Liberty University

Turning Small Steps into Giant Leaps:

NASA's Genesis and Its Culmination in the Apollo Program

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by

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Contents

Abstract

On July 16, 1969, NASA astronaut Neil Armstrong dropped himself onto the dusty surface of the Moon, momentarily followed by his lunar module pilot, Buzz Aldrin. It is simple to recognize the clear historical significance of the Apollo moon landings. It can also be easy, however, to overlook the work of thousands of individuals and decades of development that culminated in a lunar voyage. Because the moon landings were unprecedented, the hardware required had to be developed from scratch and mission protocol had to be written. Additionally, the United States was competing against its Cold War adversary, the Soviet Union, which had already thrusted a manmade satellite into orbit. The National Aeronautics and Space Administration (NASA) was created in 1958 to coordinate the space program of the United States. NASA was a conglomeration of various military personnel, facilities, and technology as well as an experimental aeronautics regulatory agency known as the National Advisory Committee for Aeronautics (NACA). As its first steps in manned space exploration, NASA began Project Mercury. It would loft America's first astronauts into space and set the stage for further projects that ultimately led to the Apollo moon landings. Even though Project Gemini immediately preceded Project Apollo, the Mercury program set a course for the young NASA to eventually reach the Moon. The creation of NASA from military assets and NACA, its early administrative personnel and structure, as well as its first steps in Project Mercury were foundational for later success achieved by Project Apollo.

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To my grandparents, thank you for instilling in me a love and appreciation for the past. You've taught me the importance of tradition and cultivated my love for history by providing travels in which I could discover countless stories about the past.

Finally, I could not conclude my acknowledgements without including my beautiful wife, Madison. She has never wavered in her support and encouragement in our two and a half years of marriage. She has provided direction when I would lose sight of why I spent hours in my office. She is the person I have looked forward to celebrating with upon completion of my work. I thank God for providing her as a partner and I pray that I can continually repay her in love for all that she has done and continues to do.

Introduction

When historians of the distant future look back on the twentieth century, what will be the events that are still reflected on? Certainly, the World Wars will continue to be popular topics for study. American political historians will probably be writing about the liberal and conservative movements from the 1920s, 1960s, and 1980s and their connection to the future political climate. The rise of mass media in the form of digital video and audio will continue to impact the daily lives of most. Further, what names of individuals from the twentieth century will be remembered? Many of these topics are bound by national interests or center around technological innovation. If we break the boundaries of national or technological histories, what events from the twentieth century will be remembered as a major piece in *human* history? Are there any that could possibly rank with the invention of a written alphabet, development of the heliocentric model of the solar system, or European discovery of the New World? In the grand epic of human history, historians and storytellers of centuries-to-come will continue to tell the story of the first humans to leave our terrestrial home and set foot on another celestial body. The names of the first men to set foot on the Moon, Apollo 11 astronauts Neil Armstrong and Buzz Aldrin, will be taught along with other great explorers and innovators such as Christopher Columbus, Galileo Galilei, and Leonardo Da Vinci. As the Phoenicians are known for their development of the alphabet and Renaissance Europeans are remembered for their westward exploration, the United States' coordination of the first manned voyages to our moon will likely be remembered as one of its greatest triumphs and contributions to the tale of human history.

The monumental event was televised live to hundreds of millions of viewers on Earth over 200,000 miles away. The families that sat in front of their living room television sets witnessed, not only one of the greatest feats in the history of the United States, but also the farthest humanity had traveled to arrive at another celestial body. Like any great achievement by humankind, there is a, usually largely untold, story behind the spotlight moment. The National Aeronautics and Space Administration (NASA) was created in October 1958.[1] Approval for its creation was signed into law earlier in July 1958. It is difficult to imagine the 1969 moon landing taking place without a coordinating agency like NASA being founded. There were separate entities that served as predecessors to the Administration for which test facilities were complete or being built and in which rocket development was taking place. Prior to NASA assuming all research and development of manned rockets, the Navy, Army, and Air Force all had their own respective rocket development projects. There existed an aeronautics research and regulatory entity known as the National Advisory Committee for Aeronautics (NACA) that began in World War One to address stagnation in the United States' aeronautic development since the first powered flight by Orville and Wilbur Wright in 1903.[2] The NACA served as the administrative center for the new NASA in 1958.[3]

NASA was created "…to provide for research into problems of flight within and outside the earth's atmosphere, and for other purposes."[4] To many, the genesis of a new government agency with such an ambiguous and open-ended purpose might seem like opening a pandora's box of overspending and never-ending projects. Some have even argued that overspending and

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[1] Eugene M. Emme, "Historical Origins of N.A.S.A.," *The Air Power History* 10, no. 1 (October 1, 1962): 18.

[2] Roger E. Bilstein, *Orders of Magnitude: A History of the NACA and NASA, 1915-1990* (Washington, D.C.: National Aeronautics and Space Administration, 1989), 1.

[3] Ibid., 48.

[4] National Aeronautics and Space Act of 1958, *Public Law #85-568, 72 Stat., 426.* (July 29, 1958).

never-ending projects ensued in the following decades at NASA.[5] The agency's creation was a reactionary invention created in order to respond to the launch of *Sputnik 1,* a Soviet artificial satellite. The Soviet Union's feat struck fear into millions of Americans and embarrassed the U.S. military rocket programs that were met with almost constant failure. When viewing the legislation in light of the geopolitical climate of the time, one begins to see an intentional ambiguity established so that the new agency would be free to accomplish the task of catching up to and surpassing America's communist adversary. Afterall, if the Soviets were capable of launching and sustaining constant spaceflight of a man, the ability for using the flight system to deliver nuclear materials was certainly attained. Consolidating all the nation's best minds and facilities under one banner allowed for a combined effort making use of all of the nation's resources. This system differed greatly from the Soviet system of competing leaders and their respective design bureaus that vied for supremacy. The United States, which prided itself as a capitalist system of competition, eventually found their success against the Soviet Union by unifying its various rocket programs under the newly founded NASA. The American space program stands in stark contrast to the fragmented Soviet system of competition.

With the consolidation of these various programs came the bringing together of all personnel involved. The NACA alone employed around 8,000 individuals that were transferred to NASA in October 1958.[6] Many of the first administrators and employees transferred to NASA at its inception were still employed there during the years of the Apollo program. NASA also received programs from the Department of Defense (DOD). The Advanced Research Projects

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[5] John Konicki and James Pethokoukis, "Do Americans Care About Space?", *The New Atlantis* no. 68 (Spring 2022): 92.

[6] Eugene M. Emme, "Historical Origins of N.A.S.A.," *The Air Power History* 10, no. 1 (October 1, 1962): 19.

Agency (ARPA) was brought into the fold with a sampling of space probes, satellite projects, and rocket engine programs including early development of the Saturn launch system which was the very system that lofted the Apollo missions to the moon. The Army and Air Force brought on with their rocket programs, Redstone and Centaur, respectively. The Naval Research Laboratory and its Vanguard rocket were incorporated with NASA projects along with facilities in Maryland that eventually became Goddard Space Flight Center. The Jet Propulsion Laboratory of the California Institute of Technology was also placed under NASA along with its 2,800 employees.[7]

NASA was initially tasked with eight distinct objectives outlined in the National Aeronautics and Space Act of 1958. The practical outcome of applying these objectives manifested in Project Mercury, the United States' first manned spaceflight program. By most measures, the Soviet Union outpaced the United States and would continue to do so for the ensuing few years while NASA attempted to compensate for lost time. The Mercury program, centered around a single-person capsule, was NASA's first step in closing the gap. Even still, the Soviet Union continued to outpace the United States, made evident by their launch of cosmonaut Yuri Gagarin into full orbit in 1961. Less than a month after Gagarin's feat, NASA launched Alan Shepard into space without achieving the horizontal velocity necessary to reach orbit. The brief up-and-down flight was the Mercury program's first manned success even though it still did not match the orbital flight of Gagarin from the prior month. Nevertheless, Shepard's successful flight prompted President John F. Kennedy to assign a monumental task to the young American space program. Less than three weeks after the suborbital flight, on May 25th, 1961, President Kennedy made an address before a joint session of Congress. The President stated, "…I believe

[7] Eugene M. Emme, "Historical Origins of N.A.S.A.," *The Air Power History* 10, no. 1 (October 1, 1962): 19.

that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth."[8] Not only had he tasked a three-year-old government agency with taking humanity farther than it had yet gone, but he assigned a deadline of only eight years.

Today, as efforts are currently being increased at NASA to return to the Moon, there are important stories to be told and lessons to be learned from the United States' first attempts to reach our closest celestial neighbor. Improved technologies and increased knowledge of our solar system could contribute to the even greater potential of returning to the surface of the Moon. While all separate entities had been making progress since the end of World War Two on their respective rocket and spaceflight programs, it wasn't until their combination that the United States began to legitimately compete with the Soviet Union. It was the early days at NASA that set the course for the eventual surpassing of the Soviet Union and completion of President Kennedy's great commission. The creation of NASA from military assets and NACA, its early administrative personnel and structure, as well as its first steps in Project Mercury were foundational for later success achieved by Project Apollo.

[8] John F. Kennedy Presidential Library, "Address to Joint Session of Congress May 25, 1961," Historic Speeches, May 25, 1961.

Chapter 1: Documenting Small Steps and Giant Leaps

In the five decades since the final Apollo moon landing, there has not been a single attempt by any nation, including the United States, to replicate the amazing feat of placing boots in the moondust. Several space-faring nations have dispatched unmanned probes and rovers to conduct scientific observations and research, but none have chosen to expend the resources necessary to sustain life on the natural satellite. This has created a unique situation for historians that continue to analyze the successful, and one not-so-successful, missions that are likely to be remembered as the most historically significant series of events in the twentieth century. Historical analysis has continued without the context of further manned exploration that built upon the progress made by the Apollo Program. This has created a topic of study that is essentially in situ but has had a great impact on societal experience and the trajectory of the United States as a world power.

It doesn't require much effort to find excellent scholarly analysis of the Apollo Program. Countless histories and biographies have been written about the events and individuals that took those first steps on the Moon. While these are important stories to be told, the story of the moon program begins in the fifteen years after World War Two and in the decade prior to President Kennedy's great commission of sending a man to the Moon and returning him safely. When President Kennedy committed the National Aeronautics and Space Administration (NASA) to its greatest achievement in a speech to Congress in 1961, the agency was only four years old and it had only placed its first man in space three weeks prior. NASA began out of the National Advisory Committee for Aeronautics (NACA), an agency dedicated to aerospace research for military purposes during the First World War. NACA, together with the respective rocket programs of the Army, Air Force, and Navy, combined their efforts to fulfill President Kennedy's commission.

Individual works on the organizational history of NASA and its first full scale space program, the Mercury Program, have been completed. These works must be synthesized to answer the question of how the agency and its earliest projects set the stage for the lunar landings over a decade later. A fine place to begin is with Roger D. Launius' *Reaching for the Moon: A Short History of the Space Race* (2019).[9] Launius is one of the foremost respected space historians today and will be a recurring name throughout any space history research. He served as NASA's chief historian for many years and is one of the most widely published space historians. This succinct, concise work by Launius provides basic information about the Space Race. It is valuable for providing a timeline to the program as well as supplemental information regarding the historical significance of the moon program. Because he was employed by NASA as a historian, he provides an inside look at the organizational history of the U.S. space program. Because the Mercury Program is vital to understanding NASA's early days, another work by Launius and Dennis R. Jenkins will be utilized to provide technical details of both the Mercury and Apollo hardware. *To Reach a High Frontier: A History of U.S. Launch Vehicles* (2002) provides a highly technical history of the American space program. It is valuable for tracing the manufacturing and production of much of the hardware that flew astronauts created by many of the aerospace contractors. Jenkins worked for NASA for over three decades as an engineer and partnered with historian Launius to compile this work.[10] One of Launius' most recent works

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[9] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019).

[10] Roger D. Launius and Dennis R. Jenkins, *To Reach the High Frontier: A History of U.S. Launch Vehicles* (Lexington, KY: University of Kentucky Press, 2002).

reflects on the moon program from the standpoint of a historian. It traces the most significant events and discusses their mark on the history of space travel. *Apollo's Legacy: Perspectives on the Moon Landings* (2019) is beneficial for understanding the Apollo Program from 50 years after its first landing.[11] Many other scholarly articles by Launius provide more specific details regarding the development of the moon program especially from a cultural perspective.

While most of Roger D. Launius' work pertains mostly to the Apollo Program, he details the recording of NASA's history in an article entitled "NASA History and the Challenge of Keeping the Contemporary Past."[12] This work does not provide details on the Apollo and Mercury Programs or the beginning of NASA. Instead, it details the method which NASA's early history was recorded, providing numerous resources that are made available through the website of NASA's History Office based in Washington, D.C. This involved the hiring of Eugene M. Emme as NASA's first historian. It was clear early on in the organization's beginning that great feats were to be accomplished and accurate historical records needed to be kept. NASA began publishing in-depth histories as Special Publications (SP-XXXX). This collection of hundreds of full-length books is published online and divided into various topics including General Histories (SP-4400 series), Reference Works (SP-4000 series), (Project Histories (SP-4200 series), and Management Histories (SP-4100 series). One of the works included is *Orders of Magnitude: A History of the NACA and NASA, 1915-1990* by Roger E. Bilstein (1989).[13] It

[11] Roger D. Launius, *Apollo's Legacy: Perspectives on the Moon Landings* (Washington, D.C.: Smithsonian Books, 2019).

[12] Roger D. Launius, "NASA History and the Challenge of Keeping the Contemporary Past," *The Public Historian* 21, no. 3 (Summer 1999): 63-81.

[13] Roger E. Bilstein, *Orders of Magnitude: A History of the NACA and NASA, 1915-1990* (Washington, D.C.: National Aeronautics and Space Administration, 1989).

provides great detail on the transition from NACA, which essentially served as a regulatory and advisory board, to NASA, the flight-ready hardware-producing agency.

Another work in the NASA History Series, *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space 1915-1960* by Eugene M. Emme (1961), will serve to provide technical details of the early hardware that eventually made the Apollo launch systems possible. Emme was NASA's first historian and was employed because of the necessity at its inception of accurately recording NASA's great anticipated feats. Emme, active during NASA's early years documenting its history, did a great service to later space historians by providing historical commentary on the highly technical missions and operations at the Administration. Emme also published "Historical Origins of N.A.S.A." (1962), which reflects on the origin of and work done at the agency by the time of its fourth birthday.[14]

For project-specific details on the Mercury Program, NASA published *This New Ocean: A History of Project Mercury* (republished in 1998).[15] This substantial work, authored by Loyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, is an almost exhaustive history first compiled only three years after the conclusion of the Mercury Program. Finally, the third central source used from the NASA History Series is *Moonport: A History of Apollo Launch Facilities and Operations* (1978).[16] While this work focuses mainly on the sites and operations pertaining to the Apollo Program, most of these got their start during the early days of NASA

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[14] Eugene M. Emme, "Historical Origins of N.A.S.A.," *The Air Power History* 10, no. 1 (October 1, 1962): 19.

[15] Loyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington, D.C.: National Aeronautics and Space Administration, 1998).

[16] Charles D. Benson and William Barnaby Faherty, *Moonport: A History of Apollo Launch Facilities and Operations* (Washington, D.C.: National Aeronautics and Space Administration, 1978).

and the Mercury Program. Information from this source, authored by Charles D. Benson and William Barnaby Faherty, is vital for demonstrating the necessity of the creation of NASA and the Mercury Program for making the Apollo Program a success. It is highly detailed and was written shortly after the conclusion of the Apollo Program. Benson split his career between military service and recording the history of the American space program. Faherty was a professor of history at St. Louis University where he received his Ph.D. He served on the team that worked on the history of the Apollo Program at Kennedy Space Center.

