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THESIS

**THE CHALLENGE OF SMALL SATELLITE SYSTEMS
TO THE SPACE SECURITY ENVIRONMENT**

by

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**THE CHALLENGE OF SMALL SATELLITE SYSTEMS
TO THE SPACE SECURITY ENVIRONMENT**

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ABSTRACT

During the last two decades, technological advancements to the size and performance of electronics have fostered the development of increasingly sophisticated and smaller satellites. Small satellites, or smallsats as they are commonly referred to, have recorded data on terrestrial and space environments, served as important test beds and risk reducers for emerging space technologies, and provided important hands-on educational opportunities for industry and academia. The decreased cost and improved performance of smallsats have opened up a wide range of space missions at a fraction of the cost of larger satellite systems that would have been unfathomable two short decades ago. The proliferation of smallsat technology opens up a world of new scientific possibilities and unique security challenges as well for all space-faring nations through the potential use of smallsats as anti-satellite (ASAT) systems. This thesis examines the historical development of ASAT systems for the United States, the former Soviet Union, and China and discusses how they have influenced each nation's space policy. Finally, this thesis will address current efforts to mitigate space weapons, review the implications of smallsat technology development on current space policy, and suggest courses of action to mitigate this emerging space security dilemma.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABM	antiballistic missile
AFRL	Air Force Research Laboratory
AFSC	Air Force Systems Command
ALMHV	air-launched miniature homing vehicle
ARDC	Air Research and Development Center
ARPA	Advanced Research Projects Agency
ASAT	anti-satellite
AVGS	Advanced Video Guidance Sensor
BMD	ballistic missile defense
BX-1	ban sui wei xing
C2	command and control
CAS	Chinese Academy of Science
CBMs	confidence building measures
CD	Conference on Disarmament
CEP	circular error probability
CONOPs	concept of operations
COPUOS	Committee on the Peaceful Uses of Outer Space
COTS	commercial off the shelf
CSTND	Committee on Science and Technology for National Defense
CX-1	Chuangxin-1
DARPA	Defense Advanced Research Projects Agency
DART	Demonstration of Autonomous Rendezvous Technology
DEW	directed energy weapon
DF-2	Dong Feng 2
DoD	Department of Defense
DSP	Defense Support Program
EKV	exoatmospheric kill vehicle
EMP	electromagnetic pulse

FY-1C	Feng Yun 1C
FOBS	fractional orbital bombardment system
FOC	full operational capability
FY	fiscal year
GEO	geosynchronous Earth orbit
GMD	ground-based midcourse defense
GPS	Global Positioning System
HEO	highly elliptical orbit
IC	Intelligence Community
ICBM	intercontinental ballistic missile
IGY	International Geophysical Year
IOC	initial operations capability
IS	Istrebitel Sputnikov
ISS	International Space Station
ISR	intelligence, surveillance, and reconnaissance
KKV	kinetic kill vehicle
LEO	low-Earth orbit
MEMS	micro-electromechanical systems
MEO	medium-Earth orbit
MHV	miniature homing vehicle
MIRACL	Mid-Infrared Advanced Chemical Laser
MITEX	Microsatellite Technology Experiment
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NTM	national technical means
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office
ORS	Operationally Responsive Space
OST	Outer Space Treaty
PAROS	Prevention of an Arms Race in Outer Space

PBW	particle beam weapon
PKO	Protivo Kosmicheskaya Oborona
PPWT	Prevention of the Placement of Weapons in Outer Space Treaty
PRC	People's Republic of China
PTBT	Partial Test Ban Treaty
RAND	Research and Development
RCA	Radio Corporation of America
RSO	resident space object
SAINT	Satellite Interceptor
SALT	Strategic Arms Limitation Talks
SAMOS	Satellite and Missile Observation System
SDI	Strategic Defense Initiative
SI	International System of Units
SIGINT	signals intelligence
SLBM	submarine launched ballistic missile
SSA	space situational awareness
SSN	Space Surveillance Network
SSTL	Surrey Satellite Technology Ltd.
TMD	theater missile defense
UN	United Nations
USAF	United States Air Force
USG	United States Government
USN	United States Navy
USSR	Union of Soviet Socialist Republics
WMD	weapon of mass destruction
WWII	World War Two

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I. INTRODUCTION

*Oh! I have slipped the surly bonds of Earth... And, while with silent lifting mind I've trod,
The high untresspassed sanctity of space, Put out my hand and touched the face of God.*

— Pilot Officer Gillespie Magee, No 412 squadron, RCAF¹

A. MAJOR RESEARCH QUESTION

The interconnectedness of the sea, air, space, and cyber domains increases daily and the securing of that freedom will be one of the biggest security challenges of the 21st century.² The accepted international conventions that apply throughout the sea and air domains do not apply within the space domain. The space environment in which spacecraft operate is distinctive and movement is governed by the laws of gravity, centripetal acceleration, and orbital mechanics.³ The harsh, natural environment of space provides a challenge to all satellite systems where lethal radiation, storms of micrometeoroids, extreme variations of temperature, and man-made debris can damage or even destroy unshielded payloads, sensors, and spacecraft. Despite these existing challenges, global dependence on space as an integral part of communications, scientific, and economic networks has grown at a staggering pace as global space spending increased \$20 billion from 2009 to 2010 even in the aftermath of a worldwide economic recession to reach an estimated total of \$276.5 billion.⁴

Space technology has been a significant contributor to globalization and the United States government (USG) has become ever increasingly reliant upon space since the launch of its first satellites in 1958. This reliance is exemplified by the \$64.6 billion Fiscal Year 2010 (FY10) space budget, parceled out between the Department of Defense

¹ For full verse of poem see “High Flight,” (n.d.), <http://www.deltaweb.co.uk/spitfire/hiflight.htm>.

² Patrick M. Cronin, *Securing Freedom in the Global Commons* (Stanford, CA: Stanford University Press, 2010), page ix.

³ Any good orbital mechanics or physics book discusses how the laws of physics work in space. A good physics reference that can be found online is David Wright, Laura Grego, and Lisbeth Gronlund, *The Physics of Space Security: A Reference Manual* (Cambridge, MA: American Academy of Arts and Sciences, 2005).

⁴ The Space Foundation, *Global Space Activity Report 2011*, Executive Summary, 6. http://www.thespacereport.org/files/The_Space_Report_2011_exec_summary.pdf.

(DoD), Intelligence Community (IC), and the National Aeronautics and Space Administration (NASA). The U.S. budget is almost a factor of three more than the combined budgets of the remaining fifty countries, international consortia, and nongovernmental organizations who invested in space in FY10⁵ and of the estimated 958 active satellites as of October 2011, almost half are USG owned platforms.⁶ The United States as a whole has devoted a greater percentage of its gross domestic product to technology development in space than any other country. As a result of this significant investment, the United States holds a substantial asymmetrical advantage over near peers in capability and its dependence on space as a critical military force enabler places it at risk of a potential “Space Pearl Harbor.”⁷ The loss or denial of critical space assets from emerging technological threats such as smallsats has the potential to reduce the USG from “an information age war machine to an industrial age war machine.”⁸

Given this background of emerging space challenges, this thesis examines three questions in detail. How has the development of anti-satellite (ASAT) systems by the United States, the Soviet Union, and China influenced the space security of each nation? Can the lessons learned from the fifty year development of ASAT systems be applied to the recent advancements in small satellite technology, which is emerging as a potential ASAT technology? To what extent will small satellite systems technology affect each nation’s current space policy and how can these challenges to the collective space security environment be overcome? President Obama has called “on all nations to work together to adopt approaches for responsible activity in space to preserve this right for the benefit of future generations.”⁹ Proponents of enhanced cooperation argue that

⁵ Ibid., 6.

⁶ Union of Concerned Scientists: Scientists and Citizens for Environmental Solutions, “UCS Satellite Database,” (n.d.) http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html.

⁷ See U.S. House of Representatives, *Report of the Commission to Assess United States National Security Space Management and Organization*, 8. From here on, the report will be referenced as the Space Commission report.

⁸ “Transcript of Lieutenant General Michael Maples’ Interview,” February 8, 2008, <http://www.dia.mil/publicaffairs/Press/trans01.pdf>.

⁹ National Space Policy of the United States of America, June 28, 2010, 2.

collaboration would serve as a valuable tool for combating the proliferation of space weapons and represent a significant step toward collective space security. Cooperation further allows the United States “to secure the space domain for peaceful purpose and to protect space assets from all hazards.”¹⁰ Opponents of cooperation argue that collaboration would jeopardize the national security of the United States by putting many of its space systems at risk, thereby decreasing the effectiveness of space as a tremendous force multiplier for the armed services.

B. IMPORTANCE

With the launch of the *Sputnik* satellite into low earth orbit (LEO) during the International Geophysical Year (IGY) of 1957–1958, the former Union of Soviet Socialist Republics (USSR) officially started the modern Space Age. The Soviet launch was quickly followed by the successful launches of the *Explorer I* and *Vanguard I* satellites by the U.S. government. Fear and suspicion pervaded the relations between these two countries during the highly symbolic Cold War and the resulting rivalry planted the seeds for what would evolve to become initially a hostile but eventually militarily restrained U.S.—Soviet space relationship throughout most of the next three decades.

As the technology of orbital imagery and communications matured, space quickly became recognized as the key to not only monitor and observe the adversary through national technical means, but to safeguard national assets for security as well. The United States and the Soviet Union moved through several different periods of cooperation and detente throughout the lifetime and conclusion of the Cold War that were highly dependent on the geopolitical context and events of the time. Although each nation ultimately developed, evaluated, and tested ASAT weapon systems as a hedging strategy, neither side employed an ASAT system against the other. The military space competition of the space age during the Cold War resulted in many lessons learned and more importantly a collective approach to space security between the nations.

Following the conclusion of the Cold War and the dissolution of the Soviet Union, the United States experienced a fundamental change to the collective space

¹⁰ Nancy Gallagher, “Space Governance and International Cooperation,” *Astropolitics*, 8, no. 2–3 (May 2010): 257.

security environment. Throughout the 1990s, Russia's space program suffered severe budget cuts and a lack of funding, which caused a radical transformation of its space industry. The 2000 U.S. presidential elections resulted in the election of the neoconservative George W. Bush administration, which implemented broad changes to the existing space security paradigm and abandoned the Anti-Ballistic Missile (ABM) Treaty. The early 21st century also has seen the emergence of China as a third main actor in space through its successful manned spaceflight and subsequent testing of an ASAT system in January of 2007.

With globalization and the continued proliferation and easy accessibility of space technology, developing countries such as Nigeria, Venezuela, and Iran are joining the number of space-faring countries and add to the growing number of state actors. Space offers a wide range of tangible benefits from urban planning, to weather and crop forecasting, and enhanced communications. Space technology plays an important role as a facilitator of this increasing globalization. The attractiveness of small satellites, or smallsats as they are commonly called, can provide the accessibility of space with decreased cost and acquisition timelines. The threat of smallsats as potential ASAT systems though has emerged as a concern of the major space actors.

C. PROBLEMS AND HYPOTHESES

Competition in space has existed since the advent of spaceflight and this rivalry has often resulted in nations challenging each other not only for the derived benefits of space, but for national prestige as well. The United States, the Soviet Union/Russia, and China own the preponderance of space assets and their interactions can be best understood through the study of the international relations theory known as the security dilemma.¹¹ A security dilemma results when states with fundamentally compatible security goals end up in competition with each other. The irony of the security dilemma is that when a state tries to increase its own security, it actually decreases the security of other states. This dilemma typically starts a vicious cycle of reaction and response to a competing state.

¹¹ Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia University Press, 2007), 5–6.

Each of these states acts to best serve that state's vital interests and during most of the Cold War, the United States and Soviet Union maintained a relationship of both competition and confrontation. This relationship evolved to become a more cooperative space relationship in the late 1980s and 1990s. Recent space policy in the 2000s has again undergone a change and the U.S. space policy under the Bush administration and the Hu Jintao regime in China has revived the dormant security dilemma of space. This analysis will examine the effects of technology on past national policies and try to project the role that smallsat technologies might have on future national strategy and politics.

Since the launch of *Sputnik*, the debate of militarization versus the weaponization has been waged between the military and the senior leadership in the space-faring nations. Space was initially viewed as a medium outside the traditional rules of rights of overflight and later became extended into the idea of the "sanctuary of space." This sanctuary concept sought to maintain the idea that space is an important force multiplier that allows military operations to be conducted from space. This militarization greatly enhances the traditional ground-based forces through the provision of improved imagery, communications, and positioning, navigation, and timing. Space systems have been an important part of military operations since the launch of the first reconnaissance satellites and can be considered a passive system. Weaponization is uniquely distinct from militarization in that its mission is to defend space assets and to exploit the medium of space as an active system. This thesis will explore these important distinctions and how they relate to smallsat technology development and their implications on space policy.

Although smallsats offer a wide range of benefits to hopeful space-faring nations and users, the proliferation of this technology and the dual-use dilemma that results from its accessibility will continue to pose challenges to the USG.¹² Decreased size results in more affordable launch and programmatic costs and technological improvements in solar cells, batteries, nano-electronics, and miniaturized sensors enable satellites to be a fraction of the size of their predecessors 40 years ago. Smallsats may be active or passive but are designed and built to orbit as individual entities. The mission space of smallsats is as varied as the satellite developer, but in an environment where orbital speeds exceed

¹² Johnson-Freese, *Space as a Strategic Asset*, 6-7.

17,000 miles per hour in low-Earth orbit (LEO); these satellites can produce catastrophic results when collisions occur. A large percentage of space assets can be considered dual use in that they have distinct value to the military, civilian, and scientific sectors of society but simultaneously pose a threat to the space security environment.

Improving space cooperation is a necessary step to decreasing an existing security dilemma, but one big challenge to overcome is what form this enhanced collaboration would take place under and how the enhanced cooperation would be verified. A recommended way forward could include the adoption and implementation of a space code of conduct as has been proposed recently by the Europeans.¹³ A code of conduct could provide a valuable set of legal rules or guidelines for all actors who operate in space and be an important first step toward the strengthening of existing treaties. A set of guidelines could establish and standardize valuable international norms for space actors to avoid incidents that could escalate into hostilities.

This thesis investigates the hypothesis that the emergence of smallsat technology will continue to destabilize an already tenuous space security environment unless clear space policy changes are implemented among all space actors. The thesis also reviews the arguments regarding space cooperation presented by proponents and opponents in the early decades of ASAT technology development and strives to identify new and revised arguments in the current debate.

D. HISTORICAL BACKGROUND

The concept of ASAT systems has a long and storied history and paper studies for the use of weapons against satellites began in the United States as early as 1954.¹⁴ The U.S. military's early interest in space weapons increased significantly with the successful launch of *Sputnik* in 1957. The use of military satellites soon became a critical contributor to U.S. national security with the Soviet Union developing a similar reliance on space assets. At stake is the potential loss of these systems during any conflict and the

¹³ James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford, CA: Stanford University Press, 2008), 323.

¹⁴ Paul B. Stares, *The Militarization of Space: U.S. Policy 1945–1957* (Cornell, NY: Cornell University Press, 1984), 22.

uncertainty their loss would inject into each country's national security calculations. The employment of ASAT weapons against an adversary's satellite could result in an unplanned and unwelcome escalation of hostilities.

During the long quest for military superiority in space, both the United States and Soviet Union have pursued initiatives in favor of the "peaceful use of space." Both sides early on realized the potentially destabilizing effects of space weapons and have investigated various frameworks advocating international recognition of outer space as a weapons free area. Although ASATs were recognized as a destabilizing factor, the United States and Soviet Union seldom agreed on the issues at hand and bilateral talks often amounted to a restating of each nation's position and little actual progress.¹⁵ The recent proliferation of small satellite technology and the number of actors who operate them are an additional challenge to overcome for any future international agreement. Although no multilateral agreement currently exists between the space powers today, the international space community has inherited a number of building blocks that could be used to draft future agreements to ban ASATs and the deployment of space weapons.

1. The History of Smallsats

During the last two decades, pronounced technological advancements to the miniaturization and performance of electronics have fostered the development of increasingly sophisticated and smaller satellites without the sacrifice of performance. Small satellites have recorded data on terrestrial and space environments, served as important test beds and risk reducers for emerging space technologies, and provided important hands-on educational opportunities for industry and academia.¹⁶ The decreased cost and improved performance of smallsats have opened up a wide range of space missions at a fraction of the cost of larger satellite systems that would have been unfathomable two short decades ago. Technology proliferation has produced a world of new scientific possibilities and unique security challenges for all space-faring nations.

¹⁵ U.S. Congress, Office of Technology Assessment, *Anti-satellite Weapons, Countermeasures and Arms Control* (Washington: OTA, Sept 1985), 95–96.

¹⁶ See G. Gilbert Moore chapter in, "The First Small Satellites; Sputnik, Explorer, and Vanguard," in *Small Satellites: Past, Present, and Future*, ed. Henry Helvajain and Siegfried W. Janson (El Segundo, CA: The Aerospace Press, 2008 for a detailed discussion of smallsat usage.

Although smallsats have been built and launched since the construction of *Sputnik*, they have only been classified according to mass since 1992.¹⁷ These satellites can be either active or passive, but each is designed to be a separate entity to allow it to achieve its mission objective. A classification system was first suggested by the University of Surrey Centre for Satellite Engineering Research in England, one of the pioneers of smallsat development. The system is based upon the International System of Units (SI) prefixes and has been readily adopted throughout the satellite community. Table 1 provides a listing of the smallsat size classifications where each class spans an order of magnitude in wet mass, defined as the weight of the satellite plus the weight of fuel.¹⁸ The traditional cutoff for a smallsat designation is nominally at the mini-satellite class with a mass less than 500 kilogram.

Smallsats can weigh less than 100 grams and are gaining in popularity as cheap alternatives to provide space capability to a wide range of space actors. One class of smallsats that has become pervasive during the last decade is the CubeSat class, which has evolved as a standardized satellite no greater than a liter in volume (10 cm cube) and weighs less than 1.33 kg.¹⁹ CubeSats are a subset of the nanosat class and were designed to simplify the satellite infrastructure with the dual goals of the simplification of small satellite infrastructure and the reduction of construction costs. This small class of satellites has become a valuable and inexpensive teaching tool for industry, academia, and educators alike resulting in the estimated launch of over 65 CubeSats as of November 2011²⁰ and has multiple launches planned throughout FY12.²¹ These small platforms can be designed, purchased, and flown for total programmatic costs of less than \$75,000 and have also drawn great interest from multiple industry and government sponsors because of their accessibility, cost, and modular commercial off the shelf (COTS) potential.

¹⁷ Siegfried W. Janson, "The History of Small Satellites," in *Small Satellites: Past, Present, and Future*, ed. Henry Helvajain and Siegfried W. Janson (El Segundo, CA: The Aerospace Press, 2008), 47.

¹⁸ Ibid.

¹⁹ See <http://www.cubesat.org/> for a treasure trove of information regarding CubeSat specifications, launches, and general information regarding past and current technology initiatives and upcoming seminars, launches and conferences.

²⁰ See the astronautix launch manifest at <http://www.astronautix.com/chrono/index.htm> for a summary of all CubeSats launched since 2004.

²¹ See www.cubesat.org website for a listing of the upcoming launch manifests for CubeSats.

Satellite Classification	Wet Mass	
Large satellite	>1000 kilograms	
Medium sized satellite	500–1000 kilograms	
Minisat	100–500 kilograms	Mass cutoff for smallsats
Microsat	10–100 kilograms	
Nanosat	1–10 kilograms	CubeSats are considered a subset of this class
Picosat	0.1–1 kilograms	
Femtosat	<100 grams	

Table 1. Satellite mass classification table

2. The Proliferation of Smallsats

During the last fifty-plus years of spaceflight, more than 880 microsattelites, 715 nanosatellites, and 40 picosatellites have been launched into space.²² With the initial complexity of early satellite and launch system construction, space launches typically consisted of small spacecraft with minimal redundancy and limited capability. These satellites had the advantage of being cheaper and requiring smaller launch vehicles but had the disadvantage of much shorter lifetimes—requiring constant replenishment to maintain space capability. With the early success rate of many of the space actors, small payloads were a significant way to reduce the risk of losing both an expensive payload and launch vehicle in the event of a failed launch. After a level of launch proficiency was achieved by space-faring nations, the general tendency was to move to ever bigger satellites to provide a “better bang for your buck.” Table 2 illustrates the initial appeal of smallsats throughout the early years of spaceflight, its decline during the 1970s and 1980s, and its reemergence during the last two decades.

²² Information pulled from astronautix chronological launch manifest at <http://www.astronautix.com/chrono/index.htm>. These numbers are calculated from listed satellite launch mass but should be used as only an estimate. Not all of the satellites and many of the classified satellites did not have a mass listed. The estimates are good ballpark figures to show a reliance on smaller satellites and to view emerging smaller size trends.

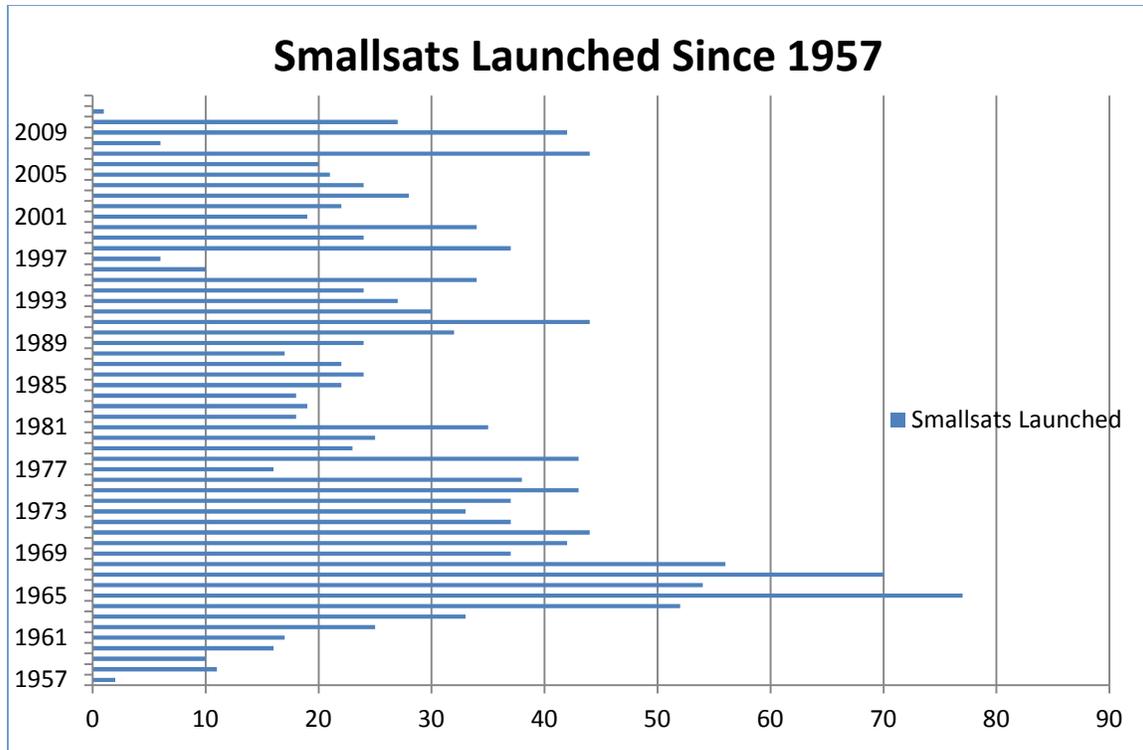


Table 2: Number of smallsats launched since 1957²³

The Soviet Union throughout its history has been a big proponent of smaller satellites and launched nearly 500 military communication mini and microsatellites throughout the 1970s, 1980s and early 1990s. The Soviet philosophy was to rely on cheaper and smaller (but short-lived) payloads to support many of their military needs, because they were better at producing boosters than electronics with high reliability and service life. Although the trend of national space actors typically has been to increase payload size, increased mass often brings with it an associated increase of cost, complexity, and risk. Given those factors, many space actors to include commercial and educational ventures and new space-faring nations with smaller budgets, have also been motivated to launch increasingly smaller payloads, although they may be increasingly reliable. Significant advances in space technology have allowed smallsats to become an

²³ Ibid. Not all of the launched satellites on the launch manifests had listed masses. The results also include a disproportionate amount of Russian Strela and Cosmos communication satellites numbering over 470 satellites that were produced from 1970–1992. These correlated results do, however, give a good idea of the general trend of the number of smallsats built and launched since 1957.

ever more affordable and attractive alternative to the larger payloads of yesteryear leading to a resurgence of smallsat launches and CubeSats in particular during the last decade.

