CAN WE IMPROVE HUMAN ACCESS TO SPACE?

SPACE POSTURE THEORY:

A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING HUMAN SPACE PROGRAM DESIGN

BY

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APPROVAL

The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

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DISCLAIMER

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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ABSTRACT

The world has entered a second space age. America's space program is undergoing significant restructuring to address the shifting political priorities, resulting in new ways to access space. Currently, a renewed space strategy is breaking the bonds of government constraints and paving pathways for America to re-emerge as the leading spacefaring nation by leveraging commercial space exploration.

The relationship between the American government and space exploration is now moving forward, finally getting over "Apolloism." As a result, technological advances are cutting the cost, allowing a crowd of new actors—space start-ups, entrepreneurs, and developing countries—into the space environment. In America, a growing space industry is creating connections from the government to the private sector, shaping the strategic means by which humans access space. This shift in space strategy leans toward an open market *laissez-faire* style approach, leveraging the positive attributes commercial industries backed by government experience.

This thesis tells the story of the United States government's evolving role in human spaceflight, and presents a theory to explain it. The resulting Space Posture Theory provides a framework for incorporating prestige, innovation, and funding as being instrumental in shaping access to space. The evolving combination of these three factors serves as an explanation for the decline in government involvement and the rise of the private sector as a tectonic shift in the new space age. Understanding Space Posture Theory will aid strategic planning efforts towards future human space exploration and America's return to the forefront of space dominance.

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Chapter 1

From Chaos to Cosmos: Space Posture Theory and the Design of Human Spaceflight

> *Cosmos is the Greek word for establishing an orderly harmonious systematic universe. It is, in a way, the opposite of Chaos. Cosmos implies the deep interconnectedness of all things. It conveys awe for the intricate and subtle way in which the universe is put together.*
>
> Carl Sagan

Introduction

The world has entered a second space age. Global bipolar superpower competition involving Cold War foes vying for international prestige in a race to the Moon does not define this era. This new epoch is also fundamentally different than the previous era where the United States saw strong multi-lateral cooperation with like-minded nations, culminating in the completion of the International Space Station. Today's age is one of economic competitiveness, and in some cases nationalistic tendencies built on the totem of entrepreneurial prestige. Soon, the most audacious endeavors in space will stem from a wellspring of achievements in the private sector, characterized by various ongoing projects designed to democratize human space travel outside of government efforts.

As of 2018, access to human spaceflight from the United States continues to be non-existent. The United States is presently reliant upon Russia to get astronauts to space. The recently selected 2017 astronaut class is the smallest in NASA's recent history due the current constraints on space access, and some astronauts have completed their careers without making it to orbit. The International Space Station is vastly underutilized and American capacity to place humans in space is at an

all-time low. However, nascent technologies from the private sector give hope that the US can return to the forefront of space dominance and human spaceflight exploration.

Policymakers presently know very little about the strategies of this new era in space for three reasons. First, the bulk of scholarly literature suffers from a Space Race hangover, focusing heavily on the superpower experiences of the United States and the Soviet Union.[1] Critics assert there is surprisingly little achievement to show for our human space endeavors following Apollo, citing the luke-warm public response to the International Space Station and the problem-ridden Space Shuttle that built the orbital habitat. Second, there is increasing attention paid to unmanned space activities, including small satellite technologies and the debate surrounding space weaponization. The third reason there is a gap in knowledge—to the extent that scholars have paid little attention to human spaceflight—is because they have focused primarily on a pro-sanctuary perspective. Doing so dilutes the topic to little more than an expensive example of international cooperation and reduces human spaceflight to a frivolous way for governments to spend money.

Such a sentiment assumes space will forever remain a global common with minor concern for the fact that American space access currently lies in the hands of Russia. Little systematic thought has been given to the consequences of relinquishing *astro-autarky* to a country with which the United States has an unpredictable on-again, off-again relationship.[2] This neglect has dangerous potential ramifications, and the gamble of interrupting human space access from American soil places the burden to 'win big' squarely on the shoulders of the private sector. At present, scholars and policymakers lack a clear analytical lens to

[1] Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict*, Princeton Studies in International History and Politics (Princeton: Princeton University Press, 2014), Phrase borrowed from Page 4.
[2] The term *"astro-autarky"* was developed by the author.

categorize, codify, and understand this shift of responsibility. The goal of this research is to formulate such a framework.

Scholarly attention has focused on Cold War *astropolitik*—the extension of global geopolitics into the vast context of human conquest for outer space—and the contrasting collective security environment of the International Space Station.[3] Presently, there is poor understanding of the unfolding dynamics in the relationship between the public and private sectors that could potentially increase human access to space if cultivated appropriately by the United States government. This strategic shift away from direct government control paves a pathway for privatization, offering an opportunity for emerging commercial participants to enter the human spaceflight market. Consequently, the current paradigm shift in the United States' space program may provide other spacefaring nations with examples by which emerging space powers can structure their space enterprise.

Background of the Problem

The connection between human space exploration and national policy is vital to understanding the initial formulation of NASA's architecture, and for what purpose it served during the first 50 years of human spaceflight. NASA represented the unique strengths of the government as the space agency expanded the frontier of space significantly from 1961 to 2011. However, recent challenges to America's space program have also revealed the weakness in complete reliance on government investment; impediments to access have grown significantly due to a lack of political will combined with a constrained budget.

A new space strategy is breaking the bonds of these constraints and creating new ways for America to re-emerge as the leading spacefaring

[3] Everett C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age*, Cass Series--Strategy and History (London ; Portland, OR: Frank Cass, 2002), 7.

nation. A growing space industry is creating new connections from the government to the private sector, shaping the strategic pathways by which humans access space. This shift in space strategy closely resembles an open market *laissez-faire* style development, leveraging the positive attributes of both government and commercial industries.[4]

Stimulated by a public-private partnership, the government can further national interests by drawing from a more expansive industrial base in the emerging commercial space sector. In return, private space companies benefit from the stability of government subsidies that inject much-needed seed money until they can support themselves without further federal involvement. Recent advances in private space activity indicate there is a promising private market emerging with companies surviving *ab ipsis*, making the transition from top-down government space activity to bottom-up commercial space enterprises complete. Managing this development has proven difficult, and a shift of such magnitude does not occur without challenges. Understanding this tectonic space shift is critical to future spacepower projection, and underwriting this conversion is the *role* of the government.

Research Question

How is the government's role in human access to space from the United States changing in the twenty-first century? This intellectual inquiry not only challenges the government's support of space exploration, but also stimulates a more in-depth scholarly investigation into the various mechanisms of American space architecture and their intended purpose. The strategic vision of America's space program—and how it has evolved over time—becomes evident by investigating distinct programs and their accomplishments. The United States has chosen a multitude of space

[4] Randy Gordon, "The Landmark Space Age Thucydides: Human Spaceflight in the State Grand Strategic Quest to Address Fears, Advance Interests, and Garner Honor" (Masters Thesis, Air University, 2011), 136.

strategies to achieve different effects, which are revealed by connecting the conduct of human space activity back to the intent of the policy at the time.

To answer the central question, an analytical framework is built around the most significant factors that influence government involvement. The three independent variables under investigation are prestige, innovation, and funding. This research analyzes these variables and assumes they are the three primary drivers that enable humans to access space at any given time period. Next, this thesis classifies the mechanisms by which these variables produce the resultant space architecture. The priorities of prestige, funding, and innovation create two unique outcomes that are distinct and testable. These outcomes are labeled "Old Space" and "New Space," respectively. As a brief introduction to the terms, Old Space encompasses the period of American human spaceflight from 1961 to 2011, and New Space speculates human spaceflight from 2011 onward. A synthesis of the variables and their associated results explain the movement by which space activity has migrated away from direct government involvement that was characteristic of Old Space toward a free-market approach currently unfolding in New Space.

A comparison between historical precedent in human space activity and future opportunities highlights the strengths and weaknesses of American space exploration through its administrative capacity to create access. Analyzing each of the three variables (prestige, innovation, and funding) under two different case studies (Old Space and New Space) evaluates the relevance of each variable as it shaped the resulting space structures. Scholarly analysis provides a correlation between the variables, which point to the underlying motivations that explain each space posture in the context of its time. A focused study of the connection between the two models is required to provide implications found in the conclusion. Consequently, the suggestions accompany a strategic

message that may aid established space powers and enable emerging space powers to garner support for their space programs. In short, these implications are brought forward by focusing on the transformation of government support towards human spaceflight in the United States.

Space Posture Theory

This thesis fills a scholarly void by examining the experience of the United States' human spaceflight enterprise writ large. Much debate surrounds the choices of space strategy resulting in different *space posture*s. In general, space posture is the incorporation and prioritization of specific variables into an overall structural arrangement, supported by rules and procedures governing how space assets are used, and under what conditions different dispositions may generate various outcomes.[5] More specifically, the term space posture refers to the capabilities, arrangements, and methods of best practice that an agency can establish to operationalize its human access to space. Simply stated, a space posture is defined by some combination of prioritized values across those three independent variables.

The central argument of this thesis asserts that the primary driver behind human space exploration cannot be narrowed down to the singular factor of prestige, innovation, or funding. Rather, a combination of two out of three variables are required to create a corridor for humans to access space. Evaluating the priorities of prestige, innovation, and funding formulates the best framework by taking a holistic approach to determine the sources of motivation for space exploration across a range of political scenarios. Subsequently, the theory developed to support this argument is appropriately called *"Space Posture Theory."* This theory is formally expressed as follows:

[5] Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict*, 4.

In order to create a human presence in space (that is, either by government or commercial efforts), the actor that is best perceived to establish a normative framework for space exploration is likely to most effectively manipulate a combination of prestige, innovation, and funding.

This analytical framework is a theory about optimal choices, processes, and resultant outcomes within a given context.[6] Simply stated, the idea is that government efforts have achieved limited yet noteworthy success in space exploration. Now, the commercial sector is creating a new opening that arranges prestige, innovation, and funding in a different manner that has the potential to increase access for a higher number of humans over a longer duration of time.

Explanation of Causal Mechanisms

Prestige, innovation, and funding have unique mechanisms that show a strong relationship between the *intent* of space programs, and their analytically distinct outcomes, or *postures*. The depiction below in Figure 1 shows the relationship between the inputs, mechanisms, and outputs resulting in Old Space and New Space postures. This political science model demonstrates that independent variables behave in a way that is expected on the basis of rationality, acting within a predictable pattern that is repeatable if the same conditions are re-created.

Figure 1 is the fundamental mental framework that connects the original intent of the space programs to their resulting posture to access space. Each independent variable (X_1, X_2, X_3) is analyzed in isolation by tracing the theme of the variable through the mechanisms listed above to characterize the type of space programs that result (Y_1 and Y_2). Each variable is allotted its own chapter to conduct such an analysis. Building upon this mental framework, an evaluation of the scope, limitations, and assumptions is now warranted.

[6] Ibid., 27.

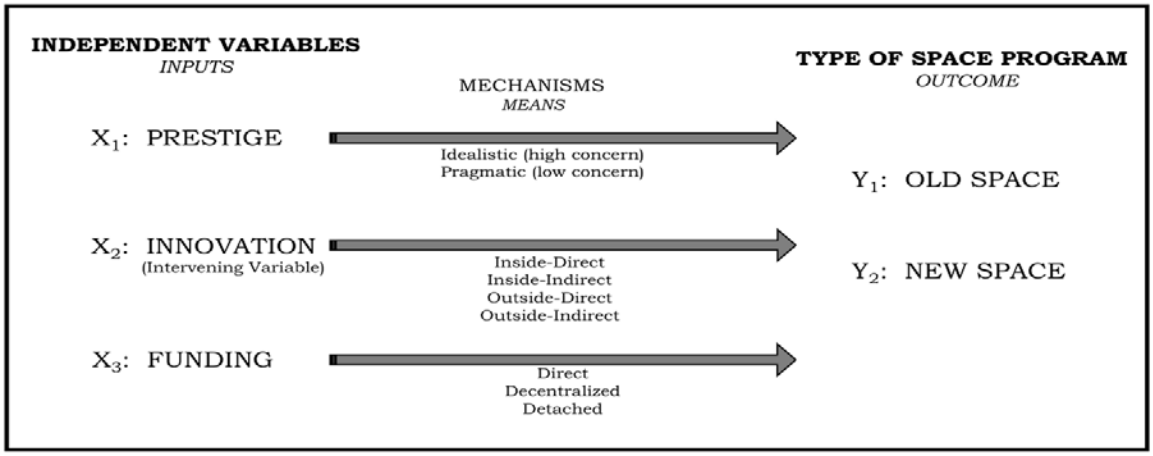

Figure 1: Mechanisms from X that Explain Variation in Outcome Y

Source: Author's Original Work

Scope, Limitations, and Assumptions

By narrowing the examination to human space activity alone, this research indirectly—yet significantly—reflects other aspects of the space domain. While human space activity can be neatly summarized under the concept of exploration, satellites and space weapons represent a broader spectrum of economic and security interests. Satellites constitute a preponderance of space activity, and the chances of weaponizing space are increasing.

Paradoxically, the economic and security considerations from satellites and space weapons indirectly influence human spaceflight and have overlapping parallels to human exploration. Therefore, the importance of keeping American leadership in the vanguard of all three sectors is interrelated. Space exploration is too critical of a strategic concept to leave its fate to chance, apathy, or in the hands of competitors. While space has never been solely about exploration, it is through human exploration that we gain a filtered, yet somewhat clear view of the overall space aspirations of a country. Summarized succinctly, the human being represents the ultimate expression of a nation's space endeavors. That is why this thesis focuses on human spaceflight.

This focus on the human element enables the strategist to assess the actions of other nations at a systemic level as national governments express themselves in space for a multitude of reasons. Regional space powers beyond the United States, Russia, and China are looking to enter the prestigious club of spacefaring nations that conduct human spaceflight. This research casts light on related space efforts that reflect domestic space structuring, and a shift in the ever-evolving international relations between great power politics and rising space nations. This thesis admits that human access is only a small component of overall space activity, yet it acknowledges that humans are the most visible and relatable representation of all space endeavors. Strategists may find utility in this narrow scope by assuming human space efforts are the penultimate reflection of a nation's image in space.

Methodology

Analyzing the two case studies—Old Space and New Space—across the three independent variables requires a cross-case comparative analysis method. This approach investigates the commonalities and differences among achievements, activities, and space-related processes to support the theory by explaining why a shift has occurred in the government's support of its space program. In addition to cross-case comparison, a process tracing method helps clarify the mechanisms by which the shift occurred over time. This study of time is relevant both internal to each case study and external across each case study. Using a historical analysis of the United States' manned space program creates a link to future commercial developments by combining the elements and their outcomes into a coherent whole. The evaluation criteria give meaning to Old Space and New Space postures by assigning a level of importance to prestige, innovation, and funding. This appraisal provides a measure to objectively sort the three variables into an order of importance during

each case study. A qualitative value assigned to each variable identifies a change in the relative significance across a span of time.

Intended Audience

This research is intended to reach the space scholar, highly interested in the particular department of human space activity and the impact it has on international relations. Curious to the reasons why America stopped sending astronauts to space from home, the scholar may find utility in the correlation between Old Space and New Space. This research questions if the United States will re-emerge as the prominent leader in space exploration or if its pre-eminence will continue to decline. This thesis also serves as a warning to the policy-maker who permits interrupted access to space, as the consequences of doing so holds the United States hostage to the policies of foreign space powers.

This study may also prove helpful to regional space power strategists seeking to learn from the colorful, yet highly erratic experience of American spaceflight. America's example presents two distinct choices for emerging space nations by which to structure a human spaceflight program. Using America's playbook, other countries may structure their space program similar to one of these models by seeking space access for reasons unique to a rising regional power. This research endeavor provides implications for specific postures depending on the motivation, political context, and desired outcome.

Independent Variables Defined

Space Posture Theory recognizes three analytically distinct independent variables. These variables are prestige, innovation, and funding. Prestige is a subjective notion that commands a position of respect in the eyes of a society, and is the result of overcoming a frontier

challenge presented in space for the purposes of this theory.[7] Prestige in space is an attractive measure that attempts to shape global opinion by cultivating a sentiment of reverence within a domestic and international audience. The importance of human spaceflight is recognized as a status symbol, allowing superpower countries to express the riches of their nation or the superiority of their political system based on domestic privilege and international admiration. Prestige is analogous to soft power, which utilizes non-coercive means to influence the behavior of others to obtain desired outcomes.[8]

Like prestige, innovation must also be defined for the purposes of human space access. Simply put, innovation is the introduction of something new.[9] Regarding access to space, innovation calls attention to the presentation of a new idea, method, or device to affect some aspect of change that will further promote human contact with the space domain. Relating innovation to government involvement, innovation emerges either directly within the government's purview, or indirectly outside of its traditional sphere of influence. Innovation is closely related to the requirements of a project, as the requirements are the essential necessities to make space access a reality. Relinquishing responsibility for setting requirements to the private domain and its community of designers is a relatively new concept for NASA, and that idea will be explored in Chapter Three. The commercialization of technological development allows the government to outsource specific research requirements, and by doing so, commercialization also allows the government to conserve its development dollars. The result is that the government is becoming increasingly reliant upon outside innovations.

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[7] Merriam-Webster Inc., *Merriam-Webster's Collegiate Dictionary*, 11th ed. (Springfield, Mass.: Merriam-Webster, Inc., 2003), 983. Initial part of definition borrowed from Websters, and the second part is modified for the sole purposes of space exploration.
[8] Joseph S. Nye, *Bound to Lead: The Changing Nature of American Power* (New York: Basic Books, 1990).
[9] Merriam-Webster Inc., *Merriam-Webster's Collegiate Dictionary*, 645.

Funding, simply stated, is the sum of financial resources set apart for a specific objective.[10] Funding for space exploration refers to the capital allocated either by public or private means for the purpose of lifting humans into space. Funding is further categorized by direct, decentralized, and detached sub-variables that create mechanisms to connect the source of money supply to the desired outcome. Direct funding is money flow resourced by the government from taxation and given directly to NASA. Decentralized funding involves a percentage sharing of the cost between the government and the private sector. Lastly, detached funding is money created to support a space project that is entirely devoid of any financial involvement from the government.

Dependent Variables Defined

The mechanisms connecting the variables of prestige, innovation, and funding—and the weight of importance attached to each variable—have produced a recognizable outcome during the first fifty years of the first space age. The term Old Space categorizes this era. Old Space encompasses a period of human spaceflight activity launching from the United States starting in 1961 and lasting until 2011.[11] Old Space includes the Mercury, Gemini, Apollo, and Space Shuttle programs. A philosophy of top-down oversight characterizes this era with elements of the program constructed to an exact specification under governmental bureaucracy managing every detail. This centralized system revolves around costly long-term programs, with extensive state-of-the-art capabilities and multiple redundancies. Such a structure was a direct reflection of political intent for a specific purpose. Old Space provides a well-crafted capability for a limited set of users over a defined time period. This defines the boundaries of the first case study called Old Space. While

[10] Ibid., 507.
[11] William E. Burrows, *This New Ocean: The Story of the First Space Age*, 1st ed. (New York: Random House, 1998).

this dependent variable is defined by a specific time period in the United States' history of spaceflight, emerging nations entering the space arena may very well select this historical model for their program. Therefore, the Old Space construct as defined in this thesis is still applicable to present day.

Since 2011, a new period has emerged, featuring a rearrangement of the priorities between funding, innovation, and prestige to form a different paradigm on human spaceflight. The altered importance assigned to prestige, innovation, and funding generate a vastly different outcome categorized as "New Space." The New Space school of thought shifts away from the nucleus of government involvement and focuses on using less expensive designs and perhaps more creative approaches to spaceflight combined with slightly higher risk tolerance. According to researcher Gary Martin, NASA is no longer the vanguard of space exploration. Martin coined the moniker New Space as an "entrepreneurial space age umbrella term for a movement and philosophy often affiliated with the new private spaceflight industry. Specifically, the term refers to a community of relatively new aerospace companies working to develop low-cost access to space and advocates of innovative spaceflight technology and policy."[12] While one must be cautious to comparing one period of a half century of space exploration (i.e., Old Space) to another of less than a decade's worth of development, it is undeniable that a new space strategy is emerging. This new approach to human spaceflight leverages the unique strengths of government experience with commercial profit-making industries.[13]

The definitions of Old Space and New Space differ slightly from the conventional labels of "First Space Age" and "Second Space Age" commonly

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[12] Gary Martin, "New Space: the Emerging Commercial Space Industry," in *SSP14*, ed. NASA Ames Research Center (https://ntrs.nasa.gov/search.jsp: NASA Ames, 2017).
[13] Randy Gordon, "The Landmark Space Age Thucydides: Human Spaceflight in the State Grand Strategic Quest to Address Fears, Advance Interests, and Garner Honor" (Masters Thesis, Air University, 2011), 136.

found in existing space literature. This thesis deemed the conventional terms imprecise and demanded more of a focus on the human element, rather than a generic phrase that canvases all space activities. Therefore, Old Space and New Space narrow the nomenclature by precisely addressing human space activity, and the strategic pathways by which we create access for humans. The tighter focus is why such precise labels are needed and established terms are inadequate.

The discussion of Old Space and New Space require a mention of how space is defined. For the purposes of this research, space is defined by the domain that exists above the internationally recognized altitude of 327,360 feet.[14] This altitude is known as the Karman Line, named after American-Hungarian physicist Theodore von Karman.[15] Von Karman recognized this altitude (approximately 62.1 statute miles above the Earth) as the point at which aerodynamic surfaces no longer contribute to controlled flight. Above this altitude, spacecraft have to orient their attitude using thrusters instead of flight controls.[16] All references to the space domain, whether orbital or sub-orbital, are anchored to this definition.

Evidentiary Base (Systematic Literature Review)

Space Posture Theory constructs conceptual frameworks that facilitate the understanding and explanation of the transformation across space paradigms.[17] Using a diverse evidentiary base, Space Posture Theory provides clarity and accuracy to the complicated space situation currently unfolding to forecast future outcomes. Space Posture Theory must assist policy makers to formulate a vision and determine their

[14] Luciano Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," *R&D Management* 41, no. 4 (2011): 364.
[15] Richard Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space* (London: Virgin, 2010), 238.
[16] Ibid., 239.
[17] M Beavis, "The IR Theory," US Department of State, http://www.irtheory.com/.

desired end state in space exploration. The strategist must then guide practitioners and convert the ideas presented in this theory to action. Understanding the value of Space Posture Theory should resolve a debate between the two competing postures: Old Space and New Space. The outcomes of the two case studies are essential to developing a framework that asserts that two of three independent variables are required to create access for humans to explore space, whether it be through an Old Space or a New Space paradigm.

A useful way to categorize competing space theories across the spectrum of the Old Space-New Space continuum is by analyzing the arguments and opinions of strategic space literature against the evolution of space policy and its outcomes. This codification divides the two paradigms with scholars that support various schools of thought surrounding the transformation of human spaceflight. The typology is further broken down into degrees of Old Space and New Space postures, varying from government's exclusive access to a completely deregulated commercial enterprise with minimal government involvement.

According to space scholar Dr. Michael V. Smith, each space theory revolves around the concept of power and the location of that power.[18] Power, by Dr. Smith's definition, is the ability to influence an outcome.[19] In general, Old Space consolidates power while New Space disperses it. More specifically, the term "spacepower" is defined as the ability of an actor to use space to influence events to achieve a desired outcome.[20] Old Space theorists argue that spacepower and human space flight are a Clausewitzian extension of politics, where New Space capitalizes on the free market forces of Adam Smith's *laissez-fai*re open economic structure.

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[18] Michael V. Smith, "The Space Corpsman's Handbook," (Maxwell AFB, AL: US Air Force, 2019), 15. Note, this is an unpublished document that was written if Congress were to create an independent Space Corps.
[19] Robert B. Cialdini, *Influence: The Psychology of Persuasion*, Rev. ed. (New York: Morrow, 1993), 4.
[20] Smith, "The Space Corpsman's Handbook," 24.

The theorists mentioned below attempt to explain how the internal structuring of a state can best be arranged to amass spacepower for itself while increasing access for humans, whether in the government or commercial sectors. While the ideas discussed by the authors apply to any spacefaring nation, the following literature review refers solely to the United States. The theories and perspectives of the authors listed in Figure 2 are discussed in detail below.

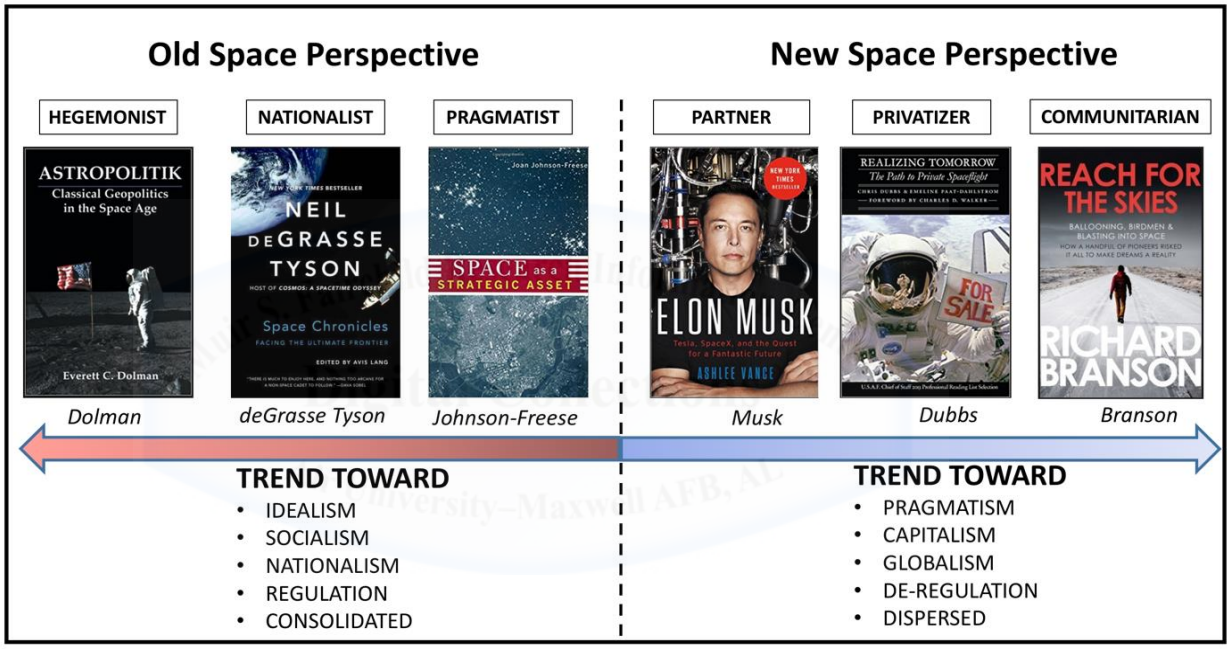

Figure 2: Human Spaceflight Theories Compared

Source: Author's Original Work

Dr. Everett Dolman ignited a firestorm of controversy by releasing *Astropolitik* in 2002.[21] Dolman's propositions were both feared and revered, making him the infamous archetype of space hegemonists.[22] This work is by far the most controversial on the subject of spacepower, as it outlines the most extreme position of the realist perspective. Arguing that

[21] Dolman, *Astropolitik: Classical Geopolitics in the Space Age*.
[22] Smith, "The Space Corpsman's Handbook," 22.

space is the ultimate expression of raw power maximization, America should seize control of all space access, regardless of political sovereignty, and impose a ruling space regime on the world. In effect, America should only permit payloads into space after inspection to verify the launcher's intentions are friendly to America's interests. Assuming the United States is a benevolent hegemon, this oversight would not upset the established world order, and this posture should inevitably be peacefully accepted by the world. Borrowing from Halford Mackinder, Dolman overlays geopolitics on the space domain, updating the neo-classical dictum: "He who controls Low-Earth Orbit controls Near-Earth Space. He who controls Near-Earth Space dominates Terra Firma. He who dominates Terra Firma determines the destiny of humankind."[23] Dr. Everett Dolman's perspective on space exploration is hegemonic.

Arguably, Dr. Neil DeGrasse Tyson is the most famous space enthusiast among Americans today. An astrophysicist, Tyson is responsible for generating the excitement of planetary science and widespread awareness of space exploration by producing his popular television series *Cosmos: A Spacetime Odyssey*. Paying homage to Dr. Carl Sagan, Tyson hopes to generate enough public support to reinvigorate NASA, bringing back its human space exploration program. In *Space Chronicles*, Tyson points out that NASA has ended the Space Shuttle program after decades of global primacy, and asserts the United States may soon find itself eclipsed by other countries' space endeavors.[24] Tyson longs for the glory days of human spaceflight when NASA was at the forefront of exploration and urges the space agency's return to the space frontier, wherever that may be. Giving only minor consideration to commercial space companies, Tyson views space exploration primarily as a government endeavor. He recommends government funding that

[23] Dolman, *Astropolitik: Classical Geopolitics in the Space Age*, Back Cover.
[24] Neil DeGrasse Tyson and Avis Lang, *Space Chronicles : Facing the Ultimate Frontier*, 1st ed. (New York: W.W. Norton, 2012).

doubles NASA's current budget to get humans to Mars by the mid-2030s. Tyson's command of the topic is persuasive but falls short of giving due acknowledgment to non-governmental breakthroughs. In summary, Dr. Neil DeGrasse Tyson's viewpoint is that of a nationalist.

In 2008, Dr. Joan Johnson-Freese openly acknowledged the increasingly relaxed control that NASA holds on the monopoly of human spaceflight from America and accurately predicted the gap in human access to space as an alarming harbinger to giving up spacepower in *Space As A Strategic Asset.*[25] She alludes to a transition away from NASA by forecasting the failures of the agency to provide a follow-on solution to the Space Shuttle, but admits it was not possible under such a modest budget. At the end of her treatise, Johnson-Freese confesses that this failure is not necessarily a bad thing, as the United States can learn from its mistakes and resurface as the leading space power, but only with an updated space posture. Dr. Johnson-Freese declares it is absurd to think NASA could retain control of the space market and argues strongly that the United States government should forego power-maximizing strategies because the pursuit of such a goal is impossible in the changing context of globalization. Instead, Johnson-Freese argues for broad international partnerships to preserve America's status quo so as not to have America's follow-on human space developments be perceived as a threat to other nations. Johnson-Freese asserts this progression would spark a security dilemma with emerging nations, which is something America should prevent. Johnson-Freese sounded the alarm of giving up human spaceflight and provides the clarion call for the shift away from government involvement. Overall, Dr. Joan Johnson-Freese is a pragmatist.