Produced by John M. Logsdon and Roger D. Launius throughout the 1990s and 2000s, NASA History's flagship publication, *Exploring the Unknown*, is a series that provides numerous primary and secondary sources for research divided among various aspects of the Administration's spaceflight history. With seven volumes in all, two are specifically relevant to the study of the beginning of NASA and its first program, Project Mercury. The first volume, subtitled *Organizing for Exploration* (1995), contains documents regarding the creation of the agency from the multiple existing entities such as ARPA, NACA, and the respective military branch programs.[17] The second volume relevant to the topic of study is *Volume VII: Human Spaceflight: Project Mercury, Gemini, and Apollo* (2008). It provides documents for study which conveniently connect the Mercury program to Project Apollo.[18] While these volumes do not

[17] John M. Logsdon, ed. and Roger D. Launius, *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I, Organizing for Exploration* (Washington, D.C.: National Aeronautics and Space Administration, 1995).

[18] John M. Logsdon, ed. and Roger D. Launius, *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume VII: Human Spaceflight: Project Mercury, Gemini, and Apollo* (Washington, D.C.: National Aeronautics and Space Administration, 2008.)

always provide full-text copies of the original documents, they are organized topically and provide location information that can be used for further research.

These works commissioned and produced by NASA are beneficial for understanding the history of the space program from an insider's perspective. Later journal articles are used to provide analysis regarding the programs and projects outlined and detailed in the NASA History Series works. For instance, Norriss S. Hetherington's article, "The National Advisory Committee for Aeronautics: A Forerunner of Federal Governmental Support for Scientific Research" (1990), can be used to provide more critical analysis of the program and its relation to the Apollo Program.[19] Karsten Werth's "A Surrogate for War- The U.S. Space Program in the 1960s" (2004) provides another perspective of the motivations for creating NASA and beginning the Mercury Program.[20] It challenges the concept of NASA as a civilian agency that was not created to be military weapons program.

Because the stories of NASA and the Space Race take place within the larger context of the Cold War, it would be remiss to neglect the contemporary activities of the Soviet Union. It was, after all, actions taken by the U.S.S.R. that prompted the reactionary founding of NASA. For information regarding the Soviet Union's space program, Asif A. Siddiqi's *Challenge to Apollo: The Soviet Union and the Space Race, 1945-1974* (2000) provides an abundance of technical, personnel, and organizational information about the Soviet space program.[21] It is made available through the History Office of NASA and details the fragmented nature of the Soviet

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[19] Norriss S. Hetherington, "The National Advisory Committee for Aeronautics: A Forerunner of Federal Governmental Support for Scientific Research," *Minerva* 28, no. 1 (March 1990): 59-80.

[20] Karsten Werth, "A Surrogate for War- The U.S. Space Program in the 1960s," *American Studies* 49, no. 4 (2004): 563-587.

[21] Asif A. Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race, 1945-1974* (Washington, D.C.: National Aeronautics and Space Administration, 2000).

Union's efforts to compete with the United States which were initially successful. While a divided and competitive research and development structure allowed the Soviet Union to excel early on in the Space Race, a lack of coordination inhibited them from scaling up their operations to compete with the United States when it came to achieving lunar aspirations. Additionally, Roger D. Launius authored an article examining the United States' efforts to discover more about the highly secretive Soviet space program throughout the Space Race in his 2001 article, "NASA Looks to the East: America Intelligence Estimates of Soviet Capabilities and Project Apollo."[22]

Finally, a comparison of two spaceflight projects would not be complete without the careful examination of technical and operational manuals of each of the vehicles. NASA has published almost all of its flight and operations manuals from its Space Race era missions along with official after-flight reports. The Mercury capsule, originally produced by McDonnell Aircraft in St. Louis, Missouri, did not see much variation throughout its service life. Its flight and operations manual was provided to NASA by McDonnell Aircraft in 1960.[23] This source would have been primarily studied by the pilots prior to their flight and includes numerous diagrams and renderings of the instrumentation. The mission protocol contained in the manual, including the multiple checklists that are often associated with space launches, would have been written for the new convention of an onboard pilot operating the spacecraft. For comparison, the *Apollo Operations Handbook* produced in 1969 contains much of the same information as the manual for the Mercury spaceflight system. The first volume of the Apollo manual is most

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[22] Roger D. Launius, "NASA Looks to the East: America Intelligence Estimates of Soviet Capabilities and Project Apollo," *Air Power History* 48, no. 3 (Fall 2001): 4-15.

[23] McDonnell Aircraft, *Project Mercury NASA Capsule Flight Operations Manual: Capsule 7* (St. Louis, MO: McDonnell Aircraft, 1960).

relevant for comparing the Mercury and Apollo command modules. It is important to note, however, the scale of these two vehicles. The Mercury-Redstone vehicle that sent astronaut Alan Shepard into space weighed 62,750 lbs. at liftoff.[24] The Saturn V vehicle which lofted the Apollo missions to the moon weighed 6.2-6.5 million lbs. at liftoff depending on payload requirements.[25] There was simply more spacecraft to operate when it came to the Apollo missions without even considering the technological developments made during the Project Gemini years. Because of the complexity of the Apollo-Saturn V vehicle, manuals were divided into multiple volumes. Regardless of the difference in complexity between the two spacecraft, there are clear similarities in way the operational guidelines are written. While the two vehicles were produced by two separate aerospace manufacturing companies, NASA required mission protocol to use specific language, most of which was pioneered in the Mercury program.

Conclusion

The remainder of the work will examine the details of NACA, military rocket development programs, administrative considerations at NASA, and Project Mercury. All aspects of these topics will be researched in light of their contributions to the success of the Apollo program. In addition to continued documentary research, on-site visits will be conducted at Kennedy Space Center where hardware is currently preserved and open to visitors. The Air Force Space & Missile Museum and the Sands Space History Center are also located near Cape Canaveral. These sites, operated by the U.S. Space Force, provide more information on the

[24] Roger D. Launius and Dennis R. Jenkins, *To Reach the High Frontier: A History of U.S. Launch Vehicles* (Lexington, KY: University of Kentucky Press, 2002), 190.

[25] Richard W. Orloff, *Apollo by the Numbers: A Statistical Reference.* SP-2000-4029. (Washington, D.C.: National Aeronautics and Space Administration, 2000), 284.

spaceflight activities which took place prior to the founding of NASA. One of the primary objectives of the Mercury program was to determine the hardware and technological requirements of sustaining life in the vacuum of space. It also provided the United States with the opportunity to develop its orbital navigation abilities which were required for a successful lunar mission. There has been more scholarship completed connecting the Gemini and Apollo programs. These works generally neglect the contributions of Project Mercury. Only five years separates the flights of Mercury and Apollo. The gap in scholarship regarding the connections between the two programs must be bridged. This will require considerable research into the technical operations and capabilities of the various models of spacecraft. NASA's History Office makes most technical manuals available via online archives. Many of these resources demonstrate that the creation of NASA from military assets and NACA, its early administrative personnel and structure, as well as its first steps in Project Mercury were foundational for later success achieved by Project Apollo.

Chapter 2: Gathering the Pieces

How do you create a governmental organization that is tasked with achieving what no one in human history has done before? The United States Congress was faced with this question in the 1950s following the monumental achievement completed by the Soviet Union of placing an artificial satellite into orbit. Even once the agency was created, what would be the first steps that began the United States' efforts to compete with its communist adversary? President Kennedy had not yet given his commission for the United States to travel to the Moon and return safely, but the nation had not even exceeded the Karman Line, the traditional altitude of 100 kilometers at which one is considered to be a space-traveler. The use of the term "Karman Line" is somewhat anachronistic considering that the designation was not created until the early 1960s, further demonstrating the novelty of the tasks at hand.[26] The new National Aeronautics and Space Administration (NASA) was expected, not only to match what the U.S.S.R had done, but to surpass it, taking humanity farther and faster than it had ever traveled before.

To address these obstacles, the United States had to explore what work had already been completed that could contribute to the mission of manned spaceflight. The experimental work which they discovered mostly consisted of a collection of research laboratories managed by the National Advisory Committee for Aeronautics (NACA), various research projects within the Department of Defense, and an academic research and development program at the California Institute of Technology's Jet Propulsion Laboratory (JPL) near Pasadena, California.

[26] S. Sanz Fernández de Córdoba, "100KM Altitude Boundary for Astronautics," *FAI Astronautics Records Commission (ICARE) at Fédération Aéronautique Internationale*, June 21, 2004, https://www.fai.org/page/icare-boundary.

The National Advisory Committee for Aeronautics (NACA)

The existing entity which most closely resembled what is now known as NASA was the National Advisory Committee for Aeronautics (NACA). The story of its founding was plagued with failed attempts and political turmoil, a stark contrast to the beginning of its successor. It was founded in 1915 to address stagnation in U.S. aerospace development since the Wright Brother's 1903 flight.[27] While Europe was at war and the United States continued its policy of isolation from European affairs, a research committee was deemed necessary to address unanswered questions regarding the military applications of heavier-than-air flight. Because the actual pragmatism of the relatively new concept of flight was still somewhat unclear, the charter which created the NACA and outlined its operations was ambiguously drafted, perhaps intentionally, then adopted:

> …it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions.[28]

Even though the United States maintained the demeanor of avoiding European entanglements, the new advisory committee was created through appropriations for the U.S. Navy and included two members from the War Department, two members from the Navy Department, as well as an additional five members which could serve from either military or civil backgrounds.[29] The timing of the NACA's creation taking place at the beginning of the First World War, when flight was first used for military applications, does not leave much room for speculation regarding its

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[27] Alex Roland, *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

[28] Public Law 271, 63d Cong., 3d sess., passed 3 March 1915 (38 Stat. 930).

[29] Ibid.

coincidence. The connections between the NACA and the War Department were conspicuous, an attribute that was avoided later on when NASA was created in 1958.

There had been attempts prior to 1914-1915 to create a sort of aviation think-tank that would conduct research on the burgeoning engineering field of flight. These were originally anchored in academia and never continued past their first failed flight attempt. The most prominent group to experiment with flight was led by secretary of the Smithsonian Institution, Samuel Pierpont Langley. In 1903, while the Wright Brothers were lifting off in Kitty Hawk, North Carolina, Langley's research group was testing their own flying contraption with little success.[30] When Langley's project was met with demise, the taxpayer-funded Smithsonian project met a swift end especially in light of the success of the privately funded Wright Brothers.

In the succeeding years, Congress rejected any attempt to initiate aeronautical research in fear of creating more taxpayer-funded failures. The Langley Aerodynamical Laboratory was shut down until its reopening in 1913 by the Smithsonian's new secretary, Dr. Charles D. Walcott. Although he came from a paleontology background, Walcott had great interest in the Smithsonian's place in the aerospace world. With careful political finesse, Walcott received approval from President Woodrow Wilson and evaded congressional approval by reopening the research laboratory with only approval from the Smithsonian board or regents and funded only by funds previously appropriated to the Institution.[31] The committee's first meeting took place in May 1913. Unfortunately, the group would not survive the end of the year due to opposition that exposed legal issues of having government officials on a committee not approved by Congress.

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[30] Alex Roland, "The Quest for a National Aeronautical Laboratory: Progress, Preparedness, and Progressivism, 1910-1915", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

[31] Alex Roland, "The Smithsonian Try", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

The Smithsonian committee's last meeting was in December of the same year and so continued the stagnation of U.S. aeronautical development.

The year 1914 brought a new political environment which Dr. Walcott intended to take advantage of. During the summer, war broke out across Europe and the 1914 midterm elections had cemented U.S. support for neutrality. Although the progressive President Wilson's policy of isolation was supported by the public, there was still a desire for progress which included a preparedness in military technology. Europe had continued aeronautical development which was made evident at the outbreak of war. European militaries swiftly found a place for the new airborne technology as they drew their battle lines which eventually turned into muddied trenches. The war was to become a contest of air superiority. The British created their own Advisory Committee for Aeronautics years earlier and Walcott presented a similar model to Congress in early 1915.[32] The tides of war and Walcott's willingness to approach Congress directly rather than circumventing it allowed for the successful approval of a government-sponsored research committee. It would coordinate efforts to thrust America back onto the world stage in aeronautics, a task that was easier said than done. Nevertheless, the National Advisory Committee for Aeronautics was established through the Naval Appropriations Act with an annual budget of $5,000.[33]

The Committee's first meeting took place in April 1915 where it tackled questions of organizing its operation. One of its first actions was surveying the metaphorical atmosphere of aeronautical research at the time. The survey was provided to 112 academic programs, 22

[32] Alex Roland, "Caesarian Section by Dr. Walcott", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

[33] Public Law 271, 63d Cong., 3d sess., passed 3 March 1915 (38 Stat. 930).

aeronautics clubs, 10 aerospace manufacturers, and 8 governmental organizations.[34] Another initiative that the NACA saw as central to its success was the establishment of a research laboratory similar to those that were attempted the prior decade. Not long after a year from its creation, the NACA audaciously requested $85,000 in the 1917 naval budget.[35] After more savvy political maneuvering by Dr. Walcott, serving as chair of the Committee, the full requested amount was signed by President Wilson and appropriated. After years of construction, what would become known as Langley Research Center, began research in 1920.[36] A major part of the laboratory included a wind tunnel for the testing of various flight articles.

Even though the NACA experienced great success during its founding and early financial appropriations, it began to be plagued by the typical ills of many governmental organizations. The Committee which was founded to address stagnation found itself stagnated by red tape, a hodgepodge of subcommittees, and internal disputes. Aeronautics was essentially uncharted territory especially in the United States. The potential for making groundbreaking strides in aeronautics was overshadowed by disputes exemplified by the debate on what to call the propulsion machine in aircraft yet to be designed. For nearly twenty years, the committee investigated whether the to call the mechanism a *motor* or an *engine.* The NACA consulted an automotive worker's union to make the decision. The decision ultimately came down to which of the terms were shipped at a lower rate and "engines" became the official term of use.[37] As the

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34 Alex Roland, "What To Do", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

35 Ibid.

36 James R. Hansen, *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958* (Washington, D.C.: National Aeronautics and Space Administration, 1987), 21.

37 Alex Roland, "What To Do", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

economic woes of the 1930s metastasized, critics began evaluating the usefulness of a program like the NACA. A 1930 article published in *Aero Digest* suggested that the NACA was an organization that only spent money, instead of producing useful hardware.[38] The author wasn't exactly critical of appropriating funds for research, but instead criticized the leadership of the NACA that decided how the funds were utilized. He ended his critique with a simple call for the President and Congress: "Let us spend money, certainly- no detail of aviation should be stinted- but let us have men in charge of its expenditure who will see to it that the money which we spend shall count."[39] In a time of fiscal tightening and scientific stagnation, the NACA began to be criticized for its practicality and usefulness.

As the Great Depression came to an end prompted by U.S. involvement in World War Two, the NACA once again found its place in aeronautical research and development. Even prior to the outbreak of the Second World War, the NACA's importance was already being bolstered as tension increased due to the rise of fascist powers in Europe. A 1938 report conducted by Major General Oscar Westover examined the usefulness of the NACA in the event of war. The report found that the Committee was still relevant and necessary to provide a solid defense in the case of another war that was likely to depend upon air superiority. Almost exactly one year prior to Adolf Hitler's and Nazi Germany's invasion of Poland, the event which most consider to be the start of World War Two, Westover's report declared that the NACA was an "Essential Industry" and that its civilian personnel would be deferred in case of military mobilization.[40]

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[38] Frank A. Tichenor, "Why the N.A.C.A.?" *Aero Digest* 47 (December 1930): 40.

[39] Ibid.

[40] Westover Committee, Report to the Chairman of the National Advisory Committee for Aeronautics on the Relation of the National Advisory Committee for Aeronautics to National Defense in Time of War (Washington, D.C., August 19, 1938).

Further, the report detailed the restraints of the laboratory at Langley.[41] As a result of this conclusion and the events taking place in Europe, it was decided that another research facility was needed. Efforts to gain Congressional approval for another research facility were as turbulent as the journey to allocate funds and approval for the NACA and its Langley facility in the 1910s. Despite rising tensions in Europe, both the House and Senate initially rejected bills to establish a second facility in Sunnyvale, California. Finally, the NACA Secretary John Victory, partnered with California Senator Hiram Johnson, received Senate approval for a west coast research facility.[42] The motion went on to fail a Joint Committee vote, but after continued rising tensions in Europe and news of advancements in German aerospace development, the NACA eventually received permission to establish a second facility near Sunnyvale at the U.S. Army's Moffett Field. Ground was broken in December 1939 for the first laboratory building.[43] The NACA was appropriated funds to build and expand into another laboratory, this one being on the west coast, and Moffett Field became known as Ames Aeronautical Laboratory.

