NASA/CR-2001-208928

Eyes on the Red Planet: Human Mars Mission Planning, 1952-1970

Annie Platoff
Lyndon B. Johnson Space Center
Houston, Texas 77058-3696

July 2001

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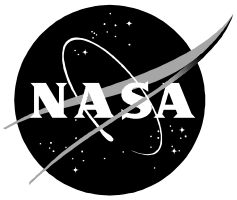

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PREFACE

Throughout the history of human space exploration, many major goals have been accomplished: humans have orbited our planet, humans have walked on the surface of the Moon, and several space stations have been maintained in Earth orbit. However, there is one major goal that has yet to be met – a human expedition to Mars. Prior to the creation of NASA in 1958, serious proposals were made on how to send humans to the Red Planet. Since its creation, NASA and its contractors have conducted a number of studies to examine the technological and human issues related to such a mission. Currently, at NASA Centers around the country, small technology test projects continue to lay the groundwork for a future human Mars mission. It seems almost inevitable that one day NASA will implement a full-scale effort for human Mars mission planning. When that time comes, the planners may want to reevaluate previous efforts and learn from them. It is for those future planners that this study has been conducted. This study uses major planning documents as a guide to present a history of human Mars mission planning from 1952 through early 1970.

In February 1990, I accepted a position as librarian for the New Initiatives Office (NIO) at NASA's Johnson Space Center (JSC). The previous July, President George H. W. Bush had used the occasion of the 20th anniversary of the Apollo 11 Moon landing to announce his vision for NASA – a return to the Moon and a human expedition to Mars. Bush's challenge was followed by NASA's response, the Report of the 90-Day Study on Human Exploration of the Moon and Mars. For 4 years, I supported the engineers, scientists, and mission planners of the NIO and of the Exploration Programs Office (ExPO) in their research to fulfill Bush's plan. I was surprised to learn that practical planning for the human exploration of the Red Planet predated the creation of NASA and that a number of studies had been conducted during the 1960s by NASA and its contractors. I also discovered that human missions to Mars have been included in practically all of NASA's long-term plans as a logical next step beyond the Earth-Moon system.

The story of Bush's Space Exploration Initiative did not have a happy ending for those who want to see humans on Mars. The program did not receive Congressional support or funding to achieve the President's goal. For many, the disbanding of ExPO in December 1992 and the elimination of NIO in March 1994 seemed to mean the death of the lunar/Mars program. However, NASA continued to include human Mars missions as a long-term goal in its strategic plans; and NASA Administrator Dan Goldin has challenged the human spaceflight community to find faster, cheaper, and better ways to place a human on Mars. In December 1996, members of the old ExPO team were reunited in a small Exploration Office as part of JSC's Engineering Directorate. It is for these "keepers of the flame" and for those who will continue the work to its conclusion that I have conducted this study. It represents the vast wealth of knowledge and ideas generated by predecessors in human Mars planning. It is hoped that it might serve as useful background for later projects in support of potential Mars missions that will carry humans.

This document was first published as a thesis for a Master of Arts degree at the University of Houston-Clear Lake in May 1999.

ACKNOWLEDGMENTS

The author wishes to thank Dr. Roger Bilstein and Dr. Peter Bishop for their guidance with this project. Gratitude is also expressed to the scientists and engineers from JSC who encouraged me to conduct this study, especially David Weaver, Eileen Stansbery, and Kent Joosten. Special thanks are given to NASA personnel and retirees who participated in oral history interviews and gave me background on the Space Exploration Initiative -- John Aaron, Jeff Bingham, Doug Cooke, Lyn Gordon-Winkler, Bill Huffstetler, Hum Mandell, and Doug Peterson. Thanks also to the staff of the former JSC History Office – Janet Kovacevich, Joey Kuhlman, and David Portree – for providing guidance and for preserving the documentation vital to this study. In addition, the author wishes to thank the staff of the JSC Scientific and Technical Information Center, particularly Janine Curnow Bolton, Laurie Caballero, and Sylvia Hu. Thanks also go to Roger D. Launius and Terese Ohnsorg who provided access to the piloted Mars mission files located in the NASA Headquarters History Office. Above all, the author wishes to acknowledge the patience and computer support provided by Michael Platoff.