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

The mystique of SpaceX founder Elon Musk is demystified by Ashlee Vance in the author's extensively written biography on Musk's ideas and motivations.[26] Through Vance's research, Elon Musk emerges as the most successful and influential space entrepreneur in the world today. While Tesla, PayPal, Solar City, and the Boring Company are all *expressions* of Musk, SpaceX *is* Musk. His other companies were created to help solve some problem in an aspect of colonizing Mars—Musk's ultimate goal.[27] To make humans an interplanetary species, Musk is currently developing affordable, reusable options that are attractive both to NASA and the private sector.[28] On the Old Space-New Space continuum, Musk represents a blended link between the two by capitalizing on public-private partnerships to service NASA's needs while growing his company to achieve his ultimate multi-planetary vision. Musk seeks help from the government, citing positive sum gains for both entities in the categories of national security and economic well-being. Musk has the most to lose if government support for SpaceX falters. At the same time, Musk recognizes that NASA's dominance will not remain forever. Other national actors have already risen to challenge American hegemony in space. However, Musk maintains that his company, not NASA, will bring America back into the human space market. In sum, Musk is best viewed as a partner to the government by combining the public and private domains.

Realizing Tomorrow tackles ongoing struggles to achieve human space travel outside of official government efforts.[29] Dr. Chris Dubbs and Dr. Emeline Paat-Dahlstrom argue that NASA has changed from being a champion to an impediment of space exploration. According to the authors, NASA is presently an obstacle, not an asset, that has to be

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[26] Ashlee Vance, *Elon Musk: Tesla, Spacex, and the Quest for a Fantastic Future*, First edition. ed. (New York, NY: Ecco, an imprint of HarperCollinsPublishers, 2015).
[27] John Gertner, "Elon Musk," *New York Times* 2017.
[28] Ibid.
[29] Chris Dubbs and Emeline Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, Outward Odyssey: A People's History of Spaceflight (Lincoln: University of Nebraska Press, 2011).

circumvented and points out that the first private citizens to reach orbit did so with the help of the Russians and not the Americans. This book highlights the failure of NASA's "Citizens in Space" program, and the resounding success of Russia's "Space Adventures" partnership. Space Adventures is meant to bridge the gap between the space elite and the space enthusiast. Critical to NASA's reluctance, Dr. Dubbs points out that Russia opened another path to space—that of capitalism—claiming yet another first among the long list of space achievements for the Russians. While acknowledging that space exploration opportunities remain only for the ultra-rich, Dubbs urges America to develop low-cost space options to fulfill the original intent of the Citizens in Space program that NASA developed with the sub-groups "Teacher in Space" and "Journalist in Space" programs. Dr. Dubbs' theory provides an account of privatization efforts through the lens of New Space, attempting to make space accessible to everyone. In sum, Dr. Chris Dubbs is a privatizer. He aims to pull away from the force of government influence. Doing so will increase access for a greater number of people.

Finally, Sir Richard Branson completes the spectrum in spacepower theory. The Virgin Galactic founder and billionaire-adventurer celebrates the lively history of airborne daredevils and aviation pioneers, including himself among the group in his treatise on human spaceflight in *Reach For The Skies*.[30] Branson is the trailblazer of the space tourism industry. He openly acknowledges that he is creating an industry based on fun, travel opportunities, and human connection. Branson's theory asserts that by creating a spaceliner for Earth, he will achieve the goal of democratizing space for the benefit of everyday life on Earth. Hoping to give more humans the vantage point of looking down on Earth from space, Sir Richard Branson believes this cosmic viewpoint will create lasting social change by advancing humanity's positive attributes. Branson believes in

[30] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*.

the interconnectedness of the human race and is using space as a vehicle to increase this notion of connectivity. Branson's vision comes at his own financial expense, utterly devoid of government involvement other than regulatory measures that cultivate spaceflight privatization. Sir Richard Branson is looking for new outlets of venture capitalism under the veil of his multibillion-dollar umbrella company, the Virgin Group. Simply put, Branson is a communitarian.

Overview of the Work by Chapter

So, how is government support of American human access to space changing in the twenty-first century? Chapter Two investigates the subjective notion of prestige, and what it means to advance space exploration. During the Cold War, President Kennedy leveraged human spaceflight to increase national prestige by showcasing unmatched capability to the rest of the world. This chapter reveals how prestige played an essential part in establishing credibility for the United States in international politics and the space program was the most effective means to broadcast America's brand across the globe. From President Kennedy's perspective, space exploration was a means to an end, not an end in itself. Chapter Two also reveals how prestige has devolved to a lower level, descending from a national imperative to a commercial accoutrement. Competition among entrepreneurial ventures now exists within the bounds of a new battlefield for prestige. Space symbolically represents the final frontier, offering ultimate social status to those able to conquer it. Presently, entrepreneurs of multibillion for-profit business enterprises are using space to boost their company's social status. The classifications of "high concern" and "low concern" further codify prestige, which completes debate in Chapter Two.

Chapter Three investigates the various bases of innovation. From an empirical perspective, this chapter investigates the evolving changes in sources of innovation since the 1960s. This analysis traces the

technological development, industrialization, and economic activity of the American space program from the beginning to present day. This chapter shows that commercialization of innovation has critical consequences on the migration away from direct government involvement under the Old Space paradigm into the more indirect model predicted to become the heart of activity under the New Space case study. In total, there are four classifications of innovation origin. Inside-Direct falls under the direct oversight of NASA, Inside-Indirect innovations are research projects that NASA outsources to universities and think tanks. Outside-Direct covers commercial products actively seeking government contracts. Outside-Indirect is the autonomous commercial section where requirements and funding are both weaned from government influence.

Chapter Four focuses on funding and the mechanisms by which space exploration is financed. The decline of federal outlays and upsurge of private investments draw the comparison between Old Space and New Space to determine the causal factors that drove each spending architecture. Unilateral government support summarizes direct funding. Public-private partnerships have developed a decentralized funding scheme, where the government and private sector share the cost and risk to mitigate the complications of the political financial process. Finally, detached funding stems from sponsorship or inducement prizes in the free market. Minimal government oversight exists for detached funding. Chapter Four reviews NASA's budget allocation, and reveals the links to political forces over the first space age. Resultantly, this investigation reveals government funding is not necessarily tied to the best interest of space exploration as greater political forces prevail over sustainable practices. However, the dispersion of financing witnessed in New Space directs the focus away from politics and places it on profit. By doing so, the concept of exploration—not political expression—might become the center of human space activity.

Chapter Five offers a synthesis of the three variables. The preceding chapters provide an analytical foundation for the overall composition that creates Space Posture Theory. By first explaining each variable *sui generis*, a causal chain links the variables to the outcomes independently. Chapter Five then correlates the variables, creating an evaluation metric of the outcomes and a holistic perspective of Old Space compared to New Space. Doing so adds strength by synthesis to further support the validity of Space Posture Theory. Assigning value to each variable and combining the variables provides metrics and a testable prediction of outcomes. Understanding each posture is unique based on the arrangement of distinct variables, this theory anticipates future space activity in the United States. Furthermore, certain arrangements of prestige, funding, and innovation may generate different results in space posture that other powers can adapt to mold their emerging space programs. To emphasize the central argument of this thesis, the primary driver behind human space exploration is not the singular considerations of prestige, funding, or innovation taken in isolation from the others. It is a combination of two out of the three.

Finally, Chapter Six offers implications and recommendations for understanding space posture optimization in a world where an increasing number of regional powers are pursuing space exploration. The concepts discussed here apply equally to established and emerging space nations alike. Examining space posture in the United States and its resulting behavior aids in addressing how developing space nations, such as China, India, and Brazil, may structure their space programs to achieve national goals. Therefore, this thesis concludes with a guide to further study on the overlooked experiences of America's shift in space posture, and how it connects to other nations.

Chapter 2

Prestige in Space: Moving from Idealism to Pragmatism

For 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.

President John F. Kennedy

Prestige to Pragmatism

The perception of prestige in human spaceflight has shifted from a national priority to an entrepreneurial endeavor. America retained a high concern for prestige in the 1960s, which was underwritten by idealistic motives to prove that capitalism was a better model for the world compared to communism. Over time, this idealistic drive shifted to a more pragmatic approach as private companies pursued more sensible motives and became poised to assume the preponderance of human space activities in the future. This chapter investigates the concern for prestige, and the outcomes resulting from either a high or low concern for this social stature.

Prestige, in its broad definition, is a commanding position in people's minds that gives credit to a general opinion.[1] Classical realist Hans Morgenthau highlighted the importance of prestige, which he defined as a "reputation for power" that could be used for achieving greater political goals.[2] As it applies to space exploration, prestige is the process of drawing forth an appealing quality that is mutually beneficial to the attractor and the audience. Simply put, prestige in space for the United States is the

[1] Merriam-Webster Inc., *Merriam-Webster's Collegiate Dictionary*, 983.
[2] Michael Sheehan, *The International Politics of Space*, Space, Power and Politics (London; New York: Routledge, 2007), 20.

ability to attract others towards the legitimacy of American policies and the values that underlie them.[3] In the context of the Cold War, landing on the moon was an odyssey of Homeric proportions, and the golden age of spaceflight created a genuine sense of prestige for the United States the first time an astronaut stepped foot on another celestial body. Non-aligned countries were enticed to align with the West as a result of conquering the moon and the prestige such a feat carried with it.

Fostering national prestige was the primary mechanism for creating access to space and advancing human spaceflight. As such, the sentiment for prestige fueled idealistic motives for creating a space program during the Cold War. The Space Race of the 1960s created an environment of competition not for footprints on the moon, but for the notion of international prestige. This attraction strategy was used by the United States to allure world opinion in favor of capitalism. After the Apollo 11 moon landing, prestige aroused a sense of reverence and emotional passion resulting from America's victory over the Soviets in space. This success created a favorable reputation for the West, which subsequently influenced non-aligned countries toward the American alliance. However, the story of space prestige starts well before the moon landing. To understand prestige, one must go back to 12 April 1961. This was the day cosmonaut Yuri Gagarin left earth on his historic orbital flight. Prestige did not initially carry much weight for the United States (or even the Soviet Union for that matter) until it became apparent that such efforts could lead to significant gains in political capital.

In the bipolar era of the 1960s, concern for this attractive measure became a priority over armed conflict, and President John F. Kennedy was keen to seek out any means that would generate the highest amount of prestige for the United States. Space exploration was the perfect pathway

[3] Joseph S. Nye Jr., "Get Smart: Combining Hard and Soft Power," *Foreign Affairs* 88, no. 4 (2009): 160.

to demonstrate national resolve to the rest of the world. For President Kennedy, space exploration was a political expression of prestige and became an extension of his efforts to shape foreign policy. America's space exploration program initially focused on the competitive social factors stemming from the Space Race, and later evolved to a more practical effort with the Space Shuttle.

Old Space Prestige

The logic of prestige in Old Space is built on the rivalry between the Soviet Union and the United States. The competition begins with the Soviets' two big firsts: Sputnik and Yuri Gagarin's orbital flight. However, this global bout for prestige ended with the United States landing on the moon. From 1961 to 1969, America's human space program served as a means to demonstrate idealist aspirations while advancing national security interests. America's first three human space programs—Mercury, Gemini, and Apollo—united its domestic population to garner global prestige. The language used in President Kennedy's famous speech to formally declare the goal of getting to the moon and back delineated his directive for the term "exploration," which by association included the words human beings, and omitted phrases using the term "science." Resurrecting the frontier narrative, Kennedy created a symbolism that drew on the popular American ideals of exploration, individualism, and geographical conquest similar to America's westward expansion following the Lewis and Clark expedition.[4] President Kennedy capitalized on the most powerful cultural tradition in American history—the frontier narrative—and reopened this romantic ideal by re-directing it towards the moon. Drawing a parallel to the classic western adventure, Kennedy

[4] David A. Mindell, *Digital Apollo: Human and Machine in Spaceflight* (Cambridge, MA: Cambridge, MA: The MIT Press, 2008), 11.

connected the elements of adventure to exploration for the purposes of prestige.

President Kennedy's masterful presentation excited the public by capturing the imagination of citizens with an unknown realm that must be conquered. The new realm entails a new geography lurking of dangers and a villainous antagonist similar to the early racist propaganda used by the American Government towards Native American tribes, casting the same image around the Soviets.[5] As a consequence, the term "Space Cowboy" came to represent the rugged individuals brave enough to boldly go where no man has gone before in a direct correlation to the western frontier romanticism.[6]

Setting The Stage for Space

Undoubtedly, the split between the two major victors of World War Two created two economic models in a newly established bipolar world. Competition between capitalism and communism surfaced in a rivalry for prestige that extended out to space exploration. This Cold War contest created many coercive outlets, but the most visible attractive expression was the Space Race. In the eyes of the countries caught between aligning with the East or the West, the Soviet Union seemed the most appealing choice in the early sixties. The Soviets possessed a military that was arguably as good as the United States, and they were viewed by many as the most technically sophisticated nation on the planet at the time. This lure was underscored by their accomplishments in space. Similar to the United States, their space exploration efforts were a symbolic reflection of their quest for global hegemony. The United States, however, had fumbled with a series of embarrassments on the global stage. President Kennedy's

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[5] Ibid.

[6] Gene Roddenberry, *Star Trek: the Final Frontier*, *Star Trek: The Original Series* (Van Nuys, CA: CBS Studios, 1966), Introductory Spoken Text, 1. Phrase borrowed from opening episode.

first encounter with Soviet President Nikita Khrushchev at the Vienna Summit did not bode well for America's reputation as a great power,[7] the botched Bay of Pigs fiasco in Cuba left serious doubts to Kennedy's handling of clandestine operations,[8] and the series of highly publicized rocket failures while struggling to keep up with Sputnik only made matters worse.[9]

America's early space program did not lay the foundation for a long-term strategic vision. Instead, it was a political vehicle created out of haste and motivated by an inferior position to make up for strategic mistakes. President Eisenhower was forced to respond to the "Sputnik moment" by establishing ARPA and NASA, even though he personally did not view a basketball-sized orbital metal ball as a threat from the Soviets. The full measure of America's response came from President Kennedy, who looked for a way to show the world that America was not falling behind the Soviets in science and technology.

After cosmonaut Yuri Gagarin's initial spaceflight, Kennedy consulted NASA Chief Scientist Werner von Braun asking for options that would give America the best chance of usurping Soviet prestige in space. Kennedy asked, "Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or a rocket to go to the moon and back with a man?"[10] The question was not about how best to explore this new space domain or how best to conduct sustainable space access. Rather, it was about using space as an extension of politics. Translating Carl von Clausewitz's theory of warfare into the space domain, President Kennedy viewed space not

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[7]Andrew Glass, "JFK and Khrushchev Meet in Vienna: June 3, 1961," *Politico* (2009): 1.
[8] Graham T. Allison and Philip Zelikow, *Essence of Decision : Explaining the Cuban Missile Crisis*, 2nd ed. (New York: Longman, 1999), 85.
[9] Gordon, "The Landmark Space Age Thucydides: Human Spaceflight in the State Grand Strategic Quest to Address Fears, Advance Interests, and Garner Honor" (Masters Thesis, Air University, 2011), 38.
[10] Rand Simberg, "Getting over 'Apolloism'," *The New Atlantis: A Journal of Technology and Society* Spring/Summer, no. 2016 (2016): 3.

merely as a political act, but as a real political instrument; a continuation of political intercourse, carrying out of the same by other means.[11] Von Braun responded to Kennedy's question by stating that the Soviets were capable of building a space station and could send a rocket to lunar orbit much faster than America. However, the United States had "an excellent chance of beating the Soviets to the first landing of a crew on the moon."[12] Kennedy took von Braun's recommendation and drafted a famous speech that was broadcast to the world on 25 May 1961.[13] In this strategic soliloquy, Kennedy declared that America would put a man on the moon by the end of the sixties and return him safely to Earth.[14]

The political weight of effort to realize Kennedy's moon goal became the largest technological peacetime project in history.[15] NASA's budget skyrocketed from zero in 1957 to more than $160 billion in 1967 to support this endeavor.[16] The economic priority given to the space program remained high until the goal of the Apollo program was accomplished, where fiscal outlays then dropped down to less than one percent of the federal budget. The fear of being outshined by the Soviets overshadowed the enormous cost of this new endeavor. The informal motto of NASA during the sixties was "waste anything but time."[17]

Tracing American Achievements

At 9:29 a.m. on 5 May 1961, Astronaut Alan Shepard lifted off Launch Complex Five in Cape Canaveral, Florida to an altitude of 116

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[11] Carl von Clausewitz, *On War* (Princeton, N.J.: Princeton University Press, 1984), 87.
[12] Simberg, "Getting over 'Apolloism'," 5.
[13] John F. Kennedy, "Jfk Moon Speech at Rice Stadium," ed. National Aeronautics and Space Administration (https://er.jsc.nasa.gov/seh/ricetalk.htm: NASA, 1962).
[14] John Fitzgerald President Kennedy, "Jfk Space Race Speech," https://er.jsc.nasa.gov/seh/ricetalk.htm.
[15] Simberg, "Getting over 'Apolloism'."
[16] Tyson and Lang, *Space Chronicles : Facing the Ultimate Frontier*, 335.
[17] Simberg, "Getting over 'Apolloism'."

miles above the Earth for a fifteen-minute flight.[18] The Redstone rocket booster was jettisoned from Shepard's spacecraft as he approached the Karman line, sending Shepard on a parabolic sub-orbital trajectory. At the height of the apogee, Shepard eased into weightlessness and the gravitational forces fell off his body. Looking at a mirror to see the portal window of his *Freedom 7* spacecraft, Shepard peeked at the curvature of the Earth, witnessing a thin layer of atmospheric dust and the blackness of the sky above.[19] After a successful re-entry and splashing down next to the Bimini Islands, Alan Shepard became the first American astronaut to touch the edge of space. As an indication of this prestigious occasion, Shepard received a standing ovation and a formal military salute from all members aboard the aircraft carrier that recovered him. This sign of respect was followed by dinner at the White House with President Kennedy and multiple parades across the country. Commander Shepard was welcomed back to Earth as an American hero and became instant cultural icon.[20]

Shepard's flight was only the beginning of a string of accomplishments for Project Mercury. Two months later, USAF Lt Col Gus Grissom repeated a sub-orbital flight profile, this time with an upgraded spacecraft design that including a window instead of a porthole and an explosive escape hatch.[21] By January 1962, Astronaut John Glenn became the first American to reach orbit, now on a more powerful Atlas rocket, lapping the globe three times before re-entering Earth's atmosphere.[22] By the time Project Mercury concluded on 16 May 1963, Gordon Cooper had circumnavigated the globe a record twenty-two times

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[18] John Catchpole, *Project Mercury : Nasa's First Manned Space Programme*, Springer-Praxis Books in Astronomy and Space Sciences (London; New York Chichester England: Springer; Published in association with Praxis Pub., 2001), 283.
[19] Ibid., 288.
[20] Ibid., 289.
[21] Ted Spitzmiller, *The History of Human Space Flight* (Gainesville, FL: University Press of Florida, 2017), 191.
[22] Catchpole, *Project Mercury: Nasa's First Manned Space Programme*, 331.

over two days, becoming the last American government astronaut to fly in space alone.[23]

In reflection, Shepard's launch was a ground-breaking event in American history, which opened the door to a new era of American prestige under the Project Mercury. This NASA project was the first human spaceflight program of the United States, and Mercury successfully accomplished its goal of placing a human into orbit and returning him safely back to Earth. The conclusion of the Mercury program gave birth to Project Gemini—NASA's second human spaceflight program—designed to develop deep space travel and docking techniques necessary to navigate the cis-lunar link.[24] Gemini was the middle step of a three-phase process that transitioned from placing men in space to planting American Flags on the moon.

Gemini expanded Mercury's success with a newly designed two-seat spacecraft, first flown by veteran astronaut Gus Grissom and John Young on 23 March 1965.[25] Then, Ed White conducted the first American spacewalk and remained in orbit for four days to evaluate work-rest cycles and eating schedules for long duration flights.[26] The final achievement of the Gemini program happened when Gemini 6 and Gemini 7 completed a rendezvous and remained within a foot of each other for five hours after launching 11 days apart. Gemini 7 held the American endurance record for eight years until it was broken by a 28 day Skylab mission in 1973. Overall, Gemini proved that humans could operate for extended periods of time in space and that astronauts were capable of spacewalking—a requirement to step onto the moon's surface.[27]

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[23] Walter A. McDougall, *The Heavens and the Earth : A Political History of the Space Age* (New York: Basic Books, 1985), 379.
[24] This term denotes the distance between the earth and the moon.
[25] Spitzmiller, *The History of Human Space Flight*, 290.
[26] David Shayler, *Gemini: Steps to the Moon*, Springer-Praxis Books in Astronomy and Space Sciences (London; New York
Chichester England: Springer; Published in association with Praxis Pub., 2001), 140.
[27] Ibid.

The magnum opus of the space program was Project Apollo. Apollo was the third and final phase of the human spaceflight program under President Kennedy's space policy. The first flight of the Apollo era was Apollo Eight, led by astronaut Frank Borman, who demonstrated the human ability to leave Low-Earth orbit and circumnavigate the moon. Ultimately, the mission of the Apollo program was to meet President Kennedy's national goal of "landing a man on the Moon and returning him safely to the Earth before the decade is out."[28] This goal was accomplished during Apollo Eleven when astronauts Neil Armstrong and Edwin Aldrin touched down on the moon's surface with their lunar lander. After planting and saluting an American flag, they explored the surface for two and a half hours collecting rock samples before climbing back into the Eagle lunar module.[29] Demonstrating the skill sets learned from Mercury and Gemini, Armstrong and Aldrin completed a rendezvous with the Command Service Module and docked with fellow astronaut Michael Collins who was observing the Moon from 40,000 feet in orbit.[30]

Like their colleagues of previous achievements, Armstrong and Aldrin returned to Earth as heroes. However, Neil Armstrong and Edwin Aldrin's names would forever be etched in history as the first humans to set foot on another world. This exploratory endeavor is widely acknowledged as the most significant human achievement, and became a historic prestigious event for the United States, the free world, and even transcended to the communists alike. However, it is essential to place this achievement in context with what is also arguably the most expansive global conflict humanity has ever known: the Cold War. Upon stepping onto the lunar surface, Neil Armstrong declared, "that's one small step for man, one giant leap for mankind," but then proceeded to place an

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[28] Mindell, *Digital Apollo: Human and Machine in Spaceflight*, 6.
[29] Spitzmiller, *The History of Human Space Flight*, 407.
[30] Andrew Chaikin, *A Man on the Moon: The Voyages of the Apollo Astronauts* (New York, N.Y.: Penguin Books, 2007).

American flag in the soil.[31] If it was indeed an accomplishment for mankind, perhaps a flag of the United Nations might have been more appropriate. The most accurate explanation of Armstrong's actions is seen through the framework of garnering American prestige, and not by his rhetoric. Jokingly, astro-physicist Dr. Neil DeGrasse Tyson quips that the lack of air outside Earth's atmosphere is a strong yet subtle indication that no flags should be flown there alluding to a notion that there is no place for nationalism in space, even though he supports nationalist efforts to explore space.[32] Admittedly, Armstrong's rhetoric departs from reality in this scenario, but undoubtedly the presence of American flags on the moon generated a high level of prestige for the United States and became one of the most potent public diplomacy tools ever created.

Unfortunately, after achieving Kennedy's goal, American public interest waned significantly in the wake of Apollo 11.[33] Television viewership dropped drastically for the follow-up Apollo 12 landing, and it was only amidst a crisis that public attention turned back to the space program. Potential tragedy stemming from an oxygen problem aboard Apollo 13 forced the crew to abort their mission and return to Earth without setting foot on the moon.[34] Narrowly escaping disaster in Apollo 13, NASA entrusted veteran astronaut and American icon Alan Shepard to lead the return mission to the moon, demonstrating American resiliency to overcome challenges and continue exploring the unforgiving environment of space. However, resting on the laurels of success by already accomplishing Kennedy's goal, combined with a lack of additional public support and an enormous price tag to bear, the Apollo program came to a conclusion on 19 December 1972 with Commander Gene

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[31] Tyson and Lang, *Space Chronicles : Facing the Ultimate Frontier*, 86.
[32] Ibid., 260.
[33] John M. Logsdon, *After Apollo?: Richard Nixon and the American Space Program*, Palgrave Studies in the History of Science and Technology (New York, NY: Palgrave Macmillan, 2015), 48.
[34] Spitzmiller, *The History of Human Space Flight*, 425.

Cernan's Apollo 17 spacecraft splashing down in the South Pacific next to Fiji.[35] While Apollo 11 was the most significant political mission, Apollo 17 was the most significant exploration mission—it holds all lunar records, including the farthest trip on the lunar rover, most time outside the lunar module, most rock samples collected, and perhaps most importantly, the first professional scientist.[36] [37] All records broken along the way became additional elements of prestige, and widened the gap between America's upward trending global standing and the waning of Soviet influence in space.

Soviet Undertones

Aside from landing on the moon, none of the triumphs listed above were truly first accomplishments. Before America launched Alan Shepard into space, the Soviet Union launched Vostok 1 into orbit three weeks prior carrying cosmonaut Yuri Gagarin, allowing the Soviets to combine two grand accomplishments into one: first ever spaceflight by a human and first to achieve Low-Earth orbit. Gagarin instantly became an international celebrity and earned the title "Hero of the Soviet Union."[38] This accolade is the Soviet Union's highest distinction for heroic feats in service to the state and society.[39] Evidence of this lasting prestige is a celebration called Yuri's Night. Yuri's Night is an international celebration held every twelfth of April at over 350 social events in 57 countries to commemorate Gagarin's global milestone in space exploration.[40] This

[35] Eugene Cernan and Don Davis, *The Last Man on the Moon: Astronaut Eugene Cernan and America's Race in Space*, 1st ed. (New York: St. Martin's Press, 1999).
[36] Ibid.
[37] Chaikin, *A Man on the Moon: The Voyages of the Apollo Astronauts*.
[38] Jamie Doran and Piers Bizony, *Starman: The Truth Behind the Legend of Yuri Gagarin* (London: Bloomsbury, 1998).
[39] Bruno Navasky, "Hero of the Soviet Union," *Soviet Documents* (1991).
[40] George Whitesides, "Yuri's Night," World Space Party Foundation, https://yurisnight.net.

celebration is often called the "World Space Party" and continues to bring prestige to Russia every year.[41]

In March 1965, cosmonaut Aleksi Leonov made the first spacewalk in history, beating his American rival Ed White by nearly three months. Averting near disaster, Leonov's pressure suit overinflated from body heat due to physical exertion and he was unable to re-enter his Voskhod 2 capsule. After making the life-or-death choice to release a pressure valve depleting his oxygen supply thereby risking suffocation to decrease the size of his suit, Leonov was finally able to wedge himself back into the spacecraft with less than ten minutes of available oxygen remaining.[42] Aleksi Leonov recorded his personal account in a letter written to his four-year-old daughter a couple days after the mission. In a Soviet public diplomacy effort, this letter was published around the world, attempting to shape the opinion of the international community from the perspective of a Soviet father conquering space in a handwritten letter to his child.[43]

In another Soviet first on 15 August 1962, cosmonauts Adrian Nikolayev and Pavel Popovich flew a landmark mission as the first two humans to rendezvous in orbit from separate spacecraft.[44] Their flights were setting the stage for the Soviet's goal of building a manned space station in Low-Earth orbit. Furthermore, the Soviets sent up the first female 20 years before American Astronaut Sally Ride entered orbit. On 16 June 1963, Valentina Tereshkova orbited the earth a record forty-eight times over three days, more than doubling Gordon Cooper's American record in the final Mercury MA-9 flight the month prior.[45] In yet another first, the Soviet's second female astronaut became the first female to

[41] Ibid.
[42] Aleksi Leonov, "Learning to Spacewalk," *Smithsonian Air and Space* (2018).
[43] Ibid.
[44] McDougall, *The Heavens and the Earth : A Political History of the Space Age*, 455.
[45] Burrows, *This New Ocean : The Story of the First Space Age*, 346-49.

perform a spacewalk in 1982, only month's before Ride's flight as a Soviet "one-upsmanship" of the competition for international status.[46]

Soviet prestige stemmed from the spacepower achievements born in the ideas of Sergei Korolev, the secretive Soviet Chief Designer and mastermind behind the USSR's early successes.[47] His progressive technological vision was to build on previous missions; whether subsequent flights lasted longer, rejoined with other spacecraft, or included a nuanced accomplishment of minor detail. His building-block mindset would advance the Soviet space program to new heights while creating a favorable public narrative for the Soviet Union at the same time. However, it was Premier Nikita Khrushchev and his successor Leonid Brezhnev who effectively sold the Soviet space story to the world through Soviet public diplomacy. By all other metrics apart from the moon landing, the Soviet Union crushed American competition in a tit-for-tat series of accomplishments. In fairness to America's competitors, Soviet political leaders never explicitly stated they were going to land a human on the moon, nor did they give any timeline associated with any of their goals.[48] They were ahead of America by every evaluation measure until the moon landing. In sum, the moonshot was the only trump card America could play to remain in contention for global prestige. The Space Race, with the grand finale of the moon landing played perfectly into President Kennedy's narrative and spoke to an international audience that became the leverage needed to gain international prestige over the Soviets

The Price of Prestige

Chief rocket scientist Werner von Braun's strategic vision for space exploration was more gradual than the audacious political measures of

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[46] Spitzmiller, *The History of Human Space Flight*, 474.
[47] McDougall, *The Heavens and the Earth: A Political History of the Space Age*, 37.
[48] John Noble Wilford, "Russians Finally Admit They Lost Race to Moon," *The New York Times* 18 December 1989 (1989).

