Celestial Visions: Imagining and Engineering Spaceflight in the United States, 1899–1969

by

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Abstract

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Human space travel in the United States was the culmination of years of research, immense technological progress, and enormous collaborative projects, particularly in the 1950s and 1960s. It was also, as this thesis argues, a product of imagination—that is to say, a consequence of space travel's fictional and imaginative conceptions. Science fiction stories advanced precise articulations of what spaceflight might be like and what its achievement would entail. Such tales inspired the pioneers of astronautics in the late 19th and early 20th centuries to translate these interplanetary fantasies into practical realities. In turn, these pioneers helped forge the nascent field of astronautics, and inspired generations of enthusiasts and engineers whose later efforts constituted a foundation upon which future developments were realized. In the American context, this process of imagination, inspiration, and innovation culminated most visibly with the Apollo 11 Moon landing in 1969. The origins of many of the ideational and technological antecedents to human space travel were located in a dream of spaceflight, and conveyed through various, imaginative means, whether fictional or extrapolative in nature. This dream, as I argue, led to meaningful technological developments and progress, and produced a cultural environment in the United States that was receptive to the advent of space travel. This thesis explores the rise and imaginative origins of American rocketry in the early 20th century, the development of large space boosters in the mid-20th century, the flourishing of space media in popular culture during the 1950s, and the influence of imaginative visual media, with a focus on the American science fiction space travel films of the 1950s and 1960s. By tracing the linkages binding sources of inspiration to their ultimate results, whether they are technological innovations or cultural phenomena, this thesis maps out "threads of imagination" that reveal the influence and effect of the cosmic imagination in the United States, and how it helped bring about spaceflight.

Acknowledgements

This thesis carries with it two very strong sentiments in my memories. The first is wonder, for I wonder how I ever managed to get it done. But this evokes the second and more powerful sentiment, that of deep gratitude for all the people who inspired and guided me along on my way.

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A most special and heartfelt thanks must also go to my mother and father. I am indebted to you both for everything you are and everything you do. Thank you for the infinite kindness, endless support, and illimitable love. Words cannot communicate the depth of my appreciation for you both.

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INTRODUCTION: AMIDST DREAMS, POSSIBILITY

Almost exactly two years before the first artificial satellite—the Soviet Union's *Sputnik*—entered orbit on 4 October 1957, German-born writer and space advocate Willy Ley penned an article for the October 1955 issue of *Galaxy Science Fiction Magazine*. Appearing under his regular "For Your Information" column, this article, entitled "The How of Space Travel," mostly covered his experiences working with Walt Disney Studios on their latest programming, a television series dedicated to space travel that had premiered in 1955. In the article, Ley wove between discussing how the series came about and the challenges of producing the show, and even explained some of the basics of rocketry and spaceflight. Then, he concluded with an important thought: "prediction is one of the causes of reality. That's true of research. It's also true of science fiction."[1]

Science fiction is a broad genre brimming with numerous ideas.[2] The science fiction Ley referred to would have been those dealing with the possibility of space travel, which had foretold that humankind's fate was to reach the stars. Cosmic fantasies of this kind had a long history, dating back as far as the 2nd century, B.C.E.[3] Varieties of such tales, telling the voyages of explorers carried to other planets and worlds by imaginative means, appeared across the centuries,[4] but none took the

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[1] Willy Ley, "For Your Information: The How of Space Travel," *Galaxy Science Fiction*, October 1955, 71, accessed August 16, 2021, https://archive.org/details/galaxymagazine-1955-10.

[2] Though speaking specifically of science fiction film, M. Keith Booker calls science fiction "a genre of ideas," an assessment that rings true beyond film as well. See: M. Keith Booker, *Alternate Americas: Science Fiction Film and American Culture* (Westport, Connecticut, and London: Praeger, 2006), 266. See also: William Sims Bainbridge, *Dimensions of Science Fiction* (Cambridge, Massachusetts: Harvard University Press, 1986), 7, 156.

[3] Frank H. Winter, *Prelude to the Space Age: The Rocket Societies: 1924-1940* (City of Washington: Smithsonian Institution Press, 1983), 19; Howard E. McCurdy, *Space and the American Imagination*, 2nd ed (Baltimore: John Hopkins University Press, 2011), 13; Frank H. Winter, *Rockets into Space* (Cambridge, Massachusetts and London, England: Harvard University Press, 1990), 2.

[4] See: McCurdy, *Space and the American Imagination*, 13; Winter, *Prelude*, 19; Winter, *Rockets into Space*, 2; Ron Miller, "Spaceflight and Popular Culture," in *Societal Impact of Spaceflight*, eds. Steven J. Dick and Roger D. Launius, (Washington, D.C.: National Aeronautics and Space Administration, Office of External Relations, History Division, 2007), 502, 505-506, https://history.nasa.gov/sp4801.pdf; Tom D. Crouch, *Aiming for the Stars: The Dreamers and Doers of the Space Age* (Washington and London: Smithsonian Institution Press, 1999), 22; Lea Gringé, "Science fiction works for the development of the aerospace sector," *Space Policy* 41 (August 2017): 43; Roger D. Launius, "Prelude to the Space Age," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration,* eds. John M. Logsdon, Linda J. Lear, Janelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 3-4, https://history.nasa.gov/SP-4407/vol1/intro.pdf.

idea of space travel as seriously as Jules Verne's *De la Terre à la Lune* (1865), and its sequel *Autour de la Lune* (1870), both of which demonstrated that spaceflight was to be attained through technology, practical means, and an application of expertise.[5] Although Verne launched his explorers to the Moon with a cannon, his imagination and scientific accuracy rendered a powerful idea—space travel *could* be realized, but only if it was approached correctly.[6]

But how was imagination, research, and technological development bound together? What value lay in prediction, where was it to be found, and how was it productive? How could imaginative, fictional, or speculative materials bring about space travel? Looking at the pioneers and prophets of astronautics reveals a part of the answer. Russian Konstantin E. Tsiolkovskii, German-Romanian Hermann J. Oberth, and American Robert H. Goddard were among the first people in the late 19th and early 20th century to cogently articulate how space might be reached through attainable technologies. Though they came to their conclusions independently, their interests in space travel were the results of relying on a common source of inspiration—science fiction. Tsiolkovskii and Oberth were both compelled to unravel the questions of spaceflight after reading Verne's space travel stories.[7] Goddard's imagination was first ignited upon reading an adaptation of H.G. Wells' *The War of the Worlds* and astronomer Garret P. Serviss' *Edison's Conquest of Mars* in 1898, and he constantly read stories penned by Wells and Verne throughout his life.[8] Tsiolkovskii, Oberth, and Goddard then translated their inspirations into treatises, articles, and investigations which, for the legions of engineers, innovators, publicists, and amateur rocketeers who sought to realize space travel in the 20th century, supplied yet another source of inspiration. This pattern of imagination,

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[5] Miller, "Spaceflight and Popular Culture," 505-506; Launius, "Prelude to the Space Age," 4.
[6] Miller, "Spaceflight and Popular Culture," 506.
[7] McCurdy, *Space and the American Imagination*, 16; Walter A. McDougall, …*the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., Publishers: 1985), 20; Winter, *Prelude*, 19; Winter, *Rockets into Space*, 7.
[8] McCurdy, *Space and the American Imagination*, 16; McDougall, …*the Heavens and the Earth*, 20; David A. Clary, *Rocket Man: Robert H. Goddard and the Birth of the Space Age* (New York: Hyperion, 2003), 15.

inspiration, and innovation then repeated in various forms and produced a meaningful impact on the advent of spaceflight.

A SPACE FOR IMAGINATION

The main focus of this thesis, therefore, is to investigate the role of imagination, spaceflight popularization, and materials of inspiration in the realization of spaceflight in the United States between 1899 and 1969. 1899 marks the year in which Robert H. Goddard sought to realize space travel, and 1969 saw humanity's first sojourn on another celestial body with the Apollo 11 Moon landing. The linkages between inspiration and their results constitute what I call "threads of imagination," and I trace them to reveal the connections binding inspiration and space travel, imaginative works and the engineers of early astronautics, and the innovations they pioneered. While the scope of this project is limited to the United States, a discussion of German technological development in the early 20th century will be necessary as it relates directly to the rise of American rocketry. It should therefore be noted that Russia also possesses a rich and complementary history of robust technological development during the early 20th century. Spaceflight in Russia benefitted greatly from work of the first significant pioneer of astronautics, Konstantin E. Tsiolkovskii, as well as the efforts of enthusiasts, publicists, and engineers building on Tsiolkovskii's work during the early-to-mid 20th century.[9] Much of Tsiolkovskii's work was unknown in the United States until at least the 1930s, and though his contributions were important to the nascent spaceflight literature of the early 20th century, it does not appear that his work significantly impacted American rocketry or American spaceflight capability, even into the 1960s.[10] As this thesis is focused on uncovering specific relationships between imagination and reality in regards to space travel and space travel

[9] Launius, "Prelude to the Space Age," 6.
[10] Winter, *Prelude*, 22-23. See also: Frank H. Winter, "The Silent Revolution: How R.H. Goddard Helped Start the Space Age," (paper presented at the 55th International Astronautical Federation Congress, Vancouver, BC, Canada, October 2004), 6, 50; Winter, *Rockets into Space*, 12-13.

technology in the United States, a thorough discussion of Tsiolkovskii's work falls outside of the scope of this project.[11]

While spaceflight in popular imaginings has been considered in Howard E. McCurdy's *Space and the American Imagination*, particularly its effects on specific individuals, public moods, and American popular culture,[12] in addition to touching on these subjects, I seek to establish the tangible effects of intangible ideas, charting out how inspiration gives way to purpose, and how individuals and organizations carried forward their influences to create the sources, contexts, and apparatuses that produced spaceflight. Connecting the direct and indirect impacts of imaginative works to their respective results, whether they are innovations, inspired engineers, or emerging ideas, is a major focus of this project.

It is important to remember, however, that technological development is generally nonlinear; there has been no straightforward nor inevitable progression in the development of space technology, and such progress is often subject to a variety of forces that may upend its progress at any moment.[13] As historians Alexander C.T. Geppert and Steven J. Dick have argued, reaching reality from imagination is not often a simple process, and care must be taken in making general assumptions about the depth of imagination's impact, as it often factors into a wider framework of influences, factors, and forces necessary to spaceflight.[14] Largely upholding McCurdy's argument

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[11] For more on Tsiolkovskii, and Russia and spaceflight, see: Asif A. Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957* (New York: Cambridge University Press, 2010); and James T. Andrews, *Red Cosmos: K.E. Tsiolkovskii, Grandfather of Soviet Rocketry* (College Station: Texas A&M University Press, 2009); Winter, *Prelude*, ch. 5.
[12] See, for example: McCurdy, *Space and the American Imagination*, chs. 1-3, 7, and the conclusion.
[13] David A. Kirby, *Lab Coats in Hollywood: Science, Scientists, and Cinema* (Cambridge, Massachusetts: The MIT Press, 2010), 195.
[14] Alexander C.T. Geppert, "European Astrofuturism, Cosmic Provincialism: Historicizing the Space Age," in *Imagining Outer Space: European Astroculture in the Twentieth Century*, 2nd ed., ed. Alexander C.T. Geppert (London, United Kingdom: Palgrave Macmillan, 2018), 16; Steven J. Dick, "Space, Time and Aliens: The Role of Imagination in Outer Space," in *Imagining Outer Space: European Astroculture in the Twentieth Century*, 2nd ed., ed. Alexander C.T. Geppert (London, United Kingdom: Palgrave Macmillan, 2018), 43-44.

that "[b]etween discovery and invention lay imagination," this thesis provides examples of imagination's direct and indirect impacts on spaceflight, and when it led to meaningful progress.[15]

SOURCES

I have relied on a number of books and articles—ranging from institutional histories, histories of technology, biographies, and autobiographies—and a number of works of secondary scholarship to consider the factors underlying technological progress and development, and public attitudes and cultural change. These works provide insight into the overall sweep of the history of spaceflight in the United States, which I have reframed to foreground how imagination, science fiction, and space popularization have factored into the development of space travel.

My primary sources include newspaper articles, letters, and diary entries, gathered in Clark University's Robert H. Goddard Papers that provide insight into his influences and intentions, as well as reactions to his work and experiments.[16] Additionally, I have consulted the memoirs and recollections of G. Edward Pendray, co-founder of the American Rocket Society, Frank J. Malina of the GALCIT research team, and aerodynamicist Theodore von Kármán who guided the GALCIT group during the 1930s across a handful of published works. I have sourced government documents and technological studies from the first volume of NASA's *Exploring the Unknown* series, and relied on the publications of spaceflight engineers, advocates, and popularizers to connect their ideas to a series of influences as well as to contextualize their effects. Moreover, for Chapter Three, I have analyzed a range of American space travel films from the 1950s and 1960s to demonstrate the ways in which space travel has been popularized and depicted in popular and imaginative visual media.

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[15] McCurdy, *Space and the American Imagination*, 310. Aldiss and Wingrove write that "Symbolism always precedes actuality, just as a belief in space travel preceded the space programmes. A concept must be visualized before it can be realized." See: Brian W. Aldiss and David Wingrove. *Trillion Year Spree: The History of Science Fiction* (New York: Atheneum, 1986), 221. Siddiqi has also argued that, in the Russian context, imagination and engineering were deeply interwoven, and both necessary to space exploration's realization. See: Siddiqi, *Red Rockets' Glare*, 8.

[16] These collections are readily available online: Clark University, Robert Hutchings Goddard Library, online document database, Robert H. Goddard Papers, https://database.goddard.microsearch.net/Home. Accessed July 28, 2020.

CHAPTER OUTLINES

This thesis runs mostly chronologically from the origins of American rocketry to the formation of NASA's first human spaceflight missions and Apollo 11 Moon landing. Chapter One investigates the foundations of American rocketry, examining how the technology was developed and improved, and who undertook these projects and for what purposes. This chapter looks at the first inspirations, work, and influence of American pioneer of astronautics, Robert H. Goddard; the work of the American Interplanetary Society (later the American Rocket Society), a group of science fiction fans who conducted amateur rocket experiments in the 1930s; the emergence of Reaction Motors Incorporated in 1941, a professional manufacturer of rocket motors that emerged out of the ranks of the ARS; and the efforts of the Guggenheim Aeronautical Laboratory, California Institute of Technology (GALCIT) rocket research team who from 1936 made fundamental strides in refining the practicality of rocket engine technology, leading to the formation of rocket motor manufacturing firm Aerojet, the Jet Propulsion Laboratory (JPL), and innovations important for later technological developments. The linkages between practical investigation and fantastical imagination are underscored in this chapter.

Chapter Two considers rocketry developments during World War II, in the postwar era, and during the Cold War. I examine the continued efforts of the JPL, the impact and effect of German rocket enthusiasm and German rocket engineers, who were brought to the United States after the Second World War, and the effects of popular media that flourished during the Space Age. This chapter argues that threads of imagination are discernable throughout most of the main rocket motors and technologies that made space travel possible. Although the role of imagination was sometimes limited next to the geopolitical tensions of the Cold War, military rationales, and wartime necessities, there were still significant examples of imagination's influence on the technologies, institutions, and individuals necessary to spaceflight.

Chapter Three focuses on spaceflight popularization, particularly as it was conducted in terms of paintings and motion pictures—what I call "imaginative visual media." This chapter builds on analyses of the space artwork of Chesley Bonestell and considers how advocates were promoting spaceflight to the American public in the 1950s–1960s, illustrating a visual parity in the aesthetic language of space travel films, the artwork of Bonestell, and paintings of the American frontier. I approach space travel film as a subgenre of science fiction cinema, emerging from and encapsulating the prevailing attitudes of space travel advocates, meant to introduce audiences to space travel and encourage them to support it. The ideas of early 20th century spaceflight enthusiasts remained compelling premises for the popular media of the 1950s and 1960s, and they were couched in frameworks and narratives that contextualized space travel as a project inherently compatible with American values and ideals. America's frontier myth, as this chapter argues, was extended in space travel films, and I analyze the promises made by these cinematic visualizations of a nearing future.

While Chapter One and Two demonstrate how imagination and rocketry provided possibilities, Chapter Three investigates how those possibilities were translated into promises and considers their impacts alongside the factors that gave rise to an American human spaceflight program. In the conclusion, I consider the impacts and limits of imagination, and argue that imagination was a necessary and important, even foundational, force that helped make space travel real.

Although it cannot be exhaustive, this project connects individuals, their inspirations, and sources of imagination to a history of cumulative, successive, and often iterative developments, both in technologies and ideas. From stories of moonshots by cannon and Martian invaders, to planetary landscape paintings and magazine articles describing space stations and lunar bases, imaginative, fictional, extrapolative, and popular expressions of space travel were necessary to its actualization. Realities were hidden between such cosmic fantasies, and they supplied, amidst dreams, possibility.

1. THE THREADS OF IMAGINATION (1899–1945)

There was a cherry tree near the barn at Maple Hill, in Worcester, Massachusetts, the family home of a teenager named Robert Hutchings Goddard. On a quiet Thursday afternoon, a little under two weeks after his seventeenth birthday, Goddard set a ladder against the tree and ascended, a saw and hatchet in hand to trim away the tree's dead branches. Just as he was about to begin, he paused to look out across the eastern fields beyond Maple Hill. The calm, warm afternoon seemed to hold only infinite promise. Perched atop the cherry tree, Goddard gazed out into this image of autumnal quietude, with the changing leaves of surrounding trees set against the azure ceiling of the sky. Then, he wondered at a thought: from the meadows below, a device ascending infinitely into the sky, beyond the atmosphere, and toward the heavens. Its destination, Goddard imagined, could be the mysterious crimson continents of Mars. He saw it clearly. The craft of his mind's eye went up and disappeared behind the clouds, but its image lingered, as it would for the rest of his life.[17]

The day of these revelations, 19 October 1899, Goddard thereafter dubbed "Anniversary Day,"[18] a critical turning point in the life of the man who would one day be conferred titles such as the "father of modern rocket propulsion,"[19] the "father of American Rocketry", or the more opulent moniker, "Father of the Space Age,"[20] among others.[21] When Goddard recalled this experience some

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[17] The account in this paragraph has drawn on: Robert H. Goddard, "1927 and 1933: Material for an Autobiography," in *The Papers of Robert H. Goddard, Volume I: 1898-1924*, eds. Esther C. Goddard and G. Edward Pendray (New York: McGraw-Hill Book Company, 1970), 7-9; Robert H. Goddard, "Diary – 1899 – Handwritten," diary entry, October 19, 1899, Robert H. Goddard Papers, Robert Hutchings Goddard Library, Clark University, Worcester Massachusetts, accessed July 28, 2020, https://database.goddard.microsearch.net/Home; Esther C. Goddard and G. Edward Pendray, eds. *The Papers of Robert H. Goddard, Volume I: 1898-1924* (New York: McGraw-Hill Book Company, 1970), 52n; Clary, *Rocket Man*, 13-14.

[18] Clary, *Rocket Man*, xix, 14; Goddard, "Material for an Autobiography," 9n.

[19] Eugene M. Emme, "Yesterday's Dream … Today's Reality: A Biographical Sketch of the American Rocket Pioneer, Dr. Robert H. Goddard," *The Air Power Historian* 7, no. 4 (October 1960): 217.

[20] Frank H. Winter, "Did the Germans learn from Goddard? An examination of whether the rocketry of R.H. Goddard influenced German Pre-World War II missile development," *Acta Astronautica* 127 (October–November 2016): 515; J.D. Hunley, "The Enigma of Robert H. Goddard," *Technology and Culture* 36, no. 2 (April 1995): 327.

[21] Clary, *Rocket Man*, 45, 253.

28 years later, he declared that "I was a different boy when I descended the tree from when I ascended, for existence at last seemed very purposive."[22]

Significantly, Goddard's vision of a device which might possess, as he put it, "even the *possibility* of ascending to Mars," came to him after reading science fiction.[23] He was inspired first by a serialized adaptation of H.G. Wells' *The War of the Worlds*, appearing in the *Boston Post* in January 1898 as *Fighters from Mars, or the War of the Worlds, in and near Boston*, and subsequently by its commissioned sequel *Edison's Conquest of Mars* written by astronomer Garrett P. Serviss.[24] Impressed by their realism, these tales, Goddard would write later, "gripped my imagination tremendously. Wells's wonderfully true psychology made the thing very vivid, and possible ways and means of accomplishing the physical marvels set forth kept me busy thinking."[25] By believing, as historian John Cheng has put it, that "possibility's purpose was its eventual realization," Goddard would offer a lifetime to realize those visions that stimulated his imagination, becoming an agent of the spaceflight vision as he sought a way to make his dreams real.[26]

But before flight into space could be achieved, a means of getting there needed to be developed, and it is that development that I address in this chapter. This chapter will show how many early rocket technologies in the United States traced their development back to the dream of spaceflight as furnished by imaginative works. However, despite science fiction's influence in stimulating these first efforts, by World War II, the dream had been overridden by the demands of

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[22] Goddard, "Material for an Autobiography," 9.
[23] Goddard, "Material for an Autobiography," 9.
[24] Sam Moskowitz, "Introduction: A History of Science Fiction in the Popular Magazines, 1891-1911," in *Science Fiction by Gaslight: A History and Anthology of Science Fiction in the Popular Magazines, 1891-1911*, ed. Sam Moskowitz (Cleveland and New York: The World Publishing Company, 1968), 28; John Cheng, *Astounding Wonder: Imagining Science and Science Fiction in Interwar America* (Philadelphia: University of Pennsylvania Press, 2012), 1; Alexander MacDonald, *The Long Space Age: The Economic Origins of Space Exploration from Colonial America to the Cold War* (New Haven & London: Yale University Press, 2017), 106-107.
[25] Goddard, "Material for an Autobiography," 7; see also MacDonald, *The Long Space Age*, 106-107.
[26] Cheng, *Astounding Wonder,* 1; Clary, *Rocket Man*, 15.

warfare, as rockets were increasingly developed as implements of combat and defense.[27] By the late 1930s, enthusiasm alone could not sustain rocket technology on a scale necessary to realize it as adherents of the spaceflight dream had envisioned. The dream of space travel nonetheless remained a key driver of American rocketry, as space travel enthusiasm undergirded many of the foundational efforts underlying basic rocket development. Such enthusiasm and motivation, derived as they were from a number of imaginative and inspirational works, preceded military demand and persisted even as wartime needs superseded interplanetary ambitions. These ambitions burned brightly for many, as they did for Robert Goddard.

ROBERT H. GODDARD'S ROCKET DREAMS

After his descent from the cherry tree, Goddard's first course of action was to see if it was possible to design the things his mind so vividly envisioned.[28] Experimenting fruitlessly with wooden models in 1899, Goddard decided that it was "a knowledge of physics and mathematics," as he later wrote, that would enable him to discover a means of navigating space, and so enrolled in Worcester's new South High School in 1901.[29] From 1901 to 1904, Goddard meditated on a variety of topics, including spaceflight.[30] In 1901, for example, he wrote an essay entitled "The Navigation of Space," which he sent to *Popular Science News* in an effort to have it published.[31] Further, he considered various means of propulsion for attaining flight into space, including gyroscopes and a sort of machine gun device whose recoil action would generate lift.[32] By 1904, not two months after

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[27] Williamson and Launius have written that: "by the beginning of World War II much of the [rocket] technology was developed by government organizations as potential weapons." Ray A. Williamson and Roger D. Launius, "Rocketry and the Origins of Space Flight," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 33, see also 42.
[28] Clary, *Rocket Man*, 15.
[29] Goddard, "Material for an Autobiography, 9-10, quote from 10; Clary, *Rocket Man*, 16-17; Hunley, "The Enigma of Robert H. Goddard," 333.
[30] Clary, *Rocket Man*, 16-17.
[31] Goddard, "Material for an Autobiography," 10. The article was not accepted. See: *Popular Science News* to R.H. Goddard, Worcester, January 2–4, 1902, in *The Papers of Robert H. Goddard, Volume I: 1898-1924*, 58.
[32] Clary, *Rocket Man*, 17-18; Goddard, "Material for an Autobiography," 11; Winter, *Rockets into Space*, 14.

deciding spaceflight was impossible, he was writing complete and meticulous "suggestions" on the possibilities of space travel in a series of notebooks.[33] "The dream," Goddard reflected later, "would not 'down'."[34] All the while, he ensured that Anniversary Day was observed regularly. His diary shows that he made the journey up the cherry tree every October 19th from 1901 to 1903 at least.[35]

His spaceflight dream persisted and matured as he obtained his Bachelor of Science Degree from Worcester Polytechnic Institute (WPI) in 1908, and his Master of Arts and Doctorate of Philosophy in Physics simultaneously from Clark University in 1910-1911.[36] In 1907, for example, he wrote for an English class a paper entitled "On the Possibility of Navigating Interplanetary Space," in which Goddard delineated various aspects of travelling and surviving in space.[37] From 1908 on, he was reaching beyond mere speculation and seeking a viable and practical means of getting into space, beginning with serious contemplation over use of a reaction engine—a rocket—by 1909.[38] On 9 February, he undertook his first experiments with a "deflagrating substance" to these ends,[39] and kept the fires of inspiration ablaze as he reread *The War of the Worlds* later that month.[40]

Goddard's dreams were to find significant expression in his pursuits of the late 1910s and the following decade. By 1913 he was on to working out the mathematical basis for rocket flight in his spare time and began making patent applications for his designs, which were issued in 1914.[41] Conducting more serious experiments by 1915, Goddard demonstrated that a rocket could provide

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[33] Goddard, "Material for an Autobiography," 11, 13; Clary, *Rocket Man*, 19.
[34] Goddard, "Material for an Autobiography," 11.
[35] Goddard, "Diary — 1900; 1901; 1902; 1903 — Handwritten," diary entries, October 19, 1900; October 19, 1901; October 19, 1902; October 19, 1903); Hunley, "The Enigma of Robert H. Goddard," 333.
[36] Clary, *Rocket Man*, 24, 27; Crouch, *Aiming for the Stars*, 32.
[37] Clary, *Rocket Man*, 27; Crouch, *Aiming for the Stars*, 32.
[38] Goddard, "Material for an Autobiography," 13-14; Clary, *Rocket Man*, 23, 28; Hunley, "The Enigma of Robert H. Goddard," 335-336; Crouch, *Aiming for the Stars*, 32; Michael J. Neufeld, *Spaceflight: A Concise History* (Cambridge, Massachusetts: The MIT Press, 2018), 7; Winter, *Rockets into Space*, 16, 18.
[39] Goddard, "Diary — 1909 — Handwritten," diary entry, February 9, 1909; J.D. Hunley, *The Development of Propulsion Technology for U.S. Space-Launch Vehicles, 1926-1991* (College Station: Texas A&M University Press, 2007), 9 (hereafter cited as Hunley, *Propulsion Technology*); Winter, *Rockets into Space*, 18.
[40] Goddard, "Diary — 1909 — Handwritten," diary entry, February 24, 1909.
[41] Clary, *Rocket Man*, 38-39, 44-45; Winter, "The Silent Revolution," 4n4.

thrust in a vacuum, one of the single most important discoveries in rocketry, for it addressed the misconception that such a thing was impossible and proved that the rocket was a possible means of space travel, thereby introducing the world to the idea of the "space rocket."[42] During this time, he also read H.G. Wells' *The First Men in the Moon* (1901),[43] and Jules Verne's *De la Terra à la Lune*,[44] perhaps to continuously stoke the fires of inspiration, as his labours were sustained by these potent sources of inspiration.

Goddard found, however, that his work was subject to not only the technical realities of actualization, but also financial ones. Despite working as a salaried assistant professor at Clark by 1915, Goddard sought more funds for his rocket labours, and wrote to the Smithsonian Institution in 1916 with a proposal to develop an apparatus designed to reach high altitudes.[45] Satisfied by the premise of his work, the Institution offered him $5000 in 1917, to be doled out in instalments, to finance the construction of his rocket apparatus.[46] His work continued but ultimately bore little fruit.[47] Following an interlude of well-funded rocketry work for the United States military during World War I, building small single-charge rockets to be used as projectiles,[48] Goddard was urged on by Dr. Arthur Gordon Webster of Clark University to publish on his rocket work.[49] Goddard acquiesced, and in 1919 submitted to the Smithsonian a paper which contained the results of his

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[42] Goddard, "Material for an Autobiography," 22; Winter, "Did the Germans learn from Goddard?," 514; Clary, *Rocket Man*, 49-57, esp. 53-54; Mike Gruntman, *Blazing the Trail: The Early History of Spacecraft and Rocketry* (Reston, Virginia: American Institute of Aeronautics and Astronautics, 2004), 115-116; Hunley, "The Enigma of Robert H. Goddard," 336-337; Neufeld, *Spaceflight*, 8; Frank H. Winter, *The First Golden Age of Rocketry: Congreve and Hale Rockets of the Nineteenth Century* (Washington and London: Smithsonian Institution Press, 1990), 253; Winter, "The Silent Revolution," 1, 48; Cheng, *Astounding Wonder*, 263.

[43] Clary, *Rocket Man*, 56.

[44] Goddard, "Diary — 1916 — Handwritten," diary entry, August 16, 1916; see also Goddard, "Diary — 1916 — Handwritten," (diary entry, January 22, 1916).

[45] Clary, *Rocket Man*, 59-60; Hunley, *Propulsion Technology*, 9; Winter, *Rockets into Space*, 28.

[46] Clary, *Rocket Man*, 61-62; Hunley, "The Enigma of Robert H. Goddard," 337; Neufeld, *Spaceflight*, 8; Goddard, "Material for an Autobiography," 22-23; Hunley, *Propulsion Technology,* 9.

[47] Clary, *Rocket Man*, 64-65.

[48] Goddard, "Material for an Autobiography," 23; Clary, *Rocket Man*, 65-79, especially 74-78; Neufeld, *Spaceflight*, 8; Gruntman, *Blazing the Trail*, 117.

[49] Hunley, "The Enigma of Robert H. Goddard," 334, 338.

work over the years entitled "A Method of Reaching Extreme Altitudes," which appeared in the *Smithsonian Miscellaneous Collections* in January 1920 and included his proof regarding rockets operating in a vacuum.[50] A foundational contribution to a nascent field, it was also, for the present, a piece garnering great popular attention.[51]

After the Smithsonian's press release on the paper, the intense media reaction to what was largely a dry technical disquisition of rocketry transformed Goddard into something of an unwitting spaceflight popularizer in 1920.[52] A section of his paper entitled "CALCULATION OF MINIMUM MASS REQUIRED TO RAISE ONE POUND TO AN 'INFINITE' ALTITUDE" considered the possibility of an unmanned rocket ascending beyond the Earth's atmosphere and continuing to an "infinite distance."[53] To prove that it had, Goddard suggested that the rocket might carry an amount of flash powder up to the Moon, whereupon it would be ignited so that watchers on Earth might be able to observe it and therefore mark its ascent as successful.[54] Goddard even went so far as to determine the amounts of flash powder necessary as well as the best kind.[55] The press reacted almost immediately. Numerous stories appeared on 12 January 1920, all with headlines claiming that a professor was building a rocket to shoot to the Moon.[56] Afterwards, a statement from Goddard

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[50] Clary, *Rocket Man*, 88; Hunley, "The Enigma of Robert H. Goddard, 338.
[51] Clary, *Rocket Man*, 88-91; Hunley, "The Enigma of Robert H. Goddard," 338; Crouch, *Aiming for the Stars*, 31; Winter, "Did the Germans learn from Goddard?," 514; Neufeld, *Spaceflight*, 10; Winter, "The Silent Revolution," 7.
[52] Clary, *Rocket Man*, 90; Emme, "A Biographical Sketch," 219; Winter, *Rockets into Space*, 29; Neufeld, *Spaceflight*, 10.
[53] Robert H. Goddard, "A Method of Reaching Extreme Altitudes," *Smithsonian Miscellaneous Collections* 71, no. 2 (January 1920): 54. Reprinted as a facsimile in Robert H. Goddard, *Rockets* (New York: Dover Publications, Inc., 2002), unabridged republication of work originally published in 1946 by the American Rocket Society, New York. Page references are to the 1920 publication.
[54] Goddard, "A Method of Reaching Extreme Altitudes," 54-57. In fact, Goddard had written that these speculations were written in the place of a more pointed investigation of interplanetary travel, "in order to avoid the appearance of too much speculation," as he wrote years later. See Goddard, "Material for an Autobiography," 22.
[55] Goddard, "A Method of Reaching Extreme Altitudes," 56-57.
[56] See, for example: "Aim to Reach Moon with New Rocket," *The New York Times*, January 12, 1920; "Science to Try Shooting Moon with a Rocket," *Chicago Tribune*, January 12, 1920; "New Rocket Devised by Prof. Goddard May Hit Face of the Moon," *Boston Herald*, January 12, 1920. All newspaper stories hereafter cited in this chapter, unless otherwise noted, are from scans found in the Robert Hutchings Goddard Library, Online Document Database, Robert H. Goddard Papers, Newsclippings, https://database.goddard.microsearch.net/Contents. See also: Clary, *Rocket Man*, 91; Winter "The Silent Revolution," 8.

appeared in a number of papers a week later, where he emphasized that "too much attention has been concentrated on the proposed flash powder experiment, and too little on the exploration of the atmosphere."[57] Atmospheric exploration, he explained, needed to be carried out first before "[w]hatever interesting possibilities there may be of the method that has been proposed … could be undertaken."[58] Then speculating on the possibilities of taking photographs in space, his statement ended with the suggestion that a sum ranging from $50,000 to $100,000 raised by "popular subscription" could prove useful to his work.[59]

What happened here was twofold: Goddard unintentionally popularized the notion of spaceflight; and the media reaction and popular response indicated a level of general enthusiasm over it.[60] The vivid reaction to the professor's mere suggestion that a rocket could theoretically reach the Moon saw numerous people volunteering to undertake a trip to the Moon or even Mars, indicating not only enthusiasm for interplanetary flight but the profound influence of news of Goddard's work on the public, even if the press overexaggerated the spaceflight aims of the professor.[61] Goddard's purposes were not, perhaps, to widely disseminate the idea of interplanetary travel—and indeed he may not have published anything at all but for Webster's urging him along in 1919—but rather to contribute his knowledge to an emerging field and emphasize that such technology, and its wider applications, were all practical and feasible. Proving this feasibility,

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[57] "Cannot Hit Moon with Rocket Yet," *Boston Post*, January 19, 1920; "Goddard Rockets to Take Pictures," *The New York Times*, January 19, 1920; "Photographing in Space by Use of Rocket Suggested in Latest Word of Dr. Goddard," *New York Herald*, January 19, 1920; see also Clary, *Rocket Man*, 92.
[58] "Cannot Hit Moon with Rocket Yet," *Boston Post*, January 19, 1920; "Goddard Rockets to Take Pictures," *New York Times*.
[59] "Cannot Hit Moon with Rocket Yet," *Boston Post*, January 19, 1920; "Goddard Rockets to Take Pictures," *New York Times*; "Photographing in Space by Use of Rocket Suggested in Latest Word of Dr. Goddard," *New York Herald*, January 19, 1920.
[60] Cheng, *Astounding Wonder*, 253-254.
[61] Clary, *Rocket Man*, 91; Cheng, *Astounding Wonder*, 2, 253-254; Winter, *Rockets into Space*, 29; Winter, "The Silent Revolution," 15-17; "Proposes to Leap to Mars," *Boston Herald*, February 5, 1920; "Four Seek Trip to Mars," *The New York Times*, February 9, 1920; "That Flight to Planet Mars," *Spokane Spokesman Review*, February 29, 1920.

however, created a short but considerable flurry of interest that would have long-term ramifications, including helping to reinforce the idea of space rockets at home and abroad.[62]

Goddard, of course, was not averse to popularizing his work, and he did so by speaking to newspapers to drum up support and funding for his efforts, and in the early 1920s, he travelled to New England, New York, Chicago, and Washington, giving talks on his experiments and the potential applications of rocketry.[63] Vying for popular and financial support, Goddard essentially acted as publicist and popularizer to fulfill his own ambitions. These ambitions were the sole products of the spaceflight vision—inspiration from science fiction. That Goddard would later write to H.G. Wells in 1932 to express his appreciation for the author's work, emphasizing the "deep impression" it had left on him, underscored the profound and continuing effect of his influences.[64]

From inspiration came motivation; a motivation that produced ideas that spread into the public's consciousness. Goddard had demonstrated the feasibility of a rocket by backing it up with experimental data, showing for the first time that a rocket could work in a vacuum, and thereby proving that spaceflight rockets were possible.[65] Space historian Frank H. Winter has even considered this experiment "the true inception of the Space Age, West or East."[66] Despite skepticism and some erroneous criticism surrounding Goddard's publication (an oft-cited example is *The New York Times* claiming in 1920 that a rocket could *not* provide thrust in a vacuum, for it would

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[62] Winter, "The Silent Revolution," 20-23, 42-48. Winter has also outlined that "A Method" may have affected French spaceflight pioneer Robert Esnault-Pelterie and his conceptions of spaceflight, which were then expounded upon in his own work, thereby "extending" Goddard's influence. Winter, "The Silent Revolution," 29.
[63] Clary, *Rocket Man*, 82-83.
[64] Robert H. Goddard to H.G Wells, April 20, 1932, in *The Papers of Robert H. Goddard, Volume II: 1925-1937*, eds. Esther C. Goddard and G. Edward Pendray (New York: McGraw-Hill Book Company, 1970), 821, 823.
[65] Clary, *Rocket Man*, 54, 88, 256; Winter, "Did the Germans learn from Goddard?" 514, 520-521; Crouch, *Aiming for the Stars*, 35; Winter, *Rockets into Space*, 28-29; Winter, *The First Golden Age of Rocketry*, 253; Winter, "The Silent Revolution," 8, 48. See also a condensed version a "A Method" that explains the vacuum chamber experiments: Robert H. Goddard, "A Method of Reaching Extreme Altitudes," *Nature* 105, no. 2625 (August 26, 1920): 810-811.
[66] Winter, "The Silent Revolution," 48.

have nothing to react against),[67] Goddard's paper "gave new public credibility to spaceflight and to rocketry as a way to get there."[68] Despite the sensationalism, the feasibility of using rocket propulsion to reach high altitudes and even achieve spaceflight meant interplanetary travel would not be forever imprisoned in the realm of science fiction, but had a chance of becoming a reality.