3. The Political Impact of Smallsats

The political impact of smallsats throughout the community is an evolving facet of contemporary technology development and its effects on the development of national space policy. Although the number of countries who participate in space has expanded to include more than 50 space-faring countries²⁴ the United States, Russia, and China continue to be the dominant national actors in space. These three nations have a combined total of nearly 600 active satellites in orbit, which comprises a total amount greater than 60% of all estimated active orbital bodies. An estimated distribution of each country’s space assets broken down into military, non-military, and mixed use is presented below in Table 3. As the dominant actors in space with the majority of satellites, the space policies of each nation help shape the collective international space security environment and justify a closer examination of each nation.

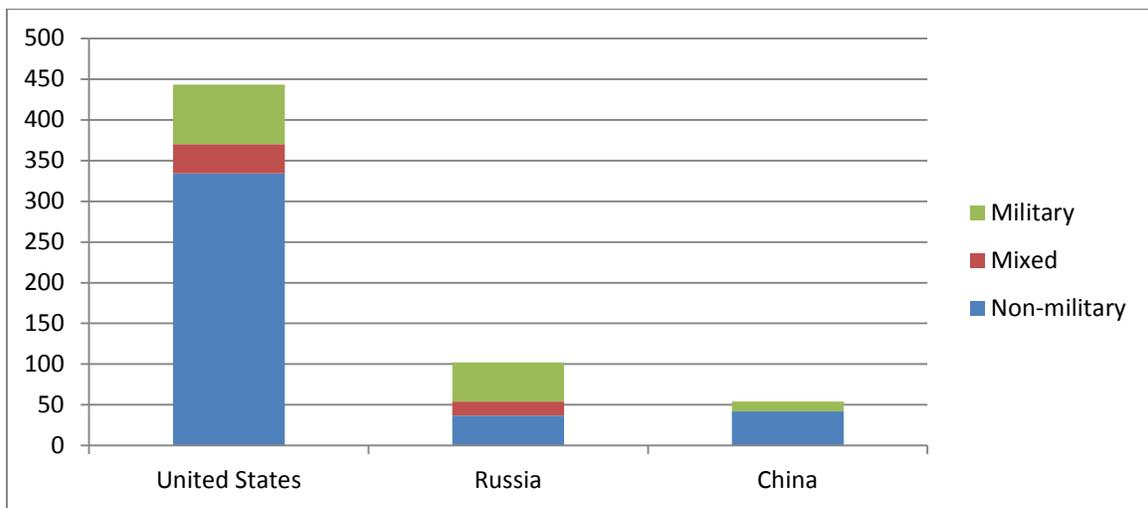


Table 3. Estimated national space assets

²⁴ The Space Foundation, *Global Space Activity Report 2011*, Executive Summary, 9. http://www.thespacereport.org/files/The_Space_Report_2011_exec_summary.pdf.

E. LITERATURE REVIEW

Even before the first launch of a Soviet spacecraft, the USG examined the role of dedicated military space program and feasibility studies were conducted by the armed services to assess the role of satellites within the military.²⁵ The following decades saw the idea of space as a source of conflict or cooperation as an area of great research and an abundance of articles, studies, and books have been written on the subject. These include works of analysis by scholars assessing the issues, works of advocacy for and against space cooperation and weaponization, and reports written by groups unable to reach a consensus, but nonetheless attempting to initiate dialogue and to offer useful recommendations.

Space policy has been in constant evolution since the launch of *Sputnik* and differing schools of thought have emerged in the debate about space security that have had a great influence on the pursuit of ASAT systems. Space policy analysts typically categorize this discussion as the struggle between the ideas of space sanctuary versus space defense.²⁶ According to Hays, this debate can be further broken down into a discussion of four schools of thought that include: the sanctuary school, the survivability school, the space control school, and the high ground school.²⁷ The schools of thought are listed from the least to the most confrontational view on space weaponization and will be discussed briefly to assess their impact to ASAT development within U.S. space policy.

The idea of space as a sanctuary proposes that space should not be weaponized but rather, used as a means to enhance national security. This school of thought argues that space must be kept free of weapons and that ASATs should be prohibited since they threaten space systems which provide critical national capabilities.²⁸ The survivability

²⁵ Paul B. Stares, *The Militarization of Space: U.S. Space Policy 1945–1984*, (Cornell: NY, Cornell University Press, 1985) 22–29.

²⁶ See Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 23 for a detailed discussion of space policy analysts' schools of thought.

²⁷ Matthew Mowthorpe, *The Militarization and Weaponization of Space* (Lanham, MD: Lexington Books, 2004), 12.

²⁸ Peter Hays, *Struggling Towards a Space Doctrine: U.S. Military Space Plans, Program, and Perspectives During the Cold War*, PhD dissertation, Fletcher School of Law and Diplomacy, 1994, 22.

school of thought emerged during the 1960s as a result of Soviet development and testing of ASAT systems and was based on the idea that space systems are at greater risk for destruction than ground forces. This school of thought believes in the protection of space assets either through active or passive means to maintain military capability.²⁹ The third school of thought to emerge has been the doctrine of space control, which posits that space superiority is a necessary prerequisite for military operations. This school believes that offensive and defensive operations will likely be conducted in space and that weaponization and ASATs play a fundamental role in maintaining the ability to operate in space while denying your adversary that same ability.³⁰ The fourth and final school of thought is the high ground school, which envisions the domination of space as the key to enabling the control of the ground through force application from space. This doctrine envisions space as the critical factor in determining a battle's outcome on ground and in the air and as such, space weapons and ASATs play a critical and necessary function.³¹ No one school of thought can completely describe the impetus for the development of ASAT weapons, but taken into context with the political events of the time, valuable insight can be gained from reviewing the nation's motivation for the development of these systems.

Recently declassified reports on several of the U.S. reconnaissance and imagery systems and their payloads provide detailed information on the systems and their capability. The use of space technology such as ASATS to counter foreign satellites, though, has produced multiple studies and several noted books as well and. several recent journals have investigated the role of smallsats and their impact on space security The majority of the writers on the space security environment have typically analyzed the material either with a chronological focus on the security environment or as a series of interrelated security topics. This broad scope of literature has been critical to provide

²⁹ C.S. Gray, "The Military Uses of Space: Space Is Not A Sanctuary," *Survival*, Volume XXV, Number 5, September, October 1983, 196–197.

³⁰ Hays, *Struggling Towards a Space Doctrine*, 23–25.

³¹ Mowthorpe, *The Militarization and Weaponization of Space*, 13.

background information on past developments regarding ASAT development, the issues raised by the potential weaponization of space, and an overview of the collective space security environment.

Several prominent political scientists have authored articles in support of furthering cooperation among the space-faring nations. Space collaboration advocates view cooperation as an important and critical part of space governance and a significant step toward international cooperation. Many technical experts believe that cooperation advances the Obama Administration's main space policy objectives and simultaneously enhances the overall space security.³² Proponents of space cooperation also argue that many of the lessons gained from nuclear strategy can be carried over to space policy to strengthen international collaboration³³ and that the United States may be able to achieve its policy goals through the skillful employment of "enhanced cooperative engagement."³⁴

Opponents of U.S. cooperation in space question believe that "Earth's orbital space is a militarily and economically critical arena to the United States, and [that] it became a battleground in 1944 when the first operational Nazi Germany V-2 weapons briefly exited the Earth's atmosphere."³⁵ Opponents also believe that a growing number of states have already developed the means to exploit space and to be able to conduct space warfare as evidenced by the Chinese ASAT test in 2007. With U.S. reliance on space services and the inherent vulnerabilities of orbiting satellites, opponents view U.S. space assets as likely targets in the event of a large scale military conflict.³⁶ As the threats to U.S. space assets from multiple actors continues to evolve, the current debate over

³² Nancy Gallagher, "Space Governance and International Cooperation," *Astropolitics*, 8, no. 2-3 (May 2010): 256-279.

³³ James Clay Moltz, "Space and Strategy: A Conceptual versus Policy Analysis," *Astropolitics*, 8, no. 2-3 (May 2010): 113-116.

³⁴ James Clay Moltz, "Preventing Conflict in Space: Cooperative Engagement as a Possible U.S. Strategy," *Astropolitics*, 4, no. 2 (Summer 2006): 121-129.

³⁵ Howard Kleinberg, "On War in Space," *Astropolitics*, 5, no. 1 (January 2007), 1-27.

³⁶ Darren Huskinsson, "Protecting the Space Network and the Future of Self-Defense," *Astropolitics*, 5, no. 2 (May 2007), 123-143.

national space policy demonstrates how contentious the question of enhanced space cooperation could become in upcoming debates and highlights the importance of a well thought out U.S. space strategy.

F. METHODS AND SOURCES

It is impractical in this thesis to examine the space technologies and space security policies of all the actors in space. This thesis investigates the question at hand by focusing on the three most influential actors: the United States, Russia and China. In other words, this is a comparative study investigating the priorities for the space security of the United States, Russia, and China.

Noted American political scientist James N. Rosenau distinguishes between orientations, plans, and behavior in his conception of foreign policy.³⁷ While acknowledging the importance of the first element, this thesis concentrates on the latter two. The investigation focuses on the specific features of these three countries' defense policies such as the main threats identified, space policies implemented, and space technologies developed. The duration and conclusion of the Cold War, the terrorist attacks of 9/11 in the United States, and the advancement of satellite technology have had significant effects on each nation's threat perceptions. This thesis identifies what each nation has perceived as the main threats to space security followed by the actions each state has undertaken to attain its desired security goals. Finally, the comparison of these three cases assesses each nation's impact on the collective space security environment to determine whether any significant changes in the ASAT debate have emerged in the intervening decade as smallsat technology and the numbers of space actors have evolved. Historical testimonies and articles from senior officials in the Department of Defense, the armed services, and the national laboratories serve as primary sources of information during the early period of discussion. Other primary sources include works of analysis and advocacy concerning the implications for U.S. space security as discussed in the literature review.

³⁷ James N. Rosenau, "The Study of Foreign Policy" in *World Politics – An Introduction*, eds. James Rosenau, Kenneth W. Thompson, and Gavin Boyd (New York: The Free Press, 1976), 15–35.

G. THESIS OVERVIEW

The rest of this thesis is organized as follows. Chapter II reviews the historical and current technological development of ASAT systems by the United States and its influence on the evolution and current U.S. space policy. Chapter III discusses the historical and current technological development of both the former Soviet Union and later Russia and the impact of this development on current Russian space policy. Chapter IV examines the emergence of the People's Republic of China as a major space actor during the last decade and its recent development and test of ASAT and space control technology. Chapter V analyzes successful and failed ASAT arms control initiatives and examines possible arms control measures for smallsats. The chapter also examines the use of treaties or codes of conduct to mitigate potential future conflict. In its conclusion, this thesis considers whether the technological advancements since 2000 have bolstered arguments for the adoption of a code of conduct for all space-faring nations. The decision by the United States to ratify a space code of conduct remains difficult to predict due to lingering doubts about the ability and resolve of the United Nations (U.N.) to enforce compliance with its provisions and the long term effects on U.S. space security posture.

II. U.S. SPACE TECHNOLOGY DEVELOPMENT

The eyes of the world now look into space, to the moon and to the planets beyond, and we have vowed that we shall not see it governed by a hostile flag of conquest, but by a banner of freedom and peace. We have vowed that we shall not see space filled with weapons of mass destruction, but with instruments of knowledge and understanding....

— John F. Kennedy, speech at Rice University, September 12, 1962

A. OVERVIEW OF U.S. ANTI-SATELLITE SYSTEMS

The strategic importance of ASAT weapons is based mainly upon the value that these systems have been designed to counter. Since their initial inception, military satellites have grown to become a critical tool to provide the reconnaissance, communications, missile warning, and signals intelligence (SIGINT) that are vital to achieving mission success on the battlefield. As the use of military satellites grew from the provision of mainly reconnaissance and communications to an ever increasing number of force enhancement and support areas, the use of satellites has become increasingly important to the successful operation of the armed forces. With an increased reliance on satellites, the negation of an adversary's satellites has been a subject investigated extensively by the major space-faring powers.

Although the history of U.S. ASAT system development dates back in origin to 1957, it was not until the 1964– 1975 timeframe that a minimally operational system was employed.³⁸ Following a short detente period during the Carter administration, the United States resumed testing with an aircraft-launched ASAT during the late 1970s into the mid 1980s. As space technology continued to evolve, the United States investigated a series of different options to negate Soviet satellites. Following a long moratorium on space weapons testing, the DoD destroyed a malfunctioning reconnaissance satellite in February 2008 and successfully demonstrated that it maintains an ASAT capability for LEO satellites in its current arsenal.

³⁸ Paul B. Stares, *The Militarization of Space: U.S. Policy 1945–1957* (Cornell, NY: Cornell University Press, 1984), 19.

This chapter examines how the pursuit of a particular school by successive presidential administrations has driven U.S. space policy and the impact of that space policy on the military's ASAT technology development. The emphasis within this chapter is on the development of the major weapon systems and the role that emerging technology has played in stimulating a space arms race. This chapter will also explore recent U.S. smallsat development and the utilization of this emerging technology as a potential ASAT weapon.

B. U.S. ASAT DEVELOPMENT

Although ASATs have consistently been an important element of the military's strategy since the first spy satellite contracts were awarded in 1956,³⁹ the primary goal of President Eisenhower's nascent space policy was to legitimize the use of satellites for peaceful purposes to include reconnaissance.⁴⁰ As described previously in the literature review section, the sanctuary school believes in the use of space as a means to enhance national security. The militarization of space was initially a consequence of the Cold War rivalry with the Soviet Union and the desire to peer within the closed Soviet society. The U.S. space policy during the late 1950s resulted in not only the covert development of the umbrella satellite program WS-117L as the foundation for the Corona and Satellite and Missile Observation System (SAMOS) national reconnaissance satellite programs, but in the eventual rationale for the military to explore ASAT systems.⁴¹

By November 1957, each of the individual services had recognized the growing strategic importance of space and proposed the development of ASATs in one form or another. The various ASAT research programs became a valuable safeguard against hostile Soviet action and established a U.S. space policy of hedging that still exists today. The U.S. Army Air Force first began investigating the possibility of satellites as early as 1946 and employed the research group Project RAND, then a part of Douglas Aircraft, to

³⁹ Jack Manno, *Arming the Heavens: The Hidden Military Agenda for Space, 1945–1995*, (New York: Dodd, Mead & Company, Inc. 1984), 142.

⁴⁰ Moltz, *The Politics of Space Security*, 93.

⁴¹ William E. Burrows, *Deep Black, Space Espionage and National Security* (New York: Random House, 1986), 80.

examine “the potential of earth-orbiting satellites.”⁴² RAND’s seminal report provided an engineering analysis that assessed the required propulsion, rocket staging, optimum design parameters, and trajectories to design a man-made satellite.⁴³ The services and the newly formed U.S. Air Force (USAF) in particular, continued to investigate the use of satellites to augment their existing U-2 aircraft reconnaissance capability and many of these early evaluations further explored the various means required to disable satellites.⁴⁴

Many of the USAF’s initial paper assessments of ASAT systems investigated the employment of the technology of the time to detect, identify, intercept, and, if necessary, destroy adversarial satellites. To disable a satellite, first required the ability to detect and track a new satellite among the thousands of objects in orbit. The next step required the characterization of the satellite’s functionality and capability to assess the satellite’s mission. Following characterization, an ASAT system would then require the ability to intercept a target and the means to disable or destroy the satellite. The complexity of this process led senior DoD leaders to explore a whole range of ASAT options to include ground-launched, ship-launched, air-launched, and satellite interceptors and eventually to the development of several significant ASAT programs.⁴⁵

1. Early U.S. ASAT Programs

The first of multiple ASAT programs was initiated in 1958 by the Air Force’s Air Research and Development Command (ARDC) and examined the brute force method of exploding nuclear weapons in space to disable satellites. The first test program was called Project Argus and began in September 1958 with the primary intent to “examine the possible blackout effects of high-altitude explosions on radars and communication links.”⁴⁶ Although the test was chiefly focused on studying the scientific findings of atmospheric nuclear explosions, the results from three successive explosions were later

⁴² Moltz, *The Politics of Space Security*, 85.

⁴³ See “Preliminary Design of an Experimental World Circling Spaceship,” Report No. SE: 11827, Douglas Aircraft Company, Inc., Santa Monica Plant Engineering Division, Contract WBB-038, May 2, 1946 for a detailed and predictive discussion of the use of satellites.

⁴⁴ Stares, *The Militarization of Space*, 106.

⁴⁵ Manno, *Arming the Heavens*, 142.

⁴⁶ Stares, *The Militarization of Space*, 107.

incorporated into subsequent Advanced Research Projects Agency (ARPA) studies on satellite interception.⁴⁷ Additional high-altitude nuclear testing codenamed Project Fishbowl occurred throughout the summer and fall of 1962 above Johnston Island in the South Pacific. The series of tests were designed to be several orders of magnitude greater than the Project Argus trials and, after two unsuccessful attempts, resulted in the successful explosion of a nuclear warhead at an altitude of 250 miles and a force of 1.4 megatons.⁴⁸ The nuclear explosions caused the embarrassing disablement of seven operational satellites but did, however, yield valuable information on the inherent vulnerability of satellites to the electromagnetic pulse (EMP) of nuclear explosions. The tests were a major driver in restarting test ban treaty negotiations and in the eventual signing of the Partial Test Ban Treaty in 1963, and the investigation of ASAT systems continued along more conventional means.

The first exclusively designed ASAT system was the air-launched ballistic missile designated Project Bold Orion. This program was initiated in March 1958 and added a second-stage capability to the existing single-stage missile to enable the system to be used as a satellite intercept demonstration.⁴⁹ The missile was launched from a USAF B-47 aircraft and was designed to intercept the *Explorer IV* satellite at its apogee above Cape Canaveral in October of 1959.⁵⁰ The test successfully completed its test objectives as the missile passed within four miles of its intended target.⁵¹ Project Bold Orion's accomplishment encouraged additional studies to be pursued although the Air Force's efforts now favored ground based launches and mandated inspection, rather than the disablement or destruction of the targeted satellite.

The U.S. Navy (USN) conducted its own investigation of ASAT capabilities with the initiation of the service's "Early Spring" program. As space military author Paul B. Stares notes, "Early Spring became an umbrella name for a variety of programs that were

⁴⁷ U.S. House of Representatives, *Department of Defense Appropriations for 1960*, Part 6, 112.

⁴⁸ See Manno, *Arming the Heavens*, 82–85 for a detailed description of the Project Fishbowl series of nuclear tests.

⁴⁹ Stares, *The Militarization of Space*, 109.

⁵⁰ *Ibid.*

⁵¹ See "ALBM Comes Close to Satellite Path," *Aviation Week & Space Technology*, 71, no.18 (2 November 1959): 33, for a detailed description of the ASAT test, objectives, and results.

put forward by the Navy between 1960 and 1964.”⁵² The principal idea behind many of the USN program variants was based on the concept of a Polaris submarine launched ballistic missile (SLBM) that could be inserted into the orbit of the intended satellite target, seek out the target through terminal guidance, and then disable it in orbit. The Polaris SLBM was a non-nuclear option and afforded greater flexibility to target satellites at varying inclinations. One significant drawback was that the system did not allow for any inspection of the hostile satellite prior to its disablement.⁵³ This perceived USN program weakness helped spur USAF research efforts in the direction of an on-orbit inspection capability.

The first full-scale U.S. ASAT system is generally credited to the Satellite Interceptor (SAINT) project that had originated as a paper study conducted by ARDC in 1956.⁵⁴ After more than three years of study, a developmental contract was awarded to the Radio Corporation of America (RCA) in the spring of 1961 to develop SAINT. Although the program was given DoD permission to proceed, the program was primarily viewed by policy-makers as strictly an inspection system that could provide additional information to ground-based assets.⁵⁵ The highly ambitious and technically challenging program was comprised of three distinct phases:

Phase 1—Demonstration of a prototype spacecraft that could rendezvous with and inspect an unidentified satellite of one square meter radar cross-section in an orbit up to 740 km altitude.

Phase 2—An automated vehicle that could make multiple orbital changes and rendezvous and inspect satellites up to 1850 to 7400 km altitude.

Phase 3—An anti-satellite vehicle that would not only inspect but destroy enemy satellites.⁵⁶

RCA envisioned the SAINT project to be comprised of a ground station for command and control (C2) operated from Colorado Springs, a launch vehicle consisting

⁵² Stares, *The Militarization of Space*, 110.

⁵³ Curtis Peebles, *Battle for Space* (New York: Beaufort Books, 1983), 81–82.

⁵⁴ Stares, *The Militarization of Space*, 112.

⁵⁵ *Ibid.*, 58.

⁵⁶ Encyclopedia Astronautica, “SAINT,” (n.d.), <http://www.astronautix.com/craft/saint.htm>.

of an Atlas-Agena first and second stage rocket, and a final stage vehicle from which on-orbit inspections would be conducted.⁵⁷ The program was originally budgeted for 19 vehicles at its inception with a total programmatic cost of \$1.28 billion and a full operational capability (FOC) by the summer of 1967.⁵⁸ The DoD directed the Air Force to use its own internal funding for the project but the lack of strong political and financial support, in addition to the program's complex technical challenges, eventually led to the program's cancellation in 1962. The on-orbit inspection of foreign satellites had significant political implications and improving electro-optical ground based systems were eventually deemed a more efficient and politically expedient option for satellite identification and characterization.

In direct opposition to Eisenhower's disdain for space weapons, the Air Force moved to lay claim to a larger responsibility of military operations in space with its high ground approach to space.⁵⁹ Air Force Chief of Staff General Thomas D. White stated on November 29, 1957, that "whoever has the capability to control the air is in a position to exert control over the land and seas beneath."⁶⁰ Air and space were perceived as one continuous medium and the service's view at the time was that the Air Force should have operational control over all space assets to ensure air superiority. The on-going investigation of ASAT systems led scientists to explore several options in addition to inspection, which by the technological standards of the day seemed rather exotic in nature. One proposal investigated the use of either lasers or masers to disable the optical sensors of adversarial satellites. Funding for this research remained low due to technical skepticism of the weapon's near-term development prospects and the projects failed to overcome many of the existing technical hurdles leading to their termination.

With the change to the Eisenhower administration, the Air Force was encouraged by the campaign promises of President Kennedy to close the perceived missile gap and

⁵⁷ Ibid.

⁵⁸ See Stares, *The Militarization of Space*, 112–117 for a detailed discussion of the SAINT program objectives and funding.

⁵⁹ Mowthorpe, *The Militarization and Weaponization of Space*, 14.

⁶⁰ Stares, *The Militarization of Space*, 48.

actively pursued the X-20 Dynasoar manned space vehicle as a potential ASAT system.⁶¹ Dynasoar faced a number of technical hurdles and an unclear mission for manned space operations, but was given permission to proceed in 1962. The Dynasoar project had its origins in studies conducted by the German Luftwaffe during WWII and, if successful, would allow “strategic reconnaissance, satellite inspection/interception, and intercontinental bombardment.”⁶² The program consisted of a manned orbital hypersonic glide vehicle that could be launched into space and “bounced off” the atmosphere. The project was envisaged of as having three separate and distinct phases:

Phase 1—Demonstration of a research vehicle that would undergo 20 air-launched test flights from a modified B-52 starting in June 1963, followed by five unmanned sub-orbital test flights, boosted by a Titan I rocket, starting in November 1963. The final part of the first stage would involve eleven manned flights from Cape Canaveral, landing at a variety of different locations.