Apollo. Von Braun envisioned first putting a space station around earth, then another one around the moon. Both space stations would act as stepping stones for astronauts to span the cis-lunar link before descending to the lunar surface.[49] Werner von Braun's vision was an incremental approach under a moderate timeline, but his scientific expertise was pushed aside for the political urgency of Apollo. In 1952, von Braun published a book titled *Across the Space Frontier* that outlined his original concept. Modules were to be assembled in orbit using smaller payloads and more frequent launches. Von Braun preferred spacecraft to refuel in space because 90 percent of their rocket's energy was expended just to exit the Earth's atmosphere.[50] Initially, von Braun estimated his Low-Earth orbit space station would be complete in 1967, and he estimated the first lunar landing to occur sometime after 1978. This approach was gradual, conservative, and carried the long-term vision of a sustainable space program that would maximize humankind's access and exposure to space.[51] If Werner von Braun had possessed the authority to develop the space program as he envisioned, astronaut Neil Armstrong's famous words might have been "that's one small step for man, one incremental—yet sustainable—step for mankind."

In 1952, von Braun did not imagine the fear that would spread across America when Sputnik launched five years later, sending shock waves of distress over the United States. President Eisenhower was under pressure to respond, and Werner von Braun was forced to abandon his well-planned vision to create ways to get to the moon quickly to serve the ends of Kennedy's policy. No space station, no orbital assembly, no on-orbit refueling. This modified approach was made in haste, crippling a sincere desire to support human space exploration. According to von

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[49] Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War*, 1st Vintage Books ed. (New York: Vintage Books, 2008).
[50] Wernher Von Braun and Cornelius Edited by Ryan, *Across the Space Frontier* (New York,: Viking Press, 1952).
[51] Catchpole, *Project Mercury: Nasa's First Manned Space Programme*, 418.

Braun after retiring from NASA in 1972, Project Apollo flew to the moon for the wrong reasons and employed the wrong methods.[52] President Kennedy later admitted that he was personally "not that interested in space" and sought space not because it was easy, but because it was an expedient to gain prestige.[53] The need to get flags and footprints on the moon in order to broadcast images over television screens in America as quickly as possible replaced von Braun's more balanced strategy of incrementalism. Instead of reflecting on the moon landings as a wondrous progression of humanity, von Braun viewed American nationalism flexing its muscle out of fear from the Soviets. After security, concern for prestige was the secondary controlling factor dominating the context of the Cold War.

The Shift of Prestige: From Competition to Collaboration

There were two main turning points in Old Space that shifted the notion of prestige away from competition and towards collaboration. These events were the termination of the Apollo program and the Soviet space station mishaps. Occurring almost simultaneously, these events marked a change America's concern for national prestige. With the Space Race over, prestige was no longer viewed through the lens of national identity. Resultantly, the Salyut One tragedy opened up a new opportunity for international cooperation and bilateral prestige. This new form of prestige was made possible through the maturation of the Soviet and American political relationship. This maturation stemmed from the conclusion of the Space Race and the Salyut One mishap.[54]

With the closing of the Space Race, Project Apollo has been a spike of technological achievement unable to sustain continued space progress;

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[52] Ibid., 420.
[53] Megan Garber, "Kennedy, before Choosing the Moon: 'I'm Not That Interested in Space'," (2018).
[54] Burrows, *This New Ocean: The Story of the First Space Age*, 509-10.

a hollow expression of American exceptionalism. In the aftermath of Apollo, the Skylab project returned attention to von Braun's original vision of establishing a space station in Low-Earth orbit. Von Braun had long pushed for a classical rotating wheel design that would produce gravity similar to Earth's gravitational environment.[55] However, lack of funding in a post-Apollo era stifled this design. Knowing they had to make use of Apollo's remaining equipment, engineers decided to gut the interior section of an upper-stage Saturn V rocket and use the exterior as a housing shell for the Skylab space station.[56]

Moonwalker Pete Conrad led the first crew of three astronauts on 25 May 1973 for a record twenty-eight days in orbit. Two more crews of three would follow over the next year, racking up 171 cumulative days in space, producing a wealth of research on the long-term effects of prolonged spaceflight on the human body.[57] Skylab became the first American space station in orbit and was mothballed in orbit during its last visit in 1974 for five more years. Unfortunately, no inhabitants returned before the program was canceled and Skylab was cut from NASA's budget. With no reason to keep it in space, Skylab re-entered the atmosphere burning up over Australia upon reentry.[58]

Skylab was not the first space station in orbit. Again, this claim would go to the Soviets, who launched their version of a human space station to orbit on 19 April 1971—almost two years ahead of Skylab. This station was called Salyut One, meaning "Salute" in Russian, which was military parlance that helped fuel the fear that the Soviets were planning on weaponizing space.[59] Not only was this the first space station in orbit, but it was also the most massive object either nation had sent to space at the time. The Soyuz 10 mission brought the first cosmonaut crew to the

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[55] Neufeld, *Von Braun: Dreamer of Space, Engineer of War*.
[56] Spitzmiller, *The History of Human Space Flight*, 459.
[57] Burrows, *This New Ocean: The Story of the First Space Age*, 443-44.
[58] Spitzmiller, *The History of Human Space Flight*, 464.
[59] Burrows, *This New Ocean: The Story of the First Space Age*, 444-45.

station four days after its launch on 23 April 1971. The cosmonauts failed to dock with Salyut 1 after experiencing problems with the Soyuz attitude control gyros.[60] The crew was forced to abort the mission after three days and returned to Earth without entering the new space station.[61]

The follow-up mission experienced failure as well, this time ending in a fatal tragedy for all three cosmonauts and a marring of Soviet prestige. Soyuz Eleven launched a backup crew that replaced the primary crew only days before the launch due to an illness of one of the cosmonauts. After a successful docking this time, the backup crew was able to enter the Salyut, but experienced environmental life support problems as the station had been vacant for over two months. The crew sensed an acrid smell and an electrical fire ensued which consumed much of the station's interior. After frantically retreating to the Soyuz capsule, the three cosmonauts remained there until the smoke dissipated. Returning to Salyut to find the source of the smoke, the cosmonauts were able to isolate and cut a faulty electrical line.[62] After 23 days in orbit, they prepared to leave but were unable to achieve a good pressure seal on the main hatch of the Soyuz. During the breakaway and reentry back into the atmosphere, cabin pressure dropped in the capsule, and all three cosmonauts suffered from depressurization resulting in their blood rising to a boil. Upon landing, corpses in the capsule were found with blood emanating from their eyes and ears. Resuscitation efforts were unsuccessful; all three had perished sometime during re-entry.[63] Attempting to keep this blunder quiet, the Soviets continued on a downward spiral away from prestigious sentiment while the Americans soared on the surface of the moon.

The first Soviet space station effort resulted in a tragedy. However, it did nudge the Soviets to collaborate with the Americans. It also marked

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[60] Spitzmiller, *The History of Human Space Flight*, 457.
[61] McDougall, *The Heavens and the Earth: A Political History of the Space Age*, 430.
[62] Burrows, *This New Ocean: The Story of the First Space Age*, 509.
[63] Spitzmiller, *The History of Human Space Flight*, 457.

a turning point in America's concern for national prestige. With the Space Race over, prestige was no longer viewed through the lens of national identity. The Salyut 1 tragedy opened up a new opportunity for international cooperation and bilateral prestige. This new form of prestige was made possible through the maturation of the Soviet and American political relationship. This maturation stemmed from the conclusion of the Space Race and the Salyut 1 mishap.[64]

Handshake in Space

With the contest for the moon now over, the United States symbolically declared victory publicly and switched from competition to collaboration with the Soviets. Following a détente with the Soviet Union in 1973 that led to the first Strategic Arms Limitation Treaty, President Richard Nixon proposed the Apollo-Soyuz Project to the Soviets as another political initiative to symbolize a warming of the relationship between the two countries.[65] American space strategy had now flipped, following a decade-long struggle to tame the hostile environment of space as a unilateral actor in a competitive environment. A new perspective of working together now emerged with America hoping to combine efforts and learn more about Soviet technology and their respective methods of best practice. By 1973, Soviet technology was well behind that of the United States as they discontinued further innovations beyond the basic Soyuz capsule. Cautiously, there was consternation on behalf of the Soviets to not lose more credibility in the eyes of their former competitor. Conversely, the Soviets also had reasonable incentive to learn from the American space program to improve theirs. In the end, this invite was welcomed as an opportunity for the Soviets to modernize their systems by learning from American procedures.[66]

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[64] Burrows, *This New Ocean: The Story of the First Space Age*, 509-10.
[65] Ibid., 447.
[66] Ibid., 448.

On 15 July 1975, Soyuz Nineteen launched from Baikonur Cosmodrome with Aleksi Leonov and Valeri Kubasov. The partnering Apollo mission launched the same day with Commander Tom Stafford at the helm and mission specialists Deke Slayton and Vance Brand as his crewmates.[67] After two days of orbital maneuvering, American and Soviet spacecraft docked together for the first time and opened the hatchway to shake hands in orbit before worldwide live television audiences. This symbolic gesture was the result of three years of close cooperation between two former rival space nations and is primarily seen as the most symbolic gesture of Nixon's rapprochement with the Soviets.[68]

While relations cooled after this engagement, it demonstrated that the two countries had both the capability and political will to collaborate on space exploration in order to create mutually beneficial prestige for both countries. Following this final Apollo event, NASA's human space activity went dormant. NASA experienced a lull in human space activity for the remainder of the 1970's as financial support continued on a steady downward trajectory, while plans for a partially reusable Space Shuttle were still underway.[69]

Enter the Shuttle

The notion of prestige evolved again with the introduction of the Space Shuttle. The United States sought more pragmatic reasons to lift humans to space and opened the aperture of collaboration to include a host of international partners. The first Space Shuttle flight was initially scheduled to launch in 1979, commensurate with the termination of the Skylab program. However, the launch was delayed another two years to fix a vibration in the nose of the orbiter during static-fire testing of the rocket

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[67] McDougall, *The Heavens and the Earth : A Political History of the Space Age*, 431-33.
[68] Spitzmiller, *The History of Human Space Flight*, 444.
[69] T. A. Heppenheimer, *The Space Shuttle Decision: Nasa's Search for a Reusable Space Vehicle*, Nasa Sp (Washington, DC: National Aeronautics and Space Administration, NASA History Office, Office of Policy and Plans, 1999), 331.

engines.[70] Exactly 20 years after Yuri Gagarin's first flight, veteran moonwalker John Young and astronaut Robert Crippen, on his first space flight, launched into orbit on 12 April 1981.[71] Accepting increased risk, NASA opted for the first launch of the Shuttle to be occupied by humans. This decision was an unprecedented step in spaceflight history and is a testament to the effectiveness of modern simulation and courage of the crew (while subtly overshadowing Soviet accomplishments by scheduling this inaugural Shuttle flight on the same day as Gagarin's flight). While this manned launch bore more risk and seemed contrary to NASA's previous risk-mitigation methodology, NASA was looking to regain prestige for its new program after a six-year hiatus following the high standards of Apollo.

Young and Crippen remained in orbit for two days, checking various systems on board the spacecraft and verifying the operation of the payload bay doors.[72] The operational design of the Shuttle was created around the payload bay; it was conceived to serve as a low cost, reusable space truck to ferry modules to the International Space Station. Human spaceflight had progressed a long way in 20 years, and the Shuttle would open up a pathway to regain prestige and increase human space activity. However, in the absence of a rival competitor, motives for space exploration had become more pragmatic by this point.

President Reagan sold the idea of a Shuttle Transport System to the American public as an easy access, high frequency vehicle that would visit space multiple times a month.[73] The Shuttle serviced a long list of customers. Everyone from military, commercial enterprise, partner nation space agencies, and NASA's scientific research branch all muscled for real

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[70] Rowland White, *Into the Black: The Extraordinary Untold Story of the First Flight of the Space Shuttle Columbia and the Astronauts Who Flew Her* (New York: Touchstone, 2016), 221.
[71] Ibid., 265.
[72] Ibid., 276.
[73] Heppenheimer, *The Space Shuttle Decision: Nasa's Search for a Reusable Space Vehicle*, 408.

estate inside the payload bay. The demands on the Shuttle expanded the astronaut corps, with the class size growing greater than previously seen. As a result, the Shuttle was responsible for launching the highest number of humans to space, launching up to 60 astronauts in space during its peak year in 1985.[74] Unfortunately, the tragic accidents of both the *Challenger* and the *Columbia* would stifle the program, requiring extensive safety investigations and modifications before returning to flight in 1987 and 2004, respectively.

The most remarkable feat of the Space Shuttle was the construction of the International Space Station. This effort is a continuation of the Apollo-Soyuz concept, aiming to increase international prestige by including a coalition of willing and credible space partners. The International Space Station is the largest orbital construction project ever built with the purpose of creating a permanent human habitation in space.[75] When the Space Shuttle returned to flight in 2004, President Bush stated "the Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station."[76] Approximately the size of a football field, the International Space Station is comprised of modular components from 15 partner nations and is tied together by a complex set of legal, political and financial agreements between the nations involved.[77] This international cooperation is a sign of multi-lateral interdependence and high-level prestige that represents a marked contrast from the unilateral beginnings of the Space Race. Returning to von Braun's original idea of a more gradual approach to space exploration that starts with a station in earth's orbit, NASA asserts the

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[74] White, *Into the Black: The Extraordinary Untold Story of the First Flight of the Space Shuttle Columbia and the Astronauts Who Flew Her*, 189.
[75] W. Henry Lambright, *Space Policy in the Twenty-First Century*, New Series in Nasa History (Baltimore: Johns Hopkins University Press, 2003), 123-24.
[76] Robert Frost, "Why Did Nasa End the Space Shuttle Program?," *Forbes Magazine* 2014.
[77] Elizabeth Howell, "International Space Station: Facts, History & Tracking," *Human Spaceflight* (2018).

International Space Station is a necessary increment in research for deep space exploration that requires extended human duration in space.

Thirty years after its maiden flight, STS-135 marked the last flight of the Space Shuttle program, touching down at Cape Canaveral, Florida on 21 July 2011.[78] Carrying three other crew members, Commander Chris Ferguson successfully delivered the Raffaello logistics module to the International Space Station onboard Shuttle *Atlantis*.[79] This final trip signified not only the termination of the Shuttle program, but the completion of the International Space Station. Although authorized by Congress, the last Shuttle mission did not receive funding appropriation until three months before the flight, requiring NASA to husband financial resources for the aging orbiter from other programs as it did not receive additional funding from Congress. In the end, the Space Shuttle fleet was getting old; the limited resources and the workforce dedicated to human space flight were transitioning to the Shuttle's follow-on Constellation program. The Constellation program was intended to return humans to the moon with a crewed flight to Mars as the ultimate goal. In total, the Space Shuttle program supported 30 years of space travel, which is about twice the expected lifespan that was initially envisioned.[80]

Reflecting on Old Space Prestige

Prestige during the Old Space era, in retrospect, is most analogous to soft power. Soft Power, a term coined by Harvard professor Joseph Nye in 1980, is the "ability of a nation to influence other countries by obtaining desired outcomes through means of attraction rather than coercion."[81] The potency of a country's soft power rests on its resources of culture,

[78] "Atlantis: Last Space Shuttle Launch," *History, Tech, and Spaceflight* (2018).
[79] Ibid.
[80] Spitzmiller, *The History of Human Space Flight*, 541.
[81] Nye, *Bound to Lead : The Changing Nature of American Power*.

values, policies, and accomplishments of those policies.[82] Furthermore, soft power is the ability to shape the preferences of other nations through appeal and magnetism in such a way that is non-forceful, changing the social and public opinion of citizens of other countries. This soft power projection attracted many non-aligned countries toward American hegemony and worked to shape the world in a way that was advantageous for the United States.

In short, soft power is public diplomacy at its finest. The best aspects of public diplomacy and strategic messaging lead to high levels of credibility, and ultimately, prestige. The policies of Old Space set forth accomplishments that built a credible platform for public diplomacy. As a result, the strategic messaging of the United States communicated the merits of western democracy and swayed other countries to favor America over the Soviet Union. It is important to note that the Soviets also sought soft power to increase prestige, and for a significant part of the race, had moderate success. The historical account of Old Space achievements mentioned above best serves as supporting evidence that asserts the Space Race was a high-level victory for American public diplomacy. America retained a high concern for prestige in the 1960s, which was underwritten by idealistic motives to prove that capitalism was a better model for the world compared to communism. Over time, this idealistic drive has shifted to a more pragmatic approach, seen by the Apollo-Soyuz project and the space shuttle program.

New Space Prestige

Prestige in New Space is quite different from its former framework. New Space is primarily driven by profit motives, which is quite different than placing prestige as priority. This section investigates how New Space

[82] Bill Callahan Callahan, "Mearsheimer Vs. Nye on the Rise of China," The Diplomat, https://thediplomat.com/2015/07/mearsheimer-vs-nye-on-the-rise-of-china/.

utilizes prestige to gain profit such that prestige in and of itself is not a desired outcome, but a *means* to a characteristically different end. Is this really prestige? Perhaps the key difference is observing the nationalistic drives toward human spaceflight in Old Space compared with socioeconomic gains in New Space.

In 2004, Scaled Composites won the 10-million-dollar Ansari X-Prize, garnering prestige to owner Burt Rutan as he triumphed over tough competition from rival companies. The Ansari X-Prize prize was awarded to the first non-government entity to launch a reusable spacecraft past the Karman Line and then repeat the flight within two weeks, demonstrating the spacecraft's reusability.[83] Scaled Composites' victory marked a watershed moment in human spaceflight history. Scaled was the first private company to reach the edge of the atmosphere without any government assistance. This achievement etched the first mark in New Space.

New Space is ushering in the dawn of an era that encompasses the globally emerging private spaceflight industry. This new framework for space exploration operates independently of direct government oversight and is driven mainly by commercial market forces.[84] New Space is fundamentally a disruptive force, revolutionizing the methods and notion of prestige that motivates humans to achieve space access. Concern for prestige in New Space has transitioned space activities within the United States from an idealist stance to an even more pragmatic approach than the Space Shuttle. No longer is prestige a concern on a national or international level. This shift redefines prestige in space exploration down to the entrepreneurial level, opening doors for a refined posture of human space travel.

[83] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 216.
[84] Ibid., 200.

New Space exploration is driven primarily by pragmatic reasons, relating to practical affairs that will become more common as the private space industry continues to grow. Pragmatic explorations are more easily justified by private companies compared to idealistic explorations. According to Dr. Randall Gordon, pragmatic explorations focus on exploiting domains for a more practical advantage and feature resourcing efforts that are sufficient to accomplish a repeatable, profit-making task.[85] This quality helps companies to feature reasonable technological development in a permissive environment with no direct competition. Similar to idealistic exploration, pragmatic exploration will also feature a clearly defined objective and desired end state to justify such a venture.[86]

The Scaled Story

At 47,000 feet, test pilot Brian Binnie released the rocket plane *Space Ship One* from the ventral side of the jet-powered carrier aircraft called *White Knight One*. This mothership was designed to bring *Space Ship One* up to the edge of the atmosphere. Flying the rocket plane below, Mike Melville ignited the motor that would launch his craft into space, pressing his back into the seat pan with a force of two and a half gravitational units. On 21 June 2004, Melville pitched the spacecraft up to eighty-five degrees nose high and launched out of the Earth's atmosphere on a trajectory that coasted him to an apogee of 337,700 feet, crossing the Karman Line by 10,000 feet.[87] Having enough time to enjoy the ride for just a second, Melville tossed up a handful of M&M's from his pocket to verify the weightlessness of his environment in front of the cameras mounted inside his craft. While in space, he took a few photographs outside the arachnid-designed portals of Space Ship One

[85] Randy Gordon, "Voyaging Beyond the Pillars of Hercules: a Model for the Future Role of Human Spaceflight Exploration in US Grand Strategy." PhD diss., Air University, 2013, 76.
[86] Ibid.
[87] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 206.

looking down at earth. Mike Melville returned to Mojave Spaceport as the first commercial astronaut in front of a crowd of tens of thousands, becoming the only pure civilian pilot to reach space via a private enterprise.[88]

To win the Ansari X-Prize, Scaled Composites had to repeat this achievement a second time within two weeks. Astronaut hopeful Brian Binnie was called to command *Space Ship One* for its second spaceflight to secure the prize. On 4 October 2004—the 47th Anniversary of launching Sputnik 1—Binnie was released from White Knight, again at an altitude of forty-seven thousand feet. Binnie repeated the profile but did so achieving a new height and speed record. One minute into the flight, Space Ship One exceeded Mach three, which was a record for any civilian aircraft to date, and climbed to an altitude of 367,500 feet breaking the record set by Air Force pilot Joe Walker in the X-15 over 40 years ago.[89]

Binnie returned to a more massive crowd than Melville, complimented by the most viewed live webcast in history. This moment connected people all over the world to an event in yet another unifying moment of technological determinism.[90] While more practical than Apollo or the Space Shuttle, Rutan was still able to garner a significant amount of prestige on a more localized level. For Rutan, concern for prestige was postured toward his company amidst stiff competition in the private sector. Scaled Composites won the ten-million-dollar Ansari X-Prize, and Rutan's company ultimately earned a highly coveted sponsorship with Virgin Galactic founder Richard Branson. This prestige has a cascading effect in the business sector, as Richard Branson is now in the process of building a spaceport in Las Cruces, New Mexico with the goal of flying commercial passengers from continent to continent through sub-orbital

[88] Ibid., 211.
[89] Burrows, *This New Ocean: The Story of the First Space Age*, 306.
[90] Erika B. Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," *Industrial Research Institute* 895, no. 11 (2011): 33.

spaceflight. Building upon Rutan's success, Branson's goal is to reduce the required travel time to anywhere on the planet to less than 45 minutes.[91] In sum, Burt Rutan demonstrated that human spaceflight is accessible through private measures, and there is a concomitant level of associated prestige as a result of his efforts. A similar push to expand space access through the private market is seen with another company called Space Adventures.

Russian Space Adventures

To date, Melville and Binnie are the only two astronauts to fly into space under the New Space construct. Space still symbolically represents the final frontier, offering the ultimate in technological and social prestige. However, national and international prestige are no longer attached to human spaceflight, as the notion of such honor is migrating into the private sector. Arguably, Russia was the first nation to embrace the commercialization of human spaceflight when it allowed an American space tourism company called Space Adventures to purchase space flights inside their Soyuz capsules.

Since 2001, wealthy individuals can now secure a seat on Soyuz spacecraft by going through the brokerage liaison of Space Adventures. A Virginia based company founded by Eric Anderson in 1998, Space Adventures offers orbital spaceflights with the option to participate in a spacewalk for a hefty price.[92] Russia began to accept payments for reservations of their third seat inside the Soyuz capsule not necessarily out of goodwill or in the spirit to democratize space, but out of desperation to create much-needed revenue for their financially desperate space program.

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[91] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*, 307.
[92] Eric Anderson, "Space Adventures," http://www.spaceadventures.com.

On 28 April 2001, entrepreneur Dennis Tito became the first private citizen in history to use his own money to pay Russia for a space flight. Tito is an American citizen who spent his career working for NASA as an orbital analyst and became frustrated by the bureaucratic dogma of his agency. After retiring, Tito created computer algorithms once used for orbital mechanics and transformed them into a sophisticated financial investing system that made him a multi-millionaire.[93] Using a portion of his earnings, Tito decided to fulfill a childhood dream and become an astronaut.

Originally stemming from a desire to experience spaceflight firsthand, Tito became an advocate for the broader implications of his historic privatized pioneering mission. Tito viewed his flight as a way of democratizing space for private citizens, developing the enthusiasm for other people to follow in his footsteps and open up space to the general public.[94] Tito also wanted to convey the openness of the Russians to this idea citing their willingness to cooperate, while criticizing NASA as still unreceptive to space tourism by operating under an Old Space construct. Tito flew to the International Space Station on a Russian Soyuz rocket for a price of 20 million dollars, and remained in space for a week.[95] NASA originally prohibited Tito from entering the American modules of the International Space Station, but Russia sternly reminded NASA the station was an international collaborative effort and that the entire project should remain open to visitors. This flight strained the relationship between NASA and Roscosmos, highlighting NASA's reluctance to accept the fact that human spaceflight was now up for sale. Commercial space entrepreneur Jeffrey Manber summarized Tito's experience by reflecting on the differences between the United States and Russia's space program: "If you wanted to fly for the socialists, you flew with NASA; if you wanted

[93] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 117.
[94] Ibid.
[95] Ibid., 116.

to fly for the capitalists, you flew for the Russians."[96] Indeed, Russia was the first country to inject free-market principles into space by laying the foundation for entrepreneurial companies to follow.[97]

Following Tito, an Iranian-American businesswoman named Anousheh Ansari flew aboard a Russian Soyuz in 2006. Ansari's name symbolized New Space prestige amongst the private spaceflight industry when she sponsored the X-Prize competition by making a 10-million-dollar pledge two years earlier in 2004. The X-Prize was officially renamed the Ansari X-Prize in honor of her sponsorship.[98] When Ansari visited the International Space Station in 2006, she wrote about her experiences in a diary-like blog that attracted widespread attention and reignited public interest across the United States. Ansari was an ordinary person experiencing the grandiose attraction of space exploration for the first time and communicated all of her triumphs and anxieties in a way that resonated with the American public. Through her writing, Anousheh Ansari created one of the most intimate and refreshing depictions of human spaceflight to date, in a book called *My Dream of the Stars: From Daughter of Iran to Space Pioneer.*[99]

Ansari's personal account created a marked contrast from the more stoic descriptions of previous military astronauts.[100] Perhaps unintentionally, Ansari fulfilled the original intent of NASA's Citizen in Space program, creating a connection between non-space professionals in space and humans on Earth. Undoubtedly, Anousheh Ansari was an ambassador for the masses by creating a notion of prestige for space enthusiasts, and her narrative helped democratize space. The attractive

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[96] Ibid., 87.
[97] Ibid., 113.
[98] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 335.
[99] Anousheh Ansari and Homer H. Hickam, *My Dream of Stars: From Daughter of Iran to Space Pioneer*, 1st ed. (New York: Palgrave Macmillan, 2010), 1.
[100] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow : The Path to Private Spaceflight*, 136.

nature of her words tapped into the human spirit that resonated with a broad audience.[101]

Scaled Composites and Space Adventures represent two companies that push for privatization efforts of space, preferring minimal levels of government involvement. Their accomplishments are noteworthy, but the national concern for prestige is quite low in their efforts. Connecting the link between NASA's more idealistic motives and the private sector's pragmatic reasons are two companies that straddle the divide between the public and private sectors. These two companies are SpaceX and Blue Origin.

Enter Elon

Elon Musk's efforts to make human spaceflight a commercial venture are nothing short of astonishing. Servicing the International Space Station ten years after starting a space company from scratch in 2002 is an accomplishment that demands respect from any space expert or enthusiast. SpaceX's Dragon capsule initially delivered cargo to astronauts and cosmonauts in 2012, but Musk's greater goal is to convert the capsule into an astronaut-carrying spacecraft in the near future. Like the Space Race of the sixties and the Ansari X-Prize from 1996-2004, Musk believes that robust competition stimulates the launch market, and the established service providers should not block new entrants to contend for government contracts. Musk is calling for a resurgence of space competition, and is calling for it by provoking established private space companies within the United States.

One of Musk's competitors is the commercial merger between Boeing and Lockheed Martin called United Launch Alliance, or ULA. Not only does Musk believe he has a truly better product than United Launch Alliance, who is the current International Space Station service provider,

[101] Ansari and Hickam, *My Dream of Stars: From Daughter of Iran to Space Pioneer*.

Musk believes in a quest for prestige through a concept called techno-nationalism. According to Dr. Joan Johnson-Freese, techno-nationalism is a measure of prestige that understands how technology affects the society and culture of a nation.[102] This prestige can build stature and perceptions of power that create a greater geopolitical force for the nation that undergoes the efforts to build hi-tech tools.[103] Musk's rockets are the only American rockets that are made entirely in the United States. The workhorse of ULA's fleet, the Atlas Five, uses a Russian-made main engine called the RD-180.[104] Additionally, approximately half of ULA's rocket airframe components are constructed overseas. Even though NASA and the Air Force rely on the Atlas Five, Musk criticizes it as an unreliable vehicle for the United States because the acquisition of its main engine depends on Russian president Vladimir Putin's permission.[105] In sum, Elon Musk criticizes ULA's outsourcing approach as a loss of national spacepower, acting against the best interest of the United States.[106] While New Space is less concerned about national spacepower and even less concerned about prestige, Musk's assertion highlights that astro-autarky is still an important strategic consideration.

It is important to note that Elon Musk is South African by birth, and he chose to become an American citizen when he was 17-years old for the business opportunities presented in the United States. According to Musk, open market capitalism is not obtainable in any other nation, and the business opportunities presented in the United States are truly unique.[107] While Musk is receiving business offers from emerging space

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[102] Johnson-Freese, *Space as a Strategic Asset*, 10.
[103] Ibid., 11.
[104] Brooke Mosley, "RD-180 Engine: An Established Record of Performance and Reliability on Atlas Launch Vehicles," in *IEEE*, ed. United Launch Alliance (Littleton, Colorado2011).
[105] Commerce, Science, and Transportation, *Elon Musk Hearing to the Senate on Open-Market Competition in the Space Industry*, 113th Congress, 2014.
[106] House Committee on Science, Space and Technology, *Statement of Elon Musk, Ceo & Cto Space Exploration Technologies Corp.*, 112th Congress, 2011.
[107] Vance, *Elon Musk: Tesla, Spacex, and the Quest for a Fantastic Future*.

nations around the world, Musk proudly flies the American flag on every Falcon Nine rocket that has left Earth.[108]

If Elon Musk's commercial manned spaceflight model succeeds, the potential increase in the number of humans accessing space could rise exponentially, topping the previous record-setting year of 1985.[109] Using a reusable, two-stage-to-orbit launch vehicle significantly lowers the cost by a ten-fold order of magnitude. Carrying a maximum manifest of seven astronauts with the potential to launch multiple times in a month, SpaceX will finally populate the International Space Station to its fullest capacity and reify commercial opportunities that exist within Low-Earth orbit.