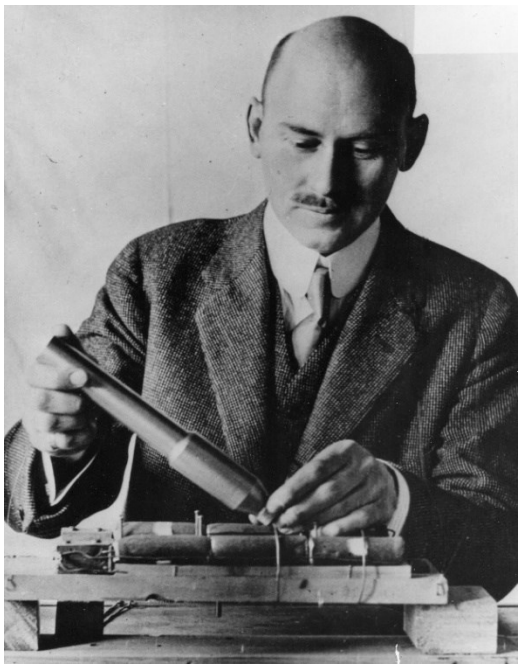

Figure 1. Dr. Robert H. Goddard. Courtesy, NASA, NASA ID: GSFC_20171208_Archive_e002214.

More than just a herald or foreseer of astronautics, Goddard was also one of its earliest experimenters. He went on to launch the world's first liquid-fuel rocket, with the help of instrument maker Henry Sachs and Clark University student Percy M. Roope, on 16 March 1926 at the farm of 'Aunt' Effie Ward in Auburn, Massachusetts, but he kept the details of this flight quiet until 1936, and even then, he offered little in the way of useful technical information in the paper that covered its flight.[69] A rocket crash on 17 July 1929 stirred up rocket publicity again and saw Goddard's Moon rocket celebrity stick, and also attracted the attention of a serious patron, famous aviator Charles A. Lindbergh.[70] With the help of Lindbergh, a true believer in Goddard's work and a close friend of Harry Guggenheim, scion of the wealthy Guggenheim family, the rocket professor

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[67] "His Plan Is Not Original," *The New York Times*, January 18, 1920; also referenced in: Clary, *Rocket Man*, 97; Neufeld, *Spaceflight*, 10; Hunley, "The Enigma of Robert H. Goddard," 339; McCurdy, *Space and the American Imagination*, 20; Winter, "The Silent Revolution," 9.

[68] Neufeld, *Spaceflight*, 10.

[69] Goddard, "Material for an Autobiography," 27n, 30; Clary, *Rocket Man*, 118, 120-122, 180-181, 256, 259-260; Hunley, "The Enigma of Robert H. Goddard," 339-340, 343; Winter, *Rockets into Space*, 31; Hunley, *Propulsion Technology*, 10. See also Goddard's account of the flight, written as a memorandum in his diary the day after: Goddard, "Diary — 1926 — Handwritten," diary entry, memorandum, March 17, 1926.

[70] Clary, *Rocket Man*, 133-136, 140-142; Goddard, "Material for an Autobiography," 32; Crouch, *Aiming for the Stars*, 40-41; Neufeld, *Spaceflight*, 12; Winter, *Rockets into Space*, 33; T.A. Heppenheimer, *Countdown: A History of Space Flight* (New York: John Wiley & Sons, Inc., 1997), 31.

received considerable funding from the Guggenheims ($100,000 over four years)[71] whose interests already revolved around fostering progress in aviation and pushing the technology forward.[72] The Guggenheims had already established the Daniel and Florence Guggenheim Fund for the Promotion of Aeronautics to support institutions like the Massachusetts Institute of Technology (MIT) and the California Institute of Technology (Caltech), so while the Guggenheims may not have been as enamored with the promises of Moon rockets as was Lindbergh, they were still interested in advancing education and technology wherever possible, much to the advantage of Goddard's rocket ambitions.[73]

With these funds, the Goddards and their small rocket team relocated to Roswell, New Mexico in 1930 where the rocket work continued but for a brief hiatus from 1932-1934.[74] The Goddards then relocated again to Annapolis, Maryland in 1942 after the professor, in search of funding, made proposals to the Navy and Army Air Forces (AAF) to develop Jet Assisted Take-Off (JATO) units as the American entry into World War II had encouraged more focused investigation into rocket technology in the United States.[75] When Goddard started work for the Navy, the spaceflight dream was consumed by perfecting the technology and by the demands of warfare.[76] His rocket work there was to help improve combat aircraft, not produce spaceflight, and was much divorced from his original ambitions conjured up by the "spell" cast by Wells' writing.[77]

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[71] Goddard was the best-funded scientist of his time. See Clary, *Rocket Man*, 198 and Neufeld, *Spaceflight*, 16.
[72] Clary, *Rocket Man*, 138-139, 142-145; Winter, *Prelude*, 102.
[73] Clary, *Rocket Man*, 138-139, 142; Winter, *Prelude*, 102; Roger E. Bilstein, *Testing Aircraft, Exploring Space: an illustrated history of NACA and NASA* (Baltimore & London: The John Hopkins University Press, 2003), 7-8; Theodore von Kármán with Lee Edson, *The Wind and Beyond: Theodore von Kármán*, *Pioneer in Aviation and Pathfinder in Space* (Boston and Toronto: Little, Brown and Company, Inc., 1967), 120.
[74] Clary, *Rocket Man*, 145, 148, 162-164; Neufeld, *Spaceflight*, 16.
[75] Clary, *Rocket Man*, 200-203, 205-209. See also: Heppenheimer, *Countdown*, 36; Bilstein, *Testing Aircraft*, 31, 34-35, 39-40.
[76] Clary writes that by this point, Goddard was producing fewer fresh ideas. Clary, *Rocket Man*, 214; Winter, *Prelude*, 114.
[77] Clary, *Rocket Man*, 209-220; Robert H. Goddard to H.G Wells, April 20, 1932, in *Papers of RHG, Vol. II*, 823.

Goddard's work continued until his death, and despite his considerable achievements, his influence on the technology remained slim.[78] As one of rocketry's earliest experimenters, however, he had anticipated a great deal of what was to come and helped spread the notion of space rockets alongside other pioneers of spaceflight, so that the idea became woven into the fabric of the public consciousness and gradually ingrained into popular culture.[79] A testament to his prescience, his many innovations were ultimately reproduced or rediscovered independently of his influence, but his unsystematic approaches to rocket development prevented him realizing his vision singlehandedly.[80] However, his most important contributions—his vision of a space rocket, his proof that a rocket could work in a vacuum, and his inspirational legacy—remained potent.[81] There were others engaged in the work of Goddard's dreams at the same time and would be in some ways indebted to his visions. These American rocket enthusiasts, to which we now turn, drew on sources of imagination similar to those that had inspired Goddard as they strove to set the foundations for future space travel. Such was the case for the American Interplanetary Society (AIS), a group of science fiction fans who set out make reality out of their dreams.

AMERICAN ENTHUSIASTS

On balance, American rocket and spaceflight enthusiasm centered first and foremost around science fiction. The AIS was formed on 4 April 1930 in the apartment belonging to *New York Herald Tribune* reporter and science fiction author G. Edward Pendray, and his wife, Leatrice May

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[78] Hunley, "The Enigma of Robert H. Goddard," 343-345, 350; Winter, *Rockets into Space*, 60; Winter, *Prelude*, 14; Hunley, *Propulsion Technology*, 8.
[79] Clary, *Rocket Man*, 257; Hunley, *Propulsion Technology*, 8; Neufeld, *Spaceflight*, 17; Winter, "The Silent Revolution," 14-17, 20-23, 33-48.
[80] Clayton R. Koppes, *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (New Haven and London: Yale University Press, 1982), 10; Frank J. Malina, "On the GALCIT Rocket Research Project, 1936-1938," in *First Steps Toward Space: Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968*, eds. Frederick C. Durant III and George S. James (City of Washington: Smithsonian Institution Press, 1974), 117 (hereafter cited as Malina, "Rocket Research Project"); Hunley, "The Enigma of Robert H. Goddard," 344-345, 347; Hunley, *Propulsion Technology*, 8.
[81] Neufeld writes that Goddard's "greatest impact would always be inspiring others to believe in rockets as the way to spaceflight." Neufeld, *Spaceflight*, 17.

Gregory.[82] Nine of the twelve founding members of the AIS were contributors to Hugo Gernsback's pulp science fiction magazine of 1929, *Science Wonder Stories*; and the remaining three, according to Winter, were most likely still science fiction aficionados.[83] Gernsback, who had put together the world's first science fiction magazine, *Amazing Stories*, in 1926, frequently featured space travel tales among his other 'scientifiction' tales.[84] Moreover, Gernsback explained in a 1927 issue of *Amazing Stories* that Goddard's rocket apparatuses pointed the way to space travel and in 1929 published a translation of spaceflight prophet Hermann Noordung's (a pseudonym for Austro-Hungarian military officer Herman Potočnik) treatment of space travel, *Das Problem der Befahrung des Weltraums* (*The Problem of Space Navigation*) (1929), in three parts in *Science Wonder Stories*.[85] Gernsback sought not only to promote space travel,[86] but also to inspire and educate his readers, facilitating their entry into technical professions and make reality of what was then only fantasy.[87] As Mike Ashley has written, of Gernsback's earlier science fiction magazines, "Gernsback wanted fiction that instructed and inspired. The inspiration was intended to make the reader creative or inventive."[88] In the very first issue of *Amazing*, Gernsback wrote that the tales within the magazine were not only "interesting reading" but also instructive insofar as they "supply knowledge that we might not

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[82] Winter, *Prelude*, 73; McCurdy, *Space and the American Imagination*, 26

[83] Winter, *Prelude*, 24, 73, see especially 73 for a list of the founding members; Cheng, *Astounding Wonder*, 17; McCurdy, *Space and the American Imagination*, 26-27.

[84] Winter, *Prelude*, 24; Cheng, *Astounding Wonder*, 17-18; Crouch, *Aiming for the Stars*, 59-60; McCurdy, *Space and the American Imagination*, 26-27, 35.

[85] Bainbridge, *Dimensions*, 57; Neufeld, *Von Braun*, 41; Clary, *Rocket Man*, 126. See also: Crouch, *Aiming for the Stars*, 48; Chris Gainor, *To a Distant Day: The Rocket Pioneers* (Lincoln and London: University of Nebraska Press, 2008), 59. These issues are also available online. Hugo Gernsback, "Interplanetary Travel," *Amazing Stories*, February 1927, 981, accessed September 28, 2021, https://archive.org/details/Amazing_Stories_v01n11_1927-02_krissburg_Missing_ibc. On Noordung, see: Hermann Noordung, "The Problems of Space Flying (Part I)", trans. Francis M. Currier, *Science Wonder Stories*, July 1929, 170-180, https://archive.org/details/Science_Wonder_Stories_v01n02_1929-07.Stellar_unknown-DPP/; Hermann Noordung, "The Problems of Space Flying (Part II)", trans. Francis M. Currier, *Science Wonder Stories*, August 1929, 265-272, https://archive.org/details/Science_Wonder_Stories_v01n03_1929-08.Stellar/; Hermann Noordung, "The Problems of Space Flying (Part III), trans. Francis M. Currier, *Science Wonder Stories*, September 1929, 361-368, https://archive.org/details/Science_Wonder_Stories_v01n04_1929-09.Stellar/. All accessed October 14, 2020.

[86] Bainbridge, *Dimensions of Science Fiction*, 57.

[87] William Sims Bainbridge, *The Meaning and Value of Spaceflight: Public Perceptions*, (Cham: Springer, 2015), 155.

[88] Mike Ashley, *The Time Machines: The Story of the Science-Fiction Pulp Magazines from the Beginning to 1950* (Liverpool: Liverpool University Press, 2000), 230-231.

otherwise obtain."[89] Although Gernsback was also focused on selling magazines,[90] and the magazines at times abandoned instructive fiction for the escapist variant,[91] the establishment of the AIS suggests that Gernsback's endeavours to inspire others to be inventive was successful, especially where space travel was concerned. Science fiction stories in the pulps had covered everything from dimensional travel to ray guns, extraterrestrial worlds to robots,[92] and yet what emerged was a society organized around the theme of interplanetary travel—spaceflight. The founding members of the AIS were united by their common interest in this theme and the primary desire to see if fiction could be translated into reality,[93] perhaps taking to heart *Amazing*'s motto: "Extravagant Fiction Today…Cold Fact Tomorrow."[94] The formation of the AIS indicated the power of imaginative works in inspiring action and how effectively ideas may be carried and spread by popular works, fictional or otherwise.

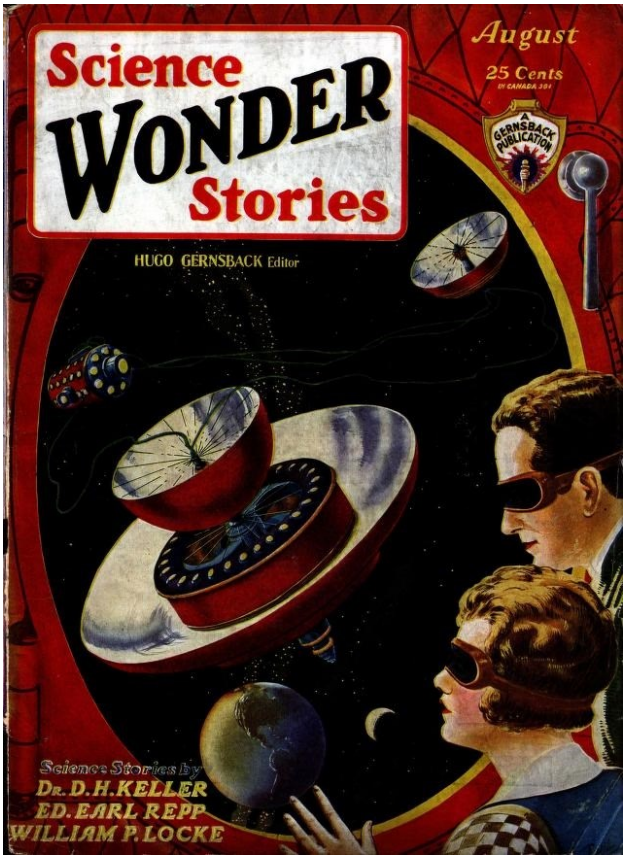

Figure 2. Illustrator Frank R. Paul's cover for the August 1929 issue of Science Wonder Stories, featuring Noordung's space station. Frank R. Paul, cover illustration, Science Wonder Stories, August 1929, ed. Hugo Gernsback.

From the onset, the AIS campaigned to popularize and encourage support for their spaceflight visions, to entreat others to join the cause, and to generate an expectation for the advent

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[89] Hugo Gernsback and T. O'Conor Sloane, eds., *Amazing Stories*, April 1926, 3, accessed April 20, 2021, https://archive.org/details/AmazingStoriesVolume01Number01.
[90] Cheng, *Astounding Wonder*, 35.
[91] Ashley, *The Time Machines*, 50-51.
[92] Cheng, *Astounding Wonder*, 81.
[93] Winter, *Prelude*, 73.
[94] Gernsback and Sloane, *Amazing Stories*, 3.

of spaceflight.[95] Among their first efforts was a mimeographed newsletter, *The Bulletin of The American Interplanetary Society*, which appeared in June 1930.[96] The first issue's introduction outlined how the AIS's "principal aims" included "the promotion of interest in interplanetary exploration and travel, and the mutual enlightenment of its members concerning the problems involved."[97] The *Bulletin*, as part of this effort, regularly surveyed information and published material dealing with spaceflight, including speculative articles, and information on European experiments as well as developments in the United States, like the work of Robert Goddard.[98] According to Winter, "[Goddard's] name became the most often cited in *The Bulletin* and its successors, *The Journal of the American Rocket Society*, and *Astronautics*."[99] Despite Goddard's unwillingness to engage with the society on a meaningful level no matter the attempts to win his involvement,[100] his efforts comprised an important influence on the society. By 1930, his experiments would have been well-known, especially after the Moon rocket sensationalism of 1920 and its follow-up in 1929, and these, combined with knowledge of European experiments, may have signalled to the members of the AIS that the contents of Gernsback's pulps and their interplanetary tales might become real if a concerted effort to realize spaceflight were made. The Society, as Pendray would write in 1963, "was born in that wave of Goddard-engendered enthusiasm."[101] Moreover, Winter has found that on account of works such as Goddard's "A Method", Oberth's 1923 treatise on spaceflight *Die Rakete zu den Planetenräumen* (*The Rocket into Interplanetary Space*), and other popular works concerning space travel, "space fiction" stories

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95 Winter, *Prelude*, 14-15.
96 Winter, *Prelude*, 74.
97 C.W. Van Devander, ed., *Bulletin: The American Interplanetary Society*, no. 1 (June 1930): 1, image reproduction of the *Bulletin's* first page in Frank H. Winter, "Planning for Spaceflight: 1880s to 1930s," in *Blueprint for Space: Science Fiction to Science Fact*, eds. Frederick I. Ordway III and Randy Liebermann (Washington and London: Smithsonian Institution Press, 1992), 111. Also cited by McCurdy, *Space and the American Imagination*, 37.
98 Winter, *Prelude*, 74.
99 Winter, *Prelude*, 74.
100 Winter, *Prelude,* 14-15, 74-75; Cheng, *Astounding Wonder*, 257; Clary, *Rocket Man*, 177.
101 G. Edward Pendray, "Pioneer Rocket Development in the United States," *Technology and Culture* 4, no. 4 (Autumn 1963): 388.

thereafter featured rockets more prominently as a means of space travel than it had before 1920, where only five such stories with reaction propulsion as a principal means of travel existed.[102] The application of a rocket to space travel was a key contribution of the pioneers like Goddard,[103] and it was this that AIS co-founder and *Science Wonder Stories* editor David Lasser responded to most strongly.[104] Inspired by these tales and the possibilities proffered by the pioneers, the AIS was encouraged to popularize spaceflight to foster an astronautical movement in the United States, thereby building upon dreams and providing new ones for others.

The AIS campaigned for space travel in the 1930s in various ways. Beyond asking Goddard to support the AIS, the society sent out cards to various universities and institutions, offering subscriptions to the *Bulletin* along with invitations to inquire about becoming a member, which attracted some modest interest.[105] Additionally, the Society held bimonthly meetings and lectures at the American Museum of Natural History, and kept in touch with spaceflight popularizer Willy Ley of the German spaceflight group, Verein für Raumschiffahrt (VfR), established in 1927, who informed them of their efforts and the establishment of the Raketenflugplatz, a proving ground for testing and flying the VfR's rockets.[106] One of the AIS's meetings scheduled for 28 January 1931 also raised more general interest for it was to be attended by France's spaceflight prophet Robert Esnault-Pelterie, and feature the first American showing of the German, UFA-produced motion picture *Frau im Mond* (dir. Fritz Lang, 1929), the first realistic depiction of spaceflight on film.[107] The

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[102] Winter, "The Silent Revolution," 42-47.
[103] Winter, "The Silent Revolution," 48. Winter has described how Goddard's *in vacuo* experiments with the rocket was revolutionary in that they overturned the previously held theoretical paradigm of rocketry that posited a rocket *could not* function in a vacuum without something to push against.
[104] De Witt Douglas Kilgore, *Astrofuturism: Science, Race, and Visions of Utopia in Space* (Philadelphia: University of Pennsylvania Press, 2003), 34-35. Kilgore outlines that Lasser wanted to encourage readers to work as professionals or amateur in scientific fields.
[105] Cheng, *Astounding Wonder*, 257.
[106] Winter, *Prelude*, 75; Cheng, *Astounding Wonder*, 257-258; Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War* (New York: Vintage Books, 2007), 42.
[107] Winter, *Prelude*, 75; Cheng, *Astounding Wonder*, 258; Crouch, *Aiming for the Stars*, 60; McCurdy, *Space and the American Imagination*, 18. On Esnault-Pelterie, see also: Gainor, *To a Distant Day*, 53-56.

museum expressed some consternation over the potential turnout, as the Society publicized the free event widely, encouraging people to attend.[108] On account of illness, Esnault-Pelterie was unable to attend the meeting, for which two thousand people had arrived, necessitating a repeat program for those attendees lined up outside the museum for hours.[109] As a popularization effort, the meeting was very successful. At the same time, however, as Cheng as written, "audiences took what they wanted from the meeting," for they were responding to the exciting promise of interplanetary travel, the celebrity of the involved scientists (like Ensault-Pelterie), and the promise of a great adventure—but the "adventure of practicing science" was different than the interplanetary promise.[110] By this point, the AIS had also garnered considerable interest from around the country and elsewhere, which resulted in numerous inquiries but returned relatively few active, paying memberships.[111] Ultimately, popular interest does not always translate into popular support. The lack of support from specialists and professionals in the field, but for a few exceptions, also underscored some of the skepticism surrounding the interplanetary aims of the AIS, and spaceflight more broadly.[112]

The interest in the AIS was still considerable, and the result of the group's various popularization efforts and campaigns in the early 1930s. Lasser, for example, completed a book entitled *The Conquest of Space* in 1931, a serious treatment of spaceflight and rocketry meant to be educational and for public consumption which presented space travel as a feasible and realizable aim.[113] At the same time, the Society took advantage of its pulp fiction roots, publishing letters in *Amazing Stories*, *Wonder Stories*, and *Astounding Stories of Super Science*, entreating readers to join the AIS

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[108] Winter, *Prelude,* 75; Cheng, *Astounding Wonder*, 258.
[109] Winter, *Prelude*, 76; Cheng, *Astounding Wonder*, 258-259. Pendray took Esnault-Pelterie's place, and despite telling attendees he was not the aviator in question, he was repeatedly mistaken for him and asked for autographs.
[110] Cheng, *Astounding Wonder*, 259.
[111] Winter, *Prelude*, 76; Cheng, *Astounding Wonder*, 259.
[112] Winter, *Prelude*, 15, 76-77, 115; Cheng, *Astounding Wonder*, 257. McCurdy has also emphasized that there existed some general public skepticism during this time as well. Despite enthusiasm, spaceflight seemed very much the stuff of the pulps and almost purely fictional. See: McCurdy, *Space and the American Imagination*, 37-38.
[113] Winter, *Prelude*, 24, 80; Cheng, *Astounding Wonder*, 260; McCurdy, *Space and the American Imagination*, 37; Kilgore, *Astrofuturism*, 34-35, 37-40.

and to make the fiction they read reality.[114] The AIS also broadcast themselves further when Pendray appeared on a number of radio shows in 1932, where he discussed space travel and rockets.[115] The Society's efforts were extensive and successful in attracting enthusiasm, and they strove to not only educate the public and disseminate the idea of spaceflight, but also to fill their ranks.[116] As Winter has written, "every convert was progress, and the more widespread the idea, the greater the chances were of raising the necessary astronomical capital."[117] At this juncture, we may extend Winter's usage of the term "capital" here to encompass both the financial and social varieties. The Society sought memberships to generate revenue, as fees were its primary source of funds, to support their activities.[118] Additionally, as the AIS was chiefly composed of "the fantasizers and publicists," they sought to attract more professionals and specialists, and their expertise, to assist them in furthering their goal of contributing to spaceflight.[119]

To these ends, AIS vice-president Pendray had been assigned to help establish a research program, and without being able to rely on Goddard's work, for "members of the Society," Pendray wrote later, "could learn almost nothing about the technical details of his work,"[120] he turned to developments overseas.[121] Touring Europe with the purpose of seeing "what some of the European experimenters were doing,"[122] Mr. and Mrs. Pendray eventually met Willy Ley in Berlin where they witnessed what they believed was the first liquid-fuel rocket flight at the VfR's Raketenflugplatz in the summer of 1931.[123] Unaware of Goddard's 1926 rocket launch, Pendray's report inspired

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114 Cheng, *Astounding Wonder*, 261-262.
115 McCurdy, *Space and the American Imagination*, 37; Winter, *Prelude*, 76; Cheng, *Astounding Wonder*, 260-261.
116 Winter, *Prelude*, 14-15, 80; Cheng, *Astounding Wonder*, 281-284.
117 Winter, *Prelude*, 75.
118 Winter, *Prelude*, 74; Cheng, *Astounding Wonder*, 282.
119 Winter, *Prelude,* 76-78, quote from 76.
120 G. Edward Pendray, "Early Rocket Developments of the American Rocket Society," in *First Steps Toward Space: Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968,* eds. Frederick C. Durant III and George S. James (City of Washington: Smithsonian Institution press, 1974), 141.
121 Pendray, "Early Rocket Developments," 141; Pendray, "Pioneer Rocket Development," 388.
122 Pendray, "Early Rocket Developments," 141.
123 Pendray, "Early Rocket Developments," 141; Winter, *Prelude*, 77-78.

members of the society to press on with rocket experiments, including later president of the AIS, Hugh Franklin Pierce, who subsequently "proposed that the Society delay no longer the beginning of its own experimental program," as Pendray recounted later.[124]

That the necessary technology—the rocket—had to be built fostered in the AIS the same transmutation of the spaceflight dream that affected Goddard, trading the dream of spaceflight for a focus on the technology necessary to achieve it.[125] On 6 April 1934, The American Interplanetary Society also became the American Rocket Society (ARS) as a reflection of their evolving aims and in pursuit of respectability.[126] Their sources of inspiration, however, remained rooted in works of imagination, doubly so when considering the influence of the VfR. The VfR, as will be discussed in Chapter Two, was a by-product of widespread rocket enthusiasm in Germany, a result of Hermann Oberth's 1923 book, popular rocket stunts, development efforts, and popularization.[127] That Oberth himself was first inspired by the writing of Jules Verne reveals a thread of imagination binding these imaginative origins to the AIS's practical experimentation in the 1930s.[128] As sources of imagination and inspiration were translated into actionable goals through a variety of means, the meeting of these products of imagination and enthusiast experimentation laid inroads to innovation.

The American Interplanetary Society thus embarked on a series of rocket experiments from 1931 to 1941 which represented, as Cheng has put it, "popular rocket science in action."[129] The Society's experiments resulted in a couple of successful flights after initial attempts and testing, those

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[124] Pendray, "Early Rocket Developments," 142; see also Winter, *Prelude*, 78.
[125] Winter, *Prelude*, 114; Cheng, *Astounding Wonder*, 290-291.
[126] Winter, *Prelude*, 15, 82-83, 114; Cheng, *Astounding Wonder*, 262, 273, 289-290; Heppenheimer, *Countdown*, 35; Neufeld, *Spaceflight*, 15; Williamson and Launius, "Rocketry and the Origins of Space Flight," 38.
[127] Michael J. Neufeld, "Weimar Culture and Futuristic Technology: The Rocketry and Spaceflight Fad in Germany, 1923-1933," *Technology and Culture* 31, no. 4 (October 1990): 725, 727
[128] Hermann Oberth, "My Contributions to Astronautics," in *First Steps Toward Space: Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968*, eds. Frederick C. Durant III and George S. James (City of Washington: Smithsonian Institution Press, 1974), 129. Also cited in Crouch, *Aiming for the Stars*, 36.
[129] Cheng, *Astounding Wonder*, 252. These experiments were publicized as well. See: Cheng, *Astounding Wonder*, 269-273.

of the ARS Rockets No. 2 and No. 4, built and launched in 1933 and 1934, respectively.[130] During this experimental phase, the Society was offering more than just a spaceflight dream, but also either an attractive engineering challenge or, at the very least, a means of escape, leisure, or fun.[131] Winter shows that the AIS attracted two such individuals who were not necessarily enraptured by a vision of conquering the stars, "itinerant handyman" Bernard Smith and mechanical engineer Alfred Africano.[132] Smith, seeking work and a sort of escape during the Depression, figured that building a spaceship was the best way off the planet where his fortunes had been poor.[133] Africano, on the other hand, sought to maintain his mechanical engineering skills as he could only find work as a civil engineer during this period.[134] Science fiction enthusiasm and interplanetary ambitions were not the only means by which rocketry might be developed; there were other motivations embedded in such pursuits that extended beyond the influence of an interplanetary dream.[135] While the efforts of the AIS/ARS did not produce interplanetary travel alone, one of its more significant contributions to astronautics was its provision of an arena wherein engineers and enthusiasts could organize, work, and innovate, thereby setting foundations upon which others could build.

PROFESSIONAL ROCKETEERS

This arena helped foster the development of the first American-made motor to apply regenerative cooling to the combustion chamber, designed by James Hart Wyld.[136] Such a method of cooling would allow a liquid rocket to fire reliably for longer, and could enable a motor to serve the purposes of improved aeronautical or astronautical performance.[137] Mechanical engineer Wyld

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130 Pendray, "Early Rocket Developments," 142-146; Pendray "Pioneer Rocket Development," 388-389; Winter, *Prelude*, 78-82; Cheng, *Astounding Wonder*, 264-266, 268-269, 273-274.
131 Winter, *Prelude*, 16.
132 Winter, *Prelude*, 16.
133 Winter, *Prelude*, 77, 81.
134 Winter, *Prelude*, 16.
135 See: Winter, *Prelude*, 16, 74.
136 Hunley, *Propulsion Technology*, 21; Cheng, *Astounding Wonder*, 307.
137 Winter, *Prelude*, 84; Cheng, *Astounding Wonder*, 296.

joined the ARS in 1935 after reading of the group in a magazine article, and turned his attention to the Society's rocket experiments after an ARS static motor test on 20 October 1935, his fascination with spaceflight stoked by Lasser's book, *Conquest of Space*.[138] Interested in the idea of the regenerative engine, Wyld surveyed various writings on rocket motor cooling, before encountering the work of Austrian spaceflight pioneer, Eugen Sänger, when translating one of Sänger's articles for Peter van Dresser, editor of the ARS's *Astronautics*.[139] Notably, both German science fiction writer Kurd Laßwitz's 1897 novel *Auf Zwei Planeten* (*On Two Planets*), and then later Oberth's *Die Rakete,* had inspired Eugen Sänger to consider the possibilities of practical spaceflight in the early 1920s.[140] By 1926, Sänger was designing rocket planes and by the 1930s, he was experimenting with regeneratively cooled motors.[141] By 1934, Sänger had obtained successful results, published a book, *Raketenflugtechnik* (*Rocket Flight Engineering*) in 1933, and a number of articles thereafter.[142] Inspired by Sänger's ideas of cooling, Wyld developed a regeneratively-cooled rocket motor of his own design whose success in 1938[143] encouraged Wyld, civil engineer John Shesta, machinist Hugh F. Pierce,

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[138] Frank Winter, "Bringing up Betsy," *Air & Space/Smithsonian*, December 1988/January 1989, 79; Winter, *Prelude*, 83. See also: Heppenheimer, *Countdown*, 35.
[139] Winter, *Prelude*, 83-84; Frank H. Winter, "'Black Betsy': The 6000C-4 Rocket Engine, 1945-1989. Part I," *Acta Astronautica* 32, no. 4 (April 1994): 283-284, (hereafter cited as "'Black Betsy' Part I"), also cited by Aleksander Kerstein and Drago Matko, "Eugen Sänger: Eminent space pioneer," *Acta Astronautica* 61, no. 11/12 (December 2007): 1085, 1087.
[140] Eugen Sänger, interview by Berlin RIAS, October 28, 1964, quoted in Irene Sänger-Bredt, "The Silver Bird Story: A Memoir," 1970, in *Essays on the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics, Volume 1*, ed. R. Cargill Hall (Washington, D.C.: NASA, 2014), NTRS, NASA Technical Reports Server, 198, https://ntrs.nasa.gov/citations/19770026086; Winter, *Rockets into Space*, 42-43; William Sims Bainbridge, *The Spaceflight Revolution: A Sociological Study* (New York: John Wiley & Sons, 1976), 64; Roger D. Launius and Dennis R. Jenkins, *Coming Home: Reentry and Recovery from Space* (Washington, D.C.: Government Printing Office, 2012), 7, https://www.nasa.gov/sites/default/files/695726main_ComingHome-ebook.pdf; Frank Horstmann, "Eugen Sänger (1905-1964)," in *"The shoulders on which we stand" – Wegebereiter der Wissenschaft: 125 Jahre Technische Universität Berlin*, ed. Eberhard Knobloch, trans. Cormac Deane and Robert Sleigh (Berlin, Heidelberg: Springer-Verlag Berlin, Heidelberg, 2004), 147.
[141] Winter, *Rockets into Space*, 42-43; Horstmann, "Eugen Sänger (1905-1964)," 147; Launius and Jenkins, *Coming Home*, 7; Winter, "'Black Betsy' Part I," 283.
[142] Winter, "'Black Betsy' Part I," 283-284.
[143] A regenerative engine designed by midshipman Robert C. Truax was also tested but did not fire successfully. See: Cheng *Astounding Wonder*, 295; and Winter, *Prelude*, 84.

and electronics engineer Lovell Lawrence of the ARS to form RMI and take on Navy contracts to develop JATO units for the war effort in the early 1940s.[144]

By the late 1930s, the Navy and Army had become interested in the capacity of rockets to assist heavily loaded aircraft in taking off, shortening takeoff distances, and increasing the speeds of fighter planes, and so turned their attention to rocketry and the development of jet-assisted take-off (JATO) units.[145] Under contract to the Navy following the attack on Pearl Harbor, RMI built the XLR-11, (also known as the 6000C-4 or "Black Betsy"),[146] as based on Wyld's small engine design, which made possible not only the world's first supersonic flight of 14 October 1947, but was also modified by 1946 to become the XLR-35-RM-1, serving as the powerplant for the MX-774B project, the precursor to the United States' first Intercontinental Ballistic Missile (ICBM), the Atlas.[147] RMI's innovations would be later adapted to develop the powerplant for North American Aviation's hypersonic research aircraft, the X–15, and further developments informed aspects of engine construction for Jupiter, Viking, Atlas, Titan, and Saturn rockets in the 1950s and 1960s.[148] Although many of these developments occurred independently of their influence, the founding members of RMI had come from the ranks of the AIS/ARS and this rocket engine traced its lineage back to imaginative origins. The developments it fostered thereby constituted, at least in part, expressions of imagination's effect.

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144 Winter, *Prelude*, 85; Winter, "'Black Betsy' Part I," 283-284, also cited by Kerstein and Matko, "Eugen Sänger," 1087; Pendray, "Early Rocket Developments," 148-149; Cheng, *Astounding Wonder*, 296-298; Heppenheimer, *Countdown*, 35-36; Winter, "Bringing up Betsy," 77-80.
145 Winter, "Bringing up Betsy," 82; Gruntman, *Blazing the Trail*, 174; Winter, *Prelude*, 85; Frank H. Winter, "'Black Betsy' Part I," 284.
146 Winter, "'Black Betsy' Part I," 294, 297.
147 Winter, *Prelude*, 85; Winter, "Bringing up Betsy," 77; Frank H. Winter, "'Black Betsy': The 6000C-4 Rocket Engine, 1945-1989. Part II," *Acta Astronautica* 32, no. 4 (April 1994): 309 (hereafter cited as "'Black Betsy' Part II"); Cheng, *Astounding Wonder*, 307; Winter, *Rockets into Space*, 40; Christopher Gainor, "The Atlas and the Air Force: Reassessing the Beginnings of America's First Intercontinental Ballistic Missile," *Technology and Culture* 54, no. 2 (April 2013): 350-351; Kerstein and Matko, "Eugen Sänger," 1087; Hunley, *Propulsion Technology*, 112; Winter, "'Black Betsy' Part I," 283.
148 Hunley, *Propulsion Technology*, 21; Winter, "'Black Betsy' Part II," 312-313; Heppenheimer, *Countdown*, 37; Cheng, *Astounding Wonder*, 307.

While the dream of spaceflight set the stage for RMI's engine, it did not fully sustain it. Besides serving JATO units, RMI's engine was chiefly employed as a powerplant for experimental research aircraft, designed to reach supersonic and hypersonic speeds. The interest in and adoption of "jet" propulsion by the United States had originally been in response to European advances and an incoming war, spurring investigation into jet engines by the Army Air Forces and later the National Advisory Committee for Aeronautics (NACA) laboratories as a matter of improving combat aircraft in the late 1930s.[149] The development of supersonic aircraft, like the X–1, to address issues encountered by high-speed fighter planes was similarly a matter of aeronautics.[150] Most NACA engineers had little interest in achieving spaceflight, as James R. Hansen has argued.[151] Interest in rocketry stemmed from a desire to stay on the cutting-edge of the technology, as was the case with the rocket team of the Lewis Flight Propulsion Laboratory in Cleveland, Ohio in 1941, and enthusiasm there was seemingly restricted to the technology alone.[152] Even when the Langley Aeronautical Laboratory of the NACA turned its attention to hypersonic research to aid the development of long-range missiles, its purposes were purely in service of practical military needs.[153] Indeed, the government's primary interest in rocketry was typically in terms of weaponry and combat capacity in WWII.[154] Moreover, as RMI expanded to become the United States' foremost rocket manufacturer during the war, going from four members to 55 employees in 1945, then 473 by

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[149] Bilstein, *Testing Aircraft*, 31, 37-40; James R. Hansen, *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958* (Washington, D.C.: NASA, Scientific and Technical Information Office, 1987), 188, 190-193, 219, 224. Hansen also describes how the NACA's primary goals during the war were to improve aircraft.
[150] Hansen, *Engineer in Charge*, 220-221, 249, 259, 271-272; Bilstein, *Testing Aircraft*, 44-46. Bilstein explains how faster fighter planes developed during World War II faced issues that could prove fatal once they hit top speeds, requiring investigation into high-speed flight with experimental aircraft.
[151] Hansen, *Engineer in Charge*, 355. Also cited by McCurdy, *Space and the American Imagination*, 86.
[152] Virginia P. Dawson, *Ideas into Hardware: A History of the Rocket Engine Test Facility at the NASA Glenn Research Center* (Cleveland, Ohio: NASA, NASA Glenn Research Center, 2004), 1, 9, https://history.nasa.gov/retfpub.pdf.
[153] While missile research and the development of blunt-body heat shields would later prove useful for spaceflight technology, the purposes of the laboratory were not aligned with a project of spaceflight. See: Hansen, *Engineer in Charge*, 347-350.
[154] Bilstein, *Testing Aircraft*, 34.

1947,[155] it is unlikely that all employees shared an interplanetary dream considering the wartime context in which RMI was operating.

RMI's contributions toward postwar experimental aircraft, especially the X-15, would, however, have some long-term ramifications for spaceflight. Furthermore, the X-15, whose development began in 1955 as part of the NACA's hypersonic research, had some debts to the threads of imagination as well, for it was designed by relying on the work of Eugen Sänger and his wife Irene Sänger-Bredt.[156] Employing versions of RMI's XLR-11 motor until the XLR-99 was prepared, this aircraft would test reaction controls in space, advance re-entry technologies for spaceflight, test materials later used on the Saturn V rocket—the very same that would take astronauts to the Moon—and point the way to space shuttles.[157] Though the involvement of thousands of other specialists, engineers and decisionmakers in these later efforts in some ways outweighed the specific influence of the AIS/ARS, RMI, and their inspirations, there existed, nonetheless, threads that ran back to science fiction pulps, spaceflight popularization, and interplanetary enthusiasm.