Phase 2—A vehicle to gather data on operations in orbit and eventually result in a reconnaissance vehicle that would also have the ability to inspect satellites.

Phase 3—An operational system that could perform reconnaissance duties and would be able to act as an intercontinental nuclear bomber.⁶³

The Dynasoar project fell victim to competition with other ongoing ASAT efforts and to the Gemini program, which was simultaneously pursuing similar rendezvousing and maneuvering objectives for NASA’s manned space program.⁶⁴ The potential offensive

⁶¹ Moltz, *The Politics of Space Security*, 106.

⁶² See Clayton K.S. Chun, “Viewpoint: Expanding the High Frontier: Space Weapons in History,” *Astropolitics*, 2, no. 1 (Spring 2004): 63–78, for a detailed description of the German Luftwaffe weapons production.

⁶³ See The Spyflight website, “Boeing X-20 Dyna-soar,” (n.d.), <http://www.spyflight.co.uk/dynasoar.htm> for a detailed description of the program and its history.

⁶⁴ Roger D. Launius, “Introduction: Episodes in the Evolution of Launch Vehicle Technology,” in *To Reach the High Frontier: A History of U.S. Space Launch Vehicles*, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: University of Kentucky Press, 2002), 58–59.

weapon faced opposition from several DoD officials and funding competition from civilian space efforts that resulted in the project's termination in December 1963 by Secretary of Defense McNamara.⁶⁵

Despite the significant shift in financial and political support to NASA, the DoD continued a hedging policy of developing an ASAT capability with its development of Program 437. In January 1963, Secretary of Defense McNamara stated “that the Soviet Union may ... soon achieve the capability to place in orbit bomb-carrying satellites” and that the United States must be prepared to counter this emerging threat.⁶⁶ The gravity of this situation moved the Kennedy administration from adhering to the sanctuary school of thought and to concentrate as well on the survivability of national space assets that the DoD was beginning to rely on in ever greater numbers.

This change to national space policy and the emerging Soviet orbital threat prompted the U.S. Army to investigate the use of the Nike Zeus nuclear missile as a means to track and intercept targeted adversarial satellites. The commonality of antiballistic missile (ABM) and ASAT technology provided the Army with a limited ASAT capability that gave rise in 1962 to the highly secret program codenamed Mudflap, which was later changed to be called Program 505.⁶⁷ The missile was conceived as a three-stage solid fuel rocket with an overall ASAT range of close to 150 miles in altitude that could carry a nuclear payload of close to 400 kilotons in yield.⁶⁸ Based on the scientific findings on the Fishbowl Series tests, the warhead would be detonated within close proximity of the targeted satellite and would rely upon either the resulting explosion to destroy the satellite *or* on the effects of secondary radiation production to disable the target. The program met multiple testing objectives to include interception of thirteen reentry vehicles and one specially equipped test body but was perceived to have several operational deficiencies.⁶⁹ McNamara canceled the program in 1966 over

⁶⁵ The Spyflight website, “Boeing X-20 Dyna-soar,” (n.d.), <http://www.spyflight.co.uk/dynasoar.htm>.

⁶⁶ Quoted from U.S. Congress, Senate, *Soviet Space Programs 1962–1965*, 75.

⁶⁷ Stares, *The Militarization of Space*, 118.

⁶⁸ Clayton K.S. Chun, “Shooting Down a ‘Star’: Program 437, the U.S. Nuclear ASAT system and Present-Day Copycat Killers,” Cadre Paper No. 6, Maxwell Air Force Base, AL: Air University Press, April, 2000, 8–10.

⁶⁹ *Ibid.*, 8–10.

concerns about the system's small throw weight, its acquisition radar, and an overlapping capability with an existing USAF program that had both a greater range and payload capacity. The cancellation of Program 505 was to signal the end of the Army's involvement with ASATs and to signal the Air Force's primacy in the pursuit of space weapons.⁷⁰

Following the conclusion of the Fishbowl test results in late 1962, the Air Force began its own investigation into the use of ABM technology as the foundation for an ASAT weapon. Secretary of the Air Force Eugene Zuckert received approval from the Secretary of Defense to proceed and bring to an operational capability the project now known as Program 437. The project was designed with the goal of demonstration of the capability of satellite interception and destruction and quickly became one of the Air Force's highest priorities.⁷¹ Codenamed Squanto Terror, Program 437 had the operational objective to launch "a simulated nuclear warhead up to 700 nautical miles high and up to 1,500 nautical miles down range."⁷² The intended targets for the program testing consisted of either dead U.S. satellites or orbiting debris left over from previous launches. Program 437 had several advantages over Program 505 that made it attractive to senior policymakers to include improved range and ceiling, a higher throw weight, and an all Air Force launch crew at the ground station.⁷³ The first of four demonstration tests took place in February 1964 and the program was declared Full Operational Capability (FOC) in June 1964 when two missiles were placed on alert at the launch complex on Johnston Island.⁷⁴ From 1964 until 1970, the program completed 16 live firings but under the convention of the Partial Test Ban Treaty (PTBT) signed in 1963, did not launch any nuclear warheads.⁷⁵ Although the Soviets commenced with ASAT testing in 1968, the

⁷⁰ Peebles, *Battle for Space*, 82–94.

⁷¹ Chun, "Shooting Down a 'Star,'" 15–20.

⁷² Thomas Karas, *The New High Ground: Strategies and Weapons of the Space-Age War* (New York: Simon and Schuster, 1983), 148.

⁷³ Chun, "Shooting Down a 'Star,'" 15–20.

⁷⁴ Stares, *The Militarization of Space*, 123.

⁷⁵ *Ibid.*

Nixon administration's changing defense priorities and a lack of Thor rockets resulted in Program 437 being reduced from 24 hours operational readiness to 30 days in 1970 and its subsequent cancelation in 1975.⁷⁶

Although Program 437 had been given official permission to proceed, the Kennedy administration was simultaneously negotiating the United Nations General Assembly Resolution 1884 (XVIII) in October 1963. The resolution called upon states to refrain from placing nuclear weapons and other weapons of mass destruction in space and laid the groundwork for the negotiation of the Outer Space Treaty (OST) of 1967.⁷⁷ This diplomatic initiative curtailed the military's view of space as the ultimate high ground, which could be dominated by the placement of nuclear weapons in space, while at the same time allowing the continued use of reconnaissance satellites in support of the sanctuary school of space.⁷⁸

With President Johnson's assumption of the presidency, the administration's space policy continued along the same dual-track as that of his predecessor. The United States continued to pursue ASAT development as a hedge against possible Soviet abrogation of existing arms control while continuing to seek arms control treaties to enhance national security.⁷⁹ In the run up to his 1964 presidential reelection, President Johnson publicized the government's pursuit of the ASAT systems Programs 437 and 505 but emphasized their use as strictly a defensive option against Soviet weapons of mass destruction (WMD) in space.⁸⁰ In 1966, the Soviet Union began testing of the Fractional Orbital Bombardment System (FOBS) that called for nuclear-tipped intercontinental ballistic missile to be placed in an orbit which would allow it the ability to approach the United States from multiple directions to elude early warning radar

⁷⁶ Chun, "Shooting Down a 'Star,'" 29.

⁷⁷ Moltz, *The Politics of Space Security*, 150–152.

⁷⁸ Mowthorpe, *The Militarization and Weaponization of Space*, 30.

⁷⁹ Stares, *The Militarization of Space*, 93–95.

⁸⁰ *Ibid.*

systems.⁸¹ Despite this emerging Soviet threat, DoD officials moved to strengthen only their ground radar capabilities and the U.S. Senate ratified the OST in April 1967.

In 1969, newly elected President Nixon founded a Space Task Group under his vice president to review the national space program and provide options for future development. The result was that the DoD would embark only on military space programs that could be accomplished cheaper than through terrestrial means.⁸² The ongoing conflict in Vietnam and the rising defense expenditures in Southeast Asia resulted in significant cuts to the space defense budget. During Nixon's administration, the ratification of the Treaty on the Limitation of Antiballistic Missile Systems and the Interim Agreement on the Limitation of Strategic Arms in 1972 provided restrictions on the use of ASAT systems. These agreements were pursued to strengthen strategic stability through the verification of arms control measures by national technical means (NTM) and signaled a shifting of the government from an emphasis on space control doctrine back to the sanctuary school of thought.⁸³ Although a nuclear warhead ASAT provided a credible deterrent for potential Soviet nuclear orbital bombs, its use would have been deemed "excessive" for any other space weapon. The FY 1980 Arms Control Impact Statement on Space Defense summed up Program 437's existence with the following comment:

The Johnston Island system was initially a response to Soviet threats to deploy orbital weapons of mass destruction. The system was deactivated because this threat was never deployed (and the Outer Space Treaty prohibited its employment), and because a low altitude [explosion] would probably damage U.S. satellites as well as the targeted Soviet Satellite.⁸⁴

⁸¹ See Peebles, *Battle for Space*, 64–76 for a detailed explanation of the FOBS weapon and the Soviet concept of operations for the weapon.

⁸² Stares, *The Militarization of Space*, 159.

⁸³ Mowthorpe, *The Militarization and Weaponization of Space*, 16.

⁸⁴ U.S. Senate, Committee on Foreign Relations and U.S. House of Representatives, Committee on Foreign Affairs, *Fiscal Year 1980 Arms Control Impact Statements*, Joint Committee Print, 96th Congress, 1st Session, Washington, D.C.:U.S. Govt. Printing Office, March 1979, "Space Defense," 64.

2. U.S. ASAT Programs in the 1970s–1980s

Although Program 437 remained operational until 1975, with the reduction in readiness in 1970 and the cancelation of the crew exercises, the program ceased to be a credible deterrent several years before its termination.⁸⁵ Given the political implications of a nuclear explosion in space, it was not likely that the United States would have chosen to employ a nuclear weapon against Soviet space systems as a primary option. Research on alternative non-nuclear options began in the late 1960s and resulted in the introduction of miniature homing vehicle (MHV) technology as a prime area of ASAT technology study in 1970.⁸⁶ The MHV technology consisted of a “cluster of rockets surrounding eight cryogenically cooled infra-red telescopes.”⁸⁷ The MHV was a kinetic kill vehicle (KKV) that relied upon being maneuvered into the vicinity of its intended target, tracking the target with its sensors, and then intercepting and ramming the targeted satellite. Orbital dynamics allowed the MHV to destroy the targeted satellite without the need of carrying an explosive payload. Although the technology showed great promise in the early 1970s, the program was shelved for the time being during the thawing of relations between the United States and the Soviet Union and the resulting detente between the two space powers.

Following the Watergate scandal and the resignation of Nixon, President Ford assumed the presidency and in 1975 convened the Slichter Panel on the military application of space to assess the threat of Soviet disruption to U.S. satellites. The report warned of a growing national dependence on satellites that were defenseless and susceptible to countermeasures.⁸⁸ These findings prompted Ford’s administration to commission a second panel to assess satellite vulnerability and to consider the need for an ASAT program.⁸⁹ The Buchsbaum Panel as it was called concluded that an ASAT capability would not significantly enhance the survivability of space assets because the

⁸⁵ Stares, *The Militarization of Space*, 120–128.

⁸⁶ U.S. Congress, House, Subcommittee of the Committee on Appropriations, *Department of Defense Appropriations For 1971*, Hearings, 91st Congress, 2nd Session (1970), Part 6, 710.

⁸⁷ Stares, *The Militarization of Space*, 206.

⁸⁸ Stares, *The Militarization of Space*, 169.

⁸⁹ Mowthorpe, *The Militarization and Weaponization of Space*, 16.

United States was far more dependent on satellites than the Soviet Union.⁹⁰ An indigenous capability, however, could be used as an effective bargaining chip to pursue an ASAT arms control agreement with Soviet leadership. Ford's administration up to this point had pursued restraint in the development of ASATs and had viewed the cancellation of Program 437 as a clear signal to the Soviets that an arms race was in neither party's best interest. The recommencement of Soviet ASAT testing in 1977 prompted the Ford administration to once again pursue the development of an ASAT system.

After the election of President Carter, the new administration proposed in March 1977 to the Soviet Union a restriction on ASAT capability and development. The administration pursued a dual-track space policy approach and simultaneously authorized the development of an ASAT system while pursuing negotiations. The administration felt that the an air-launched system such as the MHV that was being developed by the Air Force could be used as an important bargaining chip during arms control talks. High-level DoD interest in 1978 led policy-makers to define U.S. ASAT requirements and resulted in a series of studies to examine air-launched systems as an alternative weapons platform. The Air Force evaluated multiple launch platforms and determined that the F-15 aircraft was the best choice based upon its operational ceiling and rapid rate of ascent.⁹¹ The F-15 had the added advantage of operational flexibility to attack target satellites at multiple inclinations in LEO and no longer had to rely upon the target to pass overhead in orbit. The Air-Launched Miniature Homing Vehicle (ALMHV) consisted of a two-stage missile launched from an aircraft that relied upon the missile to track its intended target and on the kinetic energy of the collision to kill its intended target.⁹²

Other ASAT options were explored during the 1970s with the USAF, USN, and Army as well as the Defense Advanced Research Projects Agency (DARPA) all investigating the use of directed energy weapons (DEWs) as potential weapons for space defense. The various research activities resulted in a group of highly prominent physicists

⁹⁰ Stares, *The Militarization of Space*, 170.

⁹¹ Ibid.

⁹² Burrows, *Deep Black*, 279- 280.

to gather together in 1978 at the request of DoD to assess the feasibility of particle beam weapons (PBWs). The committee's report recommended continued research in five key technology areas and funding was authorized for PBWs.⁹³ A second completed study just two years later by a senior advisory board concluded that PBWs were a "twenty-first century phenomenon"⁹⁴ and the funding in this area was subsequently withdrawn, ending this research for the time being.

By way of contrast, research into high energy ground-based lasers during this time period met with much greater success. In FY80, funding was authorized for the development of a hydrogen fluoride laser, a laser optics system, and a laser acquisition, pointing, and tracking device.⁹⁵ The USAF and USN continued to pursue their own high-energy laser acquisition programs and tested against multiple targets. Although ground-based lasers were highly dependent on clear atmospheric conditions for efficient transmission, laser ASAT systems exhibited several distinct advantages over KKV's to include almost instantaneous effect at the speed of light, delayed attribution of the satellite disablement, the option of reversible effects, and the diminishment of orbital debris.⁹⁶

The ensuing invasion of Afghanistan by the Soviet Union in December 1979 ultimately pushed the idea of ASAT arms control to the backburner between the two countries. ASAT technology had been developed by the Air Force to be used as a bargaining chip with the Soviets for arms control measures but, with the change in political climate, it once again emerged as a viable tool for national defense space policy. The Carter administration during its tenure followed the school of survivability by pursuing research and development into ASATs to protect space assets. Although the policymakers pursued space weapon systems in no small part as a bargaining tool for

⁹³ Stares, *The Militarization of Space*, 166.

⁹⁴ *Ibid.*, 215.

⁹⁵ "Pentagon Studying Laser Battle Stations in Space," *Aviation Week & Space Technology*, 113, no.4 (July 18, 1980): 57-62.

⁹⁶ Laura Grego, "A History of Anti-satellite Programs," Union of Concerned Scientists, May 2011, http://www.ucusa.org/global_security/space_weapons/a-history-of-asat-programs.html, 7.

negotiations with the Soviets, the political events of the day did not allow the realization of the Carter administration's goal of an arms control treaty.

In 1981, President Reagan was elected to office and his administration performed its own assessment of space policy. In a departure from the Carter administration which had promoted ASAT arms control, the Reagan administration rejected arms control initiatives and called for the continued study of ASAT arms control options.⁹⁷ A notable shift in the rationale for ASAT development was articulated by the White House in that the "primary purpose of a United States ASAT capability are to deter threats to space systems of the United States ... [and to] deny any adversary the use of space-based systems"⁹⁸ The new administration now placed an increased emphasis on deterrence and the utilization of U.S. ASAT systems to counter any Soviet ASAT capability. The renewed interest in weaponization resulted in the renewed testing of the air-launched MHV in 1983 and additional research and development into additional ground-, air-, and space-based laser weapons systems. The Reagan administration's space policy closely followed the space control school of thought and in many ways was a complete 180 degree reversal of Eisenhower's view of the sanctuary of space and its use for only peaceful purposes. The role of space superiority became the foundation of the Reagan space policy with the potential use of ASATs being a key aspect of the policy.⁹⁹

With the administration's renewed interest in ASAT systems, the ALMHV was tested twice in 1984 against specific targeted points in space that did not contain any orbital bodies.¹⁰⁰ In September 1985, the interceptor was launched against an aging Solwind solar observatory payload, which was orbiting at an altitude of 550 km. The test was successful; however, the resulting collision produced more than 800 pieces of debris greater than ten centimeters that remained in orbit for the better part of the next two decades.¹⁰¹ Two more additional trials resulted in successes and, although the Air Force continued to press for added development, the Democrat-controlled Congress included a

⁹⁷ Mowthorpe, *The Militarization and Weaponization of Space*, 17.

⁹⁸ Stares, *The Militarization of Space*, 218.

⁹⁹ Mowthorpe, *The Militarization and Weaponization of Space*, 31.

¹⁰⁰ Grego, "A History of Anti-satellite Programs," 6.

¹⁰¹ *Ibid.*

ban on ALMHV testing in its next budget authorization bill.¹⁰² Although the missile had several challenging operational constraints to overcome, in the end, the political opposition against the ALMV system was firmly entrenched and resulted in the Air Force canceling the program in 1987.

3. Post-Cold War U.S. ASAT Programs

President George H.W. Bush came to office in 1989 under a vastly different geostrategic environment than his predecessors. Significant ongoing reforms within the Soviet Union prompted a reevaluation of the U.S. space policy, which now emphasized elements of science and exploration, national security, and economic growth in the administration's comprehensive strategy for space.¹⁰³ Bush's National Space Policy of 1989 articulated the desire for "freedom of action in space ... through an integrated combination of anti-satellite, survivability and surveillance capabilities."¹⁰⁴ The policy also called for a development of a comprehensive ASAT capability with an initial operations capability (IOC) at the earliest possible date.¹⁰⁵ Although the George H.W. Bush administration encountered a rapidly changing strategic environment, the policy-makers continued many of the space policy initiatives begun during Reagan's presidency. Although the end of a Cold War in space was at hand, senior decision makers continued an emphasis on ASAT development while maintaining pursuit of a space control doctrine.

Previous success with DEW ASAT systems resulted in a convergence of programs between the Air Force and the Army in the late 1980s. This cooperation resulted in the joint Mid-Infrared Advanced Chemical Laser (MIRACL) program based at White Sands Missile Range, New Mexico, to develop ground-based lasers. With the dissolution of the Soviet Union in 1991, the main threat that initiated the program disappeared overnight, and Congress banned use of the MIRACL laser as an ASAT

¹⁰² Ibid.

¹⁰³ George H. W. Bush, "National Space Policy," *NASA Historical Reference Collection*, November 2, 1989, <http://www.marshall.org/pdf/materials/862.pdf>.

¹⁰⁴ Ibid., 9.

¹⁰⁵ Ibid., 10.

weapon in the defense appropriations bills for FY91–95. Although the program was formally canceled in 1993, a residual capability was kept alive through pork barrel funding as late as FY01.¹⁰⁶ With its pricey \$40,000 per second operational costs, other ASAT systems have been deemed as more cost effective options to pursue.

The Clinton administration assumed office in 1993 and promptly reoriented the missile defense program that it had inherited from a national to theater missile defense (TMD). This refocus resulted in a concentration on ground-based defenses that produced an exo-atmospheric kill vehicle (EKV) designed to intercept an incoming hostile missile in space.¹⁰⁷ Originally designed as a critical technology for TMD, subsequent improvements to the tracking sensors and targeting algorithms provided the EKV with the inherent capability to intercept satellites in LEO and to be employed as an ASAT system by the military. President Clinton formally articulated his national space policy in 1996 and merged several defense space programs with civil programs while promoting cost savings through the exploitation of the commercial sector.¹⁰⁸ A further clarification on space policy was released in 1999, when the directive reaffirmed the importance of military space to securing national security objectives while reserving the United States' right for self-defense of its space systems.¹⁰⁹ Throughout the Clinton administration, space was viewed as a low priority with the termination of the National Space Council, an executive level review panel for space issues, and relatively low space budgets for the military in comparison to previous fiscal year budgets. Although space defense weapons such as ASATs were actively designed, the administration never actively pursued an operational use of the systems, and the nation's space policy can be best described as following Hays' survivability school of thought.

A profound shift in space policy occurred with the election of George W. Bush in the 2000 election. The incoming president ran on a campaign promise calling for a national missile defense to keep the nation safe from a small number of missiles in the

¹⁰⁶ Grego, "A History of Anti-satellite Programs," 8.

¹⁰⁷ Mowthorpe, *The Militarization and Weaponization of Space*, 189.

¹⁰⁸ The White House, "National Space Policy," September 19, 1996, <http://www.hq.nasa.gov/office/codez/new/policy/pddnsc8.htm>.

¹⁰⁹ *Ibid.*

hands of rogue states¹¹⁰ and moved from a Cold War strategy of deterrence to one that now included an operational missile defense. With this goal in mind, the administration withdrew from the ABM Treaty in 2002, opening the door up for the potential weaponization of space. In a clear break from previous policy, the tone of the administration's 2006 National Space Policy assumed a unilateralist approach to the access of space through its pursuit of the high ground school of thought. The policy rejected new treaties or limitations on American utilization of space, reflecting the fact that the United States would no longer be constrained by treaty from testing and deploying anti-missile weapons in space.¹¹¹ In February 2008, the Bush administration authorized the destruction of a U.S. satellite based on the publicized rationale that the dead satellite's fuel tank might survive re-entry and could cause a hazardous chemical spill upon impact.¹¹² Although the Pentagon provided advance notice to the U.N. of its intent and sought to mitigate the debris resulting from its ASAT test, the shoot-down generated widespread debate within the international community on the legitimacy of the incident. The ASAT test was codenamed Operation Burnt Frost and its success so soon on the heels of the Chinese ASAT test in 2007, initiated calls from the international community for a future test ban of ASAT weapons.

The Obama Administration took office in 2009 and released a revised National Space Policy the following year. The tone of the policy represented a dramatic shift from the Bush policy and returned to the language used in the Clinton era and earlier policies. Instead of emphasizing a United States-first approach as the Bush Administration's 2006 policy had done, the Obama Administration's policy placed a much greater emphasis on international cooperation.¹¹³ The policy illustrated the administration's apparent willingness to consider space-related arms control mechanisms. It has remained opposed

¹¹⁰ Massimo Calabresi, "Behind Bush's Missile Defense Push," *Time*, June 5, 2007, <http://www.time.com/time/nation/article/0,8599,1628289,00.html>.

¹¹¹ National Space Policy, <http://www.whitehouse.gov/sites/default/files/microsites/ostp/national-space-policy-2006.pdf>.

¹¹² Colonel Jay Raymond (USAF), "Operations Group blazes new trail during Operation Burnt Frost," *Inside Peterson Air Force Base*, March 11, 2008, <http://www.peterson.af.mil/news/story.asp?id=123089765>.

¹¹³ The White House, "National Space Policy of the United States of America," 28 June 2010. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

though to a treaty proposed by the Russians and Chinese on the Prevention of the Placement of Weapons in Outer Space (PPWT), calling it “unverifiable.”¹¹⁴ The wording and interpretation of the proposed treaty could allow other states to launch direct-ascent ASAT technology and other ground-based ASAT weapons, while potentially limiting the U.S. ability to deploy defenses if the defense could be defined as a space weapon.¹¹⁵ Although the Obama administration has advocated for the development of voluntary transparency and confidence-building measures to expand international cooperation, the progress to date in space security has continued to be painfully slow. The multiple advantages offered by smallsats to include: access by users around the globe, COTS availability, and the potential for ASAT usage, highlight the pressing need for improved international coordination among the space-faring nations.

