Analogical Reasoning in Orbital Warfare

By

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APPROVAL

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

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DISCLAIMER

The views 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, the United States Space Force, or Air University.

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ABSTRACT

The purpose of this thesis is to codify and evaluate the analogical reasoning present in the literature concerning space warfare. As the United States Space Force establishes a corps of Orbital Warfare professionals, those officers and enlisted personnel must understand which analogies are often evoked and how they assist or distort an accurate understanding of space forces and the space domain. This paper will provide two frameworks to assist space professionals in analyzing analogies and using those analogies productively. An analysis of two analogies—one between early airpower and modern spacepower and one between the high seas and the space domain—is then provided. Finally, an analysis of how those two analogies distort or promote comprehension of orbital warfare and space warfighting in general is provided along with best practices for the use of analogies.

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Introduction

There is no word which is used more loosely, or in a greater variety of senses, than "Analogy."

John Stuart Mill

What is an Analogy?

PUPPY : DOG ::

(A) KITTEN : CAT; (B) BIRD : NEST; (C) DOG : KIBBLE; (D) FISH : SEA

When one hears the word analogy, many immediately envision the proportional analogical reasoning questions of standardized tests like the one above. Interestingly, the College Board, which administers the Scholastic Aptitude Test (SAT), removed the analogies segment from their standardized tests in 2005 because the Board determined the section no longer reflected the type of curriculum work taught in American classrooms.[1] Others have protested the removal as short-sighted, arguing the capacity to navigate analogies accurately is foundational to logical reasoning itself.[2]

In their seminal work on analogic thinking, *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking,* Douglas Hofstadter and Emmanuel Sander claim that "without concepts, there can be no thought, and without analogies, there can be no concepts."[3] Analogies, they posit, are at the root of human thinking itself. In its most abstract form, analogy represents the ability to think about relational patterns.[4] In their most basic form, analogies serve

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[1] Adam Cohen, "An SAT Without Analogies Is Like: (A) A Confused Citizenry…," *The New York Times*, 13 March 2005, https://www.nytimes.com/2005/03/13/opinion/an-sat-without-analogies-is-like-a-a-confused-citizenry.html.
[2] Ibid.
[3] Douglas Hofstadter and Emmanuel Sander, *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking* (New York, NY: Basic Books, 2013), 3.
[4] Dedre Gentner, Keith Holyoak, and Boicho Kokinov, *The Analogical Mind: Perspectives from Cognitive Science* (Cambridge, MA: The MIT Press, 2011), 2.

their purpose by providing simple comparisons that assert parallels, both explicit and implicit, between two distinct things, based on a perception that they share some property or relation.[5]

The process of analogical extension--that is, expanding understanding from one concept to another--provides immeasurable utility to humans. However, this mental extension can be fraught with the potential for error. As humans expand a concept from one understanding to another, they may accept elements of the analogy that misrepresent the new idea. Through the misapplication of original relationships or exclusion of relevant information, the analogical process inherently includes a risk for distortion or misunderstanding.

Nevertheless, despite these risks, certain concepts seem to gravitate toward the use of analogies. One condition that appears to attract analogical reasoning is the effort to learn an utterly foreign concept or domain. There is perhaps no concept more alien to humans than that of outer space.

Background and Significance of the Problem

Over the past sixty years, the United States has grown increasingly reliant on outer space as a critical link in both its modern information economy and defense architecture. The US national security enterprise has recently identified outer space as a vital warfighting domain. In 2017, the *United States National Security Strategy* stated that "The United States considers unfettered access to and freedom to operate in space to be a vital interest. Any harmful interference with or an attack upon critical components of our space architecture that directly affects this vital U.S. interest will be met with a deliberate response at a time, place, manner, and domain of our choosing."[6] In *Space Policy Directive-4*, issued in 2019, the President of the United States declared space "a warfighting domain just like the air, land, and sea."[7] Furthermore, on 20 December 2019, the United States established the United

[5] John Pollack, *Shortcut: How Analogies Revel Connections, Spark Innovation, and Sell Our Greatest Ideas* (New York, NY: Gotham Books, 2014), xiii.
[6] President Donald Trump, *National Security Strategy of the United States* (Washington, DC: The White House, December 2017), 31.
[7] President Donald Trump, *Space Policy Directive-4: Establishment of the United States Space Force* (Washington, DC: The White House, February 19, 2019).

States Space Force (USSF) with the mission to "organize, train, and equip space forces in order to protect U.S. and allied interests in space and to provide space capabilities to the joint force [to include] developing military space professionals, acquiring military space systems, maturing the military doctrine for space power, and organizing space forces to present to our Combatant Commands."[8]

The proclamation of a new domain of warfare and the creation of an organization charged with mastering it is not unprecedented, but it is rare. Over one hundred years have passed since the creation of the Lafayette Escadrille and the USS Holland, the first American fighter squadron and modern submarine. Over one hundred years have passed since Americans last sought to paint a new domain in the art of war. Now it falls to the men and women of the USSF to develop an understanding of outer space and orbital warfare necessary to fulfill its charter.[9] The pertinent question for our purposes here is, how is this understanding of the space domain being developed? It is that question which brings this analysis back to the subject of analogies.

An Argument Concerning the Requirement for Analogical Reasoning in the Realm of Orbital Warfare

As previously stated, people use analogies in every stage and walk of life. The task set before the USSF requires a unique level of reliance on analogical reasoning. Whether it is unfortunate, inevitable, or both, as humans and their creations have ventured into space, war has gone along with them. Meanwhile, outer space stands as a domain shrouded in mystery to the ordinary person. In 1925, Billy Mitchell distinguished an "air-going people" from "land-going people" and "sea-going people."[10] He highlighted that from the beginning of time, all people have known something about the land and the sea. He contrasted this

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[8] Department of Defense, *US Space Force Fact Sheet* (United States Space Force, December 2019).

[9] As there currently exists no official DOD definition for "orbital warfare," I have defined the term for the purposes of this paper as "Warfare conducted whereby the attack vector originates in the space domain."

[10] William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power – Economic and Military* (Tuscaloosa, AL: The University of Alabama Press, 1925), 6.

with the fact that, in his day, very few people had flown in airplanes with "vantage points on high" where one could "see more of the country, know more about it, and appreciate more what the country means to them."[11] It is debatable whether Mitchell was correct in assuming that "air-going people" were imbued with more patriotism by a function of their experience at higher altitudes. Nevertheless, Mitchell did identify a dynamic that is just as relevant 95 years later: that nearly every human had, or could quickly develop, personal, visceral experience with terrestrial Earth—with the land and with the sea, but not so with the air or outer space.

Much has changed in the last century concerning humanity's overall experience with the air domain. In 2016, 81 percent of American adults reported that they had flown in an airplane at least once in their lives.[12] This percentage is a far cry from the hundreds, possibly thousands, of Americans who had ever flown in an aircraft by 1925. Today, television, movies, computer-generated graphics, the internet, video games, and virtual reality provide humans with the incredible virtual experience of flying and the aerial perspective. Over the past hundred years, the distinction between land-, sea-, and air-going peoples has shrunk dramatically. While most Americans could not fly an airplane themselves, much less engage in a bombing mission, strafing run, or aerial dogfight, most of the populace knows roughly how an airplane works. Many could explain that aircraft takeoff from airfields, that they must move forward at high speeds to stay in the air, and that it is best if their wings remain attached to the fuselage if they want to stay aloft. Let us now compare Americans' experience and knowledge of the "air" with that of outer space.

First, the number of "space-going" people, in Mitchell's literal sense, remains incredibly small. As of December 2019, only 565 humans had ever launched into outer space during nearly 58 years of human spaceflight.[13] Compared to the number of "air-going" people in Mitchell's day, the number of

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[11] Ibid., 7.
[12] Dan Reed, "Americans Love To Complain About Flying, But Probably Less Than You Think," *Forbes*, 14 April 2016, https://www.forbes.com/sites/danielreed/2016/04/14/americans-love-to-fly-they-also-complain-about-it-a-lot-but-probably-less-than-you-think/#331ea5156423.
[13] "Astronauts and Cosmonauts," *WorldSpaceflight,* https://www.worldspaceflight.com/bios/stats.php.

Americans who have been to space today is dramatically small. Only a few hundred select US astronauts possess a personal, visceral experience of the outer space environment. The fact that only 0.000001% of Americans have been to space implies that "non-space-going" people will predominantly comprise the USSF. Even if astronauts made up the entire USSF, they would still lack the understanding required to perform the prescribed USSF mission.

Astronauts surely gain an unparalleled knowledge of the differences between the physical forces exerted upon matter in Low Earth Orbit (LEO) versus terrestrial Earth. But the United States predominantly classifies its astronauts as civilian space explorers whose mission set is science and exploration, not offensive and defensive military operations. For the foreseeable future, astronauts will not be the ones conducting offensive warfighting activities in space. Furthermore, in the coming years and decades, USSF orbital warfighters will control their spacecraft weapon systems from the ground as opposed to operating in space themselves. In summary, the USSF must master orbital warfare without the benefit of its personnel having personal experience *in* space; even the rare astronaut serving in the USSF is unlikely to possess the experience relevant toward the warfighting mission of the USSF.

The task of defining the art of orbital warfare will fall to USSF members, who will face an experiential deficit never before seen by American military professionals. Today's Soldiers, Sailors, Airmen, and Marines operate in well-trod and correspondingly well-understood domains. The role of the USSF officer is to learn to fight in the figurative unknown.

Into the Unknown

In her 2018 article "Treating Outer Space Like a Place: A Case for Rejecting Other Domain Analogies," Elizabeth Mendenhall presents an argument against the use of analogies in the establishment of outer space policy and governance mechanisms.[14] Mendenhall writes that "Analogies serve as a vehicle for importing pre-existing legal principles, norms, and rules, but also ideas about what is happening in space, why it is happening, and why that

[14] Elizabeth Mendenhall, "Treating Outer Space Like a Place: A Case for Rejecting Other Domain Analogies," *Astropolitics*, Issue 16:2 (2018): 97-118.

matters."[15] Mendenhall identifies four analogies which have been used since the 1950s to aid policymakers in approaching governance issues related to outer space: "the high seas oceans," "the ocean seabed," "Antarctica," and "extended airspace."[16] Mendenhall concludes that analogies, in general, provide limited utility, at least as regards outer space, because they "are used as an expedient to understand situations without much information, so users are poorly suited to identify which parts of a given analogy are revealing, and which are concealing."[17]

Mendenhall asserts that each of the analogies used about outer space distorts policymakers' understanding of the outer space domain. She presents six major features that she argues are overlooked or distorted by the four analogies: lack of ecology, lack of fluidity, distribution of access technology, nature of movement, infinite frontier, and existential impacts.[18] The table recreated below in Figure 1 presents the essence of her findings relative to the six major functions and four analogies.

Analogy	Version	What it captures	What it misses	Presence in regime
Ocean	High seas	Vast, fluid; Solid islands; Obstacles to deep access; Coastal area (airspace)	Infinite; Effective distance (speed of vehicles); Delicate and expensive technology; Security issues; Space ports (leave, don't arrive)	National registration; International commons; CIL principles instead of positive rules; Rescue obligations
Ocean/Land	Seabed	Vast potential mineral wealth; Obstacles to access	Infinite; No ecological context; Separate mineral caches; Abundance of helium	Moon Treaty (CHM)
Land	Antarctica	Harsh environment; Fragile environment; unknown resource extent; Distance; Uninhabited except for few settlements	Infinite; Mostly unable to partition; Requirement of advanced technology	International commons; National control over humans, vehicles, stations; functional coordination comes first; scientific cooperation
Atmosphere	Airspace	Ascendance and 'flying'; Vehicle safety issues; Vehicle registration needs	Infinite; Orbital mechanics; Obstacles to partition	Liability rules

Figure 1: Analogies for Outer Space
Source: Elizabeth Mendenhall, "Treating Outer Space Like a Place: A Case for Rejecting Other Domain Analogies," Astropolitics, *vol.16, no. 2 (2018), 107.*

[15] Ibid.,104.
[16] Ibid., 107.
[17] Ibid., 104.
[18] Mendenhall, "Treating Outer Space Like a Place."

Mendenhall deals with these analogic distortions by supplanting analogies entirely. She argues, "Eventually [analogies] can be replaced with direct information about their target" and offers an "image of outer space" based on the "basic physical features and patterns of the outer space environment," which, she argues, provides a superior understanding of outer space upon which to make policy and governance decisions.[19] Mendenhall contends that her 947-word "non-analogical representation of outer space" is "superior to relying on analogical comparisons with various planetary domains."[20]

Five key components comprise Mendenhall's thesis. First, she argues that analogies, though attractive, are inherently misleading and distort a proper understanding of outer space. Second, she identifies specific distortions common with frequently-used analogies in outer space governance. Third, she states that "analogies are no longer necessary to provide a 'locational classification' for outer space" because "scientific knowledge production and technological advancement" and "scientific and technical experts generally comprehend the basic physical features and patterns of the outer space environment."[21] Fourth, due to the misleading and distorting nature of analogies and the fact that analogies are no longer necessary, "using direct scientific evidence is […] superior to relying on analogical comparisons."[22] Lastly, she provides an example of what she argues is a superior conceptual extension device, relative to analogies, with her non-analogical representation of outer space.

The USSF is setting out to create a new art of orbital warfare in a domain unknown to nearly every USSF officer and enlisted person. As such, the drive and necessity to use analogical reasoning will be incredibly high. Considering Mendenhall's condemnation of analogical reasoning in the development of space governance, what is one to make of the interactions between analogical reasoning and the development of USSF orbital warfare in 2020? Will space

[19] Mendenhall, "Treating Outer Space Like a Place," 108.
[20] Ibid., 115.
[21] Mendenhall, "Treating Space Like a Place," 108.
[22] Ibid., 111.

warfighters be as ill-served by analogies as Mendenhall argues space policymakers have been?

Mendenhall's article presents several compelling ideas worthy of examination by the modern space warfighter. If analogies have brought such destructive thinking on the community of outer space policymakers, how might analogical reasoning impact the community of space warfighters? How will analogical reasoning affect their ability to comprehend their warfighting domain properly? This thesis aims to tackle several questions concerning analogies and orbital warfare. First, what are some of the analogies most prevalent in space warfighting thought today?[23] Second, what do these analogies aim to elucidate? What specific relations do the analogies present? Third, are the analogies achieving their intended ends or distorting our understanding as badly as Mendenhall claims occurred with space governance? Lastly, what role should space warfighters afford analogies in their efforts to protect and defend US space superiority? How can space warfighters best leverage analogies, maximizing their value while minimizing distortion?

This study will not seek to uncover and examine every analogy used or possible in articulating outer space, space warfighting, or orbital warfare. Furthermore, it will not identify every significant feature of outer space or orbital warfare that may necessitate better understanding by analogical reasoning or otherwise. The goal of this study is to understand which analogies are present in the orbital warfare community already, how they are impacting the understanding of the features of orbital warfare, and what role space warfighters should allow for analogies moving forward. For this focused analysis, I have selected two prominent analogies for analysis:

Analogy #1 – Early Airpower : Modern Spacepower[24]

Analogy #2 – High Seas : Space Domain

I have chosen these specific analogies because they have seen extensive usage since the earliest days of spaceflight to the present day. Additionally, in the debate revolving around the creation of the US Space Force and the still-

[23] For the purposes of this paper I consider "space warfighting" to consist of all military space operations, terrestrial or in the space domain.

[24] For the purposes of this paper, "Early Airpower" will refer to the timespan between 1903-1947.

needed development of US space warfighting doctrine, both are repeatedly evoked by senior political and military leadership.

Chapter 2 further explores the concept of analogical reasoning and will include some of the latest research on analogies from the fields of cognitive science and psychology. In that chapter, I identify and explain two frameworks that will provide the structure for the remainder of the analysis. Chapters 3 and 4 will define, map, and attribute relational accuracy to each of the analogies listed above. In Chapter 5, I will provide an overarching analysis of analogical reasoning in space warfighting and offer my conclusions concerning how the USSF should best regard analogical reasoning moving forward.

Chapter 2

Analogical Reasoning

> *I will open my mouth in a parable; I will utter dark sayings from of old, things that we have heard and known, that our fathers have told us.*
>
> Psalm 78:2-3

Human cognition is a marvelous and wondrous abstraction. Whether one believes it has evolved over millennia or represents the very creative nature of God, the fact that humans can think and reason distinguishes our species from any other on Earth. Over the past 70 years, an explosion of research into cognitive psychology has taken place and this chapter seeks to distill the concepts discovered in that body of study into something usable for the orbital warfighter.[1] First, I will codify a firmer definition of analogy for this thesis. Next, I will provide the examination terms I use to parse the analogies of Chapters 3 and 4. Lastly, I will explain and demonstrate two necessary frameworks for analyzing and codifying analogies.