Although the United States was not yet at war in early 1940, Europe's borders were being transformed by Nazi Germany's predations. Even if the United States was not involved, it would be providing military hardware to its European allies, a move that was seen to protect the Western Hemisphere from European entanglements. In an effort to provide the most advanced and effective technology to European allies, the NACA continued work at its Langley facility and construction continued at Ames Aeronautical Laboratory. The process for a third NACA

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[41] Westover Committee, Report to the Chairman of the National Advisory Committee for Aeronautics on the Relation of the National Advisory Committee for Aeronautics to National Defense in Time of War (Washington, D.C., August 19, 1938).

[42] Edwin P. Hartman, *Adventures in Research: A History of Ames Research Center 1940-1965,* SP-4302 (Washington, D.C.: National Aeronautics and Space Administration, 1970), 14.

[43] Ibid., 27.

facility was initiated and carried through with significantly more ease than that which was required by Langley or Ames. In May 1940, Congress approved the appropriations for a third facility focused on propulsion technology.[44] The site for the laboratory was not yet decided on when Congress approved its construction. Eventually, after deliberations which considered 72 different locations, a site near Cleveland, Ohio was selected.[45] This site has seen many name changes since its establishment. Initially named the Flight Propulsions Research Laboratory, it was renamed Lewis Flight Propulsion Laboratory after World War Two. In 1999, it was once again renamed Glenn Research Center in honor of NASA Astronaut and Ohio politician John Glenn.

The NACA's primary duty outlined in its founding charter was to solve problems related to flight. In order to accomplish this goal, it partnered with military services and private aerospace manufacturers. As World War Two was coming to its conclusion, a new field of flight was being experimented with and was quickly creating more problems to be solved. During the war, aircraft had become significantly faster and their capabilities were approaching the speed of sound. Before the U.S. Air Force had been established, the U.S. Army Air Forces and the NACA were already partnered in solving the problems associated with supersonic flight. The Army established a research facility in the remote southern California desert at Muroc Dry Lake. It wasn't long before NACA personnel became involved with Army research and development at the site. To test flight problems at supersonic speeds, the Army had commissioned an experimental aircraft manufactured by Bell Aircraft Corporation and requested the NACA to

[44] Alex Roland, "Girding for War, 1936-1941", in *Model Research*, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

[45] Ibid.

supervise all data gathering and analysis.[46] The commissioned aircraft was the Bell X-series plane that was most famously piloted by Chuck Yeager when he broke the sound barrier in 1947. Although Yeager was an Air Force pilot, the instrumentation and data collection was administered by the NACA. This began the relationship between the Army Air Force (soon to be reorganized as the U.S. Air Force) and the NACA at the Muroc Army Airfield. Once the Air Force had been established, the airfield was renamed Edwards Air Force Base in 1948.[47]

For many years, the NACA team at Edwards Air Force Base was an extension of Langley Research Center. In 1951, the NACA operations at Edwards were being clearly differentiated from the work being done at Langley. That year, Congress approved construction of a new laboratory facility at Edwards Air Force Base. The Air Force leased the needed land to the NACA and construction on the laboratory facilities, quarters, and offices began in early 1953.[48] As the construction was being completed, the Edwards NACA team was finally granted autonomy from Langley and became the High-Speed Flight Station in 1954. The NACA facility within the remote, secretive Air Force research base would hold this title until 1959 when the newly created NASA renamed the station the NASA Flight Research Center. The center received a new name in 1976 and continues to be known as the Hugh L. Dryden Flight Research Center.[49]

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[46] Elizabeth A. Muenger, *Searching the Horizon: A History of Ames Research Center 1940-1976,* SP-4304 (Washington, D.C.: National Aeronautics and Space Administration, 1985), 7.

[47] Richard P. Hallion, *On the Frontier: Flight Research at Dryden, 1946-1981,* SP-4303 (Washington, D.C.: National Aeronautics and Space Administration), xvii.

[48] Ibid., 43.

[49] Ibid, xix.

Department of Defense Programs

Upon conclusion of World War Two, the National Advisory Committee for Aeronautics found itself in a difficult position. Its efforts had been primarily directed toward innovation in technology development for military aircraft. These projects, which included deicing and engine cooling technologies, were useful, but did not allow the Committee to take a leading role in jet and rocket propulsion. These brand new technologies emerged first in German laboratories and test fields. German scientists had developed the V-2 rocket under the leadership of rocket scientist, Wernher von Braun. The rocket was used against Germany's enemies, but with little success. When the United States and the Soviet Union began to close in on Berlin in early 1945, von Braun coordinated the surrender of himself and his top engineers to the American forces. Preferring a surrender to United States over the Soviet Union, von Braun assisted in the removal of over 2,000 of Germany's best engineers and most of the valuable materials to be relocated to the United States.[50] These spoils of war would be distributed throughout the branches of the military for further study in their respective rocket programs. Unfortunately, work building off of German rocket development did not continue at a steady pace due to postwar budgetary priority changes.

The Army Rocket Program

Wernher von Braun's team of German engineers were first brought to Fort Bliss, Texas to continue work on rocket development.[51] They were not immune to the budget cuts experienced

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[50] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019), 9.

[51] Ibid.

by Department of Defense programs. Their first project, the A-4 rocket, was simply an American version of the German V-2. Initially, these rockets were used for sounding experiments to discover more about the earth's atmosphere. The potential military applications were clear, however the newfound peace of the latter 1940s did not provide an appropriate place for military technology expansion. By 1950, though, the adversarial relationship between the United States and the Soviet Union was beginning to become more clear to the public. Von Braun and his team were relocated to the Army's Guided Missile Center at Redstone Arsenal, Alabama. The groundwork that was laid by the A-4 missile was expanded when the United States entered war against North Korea in the early 1950s. In an effort to build a more capable missile system, the Redstone rocket was developed and first launched in 1953.[52] The Redstone rocket made a case for itself as a first-stage launch platform for small satellites. Von Braun suggested that the Redstone be used to launch a satellite from a naval ship on the equator in 1956.[53] This mission would have lofted the first manmade satellite to be placed into orbit, beating the Soviet Union by over a year. The rocket was rejected for several government satellite missions, including the 1956 Project Orbiter mission. Rocket designs from the Office of Naval Research (ONR) and the Naval Research Laboratory (NRL) won other missions over the Army's Redstone rocket.

Wernher von Braun's team, which became known as the Army Ballistic Missile Agency (ABMA), continued to build on their Redstone design in the face of continued disregard and repeated preference given to Air Force and Navy projects. The ABMA moved on from Redstone,

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[52] Matt Bille, Pat Jonson, 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 Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 190.

[53] Ibid., 191.

although the rocket design was called on once again during NASA's first manned spaceflight projects. The ABMA's modified Redstone rocket, the Jupiter C, first launched in September 1956. It was, at least on paper, capable of placing an object into orbit, but was used to test ablative heat shielding for future projects.[54] Again, von Braun's team, while capable of surpassing Soviet capabilities, missed out on their place in history books. After some small redesigns and a slight name change to Juno I, the ABMA finally received an opportunity to make their place in space history. On January 31, 1958, a Juno I launch vehicle lofted a small satellite called Explorer I into orbit.[55] The United States was able to keep pace with the Soviets within four months of the launch of Sputnik 1 thanks to the efforts of Wernher von Braun and the Army Ballistic Missile Agency.

The Naval Rocket Program

As Wernher von Braun's team was improving the V-2/A-4 rocket, the Naval Research Laboratory (NRL) decided it needed its own project improving the German design. The Navy commission aerospace manufacturer George L. Martin Company to build ten rockets from a design it called the Viking.[56] The Viking rocket was significantly more capable than the A-4 with better navigation ability, a gimbaled engine to allow for steering, and improved structural integrity.[57] This rocket led the naval rocket launch program from 1949 through 1955 and set the

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[54] Matt Bille, Pat Jonson, 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 Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 195.

[55] Ibid., 196.

[56] Ibid., 189.

[57] Ibid.

stage for the Navy's next project, the Vanguard rocket. When the U.S. government committed itself to achieving orbit with a manmade satellite in 1955, the untested Vanguard rocket won approval. This decision incited even more rivalry between the military branches' respective rocket programs.

Part of the Vanguard's development included five suborbital launch tests prior to an official orbital launch attempt. When the Soviet Union placed a satellite into orbit in October 1957, these tests were cancelled and the orbital attempt was slotted for December 6, 1957.[58] In an effort to match the performance of Sputnik 1, an under-tested launch vehicle was prepared for launch. Within seconds of ignition, spectators witnessed the unscheduled disassembly of the Navy's Vanguard rocket, a humiliating embarrassment for U.S. space efforts. After a second Vanguard launch failure, the feat of the first American satellite was accomplished by the rejected Army Juno I. Vanguard would finally prove itself on its third launch attempt on March 17, 1958 when it placed itself into orbit.[59]

The Air Force Rocket Program

When the United States Air Force was created in September 1947, it sought an effective way to differentiate its rocket program from that of the Navy or Army. After experimenting with a cruise missile platform which relied on control surfaces such as wings and rudders to guide its

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[58] Matt Bille, Pat Jonson, 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 Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 193.

[59] Ibid.

flight, it decided to continue with ballistic missile development like that of the Army and Navy.[60] Once the cruise missile approach was dropped in 1951, the Air Force took a more calculated approach to rocket development. It was decided to focus on development of rocket subsystems prior to full scale rocket development. This approach was also abandoned as the Army and Navy threatened to take control of the field for missile development.

A report issued in 1954 found that the Air Force was six years from producing a flight-ready article. In response to the report, the Air Force gave its rocket program, known as Atlas, top priority and announced it publicly for the first time. Because the program was given top priority and would be rushed along as fast as technology would allow, the Air Force also initiated another missile program, Titan.[61] Atlas was a larger rocket than its Army and Navy counterparts and saw its first launch in June 1957. The Atlas launch vehicle did not see complete success until its third launch. While the Atlas was used to thrust John Glenn on his historic orbital, its primary purpose was to serve as an intercontinental ballistic missile (ICBM) for the Air Force and Glenn's flight served as an orbital demonstration of this capability.

As a backup plan for the Atlas program, the Air Force also developed the Titan rocket for use as an ICBM. Later in the 1960s, NASA found a non-military use for the rocket when it selected it to provide thrust for its Gemini capsules. Titan first entered development in 1955 and relied upon more rudimentary rocket technology. The Air Force had concerns over the

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[60] Dennis R. Jenkins, "Stage-and-a-Half: The Atlas Launch Vehicle," in *To Reach the High Frontier: A History of U.S. Launch Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 74.

[61] Ibid., 77.

technological advancement of Atlas.[62] While experimenting with advanced technology had its benefits for the future, the United States was in need of more immediate defense systems in light of advancements being made by the Soviet Union. Titan was also a two-stage rocket capable of carrying higher payloads and/or possessing longer ranges.

The Air Force had yet another rocket program being developed simultaneously with Atlas and Titan. The Thor program, initiated in 1954, was committed to producing an intermediate-range ballistic missile (IRBM) that could be placed in nations allied with the United States that were in close proximity to the Soviet Union.[63] It saw its first test flights in 1957 resulting in a failure during the first launch and an instrumentation error during the second. The third launch resulted in a successful splashdown that proved its usefulness as an IRBM.[64] Because of the short-range nature of the vehicle, it contributed relatively minimally on the *manned* space program. But allowed the Air Force to prove itself as an able provider of missile defense. Thor's successor, Delta, was used extensively by NASA for meteorological and atmospheric research.

Especially considering the assumption that the Air Force would be leading the way in rocket development, by the time NASA was established in 1958, the branch had produced fewer flight-ready articles than the Army or Navy. One explanation for this is the novelty of the Air Force as its own branch. As an agency, it had only existed for eleven years prior to the founding of NASA. When the military accelerated missile and rocket development after World War Two, the Air Force had not been created yet which allowed the Navy and Army their head start

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[62] Roger D. Launius, "Titan: Some Heavy Lifting Required", in in *To Reach the High Frontier: A History of U.S. Launch Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 147.

[63] Kevin S. Forsyth, "Delta: The Ultimate Thor", in in *To Reach the High Frontier: A History of U.S. Launch Vehicle,* ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 103-104.

[64] Ibid., 106.

developing and redesigning the German V-2s. By the time the Air Force began their rocket program, they sought in vain to differentiate themselves from their counterparts which only set them behind further. Once they began development of ballistic missile design, they took on three simultaneous projects, one of which (Atlas) being far more advanced and continuing only at a pace allowed by available technology. Due to the advanced nature of its research and development, the Air Force's major contributions would come later in the Space Race.

The Advanced Research Projects Agency (ARPA)

By now, the disjointed, competitive nature of the military rocket and missile programs has been made clear. Prior to the attempt to bring all spacefaring capabilities under the banner of NASA, the Department of Defense attempted a similar objective within the military. The Advanced Research Project Agency (ARPA) was created in February 1958 with the goal of cutting through red tape that was holding back many of the respective military branch programs. Most might recognize ARPA (now referred to as DARPA) for its contributions to GPS, the internet, and other mainstream technologies. In 1958, it was created to expedite the development process to produce advanced military hardware more rapidly.[65] The creation of the agency, like NASA, was prompted by the unexpected orbital launch of Sputnik 1. Its first objective was to support the development of a large booster that could be produced in a short period of time. With this in mind, and after examining the Army, Navy, and Air Force programs, ARPA granted von Braun's ABMA the authority and financial means to accomplish the task.[66] The ABMA would

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[65] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 26.

[66] Ibid., 27.

use this authority and financial allotment to build a larger Juno rocket. It would use technology already developed, saving precious time and development costs, and give birth to a new class of rocket known as Saturn. The ABMA considered this rocket to be the future of space travel comparing it to the Douglas DC-3 which revolutionized commercial air travel.[67] As work began, other ABMA engineers began to discover the complexity of scaling smaller rocket technologies to what was expected of Saturn. The ARPA commission for the Army team only lasted for less than a year until NASA was created and the work of Saturn was transferred to its oversight. Nevertheless, the foundational work for the Saturn launch vehicle had begun.

Academic Programs

Years before German rocket scientists ever developed and tested their V-2 rockets or American military branches rolled out their defense missiles, a small group of graduate students tested an alcohol-burning rocket in a flood basin outside of Pasadena, California.[68] After several failed attempts at igniting the small rocket, Frank Malina and his fellow California Institute of Technology (CIT) students finally achieved liftoff on October 31, 1936.[69] Malina's professor of Aeronautics, Theodore von Kármán, encouraged him and others to continue work on rocket development at the school, however their work was not officially affiliated with CIT and they received no funding to fuel their endeavors. After the success of the Halloween launch and subsequent attempts, the Guggenheim Aeronautical Laboratory at CIT (GALCIT) began to take

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[67] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 28.

[68] Erik M. Conway, "From Rockets to Spacecraft: Making JPL a Place for Planetary Science," *Engineering & Science* 4 (2007): 3.

[69] Ibid.

the group of rocket enthusiasts, locally known as “the Suicide Squad,” more seriously. Within months of their first tests, GALCIT allocated space for the group to do their research and development with official support from the Institute. Unfortunately, the pioneering research done also came with collateral damage. A corrosive fuel leak and other mishaps wreaked havoc on the highly advanced technological equipment and even the structure in which the team was working. After an explosion did significant damage to a wall of a building at GALCIT, the team was close to abandoning their work.[70]

The Suicide Squad’s destructive reputation was saved in 1938-1939 when a research grant accompanied with an opportunity to produce flight equipment for the U.S. Army reenergized their efforts.[71] After impressing a high-ranking administrator of the Army Air Corp, they were tasked with developing rockets to assist aircraft taking off on short runways. The development of these rockets, that became known as Jet-Assisted Takeoff (JATO) rockets, gave the Suicide Squad a new name. GALCIT Project Number One, funded by the Army Air Corps, development and tested their new rockets with great success. The ensuing Second World War only increased demand for their products. Von Kármán and Malina spun off their Army venture into Aerojet, a major defense manufacturing contractor. This allowed GALCIT Project Number One to continue research and development separate from the production of JATO rockets. Nevertheless, the Army continued to keep the GALCIT team busy with more research projects. In 1944, GALCIT Project Number One again renamed themselves the Jet Propulsion Laboratory (JPL).[72]

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[70] Erik M. Conway, “From Rockets to Spacecraft: Making JPL a Place for Planetary Science,” *Engineering & Science* 4 (2007): 3.