C. U.S. SMALLSAT DEVELOPMENT

The breadth of smallsat applications has increased dramatically during the last ten years and much of this success is due in part to significant advances in the commercial and military satellite sector. Improvements to microelectronics, high efficiency solar cells, micro-electromechanical systems (MEMS), and high efficiency motors and actuators have resulted in the smallsats becoming an affordable option for launch for many of today’s emerging space actors.¹¹⁶ The COTS availability of this technology has led the U.S. Government and the DoD in particular to investigate its use as a cheaper and more flexible option to conventional space systems. NASA has worked closely with the USAF to investigate the potential of smallsat technology for close proximity operations.

In 2005, NASA launched the *Demonstration of Autonomous Rendezvous Technology (DART)* as a flight demonstrator to establish autonomous rendezvous

¹¹⁴ Jeff Abramson, “E.U. Issues Code of Conduct,” *Arms Control Today*, January/February 2009, <http://www.armscontrol.org/print/3506>.

¹¹⁵ Moltz, *The Politics of Space Security*, 310.

¹¹⁶ Kirk Woellert, Pascale Ehrenfreund, et al., “Cubesats: Cost-effective science and technology platforms for emerging and developing nations,” *Advances in Space Research*, no. 47, (October 2010), 665-666.

capabilities for the U.S. space program.¹¹⁷ The intent of the \$95 million program was to rendezvous the demonstrator with an Orbital Sciences satellite and to perform close proximity operations with the targeted satellite.¹¹⁸ Although NASA had performed docking and rendezvous procedures during past missions, these operations had always had a “man in the loop” and relied upon astronauts and human judgment to perform complex space maneuvers. In contrast, the *DART* system was reliant on a complex mixture of reaction control system thrusters, communications equipment, and the Advanced Video Guidance Sensor (AVGS). The AVGS, the mission’s primary sensor, collected navigational data to allow the smallsat to perform the maneuvering necessary for close proximity operations with a target satellite.¹¹⁹ Reflected laser signals from the satellite allowed the smallsat to calculate the correct range and angle between the target satellite and its own system. The lasers signals worked in conjunction with the Global Positioning System (GPS) to derive an accurate onboard calculation of position relative to the satellite that enabled the smallsat to function independently.

Following the successful launch, early orbit, and rendezvous phases of the planned mission, the *DART* accomplished many of its mission objectives even though anomalies were noticed on the ground with the navigation system.¹²⁰ The demonstration had been set up to operate autonomously and did not have the ability to either receive or execute uplinked commands, leaving the ground crew no option to correct any anomalies. The demonstrator experienced problems with its navigation system throughout proximity operations and was unable to calculate accurate measurements of the range to the target. The program’s Mishap Investigation Results determined that this error led to a collision with the target satellite and eventually the expenditure of the onboard fuel less than eleven hours into the mission.¹²¹ Although the mission experienced only partial success,

¹¹⁷ NASA Facts, “DART Demonstrator to Test Future Autonomous Rendezvous Technologies in Orbit,” Marshall Space Flight Center, September, 2004, <http://www.msfc.nasa.gov/news/dart/>.

¹¹⁸ Ibid.

¹¹⁹ Ibid.

¹²⁰ “Overview of the DART Mishap Investigation Results,” (n.d.) http://www.nasa.gov/pdf/148072main_DART_mishap_overview.pdf.

¹²¹ Ibid.

the program provided valuable lessons learned on system autonomy and has been an important first step for smallsat proximity operations.

The Air Force Research Laboratory (AFRL) conducted their own investigation of smallsat technology with the launch of the microsatellite class *Experimental Satellite System 11 (XSS-11)* in 2005. Tipping the scales at 100 kg, the smallsat had been designed to demonstrate key capabilities, similar to the *DART* program, to include autonomous mission planning, rendezvous, and proximity operations. The mission objectives had been designed “to explore a variety of future military applications such as on-orbit servicing, diagnostics, maintenance, space support, and efficient space operations.”¹²² The smallsat was successfully launched in April 2005 and by the fall of that year had accomplished more than seventy-five circumnavigations of the mission’s targeted expendable launch vehicle.¹²³ The *XSS-11* was able to perform autonomously conducted rendezvous and proximity operations with minimal human-in-the-loop interactions and illustrated the growing technological evolution of smallsats.

The functionality of smallsats continued to expand with the successful launch of the Microsatellite Technology Experiment (Mitex) in June 2006. The program consisted of two microsatellites weighing approximately 225 kg each with one smallsat built by Lockheed Martin and the other built by the Orbital Sciences Corporation.¹²⁴ The two smallsats were flown in geostationary orbit and are part of a classified joint effort between DARPA and the Naval Research Laboratory (NRL). Although a limited amount of information is present in the public domain, DARPA released a list of the technologies the program utilized leading to speculation that the system is capable of proximity operations and detailed reconnaissance in GEO.¹²⁵ Journal articles have linked the experiment to the inspection of the recently failed DSP-23 satellite in pursuit of the cause

¹²²“XSS-11 micro satellite,” (n.d.), <http://www.kirtland.af.mil/shared/media/document/AFD-070404-108.pdf>.

¹²³ Ibid.

¹²⁴ Ryan Caron, “Mysterious microsatellites in GEO: is MiTEx a possible anti-satellite capability demonstration?,” *Space Review*, July 31, 2006, <http://www.thespacereview.com/article/670/1>.

¹²⁵ Ibid.

of failure for the satellite.¹²⁶ With today's existing ground systems, the U.S. Space Surveillance Network (SSN) is the only system with the current capability to detect smallsats in GEO. This advantage effectively gives the system a stealth-like capability as a smallsat technology demonstrator and further symbolizes the attractiveness of smallsat technology for military utilization as an ASAT system.

D. U.S. SPACE SECURITY STRATEGY

Since the dissolution of the Soviet Union, U.S. space policy has been formed in an ever changing and uncertain political environment. The United States and the Soviet Union were the two dominant actors throughout the Cold War and the funding for and development of technology was often justified by the security competition with the Soviets. With the recent trend toward the commercialization and privatization of space and launch activities, an influx of new actors are gaining access to space. Technology has continued to mature through ingenuity and imagination, advancing from the improbable to the possible. Emerging innovations such as smallsats now provide the potential to bring game-changing advances as well as threats to the collective space security of nations.

As examined in the previous section, security threats have often dominated U.S. policy, and the focus of the Cold War space policy implemented was based on national security. While the Clinton administration moved to maintain the nation's leadership in space activities, space was a low priority for the administration.¹²⁷ With the election of George W. Bush, his administration quickly became focused on the "military security concerns and independent action" after the horrific events of 9/11.¹²⁸ The unilateral approach of the administration became a significant barrier to international cooperation, and the ever tightening export controls on space technology of which "95% has been

¹²⁶ Craig Covault, "Secret Inspection Satellites Boost Space Intelligence Ops," *Spaceflight Now*, January 14, 2009, <http://www.spaceflightnow.com/news/n0901/14dsp23/>.

¹²⁷ The White House, "National Space Policy," September 19, 1996, <http://www.hq.nasa.gov/office/codez/new/policy/pddnstc8.htm>.

¹²⁸ Wade Huntley, "The 2011 U.S. National Space Security Policy: Engagement as a Work in Progress," *NGO Committee on Disarmament, Peace & Security*, Spring 2011, http://disarm.igc.org/index.php?option=com_content&view=article&id=429:the-2011-us-national-space-security-policy-engagement-as-a-work-in-progress&catid=154:disarmament-times-spring-2011&Itemid=2.

estimated to be dual-use,” became a regulatory nightmare.¹²⁹ Technology became viewed as a panacea and a “robust science and technology base” was a cornerstone of the space policy goals.¹³⁰ With the continued emphasis on technology development, such as smallsat systems, and the reliance on military power through Operation Burnt Frost, the Bush administration might have underestimated the degree to which U.S. capabilities are perceived as threats by other space-faring nations.

The space policy articulated by the Obama administration expressed a much more multilateral approach than its predecessor and reoriented the United States toward fostering international cooperation. With the release in February 2011 of the first of its kind National Security Space Strategy, the administration turned its attention to a strategic environment that is increasingly “congested, contested and competitive.”¹³¹ Rather than focus on state based threats, the strategy outlines its objectives to “strengthen safety, stability, and security in space; maintain and enhance the strategic national security advantages afforded to the United States by space; and energize the space industrial base that supports U.S. national security.”¹³² Referencing one of the key themes of the National Space Policy, the strategy emphasizes the “building (of) coalitions of like-minded space-faring nations”¹³³ and the implied establishment of institutional norms.¹³⁴ Although reform for export controls are called for, the role of counterspace technologies such as ASATs and smallsats remains unclear.¹³⁵ With the adoption of the National Security Space Strategy, the Obama administration appears to be sending clear

¹²⁹ Johnson-Freese, *Space as a Strategic Asset*, 30.

¹³⁰ National Space Policy, <http://www.whitehouse.gov/sites/default/files/microsites/ostp/national-space-policy-2006.pdf>.

¹³¹ National Security Space Strategy Unclassified Summary, January 2011, http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf.

¹³² *Ibid.*

¹³³ *Ibid.*

¹³⁴ Huntley, “The 2011 U.S. National Space Security Policy: Engagement as a Work in Progress.”

¹³⁵ National Security Space Strategy Unclassified Summary, January 2011.

signals concerning U.S. policy toward the recently revised European Union Code of Conduct.¹³⁶ The strategy may eventually serve as a valuable bridge to promote transparency and confidence-building measures.

E. SUMMARY

In many ways, the initial militarization of space occurred as a result of the ideological struggle between the United States and the Soviet Union and the desire of the Eisenhower administration to gain insight into the closed Soviet state during the Cold War. As the military role of space grew to provide a number of unique space utilities to the battlefield commander and senior decision makers, so too did the U.S. reliance on the services provided from orbit increase tremendously. Although ASATs have been developed by the U.S. military as a means to counter the Soviet threat, a series of factors to include national interests, financial and technical constraints, and formal agreements have influenced each administration's space policy and ultimately alleviated the need for their use.

The collective space security environment has changed dramatically since the end of the Cold War as a series of new space-faring actors have emerged. Military space technology has rapidly matured and the employment of smallsat technology by multiple space-faring actors provides a continued challenge to space security. In this era of globalization, the international space community is experiencing new security challenges that no longer can be solved unilaterally. The U.S. National Space Policy has undergone significant changes during the Obama Administration and the stated goals of the 2011 National Space Security Strategy express the desire for international cooperation. Chapter V will address suggested courses of action for U.S. policy-makers to implement regarding the proliferation of smallsats to guarantee the common security of all space actors.

¹³⁶ Jeff Foust, "Debating a code of conduct for space," *The Space Review*, March 7, 2011, <http://www.thespacereview.com/article/1794/1>.

III. SOVIET/RUSSIAN SPACE TECHNOLOGY DEVELOPMENT

We placed Gagarin and Titov in space and we can replace them with bombs which can be diverted to any place on Earth.

— Nikita Khrushchev following the successful recovery of Vostok 2, August 8, 1961¹³⁷

A. OVERVIEW OF SOVIET ANTI-SATELLITE SYSTEMS

With the launch of *Sputnik* on October 4, 1957, the Soviet Union ushered a surprised world into the space age. Although the Soviets had made tremendous technological and scientific advances since World War II, little respect had been granted to them by the international community. The Soviets had been viewed as a technologically backward country throughout the 1950s while the United States had dominated global affairs.¹³⁸ Basing much of their early work on German rocket design, the Soviets successfully produced the SS-6 (or R-7) launch vehicle which quickly became the foundation for both the ICBM and space programs. Consolidation of these programs promoted the sharing of technology and was the antithesis of the U.S space program, which strove to keep distance between the ICBM and space programs.¹³⁹

With the growth of its military space program, the Soviet Union developed and operationally deployed a nuclear-tipped interceptor as well as a kinetic ASAT system from the mid-1960s until the late 1980s, which was capable of attacking U.S. satellites in LEO. The ASAT program began with the testing of a satellite interceptor program in 1968 that was suspended in 1971 and was just one of a number of new Soviet space programs during that era.¹⁴⁰ Throughout the 1970s, the Soviet military space program once again expanded and in 1976 resumed ASAT interceptor testing after a five-year hiatus. ASATs weapons were periodically tested up until the early 1980s as the Soviets investigated a series of different options to negate U.S. satellites. Since the fall of the

¹³⁷ Phillip J. Klass, *Secret Sentries in Space* (New York: Random House, 1971), 62.

¹³⁸ Nicholas L. Johnson, *Soviet Military Strategy in Space* (London: Jane's Publishing Inc., 1987), 18.

¹³⁹ Manno, *Arming the Heavens: The Hidden Military Agenda for Space, 1945–1995*, 31.

¹⁴⁰ Stares, *The Militarization of Space*, 135.

Soviet Union, Russia has maintained a moratorium on space weapons testing, but following the recent U.S. and Chinese ASAT tests, the military has announced a renewed interest in weapons testing.¹⁴¹

This chapter examines the history of both the Soviet and Russian ASAT development and the formation of the accompanying space policy since the beginning of the space age. The emphasis is on the development of the major ASAT systems and the role that the emerging technology has played in stimulating a space arms race. This chapter will also explore recent Russian smallsat development and the role that this emerging technology could have on arms control and continued ASAT development.

B. SOVIET ASAT DEVELOPMENT

Following the conclusion of World War II, the Soviet Union found itself engaged in a struggle of ideologies with the United States for global influence. This race for supremacy soon expanded into space and the Soviets took the early lead with several significant accomplishments in space to include the first satellite, animal, and human being in space. The Soviet space program was originally an offshoot of the state's nuclear weapons program and the early struggle to create ICBMs, which placed the military at the very heart of the program.¹⁴² Much of the launch technology built for ICBMs was modified and used by the space program. This organizational structure greatly benefited the space program as it received large amounts of research and development money from the Soviet leadership that it otherwise would not have had access to.¹⁴³

As a result of early success and multiple U.S. launch failures, the Soviet Union garnered international prestige and moved to cast off the perception of its technological inferiority and backwardness. Unlike the United States, the Soviets chose to exploit existing space technology rather than waste time and effort on pursuing the state of the art. The Soviet leadership extracted political gains from each successful space event and

¹⁴¹ "Russia is building anti-satellite weapons," March 5, 2009, <http://www.independent.co.uk/news/world/europe/russia-building-antisatellite-weapons-1638270.html>.

¹⁴² See Victor Mizin, "Russian Perspectives on Space Security," in *Collective Security in Space European Perspectives*, ed. John M. Logsdon, James Clay Moltz, and Emma S. Hinds (Washington, DC: Space Policy Institute, 2007) for a synopsis of the early Russian space program.

¹⁴³ Mowthorpe, *The Militarization and Weaponization of Space*, 56.

frequently engaged in political one-upmanship with the U.S. space program.¹⁴⁴ The politicization of space and the inherent Communist fear of Western motives resulted in the Soviet Union becoming a reactive country throughout the 1960s, which in turn responded to U.S. policy and technology development.

Even though the Soviets had launched the first satellite into space, the Soviets quickly fell behind in space exploration and military utilization.¹⁴⁵ Although the Soviets had a significant advantage in space lift, the United States' investment in space technology started to pay dividends early on. The Soviet Union under Nikita Khrushchev had a vastly different set of national priorities, as the country recovered from the horrors of WWII and the loss of 20 million dead. The perceived threat of the United States and capitalism in general provided a challenge to the Soviet Union around which the population could rally. The fear of American aggression and lack of a capable strategic bomber drove the Soviets' pursuit of intercontinental ballistic missiles, which was to become the cornerstone and key technology provider for the space program.

The Soviet Union's more limited technical capabilities resulted in the production of massive launchers and a much different satellite philosophy than that of the United States. Rather than rely upon fewer numbers of complex satellites with longer mission duration, the Soviets instead relied upon larger numbers of simpler satellites that had much shorter lifetimes to perform the same core set of capabilities. Whereas a typical U.S. satellite could be expected to operate several years in orbit, Soviet satellite mission durations were often measured in months or days. This dichotomy drove the Soviets to develop standardized launch vehicles and satellites designs that were both simple and mission-effective.¹⁴⁶

1. Early Soviet ASAT Development Programs

At the very beginning of the space age, the initial goals of the Communist Party were to establish a Soviet capability for reconnaissance to “see within the boundaries of

¹⁴⁴ Johnson, *Soviet Military Strategy in Space*, 21.

¹⁴⁵ *Ibid.*, 46.

¹⁴⁶ *Ibid.*, 50.

sovereign states.” Although this purpose appears to reflect the sanctuary school of space power through the peaceful use of space, the Soviet military strategy of the day acknowledged “the need to study the use of space and space vehicles to reinforce the defense of the socialist states.”¹⁴⁷ As the United States started their investigation of ASAT systems, the Soviet regime shifted to a survivability school of thought as the military leadership looked to protect their nascent space assets. The 1963 version of the Soviet Military Strategy articulated the Soviet military’s view on the U.S. DoD’s space policy by describing it as “aimed at mastering space for military purposes.”¹⁴⁸ The Soviet Military Strategy summarized the problem it was facing with the United States as:

The rapid development of spacecraft and specifically of artificial Earth satellites, which can be launched for the most diverse purposes, even as vehicles for nuclear weapons, has put a new problem on the agenda, that of defense against space devices...¹⁴⁹

Despite the significant Soviet accomplishments in space throughout the late 1950s, the Kremlin feared that the West was intent on regaining a perceived loss of military superiority and that the U.S. science experiments were really a cover for military plans.¹⁵⁰ Although the military strategy contained a fair amount of Communist propaganda, the document illustrated the Soviet fear of the U.S. development of “space vehicles intended for delivery of nuclear strikes” and for “the creation of anti-satellite weapons to destroy space vehicles.”¹⁵¹ These perceived threats were part of the security dilemma that existed between both countries as each country explored the militarization and potential weaponization of space. What each side feared for space technology development was the unknown, and that fear justified the spending of large amounts of money to build an indigenous technological base to counter the perceived threat.

¹⁴⁷V.D. Sokolovskii, *Soviet Military Strategy*, trans. H. Dinerstein, L. Goure, and T. Wolfe, United States Air Force Rand, April 1963, pg 427, <http://www.rand.org/content/dam/rand/pubs/reports/2005/R416.pdf>.

¹⁴⁸ Sokolovskii, *Soviet Military Strategy*, 428.

¹⁴⁹ Johnson, *Soviet Military Strategy in Space*, 140.

¹⁵⁰ Ibid.

¹⁵¹ Ibid.

Similar to the United States, the Soviet Union began investigating the use of ASAT weapons in the early 1960s. The Soviets' first ASAT system consisted of a basic direct-ascent weapon similar to the U.S. programs 437 and 505.¹⁵² The ABM-1 Galosh had a primary mission as an anti-ballistic missile with a maximum range of 250 km that was capable of carrying up to a fifty megaton nuclear-tipped warhead.¹⁵³ The warhead's yield provided the ABM with a residual ASAT capability, which enabled it to destroy all spacecraft out to blast radius of 1,000 km. The indiscriminate explosion would have disabled Soviet satellites as well as U.S. targets, similar to what had occurred with the U.S. Project Fishbowl testing. The Soviets conducted three nuclear explosions during a two week period in the fall of 1962 that were of intermediate yields, but stopped testing shortly thereafter. The launcher's limited altitude and the unknown nuclear effects on the atmosphere from large nuclear warheads prompted Soviet leadership to forgo the operationalization of this weapon system. The ABM-1 Galosh provided the Soviets with a rudimentary nuclear ASAT capability to counter early U.S. reconnaissance satellites in the event of hostilities, but was abandoned for more precise weapon systems.

When the Soviet military started its research into an ASAT interceptor, there were several marked differences between their approach and the SAINT system that had been proposed by the United States. Unlike its counterpart, the Soviet version was meant to destroy important hardened spacecraft in LEO, rather than rendezvous and inspect. The concept of operations for the Soviet version was known as "the hot metal kill" and called for the detonation of an explosive device in the near vicinity of the targeted satellite, which then spread a spherical cloud of shrapnel toward the target.¹⁵⁴ The technique for disabling or destroying the satellite had the advantage of allowing the Soviets to avoid using nuclear weapons and of selectively targeting satellites. This system had the disadvantage though of requiring the ASAT to be within a one-km blast distance for the shrapnel to hit its target and the kill to be successful.

¹⁵² Ibid., 21.

¹⁵³ "A-350Zh," *Encyclopedia Astronautic*, <http://www.astronautix.com/lvs/a350zh.htm>.

¹⁵⁴ Peebles, *Battle for Space*, 102.

The development of what would become the first operational Soviet ASAT weapon was conceived in 1959 and began in 1961 under the program name, Istrebitel Sputnikov (IS), which translates as “destroyer of satellites.”¹⁵⁵ The IS system eventually won out over the other systems in development because of the simplicity of its technical approach, which used a large fragmentation charge requiring far less precision than the other techniques. The IS system utilized the Korolev R-7 rocket and was capable of putting a 1,400 kg payload into a 300 km LEO orbit.¹⁵⁶ The first test was launched November 1, 1963, and demonstrated significant mobility through its extensive use of maneuvering thrusters. The vehicle transferred from an orbit of 592 km by 339 km to a final orbit of 1,437 km by 343 km, illustrating a significant competence to be able to change both altitude and inclination.¹⁵⁷ The next test in April of 1964 performed a similar set of orbital maneuvers in its flight path. The flight testing demonstrated a significant rendezvous and docking ability and was both an important precursor of later manned Soviet spacecraft and a critical building block for the follow-on satellite interceptor.

As a result of the increasing Soviet competence, the U.S. DoD closely monitored Soviet space activity to assess rendezvous docking proficiency.¹⁵⁸ In August 1962, the Soviets placed two spacecraft, *Vostok 3* and *Vostok 4*, into space that passed within four miles of each other.¹⁵⁹ Although the close proximity was due to similar flight paths and launch timing, the Soviets demonstrated a rudimentary ability to intercept a target spacecraft. The Soviets further tested this capability with a similar exercise conducted by *Vostoks 5* and *6* during June 1963. Although the four kilometer range was outside the kill zone of an explosive kinetic detonation, the distance would have been easily surmountable for a nuclear-tipped ASAT, if the need arose.

¹⁵⁵ Sven Grahn, “Simulated Warfare in Space - Soviet ASAT Tests,” (n.d.), <http://www.svengrahn.pp.se/histind/ASAT/ASAT.htm>.

¹⁵⁶ Ibid.

¹⁵⁷ Peebles, *Battle for Space*, 102.

¹⁵⁸ Klass, *Secret Sentries in Space*, 126.

¹⁵⁹ Peebles, *Battle for Space*, 102.

Throughout 1962, the military explored the use of manned ASAT systems and produced several studies to investigate their viability. The studies researched the use of manned spacecraft modules that would be capable of close proximity operations with a target satellite.¹⁶⁰ The first of these programs resulted in the development of the Soyuz-P in 1964. The concepts of operations for the program intended that the Soyuz-P would rendezvous with the target satellite and allow the cosmonaut to exit the spacecraft for inspection of the satellite.¹⁶¹ Depending on the results of the inspection, the cosmonaut would then destroy, neutralize, or bring the satellite back to the Soviet Union for further study.¹⁶² This approach was quickly rejected by Soviet leadership due to its multiple technical complexities and the obvious danger to the cosmonaut. All Soviet satellites were equipped with automatic destruct systems to prevent them from falling into enemy hands and would detonate if certain parameters were met. Soviet leadership assumed the U.S. satellites were similarly equipped and any attempt to interfere with their operations would yield very little information and likely lead to the cosmonaut's death.¹⁶³

A variant of the Soyuz-P yielded the Soyuz 7K-PPK or pilotiruemyi korabl-perekhvatchik, which is translated as "manned interceptor spacecraft."¹⁶⁴ This version had both manned and unmanned options and relied upon inspection of a targeted satellite by using on-board equipment. Increasing developmental delays and technical challenges resulted in the program's eventual cancellation. The Soviet military leadership also explored the ideas of a large space mine dispenser, which would carry twelve interceptors into orbit and a dormant unmanned space interceptor.¹⁶⁵ Both programs had unique advantages to make them attractive for their development but cost and technical hurdles drove leadership to pursue the kamikaze satellite approach.¹⁶⁶

¹⁶⁰ See <http://www.astronautix.com/alpha/s.htm> for an excellent description of the varied *Soyuz* missions.

