy at a Glance*, OECD (2011), *available at* http://www.oecd-ilibrary.org/economics/the-space-economy-at-a-glance-2011_9789264111790-en.

[xvi] *See* Keny Fuchter, *China's Military Space Strategy*, RAF AIR POWER REV., Summer 2009, at 53, 62. To underscore its importance, consider the early loss of a satellite in 1998 that affected some forty-five million people. Those impacted ranged from "on-call doctors, who could not be contacted via their pagers, to gas station owners who lost pay-at-the-pump functions." Mike Manor & Kurt Neuman, *Space Assurance*, *in* SECURING FREEDOM IN THE GLOBAL COMMONS, *supra* note 15, at 100.

[xvii] ROBERT C. HARDING, SPACE POLICY IN DEVELOPING COUNTRIES: THE SEARCH FOR SECURITY AND DEVELOPMENT ON THE FINAL FRONTIER 2 (2012).

[xviii] Scott N. Pace, *The Future of Space Commerce*, *in* SPACE POLICY IN THE 21ST CENTURY 55, 58-59 (W. Henry Lambright ed., 2003).

[xix] *See* SPACE FOUNDATION, THE SPACE REPORT 2008: THE AUTHORITATIVE GUIDE TO GLOBAL SPACE ACTIVITY 1-2 (2008) [hereinafter THE SPACE REPORT]. Recent developments such as U.S.-based Space Exploration Technologies Corporation (SpaceX) successful resupply mission to the ISS underscore this trend. *See*, *e.g.*, Frank Morring, Jr., *SpaceX Success Gives Commercial Spaceflight A Boost*, AVIATION WK., June 18, 2012, http://www.aviationweek.com/Article.aspx?id=/article-xml/AW_06_18_2012_p26-466690.xml.

[xx] Michael Griffin, Adm'r, NASA, Remarks at Ctr. for Strategic & Int'l Stud. (CSIS), Workshop on Space Exploration and International Cooperation at 1 (Nov. 1, 2005), www.nasa.gov/pdf/137173main_mg_csis.pdf.

[xxi] Robert O. Keohane & David G. Victor, *The Regime Complex for Climate Change*, HARVARD KENNEDY SCH. 10 (2009), http://belfercenter.ksg.harvard.edu/files/Keohane_Victor_Final_2.pdf (arguing that a "global commons" is a descriptive term referring to "a resource that it is difficult or impossible to exclude others from enjoying but that is degraded by use"). *See also* CHRISTOPHER JOYNER, GOVERNING THE FROZEN COMMONS: THE ANTARCTIC REGIME AND ENVIRONMENTAL PROTECTION 221-22, 255 (1998) (discussing the global commons in the context of Antarctic governance).

[xxii] *See Closed Seas*, *supra* note xii (exploring the extent to which governance of the deep seabed is fragmenting with enclosure increasing).

[xxiii] Kal Raustiala & David G. Victor, *The Regime Complex for Plant Genetic Resources*, 58 INT'L. ORG. 277, 277 (2004) (defining a "regime coplex").

[xxiv] *Cf.* Daniel H. Cole, *From Global to Polycentric Climate Governance*, 2 CLIMATE L. 395, 412 (2011) (arguing that certain "regime complexes" are analogus to polycentric governance).

[xxv] Michael D. McGinnis, *Costs and Challenges of Polycentric Governance: An Equilibrium Concept and Examples from U.S. Health Care*, Workshop on Self-Governance, Polycentricity, and Development, at 1 (Conference on Self-Governance, Polycentricity, and Development, Renmin Univsity, in Beijing, China) (2011), *available at* http://php.indiana.edu/~mcginnis/Beijing_core.pdf.

[xxvi] *Id*. at 1-2.

[xxvii] Michael D. McGinnis, *An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework*, 39(1) POLICY STUD. J. 163 (Feb. 2011), *available at* http://php.indiana.edu/~mcginnis/iad_guide.pdf at 6-7 (defining "polycentricity" as "a system of governance in which authorities from overlapping jurisdictions (or centers of authority) interact to determine the conditions under which these authorities, as well as the citizens subject to these jurisdictional units, are authorized to act as well as the constraints put upon their activities for public purposes.").

[xxviii] However, it should be noted at the outset that for polycentric governance to work well, it requires certain preconditions similar to those necessary for a "'highly federalized' political system," including: "(1) market arrangements; (2) the legal community; (3) constitutional rule; and (4) [certain] political conditions." *Id*. at 7.

[xxix] William Boyd, *Climate Change, Fragmentation, and the Challenges of Global Environmental Law: Elements of a Post-Copenhagen Assemblage*, 32 U. PA. J. INT'L L. 457, 516 (2010).

[xxx] Comparisons with the deep seabed and atmospheric regimes are offered to give the analysis greater context and allow for a critical appraisal. Other outstanding issues in space law, such as defining all the facets of property rights, are beyond the scope of this Article.

[xxxi] *But see* Ellen P. Goodman, *Spectrum Rights in the Telecosm To Come*, 41 SAN DIEGO L. REV. 269, 399 (2004) (noting that "spectral pollution presents the kind of polycentric problem that courts have difficulty resolving"); *and* Charity T. Ryabinkin, *Let There Be Flight: It's Time To Reform the Regulation of Commercial Space Travel*, 69 J. AIR L. & COM. 101, 118 (2004) (noting that space tourism exists within "a polycentric universe of international obligations and economic limitations").

[xxxii] *See Closed Seas*, *supra* note xii, at 6 (making similar arguments in the context of the deep seabed).

[xxxiii] *See, e.g.*, Press Release, European Space Agency, New Opportunities for Business in Space – ESA Commercialization and Technology Transfer at Hanover Fair (Apr. 2, 2003), *available at* http://www.esa.int/For_Media/Press_Releases/New_opportunities_for_business_in_space_ESA_commercialisation_and_technology_transfer_at_Hanover_Fair_2003 (discussing the link between technological advancement and commercial opportunities associated with the International Space Station).

[xxxiv] *See, e.g.*, Brian Weeden, *China's BX-1 Microsatellite: A Litmus Test for Space Weaponization*, SPACE REV., Oct. 20, 2008, http://www.thespacereview.com/article/1235/1 (noting that "[B]ecause of the dual-use nature of so many space technologies [such as satellites that are put to both commercial and military uses], any arms control regime or space weapons ban is inherently unverifiable.").

[xxxv] *See* Press Release, Planetary Resources, Planetary Resources, Inc. Announces Agreement with Virgin Galactic for Payload Services (July 11, 2012), *available at* http://www.planetaryresources.com/2012/07/planetary-resources-inc-announces-contract-with-virgin-galactic-for-payload-services/ (discussing the activities of Planetary Resources as the firm ramps up to begin mining asteroids) [hereinafter Planetary Resources Press Release].

[xxxvi] *See* FRANK LYALL & PAUL B. LARSEN, SPACE LAW: A TREATISE 37 (2009). The phrase "golden age," while popular in the literature, is misleading since this period of progress in multilateral treaty making in the deep seabed and outer space was also marred by deep political divides and security concerns. It is used here merely as shorthand referring to the period extending from the 1967 Outer Space Treaty to the 1982 Moon Treaty.

[xxxvii] *See* Elinor Ostrom, *Foreword*: SUSAN J. BUCK, THE GLOBAL COMMONS: AN INTRODUCTION xiii (1998).

[xxxviii] JOYNER, *supra* note xxi, at 222.

[xxxix] *See* Space Exploration Technologies Corporation-Company, http://www.spacex.com/company.php (last visited Oct. 23, 2012); *Advanced Space Transportation Program: Paving the Highway to Space*, http://quest.arc.nasa.gov/aero/virtual/demo/research/youDecide/advSpacTrans.html (last visited Sept. 21, 2011) [hereinafter *Advanced Space Transportation Program*]; *and* Andrew Mayne, SpaceX Signs Up First Customer for World's Most Powerful Rocket, http://weirdthings.com/category/spacex/ (last visited Dec. 28, 2012).

[xl] *See Advanced Space Transportation Program*, *supra* note xxxix.

[xli] *See* NASA, Commercial Crew & Cargo, http://www.nasa.gov/offices/c3po/home/ (last visited Dec. 28, 2012).

[xlii] *See NASA Offers $200 Million for Gas Station Demo in Space*, SPACE.COM (May 9, 2011, 8:49 AM), http://www.space.com/11608-space-gas-stations-nasa-orbital-refueling.html.

[xliii] *See* Irene Klotz, *Boeing Tapping Heritage Programs for Space Taxi Design*, SPACE NEWS (Nov. 25, 2011), http://www.spacenews.com/civil/111125-boeing-heritage-space-taxi-design.html.

[xliv] Technological advancements prompted Judge Manfred Lachs, former President of the International Court of Justice (ICJ), to say, "As science and technology open up space at an enormous speed, much more remains to be done." Vladimir Kopal, *Evolution of the Doctrine of Space Law*, *in* SPACE LAW: DEVELOPMENT AND SCOPE 29 (Nandasiri Jasentuliyana ed.,1992) (quoting 33 COLLOQUIUM ON THE LAW OF OUTER SPACE, at v).

[xlv] *See* BUCK, *supra* note xxxvii, at 138; Taylor Thompson, *The Hundred Mile Club*, COLUM. POL. REV. (Dec. 5, 2010), *available at* http://cpreview.org/2010/12/the-hundred-mile-high-club/; *and* Dan St. John, *The Trouble with Westphalia in Space: The State-Centric Liability Regime*, 40 DENV. J. INT'L L. & POL'Y 686, 688 (2012).

[xlvi] *See* Charles Q. Choi, *Earth-based Lasers Could Zap Space Junk Clear* From *Satellites*, SPACE.COM (Mar. 17, 2011, 3:42 PM) http://www.space.com/11157-nasa-lasers-shooting-space-junk.html.

[xlvii] *See* U.S. Space-Based Positioning, Navigation, and Timing Policy, http://www.gps.gov/policy/ (last visited Dec. 28, 2012).

[xlviii] *See Satellite Telecommunications: Market Perspectives and Industrial Situation*, EUR. SPACE AGENCY (ESA), at 4 (Sept. 2005), *available at* www.esa.int/esapub/br/br254/br254.pdf (stating that as of 2005, "The average number of telecommunication satellites launched per year in the 1990's was 23, while the estimate for the first decade of the 2000's is less than 20.").

[xlix] *See* Charlotte Matthieu, *Space-Based Services in Europe: Addressing the Transition Between Demonstration and Operation*, EUR. SPACE POL'Y INST., at 10 (Mar. 17, 2009), *available at* http://www.eomag.eu/articles/896/espi-report-17-on-the-development-of-space-based-services-in-europe-online.

[l] *See* John Baffes & Betty Dow, *Global Commodity Watch*, WORLD BANK BLOGS, (Apr. 11, 2012, 12:18PM), http://blogs.worldbank.org/prospects/category/tags/historical-commodity-prices (reporting changes in commodity prices from 1980 to 2010).

[li] Patrick M. Cronin, *Foreword*: SECURING FREEDOM IN THE GLOBAL COMMONS ix (Scott Jasper ed., 2010).

[lii] Dev., Concepts and Doctrine Ctr., U.K. Ministry of Defence, *Strategic Trends Programme: Global Strategic Trends – Out to 2040*, at 15, 40 (4th ed. 2010) [hereinafter DCDC] .