ABSTRACT

The history of human Mars mission planning from the early 1950s through the 1960s is examined. For centuries, Mars has been an object of fascination and, since the 1800s, science-fiction authors have imagined what it would be like for humans to travel to that planet. Space enthusiasts have shared this dream and as early as the 1950s were presenting feasible proposals for human missions to Mars. Since the creation of NASA, the Agency has maintained the idea of human Mars missions as an important long-term goal. Throughout its history, NASA has conducted studies aimed at landing an astronaut on Mars. NASA's current strategic plan still includes this goal. Therefore, it is important to look at previous planning efforts to see what work has been accomplished and to discover lessons that future planners can apply to their programs.

CONTENTS

GLOSSARY

90-Day Study. A study conducted by NASA in response to President George H. W. Bush's 1989 announcement that NASA should return to the Moon and continue on to Mars.

Augustine Committee. The Advisory Committee on the Future of the U.S. Space Program, an independent review board chaired by Norman Augustine, chairman of Motorola.

Exploration. Although this term aptly can be applied to all robotic and human activities in space, for the purpose of this study it will be used in the more typical NASA usage to describe human exploration of the Moon and Mars.

Fiscal Year. The 12-month period covered by a single budget cycle. The federal fiscal year begins on October 1 of each year.

Human Exploration Initiative. See Space Exploration Initiative.

Purcell Panel. A panel of the President's Science Advisory Council established in 1958 to make recommendations on the outlines of a space program and an organization to manage it The panel was chaired by Nobel laureate Edward M. Purcell.

Space Act. National Aeronautics and Space Act, the legislation authorizing the creation of NASA.

Space Exploration Initiative. The program to return to the Moon and continue on to Mars introduced by President George H. W. Bush on July 20, 1989, the 20th anniversary of the Apollo 11 Moon landing. Originally called the Human Exploration Initiative.

Space Task Group. NASA group established in 1958 to develop and implement the human spaceflight program. In November 1961 the Space Task Group ceased to exist; its mission and personnel were transferred to the new Manned Spacecraft Center in Houston, Texas.

Space Task Group (1969). Independent group chaired by Vice President Spiro T. Agnew and charged with determining the direction for the post-Apollo space program.

Synthesis Group. An independent panel established in May 1990 to study ideas for the Space Exploration Initiative. The panel was chaired by astronaut Thomas Stafford.

Townes Task Force. A task force established by President-elect Richard M. Nixon to provide advice on the post-Apollo space program.

ACRONYMS

AAP	Apollo Applications Program
AAS	American Astronomical Society
ABMA	Army Ballistic Missile Agency
AIAA	American Institute of Aeronautics and Astronautics
ARC	NASA Ames Research Center (Moffett Field, California)
ARPA	Advanced Research Project Agency (Department of Defense)
BIS	British Interplanetary Society
DOD	Department of Defense
EEM	Earth entry module
EMPIRE	Early Manned Planetary-Interplanetary Roundtrip Expedition (NASA studies conducted in the early 1960s)
EVA	extravehicular activity
ExPO	Exploration Programs Office (located at JSC, Houston, Texas)
HEI	Human Exploration Initiative; later called the Space Exploration Initiative
IGY	International Geophysical Year
JAG	Joint Action Group
JSC	NASA Lyndon B. Johnson Space Center (Houston, Texas); formerly called the Manned Spacecraft Center
LaRC	NASA Langley Research Center (Hampton, Virginia)
LeRC	NASA Lewis Research Center (Cleveland, Ohio); currently called the Glenn Research Center
LLNL	Lawrence Livermore National Laboratory (Department of Energy)
LM	lunar module
MEM	Mars excursion module
MMM	Mars mission module
MSC	NASA Manned Spacecraft Center (Houston, Texas); currently called the Lyndon B. Johnson Space Center
MSFC	NASA Marshall Space Flight Center (Huntsville, Alabama)
MSSR	Mars surface sample return
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NASA HQ	NASA Headquarters (Washington, D.C.)