¹⁶¹ Ibid.

¹⁶² See "IS-A," *Encyclopedia Astronautix*, <http://www.astronautix.com/craft/isa.htm> for a detailed description of early U.S. and Soviet ASAT program approaches.

¹⁶³ Peebles, *Battle for Space*, 102–107.

¹⁶⁴ "IS-A," *Encyclopedia Astronautix*, <http://www.astronautix.com/craft/isa.htm>.

¹⁶⁵ Johnson, *Soviet Military Strategy in Space*, 172.

¹⁶⁶ "IS-A," *Encyclopedia Astronautix*, <http://www.astronautix.com/craft/isa.htm>.

During the 1963–1964 timeframe, the Soviet regime began to place a greater emphasis on an operational ASAT capability and established a branch of the military to develop and deploy ASATs. The organization was designated the Protivo Kosmicheskaya Oborona (PKO) and was established under the Soviet Air Defense Forces with the goal of “combating an aggressor’s nuclear attack and his attempt to reconnoiter our country from the air and space.”¹⁶⁷ The PKO investigated the use of spaceships and satellite fighters to counter the perceived imperialist threat and to bring some semblance of order to multiple Soviet ASAT efforts that were currently in development within the Soviet military. This reorganization brought about a subtle shift in Soviet space policy took place as the Brezhnev-led government began to challenge the United States lead in space and moved from the school of survivability to now follow a mixed doctrine of space control with elements of the doctrine of the high ground school of space.

The 1968 Soviet Military Strategy outlined the Soviet perspective of space as being supported by three distinct goals: creating combat effective space systems for all armed service branches; preventing other countries from utilizing space; and developing offensive systems to conduct battles in space.¹⁶⁸ With these goals in mind, the Soviet Union established several space control goals to include:

- 1) protection of Soviet tactical and strategic strike capabilities;
- 2) support of Soviet tactical and strategic operations;
- 3) prevention of the use of space by the enemy for military, political, or economic gain; and
- 4) unhampered utilization of space assets to further the Soviet system and goals.¹⁶⁹

The intent of this doctrine was to protect Soviet space assets which the leadership was becoming more reliant on while simultaneously targeting the use of space by the United States and its North Atlantic Treaty Organization (NATO) partners for communications and reconnaissance.

¹⁶⁷ Peebles, *Battle for Space*, 97.

¹⁶⁸ V.D. Sokolovskii, *Soviet Military Strategy*, ed. Harriet Fast Scott (New York: Crane, Russak, 1975), 83–85.

¹⁶⁹ Johnson, *Soviet Military Strategy in Space*, 198.

As the Soviets continued their investigation of space weapons throughout the mid to late 1960s, space became viewed by the Soviet leadership as the ultimate arena to deploy weapons. In January 1967, the Soviets recommenced the testing of space weapons programs with the launch of *Kosmos 139*. The launch vehicle for the test consisted of a modified SS-9 Scarp ICBM, which, when outfitted with either a fourth stage retrorocket or multiple-burn fourth stage rocket, enabled the Soviets to employ their Fractional Orbital Bombardment System (FOBS).¹⁷⁰ FOBS consisted of a large nuclear warhead that could de-orbit into a LEO orbit of 150 km altitude and could approach the United States from any direction and below missile tracking radar. The *Kosmos 139* test illustrated the ability to drastically shorten the warning time of an ICBM by placing it into a partial LEO orbit and out of sight of many of the north-facing U.S. ground radars. The warhead would be de-orbited with less than one orbital revolution to complete its mission or be allowed to remain in orbit until needed, drastically reducing the amount of warning time. Although FOBS provided a crucial element of surprise, in reality the system had two big disadvantages that precluded its implementation. One drawback was that because of its greater need for fuel to maneuver, a smaller warhead had to be used to compensate for launch weight management. A second drawback was that the system's trajectory resulted in a larger circular error probability (CEP) that made the system effective primarily against only soft military and civilian targets.¹⁷¹

Altogether, the Soviets completed sixteen estimated FOBS tests from January 1967 to the cancellation of the program in August 1971. The continued system testing indicates the pursuit of a dual-track strategy, given the fact that the Soviet Union was engaged in WMD negotiations in the Outer Space Treaty with the United States throughout 1967, when a large number of the early tests were conducted. Sea-launched ballistic missiles (SLBMs) provided the same type of capability as FOBS and became the Soviets' choice for a more maneuverable nuclear weapon against the United States.¹⁷² Further negotiations between the Soviets and the United States resulted in the Strategic

¹⁷⁰ Ibid., 127–135.

¹⁷¹ Ibid., 132.

¹⁷² Ibid., 133.

Arms Limitation Talks (SALT I), which discussed the allowed number of bombers, ICBMs, and SLBMs for both countries but failed to include mention of the number of ASATs. As a result of the growing detente with the United States, Soviet leadership eventually cancelled FOBS testing and halted their pursuit of ASATs during the early 1970s.

At the same time as the Soviets were testing the FOBS system, the PKO continued testing the IS ASAT system in partial response to perceived American ASAT programs. Following the launch of *Kosmos 185* in October 1967 into an eccentric low earth orbit, the spacecraft was then maneuvered into its final parking orbit as an intended target satellite. Several months later, *Kosmos 217* was launched into a similar orbit as *Kosmos 185*, but Western sensors tracked only debris, suggesting that either a failure had occurred or a possible weapons test had occurred. *Kosmos 248* and *249* were launched on successive days into the same orbital plane in October 1968, and when *Kosmos 249* was detonated when it flew by the targeted satellite.¹⁷³ From this test and several successive tests during the next three years with varying targets and orbital parameters, the United States was able to determine that the Soviets had developed an operational IS kinetic weapon system. Five of the seven tests of the Soviet IS system were deemed to have been successful by Soviet military experts but more importantly demonstrated the Soviet ability to attack a variety of satellites throughout the LEO orbital plane.¹⁷⁴ The IS system provided the military leadership an alternative to the FOBS platform, but like that system, testing was halted in 1971 with the signing of the SALT I accords and a self-imposed hiatus.

2. Soviet ASAT Development in the 1970s—1980s

The Soviet Union resumed testing of their ASAT weapon system in February 1976, with the launching of a Kosmos target from their Plesetsk Cosmodrome 800 kilometers north of Moscow. The latest series of weapons testing exhibited a new

¹⁷³ Stares, *The Militarization of Space: U.S. Space Policy, 1945–1984*, 137–140.

¹⁷⁴ See either Johnson, *Soviet Military Strategy in Space*, 131 or “IS-A,” *Encyclopedia Astronautix*, <http://www.astronautix.com/craft/isa.htm> for a detailed listing of the IS tests and results. Both sources provide a detailed insight into the Soviet test methodology and results.

flight profile that caused great concern for military observers.¹⁷⁵ This innovative approach was nicknamed the “pop up” profile, and consisted of the launching of a target first, followed by the launch of an interceptor four minutes after the pass of the target vehicle over the launch site. The interceptor was placed into a lower orbit, which allowed it to quickly gain on the target and then assume an elliptical orbit to enable interception of its target.¹⁷⁶ From launch to interception, the Soviets now had an ASAT capability that could engage targets in certain orbits within a window of approximately forty-two minutes. This short interval allowed little time for any evasive U.S. action and could be done surreptitiously outside of U.S. tracking range and observation.

Soviet military leadership tested three different variants for the ASAT system’s orbital tracking CONOPs to include a fast “flypast,” a slow “flypast,” and the original “pop up” technique.¹⁷⁷ The military explored the weapon’s ability against several different orbital planes to include a medium altitude circular orbit, a highly elliptical orbit (HEO), and a target in LEO during the 1978–1982 timeframe with a marginal success rate.¹⁷⁸ After the final launch of the system in June 1982 ASAT, the Soviets had tested an ASAT weapon twenty times during a fourteen-year period. The program provided the Soviet military a significant capability against U.S. LEO satellites, but the operational range limitations of the ASAT systems kept the geostationary U.S. assets beyond reach.

The continued testing during this period may be attributable to several factors to include the ongoing political turmoil in the United States, the lack of a SALT II agreement, and the beginning of the Chinese space program. From 1972–1975, the ongoing Watergate scandal distracted the Nixon administration from the pursuit of a SALT II agreement and resulted in the resignation of both the president and vice-president. This perceived weakening of American political strength and the dismantlement of the U.S. Johnston Island Facility in 1975 provided a boost to the Soviet’s perceived military posture. At the same time, the PKO feared losing their ASAT

¹⁷⁵ Peebles, *Battle for Space*, 106.

¹⁷⁶ See *Ibid.*, 107–108, for a detailed description of the flight profile for the Soviet ASAT weapons testing throughout 1976.

¹⁷⁷ Mowthorpe, *The Militarization and Weaponization of Space*, 123.

¹⁷⁸ Peebles, *Battle for Space*, 109.

capability as a result of a lack of training and the testing may have begun again as a Soviet bargaining tool to bring the United States back to the table for arms control negotiations.¹⁷⁹

An additional factor that may have influenced renewed ASAT testing is the initiation of the Chinese space program. Soviet ASAT tests were conducted in 1970 shortly following the launch of China's first two satellites in spring of 1970. The Soviets again resumed testing with the new "pop up" flight profile in 1975 following the launch of three subsequent Chinese satellites. Although the Soviet ASAT tests were conducted within many of the similar inclinations as the Chinese satellites, a clear linkage between the two has been indeterminate since the Soviet launch facilities' locations and orbital mechanics dictate the ASAT system's range of inclinations.¹⁸⁰ The timing of the weapons testing though suggests a continuation of the Soviets' pursuit of space as a political tool and a space policy throughout Brezhnev's leadership that contained elements of both of the schools of space control and the high ground. Although the military developed both the FOBs and various ASAT systems to be used in the event of a space conflict, ultimately, the Soviet leadership's restraint from employing weapons reflected a partial acceptance of the sanctuary school of thought.¹⁸¹

The 1984 and 1985 editions of the *Soviet Military Power* claimed that the ASAT systems had been operational since 1971, and more importantly illustrated the importance placed on the space weapon system by the Soviet military leadership. The Soviet Premier, Yuri Andropov, announced in 1983 a unilateral moratorium on ASAT testing, which brought dismay from much of the Soviet military establishment, who had become dependent on the system as a probable course of action in the event of conflict.¹⁸² The Soviet Union vowed not to deploy any space weapon as long as other countries refrained

¹⁷⁹ Johnson, *Soviet Military Strategy in Space*, 148.

¹⁸⁰ *Ibid.*, 156.

¹⁸¹ Mowthorpe, *The Militarization and Weaponization of Space*, 59.

¹⁸² Anatoly Zak, "Spacecraft: Military: IS anti-satellite system," *Russian Space Web*, (n.d.), <http://www.russianspaceweb.com/is.html>.

as well from employing ASATs.¹⁸³ Following Mikhail Gorbachev's assumption of the leadership, the IS ASAT system was discontinued as a struggling economy and domestic priorities became a higher priority within the Communist Party.

Although the IS system had been the foundation of the Soviet ASAT program throughout the program's existence, the military continued the development of several new systems in the early 1980s in response to the Reagan administration's Strategic Defense Initiative (SDI), continuing U.S. ASAT plans, and the U.S. pursuit of the space shuttle. These projects included the construction of the Kaskad and Skif ASAT orbital stations that were to be armed with both laser weapons and short-range interceptor missiles.¹⁸⁴ Both platforms had been on the drawing board since 1976 but with the continued U.S. pursuit of the SDI program, the military moved forward in development. Soviet engineers adapted a compact, one-megawatt carbon dioxide laser that had been previously tested on an Il-76 transport aircraft as a weapon against missiles on the Skif station. In August 1984, the new spacecraft was approved and designated Skif-D, the "D" standing for the Russian word for "demonstration."¹⁸⁵ Skif-D "grew to be almost 131 feet long, more than 13 feet in diameter, and weighing 210,000 pounds, more massive than NASA's Skylab space station,"¹⁸⁶ and was both incredibly complex and expensive. The launch of the system now called Skif-DM for Demonstration Model (which had no weapons systems aboard), slipped to early 1987. After reaching orbit, a software glitch resulted in the Skif-DM tumbling through two revolutions before heading back into the atmosphere, where it broke apart on reentry.¹⁸⁷ This lack of success and the program's exorbitant price tag resulted in the cancellation of the system by its opponents.

Throughout the mid-1980s, the Soviet military developed the Naryad ASAT system to ride aboard a silo-based missile. The launcher was derived from an existing

¹⁸³ Vladimir Dvorkin, "Space Weapons Programs," in *Outer Space: Weapons, Diplomacy, and Security*, ed. Alexei Arbatov and Vladimir Dvorkin (Washington, DC: Carnegie Endowment for Peace, 2010), 32.

¹⁸⁴ *Ibid.*

¹⁸⁵ Dwayne A. Day and Robert G. Kennedy III, "Soviet Star Wars: the launch that saved the world from orbiting laser battle stations," *Air and Space*, January 2010, <http://www.airspacemag.com/space-exploration/Soviet-Star-Wars.html?c=y&page=1>.

¹⁸⁶ *Ibid.*

¹⁸⁷ *Ibid.*

Soviet UR-100NU ICBM that had been modified to include a highly maneuverable upper stage.¹⁸⁸ The upper stage would then release several kill vehicles that were capable of reaching satellites in GEO, a significant upgrade over the previous IS ASAT platform. The interceptor was outfitted with four thrusters which it could use to home in on its intended target before switching to an onboard computer for its final approach and detonation of its warhead.¹⁸⁹ Although the ASAT originally had been envisioned as key element of a Soviet equivalent “Star Wars” program, the development of the system continued with minimal support, and it was not shortly before the fall of the Soviet Union that the system was tested.

Although the Naryad ASAT system had been on the drawing board for the better part of a decade in response to the development of the American SDI program, the program did not undergo its first test evaluation until November 1990. The Naryad ASAT was launched from the Baikonur Cosmodrome and quickly became the foundation of first the Soviet, and later the Russian, ASAT arsenal. A second suborbital test, that was more comprehensive in nature, was completed in December 1991 shortly before the dissolution of the Soviet Union. Both tests were successful and were conducted on a ballistic trajectory to demonstrate the platform’s capacity to use its multiple thrusters in a series of orchestrated firings. Following the breakup of the Soviet Union, the Naryad underwent a final test in December 1994, when the ASAT was launched into orbit. Although the experiment was successful, the task force responsible for the ASAT testing was immediately disbanded after the trial, and the program’s operations and oversight were officially transferred to the Plesetsk Missile Facility.

Under Gorbachev’s leadership, the Soviet Union underwent a significant transformation to its space policy. Although his Soviet space policy analysts argued for pursuit of a sanctuary school of thought policy, the unwillingness of the military to abandon ASATs as a fundamental element of its arsenal prohibited the Kremlin from fully pursuing this option. With Gorbachev at the helm, the Soviets moved to implement policies of Glasnost and Perestroika and to slow the military competition with the United

¹⁸⁸ Anatoly Zak, “The Naryad Program,” *Russian Space Web*, (n.d.), <http://www.russianspaceweb.com/naryad.html>.

¹⁸⁹ *Ibid.*

States to focus on increasingly problematic domestic issues. Although several military projects that were in the final stages of development (such as Naryad) were completed, many of the high profile space programs that had existed under the previous regimes were cancelled.

3. Post-Cold War Russian ASAT Development

After the fall of the Soviet Union, the new Russian Federation inherited much of the leftover Soviet space and ASAT infrastructure and Vice President Aleksandr Rutskoi promised that Russia would continue to remain a space power.¹⁹⁰ The primary challenges of the newly emerged Russian Federation were to preserve the nation's military space capabilities which it had inherited from the Soviet Union, while maintaining the facility infrastructure necessary to support effective space operations.¹⁹¹ Russia struggled to maintain full operational capability and was forced to rely on much of the equipment remaining from the deteriorating Soviet arsenal.¹⁹²

The Soviet leadership had been highly dependent on space and developed a military space program that grew to rely on reconnaissance, electronic intelligence, communications and early warning. With the end of the Cold War, Russia struggled to maintain these military capabilities but continued to invest in space even moving to pursue the commercialization of space. The first sign of this change began under Gorbachev's leadership when the general secretary moved to break the military's dominance of space and the use of space as primarily a political propaganda tool. Although the military continued to maintain and develop ASAT systems, space was viewed as a critical enabler to help the crumbling Soviet Union gain entry into high technology world markets and signified a shift in Soviet doctrine back to the sanctuary school of thought. The Soviets began to emphasize the scientific side of space exploration often at the expense of the military and manned space elements of the Soviet

¹⁹⁰ Ibid, 69.

¹⁹¹ Pavel Podvig and Hui Zhang, *Russian and Chinese Response to U.S. Military Plans in Space* (Cambridge, MA: American Academy of Arts and Science, 2008), 5.

¹⁹² Ibid.

space program. Rather than focus on a continued military space competition with the United States, the Kremlin increasingly relied on a space policy of cooperation rather than confrontation.

Although the Russians had acquired the leftover ASAT hardware and plans from the Soviet period, the military leadership continued to research multiple approaches. During the 1980s, the Soviets had examined the possibility of deploying a third-generation miniaturized nuclear weapon from their Buran space shuttle, that would have a two-fold increase in yield and a hundred-fold reduction in weight from previous versions.¹⁹³ The deployment of nuclear weapon by the Buran shuttle did not complete a full orbit and as such did not violate any of the existing disarmament treaties or the 1967 OST. The project received little political support from the Kremlin and was eventually abandoned with the cancellation of the shuttle program in 1993 due to pronounced Soviet funding shortfalls.

Throughout the late 1980s and into the early 1990s, the military investigated several alternative space- and air-based ASAT weapons systems to counter U.S. space systems. One air-based option was the development of the Kontakt missile system that bore a striking resemblance to the U.S. F-15 delivered ASAT system. The missile was carried by a MiG-31 fighter that could destroy spacecraft up to an altitude of 600 km, but it too was halted by budget shortfalls.¹⁹⁴ Space-based directed-energy weapons were an additional area that was researched and partially tested by the military. The research and development culminated in Russian cosmonauts firing an electron beam gun at a targeted Swedish satellite to examine laser behavior in space in 1994.¹⁹⁵ Although the scientists made significant technical advances toward creating an operable compact space weapon, remaining technical and fiscal challenges ultimately led the military leadership to rely on the Naryad system as the mainstay of the Russian ASAT arsenal.

During President Yeltsin's administration, the Russian Federation underwent dramatic changes to its space policy as the new state struggled to maintain its space

¹⁹³ Ibid., 70.

¹⁹⁴ Dvorkin, "Space Weapons Programs," in *Outer Space: Weapons, Diplomacy, and Security*, 32.

¹⁹⁵ Ibid., 69.

capabilities. Russia curtailed space spending at the start of his presidency but quickly realized that space was an avenue to obtain hard currency for the government while simultaneously maintaining international prestige. This reasoning led to increased cooperation and the sharing of space technology between Russia and the United States and to an agreement on the joint development of the International Space Station (ISS). A significant reduction in the number of Russian military and unmanned missions started to occur in the mid-1990s as many of space enterprises were on paper bankrupt from a lack of government financial support. Reduced military launches can be attributed to diminished funding and to relaxed tensions between the United States and Russia. The lack of available state funding forced the space program to become highly commercialized to survive and the Yeltsin government to continue pursuit of a sanctuary school of thought.

The turn of the century saw a new leadership emerge for the Russian government under President Putin and a renewed emphasis on space capabilities from a country now flush with money from soaring oil prices following the terrorist attacks of 9/11. Russia regained its leadership in 2000 as the top space-faring nation in terms of number of launches per year and became the sole provider for transport to the ISS following the Columbia shuttle accident in 2003.¹⁹⁶ Putin's administration called for an aggressive revitalization of the Russian military space program, which resulted in the development of new launch facilities and of a new series of rockets.¹⁹⁷ Although some of the planned developments have been canceled or delayed, Russia has been more successful in the reinvigoration and reconstitution of many of its early warning, reconnaissance and navigation satellites. As satellites reached the end of their mission duration throughout the past decade, a lack of timely replenishment resulted in the military experiencing an ever-decreasing capability. Inadequate funding and program mismanagement had led to a severe decline in several of the military constellations' performance even resulting in a Russian inability to detect foreign missile launches for a four-month period in 2001.¹⁹⁸

¹⁹⁶ Ibid., 216.

¹⁹⁷ Ibid.

¹⁹⁸ Pavel Podvig and Hui Zhang, *Russian and Chinese Response to U.S. Military Plans in Space*, 7.

Recent launches have brought the Russian Glonass navigational system to a fully functional status as part of a broader modernization effort of the Soviet-era system.¹⁹⁹

The Putin administration funneled increasingly larger amounts of money into the space budget throughout the mid-2000s and perhaps more importantly provided both a short and long term strategic vision for the state in October of 2005. In addition to the pursuit of a next-generation manned spaceship, Russia committed itself to build a new launch complex at the Plesetsk launch site, to upgrade launch facilities in Svobodnyy in the Far East, and to construct a fleet of rockets with a wide range of capabilities.²⁰⁰ Following the United States and Chinese ASAT tests in 2007 and 2008, Russia has noticeably shifted from a sanctuary school of thought back to a space control school of policy. Although the system has remained a highly classified program and little information currently exists in public, President Putin mentioned “the availability of the Naryad system as a potential response to the U.S. decision to withdraw from the anti-missile defense treaty” in a January 2002 edition of the *Krasnaya Zvezda* newspaper.

Following the successful Chinese and American ASAT actions in 2007–2008, Deputy Defense Minister General Vladimir Popovkin intimated that the Russian military was developing anti-satellite weapons in response to U.S. and China conducting the same activities.²⁰¹ Putin’s hand-picked successor, Medvedev, has continued many of the former president’s space policies under his current guidance as prime minister, and today’s Russian military continues to explore ASAT technology to counter the existing U.S. and China space threats. As one of the pioneering space-faring powers, Russia continues to be at the forefront of space activities, illustrating the continued need for coordination with Russia to affect any effective international cooperation.

¹⁹⁹ “Glonass up and ready to go,” *The Moscow Times*, October 3, 2011
<http://www.themoscownews.com/news/20111003/>.

²⁰⁰ Harvey, *The Rebirth of the Russian Space Program*, 317.

²⁰¹ Frank Moring Jr., “Russian ASAT Restarted,” *Aviation Week & Space Technology*, March 9, 2009.

C. RUSSIAN SMALLSAT DEVELOPMENT

The former Soviet Union was a builder of smallsats and a strong advocate for the development and employment of smallsat technology. Throughout the early stages of its military satellite development, the Soviets often constructed and deployed communication smallsats that had a mass less than 220 kilograms and were based upon a robust and dependable design. Although the mission lifetime of the smallsats was considerably less than many of its U.S. counterparts, the relative cheaper cost of the satellites allowed a faster replenishment rate that was hindered only by Russian launch vehicle availability. The dependence on smaller cheaper satellites ultimately resulted in the launch of more than 650 Russian Strela military communication smallsats from 1964 to the present.²⁰² Russia has developed many different sizes of satellites depending upon the orbit and mission of the asset, but the smallsat has continued to be a featured element of their past and current space system architecture.