[liii] *See* Jean-Paul Rodrigue, *World Annual Oil Production (1900-2011) and Peak Oil (2010 Scenario)*, (HOFSTRA UNIV., 2011), http://people.hofstra.edu/geotrans/eng/ch5en/appl5en/worldoilreservesevol.html.
[liv] *E.g.*, Thomas D. Kelly & Grecia R. Matos, *Historical Statistics for Mineral and Material Commodities in the United States*, U.S. GEOLOGICAL SURVEY DATA SERIES 140 (2011), http://minerals.usgs.gov/ds/2005/140/.

[lv] LOTTA VIIKARI, FROM MANGANESE NODULES TO LUNAR REGOLITH: A COMPARATIVE LEGAL STUDY OF THE UTILIZATION OF NATURAL RESOURCES IN THE DEEP SEABED AND OUTER SPACE 10 n.26 (2002).
[lvi] *See* Wei Long, *China Eyes Territorial Claim of Outer Space*, SPACE DAILY (Jan. 21, 2003), http://www.spacedaily.com/news/china-02f.html.

[lvii] *See* Planetary Resources Press Release, *supra* note xxxv

[lviii] *See* IPCC, *Climate Change 2007: Synthesis Report, Summary for Policymakers* (Nov. 17, 2007), http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf (discussing the issues of atmospheric pollution and climate change). *But see* Adam Mann, *Space tourism to accelerate climate change*, NATURE, Oct. 22, 2010, *available at* http://www.nature.com/news/2010/101022/full/news.2010.558.html (reporting that "soot from commercial space flights will change global temperatures.").

[lix] EVERETT C. DOLMAN, ASTROPOLITIK: CLASSICAL GEOPOLITICS IN THE SPACE AGE 11 (2002).

[lx] *See* Turner Brinton, *Obama's Proposed Space Weapon Ban Draws Mixed Response*, SPACE.COM (Feb. 4, 2009, 2:50 PM), http://www.space.com/news/090204-obama-space-weapons-response.html.

[lxi] *See* Michael Listner, *The Moon Treaty: Failed International Law or Waiting in the Shadows?*, SPACE REV., Oct. 24, 2011, *available at* http://www.thespacereview.com/article/1954/1; *and* UN OOSA, DISSEMINATING AND DEVELOPING INTERNATIONAL AND NATIONAL SPACE LAW 172 (2005) (discussing the potential for revising the Moon Treaty in comparison with the Law of the Sea). *See also* Christopher C. Joyner, *Legal Implications of the Concept of the Common Heritage of Mankind*, 35 INT'L & COMP. L.Q. 190, 190-99 (1986) (laying out the five contested elements of the CHM concept). A precise definition of the CHM concept has never been specific as applied to outer space. In its most positive form, it fosters international cooperation to develop and equitablly distribute the benefits to common pool resources. Most conceptions of the CHM share five primary elements. First, there can be no private or public appropriation of the commons. *Cf*. LAURI HANNIKAINEN, PEREMPTORY NORMS (JUS COGENS) IN INTERNATIONAL LAW 562 (1988) (noting that portions of the global commons may in fact be appropriated under international law). Second, "representatives from all nations" must manage common resources. Jennifer Frakes, *The Common Heritage of Mankind Principle and the Deep Seabed, Outer Space, and Antarctica: Will Developed and Developing Nations Reach a Compromise?*, 21 WIS. INT'L L.J. 409, 412 (2003) (citing Barbara Ellen Heim, Note, *Exploring the Last Frontiers for Mineral Resources: A Comparison of International Law Regarding the Deep Seabed, Outer Space, and Antarctica*, 23 VAND. J. TRANSNAT'L L. 819, 827 (1990)). Third, all nations must share in the benefits acquired through exploitation of the area. *Id*. at 412-13. Fourth, the commons must be used for "peaceful purposes." *Id*. at 413. Fifth, the commons "must be preserved for the benefit of future generations." *Id*. at 413.

[lxii] *See* DOLMAN, *supra* note 61, at 12 (defining geopolitics as "the study of states as spatial phenomena, with a view towards understanding the geographical bases of power," and astropolitics as "the study of the relationship between outer space terrain and technology, and the development of political and military policy and strategy.").

[lxiii] DCDC, *supra* note lii, at 10.

[lxiv] Fareed Zakaria, *The Rise of the Rest*, NEWSWEEK, May 3, 2008, http://www.newsweek.com/id/135380. *But see* Richard N. Haass, *The Age of Nonpolarity: What Will Follow U.S. Dominance*, 87 FOREIGN AFF. 44, 45 (2008)

(arguing for a nonpolar over a multipolar world order, and stating that "States are being challenged from above, by regional and global organizations; from below, by militias; and from the side, by a variety of nongovernmental organizations (NGOs) and corporations. Power is now found in many hands and in many places.").

[lxv] *See* Matthew Happold, Introduction, *in* INTERNATIONAL LAW IN A MULTIPOLAR WORLD 1 (Matthew Happold ed., 2011).

[lxvi] *See* OSCAR SCHACHTER, INTERNATIONAL LAW IN THEORY AND PRACTICE 9 (1991) (discussing the importance of power distribution among states in forming international law).

[lxvii] *See* Emma Duncan, *Getting Warmer*, ECONOMIST, Dec. 3, 2009.

[lxviii] *See* Jonathan M. Harris & Brian Roach, *The Economics of Climate Change*, GLOBAL DEV. & ENV'T INST. at 8 (2009); Intergovernmental Panel on Climate Change Special Report on Climate Change, http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=55; *and* IPCC WORKING GROUP III IN CLIMATE CHANGE 1994: RADIATIVE FORCING OF CLIMATE CHANGE AND AN EVALUATION OF THE IPCC IS92 EMISSIONS SCENARIOS 233 (J. T. Houghton et al. eds., 1995).

[lxix] Ostrom, *supra* note xi, at 1 & 8.

[lxx] *See Key Powers Reach Compromise at Climate Summit*, BBC NEWS, Dec. 19, 2009, *available at* http://news.bbc.co.uk/2/hi/europe/8421935.stm.

[lxxi] *See* Cole, *supra* note xxiv, at 395 (discussing the potential of polycentric governance to better address climate change given the failures of multilateral efforts).

[lxxii] Telephone interview with Michael Oppenheimer, Albert G. Milbank Professor of Geosciences and International Affairs, Princeton Univ. (Feb. 7, 2010).

[lxxiii] Electronic interview with Michael Oppenheimer, Albert G. Milbank Professor of Geosciences and International Affairs, Princeton Univ. (Jan. 23, 2012).

[lxxiv] *Id*.

[lxxv] *See* Lauren Graham, *Second Time Around: Reflections from COP17 to COP18*, F&ES BLOG, Dec. 6, 2012, http://environment.yale.edu/blog/2012/12/second-time-around-reflections-from-cop17-to-cop18/ (last visited Dec. 28, 2012) (reviewing more recent developments from COP17 and COP18). Other analogies are also important to consider in analyzing space governance but are only mentioned here due to space constraints, such as the regulation of commercial space activity, the allocation of property rights, and protection of public interests in space. *See* Yun Zhao, *An International Space Authority: A Governance Model for Space Commercialization Regime*, 30(2) J. SPACE L. 277, 277 (2004); Ran Jakhu, *Legal Issues Relating to the Global Public Interest in Outer Space*, 32(1) J. SPACE L. 31, 31 (2006); Melanie Walker, *Suborbital Space Tourism Flights: An Overview of Some Regulatory Issues at the Interface of Air and Space Law*, 33(2) J. SPACE L. 375, 375 (2007).

[lxxvi] *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243, 1244 (1968).

[lxxvii] *Id*.

[lxxviii] *See, e.g.*, Ostrom, *supra* note xi, at 7.
[lxxix] *See id*. at 8.

[lxxx] MANCUR OLSON, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS 2 (1965).

[lxxxi] Hardin, *supra* note lxxvii, at 1244.

[lxxxii] Robert C. Bird, *Procedural Challenges to Environmental Regulation of Space Debris*, 40 AM. BUS. L.J. 635, 657-58 (2003) (citing Lawrence D. Roberts, *Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes*, 15 B.C. INT'L & COMP. L. REV. 51, 58 (1992)).

[lxxxiii] Lori Scheetz, *Infusing Environmental Ethics into the Space Weapons Dialogue*, 19 GEO. INT'L ENVTL. L. REV. 57, 67 (2006-2007).

[lxxxiv] David Feeny et al., *The Tragedy of the Commons*: *Twenty-Two Years Later*, 18 HUM. ECOLOGY 1, 2 (1990).

[lxxxv] *See* Bernard H. Oxman, *The Territorial Temptation: A Siren Song at Sea*, 100 AM. J. INT'L L. 830, 833 (2006) (discussing the tragedy of the commons in the Law of the Sea context).

[lxxxvi] *See* Ralph Matthews, *Federal Licensing Policies for the Atlantic Inshore Fishery and Their Implementation in Newfoundland, 1973–1981*, 17 ACADIENSIS 83 (1988).

[lxxxvii] *See* Feeny et al., *supra* note lxxxiv, at 1 & 14.

[lxxxviii] *See* Kenneth Ruddle, *Solving the Common Property Dilemma: Village Fisheries Rights in Japanese Coastal Waters*, *in* COMMON PROPERTY RESOURCES: ECOLOGY AND COMMUNITY-BASED SUSTAINABLE DEVELOPMENT 168 (Fikret Berkes ed., 1989); *and* Feeny et al., *supra* note lxxxiv, at 14.

[lxxxix] *See* Ostrom, *supra* note xi, at 10 & 13.

[xc] *See* Raymond De Young & Stephen Kaplan, *Adaptive Muddling*, *in* THE LOCALIZATION READER: ADAPATING TO THE COMING DOWNSHIFT 287-88 (Raymond De Young & Thomas Princen eds, 2012), *available at* http://www-personal.umich.edu/~rdeyoung/tragedy.html; Carl Jay Bajema & Garrett James Hardin, *Ecologist, Educator, Ethicist and Environmentalist*, 12(3) POPULATION & ENV'T, Mar. 1991, at 193, 211*; and* Jeffrey Weiss, *Elinor Ostrom and the Triumph of the Commons*, POLITICS DAILY (Oct. 14, 2009), http://www.politicsdaily.com/2009/10/14/elinor-ostrom-and-the-triumph-of-the-commons/.

[xci] *See* Weiss, *supra* note xc.

[xcii] *See, e.g.*, *Closed Seas*, *supra* note xii, at 32; *and* Catherine Corson & Kenneth Iain MacDonald, *Enclosing the Global Commons: The Convention on Biological Diversity and Green Grabbing*, 39 J. PEASANT STUD. 263, 264 (2012), *available at* http://www.tandfonline.com/doi/abs/10.1080/03066150.2012.664138.

[xciii] *See infra* p.27.

[xciv] Emily Young, *State Intervention and Abuse of the Commons: Fisheries Development in Baja California Sur, Mexico*, 91 ANNALS ASSOC. AM. GEOGRAPHERS 283, 283 (2001) (citing K. J. Walker, *The State in Environmental Management: The Ecological Dimenson*, 37 POL. STUD. 25, 32 (1989)). *See also* J. H. Huebert & Walter Block, *Space Environmentalism, Property Rights, and the Law*, 37 U. MEM. L. REV. 281, 298 (2007) (arguing that national governments, including the United States, may not sustainably manage celestial resources by evoking comparisons with the national parks).

[xcv] *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 20 & 136 (1990).

[xcvi] *See* Hardin, *supra* note 61, at 1244-45 (discussing the causes of the classic tragedy of the commons).

[xcvii] Vladimir Kopal, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, UN AUDIOVISUAL LIBRARY INT'L L.., *available at* http://untreaty.un.org/cod/avl/ha/tos/tos.html. *See also See* BUCK, *supra* note xxxvii, at,148 (discussing the development of the OST).