Musk is concerned with national prestige only to the point that it serves his techno-national interests in getting humans to Mars. Looking beyond Low-Earth orbit, Musk plans to colonize Mars and intends to do so within his lifetime. This audacious goal has the potential to garner prestige similar to President Kennedy's moon goal. However, prestige, will not go to a nation in this case. At its most optimistic outlook, prestige will go to all of mankind as such an accomplishment that unifies the entire world, in line with the first words spoken by Neil Armstrong on the moon. A more skeptical perspective surmises that the accomplishment will become a giant advertisement for SpaceX, boosting the status of Musk's company over the status of a nation or any semblance of international cooperation. Either way, the power to create the narrative will lie with the private entrepreneur and not the government.

Entrepreneurial Space Race

Elon Musk's closest competition in the commercial space market is Amazon founder Jeff Bezos. Bezos is a multi-billionaire entrepreneur who built a space company called Blue Origin in 2002, the same year that Musk

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[108] Ibid.

[109] James Davenport, "Space Access by the Numbers," in *Number of Humans Launched into Space* (NASA Archives2001).

started SpaceX.[110] After making a fortune by selling online books, Bezos' business became the largest electronic cloud computing internet retailer in the world. In 2002, Bezos used his wealth to pursue his childhood dream of getting to space. Like Musk, Bezos is working on a reusable, two-stage-to-orbit rocket. His rocket is called the New Glenn, named after the first American astronaut to orbit the Earth, and is planned for servicing the International Space Station. Bezos' sub-orbital vehicle called the New Shepard has already flown to the edge of space. This Vertical Takeoff, Vertical Land initial prototype has a pressurized crew capsule capable of carrying three astronauts to 325,000 feet.[111] Bezos recently bought 165,000 acres of land east of El Paso, Texas where he plans to build a private spaceport, following Branson's Spaceport USA archetype in New Mexico.

Elon Musk and Jeff Bezos are ushering in a new space race. The new race is one of private companies competing for entrepreneurial prestige. SpaceX and Blue Origin represent the most mature private organizations amongst a growing pool of competitive entrepreneurial space activity working to make commercial human spaceflight possible. The organizational prestige that both companies have experienced stems from this competitive climate amongst the private sector. Small innovative teams are working on high-performance space vehicle developments using an affordable business model that may make space a profit-sharing venture, opposed to a sunk cost of government tax dollars. While the official motto of Blue Origin is "Gradatim Ferocitier" which means *step by step, courageously*, Jim Benson asserts that the unofficial entrepreneurial motto of Bezos' company is "if we want space to stay, space has to pay."[112] The corporate culture and technological developments that result in a

[110] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 163.
[111] Ibid., 165.
[112] J. Benson, "The Role of the Private Sector/Entrepreneur in Future Human Space Exploration," *Space Studies* 7, no. 1 (2017): 6.

profit for companies that venture into the space market may eventually result in humans exploring and colonizing space within our lifetime.[113]

Final Words on Prestige

The Old Space paradigm was custom-built to create the desired end state of national prestige. Over time, this had a 50-year slide towards pragmatism. New Space, however, cares not for prestige, but to utilize the notion of prestige as a means to a profit-making end. This chapter argued that prestige, in its purest form, was most salient during the moonshot Space Race of the 1960s. Every human endeavor since then has been a dilution of the prestige sentiment.

If a prime motivation for human spaceflight is to garner prestige at the national level during the Old Space era, then we must be cautious to the ephemeral nature of using space as an extension of politics. President Kennedy pointed out that it was necessary to show that the classical American hero—skilled, courageous, self-reliant—had a role to play in a world increasingly dominated by a competition between capitalism and communism. Kennedy effectively used the western frontier narrative to stir public interest to gain support for this attractive political expression of soft power.[114] Acknowledging the greater political objectives, NASA's first administrator James Webb argued that spaceflight "can and should not be made purely on the basis of technical matters, but rather on the social objectives of putting people into space."[115] Webb, along with Defense Secretary Robert McNamara argued that "it is man, not merely machines, in space that captures the imagination of the world."[116] In turn, the prestige that was so desperately sought after during the Cold War

[113] Ibid., 7.
[114] Mindell, *Digital Apollo: Human and Machine in Spaceflight*, 5.
[115] Ibid.
[116] Ibid.

created a captive audience for public diplomacy to tell the story of American exceptionalism.

Placing footprints on the moon helped communicate the merits of capitalism to the rest of the world—accomplishing this feat was generated by a high concern for national prestige at the time. This quest for prestige was driven by competition created from international conflict and was underscored by nationalistic motives. Concern for national prestige waned over time, spawning a more collaborative approach to human space exploration that generated prestige at the international level. An even more pragmatic approach devolved down to the commercial level, thereby creating the opportunity for a profit motive to emerge.

Now, the responsibility and desire for human space exploration rests with private companies competing to claim a heightened social status associated with their efforts. Prestige has shifted down to a sub-state level. This chapter identified prestige across the idealistic and pragmatic motivations through various human space projects and their motivations for accessing the space domain.

Chapter 3

Sources of Space Innovation: Transforming the Technological Edge

> *I think frugality drives innovation, just like other constraints do. One of the only ways to get out of a tight box is to invent your way out.*
>
> Jeff Bezos

The Origins of Innovation

The origins of innovation in human spaceflight are changing. Strategists solve the paradox between resistance to change and technological progress by cultivating connectivity between inside agencies and outside possibilities. NASA used to dominate the field of space innovation as the sole source of technological breakthroughs in the United States. However, the emerging private space sector is experiencing an increasing amount of credit for making spaceflight more accessible. While NASA's innovative capacity is still active, its influence has become dormant. A new innovation paradigm is emerging to take NASA's place.

This chapter uncovers a discernable shift in innovation sources that make human spaceflight possible, and reveals that a preponderance of innovation activity is moving toward the New Space paradigm. The government has begun to shift its support of innovation toward the private market by directing its research and development dollars to commercially available products. New technologies emerging from the private sector give hope that the United States can return to the forefront of human spaceflight exploration, and successfully transition to a second space age. This chapter asserts that sources of innovation now occur beyond NASA's conventional boundaries, and Space Posture Theory credits the New Space paradigm with these outside innovation opportunities. By supporting this development in New Space, the government is fostering innovation that

occurs beyond the traditional jurisdiction of NASA. First, we must explore the innovation characteristics of Old Space.

Old Space Innovation

Space exploration was once a national will, with full public support behind NASA's efforts to explore humankind's last frontier. In arguably one of the most significant accomplishments in the history of humankind, it took only 11 years from launching the first American into space until Neil Armstrong and Buzz Aldrin placed footprints on the moon. Motivated by a conviction that NASA was responding to a national calling for prestige in the face of an existential threat, this government organization attracted the best engineers, pilots, and top talent across the United States at the time. Apollo Mission Director Gene Kranz recounted NASA's pioneering accomplishments proudly by stating "every single thing we did, we had to innovate the tools, concepts, tactics, and systems to get to the moon."[1]

At the epicenter of space activity, NASA gave the world the most exceptional example of innovation. This government organization found a way to solve the seemingly impossible challenge of landing a man on the moon and returning him safely to earth.[2] As a result, NASA's breakthroughs were a driving force that created prestige and had a lasting influence on society, debatably more than any other innovative endeavor to date.[3] NASA could be credited for creating a sense of unity across the planet for a brief period of time from 1969-1972. NASA generated globalized excitement and awe at their moon landings and the reflective inner-awareness this created for the human race. An obvious demonstration of this united feeling was when Apollo 12 astronaut Alan Bean returned from the moon and went on a worldwide diplomacy tour to

[1] Gene Kranz, interview by Jason Curtis, 2015, Galveston, Texas.
[2] Kennedy, "JFK Moon Speech at Rice Stadium." 12 September 1962.
[3] Merritt Roe Smith and Leo Marx, *Does Technology Drive History?: The Dilemma of Technological Determinism* (Cambridge, Mass.: Cambridge, Mass.: MIT Press, 1994), 2.

communicate his space story. Bean noted that people jubilantly declared "We did it!" rather than saying "You did it!" or "America did it!"[4] Bean's observations are further confirmation that NASA's technological innovations truly shaped the international social environment and united humans around a globally perceived accomplishment.

Now, it has been 45 years since the United States sent its last crew of astronauts to explore the moon, and NASA has been stuck in the wrong innovative orbit. NASA fell from a pioneer of new horizons to a stagnant government bureaucracy, one mainly concerned with its own continued existence. Once a highly sought-after organization, NASA is no longer an innovative risk-taker, nor is it creative. In fairness, bureaucracies don't normally possess the ability to re-invent themselves, but NASA's lack of innovation reveals a true deficit of new ideas and modern technology to support space travel.[5]

Is it right to blame NASA, given the budgetary restrictions it has faced? Perhaps NASA would innovate with more resources, but this chapter highlights that private organizations are even more cash-strapped than NASA, even at NASA's lowest levels of financial support. Bureaucracies exist at the pleasure and will of the government, and self-perpetuation has become a critical organizational goal for NASA. When bureaucracies forfeit influence unwillingly, the purpose of its self-perpetuation is threatened.[6] This is happening right now with regards to the emerging sources of innovation outside NASA's direct control. NASA's resistance to modernization may explain the migration of innovation sources away from government oversight in Old Space to a fresh wellspring currently emerging in New Space.

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[4] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 5.
[5] Johnson-Freese, *Space as a Strategic Asset*, 53.
[6] Ibid., 151.

The Space Paradigm Shift

NASA's human spaceflight division became an old bureaucracy unable to sustain astro-autarky for human spaceflight missions by 2011. The term astro-autarky refers to the quality of a nation-state being self-sufficient in outer space, having the ability to survive and continue space-related activities without external assistance.[7] In NASA's current state, a lack of innovation possibilities eroded any lure of attraction for the nation's top talent. Seven years after the last shuttle launch, there is still no replacement vehicle carrying humans to space in near sight. In *Lost in Space*, author Greg Klerkx calls the Space Shuttle "the Edsel of space transportation," and claims its clumsy development has gobbled precious innovative capacity and money inside the agency.[8] [9] Innovation has stagnated, and NASA's human spaceflight division has simply dwindled. Engineers are now transitioning to the private sector to find jobs elsewhere, fleeing from a system of administration marked by red-tape, budgetary rules, and procurement constraints with a lack of innovation activity to support an outdated top-heavy framework. NASA's Old Space paradigm desperately needs change. Calling for a paradigm shift, New Space gives rise to an alternative space movement that may hold the key to the future of humans in space.[10] This movement may happen with or without NASA.

Paradigm Defined. It is important to define a paradigm before discussing the shift that connects the two paradigms. Ray Kurzweil describes a paradigm in *The Singularity is Near* as "an order of information that fits a purpose—the measure of the order is the degree of how well the

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[7] Author coined this term, borrowing from the base term "autarky" in the context of international relations.

[8] Using the term "Edsel," the author likens the Space Shuttle to the lemon-like car built by Ford in the 1950's. The design of this car was plagued with irrational groupthink and became a failure of organizational output.

[9] Greg Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 1st ed. (New York: Pantheon Books, 2004), 254-56.

[10] Ibid., 96-114.

information fits the purpose."[11] In *The Structure of Scientific Revolutions*, Thomas Kuhn describes a paradigm as a theoretical framework of discipline within which theories, laws, generalizations, and experiments are performed in support of an idea.[12] A specific paradigm, like the Old Space framework, generated significant innovative growth within NASA until its potential became exhausted and it could no longer support innovative ideas to sustain human access to space.

Paradigm Shift Defined. Addressing the concept of a paradigm shift is now warranted. According to Thomas Kuhn, a paradigm *shift* is a fundamental change in the basic practices of a discipline.[13] Kuhn states that "the emergence of new theories is generally preceded by a period of pronounced professional insecurity generated by the persistent failure of the puzzles of [bureaucracy] to come out as they should."[14] For NASA, this insecurity started when funding for Apollo dropped after the moon landing, and worsened when the Shuttle retired. While there was a follow-on government program after Apollo, the future of NASA become more uncertain after Congress cancelled the Constellation project and allotted scant resources to the cheap replacement Space Launch System. The government began to look for more attractive models, moving the focus away from NASA and toward the private sector. This paradigm shift occurred when the emergence of a new paradigm became more attractive than the older model. This exchange is currently taking place as one model is supplanting the other.

According to Kuhn, the innovation crisis forced NASA to look toward the private sector as the new innovation theory "loosened the rules of normal puzzle-solving in ways that ultimately permit a new paradigm to

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[11]Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking, 2005), 38.
[12] Thomas S. Kuhn and Ian Hacking, *The Structure of Scientific Revolutions*, Fourth edition. ed. (Chicago ; London: The University of Chicago Press, 2012), 11.
[13] Ibid., 88.
[14] Ibid., 68.

emerge."[15] In this case, New Space innovation presents a low-cost, lean, and more efficient approach to access space. This shift brings significant changes in methods and intellectual processes that NASA has come to accept, creating a paradigm shift of innovation in the space community.

Today, the framework surrounding human space access differs significantly from the Old Space structure, and innovation is the connecting variable that has enabled both frameworks to become reality. However, the mechanisms and processes by which innovation occurs in each model is different. With the passing of the Shuttle era, the government will no longer possess the capacity to set up its previously tightly integrated management systems that proved useful during the first 50 years of spaceflight.[16] Now, the government has less control over dictating the terms and requirements to access space. In short, the erosion of NASA's bureaucratic ability to provide human access to space created a crisis that spurred the government to look for new methods at a cost acceptable to the public, thus creating the New Space paradigm. This new approach enables innovation to continue on an upward trajectory, even though the transition period has proven to be a turbulent process.[17]

The Innovation S-Curve

An S-Curve represents the *life cycle* of a paradigm, displaying the decay from innovation to stagnation. In an S-Curve, the innovation life cycle generates slow growth during the initial phase. This is due to the learning costs associated with an initial investment of a new idea. After the major lessons are learned from the initial formulation phase, rapid innovative growth happens during the explosive stage. This is followed by

[15] Ibid., 80.
[16] Thomas Parke Hughes, *Rescuing Prometheus*, 1st ed. (New York: Pantheon Books, 1998), 139.
[17] Kurzweil, *The Singularity Is Near : When Humans Transcend Biology*, 43.

a leveling off period as the model matures and stagnation sets in, presiding over future innovation growth as shown in Figure 3 below.[18]

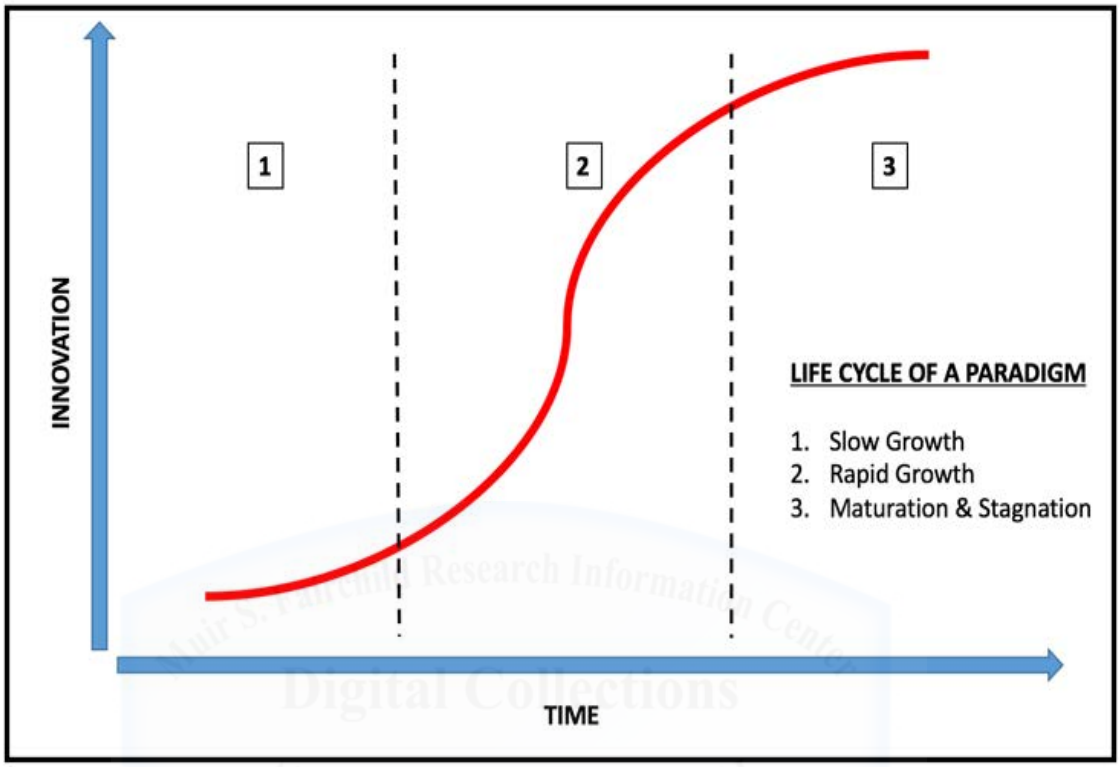

Figure 3: Life Cycle of a Paradigm

Source: Adapted from Ray Kurzweil's Singularity Theory

According to futurist Ray Kurzweil, when a paradigm shift occurs, the complexity of the new paradigm increases significantly as the single S-curves are linked together over time. This ongoing upward trend of innovation is composed of a cascade of increasingly compressed S-curves. Abiding by Moore's Law, each successive curve is happening at a faster rate incorporating heightened levels of complexity. This is shown in Figure 4 below.[19] Kurzweil admits that a paradigm shift is more of an evolutionary process such as in biology—and its continuation through

[18] Ibid.
[19] Ibid.

technology—which represents an increase in systems complexity.[20] This observation further supports the idea that innovation is the intervening variable in Space Posture Theory, as New Space innovation has the benefit of learning from the experience of Old Space innovation. This innovative progression is highlighted in Figure 4 below.

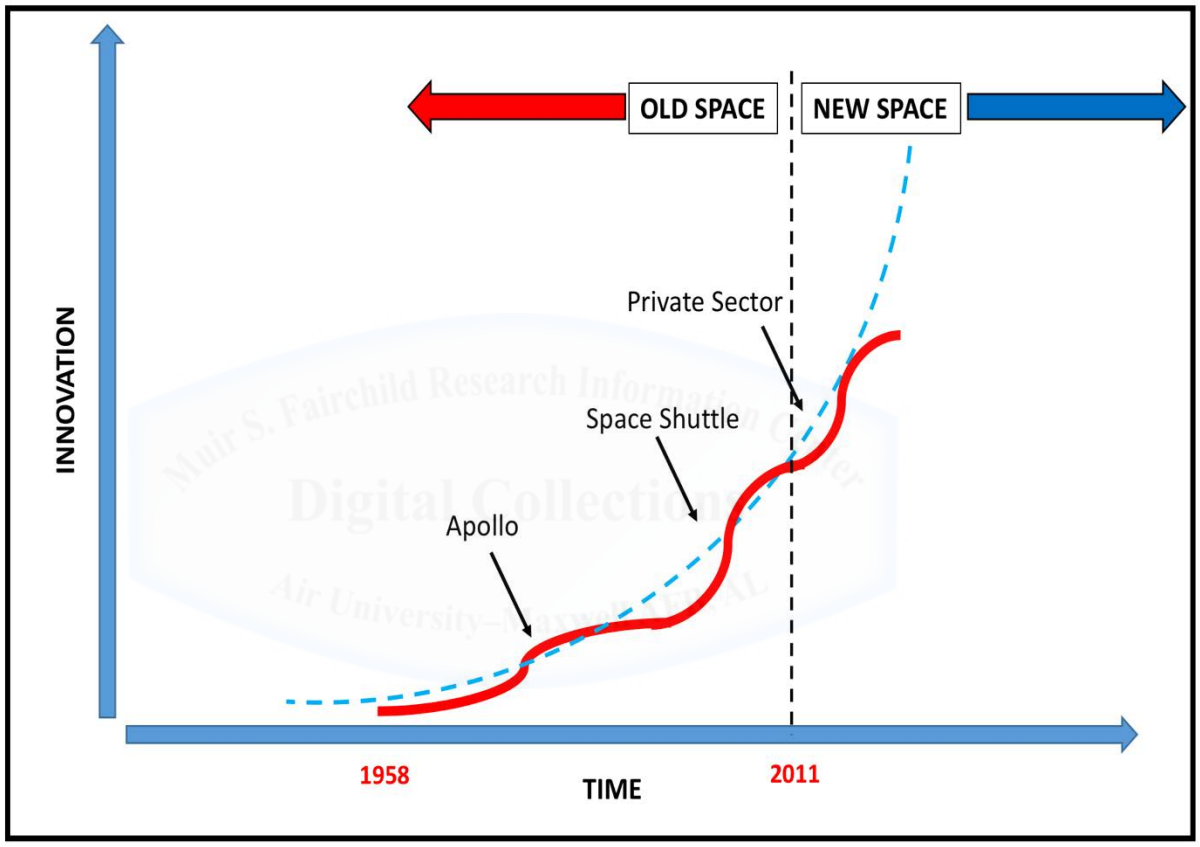

Figure 4: Cascading Paradigm Shifts

Source: Adapted from Ray Kurzweil's Singularity Theory

Looking at Figure 4, an innovation paradigm shift happened twice inside NASA's bureaucracy with the transition from Apollo to the Space Shuttle. Space Posture Theory predicts that the next change will most likely occur outside the realm of direct government involvement, pointing

[20] Ibid., 38.

to a major shift in innovation under the New Space paradigm. This next paradigm shift most likely will take a direction that is not mandated directly by NASA and may lead to results that are unpredictable by the previous historical government case study.

Recognizing when the S-Curve begins to level off as the paradigm matures is squarely in the realm of the space strategist. This realm of diminishing returns represents a calling for change and a need to move away from established practices that exist in a bureaucracy. The leveling off of the innovation S-Curve is important to the government as it may dictate where it chooses to invest its limited financial resources, and help catalyze the emerging shift in posture. One could argue that bureaucratic procedures are designed to produce innovation *inside* an S-Curve, but exogenous crises—like a change in international relations or funding cuts—better predict when an innovation shift will occur *between* S-Curves, requiring a disruptive force to develop a new way to access space.

Understanding the primacy that innovation plays in the future of space access, it becomes clear that NASA must redefine itself to fully embrace this paradigm shift and the new reality of space access. The paradigm shift reveals that NASA must leverage outside innovation. Leveraging outside innovation should become an essential complement to NASA. Incorporating innovative technology from the commercial sector will transform NASA from a supported agency to a supporting agency by upturning the role of customary government centrality. There is little doubt that NASA will continue to exist, but the forefront of space innovation now occurs outside of its centralized model. Arati Prabhakar, the director of DARPA, asserts that the most promising innovations will no longer be found in the traditional government industries. Many technologies of importance to NASA are now driven by the commercial sector and have become a global commodity.[21]

[21] Andrew P. Hunter and Ryan A. Crotty, "Keeping the Technological Edge: Leveraging

New Space Innovation: The Connecting Variable in Space Posture Theory

Innovation is the link between commercial space activities and NASA. This bridge is supported by both entities through a relationship of awareness and access. This relationship gives the private sector an opportunity to incorporate their advancements into NASA's pre-existing infrastructure, while giving NASA the chance to embrace innovative ideas that it would not have come up with on its own. This integration creates a link between the Old Space and New Space postures. The two outcomes value innovation almost equally, and Space Posture Theory credits innovation as the essential variable for both postures. Space Posture Theory highlights innovation as the necessary requirement to transition from one paradigm to the other.

According to researcher Gary Martin, NASA is no longer at the vanguard of innovation for space exploration. Space Posture Theory recognizes this paradigm shift in innovation to New Space as a transfer away from top-down government requirements and toward a blended approach that incorporates the *laissez-faire* economic concept of open market capitalism with the existing government space infrastructure. This new approach to human spaceflight blends the unique strengths of government space experience while leveraging innovative ideas driven by commercial profit-making industries.[22]

Obstacles to Innovation. In 2014, Secretary of Defense Chuck Hagel recognized this tectonic shift of innovation from the government to the private sector by stating "the government cannot assume—as we did in the 1950s through the 1970s—that the Defense Department will be the

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Outside Innovation to Sustain the Department of Defense's Technological Advantage," in *Defense-Industrial Initiatives Group*, ed. Center for Strategic and International Studies (New York, NY
London, UK CSIS, 2015), 10.

[22] Gordon, "The Landmark Space Age Thucydides: Human Spaceflight in the State Grand Strategic Quest to Address Fears, Advance Interests, and Garner Honor" (Masters Thesis, Air University, 2011), 136.

sole source of key breakthrough technologies."[23] Hagel recognized the nation's need to integrate outside sources of innovation into the existing government bureaucracy. Drawing parallels to Hagel's comments about the Defense Department, NASA historically has been responsible for innovating required space technology by utilizing its congressionally allocated budget. NASA continually struggles with its waning financial influence in Congress, receiving high demands to innovate with little funding to support research and development. Consequently, NASA's traditional inward looking innovative construct feels pressure from outside innovation opportunities that now compete for the government's business in space access, thereby forcing NASA to look outward. This change in posture is not typically a welcome shift for established organizations, because bureaucracies struggle to innovate as a result of the dogmatic institutionalization process.[24] Most members of an organization have a stake in the way things are (i.e., the status quo), so the organization itself will rarely sponsor any doctrinal re-organization.[25] In short, re-invention is not the strength of a bureaucracy.

How Innovators Can Overcome Obstacles. Despite institutional hesitancy towards change, NASA must remain relevant and evolve to accept that it may no longer lead all space innovation opportunities. By necessity, NASA must now look beyond its existing framework to construct a metaphorical bridge that connects private sector innovation with government needs.[26] This blended approach is currently ongoing in the emerging New Space posture. Circumstances now dictate an open-

[23] Hunter and Crotty, "Keeping the Technological Edge: Leveraging Outside Innovation to Sustain the Department of Defense's Technological Advantage," 14.
[24] Barry Posen, *The Sources of Military Doctrine : France, Britain, and Germany between the World Wars* (Ithaca: Ithaca : Cornell University Press, 1984), 59.
[25] Ibid., 58.
[26] Colin S. Gray, *The Strategy Bridge: Theory for Practice* (New York, NY: Oxford University Press, 2010), 29.

innovation system that is predominantly shaped by outside innovation in order to re-invigorate NASA's eroding technological advantage.[27]

The Origins of Innovation. In *Keeping the Technological Edge*, Andrew P. Hunter developed a political science model that displays the new relationship between the government's traditional sphere of influence and its sources of innovation in a research project that reveals distinct quadrants of innovation.[28] This model helps explain the migration of innovation away from NASA's direct oversight. Figure 5 denotes a categorization of innovation sources that connects emerging commercial innovations with NASA's traditional sphere of influence. This model is called the "Centers of Innovation Matrix."

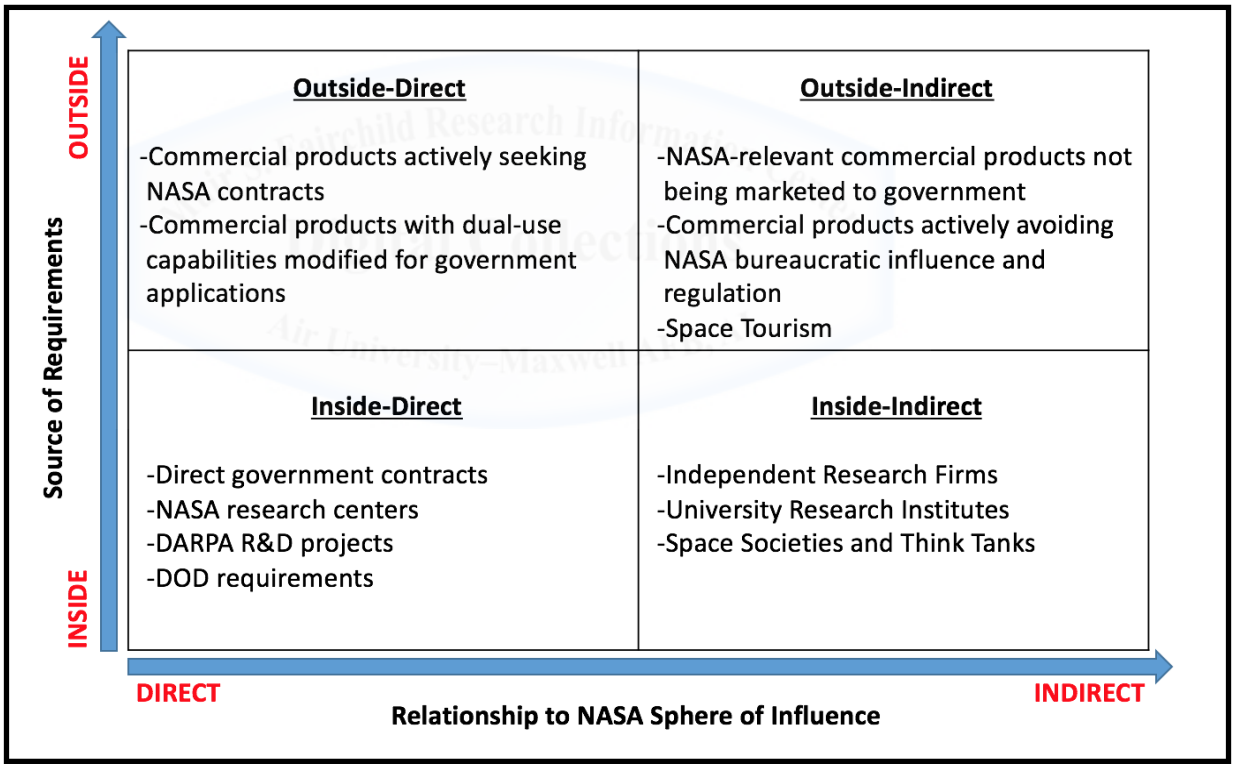

Figure 5: The Centers of Innovation Matrix

Source: Adapted from Hunter and Crotty's "Keeping the Technological Edge."