[71] Ibid., 4.

[72] Ibid.

In only a decade, what started as an unofficial group of rocket enthusiasts launching small projectiles from a flood basin had grown into a substantial, self-sustaining defense contractor. From 1944 until 1954, JPL developed three missile systems for the Army. It had also worked with Wernher von Braun's team as it planned Project Orbiter, the Army's competitor to the Naval Research Laboratory's Project Vanguard. Unfortunate for both the Army Ballistic Missile Agency (ABMA) and JPL, Project Orbiter was not selected. This rejection perhaps set the course for history to remember, not the United States, but the Soviet Union as the first people to place a manmade object into orbit. It seemed that JPL had lost the chance to place itself in history books, but the Soviet Union's feat only came to cement JPL's legacy. When the Naval Research Laboratory was unable to beat the Soviets to orbit, the ABMA and JPL were called on to build the United States' first orbital craft, Explorer. The ABMA developed and built the lower stage of Explorer while JPL was tasked with the upper stage and guidance systems.

The embarrassment of the United States by the Russians incited the creation of JPL's future parent organization, the National Aeronautics and Space Administration (NASA). As NASA was being organized, the Jet Propulsion Laboratory of the California Institute of Technology was highly regarded as a government contractor and partner. For over a decade, it provided research and development on military projects and had only recently assisted in the rebuilding of U.S. reputation after being beat to orbit. The academic laboratory with surprising real-world experience soon found itself under new management with a daunting task ahead: to take the United States beyond the atmosphere above and to Earth's closest celestial neighbor.

Conclusion

In the telling of the successful story of the United States' journey to the Moon, NASA stars as the main protagonist. At odds with its antagonist, the Soviet Union, NASA partners with supporting characters like private aerospace companies and politicians to appropriate funds and build hardware that took astronauts to the lunar surface. The best stories always include detailed character development, though. It is necessary to understand the backstory of NASA and how it came into being so that the amazing feats could be accomplished. A student of space history discovers aspects of NASA's past. At its core, it grew out of a younger version of itself, the National Advisory Committee on Aeronautics (NACA). In the four decades prior to NACA's reorganization as NASA, it had come to possess four research centers that laid the foundation for aeronautical research in the United States. Langley Research Center in Virginia served as the Committee's first facility. Following Langley, Ames Aeronautical Laboratory, Lewis Flight Propulsion Laboratory, and the High-Speed Flight Research Center all came into being as a result of political maneuvering or wartime necessity. These facilities went on to serve as the research and development nucleus of NASA.

Perhaps an even more complex aspect of NASA's past were the various Department of Defense programs that were rolled into its supervision in 1958. The U.S. Army, and its main rocket development group known as the Army Ballistic Missile Agency (ABMA), brought a series of four previous rocket programs to NASA. The ABMA brought history designing and launching the A-4 rocket, the Redstone rocket, the Jupiter program, and its close relative, the Juno program. It was a Juno rocket which thrust the United States' first satellite, Explorer 1, into orbit. The Navy rocket program brought somewhat less to NASA's manned spaceflight aspirations. This is significant considering that the Navy projects were most often selected over the Army or Air Force for government satellite projects. Its contributions to the 1958 NASA contained both Viking and Vanguard research and development. The Air Force rocket program was delayed early on as the branch was being organized and they sought to differentiate themselves from the Navy and Army missile programs. Once the Air Force rocket program found its place in the ranks, it was able to begin research and development on the Atlas, Titan, and Thor rockets. All three programs saw service with NASA in both manned and unmanned launches.

Before Congress was inspired to consolidate U.S. space efforts under one banner, the Department of Defense was first to attempt a consolidation of its rocket programs. The Advanced Research Projects Agency (APRA) preceded NASA by only a few months. In that short time, it organized what would become known as the Saturn program. It was led by Wernher von Braun's ABMA team and the foundational work was transferred to NASA upon its creation. Most recognize the Saturn designation for its contributions to the Apollo program as it would provide thrust for Neil Armstrong's and Buzz Aldrin's Apollo command and lunar modules eleven years later.

Finally, another research facility plays a part in NASA's past. The Jet Propulsion Laboratory at the California Institute of Technology (JPL) built itself as a government aerospace contractor from a modest academic program. World War Two fueled its rise to prominence in the aerospace industry and allowed a large manufacturing contractor to be spun off known as Aerojet. After Aerojet separated itself from JPL, the academic research laboratory with significant real-world experience continued to collaborate with the ABMA on Explorer 1. Once a government agency like NASA was deemed necessary, JPL was highly regarded and seen as an integral part to the work that would be done at the new agency.

To answer the questions associated with taking the United States out of Earth's atmosphere and to its closest celestial neighbor, NASA consolidated the work which had been done in the prior half-century. Most relevant projects were done in and around World War Two and within two decades prior to NASA's creation. As 1958 served as the year the United States responded to the Soviet launch of Sputnik 1, NASA relied on the work done by NACA, military rocket programs, and JPL to keep itself at pace with its adversary. It also used these to form its administrative structure and start its first project, Mercury. In order to allow Neil Armstrong to take his first steps on the lunar surface, NASA had to take its first steps out of the atmosphere.

Chapter 3: Go For Liftoff

The winter of 1957-1958 was particularly cold for Americans. Not only did southern states like Florida experience record-breaking cold snaps that damaged millions of dollars' worth of crops, but the recent orbital success of the Soviet space program made American citizens feel the effects of the Cold War more closely to home.[73] In October 1957, the Soviet Union launched an inert satellite into orbit that circled over the United States before eventually falling back into the Earth's atmosphere. The event struck fear into millions of Americans as they watched reports on their television screens and listened in to Sputnik's beeping with their amateur radio stations. One month later, the Soviets followed the feat by lofting an even larger projectile into orbit that carried a dog named "Laika" which proved that life could be sustained outside of the atmosphere. Unfortunately, Laika was not recovered after the video was collected of her living and breathing in space. Within three days of the second Soviet orbital flight, President Eisenhower declared to the American people that U.S. defenses were prepared and adequate to match their Soviet adversary.[74] In the same speech, to quell anxieties, he announced that Dr. James R. Killian would assume the position of Special Assistant to the President for Science and Technology and lead the reconstituted President's Scientific Advisory Committee (PSAC).[75] Killian had been the president of the Massachusetts Institute of Technology. These actions, although not detrimental to the nation's efforts to compete with the Soviet Union in space, were little but a knee-jerk reaction to comfort a nervous citizenry that saw the United States as lagging behind their communist counterpart.

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[73] National Oceanic and Atmospheric Administration. *Report from the Preserve America Initiative,* "Freeze Damage Florida Crops, 1957-1958."

[74] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 6.

[75] Ibid.

Assembling NASA

Real action to begin to catch up to the Soviets took place in the following months. President Eisenhower and his advisor, Dr. Killian, began consulting one another on the needs of the country's space program during the first quarter of 1958. Killian stated that March 5, 1958 was the date in which the President decided to move forward with the creation of what became the National Aeronautics and Space Administration (NASA) "upon the NACA structure."[76] Building upon the NACA's structure was the obvious decision for many reasons. It had already broken into the field of space research and development and had multiple facilities dedicated to these activities already under its management. It also had a history of working with the Department of Defense but was considered a civilian organization separate from any military command. It was important that the new space program was civilian in nature in order to avoid escalation of the warming Cold War. The research, development, and experimentation conducted by NASA would still be of great use to the military even if it was being completed by a civilian agency. The United States lessened its liability of being accused of increasing military spending for space-capable weapons as money appropriated to NASA would be seen as scientific in intent.

On April 2, 1958, a collection of documents as well as draft legislation that would establish NASA were sent to Congress for review.[77] The documents were received in the Senate by future president and Senate majority leader, Lyndon B. Johnson who was also serving as the chair of the Special Committee on Space and Aeronautics. After months of hearings and review, Congress passed the National Aeronautics and Space Act of 1958 and it was signed into law by President Eisenhower on July 29. Before NASA's official establishment date of October 1, 1958

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[76] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 9.

[77] Ibid., 12.

came two months of deliberations to consider who would lead the agency. The task was handed to Dr. Killian who ultimately decided upon Thomas Keith Glennan.[78] Glennan had served as the president of the Case Institute of Technology in Cleveland, Ohio. His background included work during World War Two for the U.S. Navy's Underwater Sound Laboratories and serving as a member of the Atomic Energy Commission. Although he is most often remembered as a strong administrator for the new agency, he wasn't the most obvious selection for the position. Most would have assumed that the Director of NACA, Hugh Dryden, would take the place of NASA Administrator along with the nearly 8,000 personnel that transferred from NACA.[79] There are varying opinions on why Dryden was passed by including his not-so-warm relationship with Congress or his identification as a Democrat, opposite the Republican President Eisenhower who was unlikely to nominate Democrats to top positions.[80] After Senate confirmation, T. Keith Glennan was sworn into his position of NASA Administrator at the White House on August 19. During his swearing in, President Eisenhower stood next to him along with Hugh L. Dryden, who was simultaneously sworn in as Deputy Administrator of NASA.[81] Dryden had not been completely overlooked. His experience leading the NACA was integral to the success of its expansion into NASA.

The first task on the plates of Glennan and Dryden was facilitating the transfer of projects from the NACA, Department of Defense, and the Jet Propulsion Laboratory into NASA. Technically, an executive order corresponding with the establishment of NASA on October 1 legally transferred many projects to the agency, but the job was easier said than done. The task of

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[78] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 41.
[79] Ibid., 48.
[80] Ibid., 41.
[81] Ibid., 42.

transferring projects to NASA management was especially difficult for Department of Defense programs. Many of the military branches' rocket programs were themselves intricately tangled with Advanced Research Projects Agency (ARPA) appropriations and private aerospace contracts. In many cases, the military research projects were transferred to NASA along with their monetary allocations and immediately handed back to the military branches and then were managed as a NASA contractor. In other cases, NASA would simply continue the project as it was handed to them. One of the most significant instances of this type of handoff was the Air Force's F-1 engine project. The engine was in development at North American Aviation, an aerospace contractor with the Air Force, but NASA became the contracting agency after its establishment.[82] The F-1 continued in development until it was eventually used to provide thrust for the Saturn V launch vehicle during the Apollo program.

These transfers took several months to finalize. Project Vanguard of the Naval Research Laboratory (NRL) was also officially transferred on October 1 but wasn't practically transferred for almost seven weeks. In order to avoid delays resulting from the transfer, NASA sought to conduct a slow rollover from the Department of Defense to NASA. The NRL was given responsibility to continue management of the project for NASA after its transfer. Existing contracts created by the NRL were to be fulfilled as all civilian personnel were transferred along with hardware. As of November 16, 1958, these personnel were employed by NASA, but continued to work at the NRL facility. Even after the project was moved to a NASA facility in the new year, the NRL was still called on to provide support to NASA as a contractor.[83]

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[82] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 45.

[83] Ibid.

The Jet Propulsion Laboratory at the California Institute of Technology (JPL) was transferred as easily as the Air Force and Naval rocket programs. JPL was permitted to retain its military contracts apart from the NASA transfer as these were deemed necessary for national security.[84] When it came to the Army Ballistic Missile Agency (ABMA) led by Wernher von Braun, NASA ran into considerably more opposition. This was especially disheartening because the Army program, in conjunction with JPL, had seen the most success with its orbital launch of Explorer 1 in January 1958. Explorer 1 was the probe which was launched in response to Sputnik 1 to demonstrate U.S. capabilities. At the time of NASA's establishment, the work of the ABMA and JPL was seen as the agency's greatest hope to vault itself past the Soviet feats. Army command was hesitant to transfer its rocket research and development out of its control. It viewed the program as necessary for battlefield readiness and thus the national defense.[85] Political maneuvering in Congress and a leak to the *Baltimore Sun* necessitated an alternative plan for the future of the Army rocket program and NASA.[86] The ABMA was not transferred to NASA regardless of the provisions of the National Aeronautics and Space Act of 1958. Even though the relationship between NASA and the ABMA seemed to have an icy start, a subsequent legal agreement permitted ABMA cooperation at NASA's request if deemed appropriate by Army command.

Due to the agreement, NASA began its operations without one of its most iconic rocket development programs under its management. The agreement apparently worked well as

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[84] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 47.

[85] Ibid., 46.

[86] Ibid.

expressed by NASA Administrator Glennan in September 1959.[87] The fate of the Saturn launch vehicle was not settled, though. Congressional pressure forced the downsizing of ARPA which included the Army's Saturn rocket program. One option was for the Saturn rocket to be moved under the Air Force's management because the service was more likely to be in need of a large launch vehicle rather than the Army.[88] Rivalry between the Army and Air Force made this solution unsavory to Army command and those that developed the vehicle. Another option was to transfer the program to NASA which had special interest in obtaining a large launch vehicle that was already in development. This solution was significantly more agreeable for all parties involved and the decision was made by President Eisenhower on October 21, 1959.[89] Mass transfer of personnel to NASA did not take place until July 1, 1960 due to planning and the Congressional process require to complete it. Robert L. Rosholt, professor and author of the definitive *An Administrative History of NASA, 1958-1963* claimed that the transfer of Saturn and the ABMA to NASA was "the most significant event in NASA's history between its establishment…and the Kennedy announcement" which committed the country to reaching the Moon by the end of the 1960s.[90] NASA finally had the final piece of the defense programs under its management, only a year and a half after its establishment. Along with the program, came an additional 4,000 personnel which would now be on the NASA payroll and a new facility, the Marshall Space Flight Center.

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[87] Robert L. Rosholt, *An Administrative History of NASA, 1958-1963.* SP-4101. (Washington, D.C.: National Aeronautics and Space Administration, 1966), 108

[88] Ibid.

[89] Ibid., 109.

[90] Ibid., 107.

Project Mercury

In November 1957, the Soviets launched Sputnik 2 carrying a dog named "Laika" as a living specimen. The flight made clear their intentions for Soviet spaceflight in the coming years. Payload capacity in these early spacecraft was considered precious even for Russian rockets which consistently provided more thrust than their American counterparts. Instead of scientific or data collection equipment on board Sputnik 2, the Soviet Union decided to occupy payload space with life support systems and the unknowing canine. This indicated to American intelligence and the scientific community that the Soviets were intending to place a man in orbit in an attempt at least similar to the mission profile followed by Sputnik 2. Once their life support systems were proven to be effective, the pilot's seat could be occupied by a cosmonaut rather than an animal specimen. As a result of the Sputnik 2 mission, the Air Force began evaluating the feasibility of a manned mission using an Atlas rocket in a "Man-in-Space-Soonest" campaign.[91] The Air Force set to move forward with the efforts regardless of the July 1958 decision to create NASA. Afterall, NASA would not be operational for months and the race had started to build American prestige in space in light of the Soviet feats. It was believed that the mission could be completed by June 1960 with the Atlas rocket within the current budgetary allotment.[92] Additionally, a five-year plan was also proposed by the Air Force that included an orbiting space station and lunar missions.

The Army and Navy also presented plans to ARPA for manned missions at around the same time. The passive astronaut would ride in an elongated capsule on a Redstone rocket up

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[91] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Birth of NASA" in *This New Ocean: A History of Project Mercury,* SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[92] Ibid.

into space and immediately return to the Earth without attaining orbit. The Army's plan outlined a suborbital mission profile using a Redstone rocket that was not capable of reaching orbital velocity but would at least place an American in space by the end of 1959. The Army planned named "Project Adam" was met with a cold reception from NACA Director Hugh Dryden who convinced Congress and the director of ARPA to direct their attention to more complicated orbital missions.[93] Once again, the Army team was looked over by top decision-makers. The Navy plan was presented to ARPA in April 1958 and was distinctly more complicated than Project Adam. It planned for an orbital flight and called for an elongated capsule that would be mechanically manipulated in space to create a sort of glider for reentry. By the time private aerospace companies proposed feasible plans to make the mission a possibility, Project Mercury was already moving along within the new NASA.[94] The Mercury program would attempt to find a place between the simplistic Army mission and the more complex plans of the Air Force and Navy.