ENTHUSIASM, PRACTICALITY, AND MILITARY FUNDING

Taking the technology seriously and removing it from the realms of fantasy, as RMI did, would be a significant project in building America's capacity to engineer rockets, a project extending beyond mechanical or technological aspects, and fostering psychological distance from fiction and

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155 Gruntman, *Blazing the Trail*, 174; Cheng, *Astounding Wonder*, 296.
156 Richard P. Hallion, *On the Frontier: Flight Research at Dryden, 1946-1981* (Washington, D.C.: NASA, Scientific and Technical Information Branch, 1984), 106-108; also cited by Bilstein, *Testing Aircraft*, 59; Hansen, *Engineer in Charge*, 366.
157 Bilstein, *Testing Aircraft*, 60; Hallion, *On the Frontier*, 110; Winter, "'Black Betsy' Part II," 312-313; Launius and Jenkins, *Coming Home*, ix; Richard P. Hallion, Editor's Introduction to Robert S. Houston, Richard P. Hallion, and Ronald G. Boston, "Case I: Transiting from Air to Space: The North American X–15" in *The Hypersonic Revolution: Case Studies in the History of Hypersonic Technology, Volume I: From Max Valier to Project PRIME (1925-1967)*, ed. Richard P. Hallion (Washington, D.C.: Air Force Historical Studies Office, 1998), I-ix, 138, https://apps.dtic.mil/sti/citations/ADA441126; John V. Becker, "Case III: The Development of Winged Reentry Vehicles: An Essay from the NACA-NASA Perspective, 1952-1963" in *The Hypersonic Revolution: Case Studies in the History of Hypersonic Technology, Volume I: From Max Valier to Project PRIME (1925-1967)*, ed. Richard P. Hallion (Washington, D.C.: Air Force Historical Studies Office, 1998), 385; Hansen, *Engineer in Charge*, 366.

fantasy. This was especially the case for the GALCIT rocket research group, who later formed JPL and made significant leaps in rocketry, both in terms of technological achievement and helping to reduce the skepticism surrounding it. Clayton R. Koppes has written that the advances made by the GALCIT group during WWII "played an important role in converting rocketry from science fiction into respectable science and engineering."[158] Their example also shows how influences including but not limited to the spaceflight dream could produce the means to realize it.

This rocket research project came together in 1936 at the California Institute of Technology (Caltech). It started with Caltech graduate student Frank J. Malina, whose mind turned to considering other and more advanced means of propulsion while working on a master's thesis focused on aircraft propellers in the mid-1930s.[159] Though Koppes has pointed out that Malina was not in possession of an overwhelming sense of "space exploration destiny,"[160] Malina has reflected that Verne's *De la Terre à la Lune*, which he read when he was 12 years old, first interested in spaceflight, and a paper written for an English course at Texas A&M College in 1933, wherein Malina briefly considers interplanetary travel, suggests the topic was not far from his mind years later.[161] Then, in 1935, Malina attended a seminar lecture at which Caltech graduate assistant William Bollay gave a talk on the possibilities of rocket propulsion, notably drawing on the work of Eugen Sänger.[162] Bollay's review helped transform Malina's interests into a motivating force as Malina decided to pursue the topic of rocketry for his doctoral dissertation after the lecture.[163] His

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158 Koppes, *JPL*, ix.
159 Malina, "Rocket Research Project," 113; Frank J. Malina, "Origins and First Decade of the Jet Propulsion Laboratory," in *The History of Rocket Technology: Essays on Research, Development, and Utility*, ed. Eugene M. Emme (Detroit, Michigan: Wayne State University Press, 1964), 47 (hereafter Malina "Origins"); Koppes, *JPL*, 3; Crouch, *Aiming for the Stars*, 93.
160 Koppes, *JPL*, 2.
161 Malina, "Rocket Research Project," 113; Koppes, *JPL*, 2-3; Michael H. Gorn, *The Universal Man: Theodore von Kármán's Life in Aeronautics* (Washington: Smithsonian Institution Press, 1992), 74.
162 Malina, "Rocket Research Project," 113; Malina, "Origins," 47; Koppes, *JPL*, 3; Crouch, *Aiming for the Stars*, 93; Gorn, *The Universal Man*, 74-75.
163 Koppes, *JPL*, 3; Crouch, *Aiming for the Stars*, 93.

professors, however, advised against this. Clark Millikan suggested he instead find work in industry; and astronomer Fritz Zwicky recapitulated that a rocket could not work in a vacuum.[164] Goddard's gospel had apparently not gone very far or sunk very deep. Malina then turned to Hungarian aerodynamicist Theodore von Kármán, recent émigré from Germany, whose interests in pushing the boundaries of flight and reputation for appreciating the unconventional made him seem a suitable supervisor for a project as unusual as rocketry.[165] Even despite the work of the pioneers, both Malina and von Kármán have pointed out that rocketry and its literature was still very much considered to be the stuff of science fiction.[166] The distance between theory and practice was still so great that the development of a rocket engine in the mid-1930s still smacked of fantasy and fostered only skepticism within academic and bureaucratic circles.[167] Fortunately, Malina was not alone. He went to von Kármán with two individuals unattached to Caltech, self-taught chemist John W. Parsons and mechanic Edward S. Forman, both of whom were spaceflight enthusiasts, keenly followed the work of the rocket societies at home and abroad, and dedicated readers of science fiction, with Parsons especially being a fan of *Amazing Stories*.[168] Their efforts in rocketry had been thus far crude, but after having read of Bollay's lecture in a Pasadena newspaper, they arrived at Caltech hoping to find help in making their dreams a reality.[169] With the moral support of Caltech president Robert A. Millikan and Irving P. Krick, head of meteorological research and instruction,

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[164] Malina, "Rocket Research Project," 115; Koppes, *JPL*, 3; Crouch, *Aiming for the Stars*, 95; Frank J. Malina, "The U.S. Army Air Corps Jet Propulsion Research Project, GALCIT Project no. 1, 1939-1946: A Memoir," 1969, in *Essays on the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics, Volume 2*, ed. R. Cargill Hall (Washington, D.C.: NASA Scientific and Technical Information Office, 2014), 159, https://ntrs.nasa.gov/citations/19770026104 (hereafter cited as Malina, "A Memoir."). Also cited by Dawson, *Ideas into Hardware*, 6.

[165] Malina, "Rocket Research Project," 115; Koppes, *JPL*, 2; Gorn, *The Universal Man*, 75; Crouch, *Aiming for the Stars*, 95

[166] Malina, "Rocket Research Project," 114; Malina, "Origins," 47; Koppes, *JPL*, 1; Crouch, *Aiming for the Stars*, 41.

[167] Von Kármán with Edson, *The Wind and Beyond*, 238; Malina, "Rocket Research Project," 114; Malina, "Origins," 47; Koppes, *JPL*, 2.

[168] George Pendle, *Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons* (Orlando: Hartcourt, Inc., 2005), 35-37, 46, 54-55, 65-66; Malina, "GALCIT," 113-114; Koppes, *JPL*, 3; Von Kármán with Edson, *The Wind and Beyond*, 235; Crouch, *Aiming for the Stars*, 93.

[169] Malina, "Rocket Research Project," 113-114; Malina, "Origins," 47; Koppes, *JPL*, 3; Pendle, *Strange Angel*, 74-75; Gorn, *The Universal Man*, 75.

and a receptive von Kármán who approved the project, work, unfunded as it would be, began toward building a sounding rocket meant to explore the upper regions of the atmosphere.[170]

Importantly, von Kármán was not affected by a spaceflight dream.[171] His interests had been in aviation, and his fascination with rocketry and its possibilities, while serious, was not of the same stock as that of the spaceflight enthusiasts.[172] As a result, he guided the rocket research team to address their project systematically, and with an emphasis on theory and understanding the basic principles underlying their efforts.[173] Despite reviewing the work of Goddard, Oberth, Tsiolkovskii, Esnault-Pelterie and even the ARS, the Caltech team determined that building sounding rockets to reach altitudes than higher than that achievable by balloons was impossible without sound theoretical knowledge, and that static engine tests should be conducted first to gain an understanding of the technology.[174] While the enthusiasts Parsons and Forman, and even Malina, wanted to get to launching rockets, they agreed to undertake a slower, more methodical approach—one that led to greater success down the line.[175] The GACLIT team sought to push the boundaries of technology, and so while the spaceflight dream had to be tempered as a result, it had nonetheless exerted a significant influence. From the profound effect of Bollay's review of Sänger's work,[176] work whose origins can be traced back to inspirational science fiction and spaceflight enthusiasm, to the very same sorts of interests affecting the first GALCIT members, imagination and the spaceflight dream had a central role to play in the group's formation and early efforts.

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[170] Von Kármán with Edson, *The Wind and Beyond*, 238; Malina, "Rocket Research Project," 115; Malina, "Origins," 48-49; Koppes, *JPL*, 4; Gorn, *The Universal Man*, 76-77.
[171] Von Kármán with Edson, *The Wind and Beyond*, 42-44; Koppes, *JPL*, 2; Heppenheimer, *Countdown*, 37.
[172] Koppes, *JPL*, 2; Von Kármán with Edson, *The Wind and Beyond*, 236; Gorn, *The Universal Man*, 73-74; Heppenheimer, *Countdown*, 37.
[173] Malina, "Rocket Research Project," 114; Koppes, *JPL*, 3; Gorn, *The Universal Man*, 76, 78; Gruntman, *Blazing the Trail*, 170.
[174] Malina, "Rocket Research Project," 114; Koppes, *JPL*, 3-4. The work of the pioneers was also too general for them to use. See: Clary, *Rocket Man*, 179. Gorn has also pointed out that Malina sought to model his project on the work of Goddard and Sänger but could not for a lack of technical or otherwise useful data. Gorn, *The Universal Man*, 76.
[175] Malina, "Rocket Research Project," 114; Koppes, *JPL*, 3; Gorn, *The Universal Man*, 76.
[176] Malina, "Rocket Research Project," 118; Crouch, *Aiming for the Stars*, 114.

This dream may have had an even larger effect had Robert Goddard, agent of the spaceflight vision, assisted the GALCIT group in the 1930s. In 1936, for example, Robert Millikan arranged a meeting between Malina and Goddard, and despite a cordial meeting, Goddard was unwilling to divulge much about his work, referring Malina to his 1936 publication which carried little useful information.[177] Goddard later wrote to Robert Millikan to say that giving up information on his life's work for a student's thesis was impossible.[178] Goddard's unwillingness to engage with the ARS and now the Caltech rocket project also reveals the unfulfilled potential of his work and his influence. Even despite Harry Guggenheim's later efforts to arrange a cooperative endeavour among the NACA, Clark Millikan, von Kármán, and Goddard in 1938, the latter's refusal to give up his secrets precluded further and deeper involvement and cut off any mutually beneficial information exchange between the others and himself.[179] Von Kármán later suggested that because of Goddard's solitary approach to rocketry, "there is no direct line from Goddard to present-day rocketry. He is on a branch that died."[180] Beyond his inspirational effect and undeniable achievements, a further expression of his spaceflight dream remained closed off from flourishing because of his hesitancy to cooperate with others outside his inner circle.[181] The first engineers of the Space Age would thus go forward without the professor's aid.

After the Caltech rocket team pooled their personal funds to finance their work, conducted tests and endured failures, their project was finally seeing success, with a motor running for 15 seconds without failure on 28 November 1936, and then 44 seconds on 16 January 1937 at Arroyo Seco.[182] By this time, other graduate students had been inspired to join the project, perhaps for the

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[177] Malina, "Rocket Research Project," 117, see also 117-118; Malina, "Origins," 49; Clary, *Rocket Man*, 178-181; Koppes, *JPL*, 4; Crouch, *Aiming for the Stars*, 67-68.
[178] Clary, *Rocket Man*, 179; Crouch, *Aiming for the Stars*, 68.
[179] Von Kármán with Edson, *The Wind and Beyond*, 241-242; Malina, "Rocket Research Project," 118; Malina, "Origins," 52; Koppes, *JPL*, 4; Gorn, *The Universal Man*, 83; Hunley, "The Enigma of Robert H. Goddard," 342.
[180] Von Kármán with Edson, *The Wind and Beyond*, 242.
[181] Von Kármán with Edson, *The Wind and Beyond*, 242; Koppes, *JPL*, 10.
[182] Malina, "Rocket Research Project," 119; Koppes, *JPL*, 4-5.

same reasons some members of the ARS joined a rocket project: because it offered a unique and fascinating challenge unlike any other. These students were Apollo Milton Olin Smith, and research engineer and mathematician Hsue-Shen Tsien, who joined the team in 1936 and 1937, respectively.[183] Experiments continued at Caltech when von Kármán approved small motor tests on campus after reading Smith and Malina's encouraging report "Flight Analysis of the Sounding Rocket," which was later published in the *Journal of the Aeronautical Sciences* and won the attention of the press.[184] Additionally, after Malina gave a seminar on the team's first year of work in April, graduate student Weld Arnold found himself so interested in the project that he offered to join in with a contribution of a much-needed $1000 toward the efforts of the team.[185]

The rocket research project, however, would need further support if it was to flourish. Koppes has pointed out that even despite some of the group's better results with a motor running for more than a minute in May 1938, the "project drifted into the doldrums" after Smith left for Douglas Aircraft, Arnold dropped out, and Tsien turned his focus to his Ph.D.[186] While their work had interested the Consolidated Aircraft Company of San Diego, who asked GALCIT for advice regarding rocket-assisted take-off units for aircraft in 1938,[187] serious interest would come from the commanding general of the Army Air Corps, Henry H. Arnold, who visited Caltech often to see his friend Robert Millikan and had been introduced to von Kármán in 1935.[188] With war on the horizon, Arnold made a "surprise visit" in 1938, with an eye toward the military applications of GALCIT's work, and it was then that he was shown the rocket work brewing at Caltech.[189]

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[183] Koppes, *JPL*, 5; Crouch, *Aiming for the Stars*, 95.
[184] Malina, "Rocket Research Project," 124; Malina, "Origins,"49-50; Koppes, *JPL*, 7-8; Gorn, *The Universal Man*, 81.
[185] Malina, "Rocket Research Project," 120; Malina, "Origins," 50; Koppes, *JPL*, 5; Gorn, *The Universal Man*, 79-80; Crouch, *Aiming for the Stars*, 95.
[186] Quote from Koppes, *JPL*, 8; Malina, "Origins," 51; Gorn, *The Universal Man*, 81.
[187] Von Kármán with Edson, *The Wind and Beyond*, 243; Malina, "Rocket Research Project," 125; Malina, "Origins," 51; Gruntman, *Blazing the Trail*, 170; Gorn, *The Universal Man*, 83; Crouch, *Aiming for the Stars*, 96.
[188] Koppes, *JPL*, 8; Gorn, *The Universal Man*, 81-83.
[189] Gorn, *The Universal Man*, 82-83, quote from 82; Malina, "Origins," 52, 52n12; Von Kármán with Edson, *The Wind and Beyond*, 243.

This visit produced the kind of support that led to a considerable expansion of the rocket project, resulting in enterprises such as Aerojet, a JATO firm like RMI, and the Jet Propulsion Laboratory. With General Arnold's interest in GALCIT's rocket work, Malina presented findings before the National Academy of Sciences (NAS) Committee on Army Air Corps Research who were looking at a variety of air power projects, including JATO at the General's behest.[190] Following Malina's presentation, the Academy accepted von Kármán's offer to take on the investigation of JATO with the GALCIT rocket research group in 1939.[191] Jerome Hunsaker, head of the Guggenheim Aeronautics Department at MIT, jested that while he would take on the project of de-icing aircraft windshields, von Kármán could have "the Buck Rogers job."[192] As von Kármán and Malina later reflected, this was indicative in part of the general skepticism that still surrounded rocketry.[193] Malina and von Kármán, for example, effaced the word "rocket" from their reports and vocabulary altogether, favouring "jet" instead to dodge the former's negative associations with the unserious stuff of interplanetary romps and science fiction pulps.[194] Even when the NAS committee granted $10,000 for the investigations into JATO in 1939, Major Benjamin Chidlaw still asked von Kármán if the army should really be spending that sort of money on rockets of all things.[195] Not only was the GALCIT team working with a largely unproven technology, but they also had to demonstrate its viability as an endeavour of legitimate engineering interest in the face of skepticism. It would not be until 1945 that rocketry would find what von Kármán called "a firm engineering basis," something toward which the GALCIT group would contribute.[196]

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[190] Malina, "Rocket Research Project," 125; Malina, "A Memoir," 154; Koppes, *JPL*, 8; Gorn, *The Universal Man*, 83-84; Gruntman, *Blazing the Trail*, 170-171; Crouch, *Aiming for the Stars*, 97.
[191] Malina, "Rocket Research Project," 125; Malina, "Origins," 52; Malina, "A Memoir," 155; Koppes, *JPL*, 8.
[192] Von Kármán with Edson, *The Wind and Beyond*, 243.
[193] Von Kármán with Edson, *The Wind and Beyond*, 243; Malina, "Origins," 52.
[194] Malina, "Rocket Research Project," 125; Malina, "Origins," 52; Malina, "A Memoir," 155; Koppes, *JPL*, 1; Bilstein, *Testing Aircraft*, 35; Von Kármán with Edson, *The Wind and Beyond*, 243; Gorn, *The Universal Man*, 84; Neufeld, *Spaceflight*, 20, 141-142; Crouch, *Aiming for the Stars*, 97.
[195] Koppes, *JPL*, 9; von Kármán with Edson, *The Wind and Beyond*, 244; Gorn, *The Universal Man*, 86.
[196] Von Kármán with Edson, *The Wind and Beyond*, 266-267, quote from 267; Koppes, *JPL*, ix, 17.

Reports written by Malina in 1938 and 1939 as investigations continued won them greater funds to continue working, as reports of European aeronautical advances inspired a more urgent pursuit of rocket technology to aid aircraft as a result.[197] The interest in rocketry was mainly a matter of developing a capacity for combat and for aeronautical advancement. In a 1969 memoir, Malina wrote that by the outbreak of the war, "work toward our dream of designing rockets for scientific research at high altitudes and for space flight had to be deferred for several years."[198] The Air Corps Jet Propulsion Research Project, GALCIT Project No. 1, which came into being on 1 July 1939 for the purposes of investigating rocket engines for aircraft "super-performance,"[199] was then a product of several forces, including spaceflight dreams, especially as the GALCIT team had turned to the work of the pioneers in search of leads concerning their work.[200]

Working with the grant from the National Academy of Sciences Committee, the rocket research project team members committed themselves to working out the problems of liquid- and solid-fuel engines.[201] An optimistic report written by von Kármán and Malina for the NAS won them the direct sponsorship of the AAF in July 1940, and their grant was increased to $22,000 for the fiscal year (FY) of 1941, which they used to lease land at Arroyo Seco, expanding and setting down the foundations of what would become JPL.[202] Making progress in 1941 with $125,000 for FY 1942, and as American involvement in the war appeared more likely, the GALCIT group outfitted an Ercoupe Monoplane with the country's first solid-propellant jet-assisted take-off units which, after static tests, flew successfully on 12 August, with Lt. Homer A. Boushey in the cockpit, marking

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[197] Koppes, *JPL*, 10; Gorn, *The Universal Man*, 85; Bilstein, *Testing Aircraft*, 31, 35.
[198] Malina, "A Memoir," 154.
[199] Malina, "Origins," 53; Malina, "A Memoir," 158.
[200] Malina, "Rocket Research Project," 118, 124; Malina, "Origins," 50-51.
[201] Koppes, *JPL*, 9-10.
[202] Koppes, *JPL*, 10-11, figures from 11; Malina, "Origins," 54; Gorn, *The Universal Man*, 87-88. Caltech faculty and staff also became more involved with the project, lending their expertise. See: Malina, "A Memoir," 159-160.

the first time an American craft had taken off using rocket power.[203] The team thereafter also addressed the storability problems of solid fuels, which cracked and then exploded once ignited after having been stored for long periods of time, an issue which would make their JATO units unviable as wartime materiel.[204] After a great number of investigation, Parsons discovered and developed, possibly in collaboration with mechanic Fred S. Miller and Caltech graduate Mark M. Mills, the combination of tar and potassium perchlorate to produce a propellant suitable to store almost indefinitely.[205] This propellant, GALCIT 53, was later refined to become GALCIT 61-C and saw extensive use during the final years of the war, 1943-1945.[206] This constituted a "fundamental breakthrough in solid-propellant rocketry" according to Koppes.[207] It is thus worthwhile to note that it was a breakthrough produced by someone whose dreams of spaceflight had led him to the GALCIT rocket project.

In the early 1940s, the GALCIT team had also turned its attention to liquid-fuel units and felt confident about constructing them because, as Malina has stated, "Goddard and other investigators had demonstrated that it was possible to do so."[208] The mere possibilities of work done by pioneers like Goddard helped catalyze continued investigation into improved designs. With the help of physicist Martin Summerfield, Malina's erstwhile roommate, the GALCIT group began work on a liquid-fuelled unit, and Summerfield helped confirm the feasibility of a self-cooling engine before Malina learned of RMI's innovations.[209] Failures and explosions caused by unstable

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[203] Koppes, *JPL*, 11-12, figures from 11; Malina, "Origins," 56; Von Kármán with Edson, *The Wind and Beyond*, 250; Crouch, *Aiming for the Stars*, 97; Winter, *Prelude*, 103.
[204] Koppes, *JPL*, 12; Malina, "Origins," 56.
[205] Koppes, *JPL*, 12-13; Pendle, *Strange Angel*, 199; Von Kármán with Edson, *The Wind and Beyond*, 246; Gorn, *The Universal Man*, 87. Koppes has pointed out that it is not known how Parsons arrived at his conclusion. Pendle has recorded various accounts of this discovery (see Koppes, *JPL*, 12; and Pendle, *Strange Angel*, 199). That Parsons was aided by Miller and Mills is also put forth in Malina, "Origins," 57; but Malina, "A Memoir," 172, suggests that Parsons discovered the mixture independently, but with Miller and Mills assisting with its final development.
[206] Koppes, *JPL*, 13.
[207] Koppes, *JPL*, 13. Von Kármán also suggested that this mixture made possible rockets such as Polaris and Minuteman. See: Von Kármán with Edson, *The Wind and Beyond*, 246.
[208] Malina, "Origins," 54.
[209] Koppes, *JPL*, 13; Hunley, *Propulsion Technology*, 19, 146; Von Kármán with Edson, *The Wind and Beyond*, 255.

combustion of their fuel were then resolved with the help of chemical engineer Ray C. Stiff at the Naval Engineering Experiment Station at Annapolis, who suggested adding aniline to the gasoline.[210] The GALCIT team thereafter replaced gasoline with aniline altogether, and successfully fired it with red fuming nitric acid, solving the issue.[211] It may be also worthwhile to note that the JATO work at the Experiment Station had been fostered chiefly by Robert C. Truax, himself a spaceflight enthusiast, and science fiction and Goddard fan.[212] Though the Experiment Station rocketry work was military in nature, springing from practical needs, most likely having largely involved those who did not harbour grand fantasies of spaceflight, there were, nonetheless, some legacies of inspiration at work, and these inspirations had generated arenas wherein rocketry work could proceed and find numerous applications besides spaceflight.

This sort of work overall brought with it a move toward respectability and demonstrated the practical viability of rocketry.[213] Similarly, after a great many trials, the successes of the GALCIT team's liquid-fuel JATO units, the first successful kind in the United States, led to the rocket team forming Aerojet Engineering Corporation in 1942 to fulfill contracts for the AAF and Navy, in time becoming one of the U.S.'s primary rocket firms.[214] Aerojet itself and the GALCIT group had evolved beyond the spaceflight dreams from which they had arisen, yet their influences still constituted an important link to the realm of fantasy that their efforts now transformed into

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[210] Koppes, *JPL*, 14; Malina, "Origins," 57; Malina, "A Memoir," 167-168; Von Kármán with Edson, *The Wind and Beyond*, 252-253.
[211] Koppes, *JPL*, 14; Malina, "Origins," 57-58; Malina, "A Memoir," 168; Von Kármán with Edson, *The Wind and Beyond*, 253.
[212] R.C. Truax, "Annapolis Rocket Motor Development, 1936-1938" in *First Steps Toward Space: Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968,* eds. Frederick C. Durant III and George S. James (City of Washington: Smithsonian Institution press, 1974), 295, 301; Wernher von Braun and Frederick I. Ordway III with Dave Dooling, *Space Travel: An Update of History of Rocketry & Space Travel*, 4th ed. (New York: Harper & Row, Publishers, 1985), 82-83; Clary, *Rocket Man*, 206; Von Kármán with Edson, *The Wind and Beyond*, 253.
[213] Koppes has called the expansion of GALCIT one of "inspired lunacy to wartime respectability," for example. Koppes, *JPL*, 14.
[214] Hunley, *Propulsion Technology*, 17, 147; Koppes, *JPL*, 16-17; Malina, "Origins," 58; Malina, "A Memoir," 194; Von Kármán with Edson, *The Wind and Beyond*, 255; Gorn, *The Universal Man*, 89; Crouch, *Aiming for the Stars*, 97; Heppenheimer, *Countdown*, 40.

practical realities. Enmeshed as they were with the needs of national defense, these developments led more directly to building a capacity for spaceflight, as we will see in Chapter Two.

IMAGINATIVE THREADS, PRACTICAL NEEDS

Changing contexts prompted the renegotiation of rocketry's application. Rocket technology in the United States first began flourishing thanks to the possibilities offered by science fiction and imaginative inspirations, but wartime funding and military interest were necessary to sustain and carry this rocket work beyond its beginnings. Although practical use amidst rocket developers like GALCIT, Aerojet, and RMI was prioritized over faraway possibilities by the mid-to-late 1930s, the interplanetary dream served as a significant factor underlying the initiation of American rocket development. Spaceflight pioneers, enthusiasts, and engineers were often so moved by the premises of science fiction and other imaginative works that they would actively seek to realize them. Goddard gave his life to the pursuit; American enthusiasts fostered communities of like-minded innovators and popularized space travel; and the GALCIT team built on these foundations, progressing the technology while hearkening back to its fantastical origins, and setting the stage for advancements later necessary for spaceflight. The examples in this chapter indicate that imaginative works conveyed a potent, organizing idea—the dream of spaceflight—and furnished individuals an objective around which their efforts and purposes could be shaped. By serving as the point of reference for many of America's earliest rocket developers, imaginative works had factored in significantly to the work of those paving the road toward space travel.

2. BRINGING THE THREADS TOGETHER (1943–1969)

By 1943, enthusiasts, innovators, and engineers had effected rocketry's most crucial transformations. Rocketry became a priority of the United States' armed forces as research centers produced jet assisted take-off (JATO) units to improve combat aircraft with the American entry into World War II. This technology had in different ways drawn on work done decades earlier and had its roots in an imaginative vision of spaceflight. Some of the most ardent space travel enthusiasts and experimenters, building on the work of the pioneers, had paved the road toward making rocketry practical, so that when the time came for the United States to employ this technology to reach space, the foundations, engineering, and understanding of rocketry had been set firmly in place.

This chapter will investigate the imaginative roots of the rocket technology pursued and built by the United States from 1943 onwards, arguing that this technology was bound to the dreams of science fiction, the pioneers of astronautics, and their inspired disciples, by threads of imagination which, when traced, reveal an enmeshment of imaginative inspiration and practical application. While American military interest in large missiles made possible the technologies that would breach space, these rockets still relied on the ideas and expertise of individuals variously inspired by works of imagination, whose contributions laid the groundwork for successive technological iteration and development. The American space program to which these technologies were later applied, at least in part, was also defined by ideas dating back as far as the 19th century, whose 20th century manifestations were expressed by the agents of the human space travel vision. Their visions of a comprehensive and attainable framework for human spaceflight also provided inspiration and guidance for engineers, decisionmakers, and the public on the eve of spaceflight's advent.

THE ADVENT OF THE V-2 ROCKET AND THE BIRTH OF THE JET PROPULSION LABORATORY

In the United States, the first moves toward adopting the technology of later space boosters began with the appearance of a weapon unlike any other. In 1943, intelligence reports of German

military installations provoked consternation amidst the United States Army Air Forces.[215] British Intelligence photographs of missile installations in France sent to the Air Materiel Command Experimental Engineering division in Dayton, Ohio indicated that Nazi Germany was developing rocket missiles, and was "the first tangible proof," as von Kármán put it, "that Germany was doing something with large and novel missiles."[216] Rumours of German rocket research had circulated as early as 1939 which—with the German occupation of Czechoslovakia—had given urgency to GALCIT's Air Corps Jet Propulsion Research Project.[217] These reports, however, now gave the GALCIT project, as Malina recounted later, a "new impetus" in 1943.[218]

Having previously felt little need to invest in large-scale missile technology on account of a well-developed air combat capacity, these intelligence reports prompted a near-immediate response in the United States.[219] In September 1943, Army Ordnance established a rocket development division, and Malina and Hsue-Shen Tsien were urged by Army Air Forces (AAF) Materiel Command Liaison Officer at Caltech, Colonel W. H. Joiner, to investigate the possibilities of long-range projectiles and see if they could build something to match the specifications of the reported German missile, the V-2 (Vergeltungswaffe 2).[220] While present engines could not meet the reported 160.9 km/100 mi range of the V-2, Malina and Tsien believed that the JATO engine work already conducted provided a good basis for the development of long-range missiles, which were well within the realm of technical feasibility by this point.[221] The GALCIT rocket team, which had seven years previously begun investigating rocketry as a result of inspirational ideas found in science fiction and

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[215] Koppes, *JPL*, 18.
[216] Koppes, *JPL*, 18; Gorn, *The Universal Man*, 94. Quote from: Von Kármán with Edson, *The Wind and Beyond*, 264.
[217] Gorn, *The Universal Man*, 84-85.
[218] Quote from: Malina, "Origins," 60; see also: Peter J. Westwick, *Into the Black: JPL and the American Space Program, 1976-2004* (New Haven & London: Yale University Press, 2007), 1-2.
[219] Koppes, *JPL*, 18.
[220] Gorn, *The Universal Man*, 95; Malina, "Origins," 60; Koppes, *JPL*, 18; Von Kármán with Edson, *The Wind and Beyond*, 264. Vergeltungswaffe translates to "vengeance weapon." The V-2 was also known as the Aggregat-4 (A-4).
[221] Koppes, *JPL*, 18-19; Williamson and Launius, "Rocketry and the Origins of Space Flight," 44.

the work of the pioneers of rocketry, would now draw on expertise garnered, in part, by striving to realize the visions on offer by works of imagination.[222] The concomitant flourishing of engineering interest in rocketry, an effect of their expanded activities and wartime support—which saw the GALCIT rocket project expand to 85 employees with numerous facilities in Pasadena by 1943—had also made it possible for military forces to rely on the research center.[223]

Malina and Tsien conducted a study on the possibilities of long-range rockets and forwarded it along with a memorandum written by von Kármán to Col. Joiner and Captain Robert Staver of Army Ordnance.[224] The 20 November 1943 report was designated JPL-1, referring to and bringing into being the Jet Propulsion Laboratory, which would become the United States' first major center for space research and long-range missile development.[225] On the basis of Malina and Tsien's study, von Kármán proposed a phased research program to develop a capacity for long-range missiles.[226] Although the AAF did not pick up on the JPL-1 proposal straight away, because it offered little in the way of immediate results, in January 1944 Army Ordnance requested that JPL pursue a program for the development missiles with a range of 241.4 km/150 mi, accurate to within 4.8 km/3 mi of a target, and fitted for a payload of 453.59 kg/1000 lbs, leading to a contract for rocket missiles between the Ordnance Department and Caltech called ORDCIT, the first American research program for long-range rocket missiles.[227] Colonel Gervais W. Trichel, assistant to the chief of Army Ordnance, then asked GALCIT to develop a comprehensive research project, offering $3 million in

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[222] Hunley, *Propulsion Technology*, 17.
[223] Gorn, *The Universal Man*, 94.
[224] Koppes, *JPL*, 19; Malina, "Origins," 60; Gorn, *The Universal Man*, 95.
[225] Koppes, *JPL*, 18; Malina, "Origins," 60; Von Kármán with Edson, *The Wind and Beyond*, 265; Gorn, *The Universal Man*, 95.
[226] Koppes, *JPL*, 18-19.
[227] Koppes, *JPL*, 19-21; Gorn, *The Universal Man*, 95; Von Kármán with Edson, *The Wind and Beyond*, 265; Malina, "A Memoir," 196; Gainor, *To a Distant Day*, 132. JPL worked on numerous projects during this time, but ORDCIT received the lion's share of attention. See: Koppes, *JPL*, 21-22.

funding to develop working prototypes of guided missiles.[228] With this, major large-scale rocket missile development in the United States had begun.

Accommodating the ORDCIT project entailed a reorganization and expansion of GALCIT into the Jet Propulsion Laboratory, which officially came into being on 1 July 1944.[229] JPL's facilities expanded, and the laboratory conducted investigations into a range of projects, with a primary focus on the guided missile work for the ORDCIT project.[230] The laboratory began with a solid-fuel rocket called Private A, which utilized an Aerojet engine and GALCIT 61-C propellant—a derivative of GALCIT 53—and was based on Malina and Tsien's studies in their JPL-1 report.[231] Successful launches of the unguided Private A missile in December 1944 provided JPL engineers a wealth of technical information and represented "the laboratory's first success with real rocket flight."[232] Although the winged projectile called Private F did not perform satisfactorily in 1945, JPL had already turned their attention to the Corporal rocket.[233] Being that the Corporal was a more intricate offering, Malina suggested building a smaller liquid-fuel sounding rocket first, the WAC Corporal, an idea he had after examining German military installations in France during a mission for Ordnance in December 1944.[234] This rocket project resurrected the "original dream" of the 1936 GALCIT Rocket Research Group—building a sounding rocket capable of reaching space.[235]

For the military services, however, nowhere was spaceflight a guiding rationale for the support afforded to the development of this technology.[236] In September 1944, General Henry H.

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228 Koppes, *JPL*, 19-20; Gorn, *The Universal Man*, 95; Malina, "Origins," 60.
229 Koppes, *JPL*, 20-21; Westwick, *Into the Black*, 2; Gorn, *The Universal Man*, 95; Malina, "Origins," 61.
230 Koppes, *JPL*, 18-19, 21-22; Malina, "Origins," 60-61.
231 Koppes, *JPL*, 13, 22; Heppenheimer, *Countdown*, 43.
232 Quote from: Koppes, *JPL*, 22; Malina, "Origins," 62-63.
233 Koppes, *JPL*, 22-23; Malina, "Origins," 63.
234 Koppes, *JPL*, 22-23; Malina, "Origins," 63. WAC stood either for "Women's Auxiliary Corps" (because the missile was considered the Corporal's "little sister") or for "Without Attitude Control," a proper technological reference. See: Koppes, *JPL*, 23.
235 Koppes, *JPL*, 22-23; Malina, "Origins," 63; Von Kármán, *The Wind and Beyond*, 265. See also: Malina, "A Memoir," 154.
236 Siddiqi, *Red Rockets' Glare*, 196.

Arnold of the Army Air Corps, concerned with the future of aerial combat and retaining U.S. air supremacy, requested that von Kármán organize a study to consider the scope, possibilities, and requirements of air power technology for the AAF generations into the future.[237] That same month, V-2 rockets were launched against London and Paris from sites in the Ardennes and Holland.[238] To fulfill the General's request, Von Kármán temporarily left JPL that year to form the Army Air Forces Scientific Advisory Group, and by late 1945 the group produced a multivolume report entitled *Toward New Horizons*.[239] Von Kármán's introductory essay urged the development of new aircraft, ballistic missile technology, and even suggested that, "in the case of the rocket ship," with the appropriate propellant and great amounts of exhaust velocity, rocket navigation and "the 'satellite' is a definite possibility."[240] While the report did not mention what sort of satellite this might be, in the February and October 1945 issues of *Wireless World* magazine, science fiction author Arthur C. Clarke had advanced, for the first time, the idea of communications satellites, and he believed they could be launched by V-2 rockets.[241]

The advent of the V-2 had indicated to American military services that advanced rocketry pointed the way to future combat supremacy, catalyzing major investigations into large missile technology in the country and sparked talk of space technologies. Importantly, the V-2 possessed, according to historian Michael J. Neufeld, "utopian origins in the [German] spaceflight movement of the 1920s," and it was at the height of this movement that German Army Ordnance pursued a

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[237] Michael H. Gorn, "Introduction: The Marriage of Science to Air Power," introduction to *Prophecy Fulfilled: "Toward New Horizons" and Its Legacy*, ed. Michael H. Gorn (Washington, D.C.: Air Force History and Museums Program, 1994), 2-3, https://apps.dtic.mil/sti/citations/ADA305537; Von Kármán with Edson, *The Wind and Beyond*, 267-269; Malina, "Origins," 61.
[238] Michael J. Neufeld, "Hitler, the V-2, and the Battle for Priority, 1939-1943," *The Journal of Military History* 57, no. 3 (July 1993): 536; Neufeld, *Von Braun*, 184.
[239] Gorn, "Marriage of Science to Air Power," 11; Von Kármán with Edson, *The Wind and Beyond*, 269, 290; Gainor, "Atlas and the Air Force," 350; Malina, "Origins," 61.
[240] Quotes from: AAF Scientific Advisory Group, *Science, the Key to Air Supremacy*, in *Prophecy Fulfilled: "Toward New Horizons and Its Legacy*," ed. Michael H. Gorn (Washington, D.C.: Air Force History and Museums Program, 1994), 124; Gorn, "Marriage of Science to Air Power," 12; Koppes, *JPL*, 21; Gainor, "Atlas and the Air force," 350.
[241] Gainor, *To a Distant Day*, 146; Crouch, *Aiming for the Stars*, 281; Megan Prelinger, *Another Science Fiction: Advertising the Space Race, 1957-1962* (New York: Blast Books, 2010), 30; Winter, *Rockets into Space*, 54-55.

missile development program.[242] The V-2 was built first as a weapon for Hitler, but its latent enthusiast underpinnings exerted an indirect influence on American rocketry by catalyzing, in part, interest in, and commitments to, larger missile development efforts in the United States.[243]

GERMAN SPACEFLIGHT ENTHUSIASM

The origins of widespread spaceflight enthusiasm in Germany can be traced back to Jules Verne's *De la Terre à la Lune* (1865) and its sequel, *Autour de la Lune* (1869). In the winter of 1905-1906, these space travel stories inspired an 11 year-old Hermann Oberth to consider the possibilities of space travel and rocket propulsion.[244] Dedicated to unravelling the problems of spaceflight, his later efforts were eventually compiled and presented in a book entitled *Die Rakete zu den Planetenräumen* which appeared in 1923 and, according to Oberth, "fulfilled its purpose" by stimulating public interest in the topic.[245] Where Goddard had been conservative in "A Method," Oberth went much further, and suggested that with technological advancement, building devices capable of reaching orbit *and* taking humans with them would be possible, and that under the right economic conditions, such devices could even finance themselves.[246] Oberth considered vehicle designs, liquid-propellant rocket staging, space stations, space missions, the effects of spaceflight, and stressed, as Winter has written, "the technological *feasibility* of space flight."[247] Like Goddard, Oberth had become an agent of a spaceflight vision, translating imaginative ideas into a technical investigation that served as a basis for the nascent fields of rocketry and astronautics.