[xcviii] *See* BUCK, *supra* note xxxvii, at 100 (discussing the evolution of the freedom of the seas).

[xcix] *See* PHILIP C. JESSUP & HOWARD J. TAUBENFELD, CONTROLS FOR OUTER SPACE AND THE ANTARCTIC ANALOGY 211 (1959).

[c] *See* BUCK, *supra* note xxxvii, at 137; *and* MORRIS R. COHEN & FELIX S. COHEN, READINGS IN JURISPRUDENCE AND LEGAL PHILOSOPHY 12-13 (1954).

[ci] *See* Bosco, *supra* note viii, at 612 n.17; *and* BUCK, *supra* note xxxvii, at,164 n.4.

[cii] *See* BUCK, *supra* note xxxvii, at 138; *and* NANDASIRI JASENTULIYANA, INTERNATIONAL SPACE LAW AND THE UNITED NATIONS 2 (1999).

[ciii] *See* ANDREW HALEY, SPACE LAW AND GOVERNMENT 65-66 (1963).

[civ] *See* BUCK, *supra* note xxxvii, at 139; G.A. Res. 1148[XII] of Nov. 14, 1957, par. I[f]; *and* G.A. Res. 1348, 13 U.N. GABR Supp. (no. 18) at 5 U.N. Doc. A/4090 (1958).

[cv] *See* HALEY, *supra* note ciii, at 73l; BUCK, *supra* note xxxvii, at 141-42; *and* C. WILFRED JENKS, SPACE LAW 97-98 (1965).

[cvi] These include G.A. Res. 1348, ¶13, U.N. GAOR, 13th Sess., Supp. No. 18, U.N. Doc. A/4090 (Dec. 13, 1958); G.A. Res. 1472, ¶ 13, U.N. GAOR, 14th Sess., Supp. No. 16, U.N. Doc. A/4354 (Dec. 12, 1959); G.A. Res. 1721, ¶ 16, U.N. GAOR, Supp. No. 17, U.N. Doc. A/5100 (Dec. 20, 1961); G.A. Res. 1802, ¶ 17, U.N. GAOR, 17th Sess.,, U.N. Doc. A/RES/1802 (Dec. 14 1962); and G.A. Res. 1962, ¶ 18, U.N. GAOR, Supp. No. 15, U.N. Doc. A/5515, at 15 (Dec. 13, 1963).

[cvii] United Nations Committee on the Peaceful Uses of Outer Space: Members, http://unoosa.org/oosa/COPUOS/members.html (last visited Nov. 7, 2011). The original COPUOS Member States included: "Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, France, India, Iran, Italy, Japan, Mexico, Poland, Sweden, the United Arab Republic, the United Kingdom, the United States, and the USSR." BUCK, *supra* note xxxvii, at 146. Membership grew gradually, with China joining in 1980, and many developing nations becoming involved to increase regional representation. *Id*.

[cviii] *See* BUCK, *supra* note xxxvii, at 146-47.

[cix] VIIKARI, *supra* note lv, at 87-89. *See* BIN CHENG, STUDIES IN INTERNATIONAL SPACE LAW 155-57 (1997). For a more complete analysis of the golden age of space law and the failure of the Moon Treaty, see Scott J. Shackelford, *The Tragedy of the Common Heritage of Mankind*, 28 STAN. ENVTL. L. J. 109, 141-51 (2009) [hereinafter *Tragedy*].

[cx] *See* BUCK, *supra* note xxxvii, at 145

[cxi] *Id*. at 152.

[cxii] *Id*. at 146.

[cxiii] *See* Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, arts. 2 & 4 (entered into force Oct. 10, 1967), Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter OST].

[cxiv] *See id*. at art. II; *and Tragedy*, *supra* note cix, at 142.

[cxv] *See, e.g.*, Jonathan C. Thomas, *Spatialis Liberum*, 7 FLA. COASTAL L. REV. 579, 592 (2006).
[cxvi] OST, *supra* note cxiii, art. I.
[cxvii] *See supra* p.8 n.62.

[cxviii] *See* Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), Vienna, Austria, 1999, *United Nations Treaties and Principles on Outer Space: A Commemorative Edition*, U.N. Doc. A/CONF. 184 (1999) [hereinafter UNISPACE III]. *See also* KEMAL BASLAR, THE CONCEPT OF THE COMMON HERITAGE OF MANKIND IN INTERNATIONAL LAW 170 (1998) (discussing the common heritage provisions of the Moon Treaty).

[cxix] *See e.g.*, Nat'l Sec. Presidential Directive (NSPD) 49, U.S. Nat'l Space Pol'y 3 (June 28, 2010) (noting that "As established in international law, there shall be no national claims of sovereignty over outer space or any celestial bodies."), *available at* http://www.whitehouse.gov/the-press-office/fact-sheet-national-space-policy.
[cxx] Statement of the G-77 and China during the forty-eighth session of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, Feb. 7-18, 2011, delivered by H.E. Ambassador Ali Soltanieh, Permanent Representative of the Islamic Republic of Iran, *available at* http://www.g77.org/vienna/OOSAFEB11.htm (arguing that nations should work together to "ensure that all countries are able to have equitable access to the limited natural resources of outer space").

[cxxi] Armel Kerrest, *Outer Space as International Space: Lessons from Antarctica*, SPACE DIPLOMACY 133, 136 (2011).

[cxxii] *See* OST, *supra* note cxiii, art. IV. *Cf.* Antarctic Treaty art. I(1)., Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 72 (defining "peaceful use" in Antarctica as banning "any measures of a military nature . . . .").

[cxxiii] OST, *supra* note cxiii, art. IV(1).

[cxxiv] *Id*. art. IV(2).

[cxxv] *See* Kerrest, *supra* note 96, at 136-37.

[cxxvi] OST, *supra* note cxiii, art. IX.

[cxxvii] *See* Ram Jakhu, *Towards Long-term Sustainability of Space Activities: Overcoming the Challenges of Space Debris*, IAASS LEGAL & REGULATORY COMM., at 10 (Feb. 15, 2011), http://www.oosa.unvienna.org/pdf/pres/stsc2011/tech-35.pdf.

[cxxviii] OST, *supra* note cxiii, art. III.

[cxxix] *See* Sandeepa Bhat & Kiran Mohan V, *Anti Satellite Missile Testing: A Challenge to Article IV of the Outer Space Teraty*, 2 NUJS L. REV. 205, 209-11 (2009).

[cxxx] *Id*.

[cxxxi] *See, e.g.*, *The Principle of Common But Differentiated Responsibilities: Origins and Scope*, A CISDL LEGAL BRIEF, Aug. 26, 2002, *available at* cisdl.org/public/docs/news/brief_common.pdf (noting that common but differentiated responsibility evolved from the CHM concept and recognizes the "historical differences" between the contributions of developing and developed states to global commons challenges and their capacities to help face these challenges). This notion, for example, could be applied to future agreements relating to space debris and would put the onus on the spacefaring powers to take the lead in lowering debris to sustainable levels. However,

international political divisions would need to be overcome between developed and developing states in this regard, though recent progress in multilateral climate change negotiations show some promise. *See* Nitin Sethi, *World Agrees to Framework for New Global Climate Deal, US May Walk Out Later*, TIMES INDIA, Dec. 8, 2012, *available at* http://articles.timesofindia.indiatimes.com/2012-12-08/developmental-issues/35688596_1_climate-change-climate-convention-kyoto-protocol.

[cxxxii] *But see* Jakhu, *supra* note cxxvii, at 10-11 (noting that space debris may be illegal if it was generated purposefully with the intent to interfere with the peaceful use and exploration of space).

[cxxxiii] BASLAR, *supra* note cxviii, at 166.

[cxxxiv] *See* Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, para. 18, U.N. GAOR, 18th Sess., Supp. No. 15, U.N. Doc. A/5515 (Dec. 13, 1963); OST, *supra* note cxiii, art. I; Declaration on Principles Governing the Seabed and Ocean Floor, G.A. Res. 2749, para. 25, U.N. GAOR, 25th Sess., Supp. No. 28, U.N. Doc. A/8028 (Dec. 17, 1970); United Nations Convention on the Law of the Sea art. 137, para. 2, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS]; *and* Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 18, 1979, U.N. GAOR, 34th Sess., Supp. No. 46, at 77, U.N. Doc. A/34/46 (1980), 18 I.L.M. 1434 [hereinafter Moon Treaty].
[cxxxv] *See* UNCLOS, *supra* note cxxxiv, art. 137.

[cxxxvi] *See* Adam G. Quinn, *The New Age of Space Law: The Outer Space Treaty and the Weaponization of Space*, 17 MINN. J. INT'L L. 475, 488 (2008). *But see* United Nations Office for Outer Space Affairs, http://www.oosa.unvienna.org/oosa/SpaceLaw/treaties.html (last visited Oct. 23, 2012) (demonstrating that as of January 2012 the OST has had 101 ratifications and 26 signatures, giving it the strength of customary international law).

[cxxxvii] *See, e.g.*, *Closed Seas*, *supra* note xii, at 17-22.

[cxxxviii] Eilene Galloway, *Sputnik and the Creation of NASA: A Personal Perspective*, NASA: 50 YEARS OF EXPLORATION AND DISCOVERY, http://www.nasa.gov/50th/50th_magazine/gallowayEsaay.html.
[cxxxix] John Krige, *Technology, Foreign Policy, and International Cooperation in Space*, *in* CRITICAL ISSUES IN THE HISTORY OF SPACEFLIGHT 250 (Steven J. Dick & Roger D. Launius eds., 2006). *See also* EXPLORING THE UNKNOWN: SELECTED DOCUMENTS IN THE HISTORY OF THE U.S. CIVILIAN SPACE PROGRAM, VOLUME II: EXTERNAL RELATIONSHIPS 5 (John M. Logsdon et al. eds., 1996) (exploring the rationale for NASA's external relations program) [hereinafter NASA EXTERNAL RELATIONS].
[cxl] *See* Krige, *supra* note cxxxix, at 240.

[cxli] *See* NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 106 (discussing the U.S. perspective on the prestige value of space cooperation).

[cxlii] *Id*. at 2.

[cxliii] *Id*. (citing National Security Council, NSC 5814, "U.S. Policy on Outer Space," June 20, 1958).

[cxliv] *See* Krige, *supra* note cxxxix, at 240 (citing NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 4).

[cxlv] NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 5 & 235; *and* EXPLORING THE UNKNOWN: SELECTED DOCUMENTS IN THE HISTORY OF THE U.S. CIVILIAN SPACE PROGRAM, VOLUME VII: HUMAN SPACEFLIGHT 390-91 (John M. Logsdon & Roger D. Lanius eds., 2008).

[cxlvi] NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 4; *and* Krige, *supra* note cxxxix, at 243.

[cxlvii] *See id*.

[cxlviii] *See* George W. Bush, President, Remarks by the President on U.S. Space Policy at NASA Headquarters (Jan. 2004), *available at* http://history.nasa.gov/Bush%20SEP.htm.

[cxlix] W. Henry Lambright, *Introduction*, *in* SPACE POLICY IN THE 21ST CNETURY 1, 12 (W. Henry Lambright ed., 2003).

[cl] *Id*. at 33.

[cli] *See* Krige, *supra* note cxxxix, at 241.

[clii] *Id*. at 244.

[cliii] *Id*. at 239.

[cliv] *Id*. at 241.

[clv] *Id*.