Analogy Defined

As demonstrated in the introduction of this thesis, definitions abound when it comes to the word and concept of analogy. Douglas Hofstadter, one of the leading researchers in the field of analogy research, holds a belief that analogy is truly the core of all human cognition or thought.[2] Hofstadter goes as far as disavowing the common term *analogical reasoning* arguing that "Analogy has nothing to do with reasoning, it's a misnomer, and it's a misconception of what analogy is."[3] Hofstadter sees an analogy in everything, from a child

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[1] Dedre Gentner, Keith Holyoak, and Boicho Kokinov, *The Analogical Mind: Perspectives from Cognitive Science* (Cambridge, MA: The MIT Press, 2011), 7.
[2] Douglas Hofstadter and Emmanuel Sander, *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking* (New York, NY: Basic Books, 2013), 3
[3] Douglas Hofstadter, *Analogy as Cognition,* YouTube video, 1:08:36, 10 September 2009, https://youtu.be/n8m7lFQ3njk.

developing comprehension of who and what his mother is, to the impact of linguistic structures in various languages when it concerns applying feminine or masculine qualities to nouns and verbs. Hofstadter describes analogy as the very mechanism of human thought. This concept itself is intriguing and I will refer to it in the concluding chapter, but at this point, Hofstadter's definition of analogy proves too abstract for our usage. Despite Dr. Hofstadter's perspective on the phrase, I will use the term *analogical reasoning* if only because it permeates the remaining literature and provides the most commonly recognizable reference to the process by which analogies support thinking.

This monograph began with a simple proportional analogy, typical of those found in an everyday Intelligence Quotient (IQ) or standardized test. These simple forms of analogies do not, however, fairly characterize the richer types of analogies analyzed in this study. The term used to describe the forms of analogy addressed by Mendenhall and this paper is *interdomain analogies.*[4] Whereas proportional analogies like those in standardized tests are based on a *single* common relation, interdomain analogies represent comparisons between different knowledge domains based on a *set* of common relations.[5]

Definitions

Within the concept of analogical reasoning, a variety of other artifacts warrant definition. First and foremost, I will use the following as our definition for analogical reasoning: "The process of transferring across domains and between analogs that may have little surface resemblance but share relational structure; thinking which generates both specific inferences and more general abstractions from as few as two examples."[6] In this study, I use the terms *source analog* and *target analog* to represent the concepts that connect two domains. In analogical reasoning, one establishes a connection between a domain of familiarity and its familiar analog, to a less familiar domain, via a second corresponding analog. The source analog is the analog corresponding to

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[4] Kevin Zook, "Teaching and Learning by Analogy: Psychological Perspectives on The Parables of Jesus," *International Christian Community of Teacher Educators Journal,* vol. 6, no. 1 (2010), Article 4.
[5] Ibid.
[6] Gentner, Holyoak, and Kokinov, *The Analogical Mind*, 162.

the *base domain* (the familiar domain). The target analog corresponds to the domain of less familiarity, or the *target domain* (unfamiliar domain).[7] These domains represent the heads of the conceptual bridge formed by the interdomain analogies (between the base and target domains). The bridge itself is the analogy.

Equipped with the concepts of source and target analogs, let us briefly revisit the concept of analogical reasoning. Keith Holyoak and Paul Thagard explain that analogical reasoning is not "logical" in the sense of a logical deduction—there need not be any reason why the base and target domains would operate in manners comparable to their analogs in the real world. Nevertheless, the analogies used in Mendenhall's examples, and those I will analyze herein, are not arbitrary or random. In a less precise manner, they show some essence of logic, referred to as *analogic,* in that they constrain the way one uses the analogy (comprised of the source and target analogs) to try to understand the target domain by seeing it in terms of the base domain.[8]

How the source analog connects to the target analog--that is, how the conceptual mental bridge is constructed between the two heads--is commonly expressed as *mapping.*

Mapping

Mapping lies at the heart of analogical reasoning and refers to the systematic set of correspondences between the elements of the source analog and the target analog.[9] Mapping expresses the process by which one draws relational comparisons between the source and target analogs and then infers a variety of concepts (understandings) about the target domain.

The concepts defined so far ultimately come together under a theory known as *structure-mapping theory*. According to structure-mapping theory, interdomain analogies possess three categories of relational concepts: *object attributes*, *first-order relations*, and *higher-order (superordinate) systems of relations*. Object attributes are the literal surface features of specific objects

[7] Zook, "Teaching and Learning by Analogy."
[8] Zook, "Teaching and Learning by Analogy."
[9] Zook, "Teaching and Learning by Analogy," 4.

found in the base domain. First-order relations are relationships between objects. Superordinate relations serve to hold together sets of first-order relations as higher-order relations. Interdomain analogies often present individuals with a higher number of objects and possible relations to map than the simple PUPPY : DOG proportional analogy. An example of just such an interdomain analogy is offered at the end of this chapter.

An interdomain analogy provides the ability to compare two knowledge domains which present little or no surface similarities by relying on their shared common relational structure instead. As a result, analogies can, at times, place a high level of cognitive demand on individuals and can encourage them to form misconceptions and faulty mental models when they map the wrong ideas from one domain to another—when they extend the analogy too far or in the wrong ways.[10]

The primary difficulty individuals experience when applying interdomain analogies is determining which aspects of the base domain to map to the target domain—a critical point, especially for this paper's analysis. Depending on the specific information selected for mapping, the resultant understanding or conceptualization of the target domain is either enhanced or impeded. Furthermore, a mapping with more accurate correspondence (more interconnected facts) provides a more complete and coherent way to relate domains. A mapping with inaccurate, or less accurate, correspondence (interconnected facts) provides a distorted or incomplete understanding of how the domains relate. Structure-mapping theory represents these hazards through three types of potential mappings (see Figure 2): those to *irrelevant relations*, those to *the alternative system*, and those to *the mappable (or intended) system*.

[10] Zook, "Teaching and Learning by Analogy."

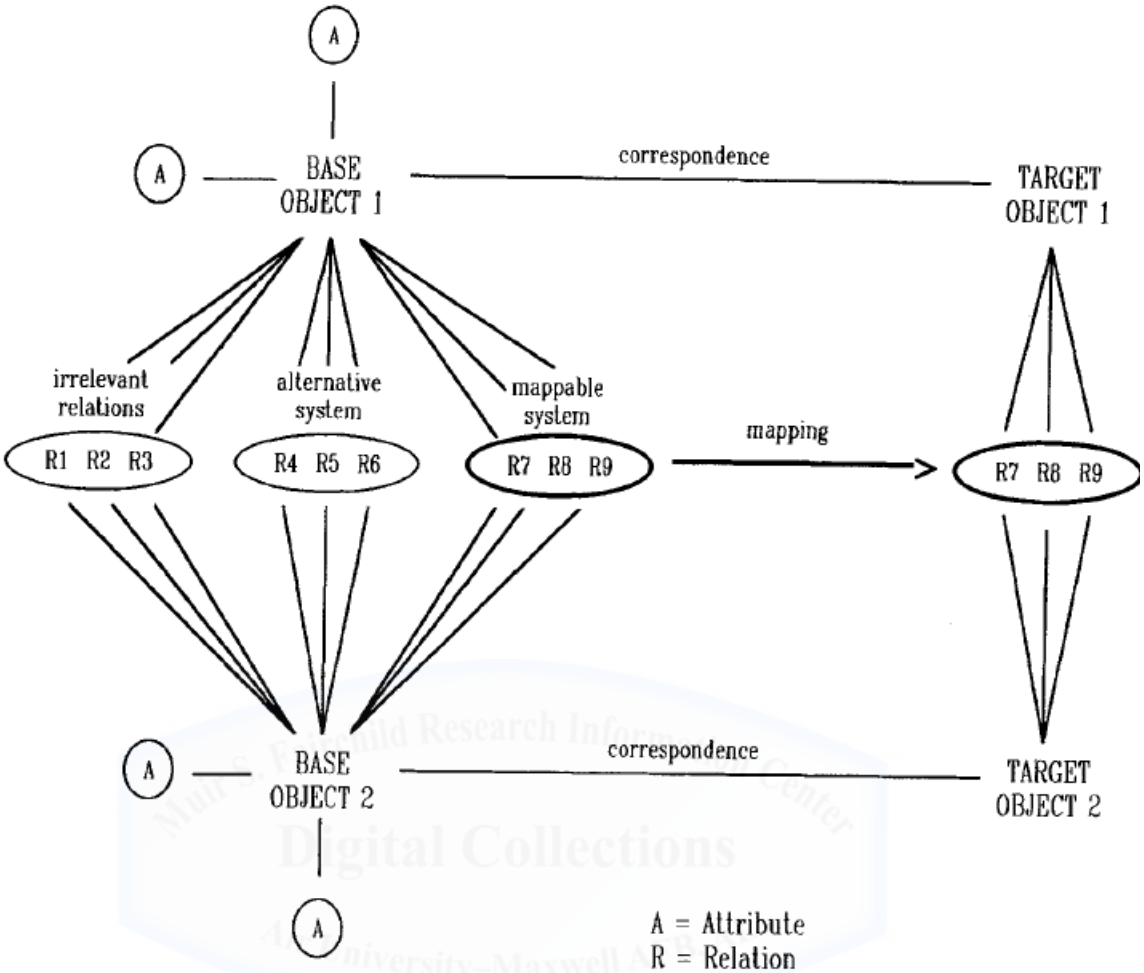

Figure 2: Analogical Mapping: Transferring the Mappable Relational System and Disregarding Extraneous Features.
Source: Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy," Cognitive Science*, vol. 7 (1983), 160.*

Figure 2 warrants additional explanation as the elements contained therein form the basis for our analysis of space warfighting analogies. As the base domain is triggered, via the source analog, several relations (R1-R9) are called to mind. These relations fall into the three broad categories identified above: irrelevant relations, the alternative system, and the mappable system. According to structure-mapping theory, under the influence of a relatively fruitful analogy, individuals are most likely to map higher-order systems of relations (R4-R9) rather than isolated first-order relations or surface object attributes. This tendency is referred to as the "systematicity principle." As a

relational system is mapped, isolated first-order base relations that are not constrained by the same superordinate relation are discarded as some of the many "irrelevant relations" (R1-R3). However, the remaining relations can be categorized as belonging to either the "mappable system" or the "alternative system." Those which contribute to better understanding of the target domain are assigned to the "mappable system" bin (R7-R9). Those relations which distort an accurate and superior understanding of the target domain are assigned to the "alternative system" (R4-R6).[11] The relations between the source analogy and target analog encompassed in the "mappable system" (R7-R9) represent the variety of correspondences that form the bridge between the base domain and target domain. In summary, analogies evoke relations between the analogs that fall into the three categories as either irrelevant to the learning objective (irrelevant relations), distorting understanding (alternative system), or promoting a better understanding (mappable system).

A Simplified Framework

A study of school-aged children's education through analogy may be well-served by carefully examining all three categories of relational systems (mappable system, alternative system, and irrelevant relations). Regularly exposed to new objects about which they yet know nothing, small children deal with abundant cognitive relations in their attempts to understand analogies. The subject of this paper is space operations and warfighting, which are novel concepts for most people. Nevertheless, the focus of analysis is on the possible distortions in an understanding of space operations and warfighting primarily among military officers. It is safe to assume that US military officers possess at least an elementary analogical reasoning ability high enough to eliminate a majority of obviously irrelevant relationships between the source and target analogs. I am willing to take this analytical risk as an exhaustive list of irrelevant relations could number in the thousands, if not more. For example, I find there to be little value in analyzing and categorizing such obviously irrelevant relations as these:

[11] Zook, "Teaching and Learning by Analogy."

Table 1: Irrelevant Relations

Army Air Corps pilots wore **green** uniforms	→	**US Air Force operators** wore **blue** uniforms
Airplanes don't stay on the ground	→	**Spacecraft** don't stay on the ground

Source: Author's Original Work

Furthermore, these types of irrelevant relations are more commonly rooted in distortions caused by direct attribute mapping rather than the relational mapping I am concerned with here. Since the analogies examined in this paper are of a more sophisticated and complex variety, I have eliminated the irrelevant attributes from the framework.[12] At the same time, for this analysis, I have sought to isolate analogies such that I will examine one pair of base-target objects per chapter. Therefore, I present a simplified form of the structure-mapping theory framework (Figure 3) for use in this and the following two chapters. This form of the framework preserves all the critical components discussed in this chapter and focuses our analysis on them. However, this framework will not be able to answer the question: What influences a person's ability to place the relationships between the source and target analogs in their proper systems (bins)? Our second framework, described next, aims to explain just that.

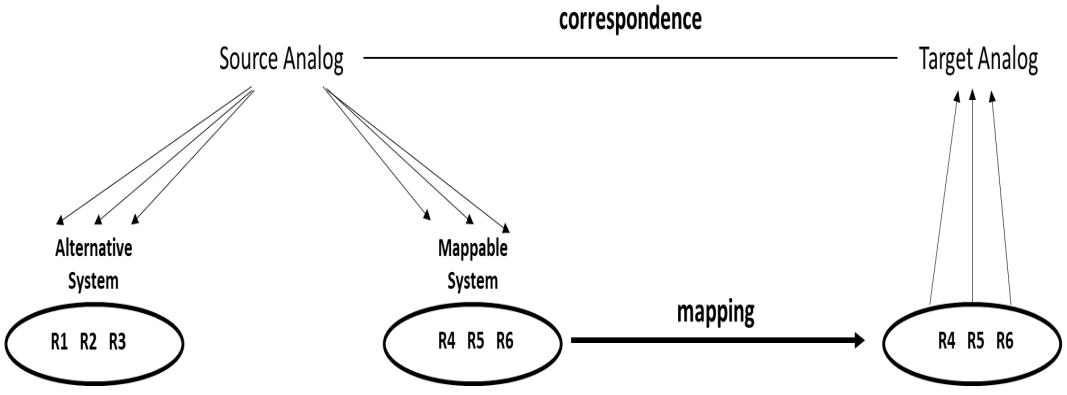

Figure 3: Simplified Analogical Mapping Framework
Source: Original work by author, based upon Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy," Cognitive Science*, vol. 7 (1983), 160.*

[12] For more on attribute mapping see Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy", *Cognitive Science,* vol. 7 (1983), 155-170.

The Six-Variable Model

A large portion of research in cognitive science related to analogies is concerned with the structural components of the analogy itself. Examining those models does not provide much toward understanding when analogies are likely to succeed or fail or enlighten or distort one's understanding. For that, one must not only examine the analogy itself but the individuals who are sending and receiving the analogy as well.

In 1994, Kevin Zook and Jean Maier developed and tested a six-variable model intended to account for the formation of analogical misconceptions. Their model sought to explain how analogies and individuals combine and interact. It is the character of this combination, they argue, that determines how many relations end up in either the alternative system (distorting understanding) or the mappable system (furthering understanding). Based on their model, *learners* (for our purposes, any person employing analogical reasoning) and *instructional variables* blend during the mapping process. This combination of learners and instructional variables is what drives cognitive interactions resulting in an accurate understanding or analogical misconceptions.

Zook and Maier break their model into two main segments: *learner variables* and *instructional variables* and six subcomponents (see Figure 3). The learner variables include *analogical reasoning ability, domain-specific knowledge,* and *processing goals*. The *instructional variables* are comprised of *analogy content*, *analogy complexity*, and *mapping support*. The appendix contains a brief definition of each category and individual variable, as presented in Zook and Maier's model. [13]

[13] Kevin B. Zook and Jean M. Maier, "Systematic Analysis of Variables that Contribute to the Formation of Analogical Misconceptions," *Journal of Educational Psychology*, vol. 86, no. 4 (December 1994), 589.

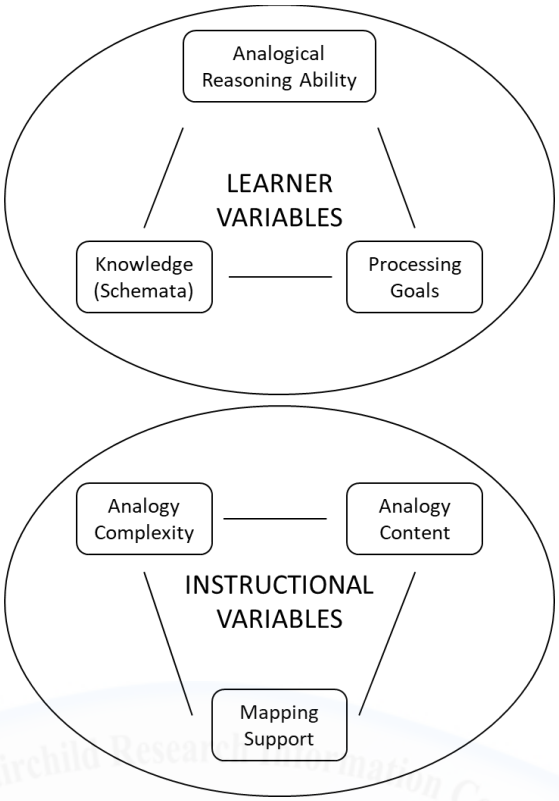

Figure 4: Six-Variable Model of Analogical Conception
Source: Kevin B. Zook and Jean M. Maier, "Systematic Analysis of Variables That Contribute to the Formation of Analogical Misconceptions," Journal of Educational Psychology*, vol. 86, no. 4 (1994), 589-600*

Zook and Maier's six-variable model provides a way to assess how and why analogy distortion occurs. While analogical structure-mapping helps us discern and dissect the possible, or at least plausible, relations elicited by an analogy, the six-variable model provides us with a means for saving analogical reasoning itself. Mendenhall has denounced the very utility of analogical reasoning for understanding outer space, however, in Chapter 5, I will use the six-variable model to examine how the forces external to the analogy itself impact our understanding of outer space.