Between the signing of the bill which created NASA in the summer of 1958 and its establishment in October, deliberations began with NACA personnel on the requirements for a manned satellite mission. In the months prior to NASA's establishment, newly appointed NASA Administrator Glennan and ARPA Director Roy Johnson agreed to move forward in conjunction to produce plans for a capsule-based manned satellite program.[95] The program would make use of the research and development already completed for orbital missions by ARPA and the respective military rocket programs. This funneled the work of the Navy and Air Force that was

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[93] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Other Means to the Same End" in *This New Ocean: A History of Project Mercury,* SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[94] Ibid.

[95] Ibid., "NASA Gets The Job."

facilitated through ARPA under the NASA umbrella. Von Braun and his Army team at the ABMA in Redstone Arsenal, Alabama retained its work for only a short time before its ultimate 1959 transfer to NASA. As of NASA's first day in operation on October 1, 1958, all manned spaceflight activities were placed under its management. Its task was at hand, but the new agency had made no decisions on which hardware to rely on for accomplishing the goal. Nevertheless, Administrator Glennan approved Project Mercury within a week of NASA's first day of operation on October 7, 1958.[96]

The Mercury Capsule

Fortunately for NASA, a relatively new American aerospace company bearing the name of its founder, James S. McDonnell, had already began asking the question of what it would take to produce an orbital manned spacecraft. With an eye on the future of both military and civilian uses for manned spacecraft, McDonnell tasked his company's Advanced Planning Group with putting together plans for a capsule in April 1958, three months prior to NASA's conception.[97] When the all-clear for Project Mercury was given by Administrator Glennan, Robert R. Gilruth, the Assistant Director at Langley Research Center was named to organize the Space Task Group, the body which coordinated the progression of Mercury.[98] This task force set the required specifications for the proposed capsule and disseminated the information to over 40 aerospace

[96] James M. Grimwood, "Part II (A) Research and Development Phase of Project Mercury: October 3, 1958 through December 1959" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[97] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, ""Aerospace" Technology" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[98] Ibid., "The People in Charge."

manufacturers on October 23, 1958 so that bids could be collected.[99] It was found that eight corporations had already began work on a manned capsule in preparation for the Air Force's planned missions.

Deliberations began over the holiday season over which contractor's proposals NASA ought to move forward with. The Space Task Group narrowed the proposals down to two companies: Grumman Aircraft Engineering Corporation and McDonnell Aircraft Corporation.[100] When the selection of McDonnell was made, Administrator Glennan personally explained the decision. Grumman was already committed to multiple projects for the U.S. Navy and it was feared that the additional workload from NASA might disrupt the company's defense contracts. McDonnell Aircraft Corporation of St. Louis, Missouri was notified of the selection of their bid on January 12, 1959.[101] McDonnell's Advanced Design team began work on the capsule while being almost constantly bombarded by contract change proposals from NASA as mission needs changed. In spite of these changes, the McDonnell team and NASA cultivated a strong relationship of idea sharing and flexibility. The contract settled upon the production of 12 flight-ready articles for total price of $18 million.[102]

Rocket Boosters for Mercury

While the Mercury capsule was being planned and set into development and manufacture, NASA also had to survey what was available to power its spacecraft into flight. At

[99] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Calling for a Capsule Contractor" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).
[100] Ibid, "Awarding the Prime Contract."
[101] Ibid.
[102] Ibid., "Costs and Cancellations."

the conception of Project Mercury, the only rocket booster in the American arsenal both capable of producing enough lift for the payload and meeting reliability ratings high enough to justify placing under a human astronaut was the Army's Redstone missile. Military missiles were designed to loft armaments rather than humans, so most of these early models did not possess the track record of successful flights except for Redstone. As in the case of Explorer 1, the previously overlooked Army Ballistic Missile Agency was to be called on to make up for technological shortcomings of other entities. The Army's ability to provide the boosters to NASA even fell within the mission timeframe. There were some potential issues that the ability to disrupt NASA procurement from the Army. The first problem faced by NASA was the cost associated with procuring the Redstone rockets. It was estimated that the cost for each Redstone launch for NASA would be around $1 million. Another predicament that met NASA was that the Redstone rocket was not capable of reaching orbit. Nevertheless, it was seen as a viable solution to testing the Mercury capsule in atmospheric flight and shallowly over the edge in space.

In addressing the cost of the Redstone rocket system, NASA resorted to developing a platform that allowed more test flights at a lower cost per firing. In January 1958, NASA personnel designed a cluster of four solid fuel Sergeant rockets, designed by JPL, that could lift the Mercury capsule.[103] This rocket system could theoretically thrust the capsule to an altitude comparable to Redstone, but did not have the proven track record needed for use in lifting astronauts. Most importantly, however, "Little Joe," as it became known as, could be used to power test flights. Little Joe was used to loft unmanned Mercury capsules to test aerodynamic effects on the craft, emergency systems, parachutes, and splashdowns. The small booster served

[103] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Shopping for Boosters" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

its purpose but did not provide for all the testing needs in the Mercury program. Neither Redstone nor Little Joe would provide the velocity necessary to test the Mercury capsule's performance at orbital speeds and reentry. For this test, an early Air Force Atlas missile aptly named "Big Joe" was produced and used to provide thrust to observe how the capsule performed at unprecedented speeds and conditions.[104] The Big Joe rocket was used for a single test in the early morning hours of September 9, 1959.[105] Its main purpose was to test the ablative heat shield that would consume the energy produced by reentry of the capsule. Even with slight deviations in flight, it was considered to be a successful test as Langley Research Center's heat-shield specialist, Aleck Bond concluded that the thermal shielding performed as expected and could be adopted for use in manned Mercury flights.[106] The Atlas design was also used to solve another problem faced by NASA and its Redstone rockets.

To address the inability of Redstone to reach orbit for manned missions, NASA sought rocket power from the Air Force's relatively novel Atlas-D rocket. Big Joe was technically part of the Atlas rocket family and had seen some operational failures during its flight. Fortunately, more advanced models proved the flight-readiness of the Atlas-D for both spaceflight and the ICBM defense program around the same time as the Big Joe flight.[107] NASA officials had ordered Atlas rockets from the Air Force for use in the Mercury program in December 1958 when the order for the Army Redstone rockets was placed.[108] The Army was able to provide their rockets more quickly as they were already in use and part of the American missile arsenal. The

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[104] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Shopping for Boosters" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[105] Ibid., "Big Joe Shot."

[106] Ibid.

[107] Ibid.

[108] Ibid, "Shopping for Boosters."

Atlas-D rockets were still in development and would take considerably more time to complete and produce.

The Astronaut Selection Process

While the process for development and procurement of a capsule and boosters for the Mercury program were taking place in the first months of NASA's organization, the agency continued to work on a final piece of the placing a man into orbit. The details surrounding the machine that would accomplish the task were being worked out and it was necessary to decide on the criteria for the astronauts that were to be selected for America's first spaceflights. Hindsight reveals that pilots from military test flight programs was an obvious choice for the first astronauts. Prior to the mid-nineteenth century, the term "astronaut" had only seen use in futuristic science fiction novels. Proposed names for the space travelers included "spaceman" and "space-pilot," both demonstrating the novelty of realistic human spaceflight.[109] Similar, and more serious, discussions were had to decide from which field the first astronauts should be selected from. What qualifications were needed to be an effective traveler in space? The Space Task Group which managed the selection and development of flight hardware was also tasked with finding the individuals to place in the spacecraft. Their deliberations concluded that 150 men would be nominated from aerospace industry and military backgrounds. Once the list of 150 names had been reached, 36 would continue to physical and psychological evaluations. Twelve of the 36 would continue to a nine-month training and qualification program. Only six of the

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[109] Colin Burgess, *Selecting the Mercury Seven: The Search for America's First Astronauts* (New York: Springer, 2011), 30.

original 150 men would qualify to be America's first astronauts.[110] At the beginning, the fields which astronauts could be selected from varied greatly compared to the final range. All applicants had to hold at least a bachelor's degree and hail from the biological or psychological sciences, engineering, or mathematics. Viable applicants had to possess three years' experience in the operation of aircraft, as a submariner, in engineering, navigations, or communications. Medical doctors would also be considered given that they had met residency requirements. Finally, arctic or Antarctic explorers would also be considered eligible to apply.[111] Over the Christmas holiday, President Eisenhower suggested that the criteria for eligibility be narrowed down to test pilots in the armed services.[112] Fortunately, this was agreed upon before the all-call went out for all interested individuals eligible through the original criteria, greatly simplifying the selection process. The Space Task Group gathered to discuss a new set of standards that would qualify existing servicemen.

The list was narrowed down to seven items: (1) be less than 40 years of age, (2) be less than 5 feet, 11 inches tall, (3) be in excellent physical condition, (4) possess a bachelor's degree or equivalent, (5) be a graduate of a test pilot school, (6) possess 1,500 hours of documented flight time, and (7) have qualified as jet pilot.[113] President Eisenhower, usually strongly in favor of separating military and civil interests, was quick to endorse the plan. Finding civilians that were qualified for jet flight was especially difficult because of the novelty of jet technology in

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[110] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Project Astronaut?" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[111] Ibid.

[112] Ibid.

[113] Ibid.

the 1950s. This reality contributed to the endorsement by President Eisenhower of military test pilots for astronaut eligibility.

Once criteria was decided on, NASA officials reached out to the Pentagon to retrieve personnel records of graduates from test pilot schools. The screening produced 508 pilots that met the most basic standards for astronaut eligibility: age and flight hours. Of the 508 servicemen first found, only 22% met the other minimum standards.[114] Once the 110 pilots were selected from the initial 508, the first phase of more detailed screenings began. This phase included 30 hours of psychological evaluation based on 17 factors that were deemed necessary for spaceflight. Candidates were evaluated for indicators including personal drive, adaptability, freedom for impulsivity, frustration tolerance, and their social relationships.[115] Finally, candidates were assigned an overall rating based on their psychological evaluations. After this phase, the list of pilots was narrowed down to 32 candidates, resulting from disqualification or self-removal. This list included 15 pilots from both the Navy and the Air Force and two represented the Marine Corps.[116]

The 32 pilots that agreed to continue in the astronaut selection program were ordered to report to the Lovelace Clinic in Albuquerque, New Mexico for thorough medical screenings. Historically, pilots and medical examiners shared a strenuous relationship as physicians held the authority to ground pilots due to potential medical hazards. Fortunately, previous screenings had

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[114] Colin Burgess, *Selecting the Mercury Seven: The Search for America's First Astronauts* (New York: Springer, 2011), 38.

[115] Ibid., 53-54.

[116] Ibid., 57-59.

resulted in producing an extraordinarily healthy group of pilots and only one of the 32 that reported to Lovelace presented any medical concern after over 30 intrusive health tests.[117]

Just over one month had passed since NASA retrieved pilot records from the Pentagon and started narrowing the candidate list. After medical screenings in New Mexico passed 31 pilots to continue, the candidates reported in six groups from February to March 1959 to Wright Air Development Center in Dayton, Ohio. After experiencing psychological tests in Washington and medical tests at Lovelace Clinic, the candidates were put through tests in Ohio that evaluated both their physical and psychological dexterity. While tests continued at Wright, the Space Task Group met Langley Research Center to narrow down the pool even further. They attempted to reach a consensus on a team of six astronauts, but the group of candidates was so strong, that STG Director Gilruth made the decision to select seven astronauts for Congressional approval.[118] After a review of medical and psychological performance data, he task group had found their astronauts:

- Lieutenant Colonel John Herschel Glenn, Jr., U.S.M.C.
- Lieutenant Commander Walter Marty Schirra, Jr., U.S.N.
- Lieutenant Commander Alan Bartlett Shepard, Jr., U.S.N.
- Lieutenant Malcolm Scott Carpenter, U.S.N.
- Captain Donald Kent Slayton, U.S.A.F.
- Captain Leroy Gordon Cooper, Jr., U.S.A.F.

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[117] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Astronaut Selection" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[118] Ibid.

- Captain Virgil I. Grissom, U.S.A.F. [119]

On April 9, 1959, the "Mercury Seven," as they would become known, were announced to the public during a press conference from Washington. The astronauts sat behind a table facing television cameras and the reporters' lenses, models of the Mercury capsule and the Atlas launch vehicle in front of them. While selection of the astronauts commenced during the first five months of 1959, development and early production of the hardware that was to deliver the astronauts to space and orbit had continued. The astronauts were presented to the House Committee on Science and Astronautics on May 28, nearly five months after their names were first selected as part of the initial 508 Pentagon records.[120] As the public became more aware of the selection, the astronauts soon found themselves in a frenzy of fame and admiration. These men were seen as the peak of American exceptionality in the mid-twentieth century. If the United States was to match and surpass the feats of the Soviet Union, these astronauts were the heroes that would pilot the nation representing freedom and democracy into first place. There was no lack of excitement for the endeavor, but many obstacles still stood in the way of the nation's desires. The U.S. had not yet placed a single astronaut in a functional spacecraft, let alone launched him into space.

[119] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Astronaut Selection" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[120] Ibid.

Mercury Flights

When the astronaut selection process began, it was anticipated that the first manned Mercury launches would take place sometime during 1959.[121] This optimistic timeframe, motivated by the fervor to follow up the Soviet launches, was slowed when the Little and Big Joe launch tests began and created more technical hurdles for NASA to address. While these complications did delay the original, hopeful schedule, the purpose of testing is to uncover potentially fatal issues that might have been overlooked by an excited effort to loft a man into space. The individual hardware components which had been developed and produced under schedule pressures had also not been tested together which created more problems to be solved. After the seven astronauts were selected for Project Mercury, they set out for months of following a training regimen that aligned with mission objectives and physical requirements for space travel. Capsule development moved into production at McDonnell Aircraft Corporation in St. Louis. Army-designed Redstone rockets were produced by the Chrysler Corporation and would provide thrust for the first full-scale Mercury missions. On June 30, 1960, the Mercury capsule that would first visit the vacuum of space, "Spacecraft No. 2," was delivered from McDonnell to Marshall Space Flight Center in Huntsville, Alabama. Here it was checked for compatibility with its Redstone launch vehicle. After the compatibility tests were complete, the capsule was transported to Cape Canaveral on July 23. The Redstone rocket booster was delivered from Huntsville to Cape Canaveral shortly after on August 3. [122] While the preparations

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[121] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Astronaut Selection" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[122] James M. Grimwood, "Part II (B) Research and Development Phase of Project Mercury: January 1960 through May 5, 1961" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

from the Mercury-Redstone flights were being made, NASA was already testing the Mercury-Atlas combination required for orbital flights. Before the Mercury capsule and Redstone missile were ever mated, an Atlas rocket launched an unmanned Mercury capsule from the Cape on July 29, 1960. The flight, called Mercury-Atlas 1 (MA-1) resulted in a structural failure about a minute into the flight.[123]

After a delay from its original launch date of November 7, Mercury-Redstone 1 (MR-1) was finally ignited on the morning of November 21. Almost as quickly as the ignition began, it was over, leaving the rocket seemingly unmoved. In reality, the rocket had briefly lifted off the pad before it resettled causing damage to the tailfins and booster.[124] In a report to NASA Administrator Glennan, engineer George Low explained that the engine had shutdown and commenced the capsule's ejection sequence.[125] At least the capsule system had performed as designed, but Mercury-Redstone's first launch attempt was considered a failure. Later, a technical error created by the discrepancy between using Redstone as a space launch vehicle rather than a missile was found and deemed responsible for the failure. A new launch attempt, MR-1A, was scheduled for December 19 and the MR-1 capsule was to be reused with the booster slotted for MR-3.[126] MR-1A was launched on schedule and the suborbital 15-minute flight was a considered a complete success, redeeming the MR-1 "four-inch flight," as it had become known. Mercury-Redstone had proven itself as a viable spaceflight combination.