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[242] Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (Cambridge, Massachusetts: Harvard University Press, 1995), 1, 5-6, quote from 1. See also: Bainbridge, *Spaceflight Revolution*, 51, also cited by Winter, *Prelude*, 113; Winter, *Prelude*, 14; and Neufeld, "Weimar Culture and Futuristic Technology," 751-752.
[243] Clary, *Rocket Man*, 220.
[244] Oberth, "My Contributions to Astronautics," 129-130. Oberth was also inspired to seize on the idea of rockets due to Verne's use of them in his story, to steer his astronauts through space and to land on the Moon. See: Jules Verne, *From the Earth to the Moon, Direct in Ninety-Seven Hours and Twenty Minutes: And a Trip Round It*, trans. Louis Mercier and Eleanor E. King (New York: Scribner, Armstrong & Company, 1874), 105, 293-297, https://archive.org/details/FromEarthMoon00Vern; Miller, "Spaceflight and Popular Culture," 506.
[245] Oberth, "My Contributions to Astronautics," 130, quote from 136.
[246] Neufeld, *Von Braun*, 24; Winter, "The Silent Revolution," 49.
[247] Neufeld, *Von Braun*, 24; Gainor, *To a Distant Day*, 57-58; quote from: Winter, "The Silent Revolution," 49.

Oberth's work enjoyed especial popularity in the 1920s and inaugurated what Winter has considered to constitute a spaceflight revolution, as much like Goddard, Oberth's application of a rocket to spaceflight was an inherently revolutionary idea, and one of his most important contributions.[248] Oberth's book, Weimar Germany's receptiveness to new technological ideas during the 1920s, and German nationalism all contributed to foster a widespread rocket fad in the 1920s, one also spurred on by popularizers and publicists.[249] Austrian Air Force pilot Max Valier, who was among the first to take Oberth's ideas seriously, became one such popularizer.[250] Valier encountered *Die Rakete* in a bookshop in 1924, and Oberth's propositions of manned spaceflight seemed to offer a means of unlocking the mysteries of the heavens, aligning well with Valier's own fascination with astronomy and cosmogony.[251] Committing himself to popularize Oberth's ideas, Valier produced *Der Vorstoß in den Weltenraum, eine Technische Möglichkeit* (*The Advance into Space, a Technical Possibility*) in 1924, wherein he summarized, for general audiences, Oberth's space travel ideas and his own, and even included references to Jules Verne.[252] Valier's book was successful enough to produce five printings between 1925 and 1929, and helped sell out Oberth's *Die Rakete*, prompting reprints.[253] With Valier's popularization efforts, the space travel by rocket idea, oftentimes a subject of skepticism, began to flourish in the German popular imagination.[254]

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[248] Winter, "The Silent Revolution," 1, 48-49.
[249] Neufeld, "Weimar Culture and Futuristic Technology," 745; Neufeld, *The Rocket and the Reich*, 5, 8; Neufeld, *Von Braun*, 25; Winter, "The Silent Revolution," 49; Jared S. Buss, *Willy Ley: Prophet of the Space Age* (Gainesville: University Press of Florida, 2017), 41.
[250] I. Essers, *Max Valier: A Pioneer of Space Travel*, NASA Technical Translation F-664 (Washington D.C.: National Aeronautics & Space Administration, 1976), iv. Translation of *Max Valier. Ein Vorkampfer der Weltraumfahrt, 1895-1930* (Düsseldorf: VDI-Verlag GMBH, 1968). Page numbers refer to the 1976 translation, https://archive.org/details/nasa_techdoc_19770006050; Neufeld, *Von Braun*, 25; Neufeld, "Weimar Culture and Futuristic Technology," 730.
[251] Essers, *Max Valier*, 1-2, 17, 56-59. Valier hoped, in part, to realize spaceflight as a means of investigating a pseudo-scientific theory called 'glacial cosmogony,' otherwise known as the 'World Ice Doctrine.' The doctrine, developed by Austrian engineer Hanns Hörbiger and high school teacher Philipp Fauth, posits that ice underlies absolutely all changes in the observable universe. See: Essers, *Max Valier*, 25-28, 33; Buss, *Willy Ley*, 36; Willy Ley, Appendix to *Watchers of the Skies: An Informal History of Astronomy from Babylon to the Space Age* (New York: The Viking Press, 1963), 514-516.
[252] Neufeld, *Von Braun*, 25; Essers, *Max Valier*, 57-60, 75-78; Gainor, *To a Distant Day*, 60.
[253] Winter, "The Silent Revolution," 49; Neufeld, "Weimar Culture and Futuristic Technology," 730.
[254] Neufeld, "Weimar Culture and Futuristic Technology," 730; Gainor, *To a Distant Day*, 60-61.

Der Vorstoß also introduced Willy Ley—who would become, according to Buss, "the most important publicist of the American Space Age"—to Oberth's theories of spaceflight in 1925, prompting Ley to seek out *Die Rakete* after encountering Valier's book.[255] Dissatisfied with Valier's popular treatment of the book, Ley wrote his own more accurate complement to *Die Rakete* for general audiences, entitled *Die Fahrt ins Weltall*, which appeared in 1926.[256] Ley later joined Valier and others in forming the Verein für Raumschiffahrt (The Society for Space Travel, or VfR), which came into being on 5 July 1927 with the express purpose of championing Oberth's ideas.[257] In addition to disseminating the idea of space travel, their aims included pursuing projects meant to eventually culminate in the construction of a spaceship, which in 1930 began as amateur rocket experiments.[258] These projects also revealed the Society's ties to science fiction. Their experimental liquid-fuel rockets, formerly called "Miraks,"[259] were later renamed "Repulsors" by Ley, directly referencing Laßwitz's science fiction novel *Auf Zwei Planeten*, wherein intelligent Martian beings employ a substance called "Repulsit" to travel through space.[260]

By the late 1920s, the German spaceflight movement had gained serious momentum. Valier collaborated with Fritz von Opel of Opel Automobile manufacturing fame and engineer Friedrich W. Sander to build a series of rocket cars for publicity stunts, which, in 1928, garnered a great deal of attention in the country.[261] While Opel was mostly concerned with his celebrity and good press

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[255] Buss, *Willy Ley*, 29, quote from 9; Jared S. Buss, "Virtual witnessing and space-age media: a case study of *The Conquest of Space* (1949)," *History and Technology* 31, no. 2 (June 2015): 164-165.
[256] Buss, *Willy Ley*, 30-31.
[257] Buss, *Willy Ley*, 35-36; Winter, *Prelude*, 35; Tom D. Crouch, "Willy Ley: Chronicler of the Early Space Age," in *Realizing the Dream of Flight: Biographical Essays in Honor of the Centennial of Flight, 1903-2003*, ed. Virginia P. Dawson and Mark D. Bowles (Washington, D.C.: National Aeronautics and Space Administration, NASA History Division, Office of External Relations, 2005), 157.
[258] Winter, *Prelude*, 35-37; Buss, *Willy Ley*, 37.
[259] For "minimum rocket." See: Winter, *Prelude*, 40.
[260] Kurd Lasswitz, *Two Planets* (*Auf Zwei Planeten*), abr. Erich Lasswitz, trans. Hans H. Rudnick (1897; Carbondale and Edwardsville: Southern Illinois University Press, 1971), 75; Willy Ley, *Rockets, Missiles, and Space Travel*, rev. ed. (New York: The Viking Press, 1961), 48, 148; Neufeld, *Von Braun*, 47; Neufeld, *The Rocket and the Reich*, 15.
[261] Essers, *Max Valier*, 141, 141n; Buss, *Willy Ley*, 39-41; Neufeld, "Weimar Culture and Futuristic Technology," 733; Winter, *Prelude*, 51.

for his automobile enterprise, Valier hoped to communicate to the public the power of rocketry in the hopes of opening the way to space travel.[262] At the height of the movement in 1929, rocket power was demonstrated more dramatically in German director Fritz Lang's film, *Frau im Mond* (*Woman in the Moon*), based on a novel and screenplay penned by Lang's wife, Thea von Harbou.[263] Oberth and Ley served as technical consultants on the picture, and Lang even asked Oberth to construct a working rocket for the film's premiere.[264] Although the rocket project did not come to fruition, the film attracted interest for its realistic and plausible portrayal of future possibilities, allowing audiences to glimpse how a multi-stage rocket might carry humans into space.[265]

All of these elements of space travel and rocket enthusiasm combined to turn minds to consider the potential of the technology. The rocket stunts, for example, convinced a young Wernher von Braun, who would one day become the technical director of the German Army Ordnance rocket project and the director of NASA's Marshall Space Flight Center, to pursue rocketry as a career.[266] Von Braun's obsession with space travel began when he purchased a copy of Oberth's *Die Rakete* in 1925 after encountering an advertisement for the book in a magazine.[267] To understand the technical elements of Oberth's book, von Braun dedicated himself to excelling in mathematics and physics, previously his worst subjects, in service of his burgeoning spaceflight dreams.[268] Still somewhat undecided on the shape of his future, it was not until 1928 that von Braun knew he wanted nothing else than to realize spaceflight after witnessing an Opel rocket car stunt in

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[262] Neufeld, *Von Braun*, 30; Buss, *Willy Ley*, 42; Essers, *Max Valier*, 141n, 150-151; Neufeld, "Weimar Culture and Futuristic Technology," 733.
[263] Neufeld, "Weimar Culture and Futuristic Technology," 738; Buss, *Willy Ley*, 46-47.
[264] Neufeld, *Von Braun*, 38; Neufeld, *The Rocket and the Reich*, 11; Winter, *Prelude*, 38; Buss, *Willy Ley*, 48-50; Crouch, "Willy Ley: Chronicler," 157.
[265] Neufeld, "Weimar Culture and Futuristic Technology," 738, 740; Buss, *Willy Ley*, 47-52; Neufeld, *The Rocket and the Reich*, 12; Ley, *Rockets, Missiles, and Space Travel*, 124; *Woman in the Moon*, directed by Fritz Lang (Berlin, Germany: UFA GmbH, 1929), Kanopy, https://www.kanopy.com/product/woman-moon.
[266] Neufeld, *Von Braun*, 30-31; Hunley, *Propulsion Technology*, 13.
[267] Neufeld, *Von Braun*, 21, 24-25; Hunley, *Propulsion Technology*, 13.
[268] Neufeld, *Von Braun*, 22, 33-34; Hunley, *Propulsion Technology*, 13-14.

April, which eliminated all doubt in his mind about dedicating himself to his dream.[269] With the help of Ley, von Braun joined the VfR and conducted basic rocket work at the Raketenflugplatz in the 1930s during his spare time while an apprentice at the Borsig engineering works.[270]

MISSILE DEVELOPMENT IN NAZI GERMANY

At the height of the rocket fad, the potential of rocketry also caught the attention of the German military.[271] The military implications of rocketry were perhaps clear in the 1920s—not even Oberth had shied away from discussing them in his 1929 book, *Wege zur Raumschiffahrt*, wherein he considered the possibility of using a rocket to deliver explosives or poison gas to an enemy target.[272] While Oberth considered the latter impractical, Lieutenant Colonel Karl E. Becker of ballistics and munitions in Army Ordnance sought to employ black-powder solid-fuel rockets as low-cost chemical weapons, hoping to establish them as precursors to liquid-fuel ballistic missiles.[273] Becker's interest in rocketry had long roots. Having worked on the Paris Gun in 1918, a heavy artillery gun that fired projectiles at a range of 128.74 km/80 mi, Becker looked for something more powerful as Germany began to make moves toward rearmament in the 1930s.[274] Moreover, Becker had in 1926 studied under Professor Julius Cranz, and helped edit *Lehrbuch der Ballistik* (*Textbook of Ballistics*), which included a review of Oberth's *Die Rakete* and Goddard's 1919 treatise, "A Method."[275] His longstanding interest in long-range artillery, his desire for something more powerful than the Paris Gun, and his familiarity with rocketry dovetailed with the German rocket enthusiasm that caught his

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269 Neufeld, *Von Braun*, 21, 26-27, 29-31, 32, 47.
270 Neufeld, *Von Braun*, 35, 42-43, 47-48; Buss, *Willy Ley*, 60; Winter, *Prelude*, 39; McCurdy, *Space and the American Imagination*, 25.
271 Winter, *Prelude*, 51.
272 Neufeld, *Von Braun,* 34. Oberth had also considered the use of a giant space mirror to focus sunlight on enemy targets in *Die Rakete zu den Planetenräumen.* See: Buss, *Willy Ley*, 30; Neufeld, *Von Braun*, 24; Michael J. Neufeld, "'Space Superiority': Wernher von Braun's campaign for a nuclear-armed space station, 1946-1956," *Space Policy* 22, no. 1 (February 2006): 53.
273 Neufeld, *Von Braun*, 50-51; Neufeld, *The Rocket and The Reich*, 8.
274 Neufeld, *Von Braun*, 82; Neufeld, *The Rocket and the Reich*, 16; Crouch, *Aiming for the Stars*, 73.
275 Neufeld, *The Rocket and the Reich*, 9; Winter, *Rockets into Space*, 45; Crouch, *Aiming for the Stars*, 73.

attention.[276] By 1929 Becker was more seriously investigating the possibilities of this increasingly visible technology with the help of artillery veteran Walter R. Dornberger.[277] Rockets also went unmentioned in the Treaty of Versailles, which had majorly restricted weapons development in Germany after World War I, making rocket weapons especially attractive to develop in the eyes of authorities like Becker.[278] While Hitler railed on about regaining military might, the Army's priority was developing a weapon of great power as it took its steps toward rearmament.[279]

In 1932, Becker received an offer from VfR member Rudolf Nebel—whom Becker had previously assisted in attempting to finish Oberth's failed sounding rocket for *Frau im Mond*, and in acquiring the grounds for the Raketenflugplatz—to arrange a demonstration of a VfR rocket launch and recovery before army authorities to win funding.[280] Seeking reliable developers of liquid-fuel rockets, Becker accepted.[281] The secret demonstration at the Army's Kummersdorf weapons range was conducted unbeknownst to the VfR's board of directors, and with only a select few members, including von Braun, but ended up a failure.[282] Ordnance thus decided to continue independently, but still drew on the expertise and talent of the VfR.[283] Von Braun especially had caught the attention of Ordnance authorities, specifically Dornberger's, and was offered a job with the Army in 1932, granting the space-dreamer an opportunity to build rockets with military funding for military

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[276] Winter, *Rockets into Space*, 45; Neufeld, *The Rocket and the Reich*, 3, 6-7.
[277] Bainbridge, *The Spaceflight Revolution*, 51; Neufeld, *The Rocket and the Reich*, 7-9; Neufeld, "Hitler, the V-2, and the Battle for Priority," 514; Winter, *Rockets into Space*, 46-48; Neufeld, *Von Braun*, 50-51, 81-82.
[278] Neufeld, *Von Braun*, 50; Neufeld, *The Rocket and the Reich*, 6; Winter, *Prelude*, 51; Crouch, *Aiming for the Stars*, 73.
[279] Neufeld, *Von Braun*, 50-51; Neufeld, *The Rocket and the Reich*, 6; Winter, *Prelude*, 51.
[280] Neufeld, *The Rocket and the Reich*, 13-14, 18-19; Neufeld, *Von Braun*, 38-39, 42-43, 50-51; Buss, *Willy Ley*, 48, 64-65; Winter, *Prelude*, 38-39, 52-53.
[281] Neufeld, *Von Braun*, 51; Bainbridge, *The Spaceflight Revolution*, 52; Neufeld, *The Rocket and the Reich*, 19.
[282] Neufeld, *Von Braun*, 51-53; Buss, *Willy Ley*, 65; Winter, *Prelude*, 53; Neufeld, *The Rocket and the Reich*, 20; Crouch, *Aiming for the Stars*, 74-75.
[283] Neufeld, *The Rocket and the Reich*, 20-21.

purposes.[284] Largely apolitical, yet not without conservative-nationalist leanings, an opportunistic and naïve von Braun accepted, and soon applied his efforts to develop the Army's superweapon.[285]

With the assistance of von Braun, the Army's work toward the development of a long-range liquid-fuel ballistic missile commenced, and by 1933, Ordnance began to suffocate spaceflight societies like the VfR in order to exercise a monopoly over rocket development and maintain secrecy around rocketry, as the Army hoped to utilize rockets as surprise weapons.[286] The project at Kummersdorf was moved to the remote village of Peenemünde on the Baltic island of Usedom in 1937 to expand the project and develop a larger facility with the cooperation of the Luftwaffe.[287] Old enthusiasts and former VfR members were brought into the fold for the missile projects, which accelerated with the outbreak of war in 1939.[288] With the missile project under the technical directorship of von Braun, Peenemünde engineers produced the Aggregat-4 (the technical name for the V-2), which flew successfully on 3 October 1942 bearing a *Frau im Mond* logo on its fuselage.[289]

Some limited spaceflight enthusiasm still bubbled under the surface at Peenemünde, although it remained solely a Third Reich installation. Von Braun, for example, was central to the development of the V-2, and as an agent of the spaceflight vision, his efforts were primarily the products of his space travel enthusiasm.[290] Dornberger had also grown increasingly enthusiastic about space travel.[291] Moreover, Walter Thiel, a former member of the VfR, whose ideas were shaped by Oberth's *Die Rakete* and *Wege*, also helped make significant progress in the propulsion

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[284] Neufeld, *Von Braun*, 52-53; Neufeld, *The Rocket and the Reich*, 22-23; Winter, *Prelude*, 53; Winter, *Rockets into Space*, 46.
[285] Neufeld, *Von Braun*, 48, 54-55; Neufeld, *The Rocket and the Reich*, 22; Winter, *Prelude*, 44; Hunley, *Propulsion Technology*, 14.
[286] Neufeld, *Von Braun*, 56-58, 64-67; Neufeld, *The Rocket and the Reich*, 23-32; Buss, *Willy Ley*, 65-68; Winter, *Prelude*, 48-49, 53; Crouch, "Willy Ley: Chronicler," 158.
[287] Neufeld, *Von Braun*, 78-81, 84-86; Neufeld, *The Rocket and the Reich*, 48-51, 54-55, 57; Neufeld, "Hitler, The V-2, and the Battle for Priority," 514-515.
[288] Neufeld, *Von Braun*, 86-89; Neufeld, *The Rocket and the Reich*, 48-51, 54-57; Winter, *Prelude*, 53; Launius and Jenkins, *Coming Home*, 11; Neufeld, "Hitler, the V-2, and the Battle for Priority," 515-516.
[289] Neufeld, *Von Braun*, 88-89, 93, 135-136; Neufeld, *The Rocket and the Reich*, 164; Winter, *Prelude*, 54.
[290] Neufeld, *Von Braun*, 92-93, 124; McCurdy, *Space and the American Imagination*, 25; Hunley, *Propulsion Technology*, 15.
[291] Winter, *Prelude*, 54; Neufeld, *Von Braun*, 137; Neufeld, "Creating a Memory," 73; Bainbridge, *The Spaceflight Revolution*, 54; Neufeld, *The Rocket and the Reich*, 9.

systems for the V-2.[292] According to Neufeld, however, while spaceflight enthusiasm had some role to play at Peenemünde, many of the engineers recruited to the rocket project after 1938 "had little or no previous exposure to rocketry,"[293] and spaceflight simply did not factor into their motivations, even if it was a subject of fascination.[294] Those that expressed strong spaceflight ambitions, like von Braun, were likely unique among the pack.[295] Moreover, the A-4/V-2, ultimately, was never meant to reach space; it was a weapon designed for Hitler.[296]

We must also examine the development and motivations undergirding the V-2 critically, for not only was it an instrument of the Nazi war machine, but by 1943 the missile was in large part manufactured by use of slave labour.[297] In addition to labour shortages on account of the war, Hitler had come to rest his hopes on the V-2 as a wonder-weapon, leading to an unrealistic demand for missile production as the tide of war turned against the Nazis.[298] Following the first Allied air raid on Peenemünde in 1943, production moved to the Mittelwerk underground factory where the SS forced sixty-thousand slave labourers from the Mittelbau-Dora concentration camp to construct jet engines, the V-1, and the V-2, and by war's end over twenty-thousand labourers had faced death by disease, exhaustion, torture, or execution at the hands of the Nazis.[299] Much has been written on the

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[292] Hunley, *Propulsion Technology*, 103; Neufeld, *Von Braun*, 85; Neufeld, *The Rocket and the Reich*, 74-76, 78; Karen Thiel and Olaf Przybilski, "Walter Thiel—Short life of a rocket scientist," *Acta Astronautica* 91 (October-November 2003): 302-303, 308.
[293] Neufeld, *The Rocket and the Reich*, 219.
[294] Neufeld, *Von Braun*, 125.
[295] Michael J. Neufeld, "Creating a Memory of the German Rocket Program for the Cold War," in *Remembering the Space Age: Proceedings of the 50th Anniversary Conference*, ed. Steven J. Dick (Washington, D.C.: National Aeronautics and Space Administration, Office of External Relations, History Division, 2008), 73, https://history.nasa.gov/Remembering_Space_Age.pdf
[296] Neufeld, "Creating a Memory," 73.
[297] Neufeld, *Von Braun*, 143-145; Gretchen Schafft and Gerhard Zeidler, *Commemorating Hell: The Public Memory of Mittelbau-Dora* (Urbana, Chicago, and Springfield: University of Illinois Press, 2011), ix, 19-22.
[298] Schafft and Zeidler, *Commemorating Hell*, 22-24; Neufeld, *Von Braun*, 142-143, 152, 181; Neufeld, *The Rocket and the Reich*, 169-170, 191-193, 208; Heppenheimer, *Countdown*, 24-26.
[299] Neufeld, "Hitler, The V-2, and the Battle for Priority," 536; Schafft and Zeidler, *Commemorating Hell*, ix, 2, 19-21, 24-27, 35-36; Monique Laney, *German Rocketeers in the Heart of Dixie: Making Sense of the Nazi Past During the Civil Rights Era* (New Haven and London: Yale University Press, 2015), 147-148; Yves Béon, *Planet Dora: A Memoir of the Holocaust and the Birth of the Space Age*, ed. Michael J. Neufeld, trans. Yves Béon and Richard L. Fague (Boulder, Colorado: Westview Press, 1997), 18-19; Neufeld, *Von Braun*, 143-145, 160-162; Neufeld, *The Rocket and the Reich*, 209-213; Gainor, *To a Distant Day*, 82-83. Hundreds of forced labourers—POWs and labourers from occupied countries—had also been forced to work in

involvement and the responsibility of the engineers working at Peenemünde, and no matter the levels of their involvement, that slave labour was used to build V-2s undeniably casts a shadow across their work.[300] Some engineers were more enthusiastic about the Third Reich,[301] and authorities, like Dornberger, actively assented to slave labour for missile production.[302] Furthermore, most engineers at Peenemünde generally seemed unbothered by building missiles for the Nazi machine, even when its most brutal aspects were at work.[303] Von Braun especially appeared to be determined to build rockets no matter the cost. Despite holding no strong ideological convictions, he had joined the Nazi party in 1937 when pressed, became an officer of the SS in 1940 to advance his career, and knew that the V-2 was built using slave labour, having seen Mittelwerk conditions, yet continued with his work.[304] He had "essentially made a pact with the devil in order to build large rockets,"[305] becoming, as Neufeld has put it, "a twentieth-century Faust."[306]

The technological achievement that was the V-2 rocket had come at a terrible price, claiming lives both in its construction and deployment.[307] A tool of the Nazi machine, the V-2 had yet come

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Peenemünde previous to 1943. After production was scaled up, the numbers of slave labourers increased dramatically and were put under SS management. See: Shafft and Zeidler, *Commemorating Hell*, 23; Laney, *German Rocketeers*, 147; Neufeld, *Von Braun*, 143; Neufeld, *The Rocket and the Reich*, 184-185.

300 See: Neufeld, *Von Braun*, 5, 159-166; Neufeld, *The Rocket and the Reich*, 212-213, 219; Neufeld, "Creating a Memory," 80; Winter, *Prelude*, 53-54; Laney, *German Rocketeers*, 4, 145, 151-155, esp. chpt. 6; Schafft and Zeidler, *Commemorating Hell*, 91-92, 114, 164-165; Michael J. Neufeld, "Introduction: Mittelbau-Dora—Secret Weapons and Slave Labour," introduction to *Planet Dora: A Memoir of the Holocaust and the Birth of the Space Age*, by Yves Béon, ed. Michael J. Neufeld, trans. Yves Béon and Richard L. Fague (Boulder, Colorado: Westview Press, 1997); Crouch, *Aiming for the Stars*, 90; Catherine L. Newell, *Destined for the Stars: Faith, the Future, and America's Final Frontier* (Pittsburgh, PA: University of Pittsburgh Press, 2019), 187.

301 An example includes engineer Arthur Rudolph, production manager at Mittelbau-Dora who had recommended the use of forced labour and, later, concentration camp labour. Rudolph was later the project manager of the Saturn V in the U.S. See: Schafft and Zeidler, *Commemorating Hell*, 114, 165; Laney, *German Rocketeers*, 4, 145, 151-159, esp. ch. 6; Neufeld, introduction to Béon, *Planet Dora,* xi-xii, xv-xvi, xxv-xxvi; Neufeld, *The Rocket and the Reich*, 184. There were other engineers enthusiastic about the Third Reich. See: Neufeld, "Creating a Memory," 80.

302 Neufeld, "Hitler, the V-2, and the Battle for Priority," 533-534; Neufeld, *Von Braun*, 141-144, 162; Neufeld, *The Rocket and the Reich*, 212-213.

303 Neufeld, *The Rocket and the Reich*, 2018, 219; Neufeld, *Von Braun*, 5; Newell, *Destined for the Stars*, 187.

304 Neufeld, "Creating a Memory," 76; Neufeld, *Von Braun*, 120-122, 143-144, 160-163; Neufeld, *The Rocket and the Reich*, 215; Crouch, *Aiming for the Stars*, 90; Newell, *Destined for the Stars*, 189-190; Laney, *German Rocketeers*, 151. Von Braun had held a brief membership with an SS cavalry unit and riding club in 1933-1934. He was readmitted to the SS in 1940 as an officer. See: Neufeld, "Creating a Memory," 76.

305 Neufeld, *The Rocket and the Reich*, 278, see also: 219.

306 Neufeld, *Von Braun*, 477.

307 Neufeld, *The Rocket and the Reich*, 264, also quoted by Siddiqi, *Red Rockets' Glare*, 208.

about in part because of the spaceflight enthusiasm of the 1920s that had augured the coming of large rockets of great power.[308] In the end, it was an ineffective weapon altogether, but had proven that rocket power was sufficient for spaceflight, especially when the first successful V-2 launch reached an altitude of 90 km/56 mi high, scraping the edge of space.[309] As historian Asif A. Siddiqi has observed, the V-2 was "the first material evidence that, in the future, nations might develop rocket technology sufficiently powerful to breach the boundaries of space."[310]

THE GERMAN ROCKET TEAM IN AMERICA

By war's end in 1945, American forces moved to capture the engineers who worked on the V-2 program as well as key documents and missile parts for recovery.[311] Questions of their involvement in the Nazi machine were deferred, and American forces ascribed responsibility for the Mittelwerk factory and the use of slave labour to the SS, suppressing the engineers' ties to Nazism.[312] American forces recognized the value of the German specialists' and their expertise, and sought to deny the Soviet Union and other Allies access to them, bringing the German team to the United States through the top-secret Project Overcast, later called Project Paperclip.[313] American capture was also in the interest von Braun who saw the United States as the place where he could fulfill his desire of building rockets to reach space.[314] The efforts of German engineers in the United States would thus constitute Oberth's indirect influence on American rocketry, as von Braun and some members of his team carried the pioneer's visions onto American soil.[315]

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308 Neufeld, "Weimar Culture and Futuristic Technology," 751-752; Bainbridge, *The Spaceflight Revolution*, 51.
309 Neufeld, *Von Braun*, 136-137, figures from 136; Winter, *Rockets into Space*, 50; Winter, *Prelude*, 54; Neufeld, *The Rocket and the Reich*, 164-165; Crouch, *Aiming for the Stars*, 91; Launius and Jenkins, *Coming Home*, 12.
310 Siddiqi, *Red Rockets' Glare*, 196.
311 Neufeld, *Von Braun*, 206-211; Siddiqi, *Red Rockets' Glare*, 196, 208-209; Winter, *Rockets into Space*, 52; Neufeld, *The Rocket and the Reich*, 267-268; Hunley, *Propulsion Technology*, 112; Gainor, *To a Distant Day*, 91-92.
312 Neufeld, *Von Braun*, 211; Neufeld, "Creating a Memory," 74; Kilgore, *Astrofuturism*, 50; De Witt Douglas Kilgore, "Engineers' Dreams: Wernher von Braun, Willy Ley, and Astrofuturism in the 1950s," *Canadian Review of American Studies* 27, no. 2 (March 1997): 106.
313 Neufeld, *Von Braun*, 208-210; Kilgore, *Astrofuturism*, 49-50; Siddiqi, *Red Rockets' Glare*, 208; Kilgore, "Engineers' Dreams," 105-106.
314 Neufeld, *Von Braun*, 190-191, 199-202, 209; Neufeld, "Creating a Memory," 76.
315 Hunley, *Propulsion Technology,* 12-13.

About 118 German engineers were moved to the army base of Fort Bliss, in El Paso, Texas in 1945 whereafter they assisted American engineers in the continued development of American rocket projects.[316] With the assistance and consultation of the German specialists, and in cooperation with contractor General Electric, American research groups studied, assembled, and launched V-2 rockets under the Army's Project Hermes.[317] Amidst over seventy V-2 launches between 1946 and 1952,[318] the V-2 was also affixed to a WAC Corporal as part of a series of vehicles dubbed "Bumper" to test rocket staging, a process whereby stacked rockets are boosted successively in flight to reach higher altitudes.[319] The Bumper series provided data that staging large rockets was possible and offered considerable performance gains, with Bumper 8 reaching an altitude of 392.67 km/244 mi on 24 February 1949 and definitively breaching space.[320] In this way, the V-2 and the German team provided a boost to American efforts, constituting an important source of technology and expertise that contributed to American rocketry.[321]

Technologically speaking, however, the importance of the V-2 should not be overemphasized, as historian J.D. Hunley has argued.[322] It was but one of several starting points for advanced rocketry, and the German rocket may have more readily demonstrated theory in practice in some instances than wholly unseen innovations.[323] Aspects of the V-2, for example, had been

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316 Neufeld, *Von Braun*, 212-218; Hunley, *Propulsion Technology*, 23, 25; Winter, *Rockets into Space*, 52-53; Gainor, *To a Distant Day*, 93; Heppenheimer, *Countdown*, 43.
317 Hunley, *Propulsion Technology*, 23; Winter, *Rockets into Space*, 53; Neufeld, *Von Braun*, 217, 238; Gainor, *To a Distant Day*, 93.
318 Winter, *Rockets into Space*, 53-54; Hunley, *Propulsion Technology*, 23.
319 Williamson and Launius, "Rocketry and the Origins of Space Flight," 46; Neufeld, *Von Braun*, 238; Hunley, *Propulsion Technology*, 23; Winter, *Rockets into Space*, 53.
320 Hunley, *Propulsion Technology*, 23-24, figures from 23; Koppes, *JPL*, 40-41; Winter, *Rockets into Space*, 53; Matt Bille, Pat Johnson, Robyn Kane, and Erika R. Lishock, "History and Development of U.S. Small Launch Vehicles," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 187-188; Williamson and Launius, "Rocketry and the Origins of Space Flight," 46; Neufeld, *Von Braun*, 238; Kilgore, *Astrofuturism*, 49; Kilgore, "Engineers' Dreams," 105; Gainor, *To a Distant Day*, 94-95.
321 Hunley, *Propulsion Technology*, 25-26, 102. Winter has also observed how North American Aviation made copies of the V-2 engine which "played an unrecognized but enormous role in the subsequent development of America's next generation of large liquid-fuel rocket engines." See: Winter, *Rockets into Space*, 53.
322 Hunley, *Propulsion Technology*, 144.
323 Hunley, *Propulsion Technology*, 112, 144; Winter, "Did the Germans learn from Goddard?," 522-523.

anticipated by rocket pioneer Robert H. Goddard, some of whose inventions resembled the German rocket's developments so closely that it led to a myth that the German rocket team had stolen Goddard's ideas.[324] But that Goddard had never managed to produce the sort of rocket he envisioned made the V-2 all the much more valuable as a manifestation of what the pioneers of astronautics had prophesized. Rocket development in the United States, however, drew on not only the German group, but also American labs like JPL, contractors like Aerojet and RMI, a variety of aviation firms, and the efforts of American enthusiasts.[325] Importantly, as the next section will show, a number of these sources for technological development had debts to the pioneers, popularizes, and imaginative works of astronautics as their impartation of inspiration had provided engineers and rocketeers enthusiasms, goals, and ideas to work from, develop, and build upon.

THE MARCH OF AMERICAN ROCKETRY

As early as 1945 the Naval Research Laboratory (NRL) wanted a successor to the German V-2, whose limited supply would necessitate a new rocket for high altitude research.[326] While JPL's WAC Corporal served as the basis for Aerojet's "Aerobee" sounding rocket, the NRL pursued the development of its own sounding rocket called the Viking.[327] The Viking's principal designer, Milton Rosen, had no overwhelming spaceflight dreams, but he suggested to his group at the NRL that they implement ARS co-founder G. Edward Pendray's idea to employ a rocket for upper atmosphere exploration.[328] In preparing to design the rocket, Rosen learned what he could at JPL between 1946

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[324] There were, indeed, key differences, but any parallels represented similar and logical approaches to rocketry on the part of Goddard and the German team at Peenemünde. Winter, "Did the Germans learn from Goddard?," 516-519, 522-523, esp. 524; Clary, *Rocket Man*, 222-224; Winter, *Rockets into Space*, 52-53; Heppenheimer, *Countdown*, 32-33.
[325] Hunley has observed how substantial progress in propellants were made in the United States independent of German influence. See: Hunley, *Propulsion Technology*, 145, esp. ch. 4. See also: Bilstein, *Testing Aircraft*, 34-35.
[326] Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 188-189; McDougall, *…the Heavens and the Earth*, 99; Winter, *Rockets into Space*, 65.
[327] Koppes, *JPL*, 24; Williamson and Launius, "Rocketry and the Origins of Space Flight," 46; Hunley, *Propulsion Technology*, 148; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 188-189; McDougall, *…the Heavens and the Earth*, 99; Winter, *Rockets into Space*, 63-65.
[328] Hunley, *Propulsion Technology*, 29.

and 1947, and conferred with Wernher von Braun and his team of experts.[329] Rosen and the engineers at the NRL then designed the single-stage steerable rocket, and contracted out its construction to the Glenn L. Martin Company, while John Shesta of Reaction Motors Incorporated (RMI) drew on his own experience and V-2 data to develop the engine.[330] The Viking later became a starting point for the Navy's Vanguard rocket, and the Viking's gimballed engine constituted an important innovation that pointed the way to advanced rocket guidance.[331] In addition to contributing to rocket technology, this rocket had relied on the expertise of enthusiasts and engineers, and essentially realized the visions of Pendray and the ARS.