Before I move toward an examination of our space warfighting analogies themselves, it will be valuable to provide an example of a widely familiar interdomain analogy. I will then show how to extract relations from the analogy and assign them within the structure-mapping framework and demonstrate how Zook and Maier's six variables operate.

Example

In a 2010 article, Zook highlights both the components of analogical mapping and the six-variable model using the Parable of the Prodigal Son as an example of analogical reasoning. As this parable is a widely known example of interdomain analogical reasoning, it will serve here as an illustration of how to use both the structure-mapping and six-variable frameworks.

The irony of interdomain analogies is that they, on the one hand, possess incredible power to facilitate rapid, meaningful understanding while, on the other hand, also possess great potential for confusion and misunderstanding.[14] It is for this very reason that Jesus employed parables (an interdomain analogy in story form) to reveal principles of the Gospel in his teachings. When his disciples asked Jesus why He used parables in His teaching, He answered them: "To you has been given the secret of the kingdom of God, but for those outside everything is in parables, so that 'they may indeed see but not perceive, and may indeed hear but not understand, lest they should turn and be forgiven.'"[15] Jesus understood that analogies had the power to either shed light or darkness on the very truths of God, based on the hearer's composition under the six-variable model.

The story of the prodigal son appears in Luke 15:11-32. Under the structure-mapping theory the following main object correspondences exist:

Base Domain (*Source Analogs)*		**Target Domain (*Target Analogs)***
Father	→	God
Son	→	Repentant Sinner
Brother	→	The Self-Righteous

Jesus's intent in the parable is that the hearer discards (into the irrelevant relations bin) the surface features (or relations) of the source analogs. Relations such as the envious brother being older than the wayward son, the fact that the father wore a robe and had other servants, the specifics about the prodigal son

[14] Zook, "Teaching and Learning by Analogy."
[15] Mark 4:11-12.

eating with pigs—all these are irrelevant and not intended for mapping. The intent is instead to map the higher-order "relations," such as the following:

Table 2: Prodigal Son – Sinner Relations

	Base Domain (*Relations)*		**Target Domain (*Relations)***
R1	**son** leaves his **father's** care and expectations	→	**sinner** leaves **God's** care and expectations
R2	**son** returns to **father** in repentance	→	**sinner** returns to **God** in repentance
R3	**father** grants forgiveness to **son**	→	**God** grants forgiveness to **repentant sinner**
R4	**father** celebrates his **son's** return	→	**God** celebrates the **repentant sinner's** return
R5	**brother** obeys and works for his **father**	→	**self-righteous** obey and do works for **God**
R6	**brother** resents his **father's** acceptance of the **son**	→	**self-righteous** resent **God's** acceptance of the **repentant sinner**

Source: Kevin Zook, "Teaching and Learning by Analogy: Psychological Perspectives on The Parables of Jesus," International Christian Community of Teacher Educators Journal*, vol. 6, no. 1 (2010).*

Jesus' warning that for "those outside everything is parables" is a teaching equivalent to stating "those outside" will be unable to map the appropriate relations to the target domain. They instead identify only the irrelevant relations or identify the alternative relations present between the source and target analogs.[16]

Let us now analyze the same example of analogy via the six-variable model. I will start by examining the learner variables present in the analogy. Analogical reasoning ability is comprised primarily of verbal aptitude learner age. An adult, hearing the Parable of the Prodigal Son for the first time, would identify different relations between the analogs than would a small child. In our analysis of space warfighting analogies, I must deal with the fact that across the USSF, all operators will be adults. Still, there is likely to be a broad range of verbal aptitudes under which the analogies will be encountered.[17]

[16] Zook, "Teaching and Learning by Analogy."
[17] Zook, "Teaching and Learning by Analogy."

Domain-specific knowledge connotes a level of understanding of the base domain by the individual. In our example, there are relations which are more likely to be mapped if the "learner" has a rudimentary understanding of social structures and practices in ancient Israel. For instance, a knowledge of the inheritance practices of the first-century allows the learner to comprehend better the nature of the mapped sinner in the target domain. This variable will be explored further in the analysis chapter as a critical fault in other domain analogies ("space is like the high seas") as USSF personnel are unlikely to have strong detailed knowledge of those base domains and source analogs.[18]

Processing goals affect how a learner maps appropriate or inappropriate relations. Studies have found that learners who understand the purpose of the analogy and the associated superordinate system constraints are better able to identify and discard "irrelevant relations."[19] Jesus used a variety of strategies to make the purpose of His parables known. In the case of the Parable of the Prodigal Son, Jesus began the grouping of four parables of which the Prodigal Son is third, in response to the grumblings of the Pharisees and scribes over Jesus' receiving and eating with sinners. In space warfighting analogies, the purpose is often readily apparent as one invokes the analogies to help understand a given aspect of orbital warfare, strategy, operations, or tactics.

Now let us examine the Parable of the Prodigal Son to understand the instructional variables of the six-variable model better. Analogy content refers to the target domain information to be learned and the source analog that is selected for relational comparison. Analogies that have readily apparent object correlations are known as having "high transparency." The correspondences between the source and target analogs are readily identifiable and understandable. The Parable of the Prodigal Son is considered to have "high transparency" as fathers and sons share many surface features with God ("our Father who art in heaven") and sinners ("children of God"). These apparent similarities prime the individual to accurately correspond God and the father, as well as sinners and the prodigal son. Analogy content will prove a key factor when assessing analogies in space warfighting. Those that have "high

[18] Zook, "Teaching and Learning by Analogy."
[19] Zook, "Teaching and Learning by Analogy."

transparency" will likely facilitate mapping, whereas those with "low transparency" may produce mapping difficulties and subsequent target domain misunderstandings.[20]

Analogy complexity speaks to the number of relations that are available to an individual for mapping. The greater the number of relations, the higher the complexity of the analogy. Complex analogies increase the potential that individuals will direct their attention away from the intended relations and draw misconceptions about the target domain. Complexity is not necessarily meant to infer length; often, it is represented by the obscurity of the analogy. The Parable of the Prodigal Son, while quite lengthy in comparison to other parables, is reasonably direct. Other parable messages such as "you are the salt of the earth" qualify as more complex. Since many analogies used in space warfighting are adapted from the military activities of other warfighting domains, complexity tends to be low. However, individuals can inadvertently increase the complexity of an analogy if they apply prior personal knowledge or add additional objects and relations that may have been related only tangentially to the analogy's initially intended purpose.[21]

Mapping support is comprised of three main aspects: direct and explicit cues concerning an analogy's purpose, cautionary messages against mapping inappropriate features, and explicitly stating the specific relations to be transferred from the base domain to the target domain. One unique way Jesus provided mapping support was the use of multiple analogs. As stated earlier, the Parable of the Prodigal Son was the third in several parable analogies Jesus used to convey the message of God's love for sinners. When it comes to space warfighting analogies, there often tends to be a sole analogy to represent a component of either the outer space domain or the space warfighting concept in question. Mapping support will be a component especially critical for USSF orbital warfighters, and I will expound upon this idea later in the analysis of the analogies.[22]

[20] Zook, "Teaching and Learning by Analogy."
[21] Zook, "Teaching and Learning by Analogy."
[22] Zook, "Teaching and Learning by Analogy."

How to Know How We Know What We Know

This chapter has sought to define several terms and concepts used by cognitive psychologists and researchers to allow for an academically rigorous analysis of space warfighting analogies. If one does not carefully investigate the analogies used, they will be unable to identify redeeming aspects of the analogy, or even the analogical reasoning process itself. By establishing clear terms and adopting two frameworks (the structure-mapping theory and the six-variable model), this analysis will be better able to assess the value of analogies in space warfighting, and any of their specific components which produce distortions in an understanding of orbital warfare.

Chapter 3

Early Airpower : Modern Spacepower

History does not repeat itself, but it often rhymes.

commonly attributed to Mark Twain

Debate concerning the best organizational structure, strategy, and doctrine for military space forces has existed since the middle of the 20th-century. Spacepower theorists and policymakers alike have looked to the analogy between early US military airpower development and modern spacepower forces for nearly as long. As discussed in Chapter 2, analogies tend to emerge as attributes between two initially unrelated analogs become evident. Thus, it is not surprising that the creation of a new organization responsible for military space activities brings to mind the analog of another organization responsible for military operations in a separate domain. This readily apparent correspondence is perhaps why the analogical connection between early airpower and modern spacepower has been so prevalent.[1] Additional contributing factors such as the housing of both US military space and air operations in the same service until just months ago plays a part in how widespread this analogy is in Air Force literature. In the remainder of this chapter, I will provide a basic form of the analogy, identify the alternative and mappable relations contained in the analogy, and analyze and justify the relations. It is through this process that we will gain a more thorough understanding of the analogy itself and be better equipped to assess what parts of the analogy are beneficial and which parts distort our understanding of orbital warfare and space warfighting.

[1] The term "modern" here is used to connote that, at the time of the analogy's presentation, it seems the user consistently refers to the struggles/issues of the day as being analogous to early airpower. Hence, the same analogy has been used since at least 1981 and is still used today. An entire other study could be done to examine how/why this same analogy, focused on the seemingly fledgling and transitory phase evoked by this analogy, has persisted for nearly 40 years.

Analogy

As shown in Chapter 2, interdomain analogies are inherently more complex and multilayered than the simple one-word analogies presented in IQ tests. For this analysis, however, I have endeavored to provide as simple an approximation of the analogy before deconstructing its elements and relations through the structure-mapping framework. In its most basic form, the analogy with which this chapter concerns itself is represented in this way:

Early Airpower : Modern Spacepower

> *Spacepower advocates are struggling, and have struggled, to articulate a strategy and doctrine for modern spacepower and are failing, or have failed, to create the forces adequate to properly defend US interests in space within a broader military service, the US Air Force. Similar situations were faced during the development of US military airpower before World War II (WWII) as airpower advocates struggled to articulate a strategy and doctrine for airpower and develop the forces they felt necessary within the parent military service of the US Army.*

This analogy has been used repeatedly since the opening of the space age. For example, in 1981, the United States Air Force Academy hosted a Military Space Doctrine Symposium during which the Chairman of the Steering Committee for the symposium, Colonel Thomas J. Eller, highlighted the early airpower : modern spacepower analogy:

> Concepts were clear to airpower advocates but were not accepted by the Army. At that critical point, a few professional air officers reflected on the organizational, technological, and operational successes; assessed the failures; and hammered out the doctrinal principles that resulted in the phenomenal advances of airpower during World War II.
>
> We stand today at a similar critical point for military space operations. Many officers know and understand our reliance upon space. Many are committed to protecting our assets while the shuttle and space weapons are opening new technological horizons. But, where are we in the development of military doctrine for space?[2]

The analogy saw continued use throughout the symposium by several participants, including Dr. I.B. Holley, a retired Major General and professor of history at Duke University and Lieutenant General Richard Henry, who was at

[2] Maj Paul Viotti, *Military Space Doctrine: The Great Frontier – The Final Report for the USAFA Military Space Doctrine Symposium, 1-3 April 1981*, (AD-A104574), 11.

the time the Commander of the Air Force Space Division. The analogy, however, was not without its critics and one panel, made up of three senior Air Force space leaders, failed to reach a consensus on whether or not the analogy between the development of airpower and spacepower was appropriate.[3]

The analogy's use has persisted through the decades since the USAFA symposium. Peter Hays claimed in 1994 that "there are numerous similarities between the development of military airpower and spacepower."[4] Hays recognized the need to analyze the analogy's similarities more deeply. He claimed that though some comparisons between the domains and historical periods were superficial, overall, the analogy could "help us assess more specifically whether spacepower developments followed a similar path to airpower developments."[5] In the new century, the analogy continued to resonate with space professionals and theorists alike. In 2006, Lt Col Mark Harter claimed "a familiar correlation between early twenty-first-century space power and airpower's infancy."[6] Harter claimed the space community of the mid-2000s was struggling with the same issues as early airpower theorists.

Mapping the Analogy – Early Airpower : Modern Spacepower

One of the most perceptive conclusions during the USAFA symposium was that "before applying airplane analogies to space systems, one must understand the factors that are unique to space."[7] The participants recognized the relations that initially appeared between airpower and spacepower may or may not be part of the mappable, alternative, or irrelevant systems. The early airpower : modern spacepower analogy is indeed multi-layered. There are aspects concerning organization, technology, as well as doctrine and strategy. First, let us attempt to identify possible base and target domain relations before applying them to our simplified framework. At this point, I admit that identifying the explicit or implicit relations in such complex interdomain analogies as those

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[3] Viotti, *Military Space Doctrine*, 14.
[4] Peter Hays, "Struggling Towards Space Doctrine: U.S. Military Space Plans, Programs, and Perspectives During the Cold War" (PhD diss, Tufts University, 1994), 25.
[5] Ibid., 29.
[6] Mark Harter, "Ten Propositions Regarding Space Power," *Air & Space Power Journal,* (Summer 2006): 65.
[7] Viotti, *Military Space Doctrine*, 1.

considered in this paper proved rather tricky. It initially seemed that there were no bounds to how far previous authors or I could go in extrapolating relations between the base and target domains. This experience is itself reflective of both the power and complications presented in analogical reasoning. To ensure some coherence, I have limited the relations to what I determined to be the six most potent or frequent system relations: R1-R3 represent alternative system relations, while R4-6 are the mappable system relations.

Table 3: Airpower – Spacepower Relations

	Base Domain (*Relations)* **Airpower Domain**	→	Target Domain (*Relations)* **Spacepower Domain**
R1	**Military Army leadership** initially dismissed the value of the **airplane**	→	**US Air Force leadership** initially dismissed the value of the **spacecraft**
R2	**Airpower concepts** were clear to **airpower advocates**	→	**Spacepower concepts** are clear to **spacepower advocates**
R3	Initial **airplanes** provided little in the way of military capability	→	Initial **spacecraft** provided little in the way of military capability
R4	**Early Airmen** struggled to advocate for **airpower** because of a lack of understanding about the **air** domain **in their time**	→	**Spacepower professionals** struggle to advocate for **spacepower** because of a lack of understanding about the **space** domain **in modern times**
R5	**Airplanes** established operations in the **Signal Corps,** a scientifically inclined suborganization	→	**Spacecraft** initially established operations in the **Air Force Systems Command,** a scientifically inclined suborganization
R6	**US Army** did not emphasize in-domain doctrine or capability for **fighter aircraft**	→	**US Air Force** did not emphasize in-domain doctrine or capability for **orbital warfare satellites**

Source: Author's original work. Evidence for the airpower domain from Maj Paul Viotti, Military Space Doctrine: The Great Frontier – The Final Report for the USAFA Military Space Doctrine Symposium*, 1-3 April 1981, (AD-A104574).*

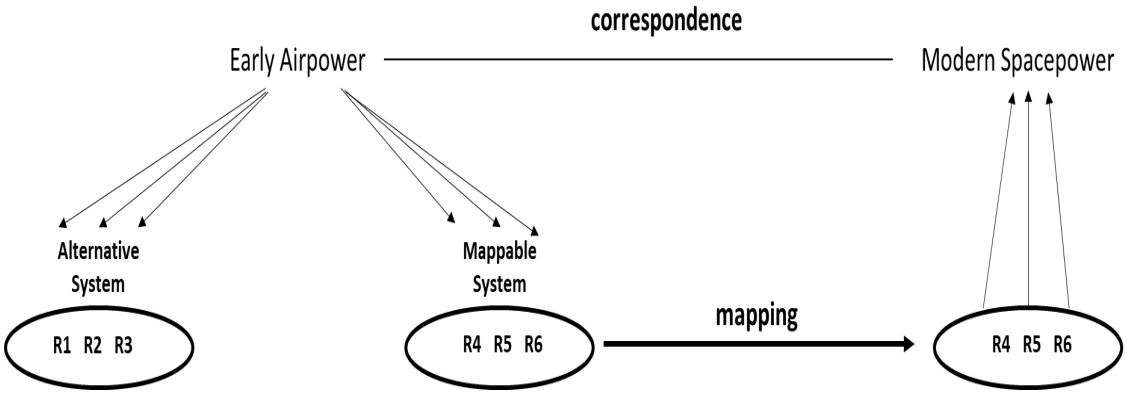

Figure 5: Analogical Map – Early Airpower : Modern Spacepower
Source: Author's Original Work, based upon Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy," Cognitive Science*, vol. 7 (1983), 160.*

Relational Analysis – Alternative System

I have categorized relations (R1, R2, R3) as belonging to the alternative system because they "distort an accurate and superior understanding of the target domain" in some significant aspects.[8] I will provide a brief exposition of each of the relations along with my rationale for assigning them alternative system status.