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[123] James M. Grimwood, "Part II (B) Research and Development Phase of Project Mercury: January 1960 through May 5, 1961" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[124] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "MR-1: The Four-Inch Flight" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[125] Ibid.

[126] Ibid.

After the single success of MR-1A, it was time for NASA to put its first living passenger in the pilot's seat of a Mercury capsule. For the MR-2 flight, NASA opted to launch a chimpanzee to test the Mercury capsule's ability to sustain life. They also prepared a series of tests to determine a primate's ability to function in the weightlessness of space and stress of spaceflight. The species of primate was selected because its internal organ arrangement, reflex time, and docile demeanor are similar to that of a human's. The three year-old "Ham" was selected out of a pool of six chimpanzees to sit aboard the January 31, 1961 flight.[127] After several delays and holds, the booster was ignited just before noon, sending the primate into the atmosphere. A cabin pressure malfunction and an early ejection of the capsule escape system due to the vehicle overaccelerating caused anxiety at mission control.[128] The flight continued upward, however, Ham unharmed in his spacesuit and with the trajectory of the vehicle higher and farther than anticipated, but still operational. Ham almost flawlessly performed his reaction and operation tests, proving a primate's ability to perform under stress and in the weightlessness of space. The capsule splashed down in the Atlantic and was discovered about 27 minutes later, miles away from the anticipated splashdown site because of the vehicle's divergence from its flightpath earlier in the flight. Ham was recovered and in great health, but when taken near another Mercury capsule later, his behavior demonstrated his desire to be retired from the spaceflight program. Nevertheless, the Mercury capsule had proven itself, with some modifications, worthy of carrying a human to space. To address the anomalies seen during flight, a follow-up mission called Mercury-Redstone Booster Development (MR-BD) was launched in

[127] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "MR-: Ham Paves the Way" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[128] Ibid.

March with a dummy boilerplate capsule mounted as its payload.[129] Its success finally gave the Mercury-Redstone combination its human-rating for spaceflight.

Just three weeks after MR-2, another Mercury-Atlas launch, MA-2, finally proved the functional compatibility of the Mercury capsule and the Atlas launch system. The flight, which was essentially a repeat of the failed MA-1 mission, launched on February 21, 1961 and was a completely nominal, an important step to matching the Soviet orbital flights. As the United States was beginning to move closer to competing with the Soviet competition, the U.S.S.R. moved the goalposts forward with another monumental feat. On April 12, 1961, Cosmonaut Yuri Gagarin lifted off in a Vostok spacecraft from Baikonur Cosmodrome. Not only did he achieve the title of the first man in space, but the Soviets were able to insert him into orbit in a flight that lasted 108 minutes.[130] It appeared that the Soviet Union had won the Space Race. NASA continued business as usual and MA-3 launched on April 25 carrying a robotic astronaut. Seven minutes into the flight, it failed to follow its prescribed flightpath prompting an activation of the capsule's emergency escape sequence.[131] Although the Atlas booster was lost, the capsule was recovered with minimal damage and was returned to McDonnell for refurbishment.[132] Since February 15, 1961, NASA had been under new leadership. James E. Webb was nominated by the new President John F. Kennedy to serve as NASA Administrator in Keith Glennan's place. Between the great success of the Soviet Union and the failure of MA-3, the United States space

[129] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "When is a Vehicle Man-Rated?" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

[130] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019), 75.

[131] James M. Grimwood, "Part II (B) Research and Development Phase of Project Mercury: January 1960 through May 5, 1961" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[132] Ibid.

program and the public needed something to celebrate and its new leader sought to set the tone for the coming years in the Space Race.

An Operational Project Mercury

After the successful MR-BD flight that resolved the booster anomalies seen in MA-2, the next Redstone launch would include one of the Mercury Seven astronauts. An April 20, 1961 meeting of the Space Task Group approved the safety of the vehicle and mission plan for the upcoming MA-3 flight.[133] On May 5, a Mercury-Redstone rocket sat on the launchpad at Cape Canaveral, Florida. Astronaut Alan Shepard was selected to be the first American to travel beyond Earth's atmosphere. Astronauts were given the opportunity to name their spacecraft and Shepard had chosen the designation "Freedom 7." The flight lasted just over 15 minutes from liftoff to splashdown and included approximately five minutes of weightlessness.[134] Astronaut Shepard was recovered as planned and the mission was deemed a complete success. The United States finally earned its first human achievement in space, but because the Redstone was incapable of reaching an orbital velocity, the nation still trailed behind the achievements of the Soviets. Astronaut Virgil "Gus" Grissom followed Shepard's flight on July 21. MR-4, designated "Liberty Bell 7" flew a nominal flight from launch to splashdown, but an anomaly occurred when the main hatch on the capsule was ejected from the craft and it began to take on water. Grissom evacuated the capsule which sank to the Atlantic seafloor along with all of its valuable

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[133] James M. Grimwood, "Part II (B) Research and Development Phase of Project Mercury: January 1960 through May 5, 1961" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[134] Ibid., "Part III (A) Operational Phase of Project Mercury: May 5, 1961 through May 1962."

data. Within minutes, Grissom was recovered from the water unharmed. With the flight of MR-4, the Space Task Group decided to retire the Mercury-Redstone combination as all objectives had been met even with the loss of *Liberty Bell 7.*

With Mercury-Redstone retired, the United States was left with no active human-rated launch system. Mercury-Atlas was the next logical step but was still in testing and had not proven its reliability for human use. The last Mercury-Atlas launch, MA-3 was had failed minutes into flight. The next mission, MA-4, was launch on September 13, 1961, less than two months after Grissom's *Liberty Bell 7* flight. It also carried a mechanical astronaut and successfully achieved orbit. [135] A Mercury capsule had finally achieved orbital velocity. The capsule splashdown after a nearly perfect flight and was recovered successfully.[136] MA-5 followed on November 29 and carried a Chimpanzee named "Enos."[137] The flight of the primate was a point of contention for some with NASA. It was believed by some that the flight was unnecessary after the success of MA-4.[138] Nevertheless, a final test flight of Mercury-Atlas with Enos on board was launched and splashed down after a successful flight. Enos was recovered in excellent condition. The minor anomalies experienced during flight could have been resolved if a

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[135] James M. Grimwood, "Part III (A) Operational Phase of Project Mercury: May 5, 1961 through May 1962" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[136] Ibid.

[137] Ibid.

[138] Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "Man or Chimpanzee for MA-5?" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

human astronaut had been in the place of Enos, so the Mercury-Atlas was human-rated for spaceflight.[139]

The two Mercury-Atlas test flights proved that the system was ready to ferry astronauts to space and return them safely to the Earth. The same day as the MA-5, John Glenn was selected as the astronaut to become the first American to orbit the Earth with Scott Carpenter as his backup.[140] On February 20, 1962 John Glenn sat atop an Atlas booster inside of the Mercury capsule he called “Friendship 7.” After launch, Glenn successfully made three orbits around the earth. During the flight, the astronaut faced to malfunctions. The first forced Glenn to take manual control of the craft after a control jet clogged. The second anomaly was eventually discovered to be an indication error rather than an actual mechanical malfunction. A short in the capsule controls caused a signal which indicated that the heat shield had been loosened prematurely, causing great stress for both Glenn and ground control. As a solution, it was decided to keep the retropack attached to the bottom of the heat shield to hold it in place during reentry. Later investigation of the capsule revealed that the solution was unnecessary.[141] After experiencing weightlessness for over four hours, Glenn was returned to Earth and recovered successfully.[142] The United States had finally matched the technological feats of the Soviet Union by placing Astronaut John Glenn in orbit.

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[139] James M. Grimwood, “Part III (A) Operational Phase of Project Mercury: May 5, 1961 through May 1962” in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[140] James M. Grimwood, “Part III (A) Operational Phase of Project Mercury: May 5, 1961 through May 1962” in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

[141] Ibid.

[142] Ibid.

Astronauts Alan Shepard, Gus Grissom, and John Glenn had all earned their astronaut wings from the Mercury flights. Donald "Deke" Slayton was slotted to pilot the next Mercury-Atlas mission, MA-7. After Glenn's flight, NASA announced that Scott Carpenter would fly in Slayton's place on the next orbital mission. Slayton had a minor heart defect that hadn't affected his screening or training to this point. As stakes in spaceflight continued to rise, the concern over this defect resurfaced and, after consultation with several cardiologists and physicians, Slayton was grounded.[143] Instead of Slayton's backup, Walter Schirra, taking his place, it was decided that Glenn's backup, Scott Carpenter, should pilot MA-7. On May 24, Carpenter was launched into orbit, returned, and recovered successfully.[144] Only minor anomalies occurred which did not affect the success of the flight. Walter Schirra had to wait over four months for his orbital flight, MA-8. He flew a nearly perfect 9-hour, 13-minute flight and was returned and recovered safely.[145] The final Mercury-Atlas flight took place on May 15-16, 1963. MA-9 was piloted by Astronaut Gordon Cooper and was the longest American spaceflight to date. The flight completed 22 orbits, as scheduled, and lasted over 34 hours.[146] Besides its longevity, it was a mostly unremarkable flight until a gravity indicator signaled that the telemetry of the craft might be less than nominal. Even though it was proven to be a false alarm, it was decided that Cooper should execute a manual reentry. He splashed down and was recovered off the coast of Japan.[147]

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143 Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, "The Slayton Case" in *This New Ocean: A History of Project Mercury*, SP-4201 (Washington, D.C.: National Aeronautics and Space Administration, 1989).

144 James M. Grimwood, "Part III (A) Operational Phase of Project Mercury: May 5, 1961 through May 1962" in *Project Mercury: A Chronology,* SP-4001 (Washington, D.C.: National Aeronautics and Space Administration, 1963).

145 Ibid., "Part III (B) Operational Phase of Project Mercury: June 1962 through June 12, 1963"

146 Ibid.

147 Ibid.

Cooper's flight brought an end to the Mercury-Atlas program. The United States did not enter the Space Race to simply match the Soviet feats. NASA intended to surpass the achievements of the Soviet Union and Project Mercury was the first step taken to do so.

Conclusion

A mere twenty days after Astronaut Alan Shepard's suborbital launch, President John F. Kennedy addressed a joint session of Congress. In the May 25, 1961 speech, he moved the goalposts of the Space Race in which the United States had been repeatedly one-upped by its Soviet adversary. He put forth a commission for the United States to "commit itself to achieving the goal, before [the 1960s were] out, of landing a man on the moon and returning him safely to the earth."[148] When the president made this commitment public, NASA, along with its astronauts and engineers, had only sent a man up out of the atmosphere and back down again on a fifteen-minute flight. NASA was still months out from sending a single man into orbit and the agency itself was only 32 months old. Not only had the president given an infantile organization a monumental, unprecedented task, but he had given it a deadline to complete it. Work had already commenced on NASA's next program, Project Gemini, which would build off Project Mercury's success.

The Gemini program is most often recognized as NASA's first steps toward the Moon because of its launches taking place after President Kennedy's speeches to Congress and at Rice University. Multi-manned missions and orbital rendezvous, which were deemed necessary for lunar attempts, were the objectives of its launches. Astronauts like Neil Armstrong and Buzz

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[148] John F. Kennedy Presidential Library. "Address to Joint Session of Congress May 25, 1961," Historic Speeches, May 25, 1961.

Aldrin got their astronaut wings during Gemini. It is no wonder that it is more closely associated with the success of the Moon program rather than Mercury. Project Mercury's conclusion in 1963 sealed NASA's first manned space program as a success in the eyes of the American people and the world. This allowed for continued public support which was necessary for funding from Congress. The United States had essentially matched the rudimentary first leaps into space that the Soviets had accomplished. Now that the United States had caught up, it could now surpass its opponent. It also proved that the new NASA could function effectively to produce flight-ready hardware and capable astronaut personnel. All these factors produced a NASA that was ready to take on Project Gemini. Even with the great strides that came with its second program, throughlines from NASA's creation, its early administrative organization, and Project Mercury can all be found in Project Apollo, the program which placed boots on the Moon.

Chapter 4: "All-Up" for Apollo

On July 16, 1969, the sun rose over Cape Canaveral, Florida to illuminate a towering Saturn V rocket perched on the LC-39A launch pad at Kennedy Space Center. It was not the first time that a Saturn launch vehicle had been prepared for launch at the site to carry humans into space. On this morning, however, the mission profile for the payload atop the behemoth rocket contained plans for a lunar surface landing. That morning, the Apollo Command and Service Module, Lunar Excursion Module, and astronauts Neil Armstrong, Edwin "Buzz" Aldrin, and Michael Collings were launched into orbit as their Saturn V launch vehicle thundered underneath them. The success of this launch required millions of components to function in symphony.

In hindsight, there were some aspects of Mercury development that would have slowed the progress that allowed for a Moon mission before the decade was out. As was the tendency of engineers, the tedious rocket scientists spent countless hours testing and retesting rocket subsystems attempting to reach perfection. Fortunately, before the method slowed the timeline past the deadline of 1970, George E. Mueller, director of NASA's Office of Manned Space Flight, successfully changed the method of operation for NASA engineers. He proposed an "all-up" method of moving forward, testing rocket components as part of making leaps in manned spaceflight.[149] The correction was made early enough to impact Gemini and Apollo development and accomplish the task on time. This was one of the major administrative shifts seen in the 1960s at NASA. Practicing the development of manned spaceflight in Project Mercury exposed the need for a shift in perspective on testing, thus further emphasizing the importance of the

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[149] Roger D. Launius, *Apollo's Legacy: Perspectives on the Moon Landings* (Washington, D.C.: Smithsonian Books, 2019), 30.

Mercury program. The foundation of NASA, the contributions of its predecessor organizations, and the success of Project Mercury created an agency that made the Apollo missions possible.

The Saturn Launch Vehicle

Work on what became the Saturn launch vehicle began long before President Kennedy's charge to send a man to the Moon and return him safely to the Earth. The Army Ballistic Missile Agency's (ABMA) repeated history of being overlooked and called upon thereafter prompted the agency to look forward into the future to avoid the same story taking place again. After initially losing the bid to provide thrust for America's first satellite, the ABMA set their sights on producing an advanced booster, larger than any platform that had previously been envisioned. The plan was to leapfrog the Army's rivals, the Air Force and Navy, and become the leader in advanced rocketry. The launch system could be used for placing weather and defense satellites into orbit as well as other space exploration endeavors. This context provides the genesis of the Saturn booster development, then referred to as "the Super-Jupiter," a name that implies the intent to build off of previous Army rocket development programs.[150]

NASA's formation in 1958 began the culmination and coordination of the nation's spaceflight capabilities. This included almost every major spaceflight entity in the nation except Wernher von Braun's ABMA team. When the ABMA began research into the viability of a large booster like Saturn in April 1957, it was not considered that a project of that scale would ultimately lead to their absorption by NASA in 1960.[151] The Department of Defense (DOD), in

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[150] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 25.

viewing the work on a large booster by the ABMA, could not see a practical use of a rocket of that size for military purposes. When the Advanced Research Projects Agency (ARPA) requested additional funds to finance the Super-Jupiter program, Herbert York, the Director of Research and Engineering at the DOD, sent a memorandum in June 1959 outlining the cancellation of the project stating, "…there is no military justification."[152] This announcement was met with great disappointment at the ABMA which had just received its first delivery of engines for testing.[153]

Wernher von Braun, ever motivated by the urge to explore the cosmos rather than produced military hardware regardless of his past employments, greeted the memorandum with the same disappointment as his team. The ABMA, once reluctant to be placed under NASA's umbrella, became the subject of discussions to transfer it to NASA. York was not opposed to the idea of what became the Saturn rocket, but did not see a place for it within the Department of Defense. When deliberations began on the transfer of the ABMA, York advocated for the group and ensured that the Saturn project would continue to receive adequate funding under NASA.[154] As the ABMA found its new home, NASA received the large launch vehicle that would be needed to thrust the Apollo program's mission hardware. Development of the Saturn rocket continued under Wernher von Braun at Redstone Arsenal, Alabama. The facilities for spaceflight development at Redstone Arsenal became known as the George C. Marshall Space Flight Center

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[151]Ivan D. Ertel and Mary Louis Morse, "The Key Events" in *The Apollo Spacecraft: A Chronology, Volume I, Through November 7, 1962* (Washington, D.C.: National Aeronautics and Space Administration, 1969).