With the technological advances to satellite electronics, Russia has explored increasingly smaller and more capable satellites since the early 1990s. Smallsats provided a cheaper and more cost-effective platform for a country that was at the time struggling to fund its space enterprises. The Mozhayets Military Space Academy in St. Petersburg was one of the Russian educational pioneers in both improving and refining existing small satellite design.²⁰³ After obtaining several spare Strela communications satellites from the military, the students modified the smallsats to test several geodetic and laser instruments.²⁰⁴ Following the successful launches of the smallsats, the students received valuable experience on the ground C2 systems while operating and maintaining the satellites in orbit throughout their missions. Other Russian universities to include the Moscow Lomonosov State University have joined in the smallsat development and designed a wide array of sensors for missions ranging from space weather to earthquake prediction.

²⁰² See “Spacecraft Index,” (n.d.), <http://www.astronautix.com/craft/index.htm> for a detailed launch manifest of the Strela family of communications smallsats.

²⁰³ Harvey, *The Rebirth of the Russian Space Program*, 100.

²⁰⁴ *Ibid.*

During the last decade, Russia has emerged as one of the key leaders in the launch of smallsats through the use of its Dnepr rocket. The Dnepr launch vehicle evolved from an ICBM that was originally decommissioned (and designated for destruction under the START II treaty) into a valuable commercial launcher. The launcher can deliver up to 4.5 tons of payload into a 200 km circular orbit and has become an affordable and popular launch vehicle for insertion of satellites into orbit.²⁰⁵ The first mission of the Dnepr flew in December 1999 and successfully inserted a smallsat built by the University of Surrey into orbit.²⁰⁶ With sixteen of the seventeen launches successful to date, the Dnepr has been used to place more than sixty-five smallsats into orbit for a multitude of foreign customers ranging from countries to universities.²⁰⁷ Russia has partnered with several countries such as Nigeria to launch their first earth observation smallsat in 2003 and was instrumental in providing design and construction knowledge, testing, and launch and orbital operations experience to the country.²⁰⁸

In 2003, the Russians' military and scientific communities made a concerted effort to move to leaner and smaller satellites.²⁰⁹ The cash-strapped space developers began focusing on the goal to decrease the size of the satellites by a factor of ten to enable significant launch cost savings.²¹⁰ Technological advances to transponders have decreased both their size and the amount necessary to perform essential mission tasks. The goal of the satellite designers is to decrease traditional geostationary satellites from as much as 3.2 metric tons down to 600 kilograms without losing any capability.²¹¹ Russia's Federal Space Agency has also shifted focus to design dual-purpose smallsats that can provide support to Russian satellite constellations while minimizing design,

²⁰⁵ "Dnepr," (n.d.), <http://www.russianspaceweb.com/dnepr.html>.

²⁰⁶ Ibid.

²⁰⁷ Ibid.

²⁰⁸ "Nigeria; Nigeriasat-1 Micro-Satellite for Launch," *Africa News*, September 16, 2003 <http://www.africasti.com/lead-stories/enters-the-%E2%80%98made-by-nigeria%E2%80%99-satellite>.

²⁰⁹ "Russians Look to Put Leaner Satellites in Space," *The Moscow Times*, September 8, 2003.

²¹⁰ Ibid.

²¹¹ Ibid.

development, and operational costs.²¹² The move to dual-purpose smallsat systems enables the Russian space community to realize potentially significant cost savings. It has also resulted in the Russian Federal Space Agency (Roskosmos) objective to double the total number of dual-purpose satellites from fifty to more than one hundred before 2015.²¹³

The increasing interest in smaller satellites encouraged the Russian scientists to develop and test a five kilogram smallsat in 2005.²¹⁴ The smallsat was released from the ISS during a four-hour-and-thirty-minute spacewalk by the station's astronauts and was the first step in a series of tests to develop future smallsat operations command and control techniques.²¹⁵ Following its launch, the smallsat orbited the Earth in LEO in tandem with the ISS, and included a Globalstar packet data modem within its communications payloads.²¹⁶ The test was successful and was unique because of both its small size and from being launched from the ISS. Smallsats have traditionally been a secondary payload aboard launch vehicles, and the launch of the Russian smallsat demonstrated a significant new breakthrough. This recent success has encouraged Roskosmos to announce plans to build and launch more than twenty smallsats for research tasks in the near term.²¹⁷

The recent successful construction and launch of smallsats has led to interest from several other countries to partner with Russia. In May 2011, Russia and Israel announced an agreement to develop a joint center for the development of smallsats.²¹⁸ The agreement will leverage Israeli surveillance satellite expertise and “aid the fast

²¹² “Russia to focus on cost-efficient dual-purpose satellite design,” *BBC Worldwide Monitoring*, May 12, 2004.

²¹³ “Russia to more than double number of its satellites by 2015,” *BBC Worldwide Monitoring*, August 26, 2009.

²¹⁴ “Russian Nano-satellite to Perform Communications Experiments,” *Satellite Week*, April 5, 2005.

²¹⁵ *Ibid.*

²¹⁶ *Ibid.*

²¹⁷ “Russian space agency announces plans to launch over 20 small research satellites,” *BBC Worldwide Monitoring*, March 11, 2010.

²¹⁸ “Israel and Russia will cooperate for construction of small satellites,” *Russian Aviation*, May 27, 2011, <http://www.ruaviation.com/news/2011/5/27/338/>.

development of cooperation” between the two space-faring nations.²¹⁹ Current plans call for the mutual construction of several joint communications satellites and a remote-sensing smallsat.²²⁰ Russia has made significant progress in smallsat technology advancement throughout the last two decades despite Roskosmos’ struggle for consistent financial support. The government’s smallsat heritage and the sustained government emphasis on smallsats signify Russia’s leadership in the continued development and launch of smallsats during the next decade.

D. RUSSIAN SPACE SECURITY STRATEGY

The former Soviet Union and the United States competed extensively with one another during the Cold War both on and above the Earth. From the earliest days of the space age, the Kremlin pursued a dual-track approach to develop military space assets in secrecy and simultaneously pursued diplomatic efforts for the peaceful use of space. Soviet leadership introduced numerous diplomatic and political initiatives that supported the non-weaponization of space, while striving to maintain the state’s strategic parity with the United States throughout its existence.²²¹

As the Soviet Union broke apart, a newfound sense of cooperation emerged between the two nations, as the United States worked closely with Russia to maintain space security and to avoid the proliferation of sensitive technology and knowledge. The cooperation between the two countries greatly enhanced the space exploration and scientific discoveries of each nation and resulted in the establishment of the ISS along with the help of fourteen additional nations. The Russian Federation moved to maintain strategic parity with the United States and prevent the costly expenditure of rapidly dwindling state funds by passing a Law of the Russian Federation on Space Activities in August 1993.²²² The legislation opposed the emergence of an arms race in outer space,

²¹⁹ Ibid.

²²⁰ “Russia plans to cooperate with Israel in making satellites,” *BBC World Monitoring*, February 25, 2011.

²²¹ Viktor Mizin, “Non-weaponization of Outer Space, Lessons from Negotiations.” in *Outer Space: Weapons, Diplomacy, and Security*, ed. Alexei Arbatov and Vladimir Dvorkin (Washington, DC: Carnegie Endowment for Peace, 2010), 49.

²²² Moltz, *The Politics of Space Security*, 245–246.

while the Kremlin pursued negotiations within the Conference on Disarmament (CD) and the Prevention of an Arms Race in Outer Space (PAROS). Although these discussions yielded little actual progress, they continued the former Soviet strategy of pursuing diplomatic initiatives to maintain an equal space capability with the United States to ensure Russian space security.

With the election of President Putin's administration in 2000, Russia again continued a dual-track approach toward its space security. In partial response to U.S. withdrawal from the ABM Treaty and President Bush's plans for a U.S. missile defense, Russia introduced a joint working paper that was coauthored with China in June of 2002. The paper was presented to the UN CD and contained elements of an international legal agreement that would prohibit the deployment of any weapons in outer space. The agreement "would also prohibit the threat or use of force against space objects, a concept that would ban anti-satellite weapons, either mounted on aircraft or ground-based."²²³ Although the discussions ultimately failed due to U.S. opposition to a formal agreement, President Putin offered in September 2003 to implement a no-first deployment of offensive space weapons.²²⁴

Although Russia pursued several diplomatic limitations on space weapons during the early 2000s, Putin's administration continued its acquisition of military space systems. In October 2005, the Russian government officially released a ten-year space plan that outlined the goals of President Putin's administration from 2006–2015. The government's space plan highlighted the need to "provide space technologies and services for the benefits of Russian security, the enhancement of international cooperation, and to guarantee access and presence in space."²²⁵ The plan was broken up into two, five-year periods, which outlined the planned development and acquisition of Russian space systems and technology that the administration plans to invest in.

²²³ "International Legal Agreements Relevant to Space Weapons," *Union of Concerned Scientists*, Feb 2004, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/policy_issues/international-legal.html.

²²⁴ Moltz, *The Politics of Space Security*, 279–280.

²²⁵ "Major provisions of the Russian Federal Space Program for 2006–2015," Oct 22, 2005, <http://www.infoespacial.com/wp-content/uploads/Major-provisions-of-the-Russian-Federal-Space-Program-for-2006-2015.pdf>.

Further Russian diplomatic initiatives resulted in the introduction in February 2008 of the draft of the Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT). The draft was prepared jointly by Russia and China for its consideration by the CD and was an attempt by both countries to bridge the gaps of existing legal frameworks. Rather than focus on the prevention of an arms race, the treaty's prohibition of space weapons would have precluded an arms race from occurring. The PPWT was initially well received by the international community, but met with resistance from the United States. The treaty proposal had several weaknesses that led to its fall from favor including: the lack of prohibition of earth-based ASATS, the vagueness of its language regarding threats or use of force, and the challenge of on-orbit verification of what is classified as a "weapon system."²²⁶ Given its limitations, the PPWT has nonetheless been an important step in maintaining the momentum toward the development of confidence-building measures among space-faring nations to lower the risk of weaponization in space.

E. SUMMARY

Since its very inception, the Soviet Union has strongly embraced the Clausewitzian philosophy that "war is nothing but a continuation of political intercourse with a mixture of other means."²²⁷ This philosophy served the Soviet leadership well as it emerged from WWII strategically inferior to the United States and unable to face the West head-on. As the Soviets forged ahead to become the first space-faring nation, any attempt to separate the military and political goals of the Communist state remained an exercise in futility. The Kremlin and military leadership grew to rely immensely on the capabilities provided from space and on the international prestige derived from their many space accomplishments. Although ASATs were developed by the military as a means to counter the perceived American threat, a multitude of factors to include party

²²⁶ Theresa Hitchens, "Russian-Chinese Space-Weapons-Ban Proposal: A Critique," *Security in Space: The Next Generation—Conference Report, 31 March–1 April 2008*, United Nations Institute for Disarmament Research (UNIDIR), 2008, 154-156.

²²⁷ Karl von Clausewitz, *On War*, translated by Col J.J. Graham (New York: Lits, 2010), 26.

interests, financial and technical constraints, and formal agreements have influenced space policy and ultimately alleviated the need for their use.

Since the end of the Cold War, no other national space program has undergone such a dramatic change shifting from a secretive, military-run, state-sponsored agency to one which is so highly commercialized and integrated with foreign space programs. Under President Putin's leadership, Russia has made a concerted political effort to restore the country's prestige and rightful place within the international community.²²⁸ Although Russia has been highly active in introducing diplomatic initiatives to avoid an arms race in space and the destabilization of strategic parity with both the United States and China, the military and Roskosmos have continued to develop and launch smallsats. Chapter V will address suggested courses of action for U.S. policy-makers to implement regarding the proliferation of Russian smallsats to guarantee the common security of all space actors.

²²⁸ See Ronald R. Krebs, "Living in Alternate Universes: Divergent Narratives and the Challenge of U.S.-Russia Relations since the Cold War," in Timothy Colton, Timothy Frye, and Robert Legvold, eds., *The Policy World Meets Academia: Designing U.S. Policy toward Russia* (Cambridge, MA: American Academy of Arts and Sciences, 2010), 20–37, for a detailed discussion on U.S. - Russian relations since the end of the Cold War.

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IV. CHINESE SPACE TECHNOLOGY DEVELOPMENT

“Over the past few years, China’s space industry has developed rapidly and China ranks among the world’s leading countries in certain major areas of space technology. Space activities play an increasingly important role in China’s economic and social development.”

— The Information Office of the State Council
White paper on China’s Space Activities in 2011,
December 29, 2011²²⁹

A. OVERVIEW OF CHINESE ANTI-SATELLITE SYSTEMS

With the launch of its ASAT on January 11, 2007, the People’s Republic of China (PRC) became just the third nation to successfully test a ground-based interceptor system against one of its own satellites. The ASAT system was launched from a mobile transporter-erector-launcher located at the Xichang Space Center and obliterated the retired Chinese *Feng Yun 1C (FY-1C)* polar orbit weather satellite at an altitude of approximately 850 kilometers.²³⁰ The head-on collision resulted in the creation of a debris cloud containing more than 3,200 pieces of NASA tracked objects greater than ten centimeters in size and also in an estimated 35,000 pieces of debris greater than one centimeter orbiting in LEO.²³¹ The test also brought the world’s attention back again to the Chinese space program and effectively demonstrated the nation’s growing political agenda, which goes beyond the mere acquisition of military or technical capabilities.

Little public information has been available on China’s space program throughout much of its lifetime, prompting noted space policy analyst Joan Johnson-Freese to title

²²⁹ “Full Text: Chinese Space Activities in 2011,” December 29, 2011, http://news.xinhuanet.com/english/china/2011-12/29/c_131333479.htm.

²³⁰ Craig Covault, “Chinese Test Anti-Satellite Weapon,” *Aviation Week & Space Technology*, January 17, 2007, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=space&id=news/CHI01177.xml.

²³¹ Nicholas Johnson, “Increasing Solar Activity Aids Orbital Debris Environment,” *Orbital Debris Quarterly News*, Vol. 16, Issue 1 (January 2012), <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i1.pdf>.

her 1998 book *The Chinese Space Program: A Mystery Within a Maze*.²³² Although little information on the space program was available during the early stages of the Chinese space program, a great deal more information has been publicized during the last decade which provides valuable insight into the country's goals to become a leading space-faring nation. Although the Chinese space program has often taken its technical cues in the past from the United States and Russia, the space program's development has been heavily influenced by the political turmoil of the Mao era and its subsequent role in service of the revitalization of the Chinese economy.²³³ Politics have played a pivotal role in the direction of the Chinese space program and thus make it necessary to understand the influence they have had on its development to better understand current Chinese intentions.²³⁴

This chapter examines the history of Chinese space and ASAT developments and the formation of the accompanying space policies since the beginning of the nation's space program. The emphasis is on the development of the major ASAT systems and the role that the emerging technology has played in stimulating a space arms race. This chapter will also explore recent Chinese smallsat development and the role that this emerging technology could have on arms control and continued ASAT development.

B. CHINESE ASAT DEVELOPMENT

Unlike the United States and the Soviet Union (and later Russia), China's ASAT program interest has been a relatively recent development, rather than an ongoing program that quickly followed the launch of its first satellite. With the country's relative late start in developing its space capabilities, China has often relied on other nations, such as the Soviet Union and later the United States, the United Kingdom, and others, for technical expertise to augment its native proficiency. The nation's various space activities

²³² See Joan Johnson-Freese, *The Chinese Space Program: A Mystery Within a Maze* (Malabar, FL: Krieger Publishing Company, 1998) for an excellent discussion of the cultural secrecy surrounding the Chinese space program.

²³³ Gregory Kulacki and Jeffrey G. Lewis, *A Place for One's Mat: China's Space Program, 1956–2003* (Cambridge, MA: American Academy of Arts and Science, 2009), 4.

²³⁴ James Clay Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press: 2012), 70.

throughout the past decade are indicative of China's growing interest in space technologies, and its success has been cited "as a testament to their economic and technical progress."²³⁵

The space program began in the late 1950s to enhance its national prestige and has evolved to become a major political symbol of modern Chinese nationalism and badge of accomplishment for China's Communist regime.²³⁶ China has experienced notable success in building an indigenous rocket and launch capability, and achieved internal prestige with its recent successful manned spaceflights. As space activities continue to play an important role in China's economic and social development, a thorough understanding of China's political and cultural climate that continues to influence the space program and the development of ASATs becomes increasingly important. The impact of politics on the launch of the first Chinese satellite in 1970 will be examined to provide insight into the nation's latest ASAT development and its continued political goal to be included among the elites of the space-faring nations.

1. Early Chinese Space Program

The Chinese space program can trace its lineage back to January 1956 when Chairman Mao Zedong proposed the rapid development of the nation's science and technology so that it could reach the world's most advanced levels.²³⁷ Mao's pronouncement spurred the Chinese to negotiate with the Soviet Union later that year for the provision of Soviet ICBMs, technical support in the form of one hundred Soviet engineers, and the exchange of fifty Chinese graduate students sent to Moscow for study.²³⁸ Although China eventually received delivery of two copies each of the outdated Soviet R-1 and R-2 rockets by January of 1958, the Soviets stonewalled requests for

²³⁵ Ajey Lee, "China: a Growing Military Space Power," *Astropolitics*, 3:1 (Spring 2005), 68.

²³⁶ *Ibid.*

²³⁷ Brian Harvey, *China's Space Program: From Conception to Manned Space Flight* (Chichester, U.K.: Praxis Publishing Ltd., 2004), 23.

²³⁸ *Ibid.*, 24.

additional technical information and Chinese progress was limited.²³⁹ The Sino-Soviet split left China to fend for itself and would greatly influence the development of the nascent Chinese space program.

Following the Soviets' successful launch of Sputnik Mao formally decided that China should have its own satellite and made the satellite program the top priority for the Chinese Academy of Science (CAS) in 1958.²⁴⁰ This decision resulted in the formation of Group 581 to begin a three-phase plan that consisted of: first developing a sounding rocket; then launching a 200 kilogram satellite; and finally, launching a satellite of several thousand kilograms.²⁴¹ The undertaking of such a complex task required the establishment of three design academies under the CAS to design and develop the satellite and rocket and the marshaling of vast resources to accomplish the ambitious goal.

Along with this ambitious scientific endeavor, the Chinese government simultaneously launched the government initiative called the "Great Leap Forward" to bring the nation to the forefront of economic development. Mao's goals were to turn China into a leading industrial power that would be capable of overtaking Britain in the production of steel and other products within fifteen years, but instead this overly optimistic venture led to widespread famine.²⁴² The political turmoil severely hindered the Chinese CAS goal to complete the first phase of satellite development in time to celebrate the ten-year anniversary of the PRC, and Chinese requests for Soviet technical assistance were rebuffed.²⁴³ Restructuring of the program led to Group 581 restarting the program from scratch. In February 1960, Chinese scientists finally launched a simplified two-stage rocket, the T-7M, which weighed 190 kilograms, was 5.3 meters tall, and was designed to reach a height of a mere ten kilometers.²⁴⁴ The successful launch of China's

²³⁹ Moltz, *Asia's Space Race*, 75–76.

²⁴⁰ Kulacki and Lewis, *A Place for One's Mat*, 5.

²⁴¹ *Ibid.*

²⁴² "The Great Leap Forward," 1958–60, (n.d.), <http://countrystudies.us/china/26.htm>.

²⁴³ Kulacki and Lewis, *A Place for One's Mat*, 6–7.

²⁴⁴ Harvey, *China's Space Program*, 29–30.

first indigenous liquid fuel rocket kick-started the nascent space program and led to a series of additional limited research and development programs in space throughout the next several years.

While the Chinese were enjoying the successful launching of their T-7M program and were reverse-engineering the Soviet-supplied R-2s, the political relationship between the Soviets and Chinese continued to crumble.²⁴⁵ The acrimonious split forced China to rely strictly on its own resources to develop its proposed family of rockets and as a result experienced considerable difficulty. The split left China isolated and also resulted in the country shifting its technical focus to military imperatives involving ICBMs, rather than the successful launch of a satellite. China's first attempt to launch a Dong Feng 2 (DF-2), the nation's first ballistic missile, ended in disaster when the rocket crashed just 69 short seconds after takeoff in 1962].²⁴⁶ The post-crash analysis determined a series of structural problems, which resulted in a significant redesign of the system and seventeen more ground tests, culminating with the successful launch of the medium-range missile in June 1964.²⁴⁷ The missile's successful trial also demonstrated sufficient progress to the party leadership to justify the Chinese pursuit of a satellite launch.

The Committee on Science and Technology for National Defense (CSTND) was the agency responsible for developing the ballistic missiles and any effort to launch a satellite based upon DF-2 technology required their approval.²⁴⁸ In April 1965, the Chinese Academy of Science received approval from the CSTND to begin the building of a one hundred kilogram satellite that would be launched into orbit no later than by 1971.²⁴⁹ The CAS plan was accepted with several important conditions: the satellite had to be more advanced than either of the United States or Soviet Union first satellites, it had to have a longer lifetime, and it had to carry more advanced technology.²⁵⁰ As Kulacki and Lewis note in their article on the Chinese space program, "the political ramifications

²⁴⁵ Moltz, *Asia's Space Race*, 77.

²⁴⁶ Harvey, *China's Space Program*, 37.

²⁴⁷ *Ibid.*, 36–38.

²⁴⁸ *Ibid.*

²⁴⁹ Kulacki and Lewis, *A Place for One's Mat*, 10.

²⁵⁰ *Ibid.*, 11.

of technical details foreshadowed the difficulties the satellite program would face in the coming years.”²⁵¹ The inability to separate the pursuit of politics and science would continue to be a challenge for CAS to overcome, and the satellite was ambitiously designed to be outfitted with an instrument package to collect data to aid in the development of follow-on systems.

Shortly after receiving permission to proceed with the development of the satellite program, Chairman Mao initiated another political movement in 1966 called the “Great Proletarian Cultural Movement.”²⁵² The Cultural Revolution targeted intellectuals, and the chaos caused by the political movement left its impact on the scientific staff in charge of the satellite. Although the CAS leadership was partially shielded from the on-going purges the “political climate now placed an emphasis on speed and propaganda” for the construction of the satellite.²⁵³ The mission changed from containing a payload that would serve as a valuable building block for long-term satellite development to one in which the first few bars of a Chinese folk song would play.²⁵⁴ The satellite was successfully launched on April 24, 1970, but was a clear example of how the nation’s politics undermined the logical technical progress of the nation’s satellite program.

The space policy under Mao’s leadership is challenging to categorize because China was concerned primarily with achieving a successful launch capability throughout much of his term. After achieving its first successful launch in 1970, the Chinese leadership then pursued a sanctuary school of policy throughout the remaining decade and throughout the last few years of Mao’s rule. During this time the nation established a rudimentary space capability through the successful launch of a satellite equipped with scientific instruments and a series of launches for electronic intelligence gathering.²⁵⁵ As the Chinese space program continued to move forward after Mao’s death, the nation was

²⁵¹ Ibid., 12.

²⁵² Moltz, *Asia’s Space Race*, 78–80.

²⁵³ Kulacki and Lewis, *A Place for One’s Mat*, 13.

²⁵⁴ Ibid.

²⁵⁵ Mowthorpe, *The Militarization and Weaponization of Space*, 86–90.

to gain valuable experience and technology through its astute partnerships with France, West Germany and the United States to gain valuable technical expertise and a more solid foothold in space.

2. Chinese ASAT Development

As Moltz notes in his book *Asia's Space Race*, "China entered into the 1990s with little discernible expertise in military space."²⁵⁶ Throughout the next two decades, China was able to witness the U.S. exploitation of space during its conflicts in the Persian Gulf and started down the road to counter the existing U.S. space supremacy China initiated a series of programs to improve its defensive posture, which included the construction of three new launch facilities, the improvement of its ground C2 and tracking capabilities, the development of a new family of improved reconnaissance satellites, and significant navigational and positioning advancements.²⁵⁷ These critical improvements to the Chinese military infrastructure greatly enhanced the existing space capabilities of the nation and the national prestige of the country.