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[27] Posen, *The Sources of Military Doctrine : France, Britain, and Germany between the World Wars*, 59.

[28] Hunter and Crotty, "Keeping the Technological Edge: Leveraging Outside Innovation to Sustain the Department of Defense's Technological Advantage," 17.

Looking at Figure 5, four categories codify the sources of innovation that pair requirements with NASA's sphere of influence. The quadrants of innovation are 1). Inside-Direct, 2). Inside-Indirect, 3). Outside-Direct, 4). Outside-Indirect. The Centers of Innovation Matrix frames outside innovation in terms of NASA-relevant innovation. The four centers encompass the range of innovation sources in reference to their proximity of NASA's existing innovation center found in the lower-left corner. Each quadrant presents different innovation challenges for NASA, and leveraging the benefits of each center requires different approaches to incorporate their potential value.[29] All quadrants are discussed in the paragraphs below.

Traditional Innovation. The traditional role of NASA's innovation is seated within the Inside-Direct category. Under the sole jurisdiction of the government, NASA's in-house innovation represented an almost closed-system as the core of human spaceflight advancement from 1961-2011. However, NASA outsources some requirements, relying on independent research firms and university laboratories to solve a portion of its access problems. Therefore, the Inside-Indirect innovations are closely linked to NASA's main source of innovation as this quadrant covers requirements established by the government. However, the responsibility rests outside of NASA's direct governmental oversight to find solutions to its problems. In return, research firms and colleges tailor their knowledge base, experience, and research toward NASA's stated requirements.

New Sources. The Outside-Direct center represents private companies actively seeking contracts with NASA, after having already established their own innovative requirements and practices. This sector is increasingly important to Space Posture Theory as an area ripe for leveraging innovation. SpaceX falls squarely into this category as a company that has developed its own indigenous space systems, and is now

[29] Ibid., 6.

bidding for contracts with NASA by competing against the Inside-Direct contracts of United Launch Alliance. An example of this quadrant highlights the partnership between NASA and SpaceX.

On May 24th 2012, SpaceX's Dragon capsule docked with the International Space Station on a mission to carry resupply cargo to the inhabitants. In doing so, it became the first commercially built vehicle to launch a payload into orbit, achieving a milestone that had only previously been accomplished by governments.[30] SpaceX founder Elon Musk reflects on his historic success by claiming that "in the history of spaceflight, only four entities have launched a space capsule into orbit and successfully brought it back to earth: the United States, Russia, China, and SpaceX."[31] Musk's goal is to soon replace cargo with humans in a manned Dragon capsule. This is a perfect example of how space travel in the future might look. The United States is shifting its posture towards increased government support of commercial enterprises.

The Outside-Indirect quadrant represents the sector of space innovation farthest away from NASA's purview. Here, space companies are not actively seeking government contracts, and sometimes these companies avoid NASA's influence on their space operations out of concern that bureaucratic dogma will stifle their agile innovative practices. The Outside-Indirect center is the most challenging sector for the government to leverage, but may offer the highest innovative reward. Scaled Composites founder Burt Rutan is a perfect example of innovation in the Outside-Indirect sector.

Burt Rutan is responsible for some of the most exotic, unorthodox aerospace designs and consequently holds many flight records, including the Ansari X-Prize and the Collier Trophy. The Collier Trophy is presented to those who have made the greatest accomplishment in aeronautics or

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[30] Chad Anderson, "Rethinking Public-Private Space Travel," *Space Policy* 29, no. 3 (2013): 1-4.
[31] *Elon Musk Hearing to the Senate on Open-Market Competition in the Space Industry*.

astronautics in America during the preceding year.[32] Rutan has built a reputation as a maverick by actively resisting the influence of NASA and the Air Force on his company, despite many contract offers from the government.[33] Rutan currently survives by sponsorship and inducement prizes with the hopes of creating a commercial space tourism market with minimum government oversight. However, the tragic crash of Space Ship Two in 2014 may dictate increased government involvement. The accident led many to accuse Rutan of a cavalier attitude towards safety precautions. Aerospace industry leaders have urged Rutan to accept mentorship from the Federal Aviation Administration and larger aerospace companies. Though devastating, the aftermath of this disaster may open the door for a partnership between NASA and Scaled Composites, creating a vital link for NASA's outward looking innovation.[34] Consequently, one might argue that the Outside-Indirect quadrant may get pulled into the Outside-Direct quadrant over time as the industry becomes more regulated. In sum, it remains to be seen whether the Outside-Indirect quadrant can remain independent over time.

The Relationship Between Awareness and Access

Innovation is the connecting link between Old Space and New Space postures. Both outcomes require high levels of innovation. The relationship between the government's awareness of innovative activities occurring in the private sector and the private sector's access to government contracts, funding, and goals is symbiotic. NASA's growth potential is multiplied by leveraging outside innovation, while smaller scale space entrepreneurs gain from government incentives. The relationship between access and awareness is one of mutual interdependence between

[32] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 125.
[33] Burt Rutan, interview by Jason Curtis, 2004, Mojave, California.
[34] National Transportation Safety Board, "In-Flight Breakup During Scaled Composites Spaceshiptwo Test Flight: Aerospace Accident Report," ed. Federal Aviation Administration (Washington, D.C.: National Transportation Safety Board, 2014).

the public and private sectors. NASA's future growth potential lies beyond its established processes of direct government investment, and this requires breaking the bounds of bureaucracy.

Outside-Indirect innovation reveals a challenge as the outermost layer of NASA's core reach. The main issues for NASA are the institutional barriers that hinder awareness of the potential applications of emerging technologies that may help advance human spaceflight. By contrast, these same institutional barriers prevent access to the government from outside companies that might be looking for support from the government. Having awareness of outside innovation should be viewed as an enabling capability for NASA, and not a threat to its existence. Conversely, outside companies seeking partnership with NASA unnecessarily become blocked by regulatory policy, un-flexible methodologies, and a closed-minded culture that hinders access to NASA's decision makers. Strategists solve this problem of insidious resistance to change by communicating the need for technological progress and cultivating connectivity between inside agencies and outside possibilities.

It is common for a large organization like NASA to develop a "not invented here" syndrome, discounting any outside innovation that is not directly tied to institutional needs.[35] This belief stems from a purpose-built organization claiming its needs are so unique that only parochial approaches will work. To cultivate both awareness and access, NASA needs to establish connections between the internal governance structure and the outside realm of innovation. NASA must liaise with non-traditional performers to leverage an aggregate source of the most practical ideas occurring outside of the government.[36]

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[35] Stephen Peter Rosen, *Winning the Next War : Innovation and the Modern Military* (Ithaca: Ithaca: Cornell University Press, 1991), 221.
[36] Board, "In-Flight Breakup During Scaled Composites Spaceshiptwo Test Flight: Aerospace Accident Report," 11.

Identifying opportunities for NASA to develop unorthodox processes with new alliances may help the space agency morph into a more complex-adaptive bureaucracy that appreciates the innovation revolution currently underway.[37] A connective link between public and private ventures may foster risk sharing measures that showcase the value of innovative technology to NASA's less flexible organization. It may be far-fetched to think the government will ever be in a position to accept risk on a level similar to the private sector, but if the government shares the risk, it may be more inclined to partake in innovative ideas. Perhaps that is why such work has typically been done separately, creating two distinct innovative postures. While the public and private sectors are not obligated to be tied together in order to produce results, this partnership reveals a benefit that creates trust between the two sectors by blending the sources of innovation in order to increase space access.[38] Despite the inherent obstacles in connecting the bureaucratic and innovative mindsets, there is a clear path forward for NASA to work with commercial space industry so that both postures can grow together. The commercial landscape has become fertile terrain for space-related innovations.

The Dispersal of Innovation

The change of location for sources of innovation points to a shift beyond the central core of the government. Space analyst Todd Harrison captures this scattering of innovation in *Implications of Ultra-Low-Cost Access to Space*. According to Harrison, the space industry has evolved over the years from an exclusive government endeavor toward a more diffuse market, increasing the levels of commercial activity.[39] Using the Centers of Innovation Matrix to chart the dispersal of innovation over time,

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[37] Todd Harrison et al., "Implications of Ultra-Low Cost Access to Space," in *CSIS Aerospace Securities Project*, ed. Center for Strategic and International Studies (Washington, DC: CSIS, 2017), 13.
[38] Rosen, *Winning the Next War : Innovation and the Modern Military*, 224.
[39] Harrison et al., "Implications of Ultra-Low Cost Access to Space," 14.

the technological developments and their relationship to the government sphere of influence are traced from the origins of human spaceflight to the present day. This progression establishes a trend that predicts what the sources of innovation may look like in the future.

In the early 1960s, NASA borrowed from pre-existing military programs to kick-start its human space program. Using repurposed Redstone and Atlas rockets that were initially designated as military Inter-Continental Ballistic Missiles, NASA converted these military weapons into human-carrying spaceships. From this initial government procurement, NASA subsequently reached out to the greater defense industry for a solution to land humans on the moon. Subsequently, Grumman Aircraft Corporation was awarded the contract for the Lunar Lander. At the time, Grumman built fighter jets under contracts that were considered traditional in the military aviation industry while also servicing the civilian aviation industry as a dual-role aerospace firm.[40] Simultaneously, NASA reached out to the Lincoln Laboratories at Massachusetts Institute of Technology (MIT) to create Apollo's navigation and control system by leveraging engineering expertise from a university.[41] Engineers at MIT's Lincoln Laboratories developed the innovative instrument-based tasks that assisted astronauts in their journey to the moon's surface.[42] Redstone, Atlas, Grumman, and MIT are charted on the Centers of Innovation Matrix, showing the locality of innovation near the center of NASA's direct purview from the 1960s to the mid-1970s.

Figure 6 below reveals the dispersion of innovation across the public and private space sectors. An overall trend in the sources of innovation activity as the progression highlights an important point. While there have been many predictions surrounding the growth of commercial spaceflight since the 1960s, analyzing the empirical data over a 57-year time span

[40] Mindell, *Digital Apollo : Human and Machine in Spaceflight*, 113.
[41] Ibid., 96.
[42] Ibid., 7.

has created a vector for commercial space that is distinct. The preponderance of space activity has migrated away from the Inside-Direct quadrant and has spread towards the upper-right quadrant. This movement is supported by developments in the commercial space market that are often supported by significant government funding and involvement from the remaining two centers. While the rate of this dispersal is not constant nor are the innovations in the private sector fully developed, it is important to acknowledge the subjective inferences of this trend. In *Implications of Ultra-Low-Cost Access to Space,* Todd Harrison asserts that "while it would be foolish to project that the development of the Outside-Indirect quadrant of the space market will grow in a predictable linear fashion from today, it would also seem unwise to ignore the potential offered by developments in this quadrant."[43] Figure 6 below displays the dispersion of innovation in the space industry across four different time slices.

[43] Harrison et al., "Implications of Ultra-Low Cost Access to Space," 14.

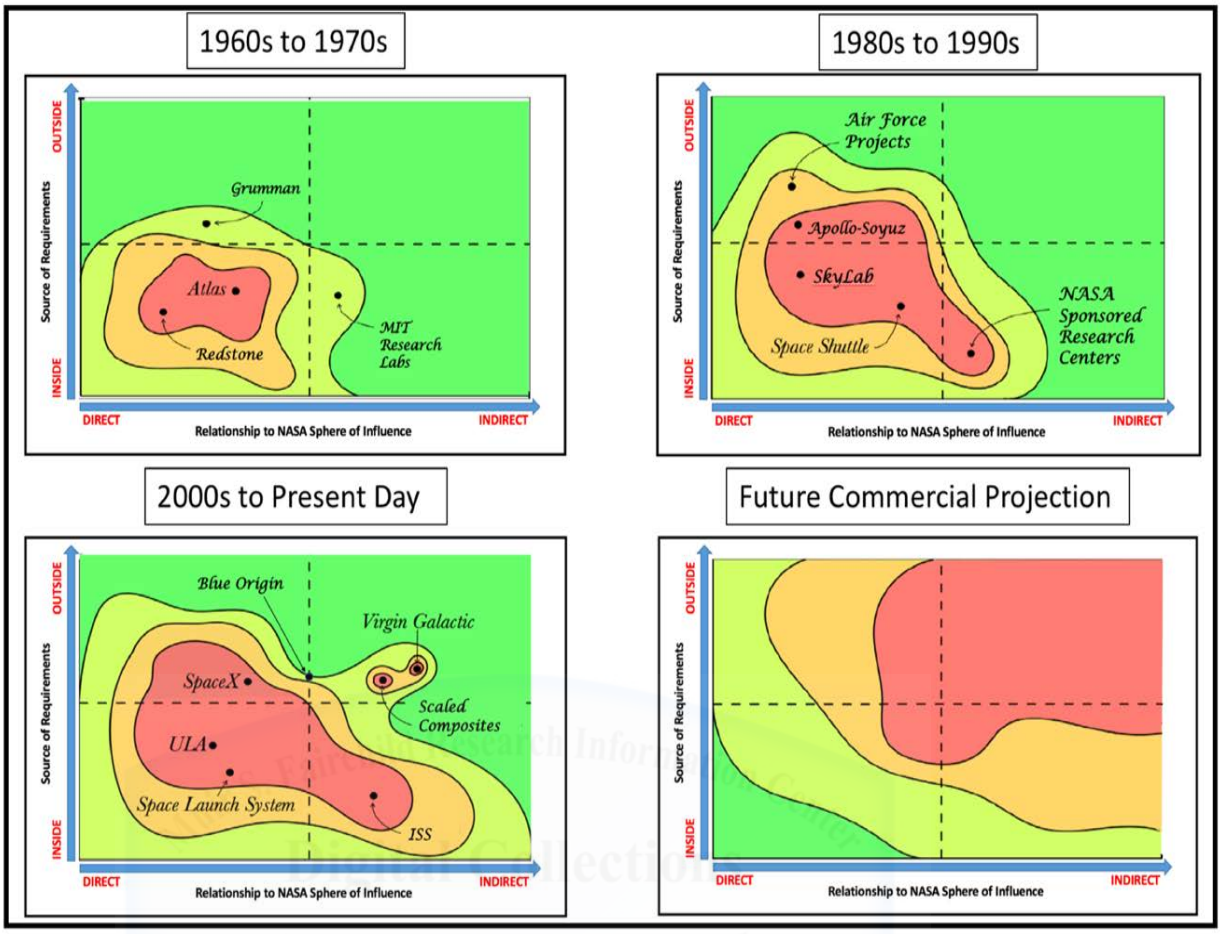

Figure 6: Evolution of the Space Industry on the Innovation Matrix

Source: Adapted from Hunter and Crotty's "Keeping the Technological Edge."

In the four matrices above, each of the colors represent a degree of innovation activity within the quadrants. The higher activity areas are annotated in red, depicting a majority of space innovation within the entire space market. Conversely, the cooler areas are annotated in green, representing fewer overall innovation activity. Tracing the progression of innovation sources, the first three graphs above codify various companies, projects, and entities that have increased human access to space. Taken as a whole, the combination of the three graphs help make a prediction of what might happen if the commercial market achieves an affordable, repetitive, and sustainable model to access space. This is shown in the

fourth graph. This hypothetical prediction is based on supporting evidence from the observed progression starting in the 1960s and extending through to the present day. Looking towards the future, the government will most likely no longer act as a direct market actor by setting the requirements. The government's influence over innovation may become significantly smaller.[44]

Moving to the end of the 1970s, the SkyLab and Space Shuttle programs took place within NASA's direct oversight, but additional space innovation activities began to emerge, creating assets that were developed by outside customers. The Apollo-Soyuz project melded the innovations of the Soviet and American governments, allowing both countries to share best practices in space and develop mating devices that connected the two capsules.[45] Additionally, the United States Air Force generated requirements separate from NASA as it began to develop the Manned Orbiting Laboratory as a successor to the canceled X-20 Dyna-Soar space plane program.[46] Both programs were intended for strictly military applications. The Manned Orbiting Laboratory was an Air Force project that aimed to build upon the innovations from SkyLab and convert them over to serve military purposes.[47] In fact, the Air Force coined the term "aerospace" as a way of asserting more influence in the space domain, attempting to establish primacy over NASA.[48] As further evidence of the Air Force's influence, the size of the Space Shuttle cargo bay was explicitly designed by the Air Force so the Shuttle could carry military intelligence payloads.[49]

NASA research centers also began to accept additional customers. By the 1980s, the ten NASA centers were routinely sponsoring civilian

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[44] Ibid., 15.
[45] Logsdon, *After Apollo?: Richard Nixon and the American Space Program*, 199.
[46] Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 65.
[47] Burrows, *This New Ocean: The Story of the First Space Age*, 257.
[48] Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 65.
[49] Johnson-Freese, *Space as a Strategic Asset*, 214.

experimentation projects that did not necessarily have a direct contribution to its human spaceflight mission. However, these sponsorships indirectly helped grow the body of scientific knowledge required to live in space. NASA's research centers became proprietors for innovation and development, linking government facilities with private efforts. These NASA centers continued to partner with private universities. NASA-Ames and Stanford University are a prime example of this innovation partnership; one that outsourced space-related ideas through the Stanford Research Institute.[50] This is why the NASA research centers are classified under the Inside-Indirect quadrant of innovation. In sum, the Apollo-Soyuz, Manned Orbital Laboratory, X-20 DynaSoar, and NASA research centers are all further examples of the widening aperture of space innovation from the mid-1970s to the 1990s.

Beginning in the 2000s and continuing to the present day, the Outside-Direct and Inside-Indirect innovation sectors have grown significantly. The International Space Station is a multi-lateral partnership and SpaceX is the first private company to service it. While NASA still maintains tight control on the requirements for the International Space Station as the primary sponsor of the project, the funding and influence of the design come from a collaboration of 15 partner nations. However, commercial demands to service the International Space Station became vital as the Space Shuttle is no longer able to service the space station, creating an opportunity for SpaceX and other private companies to fill the void.

The Space Launch System is NASA's attempt at a follow-on design to the Space Shuttle, but the program faces intense public scrutiny after the cancellation of the original Constellation program. This scrutiny, plus the fact that its expendable launch vehicle design cannot compete with

[50] NASA Ames and Stanford University, "Strategic University Research Partnerships," (2018).

other financially attractive options, make the future of this program uncertain. Furthermore, an increasingly smaller number of companies provide space technology exclusively to support NASA's requirements. Such companies now have outside customers and divergent requirements of their own. The rise of commercial space market activities helps balance the stagnation of NASA's Inside-Direct developments.

Demonstrating the rise of the commercial space market sector are companies like Blue Origin, Scaled Composites, and Virgin Galactic. Blue Origin is codified on the Innovation Matrix somewhere between the Outside-Direct quadrant and the Outside-Indirect quadrant. The reason is because Blue Origin is a company that aims to meet the needs of the government as a service provider, while simultaneously developing a private space tourism business. Progressing further in the Innovation Matrix, the Outside-Indirect quadrant has begun to develop as multiple "islands of innovation" devoid of government influence. This area consists of space companies that are not actively seeking government contracts, while sometimes avoiding NASA's influence on their space operations. Scaled Composites, and its heir Virgin Galactic, are two companies that will increase innovation activity in the commercial space market with efforts to build a space tourism business. Overall, the trend for commercial space is a "pulling away" effect from significant government support and involvement. Again, Figure 6 displays this tendency.

Final Innovation Thoughts

In *Winning the Next War*, Stephen Rosen claims that "invention is the creation of a new idea, and innovation is the choice of which ideas to develop."[51] The commercial sector can now generate new ideas *and* work towards implementing the idea into a profit-making venture that may also be beneficial to NASA. However, NASA retains significant influence in the

[51] Rosen, *Winning the Next War: Innovation and the Modern Military*, 222.

human space market because it has the authority to choose which commercial ideas to develop for government purposes, providing a large sum of financial backing to the companies that earn government contracts.

The Old Space paradigm is responsible for many remarkable innovations eventually resulting in American footprints on the lunar surface. NASA set a noble example and successfully achieved its presidentially mandated directive. Now, the paradigm is shifting away from direct government involvement, migrating towards a more diffuse base of innovation across private spaceflight firms in multiple arrangements with and without government involvement. The commercial space sector is ripe for innovation that may create a strategic advantage for the United States if government leadership is amenable to this potential.

To maintain a healthy relationship between NASA's bureaucratic establishment and smaller scale space startups, the prime consideration for the government under Space Posture Theory is to develop partnerships that leverage the best attributes of public and private domains. NASA should harness an open stance towards outside influences and have an awareness of innovation breakthroughs occurring beyond its traditional sphere of influence. Conversely, external innovation should be perceived as a critical complement to NASA's space program, allowing access of commercial technology into the government's central core. If NASA assimilates outside innovation, the power of doing so will create yet another shift towards progress in a New Space paradigm, while keeping government human space activity at a sustainable level.

The countless smaller scale innovations in Low-Earth orbit and near-orbital space are tasks that are perfectly suited for private companies. By creating competition with one another, companies like Blue Origin, SpaceX, and Virgin Galactic can all do extremely well to

increase access.[52] NASA, however, is at its best when it thinks in the long term, provided that national policies allow it to do so. In *Space Chronicles*, Dr. Neil DeGrasse Tyson asserts that NASA is best suited to remain on the frontier of space, wherever that is at the time.[53] As NASA remains on the outer edges where there is no foreseeable return on investment, private companies should handle the tasks in territories that are well mapped out, like Low-Earth orbit.[54] The smaller details of NASA's enterprise are now much better left to the private sector, ideally acting as augmentations to the bureaucracy's greater mission of remaining on the frontier of space.

[52] Branson, *Reach for the Skies : Ballooning, Birdmen and Blasting into Space*, 288.
[53] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 76.
[54] Ibid.

Chapter 4

Funding Space: From Command Economy to Open Market

If we want space to stay, space has to pay.

Jim Benson

Funding Space

Funding for human spaceflight has changed dramatically from the Old Space paradigm to the New Space paradigm. Funding is the last independent variable assessed under Space Posture Theory, but is the variable that has seen the most drastic transformation. This chapter addresses three different funding schemas that have created space access. An analysis of direct government funding, decentralized partnership funding, and detached commercial funding reveals three distinct mechanisms of financial flows that separate the two space postures.

Old Space posture addresses the top-down, government prioritized federal spending of the first 50 years of spaceflight. New Space posture contrasts this top-down structure with the transition to a bottom-up capitalist funding approach. Given the high financial barriers typically associated with human space exploration, the discussion on funding must first address historical examples of top-down funding from governments that have spent massive amounts of wealth towards toward seemingly lavish expenditures.

Commanding Extravagant Resources on a National Scale

The financial barriers for human spaceflight are incredibly high for the moment. To date, only the world's wealthiest nations have been able to accomplish this feat. In the United States, allocating large portions of the federal budget to the space program in the 1960s attracted

condemnation from critics. Such critics viewed humans in space as an extravagant expenditure not worthy of public funds, especially when many other provisional challenges demanded the attention of the government. Such sentiment still exists, making it important to acknowledge. However, it is equally important to understand how governments apportion their wealth and for what reasons.

Security for nations has always been a primary concern and the funding stream for much of the United States' space program has been predominantly defense-driven.[1] The defense budget commanded a lion's share of American non-discretionary funding, helped placate global security concerns during the Cold War, and justified spending large amounts of money on space during the 1960s. Criticism of using precious tax dollars towards this endeavor highlight the reality of widespread poverty, crime, and problem-ridden schools that existed then and continue to exist now. While potential solutions to those problems are beyond the scope of this paper, there will always be critics of large government expenditures, with space exploration becoming a prime target for budget hawks. By packaging the Space Race around security interests and our national prestige, the government was able to justify spending $160 billion a year on NASA during its peak spending timeframe.[2]

Now that the budget for NASA has plummeted and the government can no longer justify the hefty price tag traditionally associated with space exploration, opportunities for economic benefit are arising. As a result, commercial profit represents the prime driver of New Space.[3] Private companies now see the proximity of potential profit from exploiting space to serve government needs at a lower cost, along with tourism opportunities and faster travel times compared to air transportation.[4]

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[1] Ibid., 102.
[2] Logsdon, *After Apollo?: Richard Nixon and the American Space Program*, 40-43.
[3] David Gump, *Space Enterprise : Beyond Nasa* (New York: Praeger, 1990), 182-84.
[4] Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 15-19.

These repeatable and achievable tasks provide an economic incentive to explore space outside the purview of the government, while still reaching for new frontiers in space, like getting to Mars. Wrapping up the discussion on commanding extravagant resources on a national scale, security reasons and economic incentives are the two ways to obtain funding in order to break the barriers of access to space. There are three sub-categories of funding that bring clarity to the Old Space and New Space postures. Direct funding, decentralized funding, and detached funding are the three mechanisms that trace the financial flows that have created assess to space.[5] First up is direct funding.

Direct Funding

Top-down, centralized government expenditures dominated the funding source for space exploration during the Space Race and Shuttle eras. President Kennedy's 1961 moon mandate leveraged the will of the public during the Cold War to create tax revenues that fueled NASA.[6] Because this goal was constrained by time, it seemed most appropriate to set up a centralized command structure, giving the United States a space program that clashed with the traditional American values of capitalism. Instead of cultivating a sustainable free enterprise space industry, the government acted quickly to inject NASA with money to achieve a very specific goal. NASA received funding that provided sunk-cost investments to make a successful landing on the lunar surface by specifically developing an institution and the resources required for unique government needs.[7] This governmental weight of effort became the largest technological and financial endeavor in space history.[8] NASA's budget skyrocketed from nothing in 1957 to over $160 billion in less than ten

[5] Author defined and characterized the terms “direct,” “decentralized,” and “detached.”
[6] Nathan C. Goldman, *Space Policy : An Introduction*, 1st ed. (Ames: Iowa State University Press, 1992), 51-55.
[7] Simberg, "Getting over ‘Apolloism’," 2.
[8] Logsdon, *After Apollo? : Richard Nixon and the American Space Program*, 117-21.

years, commanding more than 4.5 percent of the federal budget in 1967.[9] Tying back to the second way of massing large amounts of state wealth—funding conflicts between nation-states—the fear of being outshined by the Soviets and the security threat this posed overshadowed the enormous cost of propping up a space program. Not surprisingly, the informal motto of NASA during the sixties was "waste anything but time," as money generously flowed out of the government faucet with top priority to NASA.[10]

When significant projects are driven primarily by global conflict, they stand the highest chance of getting funded. Project Apollo was America's answer to the Cold War contest for the moon, and the project had the support of the President, Congress, and the citizens of the United States. While this financial power was arguably inefficiently utilized, Apollo was branded to Congress as a security-related program that would help gain global dominance and prestige for America over the Soviet Union. By viewing space exploration as a security measure, the significance of the space program was elevated to the same level as other defense matters and the high spending became more palatable through the lens of great power conflict.

The Value of Cost-Plus Contracts. Understanding how the government amassed wealth for NASA, it is also important to understand how NASA developed the contracts it awarded to aerospace companies. The government gave birth to a business that created a space-industrial complex to support this new mission. Large aerospace companies like Grumman, North-American, Convair, Rocketdyne, McDonnell Douglas, and Lockheed Martin all received large sums of money through *cost-plus* direct government contracts to support NASA's goal. In business terms, a cost-plus direct contract is “an agreement by the government to reimburse a space industry company up front for services rendered in a dollar

[9] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 333.
[10] Simberg, "Getting over ‘Apolloism’."

amount, including an embedded profit usually stated as a percentage of the contract's full award price."[11] The cost-plus contract pays the industrial firm for direct and indirect costs—otherwise known as overhead costs—before the company provides any level of service. This up-front payment is seed money that is required to undergo large-scale engineering endeavors which might not have a clear solution at the time the contract is awarded.

Cost-Plus contracts are best utilized when time is a factor, and no clear solution exists, requiring a great deal of innovation. Companies must invent solutions to meet NASA's needs at the time of contract signing, without being able to forecast with certainty how the solution will materialize. In cost-plus contracts, strong administrative oversight requires documentation of contractor spending to support all expenses. The potential for a company to manipulate a cost-plus contract is high, leading to a squandering of money and issues dealing with fraud, waste, and abuse. Cost-plus contracts usually state that reimbursement cannot exceed a specific dollar amount to protect against cost overruns, even though overruns frequently occur.[12]

The Damage of Politicians. Another danger of direct funding is the parochial interests tied to congressional districts. Not ironically, powerful politicians created parts of the vast infrastructure of space requirements in their own districts. As a result, NASA's geographically distributed locations are spread across the eight states of the most vocal supporters of space. These space bases were primarily in the southern portion of the United States, politically acting as a counter-balance to the more economically prosperous North. Vice President Lyndon Johnson significantly influenced the location of research centers and launch sites

[11] Scott Glabe, Jennifer Plitsch, and Kathy Brown, "Senator Mccain Renews Focus on Ending Cost-Plus Contracts | inside Government Contracts," *Covington Law Policy* Covington and Burling, LLP (2015).
[12] Juan Rodriguez, "A Guide to Cost-Plus Contracts," *The Balance* (2018).

to bring jobs and spending to America's South, serving constituencies that required a stimulus from the economy.

Texas, Alabama, Florida, and Mississippi were the states benefitting the most from NASA's expenditures. While not the most efficient set-up, these states were the prime benefactors of an intentional distribution of jobs to the South. The epicenter of human spaceflight for NASA, the Johnson Space Center, was established in Vice President Johnson's home state of Texas and continues to bear his name. The high stakes of the Cold War justified this decentralized network to serve specific constituencies while utilizing the government's centralized spending. The arrangement of space centers can quickly be criticized under the domestic agenda that created them in order to achieve an ephemeral goal. However, the remaining infrastructure today looks pessimistically more like a white-collar jobs program.[13]

The Perils of Direct Funding. Unfortunately, the Apollo program was a financial dead end. The fiscal priority given to the space program remained high until Apollo 11, tapering downward drastically after that. Congress initially approved 13 missions to the moon, including ten landings on the lunar surface. Apollo 13 had to abort its landing due to a malfunction during the outbound cis-lunar leg, and Congress cut Apollo 18, 19, and 20 due to decreased national interest.[14] After achieving President Kennedy's political goal with Apollo 11, the security narrative surrounding spaceflight in the Cold War could no longer justify the financial expenditures. The remnants of the Apollo program limped along on a shoestring budget until Skylab was abandoned in 1975, leaving a six-year gap in human access to space until the Space Shuttle's first flight.