R1 – Leadership Valuation of the Domain

In the early 20th-century, the leadership of armies across the globe tended to discard the airplane; they could not conceive of it as a revolutionary weapon capable of bringing warfare into a new domain. In 1910, French General Ferdinand Foch, who eventually became the Supreme Commander of the Allied Forces in France, stated concerning the airplane, "That's good sport, but for the army the aeroplane is of no value."[9] On the American side, pre-World War I Army administrators conveyed equal disregard for the airplane, despite the general population's fascination with flying.[10] The War Department and general staff determined that plans to use the airplane for combat could

[8] Kevin Zook, "Teaching and Learning by Analogy: Psychological Perspectives on The Parables of Jesus," *International Christian Community of Teacher Educators Journal,* vol. 6, no. 1 (2010).
[9] Captain B.H. Liddell Hart, *Foch: The Man of Orleans* (Boston, MA: Little, Brown, and Company, 1932), 44.
[10] Aaron Norman, *The Great Air War* (New York, NY: The Macmillan Company, 1968), 21.

"serve no practical purpose whatever. Any dream of aerial conflict is merely the product of fertile imagination, a malady often encountered in younger men with insufficient service to recognize certain things as manifestly absurd."[11] This sentiment persisted to differing degrees throughout the interwar period as the general staff continued to denigrate the utility of military aircraft, arguing the airplane had no bearing on the future of warfare.[12]

The R1 relation proposes a parallel between early airpower and spacepower, which implies a similar initial disregard for the military utility of spacecraft by the US Air Force. A review of the historical record paints a different picture. As early as 1946, the RAND Corporation evoked a different early aviation analogy in their study on the feasibility of an earth-orbiting spacecraft. In their report concerning the military benefits of a technologically achievable spacecraft, the authors stated: "We can see no more clearly all utility and implications of spaceships than the Wright Brothers could see flights of B-29s bombing Japan and air transports circling the globe."[13] However, whereas in the early days of airpower it was the War Department shifting resources *away* from airpower, in 1948, the fledgling US Air Force was advocating for scarce resources to *support* military spacepower. As budget cuts squeezed out the first spacecraft designs, it was the US Air Force that rallied to demonstrate a military application for satellites. The US Navy was the initial mover toward a dedicated satellite program with its Earth Satellite Vehicle Project. Still, as funding grew tighter under the Truman administration, Navy leadership felt the military applications of spacecraft did not warrant the expenditure of limited funds at the time. Present during the technical review, which led the US Navy to this decision, was Major General Curtis LeMay, who, along with other Army leadership, determined to investigate the interests of the US Army in satellite technology further.[14] General LeMay later tasked Project RAND to conduct the

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[11] Ibid., 22.
[12] DeWitt S. Copp, *A Few Great Captains: The Men and Events That Shaped the Development of U.S. Air Power* (McLean, VA: EPM Publications, Inc, 1980), xiv.
[13] RAND Corporation, "Preliminary Design of an Experimental World-Circling Spaceship" (Report No. SM-11827, May 2, 1946), 1.
[14] Robert L. Perry, *Origins of the USAF Space Program: 1945-1956* (Air Force Systems Command, 1961), 10.

aforementioned study on the feasibility of creating a spacecraft.[15] While the Joint Research and Development Board, under the leadership of Vannevar Bush, was comprehensively critical of satellite technology, it was the Army Air Forces, and later the US Air Force, that continued to support study efforts in space operations.

On September 25, 1947, one week after the USAF came into being, Air Force Headquarters proactively tasked the Materiel Command's Engineering Division to study and evaluate the 1946 RAND study.[16] By January 1948, the Deputy Chief of Staff, Materiel, US Air Force, recorded that it was "imperative, in order that the USAF maintain its present position in aeronautics and prepare for a future role in astronautics, that a USAF policy regarding Earth Satellite Vehicles be promulgated."[17] Unlike the Army's dismissal of the airplane earlier in the century, on January 15, 1948, it was the USAF Vice Chief of Staff, General Hoyt S. Vandenberg, who stated: "The USAF […] has logical responsibility for the Satellite."[18] Thus, even before the launch of the world's first spacecraft, the USAF committed itself to satellite operations.

In the past few years, there has been extensive debate on whether the US Air Force values the space mission. Nevertheless, *at its origin*, there exist stark differences between how the US Army initially viewed the airplane and how the US Air Force initially regarded the spacecraft. While Army leadership considered the airplane of no military utility, the US Army Air Forces, and later US Air Force, maneuvered, negotiated, and battled to capture and own the space mission. It is this historical discrepancy that justifies assigning the R1 relation to the alternative system.

R2 – Clarity of Domain Concepts

The R2 relation emerges as a corollary of the R1 relation, evidenced by this quote, "[Before World War II] the concepts were clear to airpower advocates,

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[15] Ibid., 12.
[16] Perry, *Origins of the USAF Space Program*, 21.
[17] Maj Gen L.C. Craigie, Director of Research and Development Office, Deputy Chief of Staff, Materiel, to Brig Gen Alden R. Crawford, Air Material Command, Wright Field, Dayton, Ohio, "Earth Satellite Vehicles," 12 January 1948.
[18] Gen Hoyt S. Vandenberg, Vice Chief of Staff, United States Air Force, "Statement of Policy for a Satellite Vehicle," 12 January 1948.

but were not accepted by the Army."[19] Colonel Eller, Chairman of the Steering Committee for the USAFA Symposium, used this analogy in an attempt to galvanize USAF space leaders to share the concepts that "many officers know and understand."[20] However, there seems to be some evidence that there is a wider discrepancy between the initial clarity of airpower concepts and spacepower concepts when one consults the historical record.

The exploits and fierce advocacy of early airpower theorists earned many the moniker of "zealot."[21] The followers of early theorists such as Douhet and Mitchell, notably Arnold, Andrews, Spaatz, and Eaker, held strong convictions concerning the best use of airpower.[22] Regardless of how accurate their theories and doctrines proved, those who considered themselves airpower advocates possessed definitive concepts on the best utilization of airpower before World War II. Ideas like the invulnerability of the bomber, the industrial web theory, and the concept of centralized control of air forces were well-developed notions. While there were dissenting arguments and opinions considering the nascent doctrine of airpower, there were at least concepts about which to debate.[23] The story of spacepower doctrine is not nearly so clear or robust.

Lieutenant Colonel David Lupton, in his 1988 book, *On Space Warfare*, identified that during the interwar period between World War I and II, air advocates endeavored to answer three primary questions: the military value of the airplane, the future nature of warfare, and how to best employ air forces. It was from the advocates' answers to these questions that an argument for an independent air service arose.[24] Lupton argues that these same fundamental questions reemerged in the move to develop spacepower thought. Lupton points out that the common refrains in spacepower theory are not strong arguments in favor of a particular doctrinal concept or theory, but that "there is no space doctrine" or "we need space doctrine."[25] He details four separate schools of

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[19] Viotti, *Military Space Doctrine*, 11.
[20] Ibid.
[21] Viotti, *Military Space Doctrine*, 47.
[22] Ibid.
[23] Robert Futrell, *Volume I - Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1960* (Maxwell AFB, AL: Air University Press, 1989), 82.
[24] Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press, 1988), 35.
[25] Ibid., 33.

thought that had developed, each of which only partially addressed the theoretical needs for space warfighting. These schools of thought--sanctuary, survivability, high-ground, and control--failed to develop into a comprehensive spacepower strategy in and of themselves. Even Lupton's so-called Space Power Doctrine, in which he attempts to further develop the ideas in the control school of thought, failed to attract official or mainstream adoption. For this, among other reasons, it never became the origin of a well-developed concept or doctrine of spacepower.

In 2018, Lieutenant General retired Dave Deptula commented that US space professionals still lack mature space warfare theory, doctrine, and concepts of operation.[26] In 2019, the Department of Defense's "United States Space Force Strategic Overview" repeatedly stated that the creation of the Space Force as an independent military service was partially intended to "accelerate the development of space doctrine."[27] In 2020, the US Space Force has sought to establish a space doctrine center, not with the hopes of *refining* space doctrine, but, in the words of Major General John Shaw, to consider "thinking about how do we think about [doctrine] anew."[28] These official statements highlight that, despite the collective interest and work of Airmen in space operations since 1946, after 74 years, the United States still lacks a cohesive articulation of spacepower equivalent to that carried by the Army Air Forces into World War II.

There are many causes for why spacepower concepts have not matured as far, or as fast, as those of airpower advocates during the period of early airpower. At the same time, there can be little doubt that there are and have been considerable differences between the clarity of concepts for early airpower and modern spacepower theorists. These differences justify assigning the R2 relation to the alternative system.

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[26] Dave Deptula, "A Space Force That Would Make A Difference," *Forbes,* 5 May 2019, https://www.forbes.com/sites/davedeptula/2019/05/05/a-space-force-that-would-make-a-difference/#733d4b42737c.
[27] Department of Defense, "United States Space Force Strategic Overview," February 2019, https://media.defense.gov/2019/Mar/01/2002095012/-1/-1/1/UNITED-STATES-SPACE-FORCE-STRATEGIC-OVERVIEW.PDF.
[28] Valerie Insinna, "Space Force to Stand Up A Doctrine Hub," *DefenseNews*, 10 January 2020, https://www.defensenews.com/space/2020/01/10/space-force-to-stand-up-a-doctrine-hub/.

R3 – Initial Capability in the Domain

Compared to the primary weapon systems of the Army and Navy (vehicles, tanks, and ships), aircraft and spacecraft are relatively fragile and intricate devices. Their need to overcome the force of gravity, though in different physical domains, necessitates elaborate technological designs and construction. The early airplane, as presented to the US Army by the Wright Brothers, was described as a "rather flimsy contraption" of which Holley stated, "It is easy to see why officials in the United States had some difficulty in soundly conceptualizing the potential of this innovation at a time when the Army was still a horse-drawn institution."[29]

As soon as the Wright Brothers landed their infamous *Flyer*, they set out to market their invention. Though humans had dreamed of flight for millennia, Orville and Wilbur nonetheless experienced skepticism and reluctance when it came to government investment in their new technology. Orville Wright repeatedly transmitted offers to supply the War Department with "flying machines suitable for scouting purposes" over several years. At the time, the US government was extremely reluctant to fund any flying technology. Previously, a scandal had broken out concerning the 1898 allocation of $50,000 to Samuel Langley for airplane research, which, in the end, resulted in no viable flying technology. By October 1905, the War Department's Board of Ordnance and Fortification declined to enter any formal negotiations with the Wrights "until a machine is produced which by actual operation is shown to be able to produce horizontal flight and to carry an operator."[30] Despite breaking the surly bonds of Earth, the Wrights could not yet convince the US government of the military efficacy of the airplane.

Later, under the urging of President Theodore Roosevelt, who was personally interested in airplane technology, the Board of Ordnance and Fortifications, along with the newly established Aeronautical Division of the Army Signal Corps, reopened negotiations with the Wright Brothers. Even in 1907, the Signal Corps leadership doubted the technical capability of the

[29] Viotti, *Military Space Doctrine*, 45.
[30] Fred Kelly, "The Wright Brothers Worst Brush-Off," *Air Force Magazine*, vol. 36, 1 January 1953, 38.

airplane, believing it to be less efficient that the dirigible balloons that were being actively used in Europe at the time.[31] At the end of the decade, the Army still assessed the airplane as a doubtful proposition because it lacked range, load-carrying capability, and overall effectiveness when compared to the dirigible. When it came to the prospects of the airplane's use for offensive operations, even early airplane enthusiasts identified that "the very limited flight performance of aircraft in 1912 had not demonstrated any military value other than reconnaissance."[32]

As limited numbers of airplanes initially entered service in the militaries of Europe and the United States before WWI, many questions remained about their military efficacy. By 1913, the War Department position remained that military aviation was "merely an added means of communication, observation and reconnaissance."[33] Through the experimental use of aircraft in maneuvers, the French and US alike experimented with new tactics for aerial observation, including a variety of aircrew setups to determine the optimal arrangement between pilot and observer. While the airplane promised "more accurate and full" information compared to the cavalry, problems remained concerning how to transmit that information to ground commanders and the practicality of using the airplane in war. Would the airplane prove too vulnerable to small-arms fire? Would the noise of the airplane alert enemy forces? [34]

The first ten years of flight saw significant development in airplane technology, but the aircraft's lack of capability was a chief factor in why the US Army initially dismissed the airplane. The fact that even airplane enthusiasts doubted the prospects of any form of real *airpower* highlights the skepticism concerning the airplane's ability to contribute strategic military value in the early 20th century. The initial demonstration of orbital spacecraft capability would take a dramatically accelerated path toward acceptance some 45 years later.

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[31] Lee Kennett, *The First Air War: 1914-1918* (New York: NY, The Free Press, 1991), 16.
[32] Charles D. Chandler and Frank P. Lahm, *How Our Army Grew Wings* (New York: NY, Ronald Press Co, 1943), 206, 222-24.
[33] Futrell, *Volume I - Ideas, Concepts, Doctrine*, 16.
[34] Kennett, *The First Air War,* 17.

To assess the relative strategic impact of the world's first spaceflight compared to the world's first airplane flight, consider the instantaneous global impact of *Sputnik I.* On 4 October 1957, the ominous "beep, beep, beep" of *Sputnik 1* sent shockwaves through the geopolitical landscape and shivers down the spines of US civilians and national leaders alike. Despite the Eisenhower administration's attempts to downplay the strategic importance of the Soviet Union's accomplishment, America was rapidly infected with "Sputnikitis."[35,36] The national response to the "space Pearl Harbor" was swift and severe.[37] The ramifications of the simple communications satellite that operated for a mere three months were remarkable as the world's two superpowers were instantly thrust into a new arms race.

While it took four years for the US military to procure its first airplane, the US military was already investing in spacecraft technology before 1957. Unlike early airplanes, it took just under 17 months for the United States to field its first spacecraft with game-changing strategic military utility. *Discoverer 1* launched on February 28, 1959, as the first in the WS-117L satellite program intended to provide critical strategic intelligence on Soviet missile development.[38] Despite RAND studies throughout the 1950s repeatedly identifying the technological difficulties of fielding an electro-optical reconnaissance satellite, the importance of the mission and proven satellite potential compelled an uncertain USAF forward.[39] The commitment of the USAF to the satellite was remarkable. Though *Discoverer 1* acted as the first spacecraft in the *CORONA* program under WS-117L, it took another 13 failures or incremental successes before *Discoverer 14* finally provided the first operational intelligence in August 1960.[40] Compared to the Army's slow and

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[35] China Altman, "'Sputnikitis' Sky Report." *Madera Tribune*, 28 November 1957.
[36] Walter McDougall, *…The Heavens and the Earth: A Political History of the Space Age*, (Baltimore, MD: The Johns Hopkins UP, 1985), 147-148.
[37] U.S. Senate, Committee on Armed Services, *Inquiry into Satellite and Missile Programs. Hearings Before the Preparedness Investigating Subcommittee,* 85th Congress, 1st and 2nd Session (Washington, DC, 1958), vol. 1, 3. The first use of the analogy of a space Pearl Harbor was likely during this hearing only one month after the launch of the world's first spacecraft.
[38] Matthew Mowthorpe, *The Militarization and Weaponization of Space* (Lanham, MD: Lexington Books, 2004), 13.
[39] Hays, "Struggling Towards Space Doctrine," 73-74.
[40] Ibid., 182.

doubtful adoption of the airplane during the era of early airpower, the USAF was fully committed to the successful operation of the nation's first militarized satellites.

While both the airplane and spacecraft eventually drew warfare into new domains and justified the creation of independent military services, their origins differed technologically. Since the beginning of time, humans dreamed of flying up to touch the stars, little did they know their path to doing so would evolve in such distinct and disparate stages. While initial airplane technologies fought an uphill battle to prove their military utility, spacecraft had an immediate strategic military value evident to all.

Relational Analysis – Mappable System

R4 – Common Understanding of the Domain

The fact that analogies have so often been used to illustrate the state of spacepower thought evidences a lack of shared understanding of the space domain. As I have already examined, a broad gap exists between those who consider themselves, if not "space-going," at least "space-cognizant," and the public. I have already identified Billy Mitchell's claim considering "air-going" people's unique perspective in Chapter 1. Now I will briefly examine a few instances of airmen's fight to build a common understanding of the air domain. I will then turn toward the similar battles by spacepower professionals.