[152] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 39.

[153] Ibid.

[154] Ibid.

(MSFC) and von Braun was named as its director.[155] It was under NASA's management that von Braun was able to reach his dream of designing rockets solely to explore space. The Saturn rocket was the first propulsion hardware to be produced solely for exploration rather than hauling military payloads, a contrast from the Redstone, Atlas, and Titan launch systems.[156]

As the ABMA and its Saturn project were being transferred to NASA, a committee led by NACA engineer and Mercury program leader Abe Silverstein convened in conjunction with the Department of Defense to plan for the future of the booster.[157] There seemed to be a place for it within NASA, but it was not exactly clear what its use case would be. The Silverstein Committee, as it became known, concluded that there were three use cases for the Saturn rocket to fill: (1) lunar and deep-space missions with payloads of 9,900 lbs., (2) placing 4,950 lbs. payloads into geostationary orbits, and (3) placing humans into orbit with the Air Force's Dyna-Soar spaceplane program.[158] While these were not exactly what the launch platform would eventually be used for, its mission profiles began to more closely resemble those which took place during Apollo. In order to accomplish these tasks, other technological standards were set by the Silverstein Committee which included fuel uses and scalability requirements for future growth and mission profiles.

The excitement behind the Saturn launch vehicle developed into confusion surrounding the different variants of the rocket system. Five different variants, each capable of offering a

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155 Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 42.

156 Ray A. Williamson, "The Biggest of Them All: Reconsidering the Saturn V" in *To Reach the High Fronter: A History of U.S. Launch Vehicles*, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 302.

157 Ibid., 303.

158 Ibid.

specific mission profile, were developed and named C-1 through C-5.[159] A lunar mission was one of the mission profiles considered, but President Kennedy had not yet given his charge for a Moon mission. There was not a clear objective decided upon by NASA for the use case of Saturn. After the agency began receiving criticism regarding its plan for Saturn, NASA Deputy Administrator Hugh Dryden responded by endorsing the C-5 variant that most closely resembled what would become the Saturn V.[160] Once President Kennedy set the course for U.S. space efforts for the rest of the decade, NASA was able to reduce down its plans for the Saturn program to directly support the lunar landing by 1970. This resulted in C-1 and C-1B becoming the Saturn I and IB, respectively, and C-5 becoming the Saturn V. The Saturn I and IB vehicles were smaller, two-stage rockets that could be used for parts testing within low-Earth orbit while the Saturn V could be used for taking humans to the lunar surface. The 1963 settlement on the future of Saturn brought greater clarity to Saturn's use cases for NASA.[161]

By this time, Project Mercury had concluded and Gemini launches commenced. In the background of the Gemini missions that increased astronaut capabilities and proved orbital rendezvous viable, testing and development of the Saturn rockets proceeded. The Saturn I primarily served as a test bed for the new system. The sheer size and diameter of the rocket was larger than any team in the United States had previously undertaken. Saturn I consisted of familiar fuel tank technology as it was composed of eight Redstone tanks clustered with a tank from the Army Jupiter missile. This demonstrates the scale of the rocket compared to that of Alan Shepard's Mercury-Redstone rocket. The fuel from the tanks powered eight H-1 rockets

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[159] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 58.

[160]Ibid.

[161] Ibid., 60

manufactured by Rocketdyne.[162] Saturn I was never intended to carry humans to space but did earn NASA experience with large rocket boosters. It was also used to loft the first boilerplate Apollo spacecraft as well as satellites that conducted experiments on meteoroids and the near-Earth environment.[163] A flight test of an S-IV second stage that was similar to the S-IVB third stage rocket found on the Moon missions was also conducted using a Saturn I.

Saturn I was succeeded by its descendant, the Saturn IB. Unlike its predecessor, the Saturn IB was planned to be rated for manned spaceflight. After three unmanned flights in 1966 that tested the rocket's viability and compatibility with the S-IVB upper stage, it was decided by NASA that the rocket had proven itself to be astronaut-ready. The Saturn IB's first opportunity to ferry astronauts came in early 1967. During a preflight rehearsal on January 27, 1967, astronauts Gus Grissom, Ed White, and Roger Chaffee were killed when a fire erupted in the Apollo command module atop the Saturn IB. The fire resulted, not due to a failure of the Saturn rocket, but faulty wiring in the command module. As NASA reeled to address the issue that resulted in its first astronaut deaths, the Saturn IB was left to wait for another opportunity to prove itself capable of transporting astronauts to orbit. In the meantime, it was used to ferry an unmanned lunar landing module to low-Earth orbit for testing in January 1968.[164] In October of the same year, over 20 months after the *Apollo 1* failure resulting in loss of life, Saturn IB provided thrust for the manned *Apollo 7* mission which demonstrated the Apollo Command and Service Module's (CSM) abilities to sustain life and rendezvous with other spacecraft. *Apollo 7*

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[162] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 98.

[163] Ray A. Williamson, "The Biggest of Them All: Reconsidering the Saturn V" in *To Reach the High Fronter: A History of U.S. Launch Vehicles*, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 306.

[164] Ibid., 311.

was the final Saturn IB launch before the mighty Saturn V would take its place and ultimately ferry astronauts to the Moon. After the conclusion of the final lunar mission, Saturn IB was called back into service to deliver crews to Skylab and a final Apollo capsule in 1975 that rendezvoused with a Soviet Soyuz capsule in the monumental Apollo-Soyuz Test Project.[165] 14 years after Alan Shepard's Mercury Redstone spaceflight, Redstone fuel tanks were still transporting hardware and astronauts into space on Saturn IB rockets.

The first Saturn V launch took place on November 9, 1967.[166] It was an unmanned test of the entire rocket system which aligned with the "all-up" method of development and testing. Half of the rocket's stages, the S-IC and S-II stages, had never flown prior to the mission. The rocket delivered a CSM to the Moon's orbit and demonstrated the heat shield's ability to withstand reentry from lunar velocity as well as other necessary functions. It, along with *Apollo 6*, were the final flights that gave the Saturn V its rating for human spaceflight. Ten Saturn V launches contained human astronauts on board during its lifespan, including the monumental *Apollo 11* first lunar landing and the *Apollo 13* "successful failure." The final Saturn V transported the Skylab Orbital Workshop into orbit on May 14, 1973.[167]

The Saturn V rocket performed almost flawlessly for its entire service life. There were occasional engine shutdowns and the infamous *Apollo 12* lightning strike which affected CSM instrumentation, but the safety systems of the vehicle performed as designed and the missions were not disrupted. During the *Apollo 13* catastrophe, the Saturn V lost a second stage engine but the remaining four functional engines were able to compensate by burning longer, following the

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[165] Ray A. Williamson, "The Biggest of Them All: Reconsidering the Saturn V" in *To Reach the High Fronter: A History of U.S. Launch Vehicles*, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 312.

[166] Ibid., 320.

[167] Ibid., 321.

Saturn design. The impending failures that resulted in fear of losing the crew were cause by oxygen tank problems within the CSM once it had separated from the Saturn launch vehicle. Reflecting on the 14 years of Saturn launches, Wernher von Braun and his ABMA team that became NASA's Marshall Space Flight Center delivered a superb rocket system for Apollo. The team built upon technologies developed for the Mercury-Redstone combination as they were tried and true components for the early Saturn I and IB rockets. Their tradition of conservative research and development methods that was founded in the years preceding NASA proved highly effective for building Moon rockets.

The Apollo Command and Service Module

When Astronaut Alan Shepard made his first suborbital flight on May 5, 1961, the Space Task Group (STG) at Langley completed the first draft of the specification for the Apollo spacecraft.[168] Planning had begun on a multi-man advanced crew vehicle a year prior within the STG along with the development and testing of larger rocket engines such as the H-1, J-2, and F-1, all which eventually became propulsion components on the Saturn rockets. A crudely drawn sketch by a Langley Research Center engineer done on May 3 shows the outline of a larger reentry vehicle similar to the conic shape of Shepard's Mercury capsule.[169] Drawn eight years prior to the launch of *Apollo 11*, the sketch demonstrates the same basic components that were present on the Armstrong/Aldrin/Collins spaceflight. It shows a reentry vehicle, lander, and service module all docked together, though not in the order which actually came into fruition.

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[168] Ivan D. Ertel and Mary Louis Morse, "The Key Events" in *The Apollo Spacecraft: A Chronology, Volume I, Through November 7, 1962* (Washington, D.C.: National Aeronautics and Space Administration, 1969).

[169] Ibid., "May 2."

The General Electric Company, the Convair Astronautics Division of General Dynamics, and The Martin Company all returned reports on the feasibility of the proposed spacecraft by May 17.[170] NASA took the results from the reports and developed a second draft which further outlined the vehicle's proposed capabilities and viability. The Martin designs most closely followed the mission guidelines provided by NASA and was selected as the method of operation moving forward.[171] Within a week after the reports were turned in by the respective aerospace manufacturers, President Kennedy delivered his address to Congress declaring that the nation should commit itself to the Moon mission. Even though work had already begun on a lunar mission, the charge by the president and the deadline that was placed on the program energized efforts to accomplish the task. In the following months, every aspect of spaceflight development centered around the United States' ability to reach the Moon and return safely to the Earth.

On July 28, 1961, NASA invited twelve aerospace manufacturers to submit proposals to become the prime contractor on the Apollo command and service module.[172] Under the prime contractor's responsibilities in designing the spacecraft were the command module, the service module, and the adapter that would connect the two modules and detach them before reentry of the command module.[173] On the due date of October 9, 1961, five aerospace companies returned their proposals to NASA for review. The Martin Company made the top of the list which was no

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170 Ivan D. Ertel and Mary Louis Morse, "May 15-17" in *The Apollo Spacecraft: A Chronology, Volume I, Through November 7, 1962* (Washington, D.C.: National Aeronautics and Space Administration, 1969).

171 Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A Hsitory of manned Lunar Spacecraft,* SP-4205 (Washington, D.C.: National Aeronautics and Space Administration, 1979), 28.

172 Ivan D. Ertel and Mary Louis Morse, "July 28" in *The Apollo Spacecraft: A Chronology, Volume I, Through November 7, 1962* (Washington, D.C.: National Aeronautics and Space Administration, 1969).

173 Ibid.

surprise since they had provided NASA with the best preliminary research on the feasibility of an Apollo-type spacecraft. NASA selected General Dynamics and North American Aviation for their second tier of candidates for developing and manufacturing the Apollo CSM. Finally, the third round of manufacturers preferred for development included General Electric and McDonnell Aircraft Corporation.[174] Most surprising from these results is the grading of the McDonnell Corporation in the lowest tier. The St. Louis-based company had produced the Mercury capsule that fit NASA's needs superbly and, for that reason, was selected later on to produce the two-manned capsule for Project Gemini. Another surprising event in the collection of proposals, was the selection of North American Aviation as the prime contractor for the Apollo craft in spite of The Martin Company's high ranking. Their proposal was selected for cost effectiveness and their long record of effectively working with the NACA and NASA.[175]

As the form for the Apollo spacecraft was being set and the prime contractor had been selected, a debate on the most effective method for reaching the Moon continued between various departments within NASA. The design specifications of the Apollo spacecraft would depend on what method was decided on and President Kennedy's announcement only put more pressure on the decision-making timeline. One method proposed a direct-ascent profile. This required a large lander that would also serve as the reentry vehicle. The craft would launch from Earth and fly directly toward the surface of the Moon and land. Once the extravehicular excursions were complete, the craft would launch from the Moon's surface and return to the Earth. This was a relatively simple plan but required greater lift capacity and more fuel

[174] Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A Hsitory of manned Lunar Spacecraft,* SP-4205 (Washington, D.C.: National Aeronautics and Space Administration, 1979), 43.

[175] Ibid., 44

throughout the mission because the craft would carry all necessary components throughout the mission's entirety. The other viable mission profile required a two-part vehicle to park itself in orbit around the Moon. To reach the lunar surface, the lander portion of the vehicle would separate itself from the command module and descend toward the Moon. The command module would continue to circle the Moon. Once extravehicular excursions were complete on the surface, the astronauts would launch back to the orbiting command module, redock, and return to the Earth in the command module which also served as the reentry vehicle. In order to make the decision, NASA was required to consider technologies for each that did not even exist yet. The rocket engines that would eventually accomplish the task were still in development and there had yet to be a successful launch of an American astronaut.

Regardless of the opinions of Werner von Braun and the engineers of the Jet Propulsion Laboratory (JPL), NASA ultimately decided upon the lunar-orbit rendezvous profile. The primary problem with the direct-ascent method of reaching the Moon was that it required a larger lift vehicle than what was currently being planned in the Saturn project. There were plans to build a larger booster system called "Nova" that would have been capable of lofting a hybrid lander-reentry vehicle, but these were abandoned due to time constraints that resulted from President Kennedy's lunar surface landing deadline of 1970.[176] Saturn was considerably further along in development than Nova. The time saved by continuing with Saturn and addressing the orbital rendezvous questions later made up for the time it would have taken to compensate for Nova's design immaturity.

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[176] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 60.

When the decision was made in July 1962 to continue plans centered around the lunar-orbit rendezvous method, the United States had just established their ability to achieve orbit around the Earth five months earlier in the February 1962 John Glenn spaceflight.[177] The first Earth-orbital rendezvous was still over three years away, but NASA officials continued with their support of the plan anticipating that the agency would establish the required capabilities in time. Fortunately, orbital rendezvous and docking capabilities were proven in the *Gemini 6, 7,* and *8* missions.[178] *Gemini 6* proved that two spacecraft could launch at separate times, match their orbits, and creep within 12 inches of one another, all the while flying at orbital velocities. The *Gemini 6* capsule was maneuvered into place next to the *Gemini 7* capsule by Mercury Seven astronaut, Walter Schirra.[179] Only three months later, Astronaut Neil Armstrong docked his Gemini craft to an Agena target vehicle proving that two separate spacecraft could be linked together successfully in orbit. Both capabilities were required for the proposed mission profile of the Apollo lunar missions.

Full scale work on the design and development of the Apollo craft began at North American Aviation in 1962. Because design of the Saturn launch vehicle that the CSM would be mated to hadn't reached full maturity itself, great flexibility was required of the team assigned to the command module in Downey, California. The Apollo contract was not North American's first experience with designing manned space vehicles, even though the company had lost the bid to build the Mercury capsule years earlier to McDonnell. Prior to Mercury, the Downey,

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[177] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles,* SP-4206 (Washington, D.C.: National Aeronautics and Space Administration, 1980), 60.

[178] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019), 130.

[179] Ibid.

California company contracted with the Air Force to work with General Electric during the "Man-in-Space-Soonest" initiative.[180] Although they had some experience with government space contracting, the Apollo contract was the first of their aerospace contracts to produce hardware capable of manned spaceflight. Another subsidiary of North American Aviation, Rocketdyne, was contracted to build the S-II second stage of the Saturn V. As a result of the increase in space contracts, the relevant division of North American doubled their payroll from 7,000 employees to over 14,000 in 1962 alone.[181] Prior to producing flight-ready modules, the company was tasked with producing test articles and mock-ups. One engineer reported that the shop had produced six test vehicles and two mockups for aerodynamic and flight testing.[182] Structural components, heat-shielding, and radiation protection adopted many of the technologies that were simultaneously being proven during Project Mercury, but further testing was required because of the need to scale up size and forces to meet the necessities of the Apollo missions.

Particularly relevant to the design of the Apollo command modules was the guidance systems used to navigate the craft. This was especially important because the reentry phase of the spaceflight after visiting the Moon was one of highest-risk portions of the mission. North American Aviation sought answers to these concerns from a joint meeting between the Massachusetts Institute of Technology (MIT) and Ames Research Center of Sunnyvale, California. Ames was the NACA facility which faced congressional opposition during its proposal prior to World War Two. It provided data proving a capsule like those used in the Mercury and Apollo programs could be piloted through reentry. Other Apollo research studies

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180 Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A Hsitory of manned Lunar Spacecraft,* SP-4205 (Washington, D.C.: National Aeronautics and Space Administration, 1979), 88-89.