While the NRL focused on Viking, in 1945 the AAF, "awed by the V-2,"[332] sent out offers to major aviation contractors to come forward with proposals for a rocket missile system in preparation for their own postwar missile program.[333] By 1946, after the *Toward New Horizons* report had appeared in full, the AAF was awarding contracts to the aviation firm Consolidated-Vultee (Convair), which proposed a ballistic missile program codenamed MX-774B, and North American Aviation (NAA), which had proposed a winged-cruiser missile dubbed Navaho.[334] It may be worthwhile to note that William Bollay, whose review of Sänger's rocket propulsion work in 1935 at Caltech sparked the formation of the GALCIT group in 1936, was significantly involved in developing and designing the Navaho, using the V-2 as a point of departure for its engine combined

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329 Hunley, *Propulsion Technology*, 29; Neufeld, *Von Braun*, 220; Heppenheimer, *Countdown*, 44-45.
330 Winter, *Rockets into Space*, 65; Hunley, *Propulsion Technology*, 29-30, 113; Gainor, *To a Distant Day*, 134; Heppenheimer, *Countdown*, 45.
331 Hunley, *Propulsion Technology*, 28; Williamson and Launius, "Rocketry and the Origins of Space Flight," 46; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 189; Neufeld, *Von Braun*, 220; Crouch, *Aiming for the Stars*, 111; Heppenheimer, *Countdown*, 45; Winter, *Rockets into Space*, 66-67.
332 Winter, *Rockets into Space*, 76.
333 Winter, *Rockets into Space*, 76; Dennis R. Jenkins, "Stage-and-a-Half: The Atlas Launch Vehicle," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 71-72; Winter, *Rockets into* Space, 76; Gainor, "Atlas and the Air Force," 350; Heppenheimer, *Countdown*, 47-48; Hunley, *Propulsion Technology*, 118.
334 Gainor, "Atlas and the Air Force," 350-351; Williamson and Launius, "Rocketry and the Origins of Space Flight," 48; Jenkins, "Stage-and-a-Half," 71-72; Gainor, *To a Distant Day*, 139-140.

with the advice of numerous contractors.[335] Navaho's engine, the XLR43-NA-1, was taken up by the Rocketdyne division of NAA and upgraded for use on later missiles, as we will see.[336]

Moreover, Convair's MX-774B used a powerplant descended from RMI's XLR-11 or "Black Betsy" engine.[337] We may recall here that, as discussed in Chapter One, the XLR-11 had imaginative origins tracing back to the ARS, the work of James Hart Wyld, and his influences, including that of Eugen Sänger.[338] Although the MX-774B's motor, the XLR-35-RM-1, was not purely a case of imagination to technology, its lineage began with older spaceflight enthusiasm. While the engines for MX-774B, Viking and, later, Vanguard's first stage, did not alone, according to Hunley, "[contribute] in demonstrable ways to later launch vehicle engine technology," the experience its engineers gained from developing them "almost certainly informed later developments."[339]

Ultimately, the development of the MX-774B lagged during the 1940s, and though independent rocket research continued at Convair until 1950, the MX-774B was largely shelved for a lack of military funding in 1947.[340] The Air Force, now a military branch separate from the Army following the National Security Act of 1947, ranked long-range missiles low on its list of priorities, favouring anti-aircraft defence systems instead, and saw little reason to invest in technologies offering few immediate returns.[341] However, the MX-774 project had produced, in the words of historian Walter A. McDougall, "a pool of expertise among industrial contractors that could be

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335 Heppenheimer, *Countdown*, 50-57; Thomas A. Heppenheimer, "The Navaho Program and the Main Line of American Liquid Rocketry," *Air Power History* 44, no. 2 (Summer 1997): 6-8; Winter, *Rockets into Space*, 76; Gainor, *To a Distant Day*, 140; Crouch, *Aiming for the Stars*, 114; Hunley, *Propulsion Technology*, 117-120.
336 Winter, *Rockets into Space*, 76-77; Gainor, *To a Distant Day*, 140; Hunley, *Propulsion Technology*, 117-120 Gainor, "Atlas and the Air Force," 351; Crouch, *Aiming for the Stars*, 114-115; Heppenheimer, *Countdown*, 57.
337 Hunley, *Propulsion Technology*, 112; Jenkins, "Stage-and-a-Half," 72-73; Kerstein and Matko, "Eugen Sänger," 1087; Heppenheimer, *Countdown*, 49.
338 Winter, *Prelude*, 83-84; Winter, "Bringing up Betsy," 79-80; Winter, "'Black Betsy' Part I," 283-284; Kerstein and Matko, "Eugen Sänger," 1087.
339 Hunley, *Propulsion Technology*, 112, see also: 113.
340 McDougall, …*the Heavens and the Earth*, 98; Gainor, "Atlas and the Air Force," 351; Gainor, *To a Distant Day*, 140; Heppenheimer, *Countdown*, 49; Jenkins, "Stage-and-a-Half," 73.
341 McDougall, …*the Heavens and the Earth*, 98; Jenkins, "Stage-and-a-Half," 73; Neufeld, "Space Superiority," 54-55; Gainor, "Atlas and the Air Force," 351.

tapped in the future."[342] At the same time, work done on the Navaho, until its cancellation in 1957, would later contribute greatly to liquid-fuel rockets and launch vehicles.[343]

THE BEGINNINGS OF THE BALLISTIC MISSILE ERA

A major turning point for missile development in the United States was the outbreak of war in Korea in June 1950.[344] The conflict saw defence budgets increase as the U.S. mobilized, and surface-to-surface missiles became desirable for the war.[345] Along with the detection of the first Soviet A-Bomb detonation in 1949 and the intervention of Chinese forces into Korea in 1950, American military services sought to bolster their arsenals and capacity for deterrence, fearing a Soviet Union emboldened to make a lunge for domination of the West.[346] By the mid-1950s, advancements in thermonuclear technology had also made intercontinental ballistic missiles (ICBMs) feasible—as warheads could be made smaller and fitted to rockets—and increasingly urgent with the growing Cold War, leading to an arms race between two world superpowers.[347] These conditions produced a renewed investment into missile technology across the military services.

The Air Force returned to its previous missile studies as it pursued the development of a ballistic missile system. The Air Force awarded Convair a contract for Project MX-1593, which resurrected MX-774B and utilized the engine concepts for Navaho to produce the United States'

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342 McDougall, …*the Heavens and the Earth*, 98.
343 Jenkins, "Stage-and-a-Half," 73; Gainor, "Atlas and the Air Force," 351; Gainor, *To a Distant Day*, 140; Winter, *Rockets into Space*, 77. Kerstein and Matko have also suggested that Bollay's work on the Navaho may have been influenced by Eugen Sänger's 1936 antipodal bomber project. See: Kerstein and Matko, "Eugen Sänger," 1087-1088.
344 Neufeld, *Von Braun*, 249; Jenkins, "Stage-and-a-Half," 74; Heppenheimer, "The Navaho Program," 11.
345 Gainor, "Atlas and the Air Force," 354; Neufeld, *Von Braun*, 249; Jenkins, "Stage-and-a-Half," 74.
346 R. Cargill Hall, "Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 215-216; Neufeld, *Von Braun*, 249; Gainor, "Atlas and the Air Force," 356; Koppes, *JPL*, 41; Heppenheimer, *Countdown*, 69; Heppenheimer, "The Navaho Program," 11.
347 Neufeld, *Von Braun*, 280-281; Hunley, *Propulsion Technology*, 33; Williamson and Launius, "Rocketry and the Origins of Space Flight," 48; Bilstein, *Testing Aircraft*, 50-51; Gainor, "Atlas and the Air Force," 357-358; Heppenheimer, *Countdown*, 74-75; Koppes, *JPL*, 41; Jenkins, "Stage-and-a-Half," 70.

first ballistic missile, the Atlas.[348] Despite being designed as a potential weapon, and by engineers without apparent ties to imaginative works or space travel visions (like Karel J. Bossart of Convair, who was central to the development of the Atlas),[349] some latent echoes of imagination were brought forth when the Atlas drew upon the powerplants and designs for the MX-774B and Navaho projects, whose developmental lineages were tied to sources of imaginative inspiration.

As the military services came into conflict over controlling missile programs, the Army's rocket projects also transformed in 1950-1951 with Chinese intervention in the Korean War.[350] The Jet Propulsion Laboratory was ordered to weaponize their Corporal missile, and rocket work commenced at the Army's newly established Army Ballistic Missile Agency (ABMA) at Redstone Arsenal in Huntsville, Alabama.[351] The German group, directed by von Braun, had moved to Redstone Arsenal in 1950, where they had worked on the Hermes II experimental ramjet program, which had no missile application prospects for the future.[352] In the wake of the national emergency declared in December 1950 as the United States mobilized for the Korean war, the rocket team in Huntsville was tasked with creating an effective tactical missile, and so they turned to existing technology, namely the V-2.[353] The result was the V-2's immediate successor, the Redstone.[354]

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348 Gainor, "Atlas and the Air Force," 354; Gainor, *To a Distant Day*, 140; Hunley, *Propulsion Technology*, 32-33, 37-38; Williamson and Launius, "Rocketry and the Origins of Space Flight," 53; Winter, *Rockets into Space*, 77-78; Heppenheimer, *Countdown*, 49. Winter has called the Atlas the "direct descendant of the MX-774," for example. See: Winter, "'Black Betsy' Part II," 312. See also: Winter, "'Black Betsy' Part I," 283.

349 Virginia P. Dawson, "Taming Liquid Hydrogen: The Centaur Saga," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 336; Hunley, *Propulsion Technology*, 113; Winter, *Rockets into Space*, 77; Heppenheimer, *Countdown*, 48-49.

350 Roger D. Launius, "Titan: Some Heavy Lifting Required," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 149; Neufeld, *Von Braun*, 249; Gainor, "Atlas and the Air Force," 355; Gainor, *To a Distant Day*, 135; Bainbridge, *The Spaceflight Revolution*, 74.

351 Neufeld, *Von Braun*, 245, 249; Koppes, *JPL*, 43; Hunley, *Propulsion Technology*, 26-27.

352 Jenkins, "Stage-and-a-Half," 71; Neufeld, *Von Braun*, 248-249.

353 Bainbridge, *The Spaceflight Revolution*, 74; Neufeld, *Von Braun*, 249-250; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 189-190; Bainbridge, *The Spaceflight Revolution*, 74.

354 Jenkins, "Stage-and-a-Half," 71; Edgar Durbin, "Navigation, Guidance, and Control of a Saturn Rocket and Its Predecessors (Part I)," *Quest: The History of Spaceflight Quarterly* 21, no. 1 (2014): 53, http://edgardurbin.com/Articles/Quest_Vol21_No1_2014_Pp48-61.pdf; Winter, *Rockets into Space*, 77-78; Launius and Jenkins, *Coming Home*, 12.

The Redstone was developed from 1950, first launched in 1953, and became operational by 1958.[355] The rocket missile relied on the V-2 as well as American rocket technology, utilizing, for example, a version of NAA's Navaho booster engine as a basis for the Redstone's powerplant.[356] Moreover, von Braun still carried with him a dream of spaceflight, one that guided his efforts, even while working on the Army's rocket projects. During the late 1940s and early 1950s, he became the chief advocate of space travel by communicating a vision of human spaceflight to the public while simultaneously developing the technology and plans needed to support such a program. Developing weapon systems was the priority, but a means of reaching space was fashioned at the same time.

TRANSLATING FICTION INTO REALITY: EARLY SATELLITE PLANS

While imagination was a force necessary to developing the technology for spaceflight, it had an even greater role in envisioning its applications. A handful of days after the capture of the German rocket team in 1945, von Braun authored a report for American investigators entitled "Survey of Development of Liquid Rockets in Germany and Their Future Prospects," discussing "everything from intercontinental missiles to interplanetary expeditions,"[357] ideas which still largely relied on those articulated by Oberth and Austro-Hungarian military officer and spaceflight enthusiast Hermann Noordung decades earlier.[358] This report set in motion the first steps toward satellite development in the United States, as it caught the attention of Captain Lloyd Berkner and Commander Harvey Hall of the Navy Bureau of Aeronautics (BuAer).[359] By late 1945, after Hall established a committee on space rocketry and BuAer endorsed the "Earth Satellite Vehicle

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[355] Hunley, *Propulsion Technology*, 27; Jenkins, "Stage-and-a-Half," 71; Neufeld, *Von Braun*, 251, 273-275; Gainor, *To a Distant Day*, 136.
[356] Hunley, *Propulsion Technology*, 27, 116-120; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 190; Jenkins, "Stage-and-a-Half," 71; McDougall, …*the Heavens and the Earth*, 99; Neufeld, *Von Braun*, 250; Gainor, *To a Distant Day*, 140; Winter, *Rockets into Space*, 77-78; Heppenheimer, *Countdown*, 70.
[357] Neufeld, "Space Superiority," 53.
[358] Neufeld, "Space Superiority," 53; Neufeld, *Von Braun*, 204-205; Bainbridge, *The Spaceflight Revolution*, 68; McDougall, …*the Heavens and the Earth*, 101.
[359] McDougall, …*the Heavens and the Earth*, 101.

Program," Robert C. Truax of the Navy, and Malina and Homer J. Stewart of JPL began feasibility studies, while Aerojet and North American Phillips were contracted to produce engines for the project.[360] As Walter A. McDougall put it, "it was a full-fledged satellite program in microcosm."[361]

The AAF followed suit when it was approached by the Navy to collaborate on the project in the view of ballooning costs.[362] A year after the *Toward New Horizons* report had appeared in full, the AAF turned to the RAND Corporation, a think-tank within the Douglas Aircraft Corporation, to produce an independent satellite study which resulted in the secret 1946 report "Preliminary Design of a World-Circling Spaceship."[363] Notably, while RAND's report considered the effectiveness of utilizing rockets to launch a satellite, the military usefulness of such a device, as well as its applications to research and communication, the report also presented the satellite as a precursor to interplanetary travel.[364] Moreover, the authors of the report conveyed that they hoped their "impartial engineering analysis would bring forth a vehicle not unsuited to human transportation."[365] Their studies, coupled with V-2 data, they expressed, had ignited the hope that a crewed space vehicle would be possible.[366] Deferring the questions of living and working in space to the

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[360] McDougall, …*the Heavens and the Earth*, 101; Crouch, *Aiming for the Stars*, 104; Neufeld, *Von Braun*, 280.
[361] McDougall, …*the Heavens and the Earth*, 101.
[362] McDougall, …*the Heavens and the Earth*, 101; Crouch, *Aiming for the Stars*, 105.
[363] McDougall, …*the Heavens and the Earth*, 102; Neufeld, *Von Braun*, 280; Hall, "Origins of U.S. Space Policy," 213-214; Gainor, *To a Distant Day*, 145; MacDonald, *The Long Space Age*, 174; Winter, *Rockets into Space*, 55; Crouch, *Aiming for the Stars*, 105. See also: Heppenheimer, *Countdown*, 90. Von Kármán mentions the possible influence of the *Toward New Horizons* study on the RAND report. See: Von Kármán with Edson, *The Wind and Beyond*, 306.
[364] D. Griggs, introduction to *Preliminary Design of an Experimental World-Circling Spaceship* (Santa Monica, CA: RAND Corporation, 1946), 1, https://www.rand.org/pubs/special_memoranda/SM11827.html; L. Ridenour, "Significance of a Satellite Vehicle," in *Preliminary Design of an Experimental World-Circling Spaceship* (Santa Monica, CA: RAND Corporation, 1946), 9-16; F. Clauser, "Possibilities of a Man Carrying Vehicle," in *Preliminary Design of an Experimental World-Circling Spaceship* (Santa Monica, CA: RAND Corporation, 1946), 211-212. Excerpts of this report have also been printed in NASA's *Exploring the Unknown* series, see: Douglas Aircraft Company, Inc., "Preliminary Design of an Experimental World-Circling Spaceship," Report No. SM-11827, May 2, 1946, reprinted in Document II-2 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 236, 239, 241-244, page numbers refer to *Exploring the Unknown*. See also: McDougall, …*the Heavens and the Earth*, 102; Roger D. Launius, "An unintended consequence of the IGY: Eisenhower, Sputnik, the Founding of NASA," *Acta Astronautica* 67, no. 1-2 (July-August 2010): 259; MacDonald, *The Long Space Age*, 174; Gainor, *To a Distant Day*, 145; Heppenheimer, *Countdown*, 90-91; Crouch, *Aiming for the Stars*, 105.
[365] Clauser, "Possibilities of a Man Carrying Vehicle," 211.
[366] Clauser, "Possibilities of a Man Carrying Vehicle," 211.

"inventors," the report also added that "popular fiction writers have devoted considerable thought and ingenuity to means of furnishing [astronauts] with air, food and water," noting especially the idea of a vivarium as particularly ingenious.[367] Although no satellite was produced, as there was no budget to support the project nor sufficient interest from officials,[368] that the report was prompted by the ideas of a spaceflight enthusiast and essentially made references to science fiction in developing its technical report for the AAF is significant. While it is unclear which fiction writers the report was referring to exactly, it is clear that the imaginative propositions of interplanetary fiction had permeated the upper echelons of the military services, underscoring the potency of space travel ideas and the influence of their carriers.

THE CONQUEST OF SPACE

These ideas were never far from the minds of popularizers either. Willy Ley—who had fled to the United States in 1935—had considered the problems of habitation in space in a new edition of his popular book *Rockets: The Future of Travel Beyond the Stratosphere* which first appeared in 1944, and was revised and expanded for the 1947 edition.[369] Wernher von Braun, acting as both engineer and popularizer, also sought to publicize the possibilities and questions of space travel in an attempt to make his dreams a reality.[370] Becoming one of the central figures in this effort to promote spaceflight, von Braun's popularization efforts began as early as 1947, when he expressed his visions of spaceflight, discussing rocketry and armed space stations, in a presentation given before the El Paso Rotary Club.[371] In addition to writing a science fiction novel supported by rigorous calculations

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[367] Clauser, "Possibilities of a Man Carrying Vehicle," 212.
[368] McDougall, …*the Heavens and the Earth*, 103; Neufeld, *Von Braun*, 280; MacDonald, *The Long Space Age*, 174; Winter, *Rockets into Space*, 55; Hall, "Origins of U.S. Space Policy," 214. According to Hall, satellite research at RAND and the Navy Bureau of Aeronautics continued nonetheless from the late 1940s and into the early 1950s.
[369] See, for example: Willy Ley, *Rockets and Space Travel: The Future of Flight Beyond the Stratosphere* (New York: The Viking Press, 1947), 299-309. See also: Buss, *Willy Ley*, 12, 75-76, 125-128, 151-152; Neufeld, "Creating a Memory," 73.
[370] Von Braun is an example of a manager serving as what Hunley calls a "heterogeneous engineer"—that is, he was someone who vied for the support of the public, Congress, and Department of Defense, thereby helping to create the social contexts for the technologies he developed. See: Hunley, *Propulsion Technology*, 6, 111 fig 3.2.
[371] Neufeld, *Von Braun*, 240; Neufeld, "Space Superiority," 54.

which he hoped would popularize space travel for the public,[372] von Braun continued giving speeches and lectures, one of which was published and found its way into *Popular Science*, generating some publicity in 1950.[373] His ideas were still drawing on those put forward by Noordung and especially Oberth, as a mainstay of von Braun's vision was a wheel space station serving as a platform between Earth and the planets, and as an armed Cold War battle station to ensure American space superiority.[374] Von Braun's early visions were as much a product of his anti-communist sentiments as they were an amalgamation of his inspirations.[375] Though these sorts of visions, as we will see, did not alone produce the shape of an American space program, they still provided a look at the possibilities of the future, providing starting points and ideas upon which decisionmakers and innovators could draw.[376]

His efforts dovetailed with an emerging surge of popularization. In 1949, for example, Ley collaborated with artist Chesley Bonestell to produce a book on spaceflight entitled *The Conquest of Space*. The book delineated a vision of a spacefaring future, especially with the realistic space artwork of special effects artist Bonestell, and, in Buss' words, "inaugurated the Space Age in mass media," as it was "*the* book that created an international sensation."[377] Ley made it his mission to publicize space travel in the United States, writing books, going on lecture tours, and making television and radio appearances.[378] Still facing a skeptical public, advocates like Ley argued that spaceflight was an impending reality, and not only possible, but also very doable.[379] Popularizers figured that the

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[372] Neufeld, *Von Braun*, 224, 234, 240-244, 247, 250-251, 254; McCurdy, *Space and the American Imagination*, 27; Kilgore, "Engineers' Dreams," 114-115; Neufeld, "Space Superiority," 54.
[373] Neufeld, "Space Superiority," 55; Neufeld, *Von Braun*, 255.
[374] Heppenheimer, *Countdown*, 90; Neufeld, "Space Superiority," 55; Neufeld, *Von Braun*, 221-222, 240, 243; McCurdy, *Space and the American Imagination*, 73-75.
[375] Neufeld, "Space Superiority," 54, 60; Neufeld, *Von Braun*, 243
[376] See: Miller, "Spaceflight and Popular Culture," 511
[377] Buss, "Virtual witnessing," 160. See also: Buss, *Willy Ley*, 161.
[378] Buss, *Willy Ley*, 172; McCurdy, *Space and the American Imagination*, 38.
[379] McCurdy, *Space and the American Imagination*, 34, 37-38, 42. See also: Neufeld, *Von Braun*, 224, 270.

government might only support a space program if the public wanted it; and the public might come to want a space program if only they had their imaginations ignited.[380]

What really "provoked an explosion of interest among the public" in space travel in the 1950s was the publication of a series of spaceflight themed articles in the magazine *Collier's*.[381] *Collier's*, a large format magazine with a readership of over three million and a penchant for running stories about technology and innovation, first picked up on the spaceflight theme following the publicity surrounding the First Annual Symposium on Space Travel held at New York's Hayden Planetarium in October 1951.[382] The symposium, first of three, had been inspired by Ley and Bonestell's book, and was put together as an effort to promote the planetarium's programs.[383] With the help of Ley, who took the opportunity to promote space travel, the symposium gathered a modest audience for its presentations from experts and engineers.[384] Importantly, the symposium then caught the curiosity of *Collier's* whose journalists had attended.[385] Figuring they could capitalize on the spaceflight topic, *Collier's* sent assistant editor and writer Cornelius Ryan to a scientific conference in San Antonio on upper atmospheric research, where he ran into Wernher von Braun, as well as Harvard astronomy department chairman and spaceflight enthusiast Fred Whipple, and atmospheric physicist Joseph Kaplan, all of whom together sold Ryan on the idea of space travel.[386] *Collier's* then conducted its own "symposium" across a series of issues from 1952 to 1954, featuring

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380 McCurdy, *Space and the American Imagination*, 42-43; Neufeld, *Von Braun*, 270.
381 Neufeld, *Von Braun*, 260. See also: Prelinger, *Another Science Fiction*, 62.
382 Neufeld, *Von Braun*, 255-256; McCurdy, *Space and the American Imagination*, 43-44; Newell, *Destined for the Stars*, 178; Daniel Sage, *How Outer Space Made America: Geography, Organization and the Cosmic Sublime* (Burlington, Vermont and Farnham, Surrey: Ashgate, 2014), 28.
383 Buss, "Virtual witnessing," 160; McCurdy, *Space and the American Imagination*, 41.
384 McCurdy, *Space and the American Imagination*, 41; Neufeld, *Von Braun*, 256; Newell, *Destined for the Stars*, 177; Kilgore, "Engineers' Dreams," 123; Crouch, "Willy Ley: Chronicler," 161. Note also that Wernher von Braun had not attended this symposium.
385 Neufeld, *Von Braun*, 256; McCurdy, *Space and the American Imagination*, 41; Kilgore, "Engineers' Dreams," 123; Crouch, "Willy Ley: Chronicler," 161; Newell, *Destined for the Stars*, 178; Launius, "Prelude to the Space Age," 18.
386 McCurdy, *Space and the American Imagination*, 44; Neufeld, *Von Braun*, 256-257; Neufeld, "Space Superiority," 55-56; Crouch, *Aiming for the Stars*, 120; Newell, *Destined for the Stars*, 179; Gainor, *To a Distant Day*, 137; David Meerman Scott and Richard Jurek, *Marketing the Moon: The Selling of the Apollo Lunar Program* (Cambridge, Massachusetts: The MIT Press, 2014), 6.

Figure 3. Chesley Bonestell, cover illustration, Collier's, March 22, 1952. Courtesy, Smithsonian Libraries, image ID: SIL-SIL33-117-01.

articles on spaceflight written by Von Braun, Whipple, Kaplan, Ley, Air Force aerospace physician Heinz Haber, and UN lawyer Oscar Schachter.[387] The series also featured artwork by Bonestell, Fred Freeman and Rolf Klep.[388]

The first of these issues appeared on 22 March 1952, boldly claiming "Man Will Conquer Space Soon," and following issues concretely laid out the plans of the space advocates, presenting a vision of an "integrated" spaceflight program proposing a synergistic application of rocketry, spacecraft, and space stations to a future program of human space exploration.[389] Moreover, this vision was iterative in that it essentially built upon ideas proposed as early as the 19th century. The idea of a wheel space station as a midway point between the planets, which figured so prominently in von Braun's space program visions, could be dated as far back as 1897, as Kurd Laßwitz had described just such a space station in the shape of a "huge wheel" belonging to the Martians in his novel *Auf Zwei Planeten*, a favourite of von Braun's.[390] Moreover, Hermann Noordung, whom we saw

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[387] McCurdy, *Space and the American Imagination*, 44; Neufeld, "Space Superiority," 56; Crouch, *Aiming for the Stars*, 120; Kilgore, "Engineers' Dreams," 123-124; Scott and Jurek, *Marketing the Moon*, 6; Neufeld, *Von Braun*, 256-259; Newell, *Destined for the Stars*, 180.

[388] Neufeld, *Von Braun*, 257-258; McCurdy, *Space and the American Imagination*, 44; Neufeld, "Space Superiority," 56.

[389] Dwayne A. Day, "Paradigm Lost," *Space Policy* 11, no. 3 (August 1995): 153, 155; Neufeld, "Space Superiority," 56; Newell, *Destined for the Stars*, 208-209; Gainor, *To a Distant Day*, 137; Prelinger, *Another Science Fiction*, 62; Launius, "Space stations for the United States: An idea whose time has come—and gone?," *Acta Astronautica* 62, no. 10-11 (May-June 2008): 540.

[390] Wernher von Braun, "Crossing the Last Frontier," *Collier's*, March 22, 1952 reprinted in Document I-13 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 187, page numbers refer to *Exploring the Unknown*; McCurdy, *Space and the American Imagination*, 187; Lasswitz, *Two Planets*, 12-13, 16, quote from 12; Winter, *Rockets into Space*, 55; Barton C. Hacker, "The

in Chapter One, had also described a circular space station in his 1929 treatise on spaceflight.[391] It is also noteworthy that astronautics pioneer Konstantin E. Tsiolkovskii of Russia had also explored the ideas of a space station in his science fiction writing, having also worked out the mathematics for space travel across a series of articles and studies written in the late 19th and early 20th century.[392]

Importantly, the *Collier's* series emphasized not only the possibilities of such space technologies, but also their military applications, situating the development of such a program in a Cold War context. The editors conveyed in an article called "What Are We Waiting For?" that not only were their following proposals "serious fact", but also "an urgent warning that the U.S. must immediately embark on a long-range development program to secure "space superiority" for the West.[393] If they lagged behind, the article argued, someone else would win this superiority—most likely the Soviet Union.[394] Balanced with the military angle of space superiority was also an exploration of the peaceful applications of this technology, where von Braun communicated that the "oldest and last frontier" was the "heavens themselves," and that the means of conquering this frontier was through the adoption of a human spaceflight program and the development of its necessary technologies.[395] With an intense publicity push on the part of *Collier's*, von Braun's various

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Idea of Rendezvous: From Space Station to Orbital Operations in Space-Travel Thought, 1895-1951," *Technology and Culture* 15, no. 3 (July 1974): 375; Heppenheimer, *Countdown*, 88. Von Braun expressed how he "devoured this novel with curiosity and excitement as a young man" in the epigraph to a 1971 edition of the novel. See: Wernher von Braun, epigraph to *Two Planets* (*Auf Zwei Planeten*), by Kurd Lasswitz, abr. Erich Lasswitz, trans. Hans H. Rudnick (1897; Carbondale and Edwardsville: Southern Illinois University Press, 1971).

391 Bainbridge, *Dimensions of Science Fiction*, 57; Launius, "Space stations," 540; Heppenheimer, *Countdown*, 88.

392 Siddiqi, *Red Rockets' Glare*, 22, 26-30; Winter, *Rockets into Space*, 8-13; Winter, "The Silent Revolution, 4; Launius, "Space stations," 540; Hacker, "The Idea of Rendezvous," 376-377. Tsiolkovskii had also worked out the requisite mathematics for space travel across a series of articles and studies he wrote in the late-19th and early-20th centuries. See also: Clary, *Rocket Man*, 31-32; Winter, *Rockets into Space*, 9-13. On space stations in general, also see McCurdy, *Space and the American Imagination*, ch. 7.

393 The Editors of *Collier's*, "What Are We Waiting For?," *Collier's*, March 22, 1952, reprinted in Document I-13 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 177. See also: Newell, *Destined for the Stars*, 208.

394 Editors of *Collier's*, "What Are We Waiting For?," 177; Neufeld, "Space Superiority," 56; Neufeld, *Von Braun*, 260; McCurdy, *Space and the American Imagination*, 185; Gainor, *To a Distant Day*, 137.

395 Wernher von Braun, "Crossing the Last Frontier," 188. See also: Neufeld, *Von Braun*, 259.

television appearances and rising celebrity, as well as a trilogy of popular books based on expanded versions of the *Collier's* articles appearing in the early 1950s, these visions of a spacefaring future were cast widely across the United States and its elements constituted the dominant paradigm for space travel.[396] The considerable attention afforded to these ideas meant that the American public was introduced to a concrete image of a future spaceflight program, and renewed decades-old space travel ideas for popular consumption in terms of feasibility and attainability.[397]

Space travel found even greater mainstream popularity when the *Collier's* series piqued the interest of Disney animator Ward Kimball. Walt Disney sought a subject for his upcoming *Disneyland* program in the early 1950s, which would also promote his theme-parks categorized as Adventureland, Fantasyland, Frontierland, and Tomorrowland.[398] Tasked with finding a theme suitable to Tomorrowland, Kimball suggested space travel, having encountered the space-themed issues of *Collier's*.[399] Disney approved and seized on the theme after the *Collier's* issue on Mars appeared in late April 1954.[400] To produce the series, Disney collaborated with Willy Ley, Wernher von Braun, Heinz Haber, and Paperclip German expert Ernst Stuhlinger to prepare and present material for the upcoming program.[401] This led to the production of Disney's *Man in Space* series whose first eponymous episode aired on 9 March 1955 for which millions of Americans tuned in.[402] "Man in Space" was then followed by two more episodes, "Man and the Moon" and "Mars and

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396 Neufeld, "Space Superiority," 56; Neufeld, *Von Braun*, 258-260, 265-266, 268-270; McCurdy, *Space and the American Imagination*, 46-47, 48-49; Newell, *Destined for the Stars*, 207-208 Scott and Jurek, *Marketing the Moon*, 6; Kilgore, "Engineers' Dreams," 124-125; Day, "Paradigm Lost," 153; Newell, *Destined for the Stars*, 209-210; Crouch, *Aiming for the Stars*, 120. These books were *Across the Space Frontier* (1952), *Conquest of the Moon* (1953), and *The Exploration of Mars* (1954).
397 McCurdy, *Space and the American Imagination*, 48-49; Kilgore, "Engineers' Dreams," 124; Scott and Jurek, *Marketing the Moon*, 9.
398 McCurdy, *Space and the American Imagination*, 47; Crouch, *Aiming for the Stars*, 120; Gainor, *To a Distant Day*, 138-139; Sage, *How Outer Space Made America*, 30; Scott and Jurek, *Marketing the Moon*, 10-11.
399 McCurdy, *Space and the American Imagination*, 47; Neufeld, *Von Braun*, 285; Newell, *Destined for the Stars*, 222; Scott and Jurek, *Marketing the Moon*, 11; Crouch, *Aiming for the Stars*, 120.
400 McCurdy, *Space and the American Imagination*, 46-47; Neufeld, *Von Braun*, 285; Crouch, *Aiming for the Stars*, 121.
401 Neufeld, *Von Braun*, 286, 288; Miller, "Spaceflight and Popular Culture," 511; Newell, *Destined for the Stars*, 223; Crouch, *Aiming for the Stars*, 121; Gainor, *To a Distant Day*, 139.
402 McCurdy, *Space and the American Imagination*, 47; Neufeld, *Von Braun*, 290; Newell, *Destined for the Stars*, 223, 225; Scott and Jurek, *Marketing the Moon*, 10.

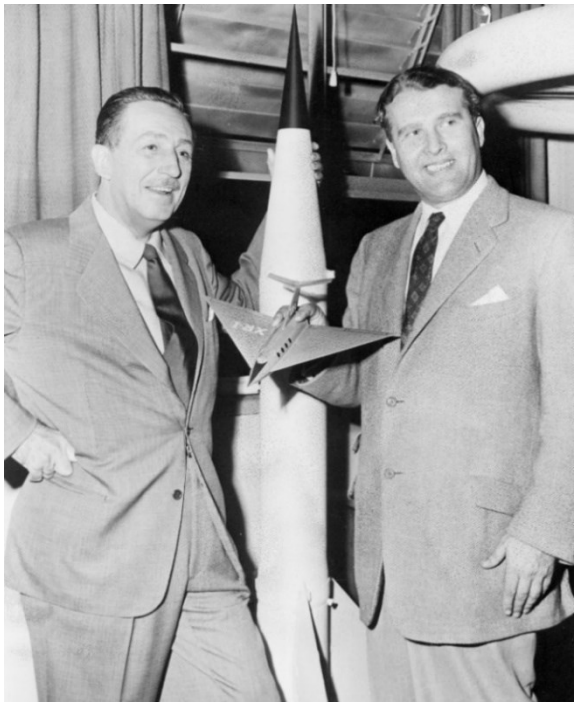

Figure 4. Walt Disney and Wernher von Braun at the Marshall Space Flight Center (MSFC) in 1954. Courtesy, NASA, image ID: 9132000.

Beyond" in 1955 and 1957, respectively.[403] Von Braun had hammered out the basic details of achieving a trip to the Moon for the "Man in Space" episode, and presented the specifications and design of a four-stage rocket-ship.[404] "Man and the Moon" treated audiences to visions of a wheel-like space station as a halfway point between the Earth and the Moon.[405] The series had discussed no military applications besides the possibilities of reconnaissance and only focused on the "scientific and engineering problems of space exploration."[406] At one point in "Man in Space," von Braun addressed the audience: "If we were to start today on an organized and well-supported space program, I believe a practical passenger rocket could be built and tested in ten years."[407] Von Braun's main point was that not only was this possible, but very much within the grasp of current technologies.

THE OPENING OF THE FINAL FRONTIER

The success of the *Collier's* series, Disney programs, and, as we will see in Chapter Three, numerous books, other magazines, television programs, and science fiction films, all contributed to the growing Space Age in American popular culture, and conveyed the possibilities of space travel to

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[403] Launius, "Prelude to the Space Age," 19; McCurdy, *Space and the American Imagination*, 48; Newell, *Destined for the Stars*, 226; Scott and Jurek, *Marketing the Moon*, 11.
[404] Neufeld, *Von Braun*, 289.
[405] Launius, "Prelude to the Space Age," 19.
[406] Neufeld, "Space Superiority," 59.
[407] Clip from *Disneyland*, episode 1, "Man in Space," directed by Ward Kimball and featuring Wernher von Braun, aired March 9, 1955, on ABC, uploaded on November 4, 2014, YouTube video, 2:38, accessed May 25, 2021, https://www.youtube.com/watch?v=8zcU85O82XE. See also: McCurdy, *Space and the American Imagination*, 48; Neufeld, *Von Braun*, 289-290; Launius, "Prelude to the Space Age," 19.

millions, helping sell the public on the idea of spaceflight and reinforcing some of the dominant ideas of the Space Age.[408] Gallup poll numbers also demonstrated a change in Americans' attitudes toward space travel. In 1949, respondents were asked if they believed humans in rockets could reach the Moon within the next 50 years, to which only 15% said "yes", while a staggering 70% said "no" and another 15% offered no opinion.[409] When asked again in 1954-1955, 38% said "yes," while 51% said "no," and 11% offered no opinion.[410] Though the figures of the mid-1950s still paint a picture of general skepticism, they offer evidence nonetheless that a significant change had taken place in a period before the first satellite had even reached orbit. This change may be attributed to not only the popularity of the *Collier's* series but also, and more broadly, the efforts of the popularizers and the cumulative effect of publications, films, and other popular media.[411]

This rush of popularization also occurred during a time when technology had advanced sufficiently to the point where the "frontier" of space could at last be opened. With the upcoming International Geophysical Year (IGY) for 1957-1958—a collaborative, scientific effort across nations to conduct atmospheric research during a period of high solar activity—Lloyd Berkner and other scientists lobbied as early as 1954 to have satellites put on the formal agenda for the United States' participation in the IGY.[412] President Eisenhower, however, was more concerned with the reconnaissance applications of satellite technology at a time when ICBM development continued

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[408] Launius, "Prelude to the Space Age," 19; McCurdy, *Space and the American Imagination*, 49; Scott and Jurek, *Marketing the Moon*, 9.
[409] George H. Gallup, *The Gallup Poll: Public Opinion 1935-1971*, vol. 2, 1949-1958 (New York: Random House, 1972), 875.
[410] Gallup, *The Gallup Poll*, 2:1306; See also: McCurdy, *Space and the American Imagination*, 54; Launius, "Prelude to the Space Age," 16.
[411] Neufeld, *Von Braun*, 276-277; McCurdy, *Space and the American Imagination*, 48-52.
[412] Joan Johnson-Freese, *Space as a Strategic Asset* (New York: Columbia University Press, 2007), 42; Prelinger, *Another Science Fiction*, 27; McDougall, *…the Heavens and the Earth*, 118; Siddiqi, *Red Rockets' Glare*, 321; Crouch, *Aiming for the Stars*, 132; Heppenheimer, *Countdown*, 92; Allan A. Needell, "Lloyd Berkner and the International Geophysical Year Proposal in Context: With Some Comments on the Implications for the Comité Spéciale de l'Année Géophysique Internationale, CSAGI, Request for Launching Earth Orbiting Satellites," in *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years*, eds. Roger D. Launius, James Rodger Fleming, and David H. DeVorkin (New York: Palgrave MacMillan, 2010), 217.

apace in both the U.S. and USSR; and with the latter detonating an atomic bomb in 1949, the United States sought to breach the veil of secrecy obscuring the developments of the Soviet Union.[413] In 1954, President Eisenhower commissioned MIT president James R. Killian, Jr. and Caltech president Lee A. DuBridge to establish a study into the possibility of surprise attack on the U.S. by the Soviet Union, concerned the latter may outpace American ICBM development.[414] Killian and DuBridge established the Surprise Attack Panel/Technological Capabilities Panel whose report included recommendations of accelerating ICBM and IRBM programs, developing technologies for reconnaissance, and setting the groundwork for a spy satellite by way of a scientific one.[415] Despite Eisenhower's attempts to establish transparency between the United States and the Soviet Union through "mutually supervised reconnaissance overflights," he turned to considering more advanced forms of reconnaissance when the USSR proved uninterested in engaging with such a policy.[416] While the American U-2 spy plane conducted missions from 1956, it was a risky means of surveillance; a satellite equipped with a camera was a better option.[417] Although popular media may have communicated to American decisionmakers what was possible in terms of space activities, it was the Cold War, and not a dream of spaceflight, that encouraged the Eisenhower administration to formally announce their decision to participate in the IGY on 29 July 1955.[418] A key rationale for

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413 McCurdy, *Space and the American Imagination*, 67; Neufeld, *Von Braun*, 280-281; MacDonald, *The Long Space Age*, 176; Emily S. Rosenberg, "Far Out: The Space Age in American Culture," in *Remembering the Space Age: Proceedings of the 50th Anniversary Conference*, ed. Steven J. Dick (Washington, D.C.: National Aeronautics and Space Administration, Office of External Relations, History Division, 2008), 160; Hall, "Origins of U.S. Space Policy," 215-216, 218; Johnson-Freese, *Space as a Strategic Asset*, 37.

414 McDougall, …*the Heavens and the Earth*, 115-118; Neufeld, *Von Braun*, 281; Crouch, *Aiming for the Stars*, 129; J.D. Hunley, "Minuteman and the Development of Solid-Rocket Launch Technology," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 239; Hall, "Origins of U.S. Space Policy," 218-219.