NDEA	National Defense Education Act
NERVA	nuclear engine for rocket vehicle application
NIO	New Initiatives Office (NASA JSC)
OART	Office of Advanced Research and Technology (NASA HQ)
OMSF	Office of Manned Space Flight (NASA HQ)
OSSA	Office of Space Science and Applications (NASA HQ)
PDP	project development plan
PSAC	President's Science Advisory Committee
PSG	planning steering group
RFP	request for proposal
SEI	Space Exploration Initiative
STAC	Science and Technology Advisory Committee (NASA)
STG	Space Task Group
UMPIRE	While not a true acronym, this term refers to a set of EMPIRE follow-on studies which examined human Mars missions during the unfavorable period, 1975-1985
USGPO	United States Government Printing Office

CHAPTER 1

FASCINATION WITH MARS

Astronomy of Mars

Since early in human history, the planet Mars has been an object of fascination. Earthbound observers noticed that, unlike the stars, the planets did not keep fixed positions relative to the constellations and that, unlike the other planets, Mars had a distinctive reddish color. Even before the invention of the telescope, astronomers contributed a great deal to the science based upon their observations of Mars. Tycho Brahe, a late 16th-century Danish astronomer, made precise measurements of the planet's position over a 35-year period using instruments that he had constructed himself. Though these measurements could not be reconciled with the then-accepted circular orbits of the planets, Brahe's observations contributed a great deal to Johannes Kepler's work in the area of planetary motion. Kepler, a German astronomer, published his findings in 1609 and noted that "Mars alone enables us to penetrate the secrets of astronomy which would otherwise remain hidden from us." The invention of the telescope around 1610 allowed more detailed examination of the planet. Although it is uncertain whether Kepler or Galileo Galilei, an Italian astronomer, was the first to use a telescope to view Mars, Galileo is known to have studied the planet using the instrument. The first drawings of the Martian surface were made by another Italian, Francisco Fontana, in 1638. However, the telescopes in Fontana's time were still too crude to make accurate observations of the planet. It wasn't until 1659 that Dutch astronomer Christian Huygens made the first detailed drawings of the surface. Huygens noted that Mars rotated and, in 1666, the Italian-born French astronomer Giovanni Domenico Cassini observed the rates at which markings on Mars' surface moved and estimated the period of rotation to be 24 hours and 40 minutes – only 3 minutes off from the true value. Cassini noted, too, the presence of icecaps. British astronomer Sir William Herschel was the first to suggest that these icecaps could be composed of water ice as are the icecaps of Earth. Herschel was also the first to record visual evidence of a Martian atmosphere, and he measured the tilt of the planet's polar axis. During the late 17th century, the British astronomer Sir Isaac Newton, using the foundations laid by Kepler, revolutionized the science of astronomy with his conclusions about the nature of gravity.[1]

As telescopes improved, the fascination with Mars intensified. In 1877 an Italian astronomer, Giovanni Schiaparelli, described *canali* on the surface of Mars. While the Italian word means literally "channels," it was eventually translated into English using the word "canals." The idea of canals on Mars was popularized by Percival Lowell, an American astronomer who founded an observatory in Flagstaff, Arizona, in 1894. Lowell suggested that the canals could be the remains of an ancient civilization on Mars and also noted a phenomena called "the wave of darkening" that sweeps across the planet with the melting of the polar caps. As late as the 1950s, it was suggested that this darkening was due to the growth of vegetation on the planet. The concept of another planet where life could possibly exist not only increased interest among astronomers but also made Mars a popular subject of science fiction.[2]