[clvi] *See* LOGSDON, *supra* note cxxxix, at 1; *and* GLOBAL REACH: A VIEW OF NASA'S INTERNATIONAL COOPERATION, at 3 (2008), *available at* http://www.spacepolicyonline.com/international [hereinafter GLOBAL REACH].

[clvii] *See Number of Nations with Space Agencies is Rising*, SPACE NEWS, Feb. 23, 2010, *available at* http://www.spacenews.com/article/number-nations-space-agencies-rising#.UOCQ97amCWU.

[clviii] *See* GLOBAL REACH, *supra* note clvi, at 58 & 73.

[clix] *See* MICHAEL D. MCGINNIS & JOHN T. WILLIAMS, COMPOUND DILEMMAS: DEMOCRACY, COLLECTIVE ACTION, AND SUPERPOWER RIVALRY 2 (2001).

[clx] NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 12.

[clxi] THE WORLD'S GREAT SPEECHES (Lewis Copeland et al., eds.) 741 (1999).

[clxii] Marc Selverstone, *JFK and the Space Race*, WHITE HOUSE TAPES: PRESIDENTIAL RECORDINGS PROGRAM, http://whitehousetapes.net/exhibit/jfk-and-space-race (last visited Oct. 23, 2012).

[clxiii] *Transcript of Presidential Meeting in the Cabinet Room of the White House*, NASA History Office, Nov. 21, 1962, at 14, *available at* history.nasa.gov/JFK-Webbconv/pages/transcript.pdf,

[clxiv] *Id*. at 14 & 17 (emphasis added).

[clxv] *Id*. at 17.

[clxvi] *Id*.

[clxvii] *See Soviet Space History*, Encyclopedia Astronautica, http://www.astronautix.com/articles/sovstory.htm (last visited Dec. 30, 2012).

[clxviii] *See* NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 11.

[clxix] *Krushchev-Kennedy Letters: Feb.-Mar. 1962, SP-4209 The Partnership: A History of the Apollo-Soyuz Test Project*, NASA HISTORY OFFICE, http://history.nasa.gov/SP-4209/ch2-2.htm.

[clxx] NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 13.

[clxxi] *Id*.

[clxxii] *Id*.

[clxxiii] *Id.*

[clxxiv] *Id*.

[clxxv] *Id.*

[clxxvi] *Id*. at 7 & 10.

[clxxvii] *Id*. at 9.

[clxxviii] *See id.* at 14-15; *and* G. Thomas Goodnight, *Ronald Reagan's Re-formulation of the Rhetoric of War: Analysis of the 'Zero Option," "Evil Empire," and "Star Wars" Addresses*, 72 Q. J. SPEECH 390, 391 (1986).

[clxxix] *See* NASA EXTERNAL RELATIONS, *supra* note cxxxix, at 12 & 228; *and* Krige, *supra* note cxxxix, at 331

[clxxx] Krige, *supra* note cxxxix, at 260.

[clxxxi] *Id*. at 241.

[clxxxii] Joan Johnson-Freese, *China's Manned Space Program: Sun Tzu or Apollo Redux*?, SPACE POLITICS 51, 52 (2005).

[clxxxiii] *See, e.g.*, Beth Stebner, *Neil Armstrong Dead at 82: First Man to Walk on the Moon Passes Away Following Heart Surgery, 43 Years after Giant Leap for Mankind*, DAILY MAIL, Aug. 25, 2012, *available at* http://www.dailymail.co.uk/news/article-2193587/Neil-Armstrong-dead-Famed-astronaut-man-moon-dies-aged-82.html.

[clxxxiv] *See* BUCK, *supra* note xxxvii, at 143; 2009 Space Launch Report, *available at* http://www.spacelaunchreport.com/log2009.html; HARDING, *supra* note xvii, at 5 (noting that the worldwide growth of satellite launches is expected to grow rapidly through 2015).

[clxxxv] *See* 2011 Space Launch Report, available at http://www.spacelaunchreport.com/log2011.html.

[clxxxvi] *See id.* (reporting the total number of space launches by country).

[clxxxvii] *See Governments Worldwide Invest a Record $68 billion in Space Programs*, ECOCONSULT, Feb. 23, 2010 [hereinafter EUROCONSULT].

[clxxxviii] *E.g.*, *No cut in Russian 2009 space spending, $2.4 bln on 3 programs*, RIANOVOSTI, Mar. 18, 2009, http://en.rian.ru/russia/20090318/120627935.html.

[clxxxix] *See, e.g.*, *Russian Mars Probe Crashes into Pacific*, CNN WORLD, Jan. 15, 2012, http://articles.cnn.com/2012-01-15/world/world_europe_russia-mars-probe_1_russian-mars-probe-crashes?_s=PM:EUROPE.

[cxc] Johnson-Freese, *supra* note clxxxii, at 67.

[cxci] *E.g.*, *Japan Recommends Scrapping Moon Mission*, ASSOC. PRESS, Jan. 15, 2007, http://www.msnbc.msn.com/id/16634223/ns/technology_and_science-space.

[cxcii] Johnson-Freese, *supra* note clxxxii, at 67.

[cxciii] Jeff Foust, *China, Competition, and Cooperation*, SPACE REV., Apr. 10, 2006, http://www.thespacereview.com/article/599/1.

[cxciv] *Id*.

[cxcv] *Pew Research Center/Council on Foreign Relations Survey*, PRINCETON SURV. RES. ASSOCIATES INT'L, July 8-18, 2004, http://www.pollingreport.com/china.htm.

[cxcvi] *See Strengthen Ties with China, But Get Tough on Trade*, PEW RES. CTR. PUBLICATIONS, Jan. 12, 2011, http://pewresearch.org/pubs/1855/china-poll-americans-want-closer-ties-but-tougher-trade-policy.

[cxcvii] Foust, *supra* note cxciv.

[cxcviii] *See* Jeffrey Mervis, *Spending Bill Prohibits U.S.-China Collaborations*, SCI. INSIDER, Apr. 21, 2011, http://news.sciencemag.org/scienceinsider/2011/04/spending-bill-prohibits-us-china.html.

[cxcix] *Id*.

[cc] *See* Trefor Moss, *The Asian Space Race*, JANES DEF. WKLY., Oct. 29, 2008, at 27.

[cci] *See* HARDING, *supra* note xvii, at 99.

[ccii] *See* Joe McDonald, *Project 921*, AIR & SPACE MAG., Nov. 2002, *available at* http://www.airspacemag.com/space-exploration/Project_921.html (discussing the development of Project 921).

[cciii] *See, e.g.*, Ming Xia, *"China Threat" or a "Peaceful Rise of China"?*, N.Y. TIMES COMPANION, http://www.nytimes.com/ref/college/coll-china-politics-007.html.

[cciv] *See* HARDING, *supra* note xvii, at 99; *and* Joan Johnson-Freese, *US-China Space Cooperation: Congress' Pointless Lockdown*, CHINA-US FOCUS, June 10, 2011, *available at* http://www.chinausfocus.com/peace-security/us-china-space-cooperation-congress%E2%80%99-pointless-lockdown/.

[ccv] Johnson-Freese, *supra* note clxxxii, at 53.

[ccvi] *See* Brett Arends, *IMF Bombshell: Age of America Nears End*, WALL ST. J., Apr. 25, 2011, http://www.marketwatch.com/story/imf-bombshell-age-of-america-about-to-end-2011-04-25; *The Dating Game*, ECONOMIST, Dec. 27, 2011, http://www.economist.com/blogs/dailychart/2010/12/save_date.

[ccvii] *See* Tuan C. Nguyen, *China to Launch Lunar Rover, Mine Moon for Nuclear Fuel*, SMART PLANET, May 10, 2011, *available at* http://www.smartplanet.com/blog/thinking-tech/china-to-launch-lunar-rover-mine-moon-for-nuclear-fuel/7158.

[ccviii] *See* HARDING, *supra* note xvii, at 91.

[ccix] *See id.* at 99; *and* EUROCONSULT, *supra* note clxxxvii.

[ccx] Marcia S. Smith, *U.S Experts on China's Space Program Agree There Is No Race*, SPACE POL'Y ONLINE, July 6, 2012, http://www.spacepolicyonline.com/news/u-s-experts-on-chinas-space-program-agree-there-is-no-race (last visited Jan. 2, 2013).

[ccxi] KEOHANE & VICTOR, *supra* note xxi, at 4

[ccxii] *Id*. at 4 & 16 (discussing the advantages of regime complexes in the climate change context).

[ccxiii] *Id*. at 2.

[ccxiv] *Id*.

[ccxv] ORAN R. YOUNG, GLOBAL GOVERNANCE: DRAWING INSIGHTS FROM THE ENVIRONMENTAL EXPERIENCE 10 (1997).

[ccxvi] Interview with Steve Schneider, Professor of Biology, Stanford Univ., in Copenhagen, Den. (Dec. 8, 2009).

[ccxvii] *See* KEOHANE & VICTOR, *supra* note xxi, at 13.

[ccxviii] Raustiala & Victor, *supra* note xxiii, at 277.

[ccxix] ROBERT O. KEOHANE, AFTER HEGEMONY: COOPERATION AND DISCORD IN THE WORLD POLITICAL ECONOMY 61 (1984).

[ccxx] EDWARD W. PLOMAN, SPACE, EARTH AND COMMUNICATION 155 (1984).

[ccxxi] *See* Vincent Ostrom, Charles M. Tiebout, & Robert Warren, *The Organization of Government in Metropolitan Areas: A Theoretical Inquiry*, AM. POL. SCI. REV. 831, 831 (1961).

[ccxxii] BUCK, *supra* note xxxvii, at 146.

[ccxxiii] *Id*. at 147 (noting that majority rule can be used in COPUOS when consensus is impossible to attain, but this has not been done in practice).

[ccxxiv] *See id.* (citing NATHAN GOLDMAN, AMERICAN SPACE LAW: INTERNATIONAL AND DOMESTIC 26 (2d ed. 1996)).

[ccxxv] Telephone interview with Sergiy Negoda, Chief Counsel for the U.N. Office of Outer Space Affairs, in Vienna, Austria (Jan. 27, 2012).

[ccxxvi] *See* UNISPACE III, *supra* note cxviii.

[ccxxvii] *See* COPUOS Space Debris Mitigation Guidelines (2010), http://www.oosa.unvienna.org/pdf/publications/st_space_49E.pdf.

[ccxxviii] *See* David S. Weitzel, *Where No Lawyer Has Gone Before? What A Cyberspace Attorney Can Learn from Space Law's Legacy*, 10 COMM L. CONSPECTUS 191, 191 (2002); *and infra* p.29.

[ccxxix] Electronic interview with Steven Doyle, Executive Vice President, Clean Energy Systems (July 3, 2006).

[ccxxx] Ostrom, *supra* note xi, at 35.

[ccxxxi] *Id*. at 4.

[ccxxxii] Schneider, *supra* note ccxvi.

[ccxxxiii] KEOHANE & VICTOR, *supra* note xxi, at 19.

[ccxxxiv] Interview with Elinor Ostrom, Distinguished Professor, Indiana University, in Bloomington, Ind. (Oct. 13, 2010).

[ccxxxv] Elinor Ostrom, *Polycentric Systems as One Approach for Solving Collective-Action Problems* 2-3 (Ind. Univ. Workshop in Political Theory and Policy Analysis, Working Paper Series No. 08-6, 2008).

[ccxxxvi] *Id.* at 4. *See also* Cole, *supra* note xxiv, at 405 (arguing that "Instead of a 'monocentric hierarchy,' where governmental units at higher levels make all the decisions, and units at lower levels simply follow commands from above, a truly polycentric system is one in which governmental units both compete and cooperate, interact and learn from one another, and responsibilities at different governmental levels are tailored to match the scale of the public services they provide.") (citing Ostrom, *supra* note xi, at 33).