181 Ibid., 89.

182 Ibid.

and management of the Apollo Spacecraft Project were conducted at Langley Research Center, the first NACA facility established. For communications, the Apollo craft would make use of the global tracking stations that were built for Mercury's orbital flights. The stations, with their 9-meter dishes, were retrofitted with S-band radar which provided more precise data.[183]

The Apollo Astronauts

After the original Mercury Seven were selected in 1959 to serve as the United States' first astronauts, NASA graduated classes based on the needs of the agency and its future spaceflights. Between the Mercury Seven and the first Apollo Moon landing, five astronaut classes were graduated into the program to supplement the original seven. The tradition of selecting from the nation's military aviators continued throughout most of the first astronaut classes. All but one of the Apollo astronauts possessed a military background in at least some capacity, most often as a test pilot. For the last Apollo Moon mission, Harrison "Jack" Schmitt, a Harvard-schooled geologist, was slotted to study the Moon's composition.[184] The mold cast for astronauts during the Mercury astronaut selection process was carried through the first decades of the American space program. Nevertheless, NASA ensured that all astronauts aboard a spacecraft could perform as productive members of the flight crew even as mission agendas became more centered around scientific research rather than solely exploration.[185]

[183] Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A Hsitory of manned Lunar Spacecraft,* SP-4205 (Washington, D.C.: National Aeronautics and Space Administration, 1979), 123.

[184] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019), 189.

[185] Ibid.

Only one of the original Mercury Seven astronauts flew on a Moon-bound Apollo craft. The first Mercury astronaut to achieve spaceflight, Alan Shepard, served as the commander on *Apollo 14*. He had been grounded for medical reasons and was unable to participate in Gemini flights since his *Freedom 7* flight in 1961.[186] Fortunately, Shepard had become Chief of the Astronaut Office at NASA in the meantime which kept him around until his medical restrictions were lifted. When he was eligible for spaceflight once again, he replaced fellow Mercury Seven astronaut, Gordon Cooper, as the *Apollo 14* commander. Almost ten years after becoming the first American in space, Astronaut Shepard set foot on the lunar surface, an event which demonstrated how far the United States had come from their first hops in Project Mercury.

Two other Mercury Seven astronauts found themselves on missions in Apollo spacecraft although their missions did not leave Earth orbit. Walter Schirra served as the commander on *Apollo 7* prior to the Apollo 11 Moon mission. The smaller Saturn1B launched on October 11, 1968 and maintained orbit around the Earth for eleven days.[187] *Apollo 7* was the first successful demonstration of the Apollo command and service modules that included a crew to check out craft capabilities and functionality before sending it to the Moon during *Apollo 8.* Prior to Schirra's Apollo spaceflight, he piloted the second-to-last Mercury flight, *Sigma 7*, in October 1962. Schirra also participated in the Gemini Program and commanded the *Gemini 6* mission making him the only astronaut to launch into space in a Mercury, Gemini, and Apollo spacecraft. The other Mercury Seven astronaut to experience spaceflight in an Apollo craft was Donald "Deke" Slayton. Slayton was never able to fly in either the Mercury or Gemini programs due to

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186 Roger D. Launius, "Heroes in a Vacuum: The Apollo Astronaut as Cultural Icon," *The Florida Historical Quarterly* 87, no.2 (Fall 2008): 197.

187 Ray A. Williamson, "The Biggest of Them All: Reconsidering the Saturn V" in *To Reach the High Fronter: A History of U.S. Launch Vehicles*, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 311.

an irregular heartbeat. In the meantime, he served as head of the Astronaut Office at NASA which handled training and selected crews for spaceflights. He had missed out on all opportunities to fly on an Apollo lunar mission, but his flight restrictions were lifted in 1972 after years of treatments and therapeutics. After years of helping other astronauts reach the dream of spaceflight that he was barred from, Slayton finally received his opportunity to receive his astronaut wings. He was assigned as the docking pilot on the Apollo-Soyuz Test Project which successfully mated an Apollo module with a Soviet Soyuz capsule. The mission did not have the lunar surface as its destination but was monumental in bringing a peaceful resolution to the Space Race.

Virgil "Gus" Grissom also possessed experience with flying both Mercury and Gemini capsules prior to the Apollo program. After piloting the *Liberty Bell 7* that was lost to the waves during recovery, Grissom went on to pilot the first orbital Gemini mission, *Gemini 3.* He was slotted to become the first astronaut to pilot all three command modules of NASA's first space programs but was a victim of the agency's first tragedy in the *Apollo 1* fire of January 27, 1967. He, along with Astronauts Ed White and Roger Chaffee, were killed when faulty wiring ignited the oxygen-rich cabin of the Apollo command module during a dress rehearsal of their Earth-orbital flight.[188] The ensuing investigation into the events and reevaluation of the craft led to a delay in lunar spaceflight activities, but most importantly, the nation realized the immense risks in achieving what no one had done before. Mercury Astronaut Grissom, Ed White, and Roger Chaffee, never achieved spaceflight in their Apollo command module. In Deke Slayton's 1994 memoir, the former Chief Astronaut in charge of selecting astronauts for missions claimed that

[188] Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A Hsitory of manned Lunar Spacecraft,* SP-4205 (Washington, D.C.: National Aeronautics and Space Administration, 1979), 215.

Gus Grissom would have been the first choice for sending a Mercury astronaut to the Moon. He even claimed that Grissom might have taken Astronaut Neil Armstrong's place as the first man to set foot on the Moon.[189]

Astronaut Neil Armstrong was not part of the first class of NASA astronauts, however, his background with NASA goes back farther than perhaps any other astronaut. He did have experience as an aviator in the U.S. Navy during the Korean War. After flying 78 combat missions, Armstrong became a test pilot with the NACA in 1952.[190] There he also served as an engineer and administrator at the Lewis Research Center in Ohio until the Committee formed the administrative shell for the new NASA in 1958. While the Mercury Seven astronauts were being selected, Armstrong was gaining more test pilot experience at NASA's Flight Research Center at Edwards Air Force Base in the California desert.[191] He graduated as part of NASA's second class of astronaut candidates and went on to pilot the *Gemini 8* mission which included the first docking of two orbital spacecraft, a crucial piece in the Apollo lunar mission profile.[192] When Armstrong became the first man to set foot on the Moon as mission commander of *Apollo 11,* he became a symbol, not just for humanity reaching past its Earthly home, but for the years of preparation and coordination between NASA, aviators from the military branches, and NASA's predecessor, the NACA.

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[189] Donald K. Slayton and Michael Cassutt, *Deke!: U.S. Manned Space from Mercury to the Shuttle* (New York: St. Martin's Press, 1994), 223.

[190] Roger D. Launius, "Heroes in a Vacuum: The Apollo Astronaut as Cultural Icon," *The Florida Historical Quarterly* 87, no.2 (Fall 2008): 199.

[191] Ibid.

[192] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race* (New Haven, CT: Yale University Press, 2019), 130.

Conclusion

The American lunar landing program began when NASA was implementing a shift in how it carried out its development and testing of hardware for spaceflight. Throughout the Apollo program, NASA continued a steady schedule of launches in both the Mercury and Gemini programs. For the first year of NASA's existence, the ABMA was developing its large rocket booster, Saturn, only to be absorbed into the space administration's management in 1960. Even though there was no use for a booster the size of Saturn for defense purposes, DOD officials include Herbert York found the proper place for Wernher von Braun, his team, and their work at the new NASA and ensured continued funding. The project that created the thrust engine for the lunar missions was adopted by the agency in time for it to be implemented into its plans and prior to President Kennedy's challenge. A change in name from ABMA to the Marshall Space Flight Center was the only major disruption for the important work being done by the Alabama team. Not only were they producing the thrust for the Apollo lunar missions but made history by developing and producing the first American hardware created solely for the exploration of the cosmos rather than defense. Because the booster was larger than any other ever conceived by the United States, the possibilities seemed endless for the launch system. This led to a collection of five different variants that could be used for different space missions. Once the president gave the nation the mission of putting men on the Moon, Saturn soon found its refined purpose and more relevant work began on creating a launch platform that was lunar capable.

The resulting design changes came just in time as the Mercury program was concluding and design work on the Apollo command module commenced. Data and experience from Mercury were used in conjunction with the capabilities of the Saturn IB and V rockets to create the outline for the Apollo command and service module design. Mercury capsule designer and manufacturer McDonnell Aircraft Corporation was rejected as the prime contractor for the Apollo craft but was kept busy with producing capsules for Project Gemini. The selected prime contractor, North American Aviation was not a newcomer to the space industry as they possessed experience working with NASA's predecessor organization, the NACA. As design problems were faced by aerospace contractors and NASA was forced to handle its first tragedy in the *Apollo 1* fire, von Braun's MSFC team provided consistent quality and reliable rockets for the program.

Finally, the Apollo program and the hardware produced for it would have been worthless if it weren't for the men which were placed in the seats of the command modules atop the boosters. It is in the astronaut personnel that one may see some of Apollo's greatest connections to the days prior to NASA and Project Mercury. While not all Mercury Seven astronauts were privileged enough to fly on Apollo missions, most served either as astronauts or in administrative roles at NASA. While not flying in Apollo craft, Mercury astronauts provided support to those that were in the capsules from their consoles at mission control or, in the case of Deke Slayton and Alan Shepard while they were grounded for medical reasons, as directors of the Astronaut Office at NASA. Arguably the most famous astronaut of all, Neil Armstrong originally began his story at the agency by serving as an engineer and test pilot for the NACA prior to NASA's creation. The Apollo Program married the work of the NACA, the military rocket programs, and Project Mercury with the appropriate personnel to attain its goal of a lunar landing.

Conclusion

Neil Armstrong's first steps on the Moon can still be seen by many as the pinnacle of human history to date. In the grand story of human history, the event will not likely be eclipsed until humans reach further into the cosmos to set foot on Mars or other celestial bodies. At first glance, the effort to reach the Moon first began only twelve years prior to the *Apollo 11* mission when the Soviets launched *Sputnik 1* into orbit. There is no doubt that the event sparked fear in Americans which incited the nation to strive for dominance in space. Fortunately, the groundwork for achieving that dominance had begun decades prior with the establishment of the National Advisory Committee for Aeronautics (NACA). When the Soviets launched the Sputnik satellite into orbit, the response of the U.S. government was to create an entity which could coordinate all spacefaring activities to achieve even greater feats.

The NACA was a product of the United States' stagnating aerospace industry during World War One.[193] When war broke out, it became apparent that the nation which introduced powered flight to the world in 1903 had forgotten its role in continuing the innovation of flight engineering. Due to savvy political maneuvering, the advisory agency was able to establish its first research laboratory, the Langley Aerodynamical Laboratory, in Virginia. In subsequent years leading up to and during World War Two, the NACA was able to establish its presence in four more locations around the nation. By the time that the NACA became the administrative shell for NASA in 1958, the agency was managing the Langley Center in Virginia, Ames Laboratory in Sunnyvale, California, the test flight center at Edwards Air Force Base, and yet another research laboratory in Ohio which was eventually named for astronaut John Glenn. These facilities and their respective scientists and engineers gained experience in flight research

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[193] Alex Roland, Model Research, SP-4103 (Washington, D.C.: National Aeronautics and Space Administration, 1985).

and development throughout the Second World War and were able to channel their work into achieving a lunar landing during the 1960s. Public support and corresponding funding supported the efforts especially after President Kennedy's public challenge to surpass Soviets' capabilities in space.

The military branches of the United States contributed their own work on rocket research and development to the new NASA in 1958. Prior to their absorption, each branch had paved its own path toward space exploration, or at least the use of space exploration technologies for defense purposes. Most notably, the Army's rocket program at the Army Ballistic Missile Agency (ABMA) was producing reliable rockets for use on the battlefield from the remnant of the German rocket program of World War Two. It was led by German rocket scientist Wernher von Braun and produced the Redstone booster that launched the first American into space, officially placing the United States in the Space Race. The Naval rocket program at the Naval Research Laboratory made its own improvements to the German rocket designs in a friendly attempt to compete with the Army team. The Naval rockets were usually favored by politicians and administrators even though the Army ended up usually providing thrust when the Navy engineers fell short or missed deadlines.[194] The young U.S. Air Force attempted to set itself apart from the other branches by producing more complex rockets than its Army and Navy counterparts. This effort, along with being so recently formed in the years after World War Two, set the Air Force back considerably behind its rivals. To address the setbacks, the Air Force pushed forward with creating a daring, highly technical orbital rocket, Atlas, that would power

[194] Matt Bille, Pat Jonson, 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 Vehicle, ed. Roger D. Launius and Dennis R. Jenkins (Lexington, KY: The University Press of Kentucky, 2002), 193.

astronaut John Glenn into orbit, a great feat that essentially caught up the United States to the Soviets at least temporarily. The backup plan for the Air Force's Atlas program was the larger Titan rocket family. While Atlas performed as designed, Titan went on to provide thrust for the Gemini missions. All the military rocket programs were eventually supported through the Advanced Research Projects Agency (ARPA). This agency was formed just prior to the creation of NASA and facilitated the transfer of the military branch programs to the new NASA in 1958.

The final pre-NASA entity that was transferred as a result of the National Aeronautics and Space Act of 1958 was the Jet Propulsion Laboratory near Pasadena, California. In the years prior World War Two, a group of rocket engineers from the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT) began conducting research and testing of small rockets near their university campus. While it began as an independent project, the success of the group eventually led to its official affiliation with the school which made it eligible for public funding. As their work became more popular and attracted attention from the defense sector, the name of the group was changed to the Jet Propulsion Laboratory (JPL). After great success producing aerospace equipment for the Army Air Corps, members of the academic research group began a private aerospace contracting company, Aerojet, which provided defense hardware to the military. JPL continued its experimental work in California and was deemed to be a valuable addition to NASA when it was formed years later. JPL and its research facilities found itself under the NASA umbrella with a new objective, helping to place Americans in space.

The National Aeronautics and Space Administration channeled work from the NACA and its research facilities, the JPL, and the work from the respective military branches to take its first steps into space with Project Mercury. During the Mercury program, the United States became acquainted with the problems of spaceflight. National excitement allowed resources to be allocated to place men in space. The relatively rudimentary missions of Mercury gave NASA and its first astronauts experience with achieving orbit, sustaining life in the vacuum of space, and withstanding orbital reentry. After all, President Kennedy's commission for a lunar mission required safe return of the astronauts that walked on the Moon. Gemini's missions became significantly more complex and answered questions directly related to the Apollo lunar mission profile. The success of Project Gemini would have been impossible, however, if it weren't for the data collected from the Mercury program. As the agency was still learning from the successes of Mercury, work was already beginning on building rocket boosters that were capable of taking humanity to the Moon. The work, specifically from Wernher von Braun's ABMA, created the mighty Saturn launch vehicle. Developments from both Mercury and Gemini were scaffolded to develop the Apollo command module.

Since the Apollo Moon landings, focus at NASA has shifted to scientific study of the Earth and low-Earth orbit. National priorities changed in the latter quarter of the twentieth century to solving problems within the United States and between its foreign neighbors. NASA, along with its international counterparts, developed a fleet of Space Shuttles which built the International Space Station. The orbital station has now seen two decades of continual inhabitance and is reaching its planned age of retirement. NASA is now looking to return astronauts to the surface of the Moon as a step to prepare even further exploration into solar system, eventually achieving flight to Mars. Just as space became a unifying venture for humankind during the time of the Cold War, humanity just might once again find solutions to some of its Earthly problems among the stars. Fortunately, much of the groundwork has already been completed. The creation of NASA from military assets and NACA, its early administrative personnel and structure, as well as its first steps in Project Mercury were foundational for the success achieved by Project Apollo. The amazing achievements of NASA could be a source of optimism for an increasingly gloomy outlook found in many places around the world. How can NASA, with its international partners, build upon the success of Mercury, Gemini, Apollo, the Space Shuttle program, and the International Space Station to bring about a Part II of energized space exploration? Exploration of the cosmos has the ability to give humanity something to be proud of. Instead of seeking to eclipse its Soviet adversary during the Cold War, the United States could once again lead the way in this endeavor to eclipse *itself* in the grand epic of human history. Just as it did during the Cold War, the world may find some solutions to its many problems along the way.

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