The Edsel of Space Transportation. The Space Shuttle appeared to offer Congress a less expensive alternative than the cost-laden Apollo

[13] Simberg, "Getting over 'Apolloism'."
[14] Logsdon, *After Apollo?: Richard Nixon and the American Space Program*, 180.

commitment. Designed to be mostly-reusable, the new Space Shuttle would theoretically drive down costs and significantly upsurge human access to space, increasing frequency of flights and expanding passenger manifests from three to seven astronauts. The only item that was perishable was the centerline liquid-fuel tank. Initially, the launch cost for the Space Shuttle was advertised at $10.5 million per flight. While this was still costly, it was a significant reduction from the days of Apollo. However, lengthy safety inspections and maintenance delays between launches lowered the actual sortie rate and left the Shuttle's bill soaring to over $1.6 billion per launch.[15] Barely weathering the wake of the *Challenger* and *Columbia* accidents, safety problems and cost overruns ultimately led to the termination of the Shuttle program in 2011.[16] Accidents, high costs, lack of public support, lack of compelling mission apart from the International Space Station, and an absence of major security interests ended the program because it no longer received the direct spending money required to continue. Direct government spending was responsible for Apollo's success and the transition to the Shuttle, but direct spending was also responsible for both program's demise.

The Rise and Fall of Direct Spending. Below, Figure 7 shows the government's centralized spending on NASA from 1959 to 2010. This graph displays funding in the actual dollar amount, and also shows direct funding adjusted to reflect constant 2010 dollars. Proportionally, the financial investments for Apollo—including Project Mercury and Project Gemini—dwarf all other fiscal expenditures. Government support for spaceflight is almost directly tied to Congress' purse, with government support for human spaceflight reaching its lowest after reaching the moon, and searching for a new purpose. An uptick in spending is shown by exerting an effort to fix safety problems in the wake of the *Challenger*

[15] Michael Wall, "Nasa's Shuttle Program Cost $209 Billion—Was It Worth It?," *Human Spaceflight* (2018).
[16] Simberg, "Getting over 'Apolloism'."

disaster, and again after *Columbia*. The downturn after 2010 reflects President Obama's cancellation of the Constellation project, followed by a gradual decline until the end of all human spaceflight from the United States.

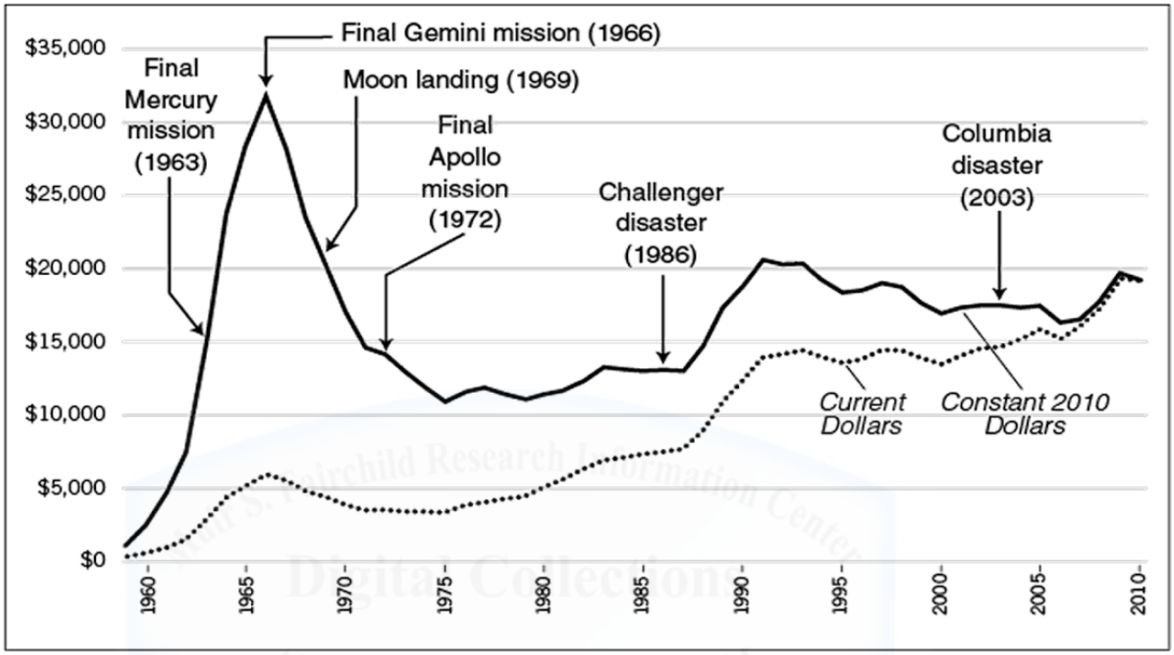

Figure 7: NASA Spending 1959-2010 in Millions of Dollars

Source: Adapted from Dr. DeGrasse Tyson's "Space Chronicles: Facing the Ultimate Frontier

Taking another approach to analyzing a centralized funding construct, Figure 8 below shows NASA's spending as a percentage of US federal government expenditures. This graph overlays a spending curve of NASA's budget in relation to the United States' Gross Domestic Product (GDP). While the relationship between national economic growth and NASA's budget has flat-lined since 1975, the amount of centralized funding has been on a downward gradient since the Space Shuttle *Challenger* accident in 1986.[17]

[17] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 335.

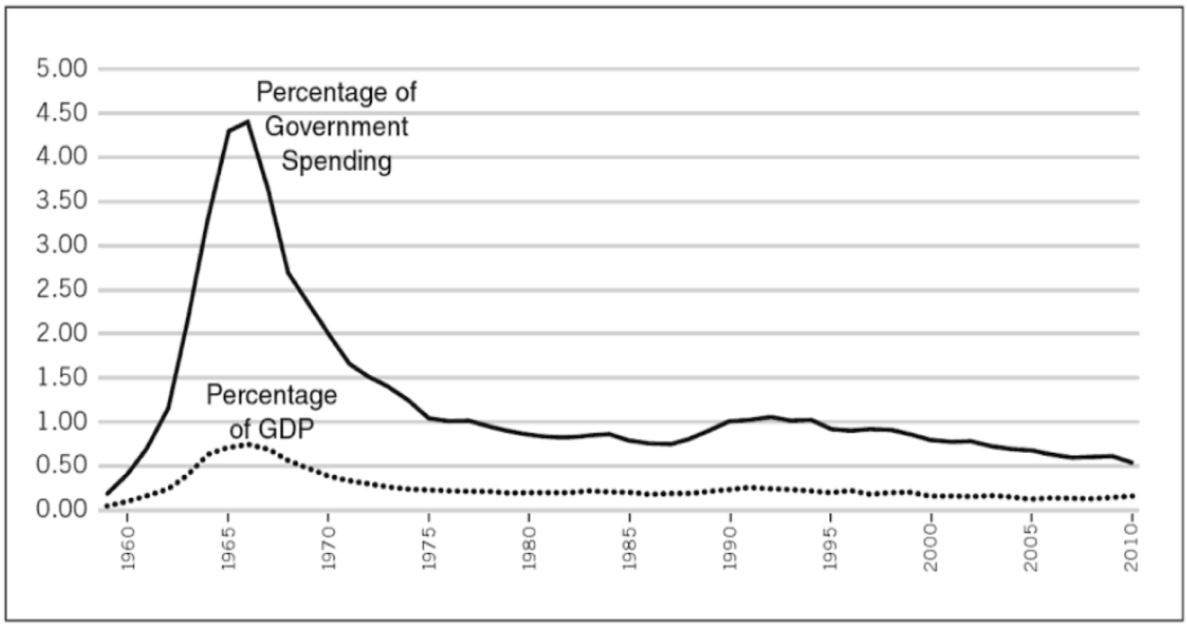

Figure 8: NASA's Percentage of US Federal Government GDP Spending 1959-2010

Source: Adapted from Dr. DeGrasse Tyson's "Space Chronicles: Facing the Ultimate Frontier"

As of 2010, the graph shows NASA's budget now residing at half of a percent of America's tax bill. This budget allocation reflects a significant drop in space exploration amongst America's priorities. NASA began its existence in 1958 as a bright star with almost limitless potential to explore space. Today, however, NASA appears to struggle in communicating its value, and congressional support has waned. NASA has been ineffective at engaging with Congress for money, and as a result has settled for a sub-optimal solution to explore space. Some would argue that NASA's decision to prioritize robotic data collection over human space exploration has given us the spectacular pics from unmanned probes. However, taking astronauts out of space exploration has severed a human connection that is paramount to generate popular support which feeds back to financial provision from Congress to NASA.

Continuing Problems with Direct Funding. Epitomizing the problems of direct funding, the mission STS-135 marked the last flight of the Space Shuttle program, touching down at Cape Canaveral, Florida on 21 July 2011.[18] Although authorized by Congress, the last shuttle sortie did not receive funding appropriation until three months before the flight, indicating that NASA was having to husband financial resources for the aging orbiter from other divisions in the agency. The budget battle forced NASA to pull funding from other programs as it did not receive any additional subsidies from Congress. In the end, STS-135 lifted off, but the Space Shuttle fleet was getting old; the limited resources and the workforce dedicated to human space flight were migrating elsewhere. In total, the Space Shuttle program supported 30 years of space travel, which is about twice the expected lifespan that was initially envisioned.[19]

The End of Direct Funding. In sum, direct government funding of human space flight is an extension of political will. Such an extension of politics has a number of drawbacks that are summarized by the constant need for justification to the public. The inefficient, government-led, and politically motivated concentrated design created a cost-heavy architecture mandated by top-down spending. This funding model is how Americans have experienced human spaceflight to date. Under the auspice of security concerns, the United States amassed large amounts of national wealth to oppose the Soviets; human space exploration was simply the mechanism to do so.

To date, the financial stream for the space program has been a thinly-veiled defense program, attaching its justification to security interests.[20] Doing so under a direct funding model was necessary under a compressed timetable, but ultimately was unsustainable because of the absences of will and the fact that the space program ran counter to free

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[18] Howell, "Atlantis: Last Space Shuttle Launch."
[19] Spitzmiller, *The History of Human Space Flight*, 541.
[20] Tyson and Lang, *Space Chronicles : Facing the Ultimate Frontier*, 102.

market principles and American values. Hopefully, a more vibrant future in manned space exploration lies ahead. The New Space financial construct taps into the third driver that amasses large sums of wealth: profit. In the New Space paradigm, sustainable space economies will become the propelling force that launches humans back into space; hopefully this time with a steady and resilient presence. An investigation of decentralized funding demonstrates a resurgence in public interest and re-alignment of American values.

Decentralized Funding

In 1984, Congress passed the Commercial Space Launch Act. This legislation set forth a new direction to acquire equipment and services offered by entrepreneurial ventures in the private market and opened the door to decentralized funding.[21] The legislation not only encouraged private participation in the space market but created an opportunity for the commercial sector to access the space frontier.[22] If we look at other areas of the American economy, it is clear that the government has proven to be a wealthy and credible institution worthy of underwriting new markets with no immediate return on the initial investment. In this bankrolling position, the government acts as an economic catalyst, pumping money into an emerging private sector before capital markets are able to place value in the market, allowing private companies like SpaceX to make a profit. The 1984 Commercial Space Launch Act placed the space sector on a similar trajectory, as President Reagan's policy specifically encouraged private launch operations for commercial purposes.[23] From a financial standpoint, New Space thrives from a different construct than direct funding. A hybrid blending of government and commercial spending is beginning to shape spaceflight in the near

[21] Lambright, *Space Policy in the Twenty-First Century*, 34.
[22] Johnson-Freese, *Space as a Strategic Asset*, 79.
[23] Lambright, *Space Policy in the Twenty-First Century*, 34.

future. This combination of government and commercial spending is called decentralized funding.

Twenty-five years after the Commercial Space Launch Act, the Obama administration continued to make fundamental shifts in the portfolio of NASA's wallet. On 15 April 2010, President Obama unveiled his National Space Policy, announcing the cancellation of the Constellation program.[24] This policy change implied the United States would become reliant upon Russia to enter orbit, relinquishing astro-autarky for the United States. After the passing of the Shuttle era, a domestic capabilities gap will remain until commercial space companies can assume the responsibility to launch astronauts back into space. This sudden change from direct funding to a more indirect financial model created a watershed moment in American space development that is less reliant upon government funding structures and more reliant upon free enterprise. This research defines decentralized funding as a cost sharing measure between the government and private sector to bring about the redistribution of wealth with regards to space access.[25]

The Subsets of Decentralization. According to Oxford economist E.S. Savas, there are three forms of decentralization: divestment, displacement, and delegation.[26] In the space market, divestiture entails NASA relinquishing its entire responsibility by liquidating its space assets to the private sector and thoroughly removing itself from the human space enterprise.[27] Full divestment is unlikely as the government continues to have an interest—albeit a lower priority—in space exploration activities. Unlike divestment, displacement happens when the private sector grows to a point well beyond government activity and surpasses the public domain's market share.[28] Deregulation is the process of removing

[24] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 12.
[25] This is the author's definition
[26] Anderson, "Rethinking Public-Private Space Travel," 271.
[27] Ibid.
[28] Ibid., 272.

government restrictions from the private sector.[29] In free markets, deregulation is the natural consequence of displacement. The aviation industry experienced this type of opening in the 1950s, and a similar transition may happen with the space market over time.[30] However, the first step to displacement is a partial privatization process by delegation. Delegation happens when the government entrusts a task or responsibility to another entity, typically one who is less senior.[31] In financial terms, a public-private partnership is the most common method to execute a delegation task. Public-private partnerships connect the gap between NASA's establishment and the nascent commercial space market.

Public-Private Partnerships. NASA defines Public-Private Partnerships as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is specifically linked to performance."[32] NASA utilizes public-private partnerships to advance “tipping point” technologies, like commercial space capsules that are competing for NASA contracts under the Commercial Orbiter Transportation Services program, or COTS. Crewed flight demonstrations are at a tipping point when government investment will result in significant advancement of the technology’s maturation and a high likelihood to create value for NASA. The COTS program is a NASA initiative that links the government with private enterprises to design and prototype critical space technologies.[33] COTS is a public-private partnership and operates under a milestone-based payment reward structure that shares risks, costs, and rewards of

[29] Ibid., 270-73.
[30] Jenifer Van Vleck, *Empire of the Air: Aviation and the American Ascendancy* (Cambridge, Massachusetts: Harvard University Press, 2013), 171.
[31] Anderson, "Rethinking Public-Private Space Travel," 272.
[32] Space Technology Mission Directorate Report, "Utilizing Public-Private Partnerships to Advance Tipping Point Technologies," in *NASA Research Announcement (NRA)*, ed. National Aeronautics and Space Administration (Washington, DC.: NASA, 2015), 2.
[33] Alan Lindenmoyer and Rebecca Hackler, "Commercial Orbital Transportation Services: a New Era in Spaceflight," (Houston, Texas: NASA, 2014), 4.

developing new space transportation capabilities for NASA, while lowering the overall price.

In *Re-Thinking Public-Private Space Travel*, researcher Chad Anderson calls NASA's new financial arrangement a "partial privatization measure that awards competitive source contracts to the most promising companies."[34] A significant benefit of the public-private partnership model for spaceflight is that it spreads the cost and risk between NASA and the commercial sector while improving operational efficiency for the government. This model also allows private companies to capitalize on existing infrastructure, research labs and expertise gained from the government's experience. Creating this diversification makes the space market as a whole more economically resilient, while introducing free market competition into NASA's human space portfolio. This benefit is tempered by an increase in operational risk to NASA. By using unproven technologies, NASA acknowledges that investing in maturing commercial systems is a risk because such capabilities have yet to prove themselves.

The Public-Private Partnership Model. The decentralized funding framework is perhaps best explained by a Venn diagram that shows the relationship between the public sector, the private sector, and their community of users. This model, put forth by Marc Ventresca and Alex Nichols, is helpful in recognizing and redefining the funding streams for space exploration.[35] Funding is no longer a matter of direct contributions from the government with its rigid and fixed set of activities to support the entire space industry. Now, funding sources span across an entire system from the public and private sectors to establish a value-creating system for the surrounding community.

In decentralized funding, NASA represents the public sector that financially backs spaceflight. As stated previously, NASA's share of

[34] Anderson, "Rethinking Public-Private Space Travel," 268.
[35] Ibid., 271.

financial influence has dwindled over time. Accounting for this financial vacancy, emerging space companies represent the private sector with different motives than NASA. These companies seek profit maximization and equity for their shareholders. The Commercial Space Act and President Obama's Space Strategy laid the foundation for this sector to grow. The last ring in the Venn diagram is the surrounding community. This is the population that benefits from space exploration, both inside and outside the government. So long as space exploration continues to create value for the government, the private sector, and the overall social structure of the United States, this new framework may become the most effective method of pooling money together for the cause.

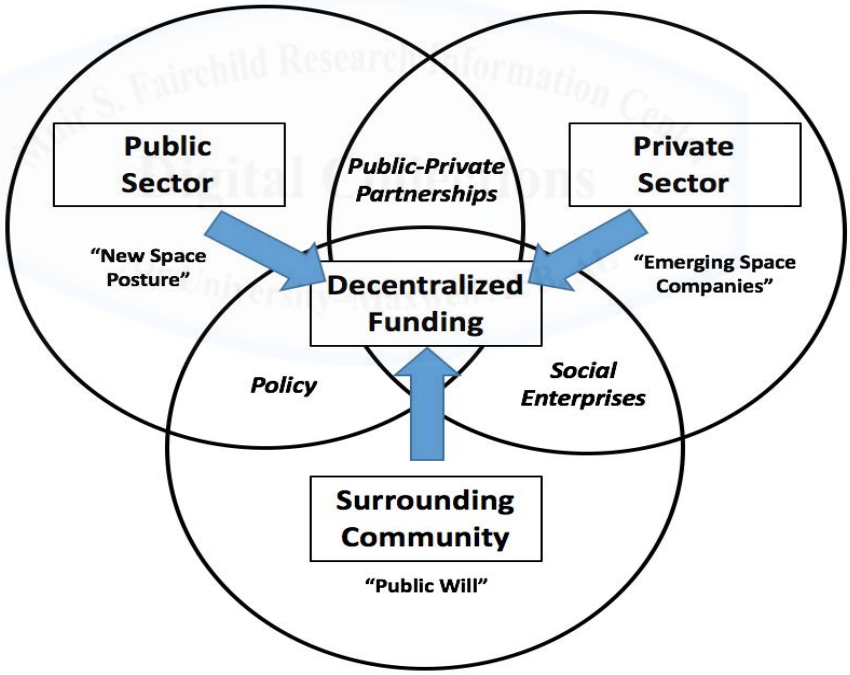

Figure 9: Decentralized Funding Framework

Source: Adapted from Anderson's "Rethinking Public-Private Space Travel"

The overlaps of the Venn diagrams in Figure 9 are policy, social enterprises, and public-private partnerships. At the center of this overlap is decentralized funding. The dual overlaps are policy, social enterprises,

and public-private partnerships. Space policy is created by the government with its provision of the public in mind, yet public policy remains to have minimal impact on the private sector. Communitarian space ventures (i.e., social enterprises) consist of companies like Virgin Galactic and Space Adventures. Public-private partnerships are the touchpoint between the government and commercial sectors, creating a cooperative arrangement that serves the needs of the government.

Commercial Orbiter Transportation Services. As a harbinger of Obama's space policy shift, NASA administrator Mike Griffin challenged the private sector to develop a commercial crew space transportation capability to service the International Space Station. The financial incentive for this challenge fell under a funding program called Commercial Orbiter Transportation Services, or COTS.[36] COTS handles all of NASA's human spaceflight partnerships, which has allocated $500 million over five years to stimulate commercial development.[37]

The Value of Fixed-Price Contracts. The funding for COTS differs significantly from the cost-plus contracts of Old Space. Most COTS contracts fall under *fixed-price* milestone based contracts. In fixed pricing, the government buys a service from a company for a specific requirement that is set by the government, who assumes the role of a vendor.[38] Fixed-price contracts are customarily utilized when exact specifications are available, and costs can be estimated with reasonable accuracy.[39] Furthermore, certain levels of the fixed-price contract become available when companies achieve specific targets. This contract type contrasts cost-plus in that it places the preponderance of risk on the private company.

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[36] Lindenmoyer and Hackler, "Commercial Orbital Transportation Services: a New Era in Spaceflight," 4.
[37] Ibid., 27.
[38] Gary Martin, "New Space: the Emerging Commercial Space Industry," in *SSP14*, ed. NASA Ames Research Center (https://ntrs.nasa.gov/search.jsp: NASA Ames, 2017), 23.
[39] Congressional Budget Office, "Fixed-Price Contracts: Subpart 16.2," ed. Library of Congress (Washington, DC: Congressional Research Service, 2018).

Overall, fixed-price contracts are the more cost-effective option for the government and fixed-pricing works well for both parties when costs are well known in advance and time is not a top concern. In general, fixed-price contracts require more time when complex projects require a significant amount of innovation. This requires development by the company to meet the requirements of the government, and lessens the accuracy of an initial quote. Historically, corporations mitigate their company's financial risk by delaying the communication of their selling price until internal cost projections stabilize. If time is crucial, a fixed-price contract may become more of a liability for the government, as a company's prediction of the cost estimate becomes less accurate. The compromise to this dilemma in the commercial space industry is to disaggregate the size of the project by establishing incremental requirements to unlock specific amounts of money each time the company attains stepping-stone type achievements.

An example of this incremental process under a fixed-price milestone based decentralized funding is SpaceX's first COTS contract. On 24 May 2012, SpaceX's Dragon capsule docked with the International Space Station on a mission to carry resupply cargo to the astronaut inhabitants. In doing so, it became the first commercially built vehicle to launch a payload into orbit and achieved a milestone that had previously only been accomplished by governments. Seven days later, the Dragon capsule splashed into the ocean, proving Elon Musk's concept a success. SpaceX founder Elon Musk reflects on this historic achievement by asserting "in the history of spaceflight, only four entities have launched a space capsule into orbit and successfully brought it back to earth: the United States, Russia, China, and SpaceX."[40]

However, unlike Russia, China, and the United States, Musk not only sent cargo into orbit which serviced the International Space Station

[40] Anderson, "Rethinking Public-Private Space Travel," 266.

and returned the capsule as a private company, but he also returned the lower stage of the rocket motor in a fly-back maneuver, landing it upright on a pad. According to Musk, SpaceX was founded to make radical improvements to space transport technology, with particular regard for reusability and affordability.[41] This successful mission is a perfect example of decentralized funding.

The Benefits of Decentralized Funding. According to Todd Harrison in *Implications of Ultra Low-Cost Access to Space*, reusability has the potential to make space launch costs lower by an order of magnitude, potentially dropping the price of space lift by a factor of ten.[42] If a launch vehicle could be reused ten times with minimal maintenance between flights, space launch would become similar to commercial aviation, giving spacefaring humans sortie-like access to space.[43] Remembering that the launch cost for the Space Shuttle rose from $10.5 million per flight to over one billion dollars per flight, there is a tremendous financial incentive in making space lift more affordable.[44] Elon Musk is striving to drive down the cost of lift by creating an orbiter and launcher that are fully reusable. This is the main contributor to driving down the cost of a launch. The graph below shows the comparative cost of the variables consisting of a rocket system. The graph reveals that all the variables taken collectively will cost less as sortie rates increase.

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[41] *Elon Musk Hearing to the Senate on Open-Market Competition in the Space Industry*.
[42] Harrison et al., "Implications of Ultra-Low Cost Access to Space," 5.
[43] Charles Miller et al., "Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges," in *Air Force Future Capabilities Strategy*, ed. Gary Payton (Maxwell AFB, Alabama: Air Univeristy, 2016), 5.
[44] Harrison et al., "Implications of Ultra-Low Cost Access to Space," 6.

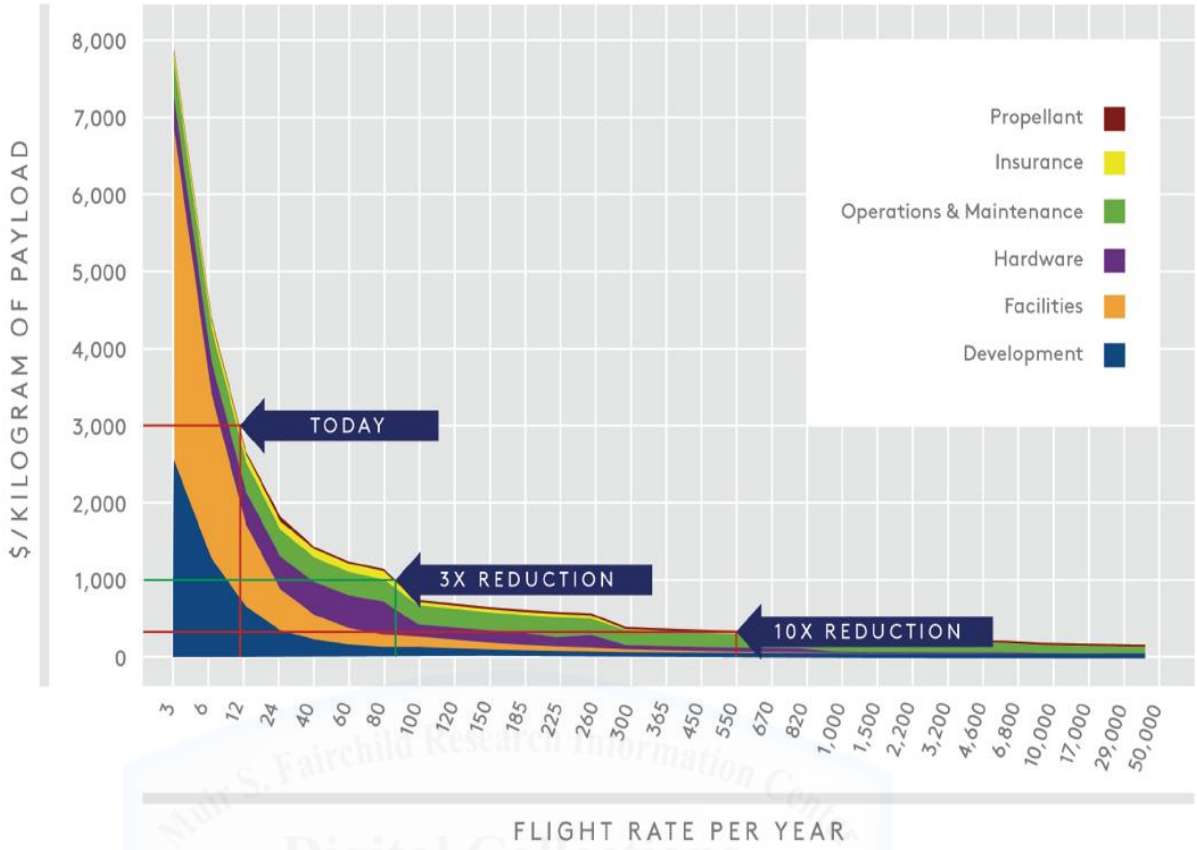

Figure 10: Nominal Launch Cost Per Kilogram Lifted

Source: Adapted from Miller, et al "Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges"

Decentralized Funding Summary. Concluding the discussion on decentralized funding, the 1984 Commercial Space Launch Act created an opportunity for a hybrid of government and commercial spending well before the service life of the Space Shuttle expired. The legislation was in place, but the United States lacked any semblance of robust commercial space activity required to enact the spirit of the statute. NASA's public-private partnership utilizes the Commercial Orbital Transport System program, and incentives like this will continue to shape future spaceflight. The ability for the government to acquire equipment and services offered by entrepreneurial ventures in the private market opens the door to decentralized funding. Bridging the gap in space exploration and acting

as an economic catalyst, public-private partnerships assist companies to create value in the emerging space market, allowing private companies to make a profit with the government's help. The 1984 Commercial Space Launch Act places the space sector of the economy on an upward trajectory by the process of delegation. Through delegation, NASA entrusts some repeatable tasks to the private sector in order to connect the gap between NASA's establishment and the nascent commercial space market.

Detached Funding

The private enterprise may someday eclipse government spaceflight activity. Signs already exist that this may become a reality, as companies are breaking into the space market, while the government's presence is decreasing. Detached funding is money used for the purposes of spaceflight that is completely separate from NASA, and represent financial resources that do not share any cost or risk with the government.[45] Detached funding occurs in the early stages of commercial development that work toward displacement. Detached funding helps the private sector grow to a point where it can begin to make a profit. The goal is not necessarily to grow beyond government activity, but that may be a by-product if detached funding efforts are successful on a wide scale. A main consideration of detached funding is resisting government oversight by finding an alternative approach to fund access to space. By doing so, private companies will "harness creativity, ambition and the human desire for advancement in order to build a future in space that everyone, everywhere can have a stake in."[46] There are two subsets to detached funding: inducement prizes and sponsorships. Both subsets are addressed in order.

[45] Author developed the term "detached" as the best way to codify space activities that have yet to return a profit, but show promise to do so sometime in the future.
[46] Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 355.

Inducement Prizes. According to Harvard scholar Liam Brunt, an inducement prize is simply "a cash reward for the accomplishment of a feat."[47] This financial value is given to a person or group that becomes the first to achieve specifically outlined criteria. Inducement prizes are typically used to extend the limits of human ability in some form. In *The Resurgence of Prizes to Stimulate Innovation*, Dr. Erika B. Wagner states that "well-designed prizes leverage the principles of competition to motivate a field of solvers to attack a particular challenge."[48] Wagner further asserts that "organizations can use prizes to engage user communities, enhance their research and development portfolios, and jump-start innovation."[49] An inducement prize is an example of detached funding, and the Ansari X-Prize—a space competition that offered $10 million to the first non-government organization that could launch a reusable manned spacecraft into space twice within two weeks—is a perfect example of a modern day inducement prize.