[ccxxxvii] *See* McGinnis, *supra* note xxvii, at 7.

[ccxxxviii] *See* KEOHANE & VICTOR, *supra* note xxi, at 18; Ostrom, *supra* note xi, at 5.

[ccxxxix] Garrett Hardin, *Lifeboat Ethics: The Case Against Helping the Poor*, PSYCHOL. TODAY, Sept. 1974, at 38-40, 123-124, 126 (examining, from an ethical viewpoint, when swimmers surrounding a lifeboat should be taken aboard).

[ccxl] *See, e.g.*, Christopher Joyce, *Climate Strategists: To Cut Emissions, Focus On Forests*, NPR, Dec. 10, 2011, *available at* http://www.npr.org/2011/12/10/143454111/climate-activists-to-cut-emissions-focus-on-forests?sc=17&f=1001 (reporting that some nations such as Norway are looking outside the U.N. framework for action on climate change). *But see EU Freezes Aviation Carbon Tax*, SYDNEY MORNING HERALD, Nov. 13, 2012, *available at* http://www.smh.com.au/travel/travel-news/eu-freezes-aviation-carbon-tax-20121113-2999v.html (reporting that the EU caved in to pressure from China and other countries over its aviation carbon tax, demonstrating the political blowback and false starts that can happen from taking bottom-up action to address global collective action problems) [hereinafter *EU Freezes*].

[ccxli] *See* Ostrom, *supra* note xi, at 16.

[ccxlii] *Id*. at 5 (citing to Michael P. Vandenberg & Anne C. Steinemann, *The Carbon-Neutral Individual*, 82 N.Y.U. L. REV. 1673, 1700 (2007)).

[ccxliii] Ostrom, *supra* note 11, at 5.

[ccxliv] *See EU Freezes*, *supra* note ccxl.

[ccxlv] KEOHANE & VICTOR, *supra* note xxi, at 23.

[ccxlvi] *See* W.J.W. Botzen, et al., *Cumulative CO2 Emissions: Shifting International Responsibilities for Climate Debt*, 8 CLIMATE POL'Y 569, 569 (2008); *and* Robert Stowe, *COP 18 and the Future of International Climate Policy*, ENERGY COLLECTIVE, Dec. 11, 2012, http://theenergycollective.com/robertstowe/155426/cop-18-and-future-international-climate-policy (last visited Dec. 31, 2012). *But see* Sethi, *supra* note cxxxi (reporting on some progress in negotiating common but differentiated responsibilities for addressing climate change).

[ccxlvii] *See* KEOHANE & VICTOR, *supra* note xxi, at 18 & 25 (discussing how "universal voting rules often yield inaction[]" and how a regime complex may help improve the status quo).

[ccxlviii] *See id*. at 6-7; *and* Ostrom, *supra* note xi, at 15-16.

[ccxlix] *See* KEOHANE & VICTOR, *supra* note xxi, at 6; *and* John Vidal, Allegra Stratton, & Suzanne Goldenberg, Low Targets, Goals Dropped: Copenhagen Ends in Failure, GUARDIAN, Dec. 18, 2009, *available at* http://www.guardian.co.uk/environment/2009/dec/18/copenhagen-deal .

[ccl] *See, e.g., Climate Talks End with Late Deal*, BBC NEWS, Dec. 11, 2011, http://www.bbc.co.uk/news/science-environment-16124670 (reporting on the outcome of COP17).

[ccli] Ostrom, *supra* note ccxxxiv.

[cclii] *See infra* p.35.

[ccliii] Ostrom, *supra* note xi, at 40. *See also* Cole, *supra* note xxiv, at 396 (arguing that "*effective* global governance institutions inevitably are 'polycentric' in nature[,]" and that "polycentric governance requires a certain level of independence, as well as interdependence, between governance institutions and organizations at various levels. The key issue—applicable to climate policy as much as to other areas of global or international concern—is to determine the appropriate division of responsibility and authority between governance institutions and organizations at global, national, state, and local levels.").

[ccliv] Ostrom, *supra* note xi, at 35.

[cclv] *Id*. at 9.

[cclvi] *See* UNCLOS, *supra* note cxxxv, art. 137.

[cclvii] *See* Feeny et al., *supra* note lxxxiv, at 4; *see also* Lon L. Fuller, *The Forms of and Limits of Adjudication*, 92 HARV. L. REV. 353, 397-98 (1978) (noting the applicability of polycentricity to the law and adjudication).

[cclviii] *See* McGinnis, *supra* note xxvii, at 7.

[cclix] U.N. Charter, pmbl & art. XIII; *see also Tragedy*, *supra* note cix, at 135 (arguing that the move away from UN-centered multilateral treatymaking is a dramatic change in affairs in the governance of outer space).
[cclx] *See* NSPD 49, *supra* note CXIX, *at* 5.

[cclxi] Press Release, U.N. General Assembly, Strength of International Space Law to Prevent Militarization of Outer Space, U.N. Doc. GA/SPD/458 (Oct. 14, 2010), *available at* http://www.un.org/News/Press/docs//2010/gaspd458.doc.htm.

[cclxii] *Id*.

[cclxiii] *Id*.

[cclxiv] *Id*.

[cclxv] *Id*.

[cclxvi] *See* Doyle, *supra* note 245.

[cclxvii] *See* Nancy Trejos, *A New Space Race: Companies Vie to Haul Cargo, Passengers*, USA TODAY, Aug. 13, 2012, *available at* http://travel.usatoday.com/news/story/2012-08-13/A-new-space-race-Companies-vie-to-haul-cargo-passengers/57036720/1.

[cclxviii] Remarks by the President on Space Exploration in the 21st Century, John F. Kennedy Space Center (Apr. 15. 2010), http: /www.nasa.gov/news/media/trans/obama_ksc_trans.html [hereinafter Remarks by the President].

[cclxix] *Id*.

[cclxx] *See* Remarks by the President, *supra* note cclxviii

[cclxxi] *See* Doyle, *supra* note 245. *But see* Jeff Foust, *A New Approach for Property Rights in Space*, SPACE POLITICS, Apr. 3, 2012, *available at* http://www.spacepolitics.com/2012/04/03/a-new-approach-for-property-rights-in-space/ (discussing a white paper from the Competitive Enterprise Institute advocating for Congressional action to clarify property rights in space).

[cclxxii] *See Tragedy*, *supra* note cix, at 146-52.

[cclxxiii] *See* Moon Treaty, *supra* note cxxxiv, art. XI(7) (laying out the purpose of the proposed future international regime for the exploitation of lunar resources).

[cclxxiv] *See* RICKY J. LEE, LAW AND REGULATION OF COMMERCIAL MINING OF MINERALS IN OUTER SPACE 160-62 & 261 (2012) (laying out some of the various possible interpretations of ambiguous space law treaty provisions relating to the commercial use of space); *and* LYALL & LARSEN, *supra* note xxxvi, at 190-92 (discussing issues with exploitation under space law more generally).

[cclxxv] *See* OST, *supra* note cxiii, arts. 8; Henry R. Hertzfeld, *The Moon is a Land without Sovereignty: Will it be a Business-Friendly Environment?*, HIGH FRONTIER 43-44 (2007), *available at* http://www.gwu.edu/~spi/articles.cfm; *and* Henry R. Hertzfeld & Frans G. von der Dunk, *Bringing Space Law into the Commercial World: Property Rights without Sovereignty*, 6 CHI. J. INT'L L. 81, 85 (2005).

[cclxxvi] *See* John Lewis, *Space Procedures: A Closer Look at the International Framework for Satellite Networks*, ITU, *available at* http://www.itu.int/itunews/manager/display.asp?lang=en&year=2009&issue=02&ipage=26&ext=html.

[cclxxvii] *See, e.g.*, OECD INT'L FUTURES PROGRAMME, SPACE 2030: TACKLING SOCIETY'S CHALLENGES 189 (2005).

[cclxxviii] *Id.*; *and* Edmund L. Andrews, *Tiny Tonga Seeks Satellite Empire in Space*, N.Y. TIMES, Aug. 28, 1990, *available at* http://www.nytimes.com/1990/08/28/business/tiny-tonga-seeks-satellite-empire-in-space.html?pagewanted=all&src=pm (reporting that Tonga's efforts were at least in part encouraged by a U.S. investor).

[cclxxix] *See* PRESIDENT'S COMM'N IMPLEMENTATION U.S. SPACE EXPLORATION POL'Y, A JOURNEY TO INSPIRE, INNOVATE AND DISCOVER 8, 33-34 (2004), http://govinfo.library.unt.edu/moontomars/docs/M2MReportScreenFinal.pdf (encouraging the U.S. Congress to adopt measures to help assure that "appropriate property rights [exist] for those who seek to develop space resources and infrastructure"; NSPD 49, *supra* note CXIX; *see also* Joel D. Scheraga, *Establishing Property Rights in Outer Space*, 6 CATO J. 889 (1987) (providing an early survey of theories about property rights in space).

[cclxxx] *See* Moon Treaty, *supra* note cxxxiv, art. XI; *and* Hertzfeld & von der Dunk, *supra* note cclxxv, at 85.

[cclxxxi] *See* Robert J. Samuelson, *The Spirit of Capitalism*, FOREIGN AFF., Jan. 2001, http://foreignaffairs.com/print/56674 ; *Tragedy*, *supra* note cix, at 140-41.

[cclxxxii] *See 1969: Man Takes First Steps on the Moon*, BBC, http://news.bbc.co.uk/onthisday/hi/dates/stories/july/21/newsid_2635000/2635845.stm (last visited Dec. 2, 2013).

[cclxxxiii] *See* BUCK, *supra* note xxxvii, at 141.

[cclxxxiv] *See* OST, *supra* note cxiii, art. II.

[cclxxxv] *See* Scott Shackelford, *From Asian Politics to Astropolitics: The History and Future Shape of Asian Space Policy*, 58 PROC. INT'L ASTRONAUTICAL FED'N (IAF) 68, 71-73 (2007), *available at* www.gbv.de/dms/spk/sbb/toc/584776039.pdf (representing the first iteration of this analysis).

[cclxxxvi] Hundreds more acts have also come into effect during this period, but do not deal with international cooperation, the private sector, or natural resources, and so are beyond the scope of this case study.

[cclxxxvii] *Meeting International Responsibilities and Addressing Domestic Needs*, United Nations Nigeria Workshop on Space Law, in Abuja, Nigeria (Nov. 21-24, 2005).

[cclxxxviii] *Id*.

[cclxxxix] Pace, *supra* note xviii, at 84.

[ccxc] *See* Astropolitics, *supra* note cclxxxv, at 78-82 (publishing the analysis from *New Frontiers* in the IAF conference proceedings). *See generally* NATIONAL REGULATION OF SPACE ACTIVITIES (Ram S. Jakhu ed., 2010) (offering a contemporary review of national space activites) [hereinafter NATIONAL REGULATION OF SPACE ACTIVITIES].

[ccxci] *See* NATIONAL REGULATION OF SPACE ACTIVITIES, *supra* note CCXC, at 2; *and* Johnson-Freese, *supra* note clxxxii, at 57 (summarizing China's justifications for a human spaceflight program as being consistent with its national interests).

[ccxcii] *See* Law on the Activites of Launching, Flight Operations or Guidance of Space Objects (2005) (Belg.).