By WWI, the nascent capabilities of the airplane were sufficient to warrant them taking to the air over the trenches of Europe. But just as quickly as these aircraft could take off, their integration into the war was arrested and brought back down to the ground. Early airmen were rapidly experimenting and learning how their unique apparatus and the air domain writ large could impact the war effort. Nonetheless, integrating airpower into the broader battle plans proved to be a difficult task. As Lee Kennett identified in his survey of the first air war: "The new arm [airpower] was so different and its capacities and limitations so difficult for outsiders to grasp, that friction was inevitable."[41] A broad lack of understanding emerged among ground commanders with respect to matters concerning airpower. At the same time, the airmen of the day

[41] Kennett, *The First Air War,* 90.

struggled to educate their earthbound leaders on the considerations of airpower employment. Kennett recounts the story of a Royal Flying Corps liaison officer attempting to explain the impossibility of a long-distance reconnaissance mission because the 40-mph headwind the pilots would experience on the return flight. Exemplifying the lack of understanding of both the air domain and air operations, a British intelligence officer discounted the airman's concern exclaiming: "But the wind makes no difference to you!"[42]

Just as early airpower advocates faced a broader military bureaucracy and public uninformed and uneducated in the art of aerial operations, modern spacepower advocates struggle to explain space operations to other military leaders and the layman. One prevalent opinion seems to be that moving from an understanding of air to understanding of space requires a more significant cognitive jump than the move from ground to air.[43] Modern space professionals often lament that understanding either space operations or the domain itself can prove challenging for many people, especially when compared to the more familiar military operations of airplanes, tanks, and ships.[44] Their experience counters the position that an understanding of "air and space are indivisible."[45] This difficulty can extend to senior military and civilian personnel in the Air Force and DOD, members of Congress, and the "man on the street." Colin Gray and John Sheldon recognize this same fact identifying that "people have only one natural environment, the land."[46]

To illustrate the gaps in the broader Air Force's understanding of space operations, let us first examine some historical Air Force Doctrine. Air Force Chief of Staff General Thomas D. White first coined the term "aerospace" in an August 1958 article in *Air Force Magazine.* In that article, General White, referring to expanding Soviet capabilities of the day, stated: "The primary threat facing the free nations is Soviet airpower, which is being expanded rapidly, into

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[42] Ibid.
[43] Maj Viotti, *Military Space Doctrine*, 77.
[44] Ibid.
[45] Gen Thomas White, "Air and Space are Indivisible", *Air Force,* vol. 4, no. 3 (March 1958), 40-1.
[46] Colin Gray and John Sheldon, "Space Power and the Revolution in Military Affairs: A Glass Half Full?," *Airpower Journal*, Fall 1999, 26.

aerospace power."[47] To answer this threat, the United States required an Air Force "second to none." The term aerospace and its use and misuse have been the subject of entire theses. I introduce it here only as the original articulation of how the Air Force viewed air and space operations combining.[48] Though the Air Force saw the strategic importance and expected lavish funding of the national space mission, the air service struggled to articulate its views on the utility of space operations. Months after General White's article, the Air Force made the aerospace term official with the publication of Air Force Manual 1-2, *USAF Basic Doctrine.* The document failed to, or avoided, any discussion of a specific type or characteristic of space operations, instead it defines the term as "the total expanse beyond the earth's surface."[49]

The evolution of space in Air Force doctrine has been slow and incomplete until even today. In 1981, one author identified that much of the Air Force's basic doctrine, updated in 1979 in AFM 1-1, included statements concerning space operations that "were often misleading and sometimes just false" from the perspective of a space operator.[50] The author identified one of the biggest complaints concerning the aerospace moniker that the term allowed the Air Force to make "general statements about the Air Force or aerospace operations that really applied only to atmospheric operations."[51] The Air Force has continued to struggle in the creation of space-specific doctrine resulting partially from ignorance of the domain and its capabilities. Major Robert Newberry noted that, as of 1997, the only space-specific doctrine was published in 1982, but it was ultimately rescinded with no replacement in 1991. At the time, Air Force space operators felt their service had yet to make a "serious inquiry into the characteristics of the space environment, spacecraft, and, more importantly, space operations [that] will reveal that space is a distinct medium

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[47] Gen Thomas White, "The Air Force Job and How We're Doing It", *Air Force Magazine*, Volume 41: No 8, August 1958.
[48] Gregory Billman, *The "Space" of Aerospace Power: Why and How* (University of Pittsburgh, 2000); John Collins, "U.S. Military Spacepower: Conceptual Underpinnings and Practices" in *Toward a Theory of Spacepower: Selected Essays*, (National Defense University); Howard Kleinberg, "On War in Space", *Astropolitics*, vol. 5, no. 1 (2001) 1-27.
[49] *AFM 1-2*, United States Air Force Basic Doctrine, 1 December 1959, 6.
[50] Burk, "Basic Space Doctrine," 127.
[51] Ibid., 103.

with different tenets of power and a unique operational art."[52] M.V. Smith urges that a "Failure to appreciate the differences between these two distinct media not only prevents both airpower and spacepower from developing their full potential but, more important, may lead to serious political and military consequences if spacepower is applied as if it were merely an extension of airpower."[53]

Under this analysis, the analogy of early airpower : modern spacepower accurately invokes the relation that both early airpower advocates and modern spacepower advocates struggled to develop and promote their doctrine and theory to an audience that did not understand the unique characteristics of their domain. This analysis justifies assigning the R4 relation to the mappable system.

R5 – Organizational Heritage of Initial Subservice

The US Air Force and the US Space Force both wage war in a domain accessible only by virtue of technology. Therefore, it is not surprising that the development of the airplane and spacecraft so heavily influenced the organizational structure of the services. Similarities exist both in the technological and organizational development of the services as both the airplane and spacecraft were originally established in research and development arms of the military.

Broadly speaking, airpower remained subservient to ground, and to some extent naval, commanders for decades.[54] But in its infancy, airpower was forced upon the Army. When US Army Brigadier General James Allen, Chief Signal Officer of the Army, announced the creation of the Aeronautical Division within the Signal Corps, the origins of airpower were decided. The US Army Signal Corps, the branch of the Army with the most active interest in the study of military aeronautics, appeared to be a natural fit for the new heavier-than-air craft. Nonetheless, the decision to establish airpower's nest within the

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[52] Lt Col James Eken, "Roles and Missions, Doctrine and Systems Development and Acquisition: Today's Decisions Affect Tomorrow's Space Force Capabilities", (Air University, Maxwell AFB, AL), April 1995, 6.
[53] Maj M. V. Smith, *Ten Propositions Regarding Spacepower*, Fairchild Paper (Maxwell AFB, AL: Air University Press, 2002), 4.
[54] Viotti, *Military Space Doctrine*, 95.

"scientifically inclined" non-combat arm of the Army had profound consequences on the development of airpower through the first World War.[55]

Major General Holley argues that "it was virtually inevitable that the airplane would be developed as an observation platform" first.[56] There are significant technological factors for why the airplane first found its utility as a reconnaissance and observation platform. Holley instead focuses on the fact that by placing the airplane in a non-combat arm of the Army, those officers responsible for the early development of airpower saw themselves as supporting the three combat arms of the traditional army versus establishing airpower's offensive capability from the beginning. This concept was prevalent throughout the United States at the time. In 1913, Assistant Secretary of War Henry Breckinridge explained that military aviation was "merely an added means of communication, observation and reconnaissance."[57] It was within this paradigm that a young Lieutenant Henry Arnold concluded that the Signal Corps was doing all it could to advance aviation.[58]

It is easy to see this as the conclusion because, within the Aeronautical Division of the Signal Corps, strapped for both funds and personnel, the ultimate focus was on research and development of airplanes and flight itself.[59] Captain William Mitchell remarked, "The offensive value of this [the airplane] that has yet to be proved."[60] Without a firm strategy or organizational pathway for the airplane to develop into a combat mechanism, the Army resisted fully funding it. The fact that the Signal Corps relied on officers borrowed from other branches highlights that, before 1914, aviation lacked any clearly defined status or function within the Army.[61] The Signal Corps, viewed mainly as conducting a costly military experiment, found it increasingly difficult to support the nascent air arm while fulfilling its broader assigned duties.[62] As a

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[55] R. Earl McClendon, *Autonomy of the Air Arm* (Bolling AFB, DC; Air University, 1996), 1; Viotti, *Military Space Doctrine,* 46.
[56] Viotti, *Military Space Doctrine*.
[57] Futrell, *Volume I - Ideas, Concepts, Doctrine*, 16.
[58] McClendon, *Autonomy of the Air Arm,* 16.
[59] McClendon, *Autonomy of the Air Arm,* 2.
[60] Futrell, *Volume I - Ideas, Concepts, Doctrine*, 17.
[61] Bernard Nalty, *Winged Shield, Winged Sword: A History of the United States Air Force – Volume I 1907-1950* (Washington, DC: Air Force History and Museums Program, 1997), 27.
[62] Ibid.

result, the idea of the airplane as an adjunct to ground forces became deeply entrenched.[63] It took significant congressional action and a World War to compel the US Army to operationalize at least part of its airpower initiative when it established the Signal Corps Aviation Section, which was charged with operationalizing military aircraft.[64]

Though the development of and advocacy for spacecraft experienced an accelerated path compared to the airplane (as discussed in R1), space operations found its first home and vector in a very similar manner to the early Army aviation. In 1961, shortly after taking office as the Secretary of Defense, Robert McNamara conducted a review of the United States' fractured military space programs. He concluded that, if the Air Force could "put its house in order," he would make the Air Force the executive agent for military space development. Interestingly, McNamara assigned the Air Force the responsibility for "research, development, test, and engineering of Department of Defense space development programs or projects."[65] General White's response was an Air Force reorganization, which involved the creation of the Air Force Systems Command (AFSC) to be responsible for all research, development, and acquisition of aerospace and missile systems.[66] Struggling to make the most of being named as the lead military service in space, the Air Force of 1961 was far from considering if a systems command bureaucracy would best serve space operations down the road.

The 1960s served as a transitional period for Air Force space programs as they moved from experimental stages to defective operational systems.[67] As these nascent space capabilities were realized in the 1970s, the US Navy challenged the 1961 directive claiming it was outdated and prevented wider exploitation of space for military effects.[68] While the Air Force fought to maintain its dominant position in space program acquisition, most Air Force leaders still could not see a place for space in an operational field.[69] "Air Force

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[63] Maj Viotti, *Military Space Doctrine*, 47; McClendon, *Autonomy of the Air Arm,* 16.
[64] McClendon, *Autonomy of the Air Arm*, 3.
[65] Ibid.
[66] Ibid., 90.
[67] McClendon, *Autonomy of the Air Arm*, 171.
[68] Ibid., 172.
[69] Ibid., 174.

leaders and the wider Air Force community did not make space operations a genuine institutional commitment" in the early 1970s.[70]

The 1980s brought a new challenge for Air Force space operations. The need to normalize and integrate a growing number of defense-support space missions drove the Air Force to reassess its commitment to space operations in addition to space research and development.[71] It was not until 1 September 1982 that the Air Force created a home for operational space missions with the establishment of Air Force Space Command.[72] During this period, the research and development community separated acquisition and non-acquisition activities, but confusion remained regarding the delineation between experimental and operational space systems.[73] When the Air Staff created the Directorate for Space Operations, Lieutenant General Jerome O'Malley endeavored to "provide a renewed emphasis that the Air Force plans to stay in the lead in military space operations."[74] The impetus for the creation of General O'Malley's new office came from the 1980 Scientific Advisory Board Summer Study which identified that "inadequate organization for operational exploitation of space" was resulting in space technologies that provided little to no support to field commanders.[75] By focusing almost exclusively on space acquisition and establishing Air Force space efforts within a strictly research and development organizational box, the Air Force had accomplished much in the way of evolving experimental space systems. Still, Air Force leaders had "only begun to recognize the capability of these systems for military operations."[76]

While the airplane and Airmen resided in the Signal Corps for only about seven years, spacepower's twenty-year journey from Air Force Systems Command to Air Force Space Command shows strong parallels regarding the initial placement of the technologies and the ramifications of those decisions. As members of the 1981 symposium identified, both early airpower and

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[70] Ibid.
[71] McClendon, *Autonomy of the Air Arm*, 174-175.
[72] Ibid., 176.
[73] Ibid., 197.
[74] Ibid., 198.
[75] Ibid.
[76] Ibid.

spacepower advocates "encountered significant organizational inertia and resistance to promoting their cause[s]."[77] The same symposium participants recognized the "considerable trauma associated with introducing a new medium and mission into the military force structure."[78] Both early airpower and modern spacepower were initially founded in a strictly research and development center, with little forethought toward the operationalization of the technologies for military operations, the combat effectiveness of the airplane and spacecraft similarly suffered delays. These similarities justify assigning the R5 relation to the mappable system.

R6 – In-Domain Combat Capability

The fact that the US Army emphasized the reconnaissance and observation missions of the Army's aviation forces both prior to and after WWI has already been established. Lee Kennett, in his study of airpower from 1914 to 1918, states that observation was "for the balance of the war the most important role of the airplane."[79] When he considers the in-domain role of offensive aircraft in WWI, he describes the fighter plane as playing "an ambivalent role."[80] While some pilots contended that the future of aerial warfare would be "as decisive as hostilities on land and sea," the focus of the Army Air Corps shifted away from the glamorous pilot during the interwar period.[81]

After WWI, Airmen, fueled by their aerial combat experiences over Europe, produced a flurry of airpower theory writings. Motivated to not only perfect their new form of warfare but to avoid a repeat of the horrors of the trenches, most airpower theorists shifted to a focus on strategic bombardment. "By 1933 the deterrent of pursuit to the emerging doctrine of strategic bombardment was being shot out of the sky by both the theorists and the Air Corps planners."[82] With the exception of officers like Claire Chennault, the Air Corps Tactical School was slowly overwhelmed by the influence of staunch bomber advocates who mostly dismissed the in-domain air fight. Bomber advocates, dogmatic in their rejection of the need of fighter escort, claimed that

[77] Maj Viotti, *Military Space Doctrine*, 95.
[78] Ibid., 96.
[79] Kennett, *The First Air War,* 220.
[80] Ibid., 221.
[81] Ibid., 225.
[82] Copp, *A Few Great Captains,* 319.

pursuit fighter aircraft could never match the speed, altitude, or firepower of their envisioned superbombers.[83] Despite growing evidence from the Spanish Civil War and Sino-Japanese War that bombers operating without fighter escorts suffered heavy losses, Air Corps theorists plowed on with their bomber-centric, fighter-dismissive doctrine development.[84]

One of the eventual foundations of Army Air Forces doctrine became a belief that formations of bombers could successfully operate in daylight conditions without the benefit of escort fighters.[85] The result was a significant and costly delay in the development and fielding of much-needed long-range escort fighters during WWII.[86] Just as air doctrine initially emphasized observation and reconnaissance and deemphasized offensive in-domain aircraft, US spacepower initially focused on intelligence, surveillance and reconnaissance mission sets and failed to mature robust offensive in-domain capabilities.

Like early airpower, spacepower developed in a support role. WWI quickly ushered in at least nascent fighter plane development, but modern spacepower has yet to experience a similar major conflict between adversaries, each possessing robust space capabilities. Nonetheless, just as the Army Air Corps claimed for decades that the "bomber would always get through," it seems that the US position for years has been that a satellite's location in orbit provided sufficient defense in and of itself. Further, despite the initial emergence of offensive counterair operations as a concept, the US invested little in the development of the mission area as a core competency. In space, as of this writing, no major peer-on-peer conflict has occurred between space-faring nations. As such, the US has not been compelled to develop the technologies or tactics to address the in-domain space fight. However, even in the absence of a war extending into space, US military space development could have taken a different path from early airpower and endogenously developed robust in-space offensive capabilities. USAF military space development did not take this

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[83] Ibid., 322, 355; Futrell, *Volume I – Ideas, Concepts, Doctrine,* 64.
[84] Futrell, *Volume I – Ideas, Concepts, Doctrine*, 3741.
[85] Futrell, *Volume I - Ideas, Concepts, Doctrine*, 151.
[86] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945* (Princeton, NJ: Princeton UP, 2002), 207.

alternative path for many reasons, but I will focus here on one of the most significant factors: national-level space policy.