While these programs were in development, the Chinese military also began the development of an offensive capability through its investigation of multiple offensive ASAT systems. According to U.S. congressionally-released reports, the Chinese military had investigated the use of ASATs as early as the mid-1980s, at least partly funded under China's classified 863 Program for High Technology Development.²⁵⁸ It was not until 2005, however, that the actual first of several tests of the Chinese interceptor system took place.²⁵⁹ Although released accounts differ as to whether the Chinese had two or three prior trials to the January 2007 event, post-test analysis can determine how the weather satellite was destroyed *and* how capable the Chinese ASAT is.²⁶⁰

²⁵⁶ Moltz, *Asia's Space Race*, 91.

²⁵⁷ *Ibid.*, 96.

²⁵⁸ PRC Acquisition of U.S. Technology, (n.d.), <http://www.access.gpo.gov/congress/house/hr105851-html/ch1bod.html#anchor4114640>.

²⁵⁹ Moltz, *Asia's Space Race*, 96.

²⁶⁰ Geoffrey Forden, "Viewpoint: China and Space War," *Astropolitics*, 6:2, (May 2008), 139–140.

At the time of the January 2011 attack, the *FY-1C* was heading south and the SC-19 interceptor was approaching at an angle of 346 degrees relative to the orbit of the satellite.²⁶¹ Simple calculations yield a combined interception speed of greater than 30,000 kilometers per hour.²⁶² Because of the high rates of velocity involved, the collision of the two objects can be compared to the “hitting of a bullet with another bullet.” With such high rates of speed, the Chinese ASAT would have needed to be highly maneuverable to be able to guide itself to the target reaching accelerations nearly six times that of gravity.²⁶³ Because any decrease in the interceptor’s closing speed would make the adjustment for collision easier, the Chinese ASAT would be equally effective against higher altitude targets. Given the current known projection of Chinese tracking proficiency, it is likely that the interceptor tracked the target in the visible part of the spectrum.²⁶⁴ Although the Chinese kinetic ASAT trial was impressive, the system is currently constrained within LEO to attack high-value targets only when they are illuminated in sunlight. This drawback is not as pronounced in higher altitude orbits where satellites are in direct sunlight a much greater percent of their lifetime. The SC-19 interceptor was reported to have been fired again in January 2010 against a target missile as part of a Chinese missile-defense system.²⁶⁵ The successful demonstration represents a major strategic advancement in China’s military technology build-up.

In addition to direct-ascent kinetic kill weapons, the Chinese have been reported to be exploring alternative ASAT systems. Throughout September 2006, reports began to surface that the Chinese military had investigated the use of ground-based lasers as possible ASAT systems against U.S. reconnaissance satellites in LEO.²⁶⁶ A September 28, 2006 *Defense News* story reported that China had recently “fired high-power lasers at

²⁶¹ Ashley J. Tellis, “China’s Military Strategy,” *Survival*, 49:3, (2007), 41.

²⁶² Forden, “Viewpoint: China and Space War,” 140.

²⁶³ *Ibid.*

²⁶⁴ *Ibid.*, 141.

²⁶⁵ Bill Gertz, “Inside the Ring,” *The Washington Times*, March 10, 2011.

²⁶⁶ “Satellite Laser Ranging in China,” UCS Working Paper, Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions, January 8, 2007, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/chinese-lasers-and-us.html#1.

U.S. spy satellites flying over its territory in what experts see as a test of Chinese ability to blind the spacecraft.”²⁶⁷ Shortly after the publication of the story, several high-ranking U.S. officials “cast doubt on the severity of whatever occurred and the intent behind it” and confirmed that the satellites and their optical sensors were not target nor affected.²⁶⁸ Ground-based lasers can be used to calculate the orbital parameters of a satellite to a high degree of accuracy by reflecting low intensity laser pulses off of the moving body. Although the laser events were in all likelihood preparation for the subsequent January 2007 kinetic ASAT test, the difference between ranging and blinding is simply a matter of increasing the laser’s intensity and duration on target. The laser incidents do, however, show the potential for China to quickly develop an alternative ASAT weapon if desired.

A third potential ASAT option that the Chinese have been reported to have investigated is the use of smallsats for the disablement of satellites. A FY04 Report to Congress, “PRC Military Power,” discussed in detail the Chinese efforts to develop and acquire multiple micro-satellites to augment their remote sensing, electro-optical, and radar satellite constellations.²⁶⁹ The report also discussed a January 2001 Hong Kong newspaper article claim “that China had developed and ground-tested and would soon begin space-testing an antisatellite [ASAT] system described as a ‘parasitic microsatellite’.”²⁷⁰ The parasitic smallsat was reported to have been in development by the Small Satellite Research Institute of the Chinese Academy of Space Technology (CAST). The smallsat was reported to have been ground-tested and would have attached itself through surreptitious maneuver to enemy satellites during crises and awaited the order to disable through electronic interference or explosion.²⁷¹ Although the claim was never substantiated, it did raise concerns about China’s counterspace capabilities, research efforts, and the growing interest in smallsats.

²⁶⁷ Vago Muradian, “China Attempted To Blind U.S. Satellites With Laser,” *Defense News*, 28 September 2006, <http://www.defensenews.com/story.php?F=2125489>.

²⁶⁸ “Satellite Laser Ranging in China,” UCS Working Paper, Union of Concerned Scientists.

²⁶⁹ FY04 Report To Congress, “PRC Military Power,” Pursuant to the FY2000 National Defense Authorization Act, (n.d.), <http://www.defense.gov/pubs/d20040528PRC.pdf>, 42.

²⁷⁰ *Ibid.*

²⁷¹ Harvey, *China’s Space Program*, 315.

During the last decade, China has developed a considerable military space capability through its development and acquisition of technology, and the signing of a number of international agreements with other space-faring nations. These moves have allowed the Chinese to significantly advance and upgrade their existing communications, reconnaissance, and navigation proficiency. The leadership under Presidents Jiang and Hu has also explored the development of substantial ASAT capabilities signifying a current Chinese space policy of space control. It is as yet unclear whether the policy is potential build-up for space warfare or a hedging strategy against a U.S. hegemonic position in space or regional rival such as India, which has publicly discussed military space operations.²⁷² As China continues its expansion of its space capabilities, it has taken a clear leadership in the development of smallsats and a more detailed analysis of its developmental efforts will be provided in the following section.

C. CHINESE SMALLSAT DEVELOPMENT

China entered into smallsat development and construction in the late 1990s, and has made tremendous advances in smallsat design, fabrication, and operations since that time. Much of this success can be directly attributed to the 1998 agreement between China's Tsinghua University and the Surrey Satellite Ltd., which is affiliated with the Surrey University in the United Kingdom, one of the leading smallsat development companies in the world.²⁷³ The 1998 agreement was later extended into a twenty-five year joint venture in 1999, which was seventy-five percent owned by the Chinese and twenty-five percent owned by Surrey.²⁷⁴

The joint venture company provided valuable experience for Tsinghua University and for the export of dual-use space technology to the Chinese. The partnership resulted in the building of China's first micro-satellite, the *Tsinghua-1*, which was designed as part of a satellite network to monitor natural disasters.²⁷⁵ Weighing just seventy-five

²⁷² Moltz, *Asia's Space Race*, 105–107.

²⁷³ "Tony Blair attends signing of Sino-British satellite agreement," *BBC summary of Worldwide Broadcasts*, October 9, 1998.

²⁷⁴ Richard Fisher Jr., "How May Europe Strengthen China's Military, International Assessment and Strategy Center, June 15, 2005, http://www.strategycenter.net/research/pubID.61/pub_detail.asp.

²⁷⁵ *Ibid.*

kilograms and launched from Russia, the three-axis stabilized vehicle included a GPS receiver and multi-spectral camera.²⁷⁶ Following its successful launch, the satellite took part in a series of experiments with a later smallsat, whereby each satellite participated “in a test of rendezvous and inspection of one satellite by another.”²⁷⁷ The close proximity operations of the smallsats were the first of their kind for China and illustrated significant advances of the command and control of the satellites.

The initial success of the *Tsinghua-1* collaboration stimulated widespread interest throughout Chinese academia. In 2000, Tsinghua University was given approval to start its own nano-satellite program to build on the success of the micro-sat launch.²⁷⁸ The university explored multiple designs and successfully launched a twenty-five kilogram technology demonstrator four years later.²⁷⁹ Also in 2000, the Chinese Academy of Science in Shanghai announced the development of the *Chuangxin-1* (*CX-1*) microsatellite. *CX-1* weighed in at 40 kilograms and was China’s first experimental smallsat for data communications in LEO.²⁸⁰ The satellite was successfully launched in fall 2003 and continued to represent a growing trend among Chinese universities to build an in-house smallsat capability rather than relying on foreign acquisition.

Although China started its pursuit of an indigenous smallsat capability, the Chinese continued to engage in wide-ranging space development initiatives across civil space programs. This engagement resulted in China’s developing a constellation of dedicated optical smallsats for participation in a comprehensive space-based disaster and mitigation system.²⁸¹ The smallsat construction was part of an international collaboration between China, the European Space Agency, France, and Canada and resulted in the manufacture of the disaster monitoring satellite named the *Beijing-1* in 2006. The satellite

²⁷⁶ “Surrey successfully launch two more satellites,” *Brightsurf Science News*, June 29, 2000.

²⁷⁷ Frank Moring, Jr., “At Surrey Satellite Technology, Small-and-Simple is Beautiful,” *Aviation Week & Space Technology*, June 18, 2001.

²⁷⁸ Wei Long, “China Microsat Performs Well, Nanosat is Next,” *Space Daily*, August 22, 2000, <http://www.spacedaily.com/news/microsat-00u.html>.

²⁷⁹ Craig Covault, “China Surges Again,” *Aviation Week & Space Technology*, April 26, 2004.

²⁸⁰ “Small satellite Chuangxin-1 operates smoothly,” Chinese Academy of Sciences, Dec 18, 2003, http://english.cas.cn/Ne/CASE/200312/t20031218_16342.shtml.

²⁸¹ Michael A. Taverna, “India, China to expand Earth-Observing Nets,” *Aviation Week & Space Technology*, October 29, 2001.

weighed 166 kilograms and carried “two payloads that provide[d] high-resolution (4-meter) panchromatic images alongside medium-resolution (32-meter) multi-spectral images with an ultra-wide 600 kilometer imaging swath” making it the highest resolution smallsat at the time of its creation.²⁸² China added two optical smallsats to the constellation in 2008 and was continuing to develop additional smallsats for replenishment.²⁸³

In 2008, China launched the *Shenzou 7* and the astronauts onboard released a companion satellite that has been labeled the *BX-1*, which stands for the Chinese term for companion satellite (ban sui wei xing).²⁸⁴ The experiment was an important first step in expanding the rendezvous and proximity operation capabilities of China’s smallsats. The forty kilogram *BX-1* smallsat was spring-released from the orbital module and carried a camera that would allow color pictures to be taken out to a distance of two kilometers.²⁸⁵ The smallsat orbited the launch module on an elliptical track and then was brought closer to it through a series of thruster maneuverings to allow the *BX-1* to shoot over 1,000 pictures of the module.²⁸⁶ The successful test was a precursor to more complex docking maneuvers and was part of a planned series of tests to gain experience in the inspection of a larger satellite.²⁸⁷

In June 2011, a Chinese firm announced a collaborative effort with the Surrey Satellite Technology Ltd. (SSTL) to build three high-resolution optical satellites for the Chinese government. The smallsats are 350 kilograms in size and are larger than what China has built and favored in the recent past, but will provide a one-meter resolution

²⁸²“British company delivers Beijing-1 EO satellite,” Ballard Communications Management, June 30, 2006, http://www.technologynewsroom.com/press_releases/company_releases.aspx?story=522.

²⁸³ “HJ-A/B of Environment and Disasters Monitoring Microsatellite Constellation delivered to the users,” China National Space Administration, April 1, 2009, <http://www.cnsa.gov.cn/n615709/n620682/n639462/168207.html>.

²⁸⁴ David Wright and Gregory Kulacki, “Chinese Shenzou 7 Companion Satellite (BX-1),” Union of Concerned Scientists, October 21, 2008, http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/chinese-shenzhou-7-full.html#The_Shenzhou_BX1_CompanionSat.

²⁸⁵ Ibid.

²⁸⁶ “BX-1 begins orbiting Shenzhou-VII spaceship,” October 6, 2008, China.org.cn, http://www.china.org.cn/china/shenzhouVII_spacewalk/2008-10/06/content_16568297.htm.

²⁸⁷ Wright and Kulacki, “Chinese Shenzou 7 Companion Satellite (BX-1).”

capability.²⁸⁸ The proposed project is highly indicative of the continued Chinese push to build low-cost satellites that are increasingly capable and highly reconstitutable. The joint venture is being funded at a cost of \$170 million with an expected launch in 2014. It will be a valuable addition to the Chinese disaster monitoring capability, as well as a significant advance in electro-optics.²⁸⁹

D. CHINESE SPACE SECURITY STRATEGY

China's current space security strategy involves a continued pursuit of counterspace capabilities partly in response to stated U.S. space policy and as part of a comprehensive strategy to build its national strength.²⁹⁰ The majority of military planning documents during the recent George W. Bush administration called for the "U.S. control of space and the achievement of global military superiority through the use of weapons in or from space."²⁹¹ U.S. Air Force Doctrine Document 2-2.1 set a precedent in 2004 and officially articulated counterspace as a part of the Air Force's overarching mission.²⁹² The document codified U.S. intentions not only to weaponize space, but also conduct anti-satellite operations, possibly preemptively, against enemy military satellites as well as those with primarily civilian functions and satellites owned by third-parties.²⁹³

During the past two decades, China has observed with great interest the U.S. military's growing dependence on space assets, beginning with the Gulf War in 1991 and intensifying with the more recent conflicts with Afghanistan and Iraq. U.S. space capabilities have been a critical force enhancer for our military forces and have

²⁸⁸ See SSTL's High Performance Earth Observation satellite specifications at <http://www.sstl.co.uk/divisions/earth-observation---science/high-performance-EO> for a detailed description of the satellite's performance characteristics.

²⁸⁹ Peter B. de Selding, "Surrey to Build Three Optical Imaging Satellites for Chinese," *Space News*, June 29, 2011, <http://www.spacenews.com/contracts/110629chinese-firm-orders-three-optical-imaging-satellites-from-surrey.html>.

²⁹⁰ *Ibid.*

²⁹¹ Podvig and Zhang, *Russian and Chinese Response to U.S. Military Plans in Space*, 32.

²⁹² U.S. Air Force, *Counterspace Operations*, Air Force Doctrine Document 2-12.1, August 2, 2004, http://www.dtic.mil/doctrine/jel/service_pubs/afdd2_2_1.pdf.

²⁹³ *Ibid.*

fundamentally shaped China's strategic perceptions. When coupled with the U.S. policy and military documentation, China perceives that the United States is intent on the weaponization of space.²⁹⁴ Throughout the past decade, the Bush administration also advocated for the development of a layered missile defense system that consisted of mobile ground-based midcourse defense (GMD) interceptors and a variety of possible space-based components. The interceptors had the ability to threaten and strike satellites in LEO and were viewed by the Chinese as a likely first step toward an eventual arms race in space and as a potential threat to China's homeland and nuclear deterrent.²⁹⁵ The United States active pursuit of space superiority upset the delicate strategic balance and posed an increasing risk to China's national security.

During the past decade, China has been actively involved in pursuing a diplomatic course of action while simultaneously advancing its military space program. China actively engaged with Russia to broker proposals at the CD and the United Nations for the prevention of space weaponization, but has been blocked by the United States because of a lack of credible verification measures. China again pursued a diplomatic course in 2008 and advocated the PPWT along with Russia, but again met with resistance from the United States because of its lack of verification and the lack of prohibition of earth-based ASATS.²⁹⁶ China has come to the realization that the United States is not likely to sign any immediate treaty because of a lack of trust and the possible strategic disadvantage to U.S. space capabilities. As a result, China has moved to negotiate from a position based on strength and has actively embraced a military hedging strategy.

Although it can be dangerous to make sweeping generalizations based upon historical events, the post-1949 development of China's space program can be best explained by the influence of politics on it.²⁹⁷ Political factors have had the greatest impact on the direction of space system development and the country's pursuit of

²⁹⁴ Eric Hagt, "China's ASAT Test: Strategic Response," *China Security*, Winter 2007 http://www.wsichina.org/cs5_3.pdf.

²⁹⁵ Podvig and Zhang, *Russian and Chinese Response to U.S. Military Plans in Space*, 34–38.

²⁹⁶ Hitchens, "Russian–Chinese Space-Weapons-Ban Proposal: A Critique," *Security in Space: The Next Generation—Conference Report*, 31 March–1 April 2008.

²⁹⁷ See Kulacki and Lewis, *A Place for One's Mat*, 4–28 for a detailed discussion of the authors' three historical examples drawn from China's space program.

technologies such as smallsats. China has experienced “a heightened sense of insecurity in space and its calls for a separate space command in response to the U.S. drive for space control have additional significance for the development of its military space initiatives and its eventual ASAT test.”²⁹⁸ Learning a valuable lesson from past Soviet failures, China has been careful not to overextend itself in its acquisition of technology, while at the same time making tremendous progress toward superpower status. China successfully launched its first man-rated research module into orbit in September 2011 and docked with it just two months later. The program is in the second stage of a ten-year effort to build a manned space station before the year 2020.²⁹⁹ The nation’s nineteen successful space launches in 2011 exceeded the U.S. number for the first time in history, and has announced plans for the launch of thirty satellites in 2012.³⁰⁰

Although Sino-U.S. space relations have improved with the election of the Obama administration and its adoption of a multilateral and cooperative approach to space, the Communist Party has recently announced an ambitious multi-year space program to challenge the U.S. program.³⁰¹ China’s white paper on the nation’s space program describes China’s five-year strategy to develop its space activities, transform economic development, and pursue cooperation with the international community.³⁰² Although China is still several years behind the United States in terms of capability, the plan highlights “the government’s commitment to draw military and civilian resources to meet these goals” and the continued emergence of the nation as a global space actor.³⁰³

²⁹⁸ Hagt, “China’s ASAT Test: Strategic Response,” *China Security*.

²⁹⁹ Jonathan Watts Beijing, “Space: With rivals earthbound, China takes great leap towards superpower status; Launch of Heavenly Palace space station test module Docking vehicle scheduled to follow later this year,” *The Guardian*, September 30, 2011.

³⁰⁰ Miles Yu, “Inside China,” *The Washington Times*, January 26, 2012.

³⁰¹ *Ibid.*

³⁰² “Text of China’s white paper on space programme,” *BBC Worldwide Monitoring*, December 29, 2011.

³⁰³ Edward Wong and Kenneth Chang, “China lays out ambitious space goals,” *Star Tribune World*, December 29, 2011.

E. SUMMARY

Since its inception, the Chinese space program has been heavily influenced by the political direction adopted by its leadership. This influence shaped the development of the program and the pursuit of national power and prestige. China's progress has been both significant and troubling, as the country has acquired tremendous technological capability in a relatively short time without the benefit of the experience that usually goes along with that development. China and its military leadership have grown to rely on the capabilities provided from space and on the international prestige and benefits derived from their many space accomplishments. Although the recent ASAT test was developed by the military as a hedging strategy to counter the perceived American threat, a multitude of factors to include the international community's reaction and additional space debris have influenced Chinese space policy against continued testing.

No other nation's space program has come so far and as fast as has the Chinese space program. China has made a concerted political effort to gain international prestige through its varied space accomplishments and to become one of the leaders of space-faring nations. Although China has been highly active in introducing diplomatic initiatives to avoid an arms race in space and the destabilization of strategic parity with both the United States and Russia, the space program has continued to acquire, develop, and launch military space systems and become a world leader in the development of smallsats. Chapter V will address suggested courses of action for U.S. policy-makers to implement regarding the proliferation of Chinese smallsats to guarantee the common security of all space actors.

V. CONCLUSION

Men who have worked together to reach the stars are not likely to descend together into the depths of war and desolation.

— Then U.S. Senator Lyndon B. Johnson,
addressing the U.N. General Assembly, November 17, 1958

A. HISTORICAL LESSONS

The early years of the Space Age were dominated by the superpowers, the Soviet Union and the United States. Although these two nations were locked in a geo-political struggle, these two active space-faring countries were able to establish an institutional framework to foster cooperation in space. The initial United States-sponsored effort resulted in the 1958 United Nations (U.N.) Resolution 1348, which created the ad hoc Committee on the Peaceful Uses of Outer Space (COPUOS).³⁰⁴ The committee was designed to consider a range of issues: the activities and resources of the U.N, the specialized agencies, and other international bodies relating to the peaceful uses of outer space; the organizational arrangements to facilitate international cooperation in the field within the framework of the U.N.; and the legal problems which could arise in programs to explore outer space.³⁰⁵

But the new organization met some initial resistance from the Soviet Union, Poland, and Czechoslovakia, which viewed the new organization as being dominated by Western member states. This opposition resulted in further expansion of the committee membership a year later when the U.N. General Assembly made COPUOS a permanent committee with U.N. Resolution 1472. Its membership now included communist bloc member states Albania, Bulgaria, Hungary and Romania, but Cold War tensions kept the committee from meeting until 1961.³⁰⁶ The United Nations expanded the committee's membership again in 1961 and finally began to address many of the legal questions

³⁰⁴ Moltz, *The Politics of Space Security*, 98.

³⁰⁵ United Nations Office for Outer Space Affairs: United Nations Committee on the Peaceful Uses of Outer Space: Overview, http://www.oosa.unvienna.org/oosa/en/COPUOS/cop_overview.html.

³⁰⁶ Moltz, *The Politics of Space Security*, 102.

surrounding space.³⁰⁷ Early successes led to the acceptance of international law in space and the registration of launched bodies by member states through a 1963 U.N. resolution created with COPUOUS input, but suffered from an effective means of enforcement.³⁰⁸ Although the committee initially experienced political setbacks, COPUOS was a successful attempt by the international community to collectively shape the use of space for peaceful use and began the process of creating critical linkages that led to later diplomatic achievements.

1. Successful ASAT Arms Control Measures

Although a framework for space cooperation had been established, it was not until the series of atmospheric nuclear ABM weapon tests by both the United States and the Soviet Union occurred in the early 1960s that the notion of cooperative restraint began to emerge. Both nations were becoming increasingly dependent on space services and undertook their first steps toward a common goal of securing space for future activity.³⁰⁹ The nuclear scare of the Cuban Missile Crisis and the desire to find a common ground for space cooperation brought about the signing of the Partial Test Ban Treaty (PTBT) in 1963 to ban nuclear tests “in the atmosphere; beyond its limits, including outer space; or under water.”³¹⁰ Although the treaty did not ban the deployment of nuclear weapons in space, it did prohibit further nuclear testing and explosions and a U.N. resolution passed that fall called upon states to ban all WMD in orbit. The signing of the PTBT was significant because it brought the two adversaries together to protect both the fragile environment of space and the capabilities enabled from this domain. Perhaps more importantly, these talks paved the way for a departure from a unilateral approach to space to now promote space cooperation between the two nations.

³⁰⁷ United Nations Office for Outer Space Affairs: United Nations Committee on the Peaceful Uses of Outer Space: Overview, http://www.oosa.unvienna.org/oosa/en/COPUOS/cop_overview.html.

³⁰⁸ Moltz, *The Politics of Space Security*, 110.

³⁰⁹ See Chapter 4, *Ibid.*, for a detailed discussion of the early cooperation between the Soviet Union and the United States.

³¹⁰ “Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer space and Under Water (Limited Test Ban Treaty),” Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions, International Legal Agreements Relevant to Space Weapons, (n.d.), http://www.ucsusa.org/assets/documents/nwgs/limited_test_ban_treaty.pdf.

The enhanced cooperation carried over throughout the 1960s culminating in the signing of the Outer Space Treaty in 1967 with the stated goal of “recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes.”³¹¹ The agreement “banned all military activities on the Moon and other celestial bodies...and removed [them] from territorial competition by declaring them to be ‘the province of all mankind’.”³¹² The language of the treaty did not prohibit ground-based, sea-based, air-based, or co-orbital kinetic-kill ASATs, but did express the idea that space activities were to be carried out to benefit mankind and contribute to peace. Although the treaty did not ban military activities in space, it did afford both countries a basic measure of protection against attack of their satellite systems and was meant to guarantee free and equal access to all areas of space. The treaty was at least in partial response to the growing technological space race between the two actors, and the agreement continued the shifting of both countries’ space policy back to a pursuit of a space sanctuary school of thought.