[ccxciii] *See* Raumfahrtaufgabeneubetragungsgestz [Law Governing the transfer of responsibilities for space activities], Aug. 22, 1998, RGBI I at 89, § 1 (Ger.).

[ccxciv] United Nations Nigeria Workshop, *supra* note cclxxxvii.

[ccxcv] *See id*.

[ccxcvi] Supreme Decree No. 338, Establishment of a Presidentail Advisory Committee Known as the Chilean Space Agency, Gazette No. 37039, July 17, 2001 (Chile), *available at* United Nations Nigeria Workshop, *supra* note cclxxxvii, at 128-30.

[ccxcvii] *See* OST, *supra* note cxiii, pmbl.

[ccxcviii] *See* Sobranie Zakonodatel'stva Rossiiskoi Federatsii [SZ RF] [Russican Federation Collection of Legislation] 1995, No. 468, *available at* United Nations Nigeria Workshop, *supra* note cclxxxvii, at 182; *and* United Nations Compilation of National Space Laws, http://www.oosa.unvienna.org/oosaddb/browse_all_js.jsp?dims=COUNTRY_CODE|DATE [hereinafter Compilation].

[ccxcix] *See infra* p.35.

[ccc] These include: Argentina, Australia, Canada, Chile, China, Russia, Ukraine, and the United States. *See* Compilation, *supra* note ccxcviii; *and* United Nations Nigeria Workshop, *supra* note cclxxxvii.

[ccci] *See* United Nations Nigeria Workshop, *supra* note cclxxxvii.

[cccii] *See* Commercial Space Launch Act of 1984, 49 U.S.C. § 701 (1994) (as amended in 1998).

[ccciii] Commercial Space Act of 1998, 51 U.S.C. § 50111(a) (2011 Supp.).

[ccciv] *But see* John J. Leonard, *Establishing a Global Space Lobbying Organization: Yuri's Foundation*, SPACE REV., Mar. 30, 2009, http://www.thespacereview.com/article/1336/1 (making the case that in fact more lobbying is needed in space policymaking); *and* ELIGAR SADEH, THE POLITICS OF SPACE: A SURVEY 153 (2010) (arguing that lobbying groups such as the L5 society have not had the impact that they are sometimes claimed to have had on space lawmaking, at least in the context of the Moon Treaty debates).

[cccv] *International Space Exploration Programs Before the Senate S. Comm. On Science, Technology, and Space*, 108th Cong., S. Hrg. (2004), (statement of John M. Logsdon, Director, George Washington University Space Policy Institute), *available at* http://elliott.gwu.edu/news/testimony/logsdon.cfm.

[cccvi] *See* Jonathan Lewis, *Japanese Policymaking for the International Space Station*, 7 JAPANSTUDIEN 135, 149 (1996) (making the case that the aerospace industry influenced Japan's budget for the International Space Station).

[cccvii] *See* JAXA Vision 2025 – An Ideal Society Through Aerospace Technology, *available at* http://www.jaxa.jp/about/2025/index_e.html.

[cccviii] *See* SADEH, *supra* note 324, at 153. *But see* BASLAR, *supra* note cxviii, at 128 n. 64 (noting that President Clinton maintained that the CHM concept is consistent with U.S. space policy).

[cccix] *See* John H. Jackson, *Sovereignty-Modern: A New Approach to an Outdated Concept*, 97 AM. J. INT'L L. 782, 798 (2003).

[cccx] Press Release, E.U. Comm'n, Europe's United Response to U.S. Space Plans, Feb. 19, 2004 (paragraph break ommited); Potential International Cooperation in NASA's New Exploration Initiative: Testimony to the Subcomm on Science, Tech., and Space of the S. Comm. On Commerce, Sci., and Transp., 107 Cong. (2004) (Statement of Maricia S. Smith, Specialist in Aerospace and Telecomm. Pol'y, Cong, Research Serv.).

[cccxi] There is a case to be made that the United Kingdom may be deemed market rationalists in this framework given its strong support for the commercial space sector, as well as the fact that the UK Space Agency is housed within the Department for Business, Innovation, and Skills. *See* UK Space Agency: Who We Are, http://www.bis.gov.uk/ukspaceagency/who-we-are (last visited Jan. 2, 2013).

[cccxii] *See Status of International Agreements Relating to Activities in Outer Space as of Jan. 1, 2012*, OOSA, *available at* http://www.oosa.unvienna.org/oosa/en/SpaceLaw/treatystatus/index.html [hereinafter UN Space Treaties Status].

[cccxiii] *See* Doug Palmer, *BRICs Score Lowest on Intellectual Property Index*, REUTERS, Dec. 11, 2012, *available at* http://www.reuters.com/article/2012/12/11/us-trade-copyright-countries-idUSBRE8BA0O620121211 (reporting that Brazil, Russic, India, and China are among the countries with the worst intellectual property rights protections acording to a 2012 Global Intellectual Proeprty Center survey).

[cccxiv] *See, e.g.*, Richard Brubaker, *China and Sustainability: Connecting the Dots Between Economy and Ecology*, GUARDIAN, Sept. 10, 2012, http://www.guardian.co.uk/sustainable-business/blog/china-sustainability-economy-environment-ecology (reporting that economic development remains the key component of sustainabile development in China). Russia could belong in this group given its history of state-sponsored development, wariness of limitations on its sovereignty, prohibition on property rights during the Soviet era, and drive for rapid

development. But Russia stands apart due to its stance on the CHM. *See* BASLAR, *supra* note cxviii, at 163-64 & 177; *and* Alex Shoumatoff, *The Arctic Oil Rush*, VANITY FAIR, May 2008, *available at* http://www.vanityfair.com/politics/features/2008/05/arctic_oil200805 (discussing Russia's Arctic claims as an example of current Russian policy on managing global commons spaces).

[cccxv] China's Space Activities, http://www.china.org.cn/english/2000/Nov/4288.htm (last visited Jan. 2, 2013).

[cccxvi] *See China's Next Revolution: Property Rights in China*, ECONOMIST, Mar. 8, 2007, *available at* http://www.economist.com/node/8815075.

[cccxvii] *See* Long, *supra* note lvi (reporting that certain Chinese space scientists are calling for the government to declare space China's "fourth territory"); *and* BASLAR, *supra* note cxviii, at 179 (discussing how China's commercial space sector will influence how the CHM concept evolves in space law). *But see* HARM DOTINGA & BARBARA KWIATKOWSKA, INTERNATIONAL ORGANIZATIONS AND THE LAW OF THE SEA: DOCUMENTARY YEARBOOK 1999 205 (2002) (republishing a Chinese diplomat's address to the UNGA voicing cautious support for the CHM concept in the context of the LOS).

[cccxviii] *See* UN Space Treaties Status, *supra* note cccxii.

[cccxix] *See* Rakesh Krishnan Simha, *Space: India Trailing China in the Long March*, RUSS. & INDIA REP., June 25, 2012, *available at* http://indrus.in/articles/2012/06/25/space_india_trailing_china_in_the_long_march_16044.html.

[cccxx] *Id*.

[cccxxi] Fuchter, *supra* note xvi, at 66.

[cccxxii] *Id*.

[cccxxiii] *See* BASLAR, *supra* note cxviii, at 129-30. The Bogotá Declaration was an effort by seven equatorial staetes to assert property rights to geosynchronous orbit "above their respective territories." LYALL & LARSEN, *supra* note xxxvi, at 253.

[cccxxiv] *See* Ronald J. Deibert, *Unfettered Observation: The Politics of Earth Monitoring from Space*, *in* SPACE POLICY IN THE 21ST CENTURY 99 (W. Henry Lambright ed., 2003).

[cccxxv] *See* BUCK, *supra* note xxxvii, at 144 & 149.

[cccxxvi] *See* OST, *supra* note cxiii, art. I.

[cccxxvii] Kraska, *supra* note xiv, at 60.

[cccxxviii] Manor & Neuman, *supra* note xvi, at 100.

[cccxxix] *See* Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, U.S.-U.K.-U.S.S.R., art. I, Aug. 5, 1963, 14 U.S.T. 1313 [hereinafter Test Ban Treaty].

[cccxxx] *See* Pub. L. No. 92-448, 86 Stat. 746 (1972).

[cccxxxi] *See* Peter L. Hays, United States Military Space: Into the Twenty-First Century 93 (INSS Occasional Paper No. 42, 2002).

[cccxxxii] *Id*. at 92-93.

[cccxxxiii] *See* Thomas B. Coughlin et al., *Strategic Defense Initiative*, 13 JOHNS HOPKINS APL TECH. DIG. 200, 200-205 (Mar. 1992) (discussing how the controversy surrounding SDI centered on whether the aborted initiative involved x-ray lasers).

[cccxxxiv] *See* OST, *supra* note cxiii, pmbl.; *and* BOB PRESTON ET AL., SPACE WEAPONS: EARTH WARS 23 (2002) (defining "space weapons" as "things intended to cause harm that are based in space or that have an essential element based in space.").

[cccxxxv] *See* CLAYTON CHUN, DEFENDING SPACE: US ANTI-SATELLITE WARFARE AND SPACE WEAPONRY 33 (2006).

[cccxxxvi] *See* G.F. Pieper, *A Second Radiation Belt from the July 9, 1962, Nuclear Detonation*, 68(3) J. GEOPHYSICAL RES. 651, 651 (1963).

[cccxxxvii] *See* Kestenbaum, *supra* note i.

[cccxxxviii] *See* Sterner, *supra* note x, at 109.

[cccxxxix] Tim Dobbyn, *Challenges Loom as Obama Seeks Space Weapons Ban*, REUTERS, Jan. 25, 2009, http://uk.reuters.com/article/idUKTRE50O15X20090125.

[cccxl] *See generally* Frank M. Walsh, *Forging a Diplomatic Shield for American Satellites: The Case for Reevaluating the 2006 National Space Policy in Light of a Chinese Anti-Satellite Test*, 72 J. AIR L. & COM. 759 (2007) (exploring some of the challenges associated with bilateral space arms control negotiations between the U.S. and China).

[cccxli] Dobbyn, *supra* note cccxxxix; *see also* Michael Krepon, *A Code of Conduct for Responsible Space-Faring Nations*, 50 Years of Space Technology, 40 Years of the Outer Space Treaty, Conf. Rep. 165, 170 in Geneva, Switz. (Apr. 2-3, 2007) (arguing in favor of a Code of Conduct for Responsible Space-Faring Nations).

[cccxlii] *See* Council Common Position (EC) No. 14455/10 of Oct. 11, 2010, art. IV(2), 2010 O.J., *available at* www.consilium.europa.eu/uedocs/cmsUpload/st14455.en10.pdf.

[cccxliii] *See* Denise Chow, *Space Junk Hazards Force International Response*, SPACE.COM, June 25, 2012, http://www.space.com/16289-space-junk-international-response.html (reporting that multilateral meetings were planned in the summer of 2012 on the topic of space debris mitigation).

[cccxliv] Sterner, *supra* note x, at 107-08. A zero-sum game is a situation where a participant's gain or loss is offset by another participant's gain or loss, which may be compared to a non-zero sum game in which the parties' experience aggregate gains or losses. *See* KEN BINMORE, PLAYING FOR REAL: A TEXT ON GAME THEORY 246 (2007); *and* SAMUEL BOWLES, MICROECONOMICS: BEHAVIOR, INSTITUTIONS, AND EVOLUTION 33-36 (2004).

[cccxlv] Dean Cheng, *Spacepower in China*, *in* TOWARD A THEORY OF SPACEPOWER 113, 450 (Charles D. Lutes et al. eds., 2011).