In the earliest days of US space development, much remained undecided concerning the military's role in the new domain. In 1958, President Dwight Eisenhower tasked the Presidential Science Advisory Council (PSAC) to investigate the utility of a national space program. The PSAC ultimately provided the Purcell Report which reinforced Eisenhower's belief that the most significant benefits of space operations would come from reconnaissance, communication, and weather prediction. The Purcell Report stated that the prospects for space-based weaponry did "not hold up well on close examination or appear to be achievable at an early date."[87] Eisenhower, therefore, concluded that the US policy concerning space would be to primarily use "outer space for peaceful purposes and international cooperation in science."[88]

After President Eisenhower's decision to deemphasize offensive space programs, the military services waged a public media campaign to drum up support for space weaponization.[89] Nonetheless, the Eisenhower administration continued to resist pressure to weaponize space for several reasons. The administration assessed that, as of 1960, the technology and threats simply did not warrant a US program. Soviet space reconnaissance systems and fractional orbital bombardment systems did not provide a serious enough threat to justify investment in US offensive space capabilities. There were still significant technological gaps and inefficiencies in pursuing space-to-ground weapons development and space-based missile defense did not appear any more feasible.[90] But the most significant factor for Eisenhower's reluctance to weaponize space was the need to preserve the principle of satellite reconnaissance and permissive overflight of sovereign Soviet territory.[91] Before *Sputnik I*, there was no uniform agreement in the international community that

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[87] Paul Stares, *The Militarization of Space: U.S. Policy, 1945-1984* (Ithaca, NY: Cornell UP, 1985), 47.
[88] NSC 5814/1, "Preliminary U.S. Policy on Outer Space," White House Office, Office of the Special Assistant for National Security Affairs, NSC Series, Policy Papers Subseries, Eisenhower Library.
[89] Stares, *The Militarization of Space,* 47.
[90] Ibid., 50-51.
[91] Ibid., 51.

satellite overflight for reconnaissance purposes was acceptable. The fact that the US nuclear deterrence strategy so heavily relied on an accurate assessment of Soviet missile and bomber strength drove early US decisions on space weapons programs. The prospective value of gathering space-based intelligence of Soviet nuclear capabilities was immense and Eisenhower was not willing to risk developing space weapons and spoiling the US's opportunity to gather intelligence not otherwise available. As a result, President Eisenhower never allowed the advanced development of an antisatellite system.[92]

Successive US presidential administrations continued to deemphasize or cancel US military efforts to develop in-domain space weapons programs. Some administrations assessed the risks of space weaponization as too high relative to the ISR benefits the US reaped in a "sanctuary" domain. In others, there existed a simple lack of emphasis on military space issues.[93] The culminating result of these factors was that space weaponization was never firmly established with the US armed forces. Whether the USSF and Trump administration will significantly shift US investments into in-domain space combat capabilities (orbital warfare) remains to be seen.

During both the early airpower and modern spacepower periods, there was little investment in advanced in-domain offensive capabilities. World War II changed this trend for fighter aircraft; perhaps the establishment of the USSF will shift investments toward orbital warfare capabilities. The similarities between the two experiences thus far justify placing the R6 relation in the mappable system.

Conclusion

One participant during the 1981 USAFA Military Space Doctrine Symposium made the following observation: "The core of technology of powered flight, though new, was not as highly complex as space technology. Man accompanied his machine into the air, finding flexibility in the medium that facilitated its use for military purposes. By contrast, space flight is extremely

[92] Ibid., 53.
[93] Mowthorpe, *The Militarization and Weaponization of Space,* 14-17.

technical, beyond the ken of the average man."[94] The early airpower : modern spacepower analogy is often cited, especially by those who have argued for the creation of the USSF as a separate military service. The fact that both airpower and spacepower require humans to leverage technology for the purposes of war binds the two domains together in the mind. But as we have discovered, once humans and organizations come into play, there can exist as many differences between the two paradigms as there are similarities. I will examine in a later chapter how one may best approach an analogy as complex as the airpower : spacepower example, but first, let us analyze a second analogy which offers to describe the space domain itself and the concepts of warfare therein.

[94] Viotti, *Military Space Doctrine*, 94.

Chapter 4

High Seas : Space Domain

While it is wise to observe things that are alike, it is also wise to look for things that differ; for when the imagination is carried away by the detection of points of resemblance - one of the most pleasing of mental pursuits - it is apt to be impatient of any divergence in its new-found parallels, and so may overlook or refuse to recognize such.

Alfred Thayer Mahan

False analogy is not a secure basis for a theory of war.

Sir Julian Corbett

The last chapter's analogy dealt primarily with the organizational and doctrinal factors in the development of spacepower theory and the United States Space Force. The debate concerning the creation of the Space Force continues to some degree even today after its establishment. Part of that continuing discussion revolves around how to conceptualize space as a warfighting domain. Spacepower theorists have looked to warfare in other domains hoping to elucidate the concepts and principles of warfare in outer space. Spacepower advocates, including senior military officers and civilians, tasked with figuring out how to execute Congressional and Presidential directives to establish the Space Force, continue to revisit and examine the parallels between warfare in the maritime domain and the space domain. Because this analogy has persisted for decades, and continues to be vigorously debated and evoked, I have selected the High Seas : Space Domain analogy as the second to be analyzed herein.

Analogy

In 2014, Lamont Colucci wrote in a *US News and World Report* article that just as "19th century strategic planners realized that projection of power would be determined by those that controlled the sea lanes…, [d]ominance in

space in the 21st century is the simple, logical next step."[1] In February 2020, speaking about his responsibility to guide the creation of the Space Force, Deputy Assistant Secretary of Defense for Space Policy Stephen Kitay looked to the same analogy when he remarked: "Naval power has helped guide my thinking."[2] Kitay went on to state his belief that "strong analogies" existed between space and naval power and highlighted the relationships between the two concerning "national power, prosperity, and prestige." Mr. Kitay is the latest in a long line of spacepower thinkers and policymakers who have identified the analogy between maritime, naval, or sea power and spacepower.

Some of the earliest writings on this topic emerged during the early 1960s as the United Nations considered how to regulate space activities. During this historical period, the term "high seas" was particularly well known as the Convention of the High Seas had just been signed on 29 April 1958, a mere six months after the launch of *Sputnik I.*[3] Article 1 of the Convention of the High Seas states that: "The term 'high seas' means all parts of the sea that are not included in the territorial sea or in the internal waters of a State."[4]

Even after excluding references to space as a "high ground," which are quite prevalent, the "high seas" analogy covers a broad range of spacepower

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[1] Lamon Colucci, "To the Moon and Beyond," *US News and World Report*, 29 July 2014 (https://www.usnews.com/opinion/blogs/world-report/2014/07/29/why-the-us-military-needs-to-control-the-moon-and-space).

[2] Sandra Erwin, "Defense Department Drafting New Space Strategy," *SpaceNews,* 6 February 2020, https://spacenews.com/defense-department-drafting-new-space-strategy/.

[3] Louis de Gouyon Matignon, "The Convention on the High Seas", *SpaceLegalIssues.com,* 9 May 2019, https://www.spacelegalissues.com/the-convention-on-the-high-seas/.

[4] United Nations, "Convention on the High Seas – 1958," Done at Geneva on 29 April 1958. Entered into force on 30 September 1962. United Nations, Treaty Series, vol. 450, p. 11, p. 82. In the body of literature that recognizes the high seas : space domain analogy, the terminology is often more loosely interpreted. As such, the terms "naval domain," "maritime domain," or "high oceans" will be treated as synonymous with "high seas" for the purposes of this paper. I have taken care only to equate these specified terms when they are intended to evoke the same analogical reasoning as the pure high seas : space domain analogy. Of note, I do not treat the term "high ground" as synonymous with the "high seas" analogy. When authors refer to space as a "high ground," it can be meant to induce relations that are distinct from the "high seas" source analog. Often, "high ground" is meant to suggest relations from a vantage point offering superior observation or the struggle which emerges when trying to displace an adversary from a position on higher ground with respect to land warfare. These relations are entirely separate from the high seas analogy.

concepts. To frame our relational analysis for this analogy, I separated the relations into three distinct branches reflecting three primary purposes for the analogy of the high seas. The first purpose is to inform an understanding of the space domain concerning what actions are permissible under international law. This analogical reasoning has a long history dating back to the earliest United Nations negotiations concerning the use of outer space. The second purpose for which theorists use the analogy is to understand space as a medium through which national power is built and exerted. This usage mainly points to the commercial equities (commerce) of a nation in space. Lastly, theorists use the high seas analogy to examine the concepts of warfare in, from, and through the space domain. Here theorists consider the similarity between maritime warfare and space warfare.

In its most basic form, the analogy with which this chapter concerns itself is represented in this way:

High Seas : Space Domain

> *The High Seas is representative of the Space Domain in that it is a physical domain, internationally recognized as a global commons (or province for all humankind) and used by nation-states for observation, commerce, and military purposes.*

International law commonly uses the high seas : space domain analogy; as such, I exclude a detailed relational analysis of the usage of the high seas : space domain analogy in international law. Below I have listed attributable relations in the alternative and mappable systems, including an example from each, for the remaining branches of usage: commerce and warfare.

Table 4: High Seas – Space Domain Relations

	Base Domain (*Relations)* **High Seas**	→	Target Domain (*Relations)* **Space Domain**
R1	The value of the **high seas** is in the transportation of supply and trade	→	The value of the **outer space** is in the transportation of supply and trade
R2	**Maritime warfare** is a business of positions.	→	**Space warfare** is a business of positions.
R3	The value of the **high seas** is in lines of communication	→	The value of **outer space** is in lines of communication
R4	The object of **naval warfare** is the control of communications	→	The object of **space warfare** is the control of communications

Source: Author's original work. Evidence for the high seas domain taken from John Klein, "Space Warfare: A Maritime-Inspired Space Strategy," Astropolitics*, vol. 2 (2004), 33–61; Alfred Mahan and John B. Hattendorf,* Mahan on Naval Strategy: Selections from the Writings of Rear Admiral Alfred Thayer Mahan, Classics of Sea Power *(Annapolis, MD: Naval Institute Press, 1991), 313; Julian Corbett,* Some Principles of Maritime Strategy *(Annapolis, MD: Naval Institute Press, 1988), 100; and Alfred Mahan,* The Influence of Sea Power Upon History 1660-1783 *(New York, NY: Dover Publications, 1987), 25.*

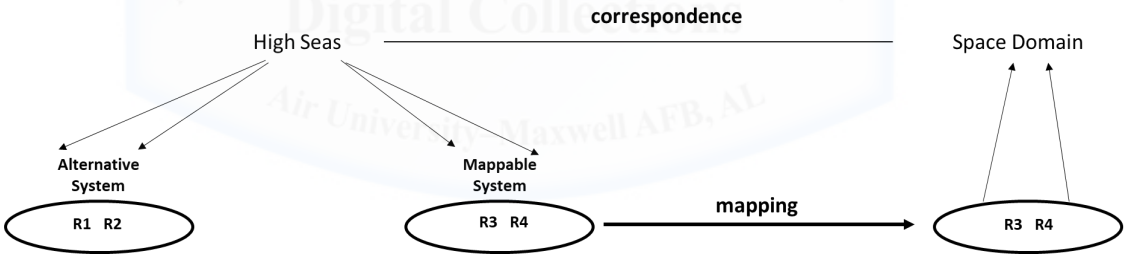

Figure 6: Analogical Map – High Seas : Space Domain
Source: Author's Original Work, based upon Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy," Cognitive Science*, vol. 7 (1983), 160.*

Relational Analysis – Alternative System

R1 – Physical Lines of Communications - Trade and Commerce

In the words of Alfred Thayer Mahan, "travel and traffic by water have always been easier and cheaper than by land."[5] Mahan saw the tracings of national power in the trade routes of his day. "The profound influence of sea

[5] Alfred Mahan, *The Influence of Sea Power Upon History 1660-1783* (New York, NY: Dover Publications, 1987), 25.

commerce upon the wealth and strength of countries was clearly seen long before the true principles which governed its growth and prosperity were detected."[6] Writing during a period of history when naval power alone could facilitate trade and commerce of such consequential volume and variety, Mahan focused much of his theory of sea power on ensuring and protecting commerce on the seas.

Mahan understood that the strength of modern nations was built upon the nation's ability to "draw to itself from near and from far all that is conducive to its growth and strength and general welfare." Mahan stated that one of war's most detrimental effects was the cutting of a "nation off from others" and forcing it to rely upon itself for resources. Without contact with the rest of the world via the sea, a nation would gradually starve for lack of resources and wealth. Mahan concluded that when countries were cut off from external resources (trade), their power rapidly diminished much as the mind and body do when starved of "healthful and varied nourishment."[7] Julian Corbett similarly identified that one only achieves the power to "strangle the whole national life" of an enemy by terminating a the adversary's ability to bring ashore commercial resources.[8] Command of the sea, he argued, imbued one state the strength to "forbid the passage of either public or private property upon the sea."[9] Ultimately, Corbett concluded that the primary method by which a maritime power can achieve victory is through the "capture or destruction of the enemy's property."[10] It becomes clearly evident that both Mahan and Corbett viewed physical commerce as a chief utility of the high seas. Nonetheless, the high seas : space domain analogy often confuses the value of physical commercial trade of the 19th century and the value found through operations in the space domain today.

Mahan identified that "oceans are not isolated from human commerce" and the trade routes of the world were established "in the history of the

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[6] Ibid., 1.
[7] Mahan, *The Influence of Sea Power Upon History*, 198.
[8] Julian Corbett, *Some Principles of Maritime Strategy* (Annapolis, MD: Naval Institute Press, 1988), 94.
[9] Ibid., 94-95.
[10] Ibid., 99.

world."[11] The commercial trafficking of physical assets through outer space, however, is quite far off. Despite estimates of future space-based trade and resource mining that range into the quintillions of dollars, there is presently minimal, if any, space-based commercial transportation of physical goods or resources, let alone anything near the scope of 19th-century maritime shipping.[12] Given this, the R1 relation distorts a proper understanding of space warfighting by inappropriately asserting that present-day space warfighting theory should incorporate the possibility of future physical commercial space trade or equating non-physical commerce with physical commerce.

Despite this, some space theorists have conjectured that the high seas analogy provides a "clear recipe for coping with the initial stages of space exploration, exploitation, sovereignty, and control."[13] Meanwhile, others state, "the future of American spacepower lies not in exploration, but in development of the inner solar system."[14] In January 2002, the US Space Command (USSPACECOM) issued its *Vision for 2020* pamphlet and evoked the analogy of the high seas when it stated, "During the rise of sea commerce, nations built navies to protect and enhance their commercial interests. Likewise, space forces will emerge to protect military and commercial national interests."[15]

[11] 1Lt Roger Burk, "Basic Space Doctrine" in *Military Space Doctrine: The Great Frontier: Volume I,* (United States Air Force Academy: CO, Department of Astronautics and Computer Science, 1981),123; Mahan, *The Influence of Sea Power Upon History,* 25.
[12] Jeff Desjardins, "There's Big Money to be Made in Asteroid Mining" *Business Insider*, 3 November 2016, https://www.businessinsider.com/the-value-of-asteroid-mining-2016-11?r=UK.
[13] Mark Sandvigen, "Alfred Thayor [Thayer] Mahan and Space: A Necessary Unity" (Monterey, CA: Naval Postgraduate School, June 1986), 63.
[14] Peter Garretson, "US Space Command: A Vision for the Final Frontier", *The Hill,* 28 August 2019, https://thehill.com/opinion/technology/459066-us-space-command-a-vision-for-the-final-frontier.
[15] US Space Command, "Vision for 2020," 11 January 2002, 4.

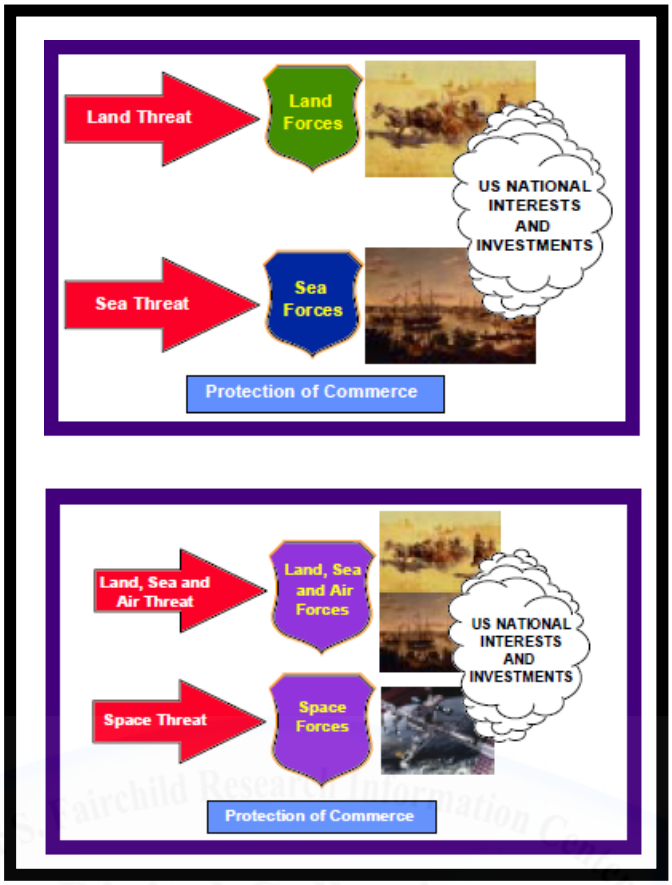

Figure 7: A Historic Perspective – the Evolution of Space
Source: US Space Command, "Vision for 2020," January 11, 2002, 4.