415 Hunley, "Minuteman," 239; McDougall, …*the Heavens and the Earth*, 115-118; Hall, "Origins of U.S. Space Policy," 219-220; Johnson-Freese, *Space as a Strategic Asset*, 42; Siddiqi, *Red Rockets' Glare*, 321; McCurdy, *Space and the American Imagination*, 67; Gainor, *To a Distant Day*, 146-147.

416 Hall, "Origins of U.S. Space Policy," 222-223, quote from 223; Siddiqi, *Red Rockets' Glare*, 322; McDougall, …*the Heavens and the Earth*, 127-128; Gainor, *To a Distant Day*, 146-147.

417 McDougall, …*the Heavens and the Earth*, 113, 117; Crouch, *Aiming for the Stars*, 129-130.

418 James C. Hagerty, "Statement by James C. Hagerty, the White House, July 29, 1955," reprinted in Document I-17 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds.

this decision was to establish a precedent for "freedom of space"—if the U.S. sought to launch spy satellites to fly over the Soviet Union, it could first orbit a benign, scientific one to produce a legal precedent to freely orbit satellites over other countries.[419] That dream of spaceflight however, had nonetheless helped, in part, put the hardware and technology in place for this undertaking.

The Air Force, Navy, and Army each accelerated their missile development programs as a result of the Killian report, leading to the Air Force's Thor launcher, the Army and Navy's Jupiter IRBM, and the Navy's own Polaris.[420] Around the same time, they also put in competing proposals to develop the launcher system for the United States' first satellite in 1955.[421] The Naval Research Laboratory's "Vanguard" launcher was eventually accepted by the committee tasked with selecting a proposal because Vanguard offered better scientific components and electronics, and it was a distinctly civilian booster, whereas the Army's "Orbiter" proposal used the Redstone booster, and the Air Force's project would not only interfere with Atlas development but also utilize a military booster.[422] The distinction of putting up the first satellite, however, went to the Soviet Union when *Sputnik I* orbited the Earth on 4 October 1957.[423] Despite panic among some government officials, the general public was initially calm, if not sometimes enthusiastic, about *Sputnik*'s launch, while the

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John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 200-201; Roger D. Launius, "Introduction: Episodes in the Evolution of Launch Vehicle Technology," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 2; Neufeld, *Von Braun*, 294-296; Hall, "Origins of U.S. Space Policy," 221; McDougall, …*the Heavens and the Earth*, 118, 121.

[419] McDougall, …*the Heavens and the Earth*, 118; Hall, "Origins of U.S. Space Policy," 221; Neufeld, *Von Braun*, 294; Siddiqi, *Red Rockets' Glare*, 321; Heppenheimer, *Countdown*, 91. See also: McDougall, …*the Heavens and the Earth*, 108-110, 118, 134; Gainor, *To a Distant Day*, 147-150.

[420] Johnson-Freese, *Space as a Strategic Asset*, 42-43; McDougall, …*The Heavens and the Earth*, 128-129; Hunley, *Propulsion Technology*, 38; Crouch, *Aiming for the Stars*, 129, 132; Williamson and Launius, "Rocketry and the Origins of Space Flight," 54. See also: Neufeld, *Von Braun*, 299-300.

[421] McDougall, …*the Heavens and the Earth*, 120-122; Neufeld, *Von Braun*, 294-295; Williamson and Launius, "Rocketry and the Origins of Space Flight," 50; Bilstein, *Testing Aircraft*, 52; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 191.

[422] McDougall, …*the Heavens and the Earth*, 121-123; Neufeld, *Von Braun*, 294-297; Crouch, *Aiming for the Stars*, 130-132. There was no requirement to select a booster with a civilian character, yet it seems to have played a role in the committee's decision. See: Neufeld, *Von Braun*, 296-297; Bille, Johnson, Kane, and Lishock, "History and Development of U.S. Small Launch Vehicles," 191-192.

[423] Neufeld has written that *Sputnik's* launch represented a "milestone in spaceflight's transition from science fiction to reality." Neufeld, *Von Braun*, 295.

media warned that such a demonstration indicated the Soviet Union could launch nuclear weapons as easily as it orbited satellites.[424] At the same time, the Soviet satellite had established freedom of space, a boon for the top-secret Corona reconnaissance satellite program under development.[425] The first Corona satellite, *Discoverer 1*, was thus later orbited using the Air Force's Thor in 1959, and by 1961, *Discoverer 25* and *26* returned photographs taken over Soviet territory that assured government officials there was no "missile gap" between the U.S. and USSR.[426]

The United States responded to the Soviets' success with *Sputnik*, and the satellite that followed, *Sputnik II*, in a number of ways. While the military services continued wrangling for control of various missile programs, the Army's rocket center, ABMA, under the technical directorship of von Braun, launched the first American satellite, *Explorer I*, into orbit on 31 January 1958 with a Jupiter-C/Juno I rocket, which was based on Redstone and had received its second and third upper stages from JPL.[427] A version of the Air Force's Atlas also successfully orbited Project SCORE, a small communications satellite which relayed Christmas greetings from the President in late 1958.[428] Though Vanguard had been ultimately unsuccessful in launching the first American satellite—a test firing resulted in an explosion on the launch pad on 6 December 1957—the launcher system managed to orbit three satellites between 17 March 1958 and 18 September 1959.[429]

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[424] Kim McQuaid, "Sputnik Reconsidered: Image and Reality in the Early Space Age," *Canadian Review of American Studies* 37, issue 3 (October 2007): 375-378; Johnson-Freese, *Space as a Strategic Asset*, 55; Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven & London: Yale University Press, 2019), 27-30. See also: Launius, "An unintended consequence," 257-258.

[425] Hall, "Origins of U.S. Space Policy," 228; McCurdy, *Space and the American Imagination*, 67-68.

[426] McDougall, …*the Heavens and the Earth*, 190, 224, 329; Winter, *Rockets into Space*, 90; Williamson and Launius, "Rocketry and the Origins of Space Flight," 54; Hunley, *Propulsion Technology*, 57; Kevin S. Forsyth, "Delta: The Ultimate Thor," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002) 107; Gainor, *To a Distant Day*, 161; Heppenheimer, *Countdown*, 145.

[427] Winter, *Rockets into Space*, 78; McDougall, …*the Heavens and the Earth*, 129, 168; Hunley, *Propulsion Technology*, 27-28; Williamson and Launius, "Rocketry and the Origins of Space Flight," 49. See also: Edgar Durbin, "Navigation, Guidance, and Control of a Saturn Rocket and Its Predecessors (Part II)," *Quest: The History of Spaceflight Quarterly* 21, no. 2 (2014): 34, http://edgardurbin.com/Articles/Quest_Vol21_No2_2014_Pp34-44.pdf; Koppes, *JPL*, 81.

[428] Johnson-Freese, *Space as a Strategic Asset*, 45; Williamson and Launius, "Rocketry and the Origins of Space Flight," 54; Jenkins, "Stage-and-a-Half," 78-79; Gainor, *To a Distant Day*, 159; Crouch, *Aiming for the Stars*, 281.

[429] Winter, *Rockets into Space*, 72; Hunley, *Propulsion Technology*, 29-30.

Eisenhower sought no Space Race, but he met the Soviet Union on their terms after he established the National Aeronautics and Space Administration (NASA) in 1958 with the National Aeronautics and Space Act to coordinate the nation's space activities.[430] Officially coming into being on 1 October 1958, NASA, under the leadership of T. Keith Glennan, laid out a long-range agenda in December 1959, which included a variety of space travel objectives for the purposes of contributing to human knowledge, improving aeronautical and astronautical technologies and vehicles, as well as conducting studies for peaceful and scientific purposes and making available discoveries of military significance.[431] Along with satellite launches and suborbital human flights, NASA mission target dates included the first launchings to lead to crewed circumlunar flights, a permanent near-Earth space station between 1965–1967, and a crewed flight to the Moon beyond 1970.[432] These plans appeared to align with the programs outlined by space advocates, and the "von Braun paradigm" of space travel, particularly in terms of space activities and space stations as a part of them.[433] Although von Braun had not been the first to suggest the usefulness of space stations, he was central to popularizing it alongside Ley and Bonestell, and had presented it to Americans as a "springboard" to reach other planets and to facilitate space missions.[434] Of course, Neufeld urges us

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[430] J.D. Hunley, ed. *The Birth of NASA: The Diary of T. Keith Glennan* (Washington, D.C.: National Aeronautics and Space Administration, 1993), 1-2; McCurdy, *Space and the American Imagination*, 69; Kilgore, "Engineers' Dreams," 107; Launius, "An unintended consequence," 260-261; Crouch, *Aiming for the Stars*, 150, 170. According to T. Keith Glennan, first administrator of NASA, President Eisenhower "couldn't care less whether a man ever reached the moon." See: Hunley, *The Birth of NASA*, 292. See also: John M. Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 378.

[431] Office of Program Planning and Evaluation, "The Long Range Plan of the National Aeronautics and Space Administration," December 16, 1959, reprinted in Document III-2 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 403. See also: Logsdon, "The Evolution of U.S. Space Policy and Plans," 377-378.

[432] Office of Program Planning and Evaluation, "The Long Range Plan," 404, table I. See also: McCurdy, *Space and the American Imagination*, 56; Logsdon, "The Evolution of U.S. Space Policy and Plans," 377.

[433] McCurdy, *Space and the American Imagination*, 56; Neufeld, *Von Braun*, 277; Day, "Paradigm Lost," 153-154; Heppenheimer, *Countdown*, 89-90.

[434] Day, "Paradigm Lost," 155; quote from Wernher von Braun, "Prelude to Space Travel," in *Across the Space Frontier*, ed. Cornelius Ryan (New York: The Viking Press, 1952), 50. See also: Wernher von Braun, "Crossing the Last Frontier," 188.

to remember that von Braun's original conception of a space station was a nuclear-armed Cold War battle station, "positively at odds with the agency's mission of peaceful space exploration,"[435] and his primary arguments for building it, namely, its military value and capacity to strike blows against the USSR, had faded by 1960.[436] Space station studies nonetheless figured prominently into NASA's planning in the 1960s,[437] and although these plans may not have been the direct consequence of space popularization, they emerged during a period in which these ideas were increasingly visible in popular spheres.

PROPHECIES FULFILLED? THE AGE OF SPACE

In the 1960s, many of the prophecies of the pioneers came true, though the development of a national space program had not come from a desire to reach the cosmos. Geopolitical tensions came into play when newly elected president John F. Kennedy committed the nation to race the Soviet Union to the Moon. The disastrous Bay of Pigs invasion of 1960 and the orbit of Russian cosmonaut Yuri Gagarin, first human in space, in 1961, prompted Kennedy to seek a means of reasserting the image of American predominance as a world leader, especially as Vice President Lyndon B. Johnson reported to Kennedy that "dramatic accomplishments in space" increasingly signified "world leadership."[438] Kennedy thus issued his challenge to the United States before Congress to land a man on the Moon, "before this decade is out," on 25 May 1961.[439] Signalling American leadership both at home and abroad, especially as nations joined the "Non-Aligned

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[435] Neufeld, "Space superiority," 59.
[436] Neufeld, "Space superiority," 59-60. See also: Neufeld, *Von Braun*, 259.
[437] Launius, "Space stations," 541. See also: Launius, "Prelude to the Space Age," 20.
[438] McDougall, …*the Heavens and the Earth*, 8; John M. Logsdon, *John F. Kennedy and the Race to the Moon* (New York: Palgrave Macmillan, 2010), 79, 117, 237-238, more generally see also ch. 5; Neufeld, *Von Braun*, 360; MacDonald, *The Long Space Age*, 189; Logsdon, "The Evolution of U.S. Space Policy and Plans," 379, 381; Scott and Jurek, *Marketing the Moon*, 113. Quote from: Lyndon B. Johnson, Vice President, Memorandum for the President, "Evaluation of Space Program," April 28, 1961, reprinted in Document III-8 in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I: Organizing for Exploration*, eds. John M. Logsdon with Linda J. Lear, Jannelle Warren-Findley, Ray A. Williamson, and Dwayne A. Day (Washington, D.C.: NASA History Office, 1995), 427.
[439] John F. Kennedy, "Special Message by the President on Urgent National Needs," 25 May 1961, John F. Kennedy Presidential Library and Museum, Presidential Papers, President's Office Files, Speech Files, Box 034, JFKPOF-034-030, 9, accessed March 14, 2020, https://www.jfklibrary.org/asset-viewer/archives/JFKPOF/034/JFKPOF-034-030.

Movement"—nations whose favourable disposition to the United States needed to be earned on an ongoing basis—Kennedy was focused more on Cold War politics than conquering space.[440]

Kennedy's lunar decision, however, could only be made in the view that the technologies and their foundations, as well as the institutions that would develop them, were already in place. Imagination had helped put them there. It had also pointed the way forward, even for those without sweeping space travel dreams. Such was the case for NACA engineer Robert R. Gilruth, who found his perceptions of spaceflight shaped, in part, by the *Collier's* series.[441] Gilruth and his team oversaw America's human spaceflight programs, Project Mercury, Gemini, and Apollo, and were instrumental to the lunar landing in 1969.[442] Additionally, agents of the spaceflight vision, like von Braun, carried the pioneers' visions during the Space Age, their efforts expressions of imagination's effect. Redstone, for example, a product of the German team's efforts, carried Project Mercury astronauts Alan B. Shepard and Virgil "Gus" Grissom into suborbital flights on 5 May and 21 July 1961, respectively.[443] Further, even before Kennedy issued his Moon landing challenge, von Braun and his team had been working on the Juno V vehicle, later called Saturn.[444] This multistage rocket, which would enable the Apollo missions of the late 1960s, was designed as a space booster from the

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[440] This movement was founded by the leaders of Yugoslavia, India, Egypt, Indonesia, and Ghana. MacDonald, *The Long Space Age*, 186. See also: Johnson-Freese, *Space as a Strategic Asset*, 55-56; Logsdon, *John F. Kennedy*, 89.

[441] Roger Launius, "Godfather to the Astronauts: Robert Gilruth and the Birth of Human Spaceflight," in *Realizing the Dream of Flight*, eds. Virginia P. Dawson and Mark D. Bowles (Washington, D.C.: National Aeronautics and Space Administration, NASA History Division, Office of External Relations), 227-228; Christopher C. Kraft, Jr., "Robert R. Gilruth," in *Biographical Memoirs*, vol. 84, ed. National Academy of Sciences (Washington, D.C.: The National Academies Press, 2004), 99, https://doi.org/10.17226/10992.

[442] Launius, "Godfather to the Astronauts," 213-214, 239, 241-242, 244, 246-247, 252; Kraft, "Robert R. Gilruth," 102-103; Andrew Chaikin, "The Quiet Force Behind Apollo: How a Research Engineer Came to Lead NASA to the Moon," *Air & Space/Smithsonian*, February/March 2016, 60.

[443] Williamson and Launius, "Rocketry and the Origins of Space Flight," 58-59; Winter, *Rockets into Space*, 78-79; Hunley, *Propulsion Technology*, 28; Crouch, *Aiming for the Stars*, 170. A modified Atlas booster, Atlas D, was employed to launch John Glenn into space on 20 February 1962 as part of the Mercury program, making him the first American to go into orbit. See: Williamson and Launius, Rocketry and the Origins of Space Flight," 59; Johnson-Freese, *Space as a Strategic Asset*, 44; Hunley, *Propulsion Technology*, 51.

[444] Winter, *Rockets into Space*, 80-81; Neufeld, *Von Braun*, 331; Crouch, *Aiming for the Stars*, 175-176. The Saturn V project also received additional funding in 1960 when Eisenhower accelerated the project in the wake of the Space Race. See: Neufeld, *Von Braun*, 346. See also: Edgar Durbin, "Saturn I Guidance and Control Systems," *Quest: The History of Spaceflight Quarterly* 17, no. 4 (2010): 19, http://edgardurbin.com/Articles/Quest_VOl17_No4_2010_Pp19-31.pdf.

onset in a collaborative effort among thousands of engineers, developers, and contractors, and was the result of decades of cumulative technological advancement and progress.[445] All the same, the development of the Saturn V at the George C. Marshall Space Flight Center was overseen by the center's director, von Braun, where his Huntsville team of German specialists served as a core group engaged in the Saturn project.[446] In effect, spaceflight enthusiast, advocate, and engineer von Braun helped translate the fantasy of his inspirations into practical reality.

There were numerous threads binding the fulfillment of the space travel prophecy to the imaginative works from which the prediction—and sometimes, proposal—had originated. Rocket technology in the 1950s and 1960s had drawn on numerous sources, tapping on a base of knowledge cut from the cloth of experimentation, engineering expertise, and imagination. The decision to establish a national space program was a result of geopolitical entanglements and Cold War maneuvering, but such a program could have only flourished if the expertise, technologies, and developers were in place. The rocket, which constituted the single most important technology for the Space Age, had only become the means of reaching space thanks to the efforts of dedicated individuals and innovators, many of whom were moved to realize rocketry and space travel once inspired by the pioneers of astronautics and works of imagination. Their efforts all paved the way to a future of space travel in the Space Age.

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[445] Ray A. Williamson, "The Biggest of Them All: Reconsidering the Saturn V," in *To Reach the High Frontier: A History of U.S. Launch Vehicles*, eds. Roger D. Launius and Dennis R. Jenkins (Lexington, Kentucky: The University Press of Kentucky, 2002), 302, 322; Neufeld, *Von Braun*, 331, 341; Andrew J. Dunar, "Wernher von Braun: A Visionary as Engineer and Manager," in *Realizing the Dream of Flight*, eds. Virginia P. Dawson and Mark D. Bowles (Washington, D.C.: National Aeronautics and Space Administration, NASA History Division, Office of External Relations), 201; Crouch, *Aiming for the Stars*, 208-209; Winter, *Rockets into Space*, 83.

[446] Neufeld, *Von Braun*, 6, 346; Gainor, *To a Distant Day*, 169; Kilgore, *Astrofuturism*, 52; Crouch, *Aiming for the Stars*, 153; Sage, *How Outer Space Made America*, 58.

3. INTO A PORTRAIT OF THE UNKNOWN (1944–1968)

For the price of a magazine, a hardcover, or a movie ticket, Americans could travel to space, set off on a lunar escapade, or visit the red plains of Mars safely and comfortably, even before the first satellites entered orbit. From the mid 1940s to the mid 1950s, Americans had flipped through the pages of *Life*, *Look*, *Scientific American*, *Coronet*, *Pic Magazine*, *Collier's*, and other such magazines to see spectacular views of space as rendered by astronomical artist Chesley Bonestell.[447] Others still saw his paintings featured alongside the prophetic writings of Willy Ley in the book *The Conquest of Space* (1949), which sold 20,000 copies by 1950 and introduced readers to the basics of rocketry and space travel.[448] Then there were those who joined astronauts on a lunar adventure in 1950 in the George Pal produced film, *Destination Moon*. This popular feature envisaged the first trip to the Moon in stunning Technicolor and marked the beginning of the American science fiction film genre.[449] Such visions were drawing on a legacy of science fiction and burgeoning technological realities, especially as technological dreams were increasingly realized. These visual media compellingly conveyed to American audiences the possibilities of spaceflight and, most importantly, helped familiarize the unfamiliar, thereby preparing the public to anticipate, accept, and even embrace a federally funded space program, a necessity if such a program was to become politically feasible.[450] By rendering the extraterrestrial in terrestrial terms, space and its many alien landscapes became familiar and knowable, and therefore feasibly traversable and conquerable.[451]

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[447] Frederick C. Durant III and Ron Miller, *Worlds Beyond: The Art of Chesley Bonestell* (Norfolk, Virginia Beach: Donning, 1983), 7; Buss, "Virtual witnessing," 160.
[448] Buss, "Virtual witnessing," 160.
[449] Bradley Schauer, *Escape Velocity: American Science Fiction Film, 1950-1982* (Middletown, Connecticut: Wesleyan University Press, 2017), 35; Scott and Jurek, *Marketing the Moon*, 9; Bradley Schauer, "'The Greatest Exploitation Special Ever': *Destination Moon* and Postwar Independent Distribution," *Film History* 27, no. 1 (November 2015): 2; Vivian Sobchack, *Screening Space: The American Science Fiction Film*, 2nd. enl. ed. (New Brunswick, New Jersey, and London: Rutgers University Press, 1998), 12; Kirby, *Lab Coats in Hollywood*, 207, 209.
[450] Kirby, *Lab Coats in Hollywood*, 20; Daniel Sage, "Framing Space: A Popular Geopolitics of American Manifest Destiny in Outer Space," *Geopolitics* 13, no. 1 (Spring 2008): 40.
[451] Catherine L. Newell argues that depictions of landscapes and explorers were important to "rendering the unknown known" and that by "picturing the frontier—in the case of either the American frontier or Saturn—as something *could*

In exploring the ideas of the American frontier, American landscape art, and the American sublime, I position these as progenitors of the language of popular visual media pertaining to space travel.[452] Scholars such as Daniel Sage and Catherine L. Newell have explored the connections between the American frontier myth, the space art of Chesley Bonestell, as well as the expression of these motifs in some films.[453] Building on these analyses, this chapter contextualizes these images of spaceflight in terms of imagination's role in producing space travel and through an analysis of a wider range of American space travel films than considered in these terms elsewhere. As this chapter cannot hope to be exhaustive, its focus is limited to film as opposed to television or serials, as this presents a more manageable number of examples to investigate fruitfully. I will argue that, by defining space travel in terms of technologies, frontiers, and adventures, film and other visual media constituted important forms of popularization that helped forerun, promise, and prompt American engagement in space. Though their effects were at times limited in contrast to the influence of the Cold War, they nonetheless helped create a cultural and social environment wherein presidential commitments to space exploration were not only acceptable but also natural.

THE FRONTIER INHERITANCE

The American nation has long been tied to the idea of the "frontier." Constituting a major part of the "American cultural narrative," and "national mythology," conceptualizations of the frontier have been deeply embedded in rationales for space travel both in popular and political rhetoric as well as spaceflight advocacy.[454] This narrative relies on American historian Frederick Jackson Turner's articulation of his famous "frontier thesis," which posited in 1893 that the

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be explored, possibilities beckoned for both adventure and redemption." See: Newell, *Destined for the Stars*, 66. See also: Sage, *How Outer Space Made America*, 47.

[452] This idea that science fiction films drew upon 19th century American landscape painting also appears in David W. Jackson, "Landscape and Science-Fiction Film," *Science Fiction Studies* 47, no. 2 (July 2020): 241.

[453] See: Sage, *How Outer Space Made America*, esp. chs. 1-3; Newell, *Destined for the Stars*, esp. chs. 1, 3-6.

[454] Linda Billings, "Overview: Ideology, Advocacy, and Spaceflight—Evolution of a Cultural Narrative," in *Societal Impact of Spaceflight* eds. Steven J. Dick and Roger D. Launius (Washington, DC: National Aeronautics and Space Administration, Office of External Relations, History Division, 2007), 483.

American nation was one born from its interaction with the frontier.[455] Turner argued that "[t]he existence of an area of free land, its continuous recession, and the advance of American settlement westward explain American development."[456] By 1914, he further argued that the "appeal of the undiscovered strong in America," and that "[f]or three centuries the fundamental process in [America's] history was the westward movement, the discovery and occupation of the vast free spaces of the continent."[457] Democracy, he argued, emerged not from theorists nor the ships that carried settlers to the North American continent, but rather, "[i]t came out of the American forest, and it gained new strength each time it touched a new frontier."[458] As the U.S. census in 1890 had officially declared the frontier closed, that carried with it an implicit need for newer and greater frontiers, so long as Turner's main argument held.[459]

The term "frontier," as historian Patricia Limerick Nelson has pointed out, is malleable but seems most closely associated with the concept of "the American nation's westward movement,"[460] which, for Turner involved a conquest of nature.[461] At the same time, Turner's narrative only

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[455] Turner's original articulation of this notion first appeared in an essay entitled "The Significance of the Frontier in American History," and was read at the meeting of the American Historical Association in Chicago on 12 July 1893. It was republished, as it originally appeared in 1893, in Turner's 1920 book *The Frontier in American History*, a collection of his essays. This section relies on this publication and the additional essays contained therein. See: Frederick Jackson Turner, *The Frontier in American History* (New York: Henry Holt and Company, 1920), 1n1; and Frederick Jackson Turner, preface to *The Frontier in American History* (New York: Henry Holt and Company, 1920).

[456] Frederick Jackson Turner, "The Significance of the Frontier in American History," 1893, in *The Frontier in American History* (New York: Henry Holt and Company, 1920), 1, https://archive.org/details/frontierinameric00turnuoft.

[457] Frederick Jackson Turner, "The West and American Ideals," 1914, in *The Frontier in American History* (New York: Henry Holt and Company, 1920), 293.

[458] Turner, "The West and American Ideals," 293; see also: Frederick Jackson Turner, "Contributions of the West to American Democracy," 1903, in *The Frontier in American History* (New York: Henry Holt and Company, 1920), 266.

[459] Richard White, "Frederick Jackson Turner and Buffalo Bill," in *The Frontier in American Culture: An Exhibition at the Newberry Library, August 26, 1994–January 7, 1995*, ed. James R. Grossman (Berkeley: University of California Press, 1994), 9-10; Richard Slotkin, *Gunfighter Nation: The Myth of the Frontier in Twentieth-Century America* (New York: Atheneum, 1992), 3, 30-31; Newell, *Destined for the Stars*, 172-173; Gary Westfahl, "Introduction: Frontiers Old and New," in *Space and Beyond: The Frontier Theme in Science Fiction*, ed. Gary Westfahl (Westport, Connecticut: Greenwood Press, 2000), 1; McCurdy, *Space and the American Imagination*, 155; Dorceta E. Taylor, *The Rise of the American Conservation Movement: Power, Privilege, and Environmental Protection* (North Carolina: Duke University Press, 2016), 26; Bainbridge, *Meaning and Value of Spaceflight*, 206.

[460] Patricia Nelson Limerick, "The Adventures of the Frontier in the Twentieth Century," in *The Frontier in American Culture: An Exhibition at the Newberry Library, August 26, 1994-January 7, 1995*, ed. James R. Grossman (Berkeley: University of California Press, 1994), quote from 73, see also 72-75.

[461] James R. Grossman, introduction to *The Frontier in American Culture: An Exhibition at the Newberry Library, August 26, 1994-January 7, 1995*, ed. James R. Grossman (Berkeley: University of California Press, 1994), 1-2.

focused on European settlers, marginalizing or entirely ignoring the experiences of Indigenous Americans and those grouped into what Limerick calls the "other side of the frontier," which includes African Americans, Asian Americans, Mexican immigrants, and Hispanic settlers.[462] At most, Turner reduced indigenous inhabitants of the frontier to elements of the landscapes that were to be overcome or conquered as Caucasian pioneers swept westwards toward social rejuvenation.[463]

Turner's frontier thesis was also joined by another narrative offering of America's past, forwarded by showman William Frederick Cody—also known as Buffalo Bill—in his dramatic *Buffalo Bill's Wild West and Congress of Rough Riders of the World* show at the 1893 World's Columbian Exposition in Chicago, where Turner presented his thesis.[464] While Turner largely ignored the presence of indigenous peoples living in the so-called "free land" of the West, the violent conflicts between native inhabitants and cowboy heroes was a central theme of Cody's presentation of the Old West.[465] Both Cody and Turner together nonetheless told a story of conquest and domination, constructing a narrative framework to explain and convey a mythic American identity.[466] At a basic level, it was the traversal of, a fascination with, and subsequent command over untamed lands—the frontier—that seemed to underscore the core tenets of the mythic representation of what it meant to be American.[467]

Cumulatively, America's "mythic identity" was cut from this cloth; whether it was the tale of Columbus upon the seas, or Buffalo Bill's conquest of the Wild West, "the American imagination,"

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462 Limerick, "The Adventures of the Frontier," 73; Grossman, introduction to *The Frontier in American Culture*, 1-2; Roger D. Launius, "Compelling Rationales for Spaceflight? History and the Search for Relevance," in *Critical Issues in the History of Spaceflight*, eds. Steven J. Dick and Roger D. Launius (Washington, D.C.: NASA, Office of External Relations, History Division, 2006), 47. See also: Sage, *How Outer Space Made America*, 16.
463 White, "Frederick Jackson Turner and Buffalo Bill," 11.
464 White, "Frederick Jackson Turner and Buffalo Bill," 7; Sage, *How Outer Space Made America*, 16.
465 White, "Frederick Jackson Turner and Buffalo Bill," 9-10.
466 White, "Frederick Jackson Turner and Buffalo Bill," 11; Sage, *How Outer Space Made America*, 16.
467 Grossman, introduction to *The Frontier in American Culture*, 1-2; Janice Hocker Rushing, "Mythic Evolution of 'The New Frontier' in Mass Mediated Rhetoric," *Critical Studies in Mass Communication* 3, no. 3 (September 1986): 265; McCurdy, *Space and the American Imagination*, 161.

writes scholar Janice Hocker Rushing, "remains fascinated by new and unknown *places*."[468] The idea that movement over vast swathes of land produce fundamentally American qualities ultimately furnished Americans with a simple, popular, and stirring creation myth.[469] As a result, Turner's frontier thesis was soon entrenched in American historical thought, became a popular trope in Westerns, and a mainstay of education throughout the early 20th century, receiving little critical reassessment until at least the 1940s.[470] This myth also complemented the longer-standing notion of manifest destiny, which originated with American magazine editor John L. O'Sullivan in 1845 when he advocated for the annexation of Texas.[471] Although limited in its original usage, over time this concept of manifest destiny came to encapsulate the suggestion that America (and specifically, its Anglo-American population) was divinely destined to expand across the continent.[472] As another expression of American exceptionalism, the frontier thesis tells what Sage calls a "Puritanical narrative" of an American people in possession of an "exceptional destiny and identity;"[473] a destiny, as Newell has written, "to go forth and conquer the frontier."[474]

A significant dimension of the "frontier," then, broadly defined, is a preoccupation with land and places, for it provides space for the setting and expansion of borders and settlements.

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468 Rushing, "Mythic Evolution," 265.
469 Grossman, introduction to *The Frontier in American Culture*, 1; Newell, *Destined for the Stars*, 174; Turner, *The Frontier*, 293; McCurdy, *Space and the American Imagination*, 161, 176; Launius, "Compelling Rationales," 47. Of course, the thesis was not accepted outright, and had its share of opponents. See, for example: McCurdy, *Space and the American Imagination*, 161.
470 Grossman, introduction to *The Frontier in American Culture*, 1; Limerick, "The Adventures of the Frontier," 75-76; Sage, *How Outer Space Made America*, 16-17; Slotkin, *Gunfighter Nation*, 3, 234-235; Glen E. Swanson, "The New Frontier: Religion in America's National Space Rhetoric of the Cold War Era," *Religions* 11, no. 11 (November 2020): 1.
471 John D. Wilsey, "'Our Country is Destined to be the Great Nation of Futurity': John L. O'Sullivan's Manifest Destiny and Christian Nationalism, 1837-1846," *Religions* 8, no. 4 (April 2017): 1, 3-4; Newell, *Destined for the Stars*, 170-171.
472 Newell, *Destined for the Stars*, 171; Sage, *How Outer Space Made America*, 16; Slotkin, *Gunfighter Nation*, 30. It is important to note that this was not necessarily a consistently experienced sentiment in the United States during the 19th century, is a concept fraught with complications, and had its opponents. See: Andrew C. Isenberg and Thomas Richards, Jr., "Alternative Wests: Rethinking Manifest Destiny," *Pacific Historical Review* 86, no.1 (February 2017): 9-17; Wilsey, "'Our Country is Destined to be the Great Nation of Futurity'," 4.
473 Sage, *How Outer Space Made America*, 16.
474 Newell, *Destined for the Stars*, 171-172, quote from 172; Asif A. Siddiqi, "Spaceflight in the National Imagination," in *Remembering the Space Age: Proceedings of the 50th Anniversary Conference*, ed. Steven J. Dick (Washington, D.C.: National Aeronautics and Space Administration, Office of External Relations, History Division, 2008), 24.

Movement cannot occur without land to move across; a natural landscape is a prerequisite for the activities that were rendered by Turner and others as the key to American development. Domination and conquest of nature then follow, for as McCurdy has put it: "Frontiers imply conquest."[475] This sort of conquest was central to the Turnerian tale of America, as it was the domination of natural landscapes that produced the conditions under which the national American character appeared—the conditions from which it had ostensibly first emerged.

SUBLIME RENDERINGS OF NATURAL VISTAS

This narrative of the frontier drew much of its power by mapping out its tenets onto representations that had preceded it, namely, those that were the means by which Americans came to know what the frontier looked like. Writers and poets had long exalted the romantic beauty of nature and advocated for its preservation, and visual artists—landscape painters, in particular—had helped visualize the grandeur of these quintessentially American vistas, literally sketching out the frontier in grandiose and awe-inspiring forms throughout the 19th century.[476] These painters were central to popularizing natural landscapes and for reading land, specifically that which was traversed and inhabited by the American population, as inherently divine, thereby laying groundwork later exploited by those like Turner.[477] 19th century American landscape painting gave rise to what is known as "the American sublime," where the sublime evoked awe, wonder, and a recognition of divinity in pictorial compositions that emphasized scale, a sense of infinity, and a majesty so overwhelming that the observer is humbled before the scene.[478]

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[475] McCurdy, *Space and the American Imagination*, 163. Moreover, Newell has suggested that in the "American imagination," frontiers exist to be conquered. See: Newell, *Destined for the Stars*, 15.
[476] Sage, *How Outer Space Made America*, 17, 19; McCurdy, *Space and the American Imagination*, 311-312; Taylor, *The Rise of the American Conservation Movement*, 291-292.
[477] Sage, *How Outer Space Made America*, 19-23; Sage, "Framing Space," 30-32; Newell, *Destined for the Stars*, 66; Diana Strazdes, "'Wilderness and Its Waters': A Professional Identity for the Hudson River School," *Early American Studies, An Interdisciplinary Journal* 7, no. 2 (Fall 2009): 358.
[478] Barbara Novak, *Nature and Culture: American Landscape and Painting, 1825-1875*, 3rd ed. (Oxford: Oxford University Press, 2007), 29; Elizabeth A. Kessler, *Picturing the Cosmos: Hubble Space Telescope Images and the Astronomical Sublime* (Minneapolis and London: University of Minnesota Press, 2012), 20; Sage, "Framing Space," 28.

Artists who developed the American sublime in the 19th century roughly fell into two closely linked groups: The Hudson River School, based around New York in the 1820s, which included artists such as Thomas Cole, Frederic Edwin Church, and Asher Durand; and the Rocky Mountain School, based around San Francisco in the 1850s, which included artists such as Thomas Moran and Albert Bierstadt.[479] The works of the Hudson River School artists, for example, as art historian Diana Strazdes has posited, "resonated with Americans' collective image of their land," and furnished Americans with "an attractive self-image, a shared political identity, and a reflection of their desire for universal moral and religious truths."[480] Artists of these schools were often wont to read divinity in the American landscape, and used motifs of light and exaggerated geological features to convey the grandeur and transcendent qualities of their chosen scenery.[481] When these landscapes were rendered as specially charged places full of meaning and wonder, they offered evidence of the destiny of the American nation and its people.[482]

This aesthetic language was embedded in the work of those artists belonging to the Rocky Mountain School who depicted for observers on the east coast of the United States a world unseen: the wilderness of the west, places like the Sierra Nevada range, the Rockies, Yosemite, and Yellowstone.[483] Thomas Moran, for example, employed the visual language of the Hudson River School, using light to suggest transcendence, and blurring terrestrial forms into the painted sky to suggest a movement from "worldly nature to spiritual wonder and awe."[484] Moran's paintings,

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[479] Sage, "Framing Space," 30; Strazdes, "'Wilderness and Its Waters'," 333-336; McCurdy, *Space and the American Imagination*, 312; Newell, *Destined for the Stars*, 77-78; Taylor, *The Rise of the American Conservation Movement*, 291; Sage, *How Outer Space Made America*, 19.
[480] Strazdes, "'Wilderness and Its Waters,'" 333; Taylor, *The Rise of the American Conservation Movement*, 291; Sage, "Framing Space," 30.
[481] Sage, *How Outer Space Made America*, 20; Sage, "Framing Space," 31-33; Newell, *Destined for the Stars*, 77-79; McCurdy, *Space and the American Imagination*, 311-312; Newell, *Destined for the Stars*, 77-78; Strazdes, "'Wilderness and Its Waters,'" 358.
[482] Sage, *How Outer Space Made America*, 19, 23; Sage, "Framing Space," 33; Newell, *Destined for the Stars*, 82; Taylor, *The Rise of the American Conservation Movement*, 291.
[483] McCurdy, *Space and the American Imagination*, 311-312; Newell, *Destined for the Stars*, 79-82; Taylor, *The Rise of the American Conservation Movement*, 291.
[484] Sage, *How Outer Space Made America*, 20; see also: Novak, *Nature and Culture*, 37.

including *The Grand Cañon of the Yellowstone* (1872) and *The Chasm of Colorado* (1873-1874) used an elevated perspective—a magisterial gaze—to emphasize the panoramic majesty of the landscape in an emotionally resonant way.[485] During a period when people viewed natural wildernesses apprehensively, and as uncontrollable and hostile, artists of the American sublime tradition depicted them as worthy of awe and preservation, encouraging observers to embrace these places.[486] These stunning landscapes, therefore, transformed nature into knowable and traversable places; they offered more than untamed hostility and all the promises of destiny.[487]

American sublime paintings also demonstrate the influence and importance of art in facilitating changes in cultural perception, as these paintings were contributors to the momentum of the national park movement.[488] Geographer Gareth E. John has commented on how the very idea of national parks emerged as "an expression of the national cultivation of a Romantic taste for the sublime."[489] Moran, for example, travelled with geologist Ferdinand Vandeveer Hayden, numerous scientists, and frontier photographer William Jackson on the U.S. Geological Survey's Hayden Expedition of 1871 to the unexplored Upper Yellowstone Valley, and composed watercolours of the region that contributed to romanticizing, popularizing, and knowing the landscape, especially as they were later presented before Congress in 1872 when Hayden and other advocates lobbied for the establishment of Yellowstone as the world's first national park.[490] The Yellowstone National Park was officially created in 1872, a decision made at least in part due to the influence of Moran's

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[485] Sage, *How Outer Space Made America*, 21, 23. Sage borrows the term "magisterial gaze," from art historian Albert Boime. See: Albert Boime, *The Magisterial Gaze: Manifest Destiny and American Landscape Painting, c. 1830-1865* (Washington and London: Smithsonian Institution Press, 1991), 1-2, also cited by Sage, *How Outer Space Made America*, 21.
[486] Newell, *Destined for the Stars*, 67, 79-80, 82; McCurdy, *Space and the American Imagination*, 311; Sage, *How Outer Space Made America*, 19-23; Taylor, *The Rise of the American Conservation Movement*, 291; Gareth E. John, "Yellowstone as 'Landscape Idea': Thomas Moran and the Pictorial Practices of Gilded-Age Western Exploration," *Journal of Cultural Geography* 24, no. 2 (Spring-Summer 2007): 5.
[487] Newell, *Destined for the Stars*, 66.
[488] McCurdy, *Space and the American Imagination*, 311-312.
[489] John, "Yellowstone as 'Landscape Idea'," 5.
[490] Joni Louise Kinsey, *Thomas Moran and the Surveying of the American West* (Washington and London: Smithsonian Institution Press, 1992), 58-62; John, "Yellowstone as 'Landscape Idea'," 6, 16, 22n12; Taylor, *The Rise of the American Conservation Movement*, 299-300; Sage, *How Outer Space Made America*, 23; Newell, *Destined for the Stars*, 67, 75-77, 80, 82-84.