[cccxlvi] NATIONAL SPACE, *supra* note cclx, at 4.

[cccxlvii] *See* OST, *supra* note cxiii, pmbl.

[cccxlviii] *See* Press Release, UN General Assembly, Gravely Concerned About Status of UN Disarmament Machinery, Especially in Conference on Disarmament, Invites States to Explore Options, U.N. Doc. GA/11182 (2011), *available at* https://www.un.org/News/Press/docs//2011/ga11182.doc.htm; *and* JOHN VOGLER, THE GLOBAL COMMONS: A REGIME ANALYSIS 106 (1995).

[cccxlix] *See* PAUL S. OH, ASSESSING CHINESE INTENTIONS FOR THE MILITARY USE OF THE SPACE DOMAIN passim (2012); *and* Craig Covault, *Chinese Test Anti-Satellite Weapon*, AVIATION WK., Jan. 17, 2007, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=space&id=news/CHI01177.xml.

[cccl] *See* BUCK, *supra* note xxxvii, at 144; *and* Joseph N. Pelton, *Satellite Security and Performance in an Era of Dual Use*, J. SPACE COMM. 1, 3-4 (2004).

[cccli] *China's Defense White Paper 2006*, PEOPLE'S REPUBLIC OF CHINA (PRC) INFORMATION OFFICE OF THE STATE COUNCIL (IOSC), Ch. 2, para. 1 (P.R.C.).

[ccclii] Bryan Krekel et al., *Capability of the People's Republic of China to Conduct Cyber Warfare and Computer Network Exploitation*, U.S. CHINA ECON. & SEC. REV. COMM. at 6 (Oct. 9, 2009)

[cccliii] Larry M. Wortzel, *The Chinese Peoples Liberation Army and Space Warfare*, AM. ENTERPRISE INST., Oct. 17, 2007, at 1.

[ccccliv] *Id*. at 6; *and* Fuchter, *supra* note xvi, at 57-59.

[ccclv] Wortzel, *supra* note ccclii, at 8; *and* Fuchter, *supra* note xvi, at 57-59.

[ccclvi] Fuchter, *supra* note xvi, at 53.

[ccclvii] *Id*. at 58.

[ccclviii] *Id.*; Stephen Jones, *Can the UK Remain a First Division Player in Military Operations Without Significant Additional Investment in Space-based Capability*?, 12(2) RAF AIR POWER REV. 16, 58 (Summer 2009); Ross Liemer & Christopher F. Chyba, *A Verifiable Limited Test Ban for Anti-Satellite Weapons*, WASH. Q. 149, 149 (July 2010).

[ccclix] *See* Sterner, *supra* note x, at 115.

[ccclx] *Id.*; *and* Press Release, General Assembly, Prevention of Outer Space Arms Race, Ratification of Nuclear Test-Ban Treaty Among Issues Addressed by Texts Introduced in First Committee, U.N. Press Release GA/DIS/3233 (Oct. 15, 2002), http://www.un.org/News/Press/docs/2002/gadis3233.doc.htm.

[ccclxi] *See* Sterner, *supra* note x, at 115.

[ccclxii] *Id.* (citing Nancy Gallagher & John Steinbruner, *Reconsidering the Rules for Space Security*, (Am. Acad. Arts & Sciences Monograph, 2008)).

[ccclxiii] *Id*. at 116.

[ccclxiv] Baker Spring, *How Congress Should Interpret the New Space Policy Directive to Provide for National Security*, HERITAGE FOUND., Jan. 19, 2007, *available at* http://www.heritage.org/research/reports/2007/01/how-congress-should-interpret-the-new-space-policy-directive-to-provide-for-national-security.

[ccclxv] *See* Comm. On the Peaceful Uses of Outer Space, Rep on its 53rd Sess., Jun 9-18, 2010, para. 43, U.N. Doc. A/65/20; GOAR, 65th Sess., (2010), http://www.oosa.unvienna.org/oosa/Reports/gadocs/coprepidx.html#A_65_20.

[ccclxvi] *See* Tom Wilson, *Threats to United States Space Capabilities*, COMM. ASSESS UNITED STATES NAT'L SEC. SPACE MAN. & ORG. (Jan. 11, 2001), *available at* https://www.fas.org/spp/eprint/article05.html.

[cclxvii] *See, e.g.*, Nicole Blake Johnson, *Report: Cyber Attacks Targeted U.S. Satellites*, DEF. NEWS, Oct. 28, 2011, *available at* http://www.defensenews.com/article/20111028/DEFSECT01/110280301/Report-Cyber-Attacks-Targeted-U-S-Satellites (reporting that hackers "'achieved all steps required to command' a NASA satellite, which put the satellite at risk of being destroyed or damaged"); *and SkyGrabber Software Used By Terrorists to Hack Drone Video Feeds*, WALL STREET PIT, (Dec. 17, 2009, 2:56 pm), http://wallstreetpit.com/13015-skygrabber-software-used-by-terrorists-to-hack-drone-video-feeds (reporting that terrorists were able to hack into the video feed from a U.S. predator drone using off-the-shelf software, demonstrating what attacks may be technically feasible with a more determined adversary).

[cclxviii] *See* Kraska, *supra* note xiv, at 60.

[cclxix] Sterner, *supra* note x, at 108.

[cclxx] *See* SDA Overview, http://www.space-data.org/sda/about/sda-overview/ (last visited Oct. 23, 2012)

[cclxxi] *See* Abraham M. Denmark, *Managing the Global Commons*, WASH. Q. 165, 174 (July, 2010).

[cclxxii] Ostrom, *supra* note xi, at 6 (referring to "settings where uncoordinated decisions motivated by the pursuit of individual benefits generate suboptimal payoffs . . . in the long run").

[cclxxiii] *Id*. at 6-7.

[cclxxiv] *Id*.

[cclxxv] *Id*. at 7.

[cclxxvi] *Id*.

[cclxxvii] *Id*. at 8.

[cclxxviii] *Id*.

[cclxxix] MARTIN J. OSBORNE, AN INTRODUCTION TO GAME THEORY 14 (2002).

[cclxxx] *Id*. at 13.

[cclxxxi] Ostrom, *supra* note xi, at 5.

[cclxxxii] *Id*. *See also* Bird, *supra* note lxxxii, at 685 (advocating for a new multilateral treaty to address the problem of space junk); *and* Jonathan Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 155 UNIV. PENN. L. REV. 1961 (2007).

[cclxxxiii] Ostrom, *supra* note xi, at 9-10.

[cclxxxiv] *See id.* at 9.

[cclxxxv] *Id.* at 10.

[cclxxxvi] Ostrom, *supra* note xi, at 10 (citing Elinor Ostrom, *A Behavioral Approach to the Rational Choice Theory of Collective Action*, 92 AM. POL. SCI. REV. 1, 1-12 (1998)).

[cclxxxvii] *Orbital Debris: A Technical Assessment*, U.S. CONG. OFFICE TECH. ASSESSMENT, *available at* http://www.nap.edu/openbook.php?record_id=4765&page=11. *See also* David Wright, *Space debris*, PHYSICS

TODAY, *available at* http://physicstoday.org/journals/doc/PHTOAD-ft/vol_60/iss_10/35_1.shtml (estimating 850 active satellites in orbit as of 2011).

[ccclxxxviii] BUCK, *supra* note xxxvii, at 150.

[ccclxxxix] *See* Jakhu, *supra* note ccxc, at 4; *and* Jakhu, *supra* note cxxvii, at 11 (noting that "States bear international responsibility for their national activities and are liable for damage caused by their space objects.").

[cccxc] An exception are articles XIV through XX of the Liability Convention, which give authority to establish an ad hoc claims commission. *See* The 1972 Convention on International Liability for Damage Caused by Space Objects, arts. 14-20, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 (entered into force Sept. 1, 1972) [hereinafter Liability Convention].

[cccxci] *See* Sean McLachlan, *Space Junk is Out of Control, Scientists Say*, GADLING, Sept. 2, 2011, *available at* http://www.gadling.com/2011/09/02/space-junk-is-out-of-control-scientists-say/.

[cccxcii] Sterner, *supra* note x, at 124 (citing Robert Lee Hotz, *Harmless Debris on Earth is Devastating in Orbit*, WALL ST. J. Feb. 27, 2009, *available at* http://online.wsj.com/article/SB123568403874486701.html).

[cccxciii] *See* Leonard David, *China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth*, SPACE.COM, Feb. 2, 2007, http://www.space.com/3415-china-anti-satellite-test-worrisome-debris-cloud-circles-earth.html.

[cccxciv] *Id*.

[cccxcv] NASA Orbital Debris, *supra* note ii, at 2.

[cccxcvi] *See* Wright, *supra* note ccclxxxvii.

[cccxcvii] Covault, *supra* note cccxlix.

[cccxcviii] *See* Wright, *supra* note ccclxxxvii..

[cccxcix] BUCK, *supra* note xxxvii, at 150.

[cd] *Id*. (noting that the USSR eventually agreed to reimburse Canada three million dollars in cleanup costs, but to date Russia has not followed through on this promise, demonstrating the difficulty of sanctioning in space law).

[cdi] *Id.*.

[cdii] *Id*.

[cdiii] *Id.*

[cdiv] *See Satellite Collision Leaves Significant Debris Clouds*, 13(2) NASA ORBITAL DEBRIS Q. NEWS 1, 1-2 (Apr. 2009).

[cdv] *Space Junk at Tipping Point, Says Report*, BBC NEWS, Sept., 1, 2011, *available at* www.bbc.co.uk/news/world-us-canada-14757926.

[cdvi] *See* Liability Convention, *supra* note cccxc, arts. XIV-XX.

[cdvii] *See* Michael Listner, *Legal Issues Surrounding Space Debris Remediation*, SPACE REV., Aug. 6, 2012, *available at* http://www.thespacereview.com/article/2130/1.

[cdviii] Convention on Registration of Objects Launched Into Outer Space, Nov. 12 & 14, 1974, art. I, 28 U.S.T. 695, 1023 U.N.T.S. 15 (entered into force Sept. 15, 1976) [hereinafter Registration Convention]; BUCK, *supra* note xxxvii, at 151.

[cdix] *Id.* at art. VII. However, the Registration Convention does define a "launching state" as "A State from whose territory or facility a space object is launched." *Id*. at art. I.

[cdx] *But see* EDWARD L. MILES ET AL., ENVIRONMENTAL REGIME EFFECTIVENESS: CONFRONTING THEORY WITH EVIDENCE 224 (2002) (analyzing the effectiveness of the regime for satellite communications since 1957).

[cdxi] *See, e.g.*, Oona Hathaway, *Do Human Rights Treaties Make a Difference?*, 111 YALE L.J. 1935, 1937-38 (2002) (analyzing the effectiveness of some provisions of international human rights law).

[cdxii] *See* Carsten Helm & Sprinz Detlef, *Measuring the Effectiveness of International Environmental Regimes*, 44(5) J. CONFLICT RES. 630, 630-33 (2000).

[cdxiii] *See* Stephen J. Kobrin, *Territoriality and the Governance of Cyberspace*, 32(4) J. INT'L. BUS. STUD. 687, 687 (2001).

[cdxiv] *See* Michael Zürn, *The Rise of International Environmental Politics: A Review of Current Research*, 50(4) WORLD POLITICS 617, 649 (1998).
[cdxv] *See* Scott Barrett, *Self-Enforcing International Environmental Agreements*, 46 OXFORD ECON. PAPERS 878, 892 (1994); Helm & Detlef, *supra* note cdxii, at 639.
[cdxvi] *See* Helm & Detlef, *supra* note cdxii, at 647.