The crucial distortion in using the high seas : space domain analogy with respect to the commercial traffic of physical goods is that Mahan and Corbett developed their theories for maritime power after observing the extant realities of sea trade and commerce in their contemporary and historical times. Attempting to establish a space warfighting theory and strategy upon supposed future possibilities of space commerce surely does not equate to the theories developed by Mahan and Corbett. In the words of Colin Gray and John Sheldon: "Space warfare is tainted with the aura of overpredicted futures."[16] Worden and Shaw, who go into some length about the possible future commercial markets within the solar system, even admit their predictions are "highly speculative."[17]

[16] Gray, Colin and Sheldon, John. "Space Power and the Revolution in Military Affairs: A Glass Half Full?," *Airpower Journal*, vol. 13, no. 3 (1999), 23.
[17] Brig Gen Simon Worden and Col John Shaw, *Whither Space Power? Forging a Strategy for the New Century* (Maxwell AFB, AL: Air University Press, 2002), 99.

In 1999, Gray and Sheldon observed that "What is needed most urgently today is not so much some grand vision of space power [but] a relatively mundane understanding of the space environment as yet another environment for conflict."[18]

The same sentiment is as true today as it was over 20 years ago. Though there is some value in distant thinking about space exploration and physical space trade, in 2020, the USSF requires strategy and theory to preserve the security of the nation today. Perhaps under that security, lofty ambitions such as solar system-wide travel and mining will develop; however, using the high seas : space domain analogy to conclude that space operations and space power should operate presently under the same construct of commerce protection is premature. In the words of Benjamin Lambeth, "because satellites involve the movement of information rather than goods, they are not strictly comparable to the commercial ships that were plundered during the bygone era of rampant piracy on the high seas."[19] Furthermore, the assumption that space commerce will carry the same national importance as 19th-century sea-trade did is similarly underdeveloped. Barry Watts, comparing modern space trade to historical sea trade, concludes that "orbital assets have yet to acquire the economic import of Spanish treasure galleons."[20] Watts identifies that "the value of space systems has resided largely in the information they can relay […], not in the transportation of material goods from one location on the earth's surface to another."[21] Watts highlights this form of R1 distortion most effectively when he points out: "Seizing at sea or sinking ships transporting the crude oil on which a competitor's economy depends could easily pose a direct threat to that nation's economic prosperity in time of peace, if not to national survival in time of war. Attacking satellites in the early 21st century, by comparison, poses a less direct, less vital threat to the nations utilizing them than cutting off energy supplies or other raw economic materials."[22]

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[18] Gray and Sheldon, "Space Power and the Revolution in Military Affairs," 30.
[19] Benjamin Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space* (Santa Monica, CA: RAND, 2003), 100.
[20] Barry Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, 2001), 29.
[21] Ibid., 30.
[22] Ibid.

While it is likely that the US will grow increasingly reliant on space assets for military applications, the expectation that the US will become as reliant on the transport of physical goods from or through space is less likely. As such, I argue that the R1 relation distorts a proper current understanding of what the value of outer space is today and what needs to be defended by USSF space warfighters in 2020.

R2 – Positional War Theory

Mahan strongly favored Napoleon's famous dictum, "War is a business of positions."[23] Mahan spoke of positions in two main capacities: the position of a nation and a defined location of strategic importance at or along the high seas. Position in this latter form is what seems to drive the most common distortions when applied to spacepower theory.

Mahan identified three conditions that constitute a strategic position: situation, intrinsic strength, and resources.[24] He further stated that "where all three conditions, situation, intrinsic strength, and abundant resources, are found in the same place, it becomes of great consequence strategically, and may be of the very first importance."[25] Speaking specifically about the situation component, Mahan made it clear that the value of the position itself was derived from its geographic physical nearness to a sea route, "to those lines of trade which when drawn upon the ocean common, are as imaginary as the parallels of the chart, yet as really and usefully exist."[26]

Mahan identified a number of existing strategic positions that were situated at choke-points along major or intersecting sea routes. His list of seven distinct geographic positions and their description as critical "not primarily for trade, but for defense and war" highlights that Mahan saw value in the physical position proximal to these locations.[27] Mahan concluded that these strategic points necessitated control via "command of the sea." His preferred method for

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[23] Alfred Mahan, "Retrospect and Prospect; Studies in International Relations, Naval and Political" (Boston, MA: Little, Brown, and Company, 1902). Web. https://lccn.loc.gov/02024908.
[24] Alfred Mahan, *Mahan on Naval Warfare* (Mineola, NY: Dover Publications, Inc, 1999), 68.
[25] Ibid.
[26] Ibid., 69.
[27] Mahan, *Mahan on Naval Warfare*, 20.

achieving control of these locations was to keep "a superior force at the decisive point, expressed in the homely phrase of getting there first with the most men."[28] It was from this understanding that Mahan ultimately surmised that "it is power plus position that constitutes an advantage over power without position."[29] Mahan viewed strategic positions as physical locations, whose proximity to trade routes and military resources (coal, armaments, shipyards, etc.) were what drove their value and prized status. The high seas : space domain analogy sometimes distorts this view of strategic position and/or choke-points.

Space theorists have borrowed from the body of sea power theory, and Mahan primarily, terms to include in their taxonomy of spacepower theory. The concept of strategic position and choke-points has been widely used across the corpus of spacepower theory, but, as I show below, there are two primary ways this reapplication has distorted an accurate understanding of the space domain and space operations. First, theorists misapply the concepts of strategic position or choke-points to an orbit or orbital regime. Second, spacepower theorists misapply the strategic position concept to a physical space asset itself.

First, Everett Dolman argues that Mahan's chokepoints represent areas of strategic military importance and adds an obvious, but important, aside when he highlights that competitors have the option to "avoid most of these chokepoints by simply 'sailing the long way around' them" but that doing so would cost them both in terms of time and fuel efficiency.[30] In terms of space, Dolman argues, "there are specific orbits and transit routes that because of their advantages in fuel efficiency create natural corridors of movement and commerce."[31] Dolman claims that because of "gravity wells and the forbidding cost of getting fuel to orbit," certain Hohmann transfer orbits "can be shown to have or to be in themselves critical chokepoints."[32] This application, however, represents a distortion of the analogy in attempting to explain a part of space operations that do not adequately align.

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[28] Alfred Mahan, *Naval Strategy* (Westport, CT: Greenwood Press, 1975), 8.
[29] Ibid., 53.
[30] Everett Dolman, *Astropolitik* (New York, NY: Frank Cass Publishers, 2002), 34.
[31] Ibid., 37-39.
[32] Ibid., 39.

Hohmann transfer maneuvers are typically executed by spacecraft at an orbit's point of perigee or apogee to maximize fuel efficiency. In that regard, there are similarities to the "sailing the long way way around" adage Dolman makes. However, those apogee and perigee points are definable by the entity launching a satellite and differ from Mahan and Corbett's strategic positions, which are dictated by the largely unmalleable terrain of waterways and continents. Furthermore, there is a significant difference between identifying the Hohmann transfer orbit, which exists as a two-dimensional ring, as a chokepoint and the term "choke-point" as Mahan uses it. Mahan's choke-point is a one-dimensional point on the terresterial map of seas and coastlines while an orbit is an immense two-dimensional ring. An argument could be made that in a tactical, localized sense, the apogee or perigee point of an establish orbit could represent a "choke-point." But that logic applied operationally would mean that *every* physical point along the orbital path, not just the apogee or perigee, could be interpreted as a "choke-point" by the logic that the spacecraft, in order to travel in the most fuel-efficient manner, will continue along a series of choke-points to complete its orbit. Dolman overreaches when he tries to apply the concept of a strategic choke-*point* to two-dimensional space orbits because attacking or defending a static point is significantly different from attacking or defending a two-dimensional path that extends for tens of thousands of miles.

Dolman continues with this distortion when he defines both the low-earth orbital regime and the "geostationary belt" as strategic narrows.[33] Technically speaking, the low-earth orbital regime ranges from 100-1,200 miles above the earth, 360 degrees in both the lateral and longitudinal directions, and encompasses a volume of over 7.235×10^9 cubic miles. Meanwhile, the "geostationary belt" measures 1.4×10^5 miles in length. [34] Both the sheer size of these "narrows" and the fact that they represent two- and three-dimensional physical spaces versus Mahan's one-dimensional strategic position show how

[33] Dolman, *Astropolitics*, 74.
[34] Ibid.; Inter-Agency Space Debris Coordination Committee, "IADC Space Debris Mitigation Guidelines" September 2001, https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf.

this distortion can significantly impact an understanding of strategic positions in space warfighting. Again, the offensive and defensive considerations of attacking or defending an entire orbit or orbital regime are significantly different than patrolling and engaging naval vessels transiting maritime narrows.

Corbett identified that, while the ultimate objective may be "to exercise control at any place or at any moment," in essence, "permanent general control" of the seas, this was unattainable because the high seas were just too vast and extensive to permit it.[35] From this line of thinking, Corbett developed his concept of "local and temporary control" as the natural form of naval power.[36] Dolman applies Mahanian concepts across a portion of the space domain that is too vast and large. The maritime concepts of choke-points and narrows were intended to assist the maritime theorist in deciding where to patrol, defend, or engage the adversary. I argue that an idea of spacepower control spread across an entire orbit or orbital regime is too dissimilar to that of the high seas strategic position to be used as it has by Dolman and others.[37]

The second way spacepower theorists have abused the sea power concept of strategic positions is in treating specific spacecraft as "strategic positions" themselves. John Klein defines strategic positions as "locations that impart some relative advantage from operating there or hold value due to the importance of the activities performed there."[38] This definition still holds to the ideas of Mahan and Corbett of the position as a physical point, however, Klein distorts the notion of strategic positions when he goes on to the "non-physical" realm.[39] Here, Klein defines the position or choke-point as the satellite itself. His argument is that with respect to the communications routes that travel over a satellite, the satellite itself becomes a choke-point. For the practitioner of orbital warfare, this notion can become very confusing. When viewed as an application of the high seas analogy toward information warfare, as Klein is discussing, perhaps one can allow for some similarity in identifying a satellite as a node in the non-physical path upon which information travels. But

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[35] Corbett, *Some Principles of Maritime Strategy,* 211 & 104.
[36] Ibid., 339.
[37] John Klein, *Space Warfare: Strategy, Principles and Policy* (New York, NY: Routledge, 2006), 83.
[38] Klein, *Space Warfare*, 80.
[39] Ibid., 82.

applying this understanding to the physical domain of space, and using it as a concept in the broader space warfare regard, distorts an understanding of what a truly strategic position or choke-point would be. In an orbital warfare sense, one cannot consider the spacecraft itself as the choke-point; this would be equivalent to calling a ship a choke-point. Perhaps if Corbett and Mahan were analyzing the broader domain of national trade, they might view a ship as a choke-point within a particular good's transportation from the production center to the buyer. But in a military sense, they would not regard a warship as a choke-point itself within a naval engagement.

Worden and Shaw promote this same distortion when they explicitly state, "The nodes in space are the satellites themselves."[40] Their discussion of choke-points and strategic positions in terms of links and nodes blurs an understanding of both the physical domain of space and the non-physical domain of the electromagnetic spectrum and associated cyber operations. Space warfare includes operations in both domains (space and cyber) and both the concepts of strategic positions and choke-points have specific implications that are domain-dependent. By trying to force the high seas analogy onto space warfare holistically, Klein,Worden, and Shaw distort an understanding of how strategic positions manifest in either the space or cyber domains and how they are similar to or different than the concept of strategic positions in sea power.

According to Mahan, "The first and most obvious light in which the sea presents itself from the political and social point of view is that of a great highway."[41] He and Corbett identified that sea lines of communication (LOCs) exist because they present the most efficient way to accomplish the mission of transporting goods across the sea from one port to another. Space orbits are used because they are often the only way to achieve the mission intended for that satellite system. If one must draw a relation from the high seas analogy toward orbits and satellites, the concept of the orbit is a better representation of the trade route and the satellite of the ship. An understanding of either the orbit or satellite themselves as a strategic position in space warfare distorts a

[40] Worden and Shaw, *Whither Space Power?,* 101.
[41] Mahan, *The Influence of Sea Power Upon History*, 25.

proper understanding of orbital warfare. As such, I have categorized it in the alternative system for the high seas : space domain analogy.

Relational Analysis – Mappable System

R3 – Non-Physical Lines of Communication

Space warfare, in its broadest sense, includes actions and effects primarily in and through the domains of space and cyber. Contrary to the distorted understanding present in the R1 relation, the primary utility of present-day space operations is the transfer (or transportation) of information. That information comes in forms as varied as satellite communications, position, navigation, and timing data, or ISR data. The role of the USSF today, and for the foreseeable future, is to defend and leverage the value of this information which is either uniquely gathered or disseminated via spacecraft. The value of space operations is the information that is transported via the domain, when the proper relations are used, the high seas : space domain analogy promotes this understanding.

Corbett defined three forms of maritime communications: fleet support communications, communications for an overseas army, and trade routes.[42] Though Corbett's definitions of "communications" includes a component of physical sustenance, it also connotes non-physical communications in the form of information. Regardless, the high seas : space domain analogy increases understanding of space operations and orbital warfare when it is understood that the value of space comes in the form of transporting information through the domain. This parallels the value of the high seas as the transportation of "communications" in both its physical and non-physical forms. Whereas the R1 relation forced the space domain value based on physical trade, the R3 relation accepts that the target analog is not *space trade* but *information in/from/through space*. The naval use of "lines of communication" as a term to mean both the transport of physical goods and non-physical information is confusing when applied to space. Space theorists assist understanding when they focus on and clarify that "lines of communication" in space operations refer to the non-physical information form exclusively.

[42] Corbett, *Some Principles of Maritime Strategy,* 316.

Klein recognizes the non-physical information value of space operations when he points out that "while maritime communications include lines of supply and trade, they also include LOCs that are of a strategic nature and are thus critical for a state's survival."[43] Klein includes in his theory a term he calls "celestial lines of communications (CLOCs)" which he defines as "those lines of communications in and through space used for the movement of trade, materiel, supplies, personnel, spacecraft, electromagnetic transmissions, and some military effects.[44] While Klein's definition of CLOCs as a whole is dubious (for it simultaneously distorts and assists understanding), he does include the non-physical component of information in his concept.[45] Unfortunately, Klein ultimately builds his idea of "command of space" on a physical/non-physical interpretation of CLOCs; his command of space concept could be better served by focusing solely on the non-physical communications aspect.

Jean-Luc Lefebvre has stated that "non-physical lines of communication transport information, something that has become as vital to everyday global functions as the transport of merchandise. They require protection."[46] When Klein and other theorists recognize that space's chief utility now, and in the foreseeable future, remains the transportation of information, versus the transfer of physical goods, they encourage a better understanding of the domain. The understanding that space's principal value is in the non-physical LOCs that traverse it contributes to a knowledge of space and orbital warfare and has been categorized in the mappable system as such. I will now move to the high seas : space domain analogy's implication for the defense of those lines of communication.

R4 – Control Theory

In 1958, General Thomas White proclaimed, "The United States must win and maintain the capability to control space in order to assure progress and

[43] John Klein, "Space Warfare: A Maritime-Inspired Space Strategy," *Astropolitics,* vol. 2 (2004), 40.
[44] Klein, *Space Warfare*, 51.
[45] Ibid.
[46] Jean-Luc Lefebvre, *Space Strategy* (Hoboken, NJ: John Wiley & Sons, Inc, 2017), 205-206.

preeminence of the free nations."[47] The *DOD Dictionary of Military and Associated Terms* does not define the generic term control as used by General White. The Department of Defense does identify terms for each of the physical domains that describe operations to ensure freedom of action for the United States and its allies and deny an adversary freedom of action in a given domain. These terms—sea control, land control, and space control—identify the domains and military operations needed to *control* the domain. The final relation from the high seas : space domain analogy clarifies the object of space control operations.

In one of his most often quoted passages, Corbett argues that "the object of naval warfare is the control of communications, and not, as in land warfare, the conquest of territory. The difference is fundamental."[48] His understanding of naval warfare is built upon an accurate understanding of the value of maritime communications to the nation. Corbett, equipped with the knowledge that the sea provides merely a means to an end, produced an accurate description of naval strategy relative to land strategy and warfare in general. Corbett identified that "it is almost impossible that a war can be decided by naval action alone."[49] He was comfortable with the fact that his domain of warfare significantly impacted both national power and the ability of the army to operate in faraway lands, but ultimately, "since men live upon the land and not upon the sea, great issues between nations at war have always been decided by what your army can do against your enemy."[50] Understanding the integration of both land and naval forces, Corbett proclaimed that "the paramount concern, then, of maritime strategy is to determine the mutual relations of your army and navy in a plan of war."[51] Decades later, Bernard Brodie carried a similar understanding of sea power's utility when he stated "as a rule navies exist chiefly to aid and sustain armies and air forces."[52]

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[47] General Thomas D. White, "Space Control and National Security," *Air Force: The Magazine of American Airpower*, vol. 41, no. 1 (1958), 80.
[48] Corbett, *Some Principles of Maritime Strategy,* 94.
[49] Ibid., 15.
[50] Ibid., 16.
[51] Ibid.
[52] Bernard Brodie, *A Layman's Guide to Naval Strategy* (Princeton, NJ: Princeton UP 1942), 15.