Scaled Composites' success story highlights that well-designed inducement prizes can stimulate competition to bring an array of diverse, non-traditional problem-solvers to conquer space. According to Wagner, "the effect of rewards capitalize on a deep-seated competitive drive, capturing public interest for the issue at hand through the creation of visible heroes and compelling stories."[50] The Ansari X-Prize brought together the same elements that originally propelled our astronauts to the moon. These essential ingredients were competition and public interest.

The X-Prize was created by Peter Diamandis. Diamandis launched the competition in 1996 under the Gateway Arch in St. Louis. Diamandis made a spectacle of the announcement, inviting former astronauts,

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[47] Liam Brunt, Josh Lerner, and Tom Nicholas, "Inducement Prizes and Innovation," *The Journal of Industrial Economics* Volume LX, 0022-1821, no. No. 4 (December 2012): 657.
[48] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 32.
[49] Ibid.
[50] Ibid., 32-34.

celebrities, and NASA Administrator Daniel Golding on stage to announce the challenge in front of media outlets and space enthusiasts. Diamandis formally declared the challenge to launch a three-passenger space vehicle above the Karman Line and repeat it a second time within two weeks by the first of January 2005.[51]

A key benefit to an inducement prize is that it attracts non-traditional aerospace providers to the community. Such prizes are "agnostic to the competitor's level of education, and their approach to problem-solving."[52] Rather than looking for solutions only from the most established aerospace companies, prizes transcend communities and open up an entire network that may use unorthodox approaches not permissible at large establishments. A prime example of prizes attracting smaller companies is the X-Prize winner: Scaled Composites. CEO Burt Rutan's unique designs are the epitome of an anti-establishment startup industry in the space business. Rutan has continually rebuked offers to work with the government for fear that government oversight may stifle some of his more exotic designs and override his creative expression.

Another attribute of an inducement prize is that it challenges small competitors to meet specific success criteria, outlining a prescribed agenda under a well scoped desired outcome.[53] Space innovation became stagnant in the mid-1990s, and X-Prize founder Peter Diamandis was seeking a way to garner interest. According to Diamandis, "Prizes are most effective when progress is blocked and where market forces, government, and non-profits cannot readily solve a problem. Prizes mobilize entrepreneurs to achieve breakthroughs."[54] The goal of the Ansari X-Prize was simple and well defined: two flights within two weeks above 62 miles

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[51] Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," 364.
[52] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 33.
[53] Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," 365.
[54] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow : The Path to Private Spaceflight*, 172.

by 1 January 2005 for $10 million.[55] This prize was notable in that it was broadcast to anyone willing to compete. However, the goal for Diamandis was to find a single winner. Diamandis' announcement under the St. Louis Arch created a connection to the roots of the city that backed another prize winner from generations earlier. That aviator was Charles Lindbergh.

The city of St. Louis funded Lindbergh's entry vying for the Orteig Prize, named after New York hotel owner Raymond Orteig.[56] The Orteig Prize was awarded to the first aviator to fly non-stop from New York to Paris, offering a $25,000 purse to the winner.[57] In honor of St. Louis' full collaboration, Lindbergh named his custom-built Ryan aircraft the "Spirit of St. Louis" to honor the city that supported him in his quest to win the prize in 1927.[58] In 1996, Peter Diamandis tapped into this narrative, connecting one aviation achievement to another. This subtle gesture ignited a passion for aviation once again.

The Cost Efficiency of Inducement Prizes. Unlike grants and government contracts, inducement prizes only pay for results. This focus on the outcome makes them a cost effective means of igniting innovation, with most companies bearing the costs of their design ideas rather than placing the research and development burden on the prize supplier. Collectively, the 26 teams invested ten times more than the actual prize dollar amount in research and development costs for their designs, creating a total private investment of over $100 million dollars.[59] The winner was backed by Microsoft investor Paul Allen who invested $25 million in the project but saw only $10 million in return.[60] The prize was just a fraction of the overall investment, but the prize sparked innovation,

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[55] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 35.
[56] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*, 119.
[57] Ibid.
[58] Charles A. Lindbergh, Fitzhugh Green, and Carl H. Pforzheimer, *"We"*, Authors autograph ed. (New York: G.P. Putnam's Sons: Knickerbocker Press, 1927).
[59] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 32.
[60] Ibid., 33.

competition, and public interest on a global scale never witnessed in the space industry to date. Dr. Wagner credits the narrative surrounding inducement prizes with a phenomenon that taps into a broader set of innovators that bring a range of solutions.[61]

During Lindbergh's era, the field of competitors striving for the Orteig Prize spent over $400,000 chasing after a $25,000 purse.[62] In a study on the relationship between the amount of money compared to the attractiveness of the prize, Dr. Erika Wagner found the actual dollar amount meant almost nothing compared to the prestige of the prize. The dollar amount only signals to competitors the importance of the accomplishment and the seriousness of the challenge. The reason why investors poured so much money into the Orteig Prize and the Ansari X-Prize was to advance the limits of human ability, not to earn a cash amount. Investors viewed these challenges as an opportunity to work on a significant problem, the thrill of the chase, and the validation of efforts from a third-party.[63]

By leveraging outside resources, prize suppliers leverage financially efficient means of fostering competition and sparking innovation. Prizes create a parallel innovation process that allows for simultaneous, rather than sequential innovation that typically happens during milestone progression at big industry companies found in Old Space.[64] The numerous approaches attempted during the Ansari X Prize far exceeded the engineering capacity and financial possibility of traditional government contracting. The diffuse funding construct represents the financial potential that exists with a New Space spending schema, thereby creating exponential pathways to access space. This far-reaching funding schema

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[61] Ibid.
[62] Branson, *Reach for the Skies : Ballooning, Birdmen and Blasting into Space*, 120.
[63] Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," 361.
[64] Wagner, "Why Prize? the Surprising Resurgence of Prizes to Stimulate Innovation," 33.

is a marquee characteristic of New Space, and such a financial concept is quite frankly outside the capacity of Old Space direct government spending.

The Benefit of Competition. One of the most significant benefits of inducement prizes is that they attract public interest. Much like the competition of the Space Race in the sixties, this new competition resurrected an allure for space travel and drew record crowds to Mojave Spaceport for the event. Competitions are attractive because they bring out the best in humanity. In a competitive environment, winners earn the prestige associated with the thrill of the victory. The competition for a prize holds an attractive quality that provides ample opportunity to allure positive public attention.[65] This competitive spirit existed in the Space Race and it also existed during the contest for the X-Prize. To the space enthusiast, the X-Prize was arguably more exciting due to the higher number of competitors. Simply put, competition ignites interest, and more competition creates more public interest.

To emphasize, 26 entrants from multiple countries competed for the X-Prize. The high turnout not only bolstered the attention of this prize to a global scale, but also attracted the financial donor of the prize itself. Peter Diamandis did not have a donor at the time of his announcement in 1996, but the media fury attracted many listeners. One of them was Anousheh Ansari; the same Iranian American businesswoman who later went to space in a Russian Soyuz capsule. Ansari agreed to fund the stated $10 million.[66]

Sponsorship. Sponsorship happens when a person or organization pays for a project to further the organization's interests. The difference between a donor and a sponsor is two-fold: financial accountability and representation. With donorship, there is no financial accountability back

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[65] Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," 364.
[66] Dubbs and Paat-Dahlstrom, *Realizing Tomorrow: The Path to Private Spaceflight*, 178.

to the donor, and the payee does not act on behalf of the donor. In a sponsorship scenario, the trustee is accountable to the sponsor for how the money is spent and does so by representing the interests of the sponsor. Normally, the organization that covers the project costs usually get some form of advertising in return. By definition, sponsorship is "the financial or in-kind support of an activity and is used primarily to reach specified business goals."[67] Sponsorship should not be confused with advertising. Advertising is a "quantitative medium, whereas sponsorship is a qualitative medium."[68] Sponsorship promotes a company in association with the entity that it promotes.

From Inducement Prize to Sponsorship. Competition stemming from inducement prizes can lead to radical breakthroughs in technology, and small groups of people can capture the public's interest in a market usually dominated by big name corporations. The entrepreneurial spirit of some audience members have carried the victors of inducement prizes to further developments in detached funding. The Ansari X-Prize captured the attention of billionaire investor Richard Branson, who founded Virgin Galactic by sponsoring Scaled Composites. Branson's space vision is to build upon the achievements and prestige of *Space Ship One* by creating a profit-making business. Branson intends to make space accessible to a greater number of humans, while also further broadcasting the Virgin brand name to the world.[69]

According to Virgin Galactic CEO George Whitesides, Branson believes that if everyone were given an opportunity to view the Earth from outer space, it would have a profound impact not only on a greater number of human beings, but would also create a large demand signal for a

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[67] Susan Friedman, "Learning About Sponsorship," *Business and Marketing* Making Money Matter (2018).
[68] Ibid.
[69] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*, 283.

business venture in a virtually untapped new market.[70] The challenge, according to Branson, is to make spaceflight affordable. If Branson can make spaceflight affordable, he can make it accessible. Branson stated that "nothing will ever come of our dreams of space until we have developed a cheap launch system."[71] Rutan's follow-on project, *Space Ship Two*, plans to host a seven-passenger crew along with the pilot.

Branson currently offers tickets for a ride on his spaceplane for $200,000 with the hope of further driving down the cost as commercial flights rise in frequency.[72] Unfortunately, this new startup space company has already experienced a fatal setback. On October 2014, the first *Space Ship Two* prototype suffered an in-flight breakup on its way out of the atmosphere when its feathering mechanism became unlocked under maximum dynamic pressure (called “Max Q”). This accident killed the co-pilot, but the pilot survived after experiencing incapacitation and waking up on the ground under a parachute.[73] The National Transportation Safety Board faulted Scaled Composites for not having rigorous safety oversight procedures, and faulted the co-pilot for prematurely deploying the spacecraft's feathering mechanism at 0.9 Mach instead of the prescribed 1.4 Mach.[74] Despite this setback, Branson elected to continue with the project by building an additional model with upgraded safety systems. Branson hopes Virgin Galactic will return to flight in 2018 after numerous safety findings are corrected.[75]

The Progression of Detached Funding. To date, Scaled Composites is the only success story under a detached funding scheme. In this case, an inducement prize provided the stimulation to achieve the

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[70] George Whitesides, "Your First Trip to Space: George Whitesides at Tedxwallstreet - Youtube," TED Talks, https://www.youtube.com/watch?v=x769XE7aoI4.
[71] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*, 282.
[72] Ibid., 293.
[73] Luke Goossen, interview by Jason Curtis, 2018, Mojave, California.
[74] Board, "In-Flight Breakup During Scaled Composites Spaceshiptwo Test Flight: Aerospace Accident Report."
[75] Todd Ericson, interview by Jason Curtis, 2018, Mojave, California.

feat of placing two astronauts into space without assistance from the government. Earning the Ansari X-Prize gained enough prestige and credibility for Richard Branson to sponsor a larger scale follow-on project. If the innovation trend lines are correct from the previous chapter, more companies similar to Scaled Composites will likely emerge onto the market under a detached funding scheme. The progression of funding is likely to start with a prize, followed by sponsorship, until a profit can be made. When a profit is realized, detached funding will grow. When detached funding grows, displacement might occur. If displacement occurs, deregulation will likely follow. At this point, open-market capitalism takes hold and the private space company model will finally become established and sustainable.

Final Thoughts on Funding

Access to space is financially supported by three different methods. Sources of financial support have changed from the top-down government source in Old Space to a cost-sharing and a bottom-up approach in New Space. The three different funding schemes are: direct government funding, decentralized funding, and detached funding. These three funding streams reveal three distinct mechanisms of financial flows that separate the two space postures. Direct funding leveraged the will of the public during the Cold War to create tax revenues that fueled NASA. This government financial support finally died out by 2011.

The commercial Space Launch Act paved a path for a hybrid of government and commercial spending called decentralized funding. Public-private partnerships are the most common instrument NASA uses in decentralized funding as a partial privatization financial arrangement. Detached funding is money used for the purposes of spaceflight that are completely separate from NASA, and represent financial resources that do not share any cost or risk with the government. Inducement prizes and sponsorship are the two sources of detached funding that have revived

interest and amassed wealth toward space access. In summary, the move away from direct funding towards detached funding has created a clear path to privatization, exemplifying the merits of capitalism. This shift in funding helps re-align America's space aspirations with American values.

Chapter 5

Space Synthesis: Combining the Variables

There is no easy way from the earth to the stars.

Seneca the Younger

Synthesis of Variables

To reiterate the central argument, Space Posture Theory asserts that the primary driver behind human space exploration is not the singular considerations of prestige, innovation, or funding assessed without relation to the others. Conversely, Space Posture Theory argues that a combination of two out of the three variables are required to create access for humans to enter the space domain. As a negative consequence, the two driving variables in each posture come at the expense of the third.

Explanation of Causal Mechanisms

Space posture is the incorporation of specific variables arranged into an overall space structure. This structure is supported by underlying motivations about how space assets are used, and under what conditions varying degrees of priority are assigned to variables to generate distinct outcomes.[1] The term "Space Posture" refers to the resulting priorities of prestige, innovation, and funding through which the various mechanisms generate a program that creates human space access for a desired objective.

Prestige, innovation, and funding have unique mechanisms that show a strong relationship between the *intent* of space programs, and their

[1] Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict*, 4. Phrasing of this sentance was inspired by Narang's structuring of his argument for Nuclear Posture Optimization Theory.

analytically distinct *postures*. The depiction below in Figure 11 revisits the relationship between the inputs, mechanisms, and outputs resulting in Old Space and New Space postures. This political science model demonstrates that independent variables behave in a way that is expected on the basis of rationality, acting within a predictable pattern that is repeatable if similar conditions are re-created.

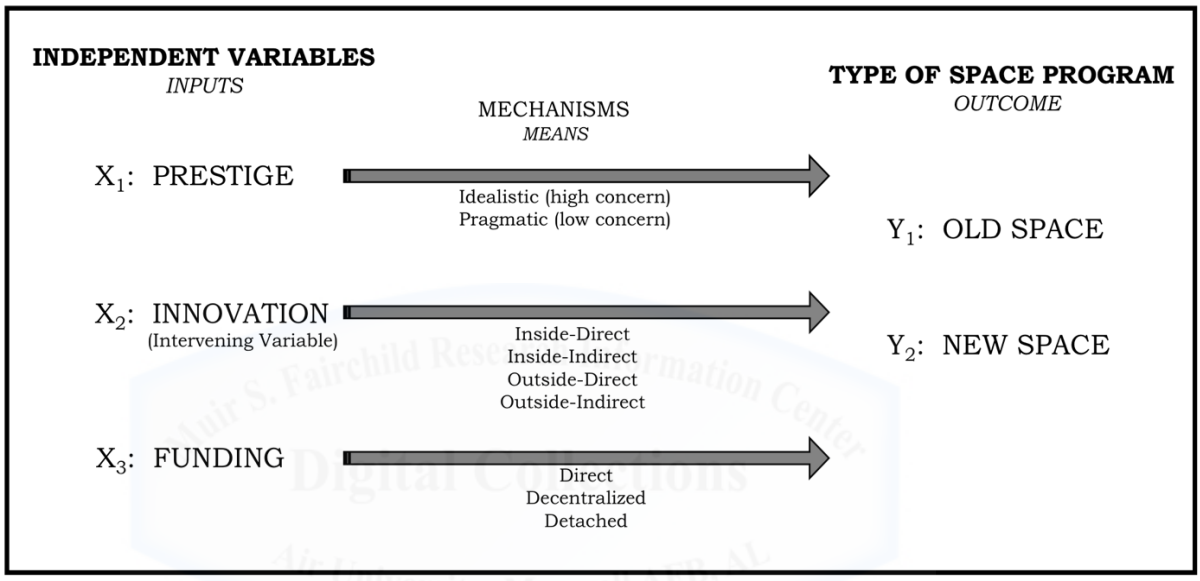

Figure 11: Mechanisms that Explain Variation in Outcome (revisited)

Source: Author's Original Work

Figure 11 is the overall fundamental architecture that connects the original intent of the space programs to the resulting postures in order to access space. Building upon this intellectual design, an evaluation of the independent variables is now warranted.

Evaluation of Variables

Evaluating the outcomes in relation to the inputs creates an opportunity for a synthesis of prestige, innovation, and funding. The value of each variable is determined by the priority level associated with it. Figure 12 and 13 below call this priority level the "Weight of Importance."

By synthesizing the priority level and giving careful appraisal to the outcomes, it becomes clear what each posture values. Three priority levels are attached to the Weight of Importance: High, Medium, and Low.

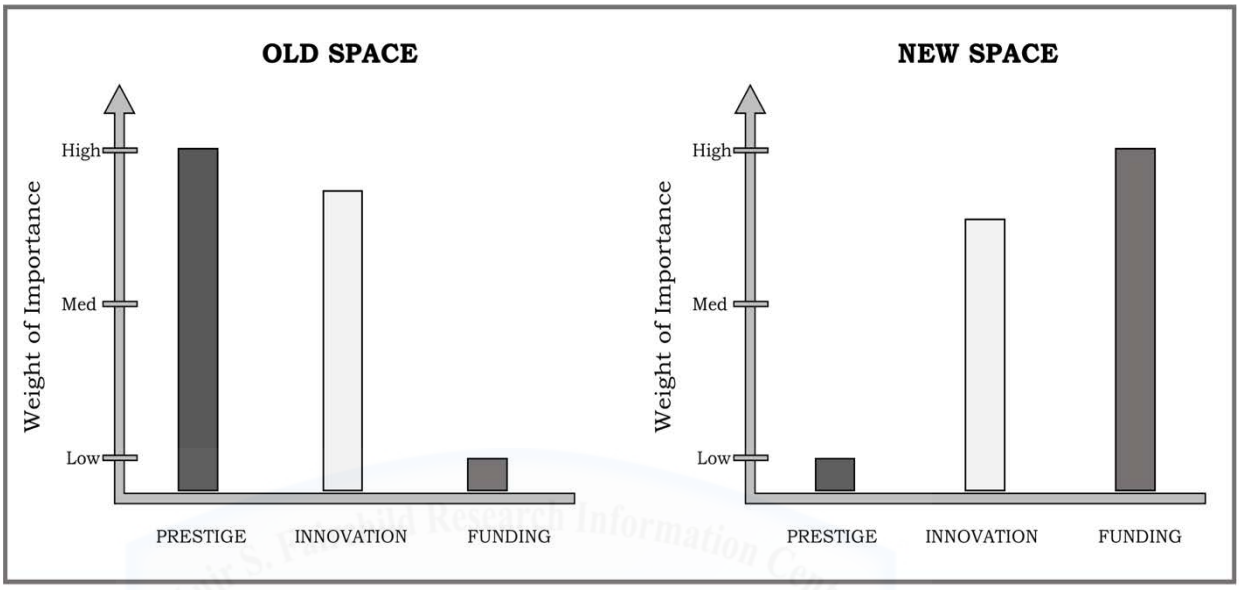

Figure 12: Old Space (12a) and New Space (12b) Compared

Source: Author's Original Work

Figure 12a displays an evaluation of variables compared to each other for Old Space, and Figure 12b does the same for New Space. Placing a subjective value on the independent variables helps establish a qualitative metric used to synthesize Old Space with New Space.

High Importance. High importance determines the overriding causal factor that predominantly shaped the outcome to produce the resulting posture. In Figure 12a below, the highest priority for the Old Space posture was associated with prestige. By contrast, Figure 12b reveals that funding is the variable given priority in New Space. Comparing Figures 12a and 12b reveal the main difference between Old Space and New Space: the variable associated with high importance. In the graph depicting Old Space, prestige overruled funding. Referring back to Chapter Two, President Kennedy leveraged political will to increase

American soft power, which was supported by a custom-made bureaucracy that used direct government funding to create technological credibility. This credibility resulted in achieving the goal of creating national prestige.

In almost a direct contrast to Old Space, the variable with the highest level of importance in New Space is funding. The fourth chapter revealed that nearly all New Space companies are striving to lower the cost of space access. This was not the case when NASA was at the center of space exploration. Lowering the cost of space access will increase the demand signal from customers outside the traditional realm of the government. Over time, this will result in a significant improvement of commercial market capture for private companies. This heightened demand could potentially lead to an exponential increase in human space activity in both orbital and suborbital flights. If the government supports this new private business, the opening of the market could dwarf the per capita space activity witnessed during NASA's most active years. When that commercial market capture happens, financial displacement will occur and private sector activity will surpass government efforts. In order to succeed and become profitable, New Space companies must lower the cost of lift. Therefore, prioritizing funding with the highest weight of importance is the causal factor that motivates human space access in the future.

Low Importance. Low importance identifies the variable least considered with regard to the outcome. A combination of two out of three variables are required to create a corridor to space, thereby making the low importance variable the one that is disregarded at the expense of the other two. To reiterate, Space Posture Theory asserts that access to space is achieved when conditions create the opportunity for a space program to effectively manipulate a combination of two out of three variables at the expense of the third. Prestige in Old Space came at the cost (quite literally) of an enormous amount of government spending that became

unsustainable. Conversely, a low regard for national prestige in New Space spurs creative funding arrangements that continue to drive down the cost of spaceflight. In lesser words, Old Space places a low importance on funding, and New Space places a low importance on national prestige.

In Figure 12a, the considerably low weight of importance attached to funding ultimately led to the decline of the government space program. Without a security reason to mass large amounts of public wealth, the spending surge of the sixties declined through the seventies, eighties, and nineties. This lack of financial support ultimately reduced the government space program to unsustainable levels by 2011. In the form of taxes, the public has been the primary financial supporter of space exploration for 50 years. In the eyes of the public, NASA is viewed as something that is desirable, however, when NASA is challenged with competing interests from the government, human spaceflight has proven optional. Without any public justification beyond a thinly-veiled security necessity or compelling need to reach another frontier, the benefits of a government human space exploration program cannot justify their financial expenditures. Absent of those two elements—a security need or frontier expansion—the government space program runs out of political propellant. Not surprisingly, the NASA budget has always been strongly associated with public will, and the lack thereof combined with the programs high cost ultimately led to its detriment.

Medium Importance. In between high and low importance is a mid-level of priority. As Chapter Three pointed out, innovation is the connecting variable and common thread between Old Space and New Space postures. Both outcomes require high levels of innovation in order to transition from one posture to the other. Due to the fact that space access did not exist before 1961, the Old Space posture had to innovate everything to reach the new frontier, as NASA flight director Gene Kranz

stated.[2] Conversely, New Space was not yet optimized for low cost, so engineers and entrepreneurs had to invent ways that addressed this primary constraint. In sum, innovation is the intervening variable across both postures and it acts as a common link. While innovation is not the causal factor in either Old Space or New Space, innovation's priority level remains high in both, resting somewhere between high and medium importance. Figures 12a and 12b are displayed next to each other for a clear comparison of this connection.

The emphasis on cost reductions under the New Space posture aim to make spaceflight attractive to a wider audience than just government interests. As a result, commercial space companies have developed innovative ways to re-think human space travel with profit being the sustaining factor that perpetuates further development. The largest opportunity to reduce cost comes from improving launch capabilities. Specifically, this assigns causality to innovative breakthroughs in reusable, two-stage-to-orbit launch vehicles. A low-cost launch vehicle has to become cost effective. When it does, low-cost options can open new markets that were previously not accessible at higher launch prices.[3] Understanding that funding is the primary concern in New Space, innovative technology leads to commercial market development, and the growth of the commercial market leads to economic development, which feeds back into the overall health of the nation.[4]

Looking at Figures 12a and 12b, the weight of importance for innovation is marked slightly lower in New Space compared to Old Space. The reason is because New Space has a benefit of learning from prior achievements. New Space innovation can improve upon the template created by Old Space to extract the experience base and resident

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[2] Kranz.
[3] Eligar Sadeh, *Space Strategy in the 21st Century: Theory and Policy*, Space Power and Politics (London; New York: Routledge, 2013), 217.
[4] Johnson-Freese, *Space as a Strategic Asset*, 9.

knowledge of NASA. The innovative concepts of New Space have replicated some of the examples set in Old Space. For example, Burt Rutan's designs were directly inspired by NASA's X-15 program. It is easy to see the similarities in design between the X-15 and *Space Ship One*. The legacy of the X-15 extends to *Space Ship One* as both are ventral-launched, single-stage-to-space suborbital rocket-ships.[5] Rutan was able to build upon existing concepts and improve designs while creating cost efficiencies along the way. In short, New Space companies like Scaled Composites are replicating the technological innovations and research NASA has already done, while making financial improvements on their systems.

Further evidence of innovation spanning both postures is NASA's willingness to share its lessons with private companies. As an example, NASA collaborated with SpaceX to improve their design after a series of three consecutive rocket launch failures in 2008 that almost put the company out of business.[6] Small scale commercial space startups may not have the luxury of a large purse, but they have the luxury of borrowing a wealth of experience from the government.

Even though private companies receive expert advice from the government, they also achieve remarkable breakthroughs in technology that have occurred outside the government. For example, SpaceX's fly-back capability of the lower stage rocket booster is something the company developed completely on its own.[7] In another example, Scaled Composites uses aerodynamic materials that are make entirely out of glue, cloth, and plastics.[8] This low-cost, durable, and lightweight approach to materials design is something Old Space innovation never achieved. The rocket motor fuel tank is a carbon blend, and the frame of the aircraft is a uniform planar design made entirely of fiber glass. These materials are what the

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[5] Klerkx, *Lost in Space: The Fall of Nasa and the Dream of a New Space Age*, 264.
[6] Vance, *Elon Musk: Tesla, Spacex, and the Quest for a Fantastic Future*.
[7] Ibid.
[8] Luke Goossen, interview by Jason Curtis, 2018, Mojave, California.

industry has nicknamed “fast glass,” and give Rutan’s company its namesake.[9] In summary, the main revelation by comparing New Space and Old Space innovation is that innovation has remained the bedrock of both space programs. This unique intervening variable helps bolster prestige and lower costs, making it an essential requirement for both postures.

The variable of innovation is prioritized with fairly high importance in each posture. Perhaps it is best to view innovation as a means to an end, rather than an end state itself. While the desired end-state for both postures is to gain access to space, prestige and funding are goals that characterize how the desired end state is perceived by the government. In Old Space, innovation was utilized not solely, or even primarily for human space exploration but it was symbolically represented by offering the ultimate in technological prestige.[10] By contrast, the goal of New Space is to achieve low-cost access, and innovation is required to pave this more economical path to space. Both outcomes require high levels of innovation in order to achieve access, just with various sources of innovation and dissimilar approaches to innovation. In summary, innovation retains a high level of importance across both postures and that is why it is the connecting variable between Old Space and New Space. Figures 12a and 12b above reflect this notion.

Space Access Synthesis

As of 2016, 556 humans achieved spaceflight during the first 55 years of space travel.[11] This group consists of citizens from 38 different countries launching from three locations: the United States, a Russian location in Kazakhstan, and China. Collectively, space travelers have spent over 77 cumulative years in space and have conducted 217

[9] Branson, *Reach for the Skies: Ballooning, Birdmen and Blasting into Space*, 257.
[10] Johnson-Freese, *Space as a Strategic Asset*, 7.
[11] Davenport, "Space Access by the Numbers."

spacewalks, cumulating a total of over 100 days of Extra Vehicular Activity.[12] Among this group, 24 humans have traveled beyond low Earth orbit, and 12 have walked on the moon.[13] Figure 13 below displays the totality of humans whom have entered the space domain by year and magnitude (i.e., number of humans per year).

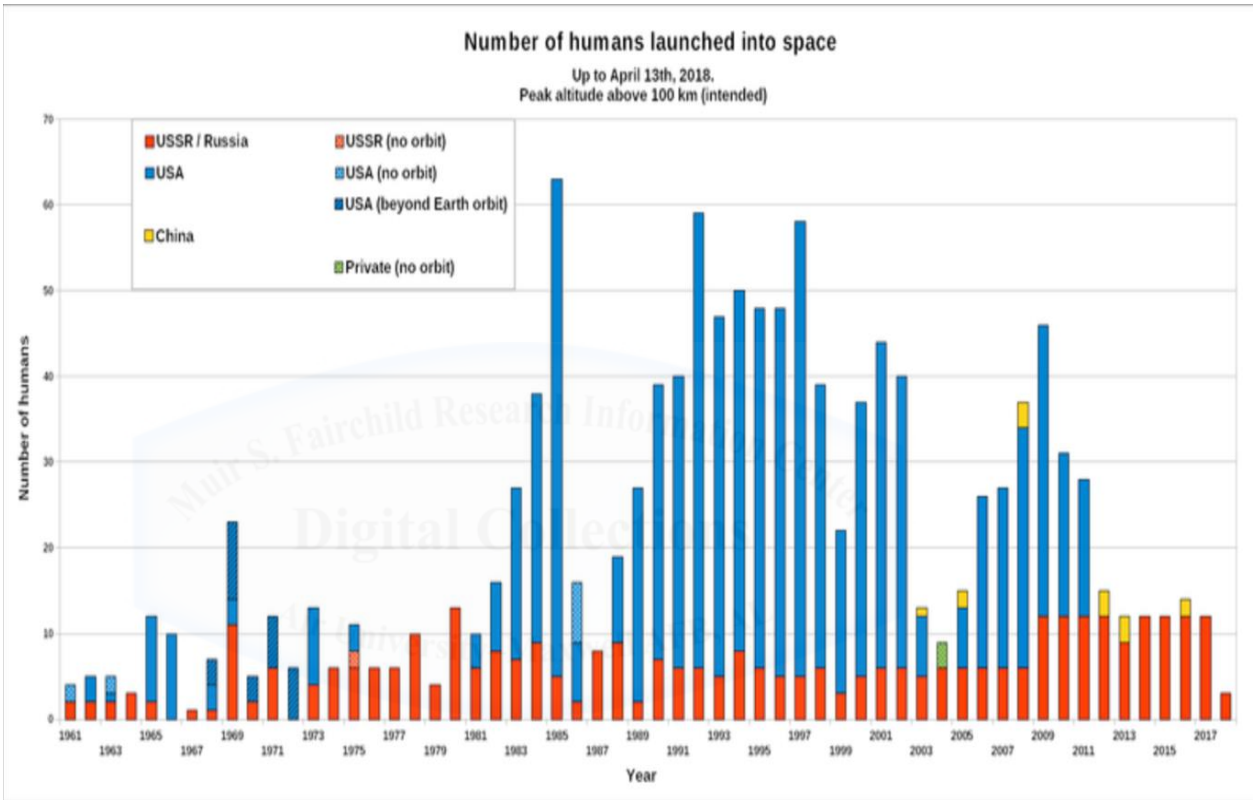

Figure 13: Number of Humans Launched into Space

Source: Adapted from Davenport's "Space by the Numbers" Human Spaceflight Graphs

Two salient indicators are apparent in this chart: the volatility of American space travel and the consistent—yet incremental—growth of Russian space travel. The fabled race between the tortoise and the hare symbolizes the differences between the Americans and Russians in each

[12] National Aeronautics and Space Administration, "Extravehicular Activity (Eva)," ed. NASA (Washington, D.C.2018).
[13] Sarah Loff, "Apollo Statistics," (2015).

one's approach to human spaceflight. The hare represents the surge and slowdown of activity in the United States. The tortoise is Russia, as the constant yet ever-so-slightly-increasing presence of human spaceflight activity. Figure 13 reveals that since the beginning of the Space Race, American presence in space has fluctuated drastically, both peaking and plummeting according to the whims of public interest and political will. In 1969, the number of humans in space reached an all-time high when spending was at its peak. Then, American access to space dropped to zero following the conclusion of the Apollo-Soyuz project. The Space Shuttle program created another surge, reaching its highest frequency in 1985 right before the *Challenger* disaster. This cycle continued after the *Columbia* fatalities, with the Shuttle Program rising again to complete the International Space Station, then retiring for good.