[cdxvii] *Id*. *See also* MATTHEW PATTERSON, GLOBAL WARMING AND GLOBAL POLITICS 6-7 (1996) (discussing the aplicability of international relations theory to global warming).

[cdxviii] *See* Helm & Detlef, *supra* note cdxii, at 647.

[cdxix] *See* ORAN R. YOUNG, THE EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL REGIMES: CAUSAL CONNECTIONS AND BEHAVIORAL MECHANISMS 4-6 (1999).

[cdxx] *See* United Nations Treaties and Principles on Space Law, *supra* note cxviii.

[cdxxi] *Id*.

[cdxxii] *Id*.

[cdxxiii] *See* CLAUDE LAFLEUR, SPACECRAFT ENCYCLOPEDIA, http://claudelafleur.qc.ca/Spacecrafts-index.html.

[cdxxiv] COMMERCIAL SPACE TRANSPORTATION: 2011 YEAR IN REVIEW, FEDERAL AVIATION ADMIN. 2-3 (2011).

[cdxxv] *See* Laura Grego, *A History of Anti-satellite (ASAT) Programs*, UNION CONCERNED SCIENTISTS, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/policy_issues/a-history-of-anti-satellite.html.

[cdxxvi] *Id.*

[cdxxvii] Jeremy Hsu, *Is a New Space Weapon Race Heating Up?*, SPACE.COM, May 5, 2010, http://www.space.com/businesstechnology/space-war-weapons-heats-up-100505.html.

[cdxxviii] *See id.*; *and* Grego, *supra* note 334.

[cdxxix] Hsu, *supra* note cdxxvii.

[cdxxx] *See* Missile Technology Control Regime, http://www.mtcr.info/english/FAQ-E.html.

[cdxxxi] *Id.*

[cdxxxii] *E.g.*, Jeremy Hsu & Jeanne Bryner, *Space Arms Race Heats Up Overnight*, Space.com, Feb. 21, 2008, http://www.space.com/news/080221-asat-aftermath.html.

[cdxxxiii] *See* Grego, *supra* note cdxxv, at 128 (note that the period from 2011 to 2030 is projected). For a more detailed chart, see *Historical Growth of Catalogued Objects*, NASA ORBITAL DEBRIS Q. (Jan. 2011). *But see* Jakhu, *supra* note cxxvii, at 16 (noting that "From the mid-90s until 2006, there was a gradual decline in the growth rate of space debris.").

[cdxxxiv] *See* Wright, *supra* note ccclxxxvii.

[cdxxxv] David, *supra* note ii.

[cdxxxvi] *See* Tory Maguire, *Australia, US Vow to Clean up Outer Space*, NEWS.COM.AU, Nov. 8, 2010, *available at* http://www.news.com.au/technology/sci-tech/australia-us/story-fn5fsgyc-1225949489905. A preference for bilateral treaties is also playing out in investment law with more than 2,000 bilateral investment treaties (BITs) now in force, symbolizing another bottom-up regulatory response to a multilateral problem, i.e., guaranteeing investor property rights to spur investment. *See* GUS VAN HARTEN, INVESTMENT TREATY ARBITRATION IN PUBLIC LAW 3-5 (2007).

[cdxxxvii] *See* OST, *supra* note cxiii, art. IX.

[cdxxxviii] Jakhu, *supra* note ccxc, at 4.

[cdxxxix] Hugh Ward, *International Linkages and Environmental Sustainability: The Effectiveness of the Regime Network*, 43 J. PEACE RES. 149, 150 (2006). *See, e.g.*, Anne-Marie Slaughter Burley, *International law and Relations Theory: A Dual Agenda*, 87(2) AM. J. INT'L L. 205, 231 (1993). Professor Slaughter has also pioneered network theory studying transnational regulatory networks and its progency. However, this work primarily focuses on states, making it less useful for analyzing space governance. *See* Anne-Marie Slaughter, *Sovereignty and Power in a Networked World Order*, 40 STAN. J. INT'L L. 283 (2004).

[cdxl] *See* Frank A. Rose, Laying the Groundwork for a Stable and Sustainable Space Environment, U.N. Inst. Disarmament Research, Space Sec. Conf., in Geneva, Switz., Mar. 29, 2012, *available at* http://www.state.gov/t/avc/rls/187090.htm (reporting that Japan, Australia, the EU, and the United States have agreed to develop a Code of Conduct for space debris mitigation).

[cdxli] *See* Bird, *supra* note lxxxii, at 661 & 682-85 (arguing that "[a]lthough not universally accepted, sustainable development invokes a principle accepted by a majority of the global community for over thirty years, and should be embraced in a space debris regime" as well as discussing the opposition and procedural hurdles to a space debris treaty).

[cdxlii] *See generally* Scott J. Shackelford, *From Net War to Nuclear War: Analogizing Cyber Attacks in International Law*, 27 BERKELEY J. INT'L L. 192 (2009) (discussing the potential to govern cyberspace through either the effects principle or the CHM concept).

[cdxliii] *See* Inter-Agency Space Debris Coordination Committee, http://www.iadc-online.org/index.cgi (last visited Jan. 3, 2013).

[cdxliv] *See* NASA Orbital Debris, *supra* note ii, at 2. *But see* Jakhu, *supra* note cxxvii, at 13 (noting that these guidelines are operational and future-oriented, and do not address space debris generation during armed conflicts).

[cdxlv] *See* Rose, *supra* note cdxl.

[cdxlvi] *Id*.

[cdxlvii] *See* Jakhu, *supra* note cxxvii, at 18-19 (advocating for the COPUOS Space Debris Mitigation Guidelines to be transformed into U.N. Principles, a code of conduct, and multilevel legal agreements).

[cdxlviii] *See* Ostrom, *supra* note xi, at 4.

[cdxlix] *See* Liemer & Chyba, *supra* note ccclviii.

[cdl] Declaration on the Fiftieth Anniversary of Human Space Flight and the Fiftieth Anniversary of the Comm. on the Peaceful Uses of Outer Space, 44th Sess. , U.N. Doc. A/AC.105/L.283/Rev.1, at para. 16, (June 1-10, 2011).

[cdli] *See, e.g.*, International Cooperation in the Peaceful Uses of Outer Space, G.A. Res. 64/86, U.N. Doc. A/RES/64/86 (Jan. 13, 2010); Nima Nayebi, *The Geosynchronous Orbit and the Outer Limits of Westphalian Sovereignty*, 3 HASTINGS SCI. & TECH. L.J. 471, 477 n.33 (2011).

[cdlii] Ultimately, for a system of polycentric governance to be successful in space, though, an array of conditions must be present, including a "a 'highly federalized' political system . . . [with] substantial degrees of democratic control within jurisdictions, and subject to an enforceable system of constitutional law." McGinnis, *supra* note xxvii, at 7. Such a federal system is not present in space law in the way that it is in U.S. constitutional law, though successful multilateral treaties such as the OST do provide an a foundation from which to build. But to increase the viability of polycentric principles in the space commons, ambiguities in the applicable international law would need to be addressed such as through additional protocols, and greater autonomy given to lower-level political units such as states relative to supranational governance to maximize the public good of a sustainable space commons. Given the direction that multipolar politics seems to be going, this may also serve to increase legitimacy by recognizing trends in space governance discussed throughout this Article. Critically though, "cooperative arrangements among government units to undertake joint activities of mutual benefit" must be better defined, which, in the space context, would involve clarifying governance responsibilities, establshing a more formalized dispute resolution system, and identifying opportunities for collaboration. *Id*.

[cdliii] *See, e.g.*, Arctic Council, Nuuk Declaration, at 2 (May 12, 2011); *and* Evan Bloom, *Current Development: Establishment of the Arctic Council*, 93 AM. J. INT'L L. 712, 712 (1999).

[cdliv] *See* Bird, *supra* note lxxxii, at 661.

[cdlv] THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, OUR COMMON FUTURE 43 (1998). *See also* Gabcikovo-Nagymaros Project (Hung. v. Slovk.), 1997 I.C.J. 7, 78 (Sept. 25) (defining sustainable development as "[the] need to reconcile economic development with protection of the environment").

[cdlvi] *See, e.g.*, John Pezzey, *Sustainable Development Concepts: An Economic Analysis* 55-62 (World Bank Env't Paper No. 2, Report No. 11425, 1992); *and What is Sustainable Development?*, IISD, http://www.iisd.org/sd/ (last visited Jan. 3, 2013).

[cdlvii] *See* ELISABETH M. BORGESE, OCEAN GOVERNANCE AND THE UNITED NATIONS 21, 173 (1995).

[cdlviii] Priscilla Schwarz, *Sustainable Development in International Law*, NON-ST. ACTORS & INT'L L. 127, 127 (2005).

[cdlix] *See* Int'l Law Ass'n, New Delhi Declaration on Principles of Int'l Law Relating to Sustainable Dev. Part 4, www.cisdl.org/tribunals/pdf/NewDelhiDeclaration.pdf [hereinafter New Delhi ILA].

[cdlx] *See* Nina Tannenwald, *Law Versus Power on the High Frontier: The Case for a Rule-Based Regime for Outer Space*, 29 YALE J. INT'L L. 363, 412 (2004) ("[T]he province of all mankind could be expanded to incorporate a notion of sustainable development."); David Tan, *Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind"*, 25 YALE J. INT'L L. 145, 147-48 (2000) ("An essential first step is to make the notions of sustainable development and intergenerational responsibility applicable to the outer-space environment . . . .").

[cdlxi] *See* Scheetz, *supra* note lxxxiii, at 74-76. But it will be important to consider the cultural variability of sustainable development discourse in multilateral negotiations, since the term has varying meanings around the world. *See, e.g.*, Brubaker, *supra* note cccxiv.

[cdlxii] It is important to note that polycentric governance is distinct from notions of network governance, which can "attribute too little importance to central coordination . . . ." McGinnis, *supra* note xxvii, at 8. The trick in the space governance context is balancing multilevel regulations with existing multilateral treaties to create an adaptable and efficient system of governance. Further research is required to better understand the contours and best practices of such a system.

[cdlxiii] *See* Scheetz, *supra* note lxxxiii, at 74-76.

[cdlxiv] *See* Jakhu, *supra* note cxxvii, at 15 (noting that the COPUOS Debris Mitigation Guidelines call on national legislatures to voluntarily implement the requirements).

[cdlxv] Manor & Neuman, *supra* note xvi, at 108 (arguing that space piracy takes the form of stealing satellite bandwith or jamming communications, similar in theory to roving bandits at sea given difficulties with enforcement).

[cdlxvi] *See* Sterner, *supra* note x, at 129; *and* Rose, *supra* note cdxl.

[cdlxvii] *See* Ostrom, *supra* note xi (calling for such an approach in the climate change context).

[cdlxviii] Recognizing and building from the sustainable development principles present in the Moon Treaty could also help this purpose, including the orderly, safe, and rational development of lunar resources. *See* Eric Husby, *Sovereignty and Property Rights in Outer Space*, 3 D.C.L. & PRAC. 359, 368-70 (1994).

[cdlxix] *See* Henry R. Hertzfeld et al., *Launch Vehicles: An Economic Perspective*, SPACE POLICY INST., Sept. 2005, at 8.

[cdlxx] *See Advanced Space Transportation Program*, *supra* note xxxix (demonstrating that NASA is already working to lower space launch costs to an extent).

[cdlxxi] *See* Trejos, *supra* note cclxvii.

[cdlxxii] *See* Manor & Neuman, *supra* note xvi, at 103.

[cdlxxiii] Sterner, *supra* note x, at 116.