In contrast to Corbett, Mahan argued that naval power was the preeminent determining factor of national power.[53] That understanding has, at times, appeared in the spacepower theory compendium. Claims such as then-Senator Lyndon Johnson's statement that "whoever controls space controls the world" give an inflated view of the preeminance of spacepower.[54] Corbett's comprehension of the integration between multiple domains is the best model for present day orbital warfighters. Gray and Sheldon pursue this when they identify that "the strategic logic of spacepower—following the maritime case just cited—is not a matter merely of abstract principle. That strategic logic has been created by the practice of space-system dependence by the US armed forces (and indeed by the US economy)."[55] They point out that it is the dependence on space-enabled communications which testifies to spacepower's true value and, ultimately, the link which military spacepower must grow to defend.

Klein's description of non-physical communications as space domain "communication of effects" is built off of Corbett's concept of naval strategy as a "question of passage and communication."[56] Corbett identified naval power's three functions as prevention or securing alliances, protection or destruction of commerce, and furtherance or hindrance of military operations ashore.[57] By separating commerce from army support, Corbett promotes a form of the high seas analogy which provides the spacepower theorist the value of non-physical LOCs without the distortion of trade and supply focused physical form of LOCs. Though Klein applies his CLOCs label to both physical and non-physical lines of communication, the fact that he breaks them apart, as Corbett did, allows one to salvage a portion of his theory. Corbett understood that the effects provided by the fleet were more important than the fleet itself; similarly, Klein

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[53] Alfred Mahan, *Naval Strategy Compared and Contrasted with the Principles and Practice of Military Operations on Land: Lectures Delivered at the U.S. Naval War College, Newport, R.I., between the Years 1887 and 1911* (Westport, CT: Greenwood Press, 1975), 50.
[54] Alan Wasser, "LBJ's Space Race: What We Didn't Know Then (part 1)," *The Space Review,* 20 June 2005, https://www.thespacereview.com/article/396/1.
[55] Gray and Sheldon, "Space Power and the Revolution in Military Affairs," 31.
[56] Corbett, *Some Principles of Maritime Strategy*, 316.
[57] Ibid., 317.

understands that it is the spacepower effects which must ultimately be controlled versus merely the spacecraft themselves.[58]

Corbett's concepts of control with respect to naval strategy, in particular the control of LOCs in a non-physical sense, as well as the integrated nature of joint warfare and its reliance on certain domains for strategic support, promote a deeper understanding of spacepower theory and orbital warfare. As evidenced by Gray and Sheldon's discussion of joint force reliance on spacepower effects and Klein's identification of non-physical CLOCs, the R4 relation bolsters understanding of the space domain by highlighting that the object and focus of space control operations is the preservation of US space-enabled communications and the denial of adversary space-enabled communications. Therefore I have categorized the R4 relation in the mappable system.

Conclusion

Peter Hays has remarked that, though "Mahan and Corbett's ideas about lines of communications, common routes, and choke points have been applied quite directly onto the space medium," to date, "no comprehensive spacepower theory has yet emerged that is worthy of claiming a place alongside the seminal seapower theories."[59] At the same time, Gray and Sheldon comment that, "we have just advised that it is useful and forward-looking to consider, for instance, what convoy, choke points, blockade control, and special operations might mean for space warfare. In contrast, we believe that it is not forward-looking to become preoccupied by how space warfare might resemble significant features of sea or air warfare."[60]

The high seas : space domain analogy will likely be used for many years by space professionals. There are too many readily apparent similarities between the domains themselves and the warfare that does, or is likely to, occur in them. The analysis in this chapter has identified that it is not the analogy itself that necessarily promotes or distorts understanding, rather it is how the analogy is analyzed or applied that furthers or hinders one's

[58] Klein, *Space Warfare*, 59.
[59] Peter Hays, *United States Military Space: Into the Twenty-First Century* (Maxwell AFB, AL: Air University Press, 2002), 18.
[60] Gray and Sheldon, "Space Power and the Revolution in Military Affairs," 28.

comprehension. The final chapter will examine the factors which influence whether an analogy is beneficially or detrimentally applied, and how space warfighters can increase their chances of constructively employing analogical reasoning.

Chapter 5

Analysis and Conclusion

> *Such disconnects with everyday earthly experience suggest that terrestrial analogies for thinking about the military value of near-earth space may contain even larger pitfalls than those commonly encountered in trying to measure more familiar forms of military power.*
>
> Barry Watts

To truly understand any concept is a challenging endeavor. That effort grows more difficult when the concept is both foreign and emerging. As such, space and the art of space warfare are difficult to understand. Lt Gen Richard Henry stated: "Space is a new medium – and, in many ways, much more difficult for the average person to understand than the medium of air was in the early part of the twentieth century. The American public – and even many of our own service members – do not really understand space systems and conceive of space only in terms of astronomy or entertainment-induced 'Star Wars' imagery."[1]

If, as Hofstadter asserts, analogy is the very mechanism of human thought, then analogical reasoning is inevitable in the human effort to understand outer space operations and orbital warfare. I have examined only two of many common analogies evoked by those seeking to understand spacepower. From this analysis, it is clear that both the early airpower : modern spacepower and the high seas : space domain analogies have the power to clarify as well as distort understanding. In our review of the early airpower : modern spacepower analogy, I found similarities and differences in both how the technology of air and space operations developed and the military's concepts for employing those systems. The analogy has helped guide officers and policymakers alike in determining if and how the US Space Force should

[1] Maj Paul Viotti, *Military Space Doctrine: The Great Frontier – The Final Report for the USAFA Military Space Doctrine Symposium, 1-3 April 1981*, (AD-A104574), 64.

break away from the Air Force. The analogy provides some clarity for how and why the USAF and USSF will be both similar and different in certain regards. Anyone trying to make sense of the history and future of the USSF will inevitably be forced to make sense of the early airpower : modern spacepower analogy.

When analyzing the high seas : space domain analogy, I found themes regarding the value of the maritime and space domain as well as how to defend or exploit those domains. As the USSF seeks to establish theory and doctrine for how to fight in and through the space domain, the analogy is continuously invoked. Broad ideas concerning the goals of orbital warfare and the value of the space domain itself are illuminated via a study of the relations between the high seas and the space domain. However, one must recognize the unique nature of both the maritime and space domains when applying strategies for each.

The most significant meta-finding of this analysis is that each major analogy is simultaneously widespread, enduring, compelling, and, at times, deceptive. Analogies themselves are not a panacea for understanding new domains, but they are, by human nature, intuitive ways for gaining understanding and, by that virtue, they possess immense power. We should employ great caution when leveraging analogies. A failure to carefully analyze the relations and context in which one uses them can have insidious effects. The distortions caused by the errant application of analogies are both substantial and deceptive. The power of analogies can provide great assistance or harm.

The power of analogies is partially grounded in the fact that analogical reasoning is inevitable. Human brains are wired to understand the world analogically, bridging from known concepts to unknown--and vice versa. Any effort to discount or condemn the use of analogies is fallacious and futile. However, for analogies to provide their greatest benefit they must be harnessed and addressed carefully and methodically. In our final analysis, I will explore a model by which space professionals can ensure they leverage and apply analogies for good.

Redeeming the Analogy via Structure Mapping and Six-Variable Model

This thesis has already provided an example of how to apply structure mapping to determine the content of an analogy. The first principle space warfighters can employ to ensure the fruitful use of analogies is simply this: determine what the analogy is trying to explain. Many times, analogies are raised simply as witty introductions or concluding thoughts. At times, there is no intent for an analogy beyond enticing a learner toward a foreign idea: if they know something about the source analog, they can understand the target domain. The structure mapping framework allows one to apply rigorous analysis toward understanding if an analogy has any substance, and if so, to be explicit about what it is the analogy intends to relate.

Conveniently, the structure mapping framework answers one of the first variables in the six-variable model—analogy content. In this paper, I have provided only one component of each of the analogies analyzed. There remain many more relations in these two analogies that theorists have, or will, conjure in their thinking on space warfare. After identifying the relevant relations and establishing the content of the analogy in question, one can examine the remaining elements of the six-variable model.

Equipped with the analogy content in the form of a structure-mapping framework, space warfighters should scrutinize the analogy for its complexity. How difficult was it to establish the relations intended by the analogy? How many readily apparent relations can be attributed to the alternative system versus the mappable system? Are irrelevant relations in the analogy likely to plague even competent audiences? The complexity of the analogy is high when there is a high probability that many irrelevant or alternative system relations are encountered. If the analogy displays high complexity, one should seek out another analogy, especially if the value of the mappable system relations does not warrant risking the misunderstanding represented in the alternative and irrelevant systems. If compelled or enticed to continue with the analogy, one can mitigate its complexity, high or low, by providing sound mapping support.

Mapping support is simply guidance provided outside the analogy as to which relations were intended to be evoked by the analogy and the category in

which they should be placed—irrelevant, alternative, or mappable. If one has done a thorough job of mapping the relations when examining the analogy content, this type of support can be easily provided. However, the final key to providing effective mapping support is to bridge the analogy-focused instructional variables and the audience, or learner variables. Different levels and types of mapping support are required depending on the learner in question and the six-variable model provides us with the three elements by which one can analyze their audience/learner.

Closely tied to mapping support is the variable of processing goals or simply, why the analogy is being used. While the instructors, or theorists in this case, have an idea of why they selected a particular analogy, the audience may approach the comparison with different intentions. For fruitful learning to occur via the analogy, both the instructor and the learner must possess a common motive and understanding of the purpose or goals for the analogy. They must agree on what the target domain is and even the capacity and context of the information presented within the target domain. If both the instructor and the learner synchronize their intellectual paths, the analogy can help them follow the same trail. While processing goals represent an abstract phenomenon in the mind of the learner, the final two variables exist as actualities in the character of the learner.

The learner's analogical reasoning ability can be simply understood as their intelligence level, specifically their verbal reasoning intelligence. This ability ranges broadly between individuals. Moving forward, USSF professionals should not rely on Industrial-era notions concerning the differences in verbal aptitudes between officers and enlisted personnel. At the same time, an increased emphasis within the USSF on science, technology, engineering, and mathematics may not translate to the recruitment of personnel necessarily well-developed in their verbal aptitudes. Theorists writing on space warfare who choose to employ analogies must accept the fact that their reading audience will represent a range of intelligence levels and should provide analogy content and mapping support as such. USSF personnel providing in-person orbital warfare instruction should familiarize themselves with their student's intellectual

strengths and weaknesses before using explicit analogical reasoning in their training or education.

The final variable to be considered is domain-specific knowledge. This component is perhaps the most often violated or ignored variable by those who use analogies to understand spacepower. Historically, space operators possessed little, if any, depth of exposure to other warfighting domains. With the establishment of the USSF as an independent military service, this thin exposure is likely to continue, if not increase. As such, the use of other warfighting domain analogies may quickly produce distortions. It is one thing for a naval officer to use sea power analogies to instruct another naval officer or for a pilot to evoke an airpower analogy to explain space to another pilot. But when space professionals try to use air or sea analogies to teach other space professionals, neither the instructor nor the learner has a depth of domain-specific knowledge. Both the teacher and the student are likely relying on a very surface-level and speculative understanding of the source analog. If each is starting from an uncertain and likely divergent base domain, there is little chance they will arrive at the same target domain. Furthermore, they will each struggle to develop much depth in their understanding of the target domain, because their depth of knowledge in the base domain is so low. Ultimately, the selection of analogy is of critical importance.

Mastering the Mind : Mastering Space

The best analogies for space warfighting will be well-researched, conscious of learner intelligence, low in complexity, and built on base domains of everyday common human experiences. While the use of other domain warfare analogies may bear fruit for those well-versed in those domains and equipped with high levels of mapping support, they will likely distort the understanding for new orbital warfare personnel. In the training of modern orbital warfighters, it will be best to use analogies of which they have innate comprehension. Relating instruction to experiences driving a car, a shared experience, will be better than comparing them to flying a fighter jet, an activity in which few if any USSF personnel have participated.

Lastly, when it comes to addressing the fact that USSF personnel will have no "space-going" intuition, analogical training will need to follow in-depth academics in orbital mechanics and application-focused simulations. Orbital warfighters will especially require some form of "orbital intuition." Efforts such as the *Black Horizons* game project are vital for space professionals to develop orbital understanding and intuition.[2] Only after developing this nascent form of orbital intuition should more complex types of analogical training be used, as this level of knowledge (schemata) is required to accurately map the analogical relations.

Orbital warfighters need to develop the foundational truths, tactics, and rules-of-thumb for their domain, as other practitioners have done in their own combat disciplines.[3] Only these types of responsive heuristics, often built on analogies, will be intuitive and dynamic enough to fight in the space domain. Mendenhall's non-analogical representation of outer space cannot suffice for military space operations, training, or orbital warfare. Instead, orbital warfighters must analyze, master, and employ analogical reasoning for best effects. By practicing these careful thinking habits in training, orbital warfighters will build the cognitive skills to understand space more for what it is, not just what it is *like*. The result of this challenging effort is that they gain an ability to rapidly identify, develop, and exploit analogies on-the-fly during combat operations. If orbital warfighters can process analogical models in the moment, as part of their space Observe, Orient, Decide, Act (OODA) loop, they will be well on their way toward dominating the space domain. They will build these skills and abilities by leveraging the structure mapping framework and the six-variable model as described in this thesis. It is worth the effort, because in the end, "an illustrative analogy is often more helpful than a rigorous proof."[4]

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[2] Black Horizons was developed as a project of the Air Command and Staff College's Blue Horizons Program. It is currently being developed for US Space Force training purposes by the USSF Training Office and MGMWERX.

[3] Col Casey Beard et al, "Space Capstone Publication-A: Spacepower (v 1.04)," November 2019, 70.

[4] Viotti, *Military Space Doctrine*, 11.

Appendix

Six-Variable Model

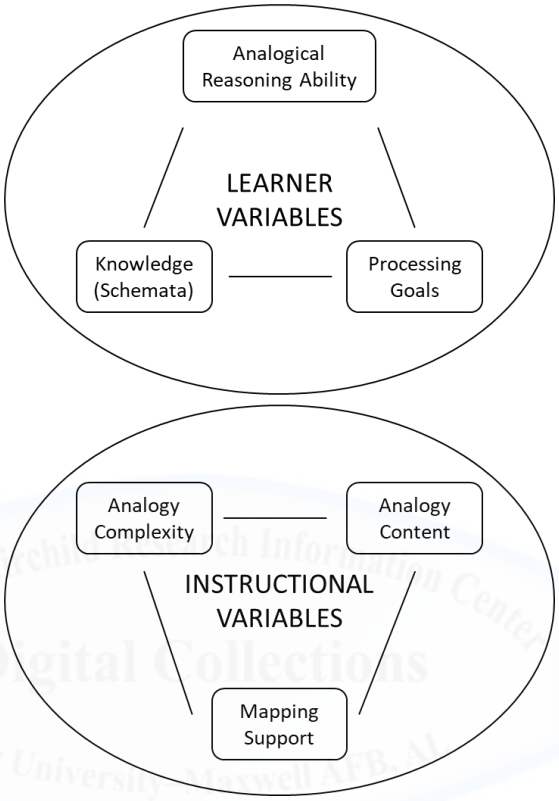

Figure 3: Six-variable Model of Analogical Conception
Source: Kevin B. Zook and Jean M. Maier, "Systematic Analysis of Variables That Contribute to the Formation of Analogical Misconceptions", Journal of Educational Psychology,*vol. 86, no. 4 (1994), 589-600*

Instructional variables - variables which are manipulatable by the provider of the analogy (in their study, the instructor).

- *Analogy Content* - the target information to be learned and understood as well as the particular source analog that is selected to assist the learner.
- *Analogy Complexity* - a function of the number of mappable relations the learner must transfer and the number of extraneous base features that the learner must discard in the mapping process.
- *Mapping Support* - the degree of assistance provided by the instructor to help the learner understand the relational similarity between the source and target domains and to prevent the learner from overextending the analogy.

Learner variables - those variables embodied within the receiver of the instruction or analogy.

- Analogical reasoning *ability* - the learner's proficiency in analogical reasoning. This variable is often correlated with intelligence.
- *Domain Specific Knowledge* - the learner's preexisting understanding of the analogy's objects and relations, as well as any related schemata that could be activated by the analogy.
- *Processing Goals* - the purpose for the instruction or analogy, they influence the specific features that are selected for mapping.

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