The cooperative effort carried over throughout the signing of the Strategic Arms Limitation Talks (SALT) and the 1972 Anti-Ballistic Missile (ABM) Treaty. The verification provisions of both SALT I and II agreements included language that the parties shall agree “not to interfere with the national technical means of verification of the other party.”³¹³ Article IX of the SALT II agreement specifically prohibited the development, testing or deployment of “systems for placing into Earth orbit nuclear weapons or any kind of weapons of mass destruction, including Fractional Orbital Bombardment Systems (FOBS).”³¹⁴ As a result, Article IX created an additional legal obstacle to the employment of ASATs. With the ABM Treaty, both the United States and the Soviet Union agreed not to deploy ABMs except under the conditions set forth

³¹¹ “Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and other Celestial Bodies,” Arms Control Association, <http://www.armscontrol.org/documents/outerspace>.

³¹² Moltz, *The Politics of Space Security*, 29.

³¹³ Paul B. Stares, *Space and National Security* (Washington, DC: Brookings Institute, 1987), 145.

³¹⁴ Treaty Between the United States and the Union of Soviet Socialist Republics on the Limitations of Strategic Offensive Arms, Together with Agreed Statements and Common Understandings Regarding the Treaty, Jun 18, 1979, <http://www.fas.org/nuke/control/salt2/text/salt2-2.htm>.

within the agreement. The treaty limited the deployment, testing, and use of national missile systems designed to intercept incoming strategic or long-range missiles.³¹⁵ Given the close resemblance between ASAT and ABM technology, an ASAT weapon would be prohibited by the treaty if the weapon was capable of negating strategic ballistic missiles. Although these treaties were not specifically developed and signed with ASATs as a fundamental feature, they did provide an important first step in indirectly prohibiting ASAT systems and were the foundation of strategic stability for their duration.

2. Failed ASAT Arms Control Negotiations

Following the SALT and ABM Treaty negotiations, both the United States and the Soviet Union looked to build upon their earlier successful ABM arms control initiatives that also indirectly impacted the arms control of ASATs. Although space cooperation had floundered during this period, a series of exploratory talks were held between both countries to discuss devoted ASAT limitations. During the early years of bilateral negotiations while restrictions were being discussed, both countries were in a détente period and had suspended their testing. At the conclusion of the third set of talks in 1979, the countries had reached an impasse over restrictions and further negotiation was put on hold as a result of the Soviet invasion of Afghanistan later that year. The talks were important for discussing the two critical themes: limits on the employment of ASATs and limits on the development of ASAT capabilities.³¹⁶ Although the discussions met with only limited success, the negotiations signaled an interest by both parties to explore diplomatic options as well as the difficulty in obtaining an expedient solution.

During the early 1980s, the Soviets again explored the idea of space arms control treaties and submitted several draft treaties to the United Nations. The provisions of the 1981 and 1983 Soviet draft treaties reflected many of the major issues that were raised in earlier discussions between both parties. The 1981 draft would have restricted further development and testing of ground-based or air-launched ASATs, but would have

³¹⁵ Stares, *Space and National Security*, 145.

³¹⁶ Bhupendra Jasani, *Space Weapons – The Arms Control Dilemma* (London: Taylor and Francis, 1984), 149.

allowed both countries to keep their current systems.³¹⁷ The 1983 draft expanded upon this language to now call for a ban on all ASAT testing and the elimination of all ASAT systems.³¹⁸ Although the Reagan administration was actively pursuing the development of the SDI system and expressed little interest in limitations on these weapons, members of Congress began to exert pressure on the DoD and the administration to halt planned U.S. Air Force testing. Their interest resulted in the banning of additional ASAT testing after the 1985 kinetic test in space within subsequent appropriation bills and, ultimately, in the abandonment of the program altogether.

Throughout the mid-1980s, the Soviet Union continued to present a series of treaty proposals to prohibit the creation or use of space weapons in space and regularly presented them at the United Nations, COPUOS, and the Conference on Disarmament (CD) in Geneva.³¹⁹ The Soviets also began to regularly submit resolutions to the UN General Assembly condemning an arms race in outer space. Meaningful progress was made in the reduction of strategic offensive arms and intermediate-range ballistic missiles and, although the Soviets declared their willingness to set up a strict monitoring system to promote the prohibition of ASATs, little additional progress occurred.³²⁰

After the fall of the Soviet Union, many of the ASAT arms control initiatives were shelved as Russia underwent significant political turmoil and the United States lacked a rival in space. As the United States continued to increase its reliance on space for its military and economic benefits, the debate again reemerged over the weaponization of space in the late 1990s. Several congressional reports were issued on the threat of foreign missile proliferation and U.S. military space security, which culminated in the release of the Rumsfeld Commission report of 2001. This study highlighted the vulnerability of U.S. space systems and warned of the need to counter this

³¹⁷ Stares, *Space and National Security*, 148.

³¹⁸ *Ibid.*, 149.

³¹⁹ Viktor Mizin, "Non-weaponization of Outer Space, Lessons from Negotiations," in *Outer Space: Weapons, Diplomacy, and Security*, ed. Alexei Arbatov and Vladimir Dvorkin (Washington, DC: Carnegie Endowment for Peace, 2010), 54.

³²⁰ *Ibid.*, 56–57.

perceived threat.³²¹ Although this viewpoint was tempered by experts skeptical of the effective employment of space weapons, the Bush administration withdrew from the ABM Treaty in 2002 and ended its ASAT moratorium in 2008 with its shoot-down of the NRO satellite (*U.S. 193*). Although both China and Russia have made several recent diplomatic initiatives to the United Nations, the current status of ASAT arms control has remained deadlocked and ineffectual. The challenge to today's space actors will be to apply the lessons learned from previous ASAT diplomatic efforts to stem the growing threat posed by smallsats.

B. SMALLSATS THREAT?

As discussed in this thesis, the revitalization of interest in smallsats is creating new opportunities for a multitude of space actors but also producing challenges in the ASAT area that must be overcome to improve the collective space security environment for today's space powers.

The resurgence of smallsat interest has resulted in the application of the technology across a broad spectrum ranging from remote sensing to surveillance to flight hardware test platforms for follow-on vehicles. The United States, Russia, and China have all demonstrated increasing proficiency throughout the last decade as each nation has tested smallsats to varying degrees. The adoption of CubeSat standards across the satellite industry and the growing availability of secondary payload launch opportunities on the SpaceX Falcon 9 rockets have revitalized smallsat development and increased the proliferation of this cheap and readily available technology.³²² In 2010, twenty-six smallsats in total were launched with four of them classified as microsats, seventeen as the smaller nanosats, and the other five the even smaller picosats.³²³ This trend looks to continue as more opportunities become available through foreign, commercial, and NASA launches throughout 2012.

³²¹ "Report of the Commission to Assess United States National Security Space Management and Organization," Pursuant to Public Law 106-65, Committee on Armed Services, U.S. House of representatives, Jan 11, 2001.

³²² Jeff Foust, "New opportunities for smallsat launches," *The Space Review*, Aug. 22, 2011, <http://www.thespacereview.com/article/1913/1>.

³²³ *Ibid.*

As the number of smallsats continues to increase, the challenges of regulating the employment of these potential dual-use technologies continues to grow for all space-faring governments. As noted space policy analyst Joan Johnson-Freese notes “space hardware is an essential part of globalization” and the recent smallsat rendezvous test activities of the United States and China uniquely highlight both the military and civilian potential of this technology.³²⁴ The current collective space security environment faces an increasingly complex set of challenges to which there are no easy answers.

C. SMALLSATS ARMS CONTROLS?

Following the recent ASAT shoot-down events accomplished by both China and the United States in 2007 and 2008 respectively, there has been an increased emphasis from within the international community to build upon the existing legal institutions of outer space. Significant progress was made throughout the early decades of spaceflight to prevent an arms race in outer space, but international diplomacy has been limited during the past fifteen years. Recent efforts by multiple actors have yielded little success to erect legal barriers against the renewal of a space weapons race.

One noteworthy effort that is gaining momentum and was recently endorsed by the Obama administration on January 17, 2012: the development of an international Code of Conduct for space. The goal of the draft code of conduct is “to prevent irresponsible behavior in space, reduce the quantity of space debris in Earth’s orbit, and ultimately make outer space more sustainable as a domain for exploration, observation, telecommunications, and navigation.”³²⁵ Originally introduced by the European Union in 2008, the code of conduct is intended to enhance space security and to prevent outer space from becoming an area of conflict.³²⁶ Critics of the proposal fear that the initiative will lead to binding U.S. military restrictions in space where the United States still

³²⁴ Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia University Press, 2007), 30.

³²⁵ Allison Kempf, “Is Anti-Satellite Arms Control Feasible? The Potential Impact of an International Space Code of Conduct,” Center for Strategic & International Studies, Feb. 3, 2012, <http://csis.org/blog/anti-satellite-arms-control-feasible-potential-impact-international-space-code-conduct>.

³²⁶ *Ibid.*

maintains a strategic advantage over its competitors.³²⁷ The Obama administration has stated that the United States will subscribe to a code if “it protects and enhances the national and economic security of the United States, our allies, and our friends, and; it does not hamper, limit, or prevent the United States from using space for peaceful purposes, including national security related activities.”³²⁸ The administration’s support signifies a fundamental shift in space policy and will continue negotiations with the major space-faring nations toward the acceptance of a final document based upon the current EU draft.

With the continued growth of non-state actors, outer space is “becoming increasingly congested, contested, and competitive” as articulated in the recent U.S. National Security Space Strategy.³²⁹ Space congestion is a growing problem and the DoD currently tracks over 22,000 man-made objects greater than 10 centimeters in length of which, only 1,100 are active satellites.³³⁰ With the acquisition of enhanced ground and space radar systems, the number of tracked objects in orbit will grow exponentially. As smallsat technology continues to become cheaper and more easily accessible, the question arises as to whether a legal framework needs to be established to regulate and constrain these space vehicles’ operations and behavior. With the international space community discussing a code of conduct, the time has arrived to draw upon the lessons learned from past ASAT arms control discussions to explore the options for regulating smallsat behavior.

³²⁷ Bill Gertz, U.S. looks to EU for military’s space rules; Pentagon fears limits too high, *Washington Times*, Jan. 17, 2012.

³²⁸ “U.S. Seeks International Code of Conduct for Outer Space Activities,” Feb 20, 2012, <http://newsroom-magazine.com/2012/executive-branch/state-department/u-s-seeks-international-code-of-conduct-for-outer-space-activities/>.

³²⁹ U.S. Department of Defense and the Office of the Director of National Intelligence, “National Security Space Strategy (Unclassified Summary),” January 2011, http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf.

³³⁰ *Ibid.*

1. Obstacles to Smallsat Arms Control

Even with the necessary political commitment from today's major space-faring nations, meaningful smallsat arms control initiatives face several formidable challenges to their acceptance. Three obstacles among many stand out to implement effective measures: the lack of an existing set of guidelines for smallsats; the growing capabilities of smallsats; and the inherent problem of verifying smallsat capabilities. The latter two factors overlap since doubts of verification spring from an imprecise knowledge of the smallsats currently in orbit, and what the true capabilities of those smallsats are. The relative significance of these obstacles is in many respects proportional to the extent of the proposed limitations on smallsats as we shall examine in greater detail.

One of the most fundamental obstacles to constraining smallsats is the lack of a legal framework that mandates smallsats' compliance within the existing space treaty framework for all space actors. Although some countries, such as Austria and Belgium, in 2011 have moved to remedy this legal shortsightedness through the introduction of national legislation, the growing number of smallsat launches and the readily available technology make effective oversight a challenge.³³¹ Both of the afore-mentioned countries are party to the Outer Space Treaty and are moving forward to participate in the European Union's (EU) Galileo navigational satellite system as well as to develop their own indigenous smallsat capability.³³² The Austrian legislation has mandated permits for all space activities that originate from or on Austrian territory or by any Austrian person or entity.³³³ The legislation will also create a domestic registry for space objects and has outlined the penalties for the violation of its provision.³³⁴ Smallsat legislation has also been examined by other EU countries to include the Netherlands, where the current launch and governance of nanosats falls outside of their existing space law.³³⁵ Rather

³³¹ Diane Howard, Summary of the Sixth Eilene M. Galloway Symposium on Critical Issues in Space Law: A Comparative Look at National Space Laws and Their International Implications, Dec 1, 2011, Washington, DC, 2.

³³² Ibid.

³³³ Michael Listner, "A first look at Austria's new domestic space law," *The Space Review*, Dec. 12, 2011, <http://www.thespacereview.com/article/1988/1>.

³³⁴ Ibid.

³³⁵ Howard, Symposium on Critical Issues in Space Law, 4.

than follow the Austrian example and introduce stricter legislation, the Dutch government has been hesitant to license and regulate the launch and mission activities.³³⁶ Current Dutch space policy does not mandate the registry of Cubesats, in part because they are normally not maneuverable, unless they are procured by the state, and additional legislation would require significant oversight from Dutch federal agencies to ensure their compliance with existing international space law.³³⁷ As one of the leading European developers of smallsats, this lack of oversight has been characteristic of many of the countries operating smallsats in space and potentially poses a problem to other space actors.

As smallsats become greater in number in orbit, defining what can be constituted as a “weapon” becomes a formidable hurdle, as evidenced by the 2009 collision of the Iridium communications satellite with a defunct Russian weather satellite. Any satellite, even a smallsat, can become a weapon if it is put on a collision course with another satellite from the high velocities and kinetic energies achievable in orbit. The close proximity operations illustrated in recent years by both China and the United States and a number of other actors to include the EU, Russia, and Japan, demonstrate an increasing ability to maneuver and dock with other satellites. Multiple countries have developed an on-orbit maneuvering and reconnaissance proficiency that can be used for either scientific investigation or to provide valuable information and insight into existing resident space objects (RSO). These capabilities in and of themselves do not necessarily pose a challenge unless they damage, destroy, degrade, or interfere with the primary function of the foreign satellite system they are observing. Although the threat from residual systems can never be truly eliminated, the adoption of such a measure as a minimum operating distance could reduce satellite vulnerability and provide enhanced stability.

A third challenge to restraining smallsat behavior is that the current verification means and methods do not enable observers to overcome the determined efforts of an actor to hide intent. Any type of meaningful and effective arms control requires the tools

³³⁶ Ibid., 4.

³³⁷ Ibid.

for verification. Any reasonable approach would require both a ground capability and national technical means (NTM) be among the permitted verification processes. The United States has today's most advanced ground-based observation system, and although it is capable of observing objects out to medium Earth orbit (MEO) with great detail, the ability to characterize and discriminate falls off proportionately depending on an object's size and altitude. No space actors would want to be totally dependent on another country for their own verification and many countries' own existing space situational awareness capabilities are too immature for such a task. Other verification means could include launch manifest declarations or on-site launch inspections of satellite payloads.³³⁸ However, with even the most stringent on site-inspections, the question arises as to what to look for to verify intent.³³⁹ Given the dual-use nature of many of the smallsat payloads, it would be a daunting if not impossible task to verify intent. In the absence of definitive intent, there would be no realistic way to reach a timely decision based upon the current verification tools at hand.

2. Benefits to Smallsat Arms Control

While the obstacles to constraining smallsats appear formidable, the potential benefits to doing so could provide significant advantages to the collective space security environment for all space operators. Although it would require a major commitment from all parties that launch and operate smallsats, the benefits could foster enhanced strategic stability, yield significant cost savings, and buttress additional space arms control activities.

One major benefit from restricting smallsat operations is the reduced likelihood of attack or malicious behavior by another satellite in orbit. From the very beginning of the space race, early warning and strategic communication satellites have played a critical part in providing stability to relations between the major space actors. Much of the aforementioned legal institutions have been developed to avoid an arms race in space and

³³⁸ Paula Sutter, "Is an Outer Space Arms Control Treaty Verifiable?" The George Marshall Institute, Washington, DC, 2008, 6–8.

³³⁹ Ibid.

to provide security for both the civilian and military activities.³⁴⁰ Many nations have become increasingly dependent on space utilities in the context of growing economic globalization and with the onset of the information age to not only support state economies but to provide common goods and services to their populations. With an increasing number of space-faring nations and actors, restrictions on smallsat behavior would provide enhanced stability. The likelihood for any misperception is significantly decreased if bounds are placed on the activities or interaction of smallsats with a nation's critical space systems.

A second major benefit from the restriction of smallsats would be the realization of significant cost savings for the major space actors who are the most dependent on space. With the recent ASAT events, a number of nations (to include the United States, Russia, India, and China) have spent considerable time investigating technologies to bolster their satellite defensive capabilities and to counter adversarial behaviors. The constraintment of smallsat behavior would provide enhanced security for satellite systems and obviate the need for extensive research and development costs to counter smallsats. Although it is still likely that these nations would continue to hedge against the prospect of cheating, it is still reasonable to assume the cost would be far less than if no arms control initiatives were in place.

Lastly, the acceptance of smallsat arms control has the potential to buttress existing arms control treaties as well as to become an impetus for the broader space code of conduct efforts currently underway. By imposing restrictions on smallsats, the limitations would be part of the bigger international space community's effort designed to encompass both the civilian and military uses of space. If made part of the more general code of conduct, a smallsat agreement could include a commitment to refrain from intentionally harming space systems, measures to control and mitigate space debris, and mechanisms for consultation. Smallsat arms control would have the added benefit of improving the international climate for enhanced cooperation and could lead to enhanced cooperation between multiple space actors in the community.

³⁴⁰ Sergey Oznobishchev, "Codes of Conduct for Outer Space," in *Outer Space: Weapons, Diplomacy, and Security*, ed. Alexei Arbatov and Vladimir Dvorkin (Washington, DC: Carnegie Endowment for Peace, 2010), 69.

D. POSSIBLE COURSES OF ACTION

There are at least three potential courses of action the United States could pursue in its negotiations to decrease the growing threat of smallsats. First, U.S. space policy officials could push for an agreement that delineates certain sectors of space as off-limits for smallsat testing, employment, or usage.³⁴¹ Given the challenging task of observing small satellites in MEO or higher orbits, it is tempting to recommend that smallsats be constrained to operate within LEO so that they can be monitored from existing ground assets. Many nations, however, have the majority of their high value reconnaissance, weather, tracking, and communications assets in LEO and defining this region as an operational area for smallsats would be highly contentious. Another possibility includes the implementation of a “keep-out” or exclusion zone, similar to what is has been adopted by states within its territorial waters. This exclusion zone out to a set distance of approximately 10 kilometers would enhance space security and decrease the risk of malicious behavior. The challenge again would be the maintenance of this buffer zone as many of the smallsat operators do not have the expertise or available technology to maintain an exact distance in a crowded orbital environment.

A second path the United States can pursue is to increase its transparency for future space activities and to initiate a number of confidence-building measures (CBMs) across the international space community. By increasing transparency, space actors are able to more clearly signal their intent for the operation of their space activities. Along with transparency, CBMs look to provide a level of information through consultation, notification, or access to make information available to other actors.³⁴² Through the implementation of the previously mentioned legal institutions, there was a general restraining influence on behavior between the United States and the Soviet Union. As the number of actors has grown, the challenge to craft and implement effective CBMs has created additional complexities. Efforts have been made from both the bottom up to include Space Debris Mitigation Guidelines, as well as, from the top down with the joint

³⁴¹ James Clay Moltz, “Breaking the Deadlock on Arms Control,” *Arms Control Today*, April 2002.

³⁴² Jana Robinson, “Transparency and confidence-building measures for space security,” *Space Policy*, Vol. 27, (February, 2011), 27–28.

Russia-China PPWT proposals. When applied to smallsats, the biggest hurdle to overcome will be to devise effective measures that are applicable to smallsats in both the private and public sectors to share data and information with commercial, educational, and foreign entities. The implementation of CBMs for smallsat space activity can be best achieved through the pursuit of a multilateral space agreement, whereby its signatories abide by a set of worldwide rules for the registration of smallsat launches and flight plans, possibly in advance, via the U.N. Registration Convention. The registration would provide basic information to include the launching state, the date and country of launch, the smallsat's orbital parameters, the general function of the smallsat, and the planned mean mission duration. This basic information would provide greater transparency and alleviate much of the uncertainty around the operation of smallsats. Although the verification and enforcement of smallsat CBMs for such a diverse audience make this a complex course of action to recommend, the additional stability to space security make it worthwhile to investigate in greater detail.

Finally, a third option the United States could pursue is to take an active leadership role in strengthening space security through cooperation with other nations to ensure free access to and responsible behavior in space.³⁴³ The emergence of new actors in space has changed the geostrategic balance in space and will continue to influence the acceptance of international space policy making. The United States has long been a leading space actor and highly influential in establishing what is viewed as the traditional norms for acceptable behavior. With the increasing presence of additional actors to include private operators, there is a greater need to integrate them into an international dialogue on space security initiatives by establishing international norms such as notification of space vehicle launches, closer coordination of space activities, and compliance with existing legislation.³⁴⁴ The United States could also pursue a more ambitious course and endorse the adoption of specific guidelines to include a ban on close proximity operations for smallsats and the adoption of end-of-life satellite measures. The implementation of these requirements would add to collective space

³⁴³ Jana Robinson, "Space Security through the transatlantic partnership," *Space Policy*, Vol. 28, (February, 2012), 61–62.

³⁴⁴ *Ibid.*

security while simultaneously mitigating the increasing orbital debris problem. Another option for increased collaboration would be through the sharing of ground radar tracking information with the international space community. The United States is already pursuing this option through its Space Fence radar acquisition, where it is partnering with the United Kingdom and Australia and this data-sharing could be expanded. As the number of smallsats continues to increase, there will be a growing demand for the establishment of regulatory requirements and space governance that will ameliorate the collective space security environment. The challenges to space security through such activities as smallsat operations need to be discussed in policy forums such as COPUOS, whereby knowledgeable experts can deal with practical issues. Lastly, the United States needs to be at the forefront of defining best practice procedures and guidelines through such measures as the European Code of Conduct with its international partners and commercial operators. The draft code is an important first step toward forging a better comprehension of responsible space activities, bolstering multilateral discussions among actors, and improving the sustainability of space. Although this course of action signals a paradigm shift from previous policy recommendations, this pursuit of international smallsat guidelines promises to enable the United States to become a key leader in defining operations with the goal of enhancing space security for the 21st century.

E. CONCLUSION

The United States continues to possess a significant technical and economic strategic advantage in space but this lead over its competitors is shrinking as new space actors have established a presence in space. As the space hegemon, the United States has the most to lose because of its reliance on its satellite system to support its broad military and civilian space activities. Technological advancements in the last decade have improved the ability of smallsats to maneuver and operate in orbit. Undoubtedly, these technologies and processes will continue to improve as new advancements are developed and launched. What is not certain, however, is what changes will occur in the geopolitical environment or how others will interpret those changes.

Debates on ASAT arms control and testing have been an integral part of the collective space security debate for the better part of sixty years. The renewed round of

ASAT activities in 2007 and 2008 and the emerging threat potential of smallsats represents the latest round of discussions on this topic. Reviewing the various options to strengthen the collective space security environment reveals three general points about a proposed U.S. course of action. First, given the large number of emerging space actors, smallsat arms control cannot totally alleviate the threat to space systems, but rather, can play an important part in bounding the behavior of the actors. Furthermore, the different approaches to smallsat arms control can work synergistically with other treaty or code of conduct agreements to enhance an increasingly unstable space security environment. Finally, although the verification of an agreement can never be totally complete, establishing a truly international space situational data-sharing system would be an important first step toward safeguarding unhampered access to space for all. The United States ignores the continued development of smallsats at its own peril. The lessons drawn from sixty years of ASAT development and testing should help us avoid asking the question a decade from now: “Why didn’t we do something to prevent these problems?”

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