Figure 5. Thomas Moran, The Grand Canyon of the Yellowstone, 1872, oil on canvas mounted on aluminium, 84x144.25" (213x366.3cm), U.S. Department of the Interior Museum, Washington, D.C., https://g.co/arts/MhtNP7piVPjwSE2E8.

artwork, and three months later Congress purchased Moran's large oil painting (roughly 2.13m by 3.66m, or 7ft by 12ft), *The Grand Cañon of the Yellowstone*, for $10,000, to hang in Capitol Hill.[491] Moran's depictions of the Yellowstone were later used on posters and postcards for the national park, and even influenced other artists' renderings of these regions, comprising a form of visual media popularization and offering Americans a glimpse at landscapes of natural wonder.[492] Such images became Americans' first point of contact with unknown places, revealing and popularizing them for the public, encouraging them to view these places as sources of wonder and national pride, also beckoning them to visit and see for themselves.[493] Moran's paintings helped inspire a shift in the way Americans encountered, interacted, and engaged with their landscapes.[494]

BONESTELL'S INTERPLANETARY SUBLIME

By the 20th century, then, Americans had a good understanding of what the frontier meant and what it looked like. Artists mapped out onto American plains, forests, and mountains a picture of unparalleled sublimity, one that simultaneously served as the stage upon which a narrative of

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491 Kinsey, *Thomas Moran*, 43; McCurdy, *Space and the American Imagination*, 312; Newell, *Destined for the Stars*, 84-86; Sage, *How Outer Space Made America*, 23; John, "Yellowstone as 'Landscape Idea'," 2, 4, 19-20; Taylor, *The Rise of the American Conservation Movement*, 300. Congress later purchased the painting's companion, *The Chasm of the Colorado*, for the same price in 1874. See: Kinsey, *Thomas Moran*, 95; Sage, *How Outer Space Made America*, 23.
492 Kinsey, *Thomas Moran*, 75-78; Sage, *How Outer Space Made America*, 23; Sage, "Framing Space," 33-34.
493 Kinsey, *Thomas Moran*, 62, 66, 84; McCurdy, *Space and the American Imagination*, 312.
494 Kinsey, *Thomas Moran*, 176; McCurdy, *Space and the American Imagination*, 312; John, "Yellowstone as 'Landscape Idea'," 15-17.

divinely ordained frontier conquest proceeded, and furnished the nation its unique character and composed its mythical heritage.[495] Certain ironies emerged, however, for the tale of the frontier was one of "eventual decline,"[496] as every frontier conquered was another one lost; progress and taming the wilderness led ultimately to the closing of the frontier.[497] Here opened room for the pursuit of a new frontier. Most importantly, the visual language of the frontier had been developed, so the visualization of this new one—space—would position it as a final, but familiar, frontier.

The depiction of space in this form was achieved most significantly by space artist Chesley Bonestell, who, in McCurdy's words, "did for space what Albert Bierstadt and Thomas Moran had accomplished for the continental frontier."[498] The most prominent artist to do so, Bonestell helped visualize spaceflight and the future in terms of landscapes and technologies, translating technical ideas into visually stunning compositions, and showing Americans *how* space travel could be achieved in this process.[499] His artwork presented the unknown of outer space in immediately recognizable forms by evoking the techniques of American sublime artists, rendering the planetary vistas of space as knowable, traversable, and most importantly, conquerable places.[500] His visually compelling paintings offered a look at the many frontiers housed in the vastness of space and, importantly, also depicted in realistic and aesthetically striking ways the tools and technologies that could get humans there, helping space travel seem more than believable, but achievable.

Before his prominence as a space artist, Chesley Bonestell led a varied career. Bonestell was born in San Francisco on 1 January 1888, where the artistic community of the Rocky Mountain

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[495] Sage, "Framing Space," 34.
[496] White, "Frederick Jackson Turner and Buffalo Bill," 49
[497] White, "Frederick Jackson Turner and Buffalo Bill," 49; Limerick, "The Adventures of the Frontier," 73-74; Rushing, "Mythic Evolution," 265-266; Novak, *Nature and Culture*, 135.
[498] McCurdy, *Space and the American Imagination*, 51. See also: Sage, "Framing Space," 34-35, Newell, *Destined for the Stars*, 95.
[499] McCurdy, *Space and the American Imagination*, 51; Sage, *How Outer Space Made America*, 27-28; Sage, "Framing Space, 40; Miller, "Spaceflight and Popular Culture," 509-510.
[500] Sage, *How Outer Space Made America*, 32; Sage, "Framing Space," 34-35, 39; McCurdy, *Space and the American Imagination*, 51; Newell, *Destined for the Stars*, 66.

School had flourished.[501] Having received fine arts instruction from an early age, and later trained in architecture at Columbia University in New York, Bonestell worked as an architect from 1911 onwards, helping to design the Chrysler Building in New York and Golden Gate Bridge in San Francisco as notable highlights of his career in 1927 and 1931, respectively.[502] Later, he pursued a career as a matte painter in Hollywood starting in 1938.[503] Working on films such as *The Hunchback of Notre Dame* (1939) and *Citizen Kane* (1941), Bonestell cultivated a talent for photorealism which, combined with interests in astronomy, led to planetary landscapes of unmatched quality.[504]

While Bonestell occasionally painted planetary landscapes during his spare time, or for family and friends, it was not until 1944 that Americans were introduced to his portrayals of the interplanetary sublime and he became the most prominent space artist of the Space Age.[505] *Life* magazine's 29 May 1944 issue included a short article on the solar system featuring Bonestell's planetary artwork of Saturn, a planet he had painted once after having observed it at the Lick Observatory when he was 17 years old.[506] Now, readers of *Life* could share in his fascinations, delighted as they were by his interplanetary landscapes.[507] In 1946 *Life* published more of his paintings, this time in an article entitled "Trip to the Moon," which, through a sequence of images including views of Earth from space and the lunar landscape, took readers on a journey to the Moon

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[501] Durant and Miller, *Worlds Beyond*, 1; Sage, "Framing Space," 39. For a concise biographical sketch, see: Ron Miller, "Chesley Bonestell's Astronomical Visions," *Scientific American* 270, no. 5 (May 1994): 76-77; and McCurdy, *Space and the American Imagination*, 51-52. See also: Newell, *Destined for the Stars*, ch. 2.
[502] Durant and Miller, *Worlds Beyond*, 1-6; Miller, "Bonestell's Astronomical Visions," 76-77.
[503] Durant and Miller, *Worlds Beyond*, 5-6.
[504] Durant and Miller, *Worlds Beyond*, 6; Miller, "Bonestell's Astronomical Visions," 77; Sage, "Framing Space," 35; Catherine L. Newell, "The Greatest Adventure Awaiting Humankind: *Destination Moon* and Faith in the Future," *Implicit Religion* 17, no. 4 (December 2014): 465-466; McCurdy, *Space and the American Imagination*, 51-52.
[505] McCurdy, *Space and the American Imagination*, 52; Miller, "Bonestell's Astronomical Visions," 77; Newell, *Destined for the Stars*, 16, 34; Buss, "Virtual witnessing," 161, 165; Miller, "Spaceflight and Popular Culture," 509; Sage, "Framing Space," 29.
[506] Durant and Miller, *Worlds Beyond*, 2. See also the issue of *Life* magazine here: "Solar System," *Life*, May 29, 1944, Accessed July 23, 2021, https://books.google.ca/books?id=Yk8EAAAAMBAJ.
[507] Miller, "Bonestell's Astronomical Visions," 77; Scott and Jurek, *Marketing the Moon*, 7.

and back.[508] This theme was continued in his collaboration with Willy Ley on the seminal and highly influential book on space travel, *The Conquest of Space* (1949), as mentioned in Chapter Two.[509] In the book, Ley urged his readers not to think of Bonestell's artwork as "artist's conceptions," but rather as close to the real thing as they could get.[510] Constituting a form of "virtual witnessing," Bonestell's scientifically accurate artwork helped audiences behold the phenomenon of space travel without directly encountering it, therefore helping to move these images into public acceptance as "matter of fact."[511] When he collaborated with Wernher von Braun on the 1952 *Collier's* series, Bonestell's artwork helped elevate the engineer's ideas of space travel into visually striking forms, helping to define elements of the Space Age and contributing in very large part to the cultural purchase of the series in the United States.[512] The popularity of Bonestell's landscapes and the countless imitations of spaceships rendered in Bonestell's style are testaments to his popularity.[513]

Rendered in masterful detail, Bonestell's paintings were aesthetically stunning and instantly recognizable as they evoked elements of 19th century sublime landscapes. Although Bonestell was an atheist and did not intend to impose upon landscapes a sentiment of divinity or destiny, numerous scholars have commented on the kinship of his techniques with those of American sublime artists.[514] The works of American sublime artists and Bonestell both used elevated perspectives, depicted

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[508] Buss, "Virtual witnessing," 161-163. This issue is readily available online: "Trip to the Moon," *Life*, March 4, 1946, Accessed June 15, 2021, https://books.google.ca/books?id=QEgEAAAAMBAJ.
[509] Durant and Miller, *Worlds Beyond*, 6-7; Newell, *Destined for the Stars*, 130-131, 133-135.
[510] Chesley Bonestell and Willy Ley, *The Conquest of Space* (New York: The Viking Press, 1949), 9-10. See also: Buss, *Willy Ley*, 161.
[511] Buss, "Virtual witnessing," 161, 165-166, 168n4; Buss, *Willy Ley*, 161. See also: Kirby, *Lab Coats in Hollywood*, 24-25; David A. Kirby, "Science Consultants, Fictional Films, and Scientific Practice," *Social Studies of Science* 33, no. 2 (April 2003): 234-235.
[512] Durant and Miller, *Worlds Beyond*, 9-10; Miller, "Bonestell's Astronomical Visions," 79, 81; Miller, "Spaceflight and Popular Culture," 509-510; McCurdy, *Space and the American Imagination*, 53; Kilgore, "Engineers' Dreams," 116. Artists Fred Freeman and Rolf Klep contributed to *Collier's* as well, but Bonestell's work stood apart. See: Sage, *How Outer Space Made America*, 28.
[513] Sage, "Framing Space," 35; Miller, "Spaceflight and Popular Culture," 510-511; Sage, *How Outer Space Made America*, 32.
[514] Sage, *How Outer Space Made America*, 28, 31; Kessler, *Picturing the Cosmos*, 57-58; McCurdy, *Space and the American Imagination*, 51; Newell, *Destined for the Stars*, 16, 66, 85-86, 114-118; Sage, "Framing Space," 35; Buss, "Virtual witnessing," 162.

explorers practically miniature in comparison to their enormous surroundings, and exaggerated geological features to convey grandeur.[515] Though he never acknowledged any influence of the Rocky Mountain School, Bonestell was aware of the techniques, compositions, and elements that made images compelling, and employed them in his planetary landscapes.[516] His realistic and scientifically accurate paintings therefore evoked the same qualities of the sublime coveted by the American landscapes artists of the 19th century, and depicted the contours of the frontier in his portraits of the unknown.[517]

Figure 6. Chesley Bonestell, Saturn as Seen from Titan, 1944. Courtesy, Bonestell LLC.

As both Sage and Newell have observed, Bonestell essentially formulated a vision of space as the next frontier by transposing elements of American frontier onto the topographies of distant celestial bodies, thereby rendering unknown places as knowable, and therefore conquerable.[518] Moreover, an important dimension of Bonestell's art was also his visualizations of the technology, informed as he was by Ley and later von Braun,[519] to take humans to this new frontier. An example of virtual witnessing, Bonestell's paintings helped audiences see the space frontier *and* the means by

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[515] Buss, "Virtual witnessing," 161; Sage, *How Outer Space Made America*, 21, 31-32; Sage, "Framing Space," 38-39; Newell, *Destined for the Stars*, 66, 85; Kessler, *Picturing the Cosmos*, 20; McCurdy, *Space and the American Imagination*, 51, 311-312. For examples, see also: "Trip to the Moon," 74; "Solar System," 79-80

[516] Sage, *How Outer Space Made America*, 32; Sage, "Framing Space," 39; McCurdy, *Space and the American Imagination*, 51.

[517] Catherine L. Newell, "The Greatest Adventure," 465-466; Sage, *How Outer Space Made America*, 31-32; Sage, "Framing Space," 37, 40; Newell, *Destined for the Stars*, 66, 95.

[518] Sage, *How Outer Space Made America*, 31-32; Newell, *Destined for the Stars*, 66, 95; Sage, "Framing Space," 37-40.

[519] Durant and Miller, *Worlds Beyond*, 6-8. Newell, *Destined for the Stars*, 113-114; Kilgore, "Engineers' Dreams," 116; McCurdy, *Space and the American Imagination*, 52.

which they could be reached and possibly conquered, thereby helping to entrench images of space technologies in Americans' popular consciousness, especially through magazines like *Life* or *Collier's* or books like *The Conquest of Space*.[520] Just as American landscape artists who transformed the public's perceptions of the wilderness, so too did Bonestell help demystify the hostility and strangeness of outer space, but also by offering a vision of technological triumph over its harshest aspects.

SPACE TRAVEL BEFORE SPACEFLIGHT: THE AMERICAN SPACE TRAVEL FILM

This sort of visualization was then extended in cinematic depictions of spaceflight, which inherited and further popularized the dominant ideas of technology and space conquest by employing elements of Bonestell's sublime pictorial language. Even before the *Collier's* space series or Disney's "Man in Space" programs, space travel films helped realize in full form what space conquest would look like and advocated for its necessity. They presented space travel ideas and technologies through what David A. Kirby has called "diegetic prototypes," that is to say, "cinematic depictions of future technologies," whose value, necessity, and significance are depicted on the screen as natural elements in the fictional world of the film—the diegesis.[521] In this vein, space travel films thus acted as "virtual witnessing technologies,"[522] presenting their diegetic prototypes in dramatic and affective ways, thereby allowing audiences to experience space travel through film.[523] Technical possibilities were embedded into cinematic narratives that more meaningfully conveyed the values of space travel, and these kinds of stories "made space travel comprehensible to the popular mind."[524] It is thus a meeting of narrative, and technological, social, and cultural verisimilitude in the film's diegesis that contextualizes a scientific endeavour, which, in turn may

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[520] McCurdy, *Space and the American Imagination*, 53; Buss, "Virtual witnessing," 166-168; Newell, *Destined for the Stars*, 91, 96-97; Sage, "Framing Space," 37.
[521] Kirby, *Lab Coats in Hollywood*, 18, quotes from 195.
[522] Kirby, *Lab Coats in Hollywood*, 25; Kirby, "Science Consultants," 234.
[523] Kirby, *Lab Coats in Hollywood*, 18.
[524] Kilgore, *Astrofuturism*, 82-83; Kirby, *Lab Coats in Hollywood*, 26, 195. Quote from: Kilgore, "Engineers' Dreams," 113.

produce public support or technological change.[525] Although these space travel films were limited in some respects—particularly in regards to gender and race, as we will see—they often excelled in visualizing future technologies and how they might enable the conquest of distant frontiers.

Most notably, in the 1950 American science fiction film, *Destination Moon*, realism, the interplanetary sublime, technological reverence, and space travel advocacy intersected in meaningful ways and helped, as Kirby has suggested, contextualize space travel for audiences in the 1950s.[526] Although pulpy space opera serials like *Flash Gordon*, *Captain Video*, and *Space Patrol* were popular around the 1930s to the 1950s, and featured some basic spaceflight ideas, they did less to present spaceflight realistically.[527] *Destination Moon*, on the other hand, built on the legacy of *Frau im Mond* and stood as an extension of space travel popularization joined with technical realism and a vision of space as a frontier.[528] With prototypes of space technology and a vision of the first stages of space conquest, audiences virtually witnessed the United States might take steps to conquer the new frontier in *Destination Moon*, an act popularly constructed to be very much in the nation's character.

The film originated with Hungarian-born producer George Pal, and his desire to capitalize on growing public interest in spaceflight, along with his own fascination with the subject, stoked as it was by *Life*'s 1946 "Trip to the Moon" article illustrated by Bonestell.[529] In 1949, Pal purchased a screenplay co-written by Alford "Rip" van Ronkel and science fiction author and spaceflight enthusiast Robert A. Heinlein, as based on Heinlein's juvenile science fiction book *Rocket Ship Galileo*

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[525] Kirby, *Lab Coats in Hollywood*, 195-196.
[526] Kirby, *Lab Coats in Hollywood*, 7.
[527] Ron Miller, "Spaceflight and Popular Culture," 509; Schauer, ""The Greatest Exploitation Special Ever'," 9; Newell, *Destined for the Stars*, 160-161; Newell, "The Greatest Adventure," 467-469; Bill Warren with research associate Bill Thomas, *Keep Watching the Skies! American Science Fiction Movies of the Fifties*, the 21st century ed. (Jefferson, North Carolina, and London: McFarland & Company, Inc., Publishers, 2010), 221; Bainbridge, *Meaning and Value of Spaceflight*, 161-162.
[528] J.P. Telotte, *Science Fiction Film* (Cambridge: Cambridge University Press, 2001), 99-100.
[529] David Kirby, "The Future is Now: Diegetic Prototypes and the Role of Popular Films in Generating Real-world Technological Development," *Social Studies for Science* 40, no. 1 (February 2010): 58; Newell, 465; Schauer, ""The Greatest Exploitation Special Ever'," 5-7; Newell, *Destined for the Stars*, 158-159; Newell, "The Greatest Adventure," 461.

and his other writings.[530] The filmmakers also recruited Bonestell as a consultant and painter,[531] whose lunar backdrops constituted the key link between his interplanetary sublime and the film's depictions of space travel. Moreover, Pal, Heinlein, Bonestell, and director Irving Pichel were all dedicated to scientific accuracy and technical realism in the film; besides relying on Bonestell's advice, as well as Ley's *Rockets* and *The Conquest of Space*, Heinlein even wrote out calculations for mass ratios, trajectories, jet speeds, and fuel requirements, whose results, he believed, would contribute to the film's verisimilitude, even if they did not directly appear in the film.[532] Heinlein especially sought to create a genuine and believable film to encourage audiences to support space travel.[533] To these ends, the film brought a legacy of space popularization to life, realizing in dynamic form the prophecies of the pioneers of astronautics.

Destination Moon follows industrialist Jim Barnes, American General Thayer, rocket engineer Charles Cargraves, and technician Joe Sweeney on a mission to the Moon against the wishes of the American government. After Cargraves' first rocket fails, possibly as a result of sabotage, Thayer convinces Barnes that only American industry can build the spacecraft to reach the Moon, an effort important to the General. Once industrialists and investors are gathered to have the idea pitched to them, Thayer explains his reasons in full to the room (and the audience). As an overture to the space advocacy of the 1950s and a reflection of Heinlein's beliefs, Thayer argues that space supremacy means global supremacy: attacks from space cannot be stopped, and the first country to establish a

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530 Booker, *Alternate Americas*, 4; Schauer, *Escape Velocity*, 33; Schauer, "'The Greatest Exploitation Special Ever'," 6; Newell, "The Greatest Adventure," 465-467; Kirby, *Lab Coats in Hollywood*, 208; McCurdy, *Space and the American Imagination*, 53; Warren with Thomas, *Keep Watching the Skies!*, 223, 225.
531 Newell, *Destined for the Stars*, 162; Newell, "The Greatest Adventure," 469.
532 Gary Westfahl, *The Spacesuit Film: A History, 1918-1969* (Jefferson, North Carolina and London: McFarland & Company, Inc., Publishers, 2012), 20; Schauer, *Escape Velocity*, 35; Newell, *Destined for the Stars*, 162; Newell, "The Greatest Adventure," 469; Kirby, *Lab Coats in Hollywood*, 209-213; Buss, *Willy Ley*, 166; Bainbridge, *Meaning and Value of Spaceflight*, 169; Robert A. Heinlein, "Shooting 'Destination Moon'," *Astounding Science Fiction*, July 1950, 7, 16-17, accessed July 5, 2021, https://archive.org/details/sim_astounding-science-fiction_1950-07_45_5/.
533 Warren with Thomas, *Keep Watching the Skies!*, 224; Kirby, *Lab Coats in Hollywood*, 209-210; Newell, *Destined for the Stars*, 162.

military base on the Moon will control the Earth.[534] "The race is on," he says, foreshadowing the Space Race to begin later in the decade.[535]

Despite the national security angle of the endeavour, before Thayer makes his appeal to the room, Barnes renders space travel in romantic terms, which ultimately becomes a greater focus of the film. When asked by one of the potential investors what the payoff of going to the Moon is, Barnes answers: "Dollars and cents? I don't know. I want to do this job because it's never been done. *Because* I don't know. It's research, it's pioneering," he says. "What's the Moon? Another North Pole, another South Pole. Our only satellite—our nearest neighbour in the sky!"[536] To Barnes, the Moon is another arena to explore, another frontier to cross. Following a didactic animated sequence outlining the basics of space travel, Barnes declares before the tycoons of American industry that the effort to reach the Moon is "the greatest adventure awaiting mankind."[537] Between issues of national security, and a fascination with this unexplored place—a fascination mythically posited as being quintessentially American[538]—space travel seems imperative.

After the characters make their daring trip to the Moon, their landing on the lunar surface dramatically depicts the meeting of the sublime, imagined space technology, and an articulation of the frontier myth all at once, visualizing Barnes' "greatest adventure." After stepping out of the rocket-ship amidst a sweeping lunar backdrop painted by Bonestell, Cargraves declares that: "By the grace of God, and in the name of the United States of America, I take possession of this planet on behalf of, and for the benefit of, all mankind."[539] Here, audiences virtually witnessed not only the first American lunar journey, but also an expression of America's cosmic manifest destiny upon the

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534 Kirby, *Lab Coats in Hollywood*, 213.
535 *Destination Moon*, directed by Irving Pichel (1950; Chatsworth, CA: Image Entertainment, 2006), DVD. For a summary and review of the film, see: Warren with Thomas, *Keep Watching the Skies!*, 221-227; Newell, *Destined for the Stars*, 174-175; Rosenberg, "Far Out," 159.
536 See also: Newell, *Destined for the Stars*, 175.
537 Kirby, *Lab Coats in Hollywood*, 211; "Rocketeering Basics," *Destination Moon*.
538 Rushing, "Mythic Evolution," 265.
539 "One Small Step," *Destination Moon*; Newell, "The Greatest Adventure," 472; Westfahl, *The Spacesuit Film*, 26.

new frontiers of space.[540] This space frontier is depicted in familiar terms, with Bonestell's mountainous and majestic lunar vista constituting the sublime environment surrounding the astronauts who claim the Moon, who essentially represent what Newell has observed to be "the revitalization of the frontiersman."[541] In *Destination Moon*, the project of space conquest is thus an extended expression of American character; moreover, it appears as a feasible project because it is realistically depicted. Importantly, all throughout this film runs a reverence for the technology, rocket-ship *Luna*, that gets the astronauts to the frontier. Both in its dramatic liftoffs and superimpositions against the sweeping lunar vistas, audiences are reminded that a journey across frontiers—and the receipt of its benisons—is impossible without the rocket-ship.

An optimistic tale of how space can be conquered by humanity and their machines, one might read *Destination Moon*'s first steps toward conquest analogous to the westward movement of American pioneers, especially as the film ends with a card reading, "This is the End…of the Beginning!"[542] A qualified success, this spectacle of technical realism and visualization of space conquest resonated with audiences, raked in $5.5 million for the film's distributor, Eagle-Lion, received enthusiastic reviews, and won an Oscar for best special effects, helping Pal secure a contract with Paramount Pictures to produce other influential science fiction films, like *When Worlds Collide* (1951) and *The War of the Worlds* (1953).[543] A cinematic success and bid for space exploration, *Destination Moon* also served as a touchstone for visualizing the next stage of frontier conquest.

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[540] Newell, *Destined for the Stars*, 174; Warren with Thomas, *Keep Watching the Skies!*, 223.
[541] Newell, *Destined for the Stars*, 169-170.
[542] Sobchack, *Screening Space*, 21-22; Newell, *Destined for the Stars*, 167, 176.
[543] Warren with Thomas, *Keep Watching the Skies!*, 225; Schauer, *Escape Velocity*, 52-53; Schauer, "'The Greatest Exploitation Special Ever'," 18-19, 23; Westfahl, *The Spacesuit Film*, 26; Telotte, *Science Fiction Film*, 100; Kirby, *Lab Coats in Hollywood*, 213; McCurdy, *Space and the American Imagination*, 53; Newell, *Destined for the Stars*, 167. Warren notes that the film made $5.5 million for the distributor, and Schauer points out that the film made $1.3 million in rentals by the end of 1950. Whether the larger figure is cumulative over a period of time or not is unclear. See: Warren with Thomas, *Keep Watching the Skies!*, 225; Schauer, *Escape Velocity*, 52-53; Schauer, "'The Greatest Exploitation Special Ever'," 19.

Although not as popular, the film *Rocketship X-M* also joined *Destination Moon* in 1950 on the silver screen, another offering for audiences to virtually witness space technology and the promises *and* perils of interplanetary adventure. Produced on a budget of $94,000, *Rocketship X-M* was developed to compete with *Destination Moon* and capitalize on its marketing and popularity, rushed to completion to beat the release of Pal's film.[544] In envisaging its interplanetary voyage, the film depicted a rocket directly inspired by the work of illustrator Noel Sickles for a 17 January 1949 article in *Life* called "Rocket to the Moon."[545] Less photorealistic than Bonestell's artwork, Sickles still employed similar techniques in rendering his lunar vistas in *Life*, and furnished readers with a look at what a lunar trip may look like, including the necessary technology.[546] This image of the rocket was essentially put into motion and contextualized in *Rocketship X-M*'s narrative. In short, the film tells of a crew bound for the Moon on a precursor mission to establishing a military base until circumstances send them careening to Mars. Once there, they find the remains of a civilization ruined by atomic destruction. Attacked by the last of the planet's inhabitants, now resembling primitive humans, the few surviving crewmembers escape to the rocket-ship (the R-XM) and return to Earth. Although they are unable to land successfully, the astronauts deliver their message of the dangers of atomic weaponry and warfare to the denizens of Earth, before perishing in the crash.[547]

Less a tale of outer-space conquest, and more a reflective, cautionary tale on the dark potentials of technology,[548] *Rocketship X-M* still implies that the specter of annihilation is to be overcome through the salvation afforded by more benevolent technologies and their applications,

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[544] Schauer, *Escape Velocity*, 53; Booker, *Alternate Americas*, 5; Schauer, "'The Greatest Exploitation Special Ever'," 17; Newell, *Destined for the Stars*, 167; Warren with Thomas, *Keep Watching the Skies!*, 709; Westfahl, *The Spacesuit Film*, 85-86.
[545] Schauer, *Escape Velocity*, 16. This issue of *Life* is available online: "Rocket to the Moon," *Life*, January 17, 1949, accessed June 10, 2021, https://books.google.ca/books?id=hUoEAAAAMBAJ.
[546] See especially: "Rocket to the Moon," 70-73.
[547] *Rocketship X-M*, directed by Kurt Neumann, 50th anniversary ed. (1950; Chatsworth, CA: Image Entertainment, 2000), DVD; Warren with Thomas, *Keep Watching the Skies!*, 708-711. See also: O'Brien Stanley, Nicki L. Michalski, Lane 'Doc' Smith, and Steven J. Zani, *Martian Pictures: Analyzing the Cinema of the Red Planet* (Jefferson, North Carolina: McFarland & Company, Inc., Publishers, 2018), 36-37; Westfahl, *The Spacesuit Film*, 85-87.
[548] Schauer, "'The Greatest Exploitation Special Ever'," 18; Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 29.

especially where spaceflight is concerned. The salvatory value of space travel is conveyed at the end of the film by the character Dr. Fleming, the R-XM's project director, who addresses reporters after one of them suggests the flight was a failure following the crash. Fleming tells them that the expedition of the R-XM has proven that space travel is possible and practical, "and it has supplied us with information which may well mean the salvation of our own world."[549] To him the flight was anything but a failure, and he declares that the construction of a second spaceship, the R-XM-2, will commence tomorrow.[550] In the context of the film, salvation is only made possible not only by the discovery and traversal of extraterrestrial frontiers, but also by the spaceship getting the astronauts to the frontiers of Mars, and it is there that they learn of the horrors of atomic warfare. While media theorist Vivian Sobchack has argued that *Rocketship X-M* treats the spaceship as a neutral utility, "a mechanical convenience which, devoid of wonder, will carry the crew to visually exciting adventures,"[551] from this vantage, it represents a harbinger of salvation, and is aligned with the positive depictions of the spaceship in films like *Destination Moon*, *The Conquest of Space* (1955), or *Forbidden Planet* (1956).[552] *Rocketship X-M* also portrays landscape less as land to conquer, but as an arena wherein social rejuvenation may be won, thereby promising the same benisons afforded to those who discover and traverse such places, reiterating a basic tenet of the frontier myth.

Rocketship X-M performed admirably against its budget, bringing in $650,000 at the box office, although it hardly lived up to the standards of *Destination Moon*.[553] As more science fiction films appeared in following years, their growing popularity perhaps indicated an emerging national fascination,[554] as the basic ideas of spaceflight technology and frontier conquest were repeated in a

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549 "Toward the Future," *Rocketship X-M*, directed by Kurt Neumann, 50th anniversary ed. (1950; Chatsworth, CA: Image Entertainment, 2000), DVD.
550 Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 29, 37; Westfahl, *The Spacesuit Film*, 88.
551 Sobchack, *Screening Space*, 73.
552 Sobchack, *Screening Space*, 68-70.
553 Schauer, "'The Greatest Exploitation Special Ever'," 17.
554 Scott and Jurek, *Marketing the Moon*, 3.

variety of films. *When Worlds Collide* (1951), for example, another Pal produced film, though not chiefly focused on spaceflight, still presented space travel technology in meaningful ways. In the film's plot, a celestial body is rapidly approaching Earth on a collision course.[555] Rendered in positive, even reverential, terms, spaceflight in this case is humanity's only escape from certain doom, the spacecraft an ark to ferry survivors away from the Earth and to a new planet.[556] Depicting space technology in this way was a boon to the popularization of spaceflight. These space travel films thus depicted space travel technology as believable and practical devices and contextualized them in terms of frontier conquest or the preservation of humanity.

While *Destination Moon* set the standard for space travel films,[557] not all that followed matched or even came close to its technical realism, use of imagery, or dedication to accuracy. Lesser-known and less popular space travel film *Flight to Mars* (1951), for example, made by the same team responsible for *Rocketship X-M*, resorted to a pulpy narrative of reaching Mars, where Martians (who simply look human) bent on conquering Earth are encountered.[558] Besides a few shots of a Bonestellian model rocket ascending and flying through space, the film lacks meaningful visualizations of technology or landscape.[559] Two years later, *Cat-Women of the Moon* (1953), what film historian and critic Bill Warren has called "one of the most alarmingly awful films in the history of movies," used spaceflight only as set-dressing for its outlandish plot of feline lunar inhabitants.[560] Remarkably, audiences would have still been treated to views of Bonestell's interplanetary sublime,

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[555] For a summary of the film, see: Warren with Thomas, *Keep Watching the Skies!*, 894, more generally see 894-900.
[556] Sobchack, *Screening Space*, 69; Warren with Thomas, *Keep Watching the Skies!*, 894; Bainbridge, *Meaning and Value of Spaceflight*, 170.
[557] Kirby, *Lab Coats in Hollywood*, 209; McCurdy, *Space and the American Imagination*, 53. Warren, for example, calls *Destination* one of the "key" science fiction films, see: Warren with Thomas, *Keep Watching the Skies!*, 221.
[558] Newell, "The Greatest Adventure," 473n15; Warren with Thomas, *Keep Watching the Skies!*, 282-284; Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 110-112; Schauer, *Escape Velocity*, 53-54.
[559] *Flight to Mars*, directed by Lesley Selander (Los Angeles, CA: Monogram Productions, Inc., 1951), Archive.org, accessed August 10, 2021, https://archive.org/details/flight-to-mars-1951.
[560] Warren with Thomas, *Keep Watching the Skies!*, 149.

as some of his moonscapes were used in the film, though he went uncredited.[561] 1953 also saw the release of *Project Moonbase*, a space adventure film produced with Heinlein's cooperation, although the film was a far cry from *Destination Moon*.[562] Cobbled together from pieces of an unaired television show, the film did at least depict a disclike space station in the film's future setting of 1970, along with the preliminary establishment of a lunar base.[563] Amidst a somewhat muddy plot involving a duplicitous saboteur bent on destroying the space station (fortunately, he is thwarted), the film offered sequences of the space station facilitating lunar exploration by sending out a lander craft to the Moon, as well as a sequence of astronaut Major Moore crossing a lunar vista reminiscent of Bonestell's paintings.[564] Although astronauts Colonel Briteis and Major Moore end up stranded on the lunar surface, their vessel becomes the first installation for a future lunar base, as well as a home for the new settlers. While not a popular film, *Project Moonbase* nonetheless explored and reiterated the basic ideas of space travel, perhaps even patterned after von Braun's comprehensive vision of a space program that included a near-Earth space station to facilitate additional expeditions.[565]

By 1955, the handful of American space travel films that followed *Destination Moon* struggled in some respects to depict space travel in meaningful and technically accurate ways, yet they still facilitated and indicated an entrenchment of the basic ideas of spaceflight. These films represented both responses to, and producers of, public interest in spaceflight, and may have been at least partly responsible for the shift in public perceptions, as reflected by the Gallup poll numbers for 1955 mentioned in Chapter Two.[566] While numerous factors, including the publication of the *Collier's*

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561 Westfahl, *The Spacesuit Film*, 93; Warren with Thomas, *Keep Watching the Skies!*, 151.
562 Warren with Thomas, *Keep Watching the Skies!*, 671-672; Westfahl, *The Spacesuit Film*, 32.
563 Warren with Thomas, *Keep Watching the Skies!*, 671-674; *Project Moonbase*, directed by Richard Talmadge (1953; Chatsworth, CA: Image Entertainment, 2006), DVD.
564 "The Mission"; "Lunar Landing"; "The Relay Station," *Project Moonbase*, directed by Richard Talmadge (1953; Chatsworth, CA: Image Entertainment, 2006), DVD.
565 Warren with Thomas, *Keep Watching the Skies!*, 673-674; Westfahl, *The Spacesuit Film*, 32.
566 McCurdy, *Space and the American Imagination*, 53-54; Scott and Jurek, *Marketing the Moon*, 3. Gallup, *The Gallup Poll*, 2:875, 2:1306, cited also by McCurdy, *Space and the American Imagination*, 54

space series and Bonestell's artwork, contributed to this increase, it is likely that science fiction and space travel films had a role to play in this as well. With popular television programs such as *Tom Corbett, Space Cadet* or *Space Patrol* airing from 1950 to 1955, American audiences were well furnished with a variety of visions of space travel that contributed to their growing acceptance of its possibilities, especially if such media took steps to ensure accuracy and believability.[567]

These visions were advanced again in 1955, when George Pal released *Conquest of Space*, a film inspired by Ley and Bonestell's book *The Conquest of Space* (1949).[568] The film was patterned after the ideas of the space program and its eventual Mars expedition forwarded by Wernher von Braun in his articles for *Collier's*, and presented diegetic prototypes of technologies envisioned most recently by Bonestell, including a crewed, wheellike space station (called "the Wheel" in the film), a winged spacecraft, and "space taxis," to ferry astronauts from the station to the rocket-ship suspended next to it.[569] Unfortunately, the film performed poorly, making $1 million against its budget of $1.65 million, and was hampered by a lackluster plot.[570] Nonetheless, *Conquest* featured accurate visualizations of spaceflight ideas that Ley, von Braun, and Bonestell had been popularizing for years, helping to further disseminate space travel ideas, even if it was limited in reach.[571]

The film's plot concerns the first expedition to Mars, where on account of one of the astronaut's madness, the spacefarers are stranded on the red planet and must survive until they can return home by rocket.[572] More important than its story is how it visualizes a crewed space station,

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[567] McCurdy, *Space and the American Imagination*, 35; Scott and Jurek, *Marketing the Moon*, 3-4; Bainbridge, *Meaning and Value of Spaceflight*, 161-163; Miller, "Spaceflight and Popular Culture," 511.
[568] Bainbridge, *Meaning and Value of Spaceflight*, 170-171; McCurdy, *Space and the American Imagination*, 54; Warren with Thomas, *Keep Watching the Skies!*, 155.
[569] Bainbridge, *Meaning and Value of Spaceflight*, 170-171; Warren with Thomas, *Keep Watching the Skies!*, 158; McCurdy, *Space and the American Imagination*, 54.
[570] Schauer, *Escape Velocity*, 67; Warren with Thomas, *Keep Watching the Skies!*, 158; McCurdy, *Space and the American Imagination*, 54.
[571] Bainbridge, *Meaning and Value of Spaceflight*, 170-171.
[572] *Conquest of Space*, directed by Byron Haskin (1955; Hollywood, CA: Paramount Pictures Corporation, 2019), DVD; For a summary and review, see: Warren with Thomas, *Keep Watching the Skies!*, 155-159. See also: Westfahl, *The Spacesuit Film*, 41-45; Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 19.

described by the film's narrator as "an observation post in the heavens, and a place where a spaceship can be assembled and then launched to explore other planets and the vast universe itself in the last and greatest adventure of mankind, a plunge toward the conquest of space!"[573] Reiterating von Braun's position that a space station is a "springboard" for planetary exploration,[574] the film then allows audiences to virtually witness how it might look, feel, and function. Moreover, when the stranded astronauts on Mars await the planet's proper orbital alignment so they can blast off and return home, astronaut Imoto plants a seed from Earth to determine whether life can flourish on the desolate planet. Later, it snows on Mars (and in time for Christmas), and after the astronauts prepare to make their return journey some months later, Imoto is thrilled to find that the seed has produced the first green shoots of a flower.[575] Coupled with the shots of the Martian landscape, evocative of Bonestell's interplanetary sublime, the film implies that, given enough time, perhaps Mars and other worlds could be shaped in the image of Earth, offering a truly new wilderness to conquer. As the budding flower and the film's celebration of space technology suggest,[576] life will flourish there as long as humanity embraces the technologies and tools necessary to the conquest of space.