At the conclusion of the Shuttle program, the Russians have increased their space presence with an upsurge of activity. Doubling the 2008 numbers, twelve cosmonauts reached space in 2009. China sent its first taikonaut, Yang Liwei, into orbit in 2003 and repeated the occasion almost every other year for a total of eleven taikonauts to date. Analyzing the origins of space access comes down to either a political or economic consideration. Both Russia and China are continually funding their programs, and don't necessarily require public support to do so as autocratic regimes. However, such disregard for public support to garner funding for space is not possible in America's democracy. Communist countries will always use prestige as helpful national propaganda. The United States now needs a reason to access space besides just looking good. Fortunately, capitalism provides such justification.

In Old Space, the instability of the American space program reflects political decisions hinging on continuing congressional support rather than a sustainable model to expand human space exploration. However, the green marker in 2004 for the first two private sector astronauts give hope that America now has a new pathway for space activity. If the New

Space posture takes hold, there is reason to believe that the profit motive will combine the higher numbers of American space activity with the sustainable presence of the Russian program. While yet to be proven, this posture could combine the best aspects of both countries, creating a more optimal means of accessing space.

Flight Safety

The consideration of flight safety as a variable is not included in Space Posture Theory. The reason is because it is assumed to be a mandatory requirement for any vehicle leaving earth, regardless of which model is analyzed. However, it is worth mentioning a nuanced consideration surrounding something called a "human-rating" certification for airworthiness in either Old Space or New Space. A human-rating certification is an official endorsement that "controls hazards with sufficient certainty to be considered safe for human operations, and provides, to the maximum extent practical, the capability to safely recover the crew from hazardous situations."[14] The space domain continues to be the most hostile operating environment for human beings. The transition to and from the space domain—both into and out of earth's atmosphere—has historically proven most dangerous for government endeavors, hence labeling it a "critical phase of flight."

In Old Space, two-fifths of the Space Shuttle fleet was destroyed during these critical phases of flight, establishing a dismal track record and revealing the dangers of accessing space. New Space draws from a much smaller experience base, but the 2014 *Space Ship Two* accident alludes to an even worse track record for private endeavors. While commercial providers aim to provide orbital and sub-orbital services at a lower cost, the threat to a promising market is that a poor reputation in

[14] NASA Procedural Requirements, "Human-Rating Requirements for Space Systems," in *NPR 8705.2B*, ed. NODIS Library (Office of Safety and Mission Assurance: NASA, July 10 2017), 9.

safety will hinder the demand signal required to make the enterprise viable and ultimately sustainable. If safety concerns continue to plague private companies, commercial markets may never open up fully.

A human-rating certification provides an acceptable standard of a spacecraft worthy of transporting humans.[15] According to Jeff Foust in *Space Launch Capabilities and Strategic Considerations*, there is considerable debate between creating a separate human safety rating for government purposes and a lower standard with decreased factors of safety for commercial purposes.[16] Separate safety measures first guarantee the assurance that space systems will accommodate human needs, but the delineation highlights the criticism of commercial space companies to the government. The commercial sector criticizes the government of over-engineering unnecessary redundant systems typically associated with overly-cautious safety requirements. If commercial systems can establish a reputation as safe stewards of space, then a separate human-rating may temper the safety concerns and control hazards with more-directed uncertainty for human protocol.[17]

For commercial enterprises operating on thin budget margins, the largest impedance to lowering cost is the human-rating standard set by NASA.[18] The intent of a separate rating is for commercial requirements to be less complex than government specific standards. It is highly likely that NASA will become a prime customer of the commercial sector in the foreseeable future, therefore, the government will most likely have significant influence over safety concerns in the spaceworthiness of commercial designs.[19] However, methods to mitigate these safety concerns may become more agile with a separate commercial human-rating. This could enable further cost savings by non-government

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[15] Ibid.
[16] Sadeh, *Space Strategy in the 21st Century : Theory and Policy*, 213.
[17] Requirements, "Human-Rating Requirements for Space Systems."
[18] Sadeh, *Space Strategy in the 21st Century : Theory and Policy*, 215.
[19] Ibid., 214.

providers.[20] As a result, the continued high weight of importance associated with funding for New Space will remain. Despite the fact that government regulation could make it difficult for companies to profit from less-refined designs, the demand for high-safety standards will inevitably attract future commercial business.

Final Thoughts on Synthesis of the Variables

Chapters two, three, and four systematically identified the sources of motivation behind Space Posture Theory as prestige, innovation, and funding. This chapter revealed the relationship across the variables by prioritizing their weight of importance. The weight of importance is codified by three gradients of high, medium, and low values. The findings of this chapter reveal a strong correlation between some combination of two out of the three independent variables and their resulting outcome in space posture. Synthesizing prestige, innovation, and funding strengthens the notion that a viable human presence in space (that is, either by government or commercial efforts) comes from the sector that is best perceived to establish a normative framework to create access by effectively manipulating the variables. The primary motivation behind human space exploration is not a singular consideration of prestige, funding, or innovation *ab ipsis*. Rather, the outcome stems from an aggregate blend that creates access to the space domain.

The two resulting postures are the product of unique arrangements between the three variables and their subsequent connecting mechanisms. The diverse set of choices connecting the variables to the outcomes create distinct and identifiable means to achieve the desired objectives of a space program. In order to understand the importance of prestige, innovation, and funding, Space Posture Theory also focuses on the sub-variable choices that America has faced as it shifted from one

[20] Ibid., 215.

space posture to another. This theory is qualitatively judged, and grouping the variables together through synthesis reveals the value of prestige, innovation, and funding in relation to the others. Space Posture Theory provides clarity to explain the seemingly chaotic activity of human spaceflight within the United States as illustrated in Figure 13.

Chapter 6

From Cosmos to Conclusion

Earth is the cradle of mankind, but man cannot live in the cradle forever.

Konstantin E. Tsiolkovsky

Outro

This thesis develops a rigorous analytical understanding of the motivations and strategies behind human space activity from the United States. To accurately explain American human spaceflight, it is necessary first to understand the history of America's space program. Studying space history—and the current transition—makes apparent there are two distinct outcomes: Old Space and New Space. Space Posture Theory provides a framework to explain the motivations and mechanisms that produce these two observable and distinct products. While reductive by necessity, this theory sheds light on the necessary and sufficient conditions that elucidate how the government's role has transformed the ways in which humans have accessed space in the twenty-first century.

Motivation and Variation

In the beginning, space was sought after by chasing one of the oldest and most persistent political virtues. This coveted virtue was prestige. Only the world's two wealthiest nations were capable of spending precious resources to compete for global hegemony as the most advanced nation on earth.[1] In the discipline of international diplomacy during the Cold War, space's soft power made a huge difference. Over the course of 50 years,

[1] Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier*Ibid. (Milton Park, Abingdon, Oxon; New York), 194.

the initial motivation for prestige evolved into searching for strategies that made space access more affordable and sustainable. By shifting the responsibility of space access to the commercial sector, the government is offering opportunities for private companies to assume repeatable tasks well inside the space frontier. By lowering its concern for national prestige, the government's intent is to open up the nascent space economy to additional actors. When private companies can successfully demonstrate a credible aptitude for human spaceflight, this opportunity will further develop the space domain.

Modalities of Space. Studying the evolution of America's space program helped identify two distinct outcomes based on the motivations of either prestige or profit. These outcomes were labeled Old Space and New Space, respectively. The historical analysis identified three primary factors that exert significant influence over how a space program develops. The factors under investigation—prestige, innovation, and funding—were cited as the primary independent variables. These independent variables identified the genesis of spaceflight activity, which then passed through a multitude of mechanisms to create the desired product (or posture). The means became the pathways that explained the variation in the outcome. By analyzing the elements mentioned above through their subsequent mechanisms, shifts in posture were traced back to their root causes which connected the motivations to their resultant outcomes.

The Results of Research

A glaring absence of any successor to the Space Shuttle motivated this research. This noticeable loss of capability demanded a more in-depth inquiry into the causal factors that led to the current predicament of the United States being reliant upon Russia. The loss of American access sparked a further intellectual investigation, questioning how government support of American human access to space has evolved in the twenty-first century. Although this study anticipates future trends in space travel

and offers some suggestions for shifts in space policy within the United States, the research was primarily analytical rather than prescriptive. Consequently, the goal of this study aims to promote a better understanding of the primary factors than to advocate for specific policy recommendations. Rather than merely pile onto a litany of directives (of which there is no shortage in academic literature), this research takes more of an explanatory approach and concludes with some thoughts for consideration and avenues of future research.

Space Posture Theory Restated

The central argument of this paper revolves around the concept of access. Space Posture Theory asserts that *to create human access to space (that is either by government or commercial efforts), the actor that is best perceived to establish a normative framework for space exploration is most likely to effectively manipulate a combination of prestige, innovation, and funding.* This argument revealed the primary driver behind human space exploration under both Old Space or New Space postures is a combination of two out of three variables, and not any singular consideration taken in isolation from the others. In short, a blended formula of two-thirds of the variables are required for humans to access space.

This study reveals a consistent and repeatable pattern that aggregates two out of the three variables. This "two-thirds arrangement" comes at the expense of the other third, which is the outcast element assigned with the lowest priority. This research suggests that it is impossible to maximize all three variables. Resultantly, Space Posture Theory explains how and why the United States selected to structure its space program the way it did at various times under different circumstances. Contextually, Space Posture Theory explains the optimization of variables to create a posture in response to the international security environment, domestic political will, internal financial constraints, and overall health of the economy. This theory offers

the most logical framework for how the United States developed its space program and it also provides explanations for how and why space exploration decisions were made.

The First and Second Space Age

The story of the first space age is rich with achievements, innovations, and experience. It was the golden age of spaceflight, with the role of the government central to human space activity. Landing on the moon was an odyssey of Homeric proportions, and the golden age of spaceflight created a genuine sense of unity for the human race the first time an astronaut stepped foot on another celestial body. Project Apollo was central to this effort, and the United States government was at the core of Apollo's power. The connection between human space exploration and national policy is vital to understanding the architecture of how NASA was formed, and for what purpose it served the Old Space paradigm.

The first 50 years of human spaceflight demonstrated the unique strengths and weaknesses of direct government involvement as space was utilized primarily for political purposes. These choices mattered significantly in creating strategic effects, which aimed to underscore the use made by space exploration to serve the ends of policy. However, recent challenges to America's space program have grown significantly due to a lack of political will and a tremendously constrained space budget. The Space Shuttle proved to be little more than a temporary cure for a figurative Space Race hangover, affording new opportunities for international collaboration with precious little to show for its high price tag, but the Shuttle's retirement ultimately left American access to space at the behest of Russia.

The United States has now entered into a second space age. The relationship between the American government and space exploration has now moved forward, attempting to get over "Apolloism." Widely under-acknowledged in academic and policy literature is the fact that in this New

Space era the United States has chosen an open market strategy to shift the government's role away from direct participation in human spaceflight. This new strategy accepts government shortfalls and creates new ways for America to re-emerge as the leading spacefaring nation. A growing space industry connects the government to the private sector, thereby shaping the strategic conduits by which humans will continue to visit space. The shift in space strategy incorporates *laissez-faire* style development by leveraging the unique strengths of commercial industries with government assistance.[2]

Stimulated by a public-private partnership, the government can further its national interests by drawing from a more extensive industrial base in the emerging commercial space sector. In return, private space companies benefit from government subsidies that inject much-needed funding to their private programs until they can support themselves. When companies can maintain a business model in the absence of government funding, the transition from top-down government mandated space activity to bottom-up commercial enterprise sustainment will be complete.

By cancelling the Shuttle Transport System without a successor, the United States placed itself in a strategic corner and is looking for a way out of its current access chokepoint. The goal of the government should ultimately be to draw from a wide selection of competition amongst a robust industrial base in the space market. The industrial base for such a variety is not quite there yet, but the government will do best by cultivating more public-private partnerships and by creating permissive regulatory policies that support small-scale space startups. Doing so will broaden the options available to create strategies that are appropriate to any context the nation is likely to encounter in space. This approach

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[2] Gordon, "The Landmark Space Age Thucydides: Human Spaceflight in the State Grand Strategic Quest to Address Fears, Advance Interests, and Garner Honor" (Masters Thesis, Air University, 2011), 136.

provides harmony across spacepower ends, ways, and means at the lowest risk possible. Providing options for multiple strategies offers the highest opportunity of regaining American space leadership in the future.

Managing the transition from Old Space to New Space has proven difficult; clear evidence of this assertion is the glaring gap in space access. Like the transition from Apollo to the Space Shuttle, a transformation of such magnitude does not come without its growing pains. A central question unique to our current transition is the role of the government, which historically has been at the center of all space activity and on the frontier of human space exploration. In the early 1960s Low-Earth orbit was the frontier. By the end of the decade, the frontier had expanded out to the moon. Since 1972, humans have not physically explored frontiers beyond the moon; the only noteworthy event has been the collaborative effort of the International Space Station. If the government can successfully garner resources for space exploration, it should remain on the frontier of space, wherever that may be.[3] New destinations await; Mars, asteroids, and the five LaGrange Points are all frontiers that remain unexplored. These are prime candidates for government involvement. The government has slowly backed away from routine space-related tasks, and doing so enables the commercial sector to capitalize on repeatable and sustainable missions to Low-Earth orbit and sub-orbital point-to-point navigation. This transition is best understood by assessing the findings through the lens of the two postures.

The Findings

This thesis systematically identifies the evolving role of the government in human spaceflight, and the subsequent restructuring of America's space program currently underway. Based on thorough historical analysis and ex-ante observable indicators, Space Posture

[3] Tyson and Lang, *Space Chronicles: Facing the Ultimate Frontier*, 76.

Theory explains how the United States created space access in the past, and for what reasons. This theory also predicts that access to space will change drastically as America's public-private space relationship has become a critical link to the transformation process. The view that America's space posture is driven top-down by political decisions is only partially correct. Open market innovation and profit potential have created bottom-up alternatives where entrepreneurial forces can now correctly predict the posture that America will most likely adopt in the future. Even in cases where security considerations mandate a top-down structure, the outcomes and rationales will become more consistent with open market decisions compared to merely political drivers. While this work focuses on the space programs of the United States, the two postures represent potential outcomes for emerging space powers to consider. As such, the Old Space paradigm offers a unique perspective compared to New Space.

Old Space Findings. An Old Space structure is ideally suited for command economies, or governments looking to use space in a competition of wills as an extension of politics. If the international environment is competitive, then an Old Space approach may be the most efficient way of leveraging non-kinetic means to bolster a nation's soft power. National prestige was the ultimate goal for the United States in Old Space. The quest to express power through attractive measures cast a shadow on all other aspects of space exploration during the Apollo era. Throughout that period the United States displayed its attractive power to the world, and cast a clear message to the Soviet Union by using human spaceflight as the means to express its political resolve.

Nestled in Cold War politics, the United States' space program balanced the government's coercive military efforts at the time by adding attractive elements to its foreign policy with space exploration. The competition with the Soviet Union manifested itself in several ways, including the Korean War and Vietnam War militarily, but space

exploration was successful at steering this competition to a peaceful outlet which resulted in arguably the most significant achievement of humankind. Employing hard power measures in direct competition with the Soviet Union could have provoked a large-scale war. However, soft power outlets in space used for peaceful purposes created an opportunity for diplomatic engagement that ultimately fostered collaboration and a brief détente with the Soviet Union after the Space Race was over.

The audacious goal set by President Kennedy required high levels of innovation. This innovation ultimately led human beings to set foot on another celestial body. The technology required to get humans to the moon invoked high levels of originality overseen by the government. Giving credit to the bureaucracy that made this possible, NASA set a noble example of innovation. NASA was the principal authority for these breakthroughs, and if they could not solve the innovation challenges by first looking inward, they relied on universities and pre-existing government contracts to help them.

The high level of importance associated with prestige and innovation came at an enormous price tag. Going to space was astronomically expensive, literally speaking. Propping up a major space program for the first time meant making major investments in infrastructure, expertise, and equipment. The only return on this investment was the resultant respect associated with doing it successfully the first time. Funding for NASA soared in the mid to late 1960s, reaching 4.5 percent of federal government spending.[4] Financial support plummeted once the goal of reaching the moon was achieved. The government could no longer sustain the support of America's domestic audience to justify the high cost of its space program.

As a result, the Old Space posture was an unsustainable endeavor. Absent international rivalry, it was a dead end and lacked the necessary

[4] Ibid., 56.

motivation to continue. Follow-on programs merely had to make do with a significantly smaller budget still seeking more pragmatic reasons to explore space. After Apollo, astronauts were chained to the bounds of Low-Earth orbit. Skylab, Apollo-Soyuz, the Space Shuttle, and the International Space Station were all moderately audacious exploration endeavors that reflected spaceflight's lower priority level in the government portfolio. From Apollo forward, NASA stomached a smaller federal budget as the government's concern for prestige in space waned. The major potential pitfalls for an Old Space program is its dependence on direct government spending and that it will only be sustainable so long as it receives support for explicitly stated government purposes.

New Space Findings. Half a century after the first human launched into space, a new posture is beginning to take shape. By pulling the priority away from prestige and placing it on profit, New Space posture allows the government to transition into a supporting role rather than consuming tax dollars through direct involvement. This posture centers around the goal of lowering the cost of space lift, thereby potentially increasing access through a higher annual frequency of flights. The current context of international politics allows America to divorce itself from the perception of prestige as a driving force in space, thereby cultivating creative options to generate sustained access.

The government is nurturing the new market through decentralized and detached funding schemas. Decentralized funding spreads financial risk across the public-private spectrum, where the government shares responsibility with the most promising commercial companies to service public-relevant applications. Decentralized funding combines government subsidies and private investment. Milestone-based fixed contracts form the foundational agreement of this sharing plan.

Decentralized funding is the progenitor of detached funding. In the future, funding for space activity most likely will come from detached funding. Detached funding is the most recent financial development, and

currently survives by ultra-lean budgets and efficient processes. Detached funding presently comes from inducement prizes and sponsorships of angel investors, as small-scale private startup companies struggle to survive without financial assistance from the government. Space Posture Theory predicts that the struggle will quell as companies continue to grow.

The sources of innovation are more diffuse in New Space. The innovation landscape has become much broader today compared to NASA's traditional modus operandi. NASA no longer mandates design requirements, and the role of the government has reversed; NASA receives rather than drives innovative requirements. Because New Space posturing has the benefit of borrowing expertise and lessons from NASA, the weight of importance for innovation in Old Space ranks slightly higher than New Space. However, ex-ante estimates predict that private space companies will achieve displacement from NASA's sphere of influence shortly and innovate indigenous solutions to lower the barriers to space accessibility. It is difficult to sustain empirically that New Space is entirely distinct and separate from Old Space, because it is more accurate to view New Space posture as an evolution of Old Space rather than a radical alteration. This assertion holds true because the independent variable of innovation is the common thread that links the two postures together, sustaining the notion of evolution rather than revolution. However, emerging space powers can cultivate a New Space posture initially, without having first built an Old Space program. The potential pitfall is that a nation would have to sacrifice a sense of urgency to develop a New Space program, especially if the country's pre-existing economic structure is not built on open market values. In short, New Space takes more time and it assumes a healthy, free-market economy.

The Globalization of Space

Space was at one time the exclusive domain of the world's wealthiest countries.[5] Due to the increased collaborative environment of the current space architecture following the Cold War, national prestige is of low concern in New Space. Certainly this varies by country which suggests that if one looks at the international system, a nation could have a combination of Old and New Space competing with each other. The motivation for the space programs in India, the United Arab Emirates, and Japan, for example, seem to suggest prestige matters. The fact that most states have a national space program alludes to the fact that prestige still has to matter somewhat. Today, 12 countries host a total of 26 public and private launch facilities which will undoubtedly service human missions in the near future.[6] The pace of international cooperation is increasing, and a wave of globalization is taking effect in the space environment as well. Thanks to advances which have lowered the cost of lift and dispersed the sources of innovation, the space domain is now open to a larger crowd of new actors.

The globalization of space has already begun, and nation-states are no longer the only participants. Entrepreneurs deserve credit for new approaches and lower costs that have helped lower the threshold to explore space. This democratization effort will pose new challenges to the space environment and may create more even more arrangements of Space Posture Theory. Various arrangements may include placing a priority on prestige and funding at the cost of innovation. Drawing from multiple space postures, it is likely that plans of space democratization will produce an exponential rise in human spaceflight activity.

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[5] Robert C. Harding, *Space Policy in Developing Countries : The Search for Security and Development on the Final Frontier*, Space Power and Politics (Milton Park, Abingdon, Oxon; New York: Routledge, 2013), 1.

[6] Dave and William Welser IV Baiocchi, "The Democratization of Space," *Foreign Affairs* May/June, no. IV (2015).

Implications

The intellectual journey set forth to address the government's evolving role in human spaceflight has alluded to many implications. The shift from Old Space to New Space has many positive and negative attributes but is primarily dependent upon the international security environment and the health of the domestic industrial space base. The government must simultaneously enable and benefit from both space postures to select the one that is most beneficial under the political context of any given time.

Exactly how the government supports a shift in posture will be most indicative of its concern for either prestige or economic growth. By desiring soft power from achievements in space in a competitive environment, prestige reigns supreme. Conversely, when space is no longer a competitive environment, government efforts can cultivate the free market enterprise, as mentioned previously, by highlighting that open market forces will better develop human space activity. By fostering economic growth to create revenue for private companies in a collaborative security environment, profit reigns supreme. A government's posturing for economic growth is likely dependent upon the relative strength of the foundation built by the commercial space industry, and the degree to which the government supports both traditional and emerging space providers. One effect of commercial space growth is that direct government involvement is becoming significantly smaller, as was the case with the aviation industry in the United States.

Approaches to develop and mature a robust commercial space market should take into account the need to diversify a government's space portfolio. Assuredly, this will create a latent space power that the government may convert for national security efforts at any time. To fully appreciate and efficiently utilize the two postures, the government needs to support private space endeavors by encouraging competition within the domestic space market. By partnering with the most assuring companies

and providing transparent, well-structured, and minimally burdensome regulatory policies, a different normative framework will emerge in a nascent but promising sector of human spaceflight activity.

Avenues for Future Research

The focus of this thesis is on the overlooked experiences of the United States' transition of human spaceflight activity from a government-led model to a private-led model. While this research focuses on the experience of the United States, Space Posture Theory is equally applicable to other space powers that aim to bolster their national power and socioeconomic development. A logical next step of this research would be to analyze the Russian space program under the framework of Space Posture Theory. A case study on Russia may further support or refute the theory and will help determine if it holds explanatory power by accurately characterizing Russia's decisions and outcomes amidst their shifting political environment before and after the fall of the Soviet Union.

China also is a prime candidate for consideration. China is quickly gaining traction in the human spaceflight arena after becoming a member of the elite human spaceflight club on 15 October 2003. Making Chinese history, taikonaut Yang Liwei blasted off in his Shenzhou Five capsule for China's first-ever human space mission, creating a hysteria of fanfare among China's domestic population.[7] To date, China has sent 11 taikonauts to space and plans to send many more.[8] China is exploiting the precedent set by the United States; America has given China a useful playbook. Borrowing heavily from the Apollo Program, China is replicating American space achievements at a much faster rate. China's first launch was orbital while America's was sub-orbital. China's first spacewalk was conducted on their third spaceflight, while America's and Russia's were

[7] Johnson-Freese, *Space as a Strategic Asset*, 204.
[8] Ibid., 208.

conducted on the eighth.[9] China has proven to be a space-minded nation of fast learners, now leading the way with the most progressive rate of any nation. In 1961, there were two superpower members of the exclusive human spaceflight club. In 2018, there are still two members, but the United States is not one of them. China has replaced America's spot.

Perhaps China is creating a third arrangement within Space Posture Theory. China's posture appears to assign high importance to prestige and funding, but low importance to innovation. The evidence to support this claim is that China has developed a reputation for replicating other nation's products and systems through reverse-engineering methods. It is not by chance that China's human launch facility—the Xichang launch site—is at 28 degrees north latitude. This site has the same orbital inclination as the Kennedy Space Center.[10] Additionally, China's Shenzhou capsule design looks strikingly similar to Russia's Soyuz spacecraft. Demonstrating a low concern for innovation, China is emulating characteristics of the two established superpower space countries. China partners with Russia for design schematics and borrows from America's open-source literature on systems design.[11]

Examining space policies of the United States, Russia, and China—and the outcomes of their policies—helps address how other states may structure their space programs to achieve national goals. If India, Brazil, Israel, and South Africa can successfully place humans in space, a cascade of spaceflight activity could emerge that would create complicated multipolar competitions very different from the Cold War Space Race or the permissive space environment in the years that followed the moon landing. It is highly likely that more nations will seek entrance into the human spaceflight club as an effective means to play an integral role in the ever-evolving environment of international politics. Developing a

[9] Ibid., 209.
[10] Ibid.
[11] Ibid.

human space program has proven to support both national security and socioeconomic goals for superpowers, and such an assertion may also hold for rising regional powers.

There is little evidence that suggests developing space countries will mirror the two models of American spaceflight, or that their behavior will follow the same patterns. What strategies and choices will these space seeking states make about their Astro-enterprise? By assessing the transition of human spaceflight from a purely governmental response to an approach that blends public and private involvement, the above question points to how the privatization of American spaceflight might affect international relations and the geopolitical balance of power. By studying the transition from one posture to the other, America's historical background and future projection are valuable data points that greatly assist other countries in developing their space programs. The choices made under the Old Space construct are distinct from New Space, and the methodology to explain this phenomenon offers a template to use for analyzing other spacefaring nations. In short, the thread between both postures is an attempt to utilize space assets to their fullest measure given the context of their geopolitical environment.

Final Words

As of 2018, access for human spaceflight from the United States continues to be non-existent. However, nature abhors a vacuum. Nascent technologies from the private sector give hope that America can return to the forefront of space dominance and human spaceflight exploration. In short order, human spaceflight activity under New Space will generate a wellspring of achievements in the private sector characterized by various ongoing projects designed to democratize human spaceflight outside of government efforts. Space Posture Theory aims to earn a place in academia as a clear theoretical framework that provides a systematic

understanding of the role of the government in the evolving arrangement between the public and private sectors.

This unique perspective of space exploration resembles a balance between state security and socioeconomic development. Clausewitz outlined the triune relationship of government, military, and people as the eighteenth-century cornerstone of Napoleonic nation-states. Since 1961, a nation's space program has become an essential extension of politics that provides a nation with continuing strategic advantage. However, one must be cautious of viewing space strictly as an augmentation of politics because this notion falls short of capturing its socioeconomic value. The successful development of a private sector space program can serve not only to ensure state survival, but also increase its prosperity.

Beyond the balance between security and prosperity, one must also consider human space activity as something more. Space access—divorced of the need to "one up" other countries—gets to the pure essence of exploration. This essence is the most uncontaminated human desire to discover. Space exploration reveals how powerful human life can be when we are just discovering to discover. As humans, we are all enticed by this new endeavor in outer space; it intrigues us to be a part of something much greater than ourselves. In short time, more humans will have the opportunity to experience space. Who knows what serendipity we may encounter? Space will become the way to equalize humanity; the view from above makes the astronauts preside over the politicians. With this vantage point, all the trivial conflicts that happen on earth just wash away and blend into one. Perhaps Apollo Fourteen Moonwalker, Dr. Edgar Mitchell, said it best. Mitchell described a sense of unity from his perspective on the lunar surface by looking back at the Earth and reflecting:

> You develop an instant global consciousness, a people orientation, an intense dissatisfaction with the state of the world, and a compulsion to do something about it. From out there on the moon, international politics look so petty. You want to grab a politician by the scruff of the neck and drag him a quarter of a million miles out and say, "Look at that!"[12]

Achievements in space truly transcend nations and genuinely affect social change. As we move forward, let us remember this fact.

[12] Neil DeGrasse Tyson and Avis Lang, *Space Chronicles: Facing the Ultimate Frontier*, 1st ed. (New York: W.W. Norton, 2012), 3.

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