TO WIN THE SUBLIME FOR ALL AMERICA

Although *Conquest of Space* underperformed at the box office, the cultural Space Age was fast becoming entrenched in the daily lives of Americans. This was the cumulative by-product of numerous sources of popularization, including films, television programs, publications, and paintings alike. Moreover, finned automobiles resembling rocket-ships, space-themed toys, and even fashion, like André Courrèges' "Moon Girl" collection of the 1960s, reflected how spaceflight

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573 "A Story of Tomorrow," *Conquest of Space*, directed by Byron Haskin (Hollywood, CA: Paramount Pictures Corporation, 1955), DVD.
574 Von Braun, "Prelude to Space Travel," 50.
575 "Mars-Quake," *Conquest of Space*, directed by Byron Haskin (1955; Hollywood, CA: Paramount Pictures Corporation, 2019), DVD. See also: Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 19; Westfahl, *The Spacesuit Film*, 44-45.
576 Sobchack, *Screening Space*, 70. Also cited by: Kirby, *Lab Coats in Hollywood*, 217.

enthusiasm and its iconography began dominating the landscape of popular culture.[577] With numerous pieces of media and spaceflight popularization making promises in the 1950s, it is perhaps no surprise that the launch of *Sputnik* was initially met with some enthusiasm from a portion of the American public.[578] Perhaps *Sputnik* provided a suggestion that the space fantasies of the screen and printed page were to materialize in reality at last, and all the possibilities offered by Bonestell's painted frontiers and film's daring expeditions would come to fruition. By the late 1950s, decisionmakers within the NACA and later NASA had also grown receptive to space travel, prioritizing activities like lunar landings as major milestones in their planning.[579] Their focus remained centered on human space travel, and spaceflight media in general coveted the role of the pioneer travelling to the frontiers of space to conquer them.[580] McCurdy has suggested that this focus on human space travel helped "promote the belief, dominant within many sectors of government, that space flight could not survive within political circles unless it emphasized human flight."[581] Indeed, the dominance of spaceflight media, as Miller has pointed out, not only "reflected contemporary fascination with space travel," but also served to inform the government, one preparing to spend billions on space travel, that its taxpayers were invested in the prospects of spaceflight.[582] It may have also served as an indication of where exactly those interests lay.

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577 Rosenberg, "Far Out," 178-182; Miller, "Spaceflight and Popular Culture," 510-511.
578 McQuaid, "Sputnik Reconsidered," 375-378; Launius, *Reaching for the Moon*, 27-30. See also: Launius, "An unintended consequence," 257-258.
579 McCurdy, *Space and the American Imagination*, 54-56.
580 McCurdy, *Space and the American Imagination*, 12-13; Prelinger, *Another Science Fiction*, 62, 64; Sage, *How Outer Space Made America*, 32; Sage, "Framing Space," 39; See also: Rushing, "The Mythic Frontier," 277-278; James Lee Kauffman, *Selling Outer Space: Kennedy, the Media, and Funding for Project Apollo, 1961-1963* (Tuscaloosa and London: The University of Alabama Press, 1994), 36-39; Newell, *Destined for the Stars*, 170.
581 McCurdy, *Space and the American Imagination*, 54-55; Despite the insistence of Kennedy's ad hoc committee on space to focus on robotic space exploration, Kennedy decided that human space exploration, which was also well entrenched in NASAS's thinking, best represented a commitment to energetic global leadership. See: William P. Leeman, "One Giant Leap: John F. Kennedy, the Apollo Program, and the Political Culture of the New Frontier," *The New England Journal of History* 75/76, no. 1/2 (Spring/Fall 2019): 104.
582 Miller, "Spaceflight and Popular Culture," 511.

Imaginative visual media had most cogently expressed the connections between the frontier and space travel, thereby supplying a framework to justify projects of space exploration within government and to the public. The goal of a lunar landing in the United States was significant for "the Moon offers a landscape," one that could be positioned analogously to terrestrial territories and facilitate the revitalization of "motifs familiar to accounts of the American West."[583] The Moon supplied the human space program with the stage upon which America's next frontier drama could take place.[584] Rushing has articulated how one of the requisite elements of a cultural myth's performance is a scene, and in the American context it is the "harsh frontier range" upon which the "rugged individualist" uses "horses, guns, and force" to conquer the land and its inhabitants for the purpose of "[expanding] the country,"[585] thereby fulfilling the tenets of manifest destiny.[586] By the 1960s, it was the frontier range of distant planets that the astronaut travelled to in spaceships, relying on ingenuity to conquer the cosmos.[587] In this vein, Newell has argued that Bonestell's paintings encouraged the United States to go to the Moon, precisely because of how he depicted lunar landscapes as the new frontier.[588] Similarly, space travel films had depicted space as the next frontier by employing Bonestell's sublime visual language in this same manner.

While President John F. Kennedy's commitment to land a man on the Moon was a political response to the Soviet Union in the midst of the Cold War,[589] it may have also been a means of indicating that not only was the United States the world's preeminent technological leader, but also its principal frontier-crossing nation. Jennifer Burwell has explained that when *Sputnik* entered orbit,

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583 Sage, *How Outer Space Made America*, 47.
584 Kauffman, *Selling Outer Space*, 5, 34-35, 47-48; Rushing, "Mythic Evolution," 283, also cited by Kauffman, *Selling Outer Space*, 34.
585 Rushing, "Mythic Evolution," 270.
586 Sage, *How Outer Space Made America*, 48. See also: Kauffman, *Selling Outer Space*, 30-31.
587 See also: Kauffman, *Selling Outer Space*, 47-48.
588 Newell, *Destined for the Stars*, 15, 95.
589 Logsdon, *John F. Kennedy*, 237-238.

space became "a Russian territory," or at the very least, threatened to become one.[590] From this vantage, the Soviet Union also threatened the United States' self-proclaimed status as the leading nation of pioneers, whose mythologized and romanticized history of frontier conquest underpinned the nation's character. Every Soviet space first eroded the mythical destiny of the American nation—a destiny which had for years been shown in various media as especially compatible with space exploration—thereby prompting a response from America's leaders on equal terms. With the popular culture of spaceflight built around the ideas of cosmic destiny advanced in space travel media, it is possible this created a cultural and political climate wherein space activities became more than ephemeral to the American character, but rather, deeply ingrained.[591]

ODYSSEYS FOR A NEW ERA

By the late 1960s, screens were also awash with the television adventures of *Star Trek* which confidently declared space to be "the final frontier" before every episode, an assertion made possible, perhaps, by all the spaceflight media that had preceded and informed it. Films continued offering visions of interplanetary flight while the United States embarked on the real effort itself. As a result, the spectacle of space travel was less emphasized than it had been in previous films, while its implications and possible adventures continued receiving attention. Although *12 to the Moon* (1960) followed *Destination Moon* by depicting a lunar journey, notably by an international crew, it quickly turned to a pulpier narrative involving hostile lunarians,[592] and *The Phantom Planet* (1961) used space travel more as a backdrop for its story of a society upon an asteroid beset by alien invaders.[593]

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[590] Jennifer Burwell, "Imagining the Beyond: The Social and Political Fashioning of Outer Space," *Space Policy* 48 (May 2019): 42.

[591] Kauffman writes that "For members of Congress, the frontier narrative advanced by the Kennedy administration and reinforced by the media not only became a way of understanding the space program and its surrounding events but also offered a specific program needing support—Project Apollo—that reaffirmed America's mythic identity during the uncertain years of the cold war." See: Kauffman, *Selling Outer Space*, 93, see also 5, 31-33.

[592] Westfahl, *The Spacesuit Film*, 109-110.

[593] *12 to the Moon*, directed by David Bradley (1960; Culver City, CA: Columbia Pictures Industries, Inc., 2015), DVD; *The Phantom Planet*, directed by William Marshall (1961; Chatsworth, CA: Image Entertainment, 2006), DVD. For a summary

In 1964, *Robinson Crusoe on Mars* similarly employed space travel as a means of getting the protagonist to the scene of the drama. Spaceflight as a reality was taken more for granted in the film, the focus rather on Commander Christopher Draper's efforts to survive on Mars, whose landscapes evoked the forms of a sublime scenery. As with *Conquest*, *Crusoe on Mars* also depicted how astronauts might overcome the hostility of worlds *out there*—an outer space frontier whose tribulations of survival remain in some ways analogous to those one might encounter on Earth (although some of Draper's challenges and triumphs remain decidedly otherworldly). Draper's eventual success and capacity to thrive on the alien planet indicates that astronauts of the future might do the same. Moreover, the spacecraft here is also representative of and literally a means of salvation in the film. Draper, his monkey companion Mona, and extraterrestrial compatriot, Friday, are able to escape once a spaceship arrives to rescue them, having received Draper's distress calls at last.[594]

Stanley Kubrick's *2001: A Space Odyssey* (1968), then, the most significant science fiction film to emerge out of the 1960s, combined the realism of *Frau im Mond*, *Destination Moon*, and *Conquest of Space* with promises of an incredible spaceflight future visualized through spectacular and highly realistic special effects.[595] Replete with sequences of a familiar but modern rotating wheel space stations, routine commercial spaceflight, lunar bases, and voyages far into the solar system, *2001* allowed audiences to virtually witness a future they were presumably on the cusp on, especially as Apollo 8 took astronauts on a circumlunar voyage the same year the film released. Where *Frau im Mond* or *Destination Moon* raised questions about "*how* do we get there?," *2001* asked, "where are we going *next*?"[596] Now that space travel had been achieved, *2001* built upon reality by projecting

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and review of *The Phantom Planet*, see: Warren with Thomas, *Keep Watching the Skies!*, 658-662, for *12 to the Moon*, see 808-811. See also: Westfahl, *The Spacesuit Film*, 109-113.

[594] *Robinson Crusoe on Mars*, directed by Byron Haskin (Hollywood, CA: Paramount Pictures Corporation, 1964), Video on Demand; see also: Westfahl, *The Spacesuit Film*, 115-117.

[595] Schauer, *Escape Velocity*, 94-95; Kirby, *Lab Coats in Hollywood*, 1, 7; Telotte, *Science Fiction Film*, 99-100; Booker, *Alternate Americas*, 12, 75, 81, 83.

[596] Kirby, for example, writes that *2001* contextualized for audiences "the cultural and social potential of space travel now that it was possible." See: Kirby, *Lab Coats in Hollywood*, 7.

nascent space travel feats decades into the future.[597] In 1966, replying to Joseph V. Charyk, president of the Communications Satellite Company, who had requested information on *2001*, Roger A. Caras, vice president of Kubrick's production company, wrote that the film "promised to be an authentic projection of contemporary technologies 35 years into the future," and that, with the expert advice received from various organizations, "the film [would] be a veritable crystal ball!"[598] *2001* thus promised a glimpse into a future opened only in space.

The film thematically offered a vision of salvation and rebirth through spaceflight as well. The plot follows humanity's encounters with a strange extraterrestrial monolith whose visitations seem to encourage the evolution of whomever it meets.[599] First during the early days of Earth, apelike humans learn to use bones as tools and then weapons after their encounter with the Monolith. Many thousands of years later, spacefaring humans discover the Monolith on the Moon and, following a signal it emits, travel to Jupiter to learn of its origins. The rest of the film follows the crew of spaceship *Discovery* on this voyage. As the crew of the ship later face the onboard A.I., HAL 9000, who goes rogue and begins killing the astronauts, this negative view of technology[600] is balanced with the salvatory aspects of space technology, much in the style of *Rocketship X-M*. The film's eponymous odyssey is complete after the last surviving astronaut, Dave Bowman, crosses the infinite in a near-psychedelic sequence of imagery, indicating his journey toward the source of the Monolith, and then is later reborn into a "Starchild" who returns to Earth. Threatened as the planet is with the specter of nuclear annihilation, as possibly indicated by a bomb-carrying satellite orbiting

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[597] Kirby, *Lab Coats in Hollywood*, 7.
[598] Roger A. Caras to Joseph V. Charyk, March 10, 1966, letter in Smithsonian Institution, National Air and Space Museum Archives, Smithsonian Online Virtual Archives, Arthur C. Clarke Collection of Sri Lanka, Acc. 2015-0010, Box 4, Correspondence, January – May 1966, Folder 1 of 2, uan: NASM-NASM.2015.0010-bx004-fd001_102 and NASM-NASM.2015.0010-bx004-fd001_103, 1-2, quotes from 2, accessed July 23, 2020, https://sova.si.edu/details/NASM.2015.0010.
[599] *2001: A Space Odyssey*, directed by Stanley Kubrick (1968; Burbank, CA: Warner Bros. Entertainment Inc., 2018), Blu-Ray.
[600] Sobchack, *Screening Space*, 70-71.

the planet in the first half of the film,[601] this evolved Bowman has presumably returned to save humanity. Importantly, then, this entire odyssey is only possible *because* of space technology: Bowman is taken to Jupiter by *Discovery*, and "beyond the infinite" in a small spacecraft. Science fiction author Arthur C. Clarke, who co-wrote the film, and Kubrick almost argue that spaceflight can help evolve humanity, although perhaps only with the prerequisite extraterrestrial contact.[602]

IMPACTS AND LIMITS

Whether it was Bonestell's paintings or space travel films, imaginative visual media conveyed to American audiences a thrilling image of space travel and helped foster a growing popular culture that coveted the icons and adventures promised and envisioned in this media. They were important means of familiarizing the nation with the prospect of space travel, just as American landscape artists depicted the natural wonders of the country's wilderness and transformed them into places full of meaning. Similarly, just as Moran's watercolours encouraged Congress to establish Yellowstone as a national park, one might consider that so too did Bonestell's paintings help encourage the public and decisionmakers to establish space, and the Moon, as the next stage of the performance of America's frontier myth.[603] Space travel films then utilized the motifs and imagery of Bonestell's artwork, contextualizing them in terms of space frontiers and technologies necessary for cosmic adventures, thereby contributing to making spaceflight seem believable, if not desirable when depicted as compatible with the nation's character. When Kennedy made a commitment to reach the Moon, it therefore seemed like no idle fantasy, but a natural evolution of the national character.

Moreover, numerous scholars point out how Bonestell's artwork inspired numerous scientists, engineers, astronauts, writers, and artists, thereby contributing to public understanding,

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601 Peter Krämer, *2001: A Space Odyssey*, BFI Film Classics, (London: British Film Institute, 2010), 43-44. In an earlier draft of the script, which featured significant voiceover narration, the spacecraft, featured in the famous match-cut scene in *2001*, was to be explicitly identified as the carrier of a nuclear bomb.
602 Booker, *Alternate Americas*, 87; Westfahl, *The Spacesuit Film*, 306-307; Telotte, *Science Fiction Film*, 100.
603 See: Sage, "Framing Space," 48; McCurdy, *Space and the American Imagination*, 51; Newell, *Destined for the Stars*, 15, 95.

producing additional popularization, and encouraging others to take roles in the aerospace field.[604] It is more difficult to map out the direct impacts of film, but some examples that indicate their potential effects remain. The entire career of German engineer Krafft Ehricke, for example, was a product of watching *Frau im Mond* when he was 12 years old.[605] So moved by the film, he dedicated his life to rocketry and space travel, and eventually went to work at Peenemünde.[606] Coming to the United States through Operation Paperclip, Ehricke was later central to designing the Centaur rocket stage which, mated to an Atlas, in 1966 took *Surveyor* probes to the Moon in preparation for the Moon landings.[607] As an indication of the power of cinematic inspiration, Ehricke's example is suggestive of film's capacity to inspire and motivate. Moreover, as with science fiction, films were useful in creating expectations about the future of spaceflight.[608] As McCurdy has pointed out, when NASA pursued the construction of a space station in the 1980s, many people at the agency assumed it would resemble a large wheel, as visualized by *2001*.[609] In effect, they were hoping for the station described in 1897 by Laßwitz, championed by von Braun and Bonestell, and updated in *2001*.

For all of their stunning visualizations of a space future, the effect of visual media, and space popularization in general, was at times somewhat limited. While they contributed to public enthusiasm, this enthusiasm hardly translated directly to public support or broad understanding.[610] As Launius and Bainbridge have shown, the American public did not particularly clamour for space travel in the 1960s, and generally, there were more people in favour of cutting budgets for spaceflight than there were those in favour of raising it.[611] By the same token, however, just as there

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[604] McCurdy, *Space and the American Imagination*, 51; Kessler, *Picturing the Cosmos*, 55; Durant and Miller, *Worlds Beyond*, 7; Newell, *Destined for the Stars*, 16, 134-135, 240; Kilgore, "Engineers' Dreams," 125.
[605] Marsha Freeman, *Krafft Ehricke's Extraterrestrial Imperative* (Burlington, Ontario: Apogee Books, 2008), 11.
[606] Freeman, *Extraterrestrial Imperative*, 11-15.
[607] Freeman, *Extraterrestrial Imperative*, 19, 31-34. See also: Dawson, "Taming Liquid Hydrogen," 339, 343.
[608] Space travel advocates vied to do the same in their work. See: McCurdy, *Space and the American Imagination*, 12-13.
[609] McCurdy, *Space and the American Imagination*, 199.
[610] Bainbridge, *The Spaceflight Revolution*, 6.
[611] Bainbridge, *The Spaceflight Revolution*, 6; Roger D. Launius, "Public opinion polls and perceptions of US human spaceflight," *Space Policy* 19, no. 3 (August 2003): 163, 165-167; Bainbridge, *Meaning and Value of Spaceflight*, 16-20.

were those opposed to financing Apollo in the 1960s, there were also those consistently in favour of it, even if they often made up the minority.[612] The numerous cultural artifacts—from books, articles, paintings, films, toys, games, and fashion—of the 1950s and 1960s indicate a national fascination, one whose shape was determined by the producers and responders to space-related media, as well as by the period's technological advances.[613] Popular enthusiasm did not always result in equivalent levels of support, but the presence of attitudes in favour of space travel are worth weighing in equal measure alongside contrary opinions. Such positive views were the results of numerous factors, among which space travel popularization, including film and visual media, was likely a large part.

Imaginative visual media had other limits, however. Though films excelled in visualizing the technologies and adventures of the future, many struggled in depicting future human societies, particularly where gender and race were concerned.[614] The structures of 1950s and 1960s American society were typically ossified and injected without alteration into these films, despite their futuristic or utopian contexts. There are almost no women in *Destination Moon* or *Conquest of Space*, and none in *Robinson Crusoe on Mars*, for example. When they do appear, they are concerned wives or mothers and do not participate in the journeys across space.[615] In *2001*, although some women are portrayed as scientists and ranking authorities, they are principally stewardesses or secretaries, and none join the astronauts onboard *Discovery*.[616]

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[612] Launius, "Public opinion polls," 166-167, 167 fig. 5; Roger D. Launius, "Why go to the moon? The many faces of lunar policy," *Acta Astronautica* 70 (January-February 2012): 168, 169 fig. 2.
[613] Miller, "Spaceflight and Popular Culture," 501, 511; Rosenberg, "Far Out," 168; Crouch, *Aiming for the Stars*, 119; McDougall, …*the Heavens and the Earth*, 99-100; Scott and Jurek, *Marketing the Moon*, 3.
[614] McCurdy, *Space and the American Imagination*, 298, 300.
[615] Bonnie Noonan, *Women in Fifties Science Fiction Films* (Jefferson, North Carolina, and London: McFarland & Company Inc., Publishers, 2005), 39. As Lorrie Palmer and Lisa Purse mention, there are a number of women astronauts in science fiction, like the heroines in André Laurie's *The Conquest of the Moon* (1889), George Griffith's *A Honeymoon in Space* (1900) and Arthur Train and Robert Wood's *The Moon Maker* (1915). The spacewoman as a character did not, however, "progress as it naturally might have," in the popular fiction that followed in the mid 19th century. See: Lorrie Palmer and Lisa Purse, "When the astronaut is a woman: beyond the frontier in film and television," *Science Fiction Film and Television* 12, no. 1 (February 2019): 3-4.
[616] Bonnie Noonan, *Gender in Science Fiction Films, 1964-1979: A Critical Study* (Jefferson, North Carolina: McFarland & Company, Inc., Publishers, 2015), 58-60. See also: Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 113.

Though some space travel films did portray women in active, positive roles, there were limits in those depictions as well, reflecting the gender dynamics of the 1950s and 1960s. Dr. Lisa van Horn in *Rocketship X-M* is depicted positively, for example, as she has made the R-XM's flight possible by her scientific genius, yet the film still places her character into a romantic subplot with Col. Floyd Graham who challenges "both [her] role in society as well as her commitment to her gender."[617] At one point, when Dr. Van Horn says Col. Graham must believe that "women should only cook, sew, and bear children," he replies, "Isn't that enough? There's such a thing as going overboard in the other direction too, you know."[618] Another example includes *Project Moonbase*'s Colonel Briteis. Though a skilled pilot and astronaut, she is repeatedly talked down to by General Greene who clearly favours Major Moore.[619] Both men are disgruntled that she is to pilot the first spacecraft to the Moon, and Greene seems to indicate toward the start of the film that her selection for this task and rank as Colonel has nothing to do with her skills, but rather because of some undue favouritism for, as it is revealed at the end of the film, the president is a woman.[620] While it is interesting to feature a woman as the president, both her and Briteis are, as Warren writes, treated with a "smirking quality," and therefore taken less seriously.[621] Moreover, when at the end of the film Major Moore and Colonel Briteis become quickly romantically entangled and are married off (Gen. Greene and the White House agree that it would be better for the two to be married as the sole occupants of the makeshift base while awaiting the arrival of space command personnel),[622]

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[617] Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 113. See also: Lorrie Palmer, "Untethered technology in *Gravity*: Gender and spaceflight from science fact to fiction," *Science Fiction Film and Television* 12, no. 1 (February 2019): 36.
[618] Stanley, Michalski, Smith, and Zani, *Martian Pictures*, 113. In Bonnie Noonan's view, the film also raises questions about how a woman might have a professional career and a personal life, but leaves them unresolved, reflecting anxieties about changing family dynamics in postwar America. See: Noonan, *Women Scientists*, 48-49, 59-60.
[619] See also: Warren with Thomas, *Keep Watching the Skies!*, 672-673.
[620] Warren with Thomas, *Keep Watching the Skies!*, 672; Westfahl, *The Spacesuit Film*, 34.
[621] Warren with Thomas, *Keep Watching the Skies!*, 672.
[622] "Man to Man," *Project Moonbase*.

Moore is promoted to Brigadier General, outranking Briteis and rearranging their relationship both in terms of marriage and military rank.[623]

In both gender and race, space travel films ended up rather unimaginative, struggling along the same lines as the space-themed *Collier's* issues, which suffered from the same lack of imagination.[624] Even in *Forbidden Planet*'s (1956) depictions of the 23rd century, Booker points out how the ethnically homogenous, solely Caucasian crew of spaceship C-57-D hailing from the "United Planets" reflected a "failure to imagine advanced social, political, and economic structures that might overcome the present-day problems of the society in which it was produced."[625] Booker considers this to be generally representative of 1950s science fiction film.[626] Indeed, diversity in crewed space stations or space voyages is rarely glimpsed, except perhaps in 1960's *12 to the Moon* which depicted an international crew, though Warren has noted that the characters are mostly stereotypes of their nationalities.[627] While the 1960 East German/Polish science fiction film, *Die schweigende Stern* (*The Silent Star/First Spaceship on Venus*), depicted a somewhat diverse crew and an intrepid woman astronaut, representations of more diverse futures were more directly confronted by the television series *Star Trek*, but in other ways also repeated patterns of the past.[628] Booker points to pressures on Hollywood during the period to sidestep more liberal depictions in the anti-Communist climate to explain, in part, this hesitancy to embrace more fulfilling depictions of utopia in films.[629] He also explains that social upheaval and the changes in and pressures on longstanding

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[623] "Man to Man" and "Marriage on the Moon," *Project Moonbase*; Warren with Thomas, *Keep Watching the Skies!*, 672; Westfahl, *The Spacesuit Film*, 34-35.
[624] Amanda Keeler, "Visible/invisible: Female astronauts and technology in *Star Trek: Discovery* and National Geographic's *Mars*," *Science Fiction Film and Television* 12, no. 1 (February 2019): 127.
[625] Booker, *Alternate Americas*, 52-53, quote from 53.
[626] Booker, *Alternate Americas*, 53. See also: Noonan, *Gender in Science Fiction Films*, 64-68.
[627] Warren with Thomas, *Keep Watching the Skies!*, 808.
[628] *Der schweigende Stern*, directed by Kurt Maetzig (East Berlin, GDR: DEFA, 1960), Kanopy; Warren with Thomas, *Keep Watching the Skies!*, 274-277; Rosenberg, "Far Out," 178; Kilgore, *Astrofuturism*, 22-29; Keeler, "Visible/invisible," 129-131. Rosenberg makes the argument that issues of gender, race, and class were dealt with in *Star Trek* "by safely projecting them into an imagined future." See: Rosenberg, "Far Out," 178.
[629] Booker, *Alternate Americas*, 53.

societal dynamics in the 1950s and 1960s produced a "social vertigo," and that "American audiences turned to films not for indications that change was possible but for reassurances that some things might, after all, remain the same."[630] As successful as space travel films were in extrapolating technologies and presenting spaceflight as possible and valuable, they were less adept in representing the political and social changes that might flourish in futures where space travel is commonplace.

THE INTERSECTIONS OF VISION AND REALITY

Portraits of distant planets and cinematic adventures of space travel effectively communicated the promises and values of spaceflight to American audiences in the 1950s and 1960s, helping to foster the cultural Space Age before the realization of space travel itself. At a fundamental level, imaginative visual media constituted significant dimensions of spaceflight popularization, and transformed ideas into icons. These icons were then embedded in a multitude of narratives hearkening back to the promises of the American frontier. Chesley Bonestell fostered visual linkages between the conquest of frontiers and the conquest of space, rendering the infinity of new lands to discover in his planetary vistas reminiscent of American sublime landscape art. As space travel films utilized and alluded to Bonestell's artwork, so too did they associate space travel with this sublime imagery and the promises of cosmic destiny. By also depicting the future space technologies that would enable adventures to these frontiers, film introduced American audiences to space travel as something possible, practical, and desirable, even an extension of what it meant to be American. It was in this context that space travel received presidential assent with the decision to go to the Moon. Films and images had contextualized space travel in a way that cemented space as the next frontier, thereby rendering Kennedy's decision more than a demonstration of global leadership but a reassertion of America's mythically constructed character. So long as space was the next frontier, the United States would seek to conquer it.

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[630] Booker, *Alternate Americas*, 53.

CONCLUSION: A CONQUEST OF THE COSMOS

Eleven days prior to the launch of Apollo 11 on 16 July 1969, astronauts Neil A. Armstrong, Edwin "Buzz" Aldrin, and Michael Collins arrived in Florida to attend a press conference, their last appearance before their voyage to the Moon.[631] Amidst fielding questions from more than two hundred eager journalists, Armstrong announced that callsigns for the spacecraft taking the astronauts to the Moon had been decided.[632] The Lunar Excursion Module (LEM), which would separate from the Command/Service Module (CSM) mothership and descend to the Moon's surface had been dubbed *Eagle*, and the CSM would carry the name *Columbia*.[633] "Columbia is a national symbol," Armstrong told reporters. "Columbia stands on top of our Capitol and, as you all know, it was the name of Jules Verne's spacecraft that went to the Moon in his novel of one hundred years ago."[634] A reference to the *Columbiad* space gun that fired Verne's projectile and its spacefarers around the Moon, the tribute was clear and fitting.[635] Commander Armstrong recalled Verne's prophecies again when addressing audiences tuning in television broadcasts of Apollo 11's return journey to Earth on 22 July. "A hundred years ago, Jules Verne wrote a book about a voyage to the Moon," he said. "His spaceship, *Columbia*, took off from Florida and landed in the Pacific Ocean after completing a trip to the Moon."[636] Calling their spacecraft "the modern-day *Columbia*," Armstrong pointed out that it was headed for the Pacific Ocean, just like Verne's spacecraft.[637]

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631 John Noble Wilford, "Astronauts Confident of Moon Landing: Apollo Crew Appears Calm 11 Days Before the Mission," *The New York Times*, July 6, 1969, 1, ProQuest Historical Newspapers.
632 Thomas O'Toole, "Astronauts Christen Craft: Lem Named 'Eagle,' Mother Ship is 'Columbia,'" *The Washington Post*, July 6, 1969, ProQuest Historical Newspapers.
633 James R. Hansen, *First Man: The Life of Neil A. Armstrong* (New York: Simon & Schuster Paperbacks, 2018), 197-198.
634 Neil A. Armstrong, quoted in James R. Hansen, *First Man: The Life of Neil A. Armstrong* (New York: Simon & Schuster Paperbacks, 2018), 198; Hansen, *First Man*, 196-198. See also: Scott and Jurek, *Marketing the Moon*, 1; O'Toole, "Astronauts Christen Craft."
635 See: Verne, *From the Earth to the Moon, And a Trip Round It*, 137-138, 149.
636 Armstrong, quoted in Hansen, *First Man*, 307-308.
637 Armstrong, quoted in Hansen, *First Man*, 307-308. See also: Scott and Jurek, *Marketing the Moon*, 1. The unedited Apollo 11 transcripts are found in the "Apollo 11 Lunar Surface Journal," which is available online: https://history.nasa.gov/alsj/a11/a11trans.html. In particular, see: National Aeronautics and Space Administration, *Apollo 11: Spacecraft Commentary, July 16-25, 1969*, (Houston, Texas: Manned Spacecraft Center, 1969), 432, https://history.nasa.gov/alsj/a11/a11transcript_pao.pdf.

Connecting Apollo's trip to the Moon to Verne's space travel adventure "[reminded] the world that a seemingly impossible dream can spark curiosity and motivate others to make it a reality."[638] The titanic efforts behind the Moon landing, the probes and satellites, the rocketry, and the basic theory underlying it all were the results of decades of intensive research, experimentation, engineering, and great financial expenditures. The trail had been blazed by theorists, engineers, and politicians, but also dreamers. From the earliest inkling that a rocket might take a human to space, to the missions that made it so, space travel in the United States was the product of numerous forces, all throughout which ran threads of imagination. When Armstrong set foot upon the grey, dusty surface of the Moon on 20 July 1969, President John F. Kennedy's mandate been fulfilled—doubly so when the crew returned home safely—and so too had the prophecies of the foreseers, pioneers, and prophets of astronautics been realized.

This thesis has argued that imagination, broadly defined, was an integral part of making space travel possible. Imaginative ideas were conveyed to individuals in fantastical, fictional, and extrapolative works that proved to be inspirational. Science fiction was a valuable source of inspiration and purpose, not only for the notable pioneers of rocketry—Konstantin E. Tsiolkovskii, Hermann J. Oberth, and Robert H. Goddard—but also for those that succeeded them. Moreover, it was a combination of science fiction sources and serious considerations of their propositions that produced the greatest effects. These pioneers distilled the basic ideas of their inspirations into technical treatises that established the literature of rocketry, and this work was typically as imaginative as science fiction, as it offered stirring propositions compatible with those found in fantasy. Where science fiction tales promised possibility, the studies of engineers and inventors showed how it might be done. Others built upon these foundations while simultaneously turning to other imaginative sources for inspiration, direction, or purpose. We may therefore even consider

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[638] Scott and Jurek, *Marketing the Moon*, 1.

that, as Tsiolkovskii, Oberth, and Goddard are the "fathers" of space travel, then Jules Verne, H.G. Wells, and even Kurd Laßwitz are the "godfathers" of astronautics. The impact of their writings was felt far into the Space Age, through, and beyond, the influence of the pioneers. As we saw in Chapters One and Two, rocket pioneers like Goddard, enthusiasts like John W. Parsons or Edward S. Forman, and engineers like Malina, found their first inspirations among Verne's tales and those inspired by them. In addition, Wernher von Braun's career was as shaped by Oberth's *Die Rakete zu den Planetenräumen* as it was by the idea of a wheellike space station in Laßwitz's *Auf Zwei Planeten*.

Science fiction, speculative treatises, and spaceflight popularization all created "agents" of space travel. These agents, inspired as they were by imaginative works, were so moved by the possibility of travelling to space that they dedicated themselves to bringing it about. The results of their efforts often inspired others and transformed them into carriers of cosmic visions themselves. Such instances produced tangible results, as we saw in Chapter One, with Reaction Motors Incorporated (RMI) evolving directly from the enthusiast group of the American Interplanetary Society, later the American Rocket Society, and a score of inspirations from various sources. RMI's work then led to the generation of expertise and development of rocket motors applied to practical ends, constituting tangible examples of rocketry's power. Similarly, the GALCIT group was composed of engineers and amateurs who drew inspiration from the same sources—science fiction stories and the nascent rocketry literature. GALCIT's work, besides building upon foundations laid by the pioneers and enthusiasts, became a major source for American rocketry.

Agents of the space travel vision, alongside their engineering efforts, worked to raise public awareness of the pursuit to enhance the believability of space travel, especially by way of a rocket. The work of these agents in tandem with waves of space travel popularization, made more visible with striking images of space travel in artwork and film, then helped create a cultural context wherein space travel was increasingly embraced by the public as a feasible endeavour, which was

especially important when it became politically necessary for decisionmakers to look to space as a theater for another Cold War entanglement with the Soviet Union.

THE FABRIC OF SPACE TRAVEL

While serious technical inquiry, research, and practical experience, instead of science fiction and other works of imagination, began to eclipse the point of reference for many engaged in realizing spaceflight, Chapter Two has argued that threads of imagination have run throughout all these efforts, and that spaceflight technology, especially rocketry, was built on a foundation cultivated by imagination. As the fundamental technology that made space travel possible, rocketry's very application to space travel whether in thought or practice required imagination, and its development as a means of spaceflight began first with a dream. As we saw in Chapter Two, a number of the space boosters of the 1960s could trace their lineages back to this dream, and many had their origins in technological foundations laid by space travel enthusiasts inspired by science fiction. Their efforts constituted the basis upon which future innovators iterated upon, leading to the rockets that launched satellites, lobbed probes to other planets, and set a man on the Moon.

Of course, amidst those examples where imagination has left a clear impression, there are parallel instances where science fiction inspirations, space popularization motivations, and fantastical ambitions simply do not play a role. Alongside those who embodied the dreams of space travel, there were hundreds of thousands, if not more, of experts, engineers, manufacturers, and consultants whose work was necessary to making space travel real, but whose inspirations and motivations may not have drawn significantly from imaginative works.[639] The examples in this thesis, however, demonstrate how ideas from science fiction and other imaginative works were translated, improved, and reconfigured by various individuals and in various media, and produced the

[639] See also: Dick, "Space, Time and Aliens," 41-44.

technological and cultural frameworks wherein progress toward spaceflight was made. From this crucible shaped first by imagination, the significant ideas and questions of space travel emerged.

The fabric of space travel is composed of numerous threads running across, around, and woven alongside the threads of imagination.[640] Political, economic, and military dimensions of spaceflight, constituting a variety of threads themselves, were inexorable elements of this total fabric. Enthusiasm, theory, and practical experience often aligned with needs external to the dream of spaceflight but needs also critical to the advent of it. Chapters One and Two demonstrated how World War II, the Korean War, and Cold War all prompted specific developments in rocket technology. Chapter Two emphasized how NASA, its programs, and President John F. Kennedy's decision to land a man on the Moon, all emerged as a part of the Cold War Space Race in the late 1950s and throughout the 1960s. But the technological capability to engage in such a race, as these chapters have argued as well, was, in part, product of imagination. The American commitment to space travel was only feasible because the expertise, implements, systems, and technologies were in place, many which traced their origins back to imaginative sources. These same imaginative sources, as Chapter Three outlined, also produced conditions wherein cultural and political climates aligned to encourage the public and decisionmakers to embrace the promises of space exploration, also rendering Kennedy's lunar decision a fulfillment of the prophecies of space dreamers, as well as a reassertion of America's national character in terms of a mythologized history of frontier conquest.

There are, without question, many threads woven into space travel. This thesis has shown examples of those threads of imagination and their real and practical effects. Such threads may fade or fray in some instances, as others bind developments, their developers, and circumstances more

[640] This idea of "weaving" threads together has also been described by historian Emily S. Rosenberg. She discusses the Space Age as a cultural phenomenon and space as a "canvas for the imagination," where various personal, national, and global meanings could be derived. She writes that "the Space Age offered an array of visual representations and symbolic threads that could, intimately and personally, weave a unique tapestry." Rosenberg, "Far Out," 157.

powerfully than that of imagination, yet they are all together bound in one cumulative whole those of imagination remain integral and significant.

A Conquest of Space at the Behest of Dreams

It was imagination that inspired and motivated individuals like Tsiolovskii, Oberth, and Goddard to take up the pursuit of space travel. This pattern of inspiration was then repeated in various forms throughout the history of American space travel. It undergirded the development of the space rocket and, by inspiring others, imagination and its expressions throughout various media helped guide it from the realm of impossible fantasy into achievable reality. Successive generations of engineers and enthusiasts took up the work of their forebears, and carried these dreams into the future, where a combination of political, societal, and technological forces merged with the vision of spaceflight, bringing it closer to reality. As a popular culture driven by the visions of artists and writers formed around this dream and infused space travel with the same promises of the mythical American frontier, Americans encountered the landscapes of distant planets and their promises of the unknown on the page and the screen, bringing them closer to the possibilities of tomorrow. In 1969, Apollo 11 transformed erstwhile fantasies into present realities, fulfilling the most basic prophecy that humanity would reach space. When Neil A. Armstrong reflected on Verne's *De la Terre à la Lune* as the crew of Apollo 11 returned to Earth, he reminded those listening that this lunar journey was one made at the behest of dreams. Imagination, after all, had crossed the cosmos long before rockets did.

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