Science Fiction and Human Trips to Mars

As the work of astronomers inspired writers of science fiction, stories of travel to Mars significantly influenced early human Mars mission planners. Science-fiction works about Mars often related the accounts of Martian invasions of Earth. However, a large number of stories dealt with human journeys to the planet Mars. Most of these fit into one of three categories: (1) stories where humans reached Mars through supernatural methods, (2) stories where humans traveled to Mars through the use of alien technology, or (3) stories where humans landed on Mars through the use of human technology. An exception to this rule was the novel *Daybreak: A Romance of an Old World* by James Cowan, in which humans reached the Red Planet through a fluke of astronomy. In Cowan's story, the Moon entered the atmosphere and settled into the Pacific Ocean. While an expedition was exploring the Moon, the Moon broke loose and transported the expedition members to Mars.[3]

Supernatural transportation of humans was the simplest method for science-fiction writers to send their characters to Mars. Two stories written in 1890 told of humans who inexplicably wake up on Mars; three stories written in 1880, 1898, and 1905 described "spiritual" visits to the Red Planet; and another story from 1903 was concerned with a scientist who discovered that human beings are reincarnated into Martians. Another popular method of reaching Mars was through "willpower" or by simply wishing to be there. Edgar Rice Burroughs used transportation by willpower in several of his Martian novels, especially in *Princess of Mars* (1917), *The Gods of Mars* (1918), and *The Master Mind of Mars* (1928).[4]

A more popular method of transporting humans to Mars in science fiction has been through the use of alien technology. In most of these stories, the technology was a spacecraft with an unexplained propulsion system. However, Gustavus W. Pope, M.D., in *Romances of the Planets. No. 1. Journey to Mars; The Wonderful World: Its Beauty and Splendor; Its Mighty Races and Kingdoms; Its Final Doom* (published in 1894), explained that the Martians traveled from planet to planet using "ether-volts" or spacecraft designed to traverse along the magnetic currents which run between the poles of all of the planets. Perhaps the most significant novel to use the "alien technology" motif, at least as far as the study of human Mars mission planning is concerned, was a German book published in 1897. *Auf Zwei Planeten* (*Two Planets*), considered to be a great early classic of German science fiction, told of a Martian civilization that traveled between Earth and Mars using a substance that is transparent to gravity. Kurd Lasswitz based this book on Lowellian visions of Mars and described an ancient civilization far more advanced than that of Earth. Martian technological superiority was illustrated by their mastery of space travel. Rocket pioneer Wernher von Braun noted that, just as many American scientists had been influenced by a childhood fascination with Burroughs' Martian novels, many of the German rocket scientists had, as children, "buried themselves in the pages of *Auf Zwei Planeten*."[5]

Human-developed technology appears to have been the most popular mode of transportation for humans traveling to Mars in early science-fiction stories. Two stories, written in 1873 and 1898, gave accounts of humans who visit the Red Planet by using balloons. Another story written in

1893 sent its character to Mars in a "flying machine;" one written in 1923 used a gasoline-driven airplane (with greased sides to reduce friction); and one written in 1929 described a journey to Mars using an airplane outfitted with oxygen and supplies. Spacecraft driven using electrical propellers were featured in stories from 1895 and 1910; and a spacecraft that used solar power to generate electricity was described in a story written in 1920. By far the most popular method of science-fiction spacecraft propulsion for visiting Mars was antigravity technology. Propulsion was achieved through the use of special metals, repelling forces, or gyroscopes; and antigravity spacecraft were mentioned in at least 15 stories written between 1880 and 1926.[6]

While science-fiction writers have continued to tell of human journeys to the Red Planet, it was these early stories which had the most impact in terms of human Mars mission planning. They inspired rocket pioneers such as Wernher von Braun to work towards making the dream a reality. In his epigraph to *Two Planets*, a 1971 English translation of *Auf Zwei Planeten*, von Braun expressed his hope that "from this book the reader can obtain an inkling of that richness of ideas at the twilight of the nineteenth century upon which the technological and scientific progress of the twentieth century is based. And we may also realize what fascinating possibilities are opening up for the generations of the twenty-first century when, through the expansion of the universe, our dreams and fancies will become realities."

As science-fiction accounts of human missions to Mars influenced the work of von Braun, von Braun's writings have influenced the work of current planners. For this reason, sending humans to Mars is no longer just fantasy; it is now technologically feasible.[7]

CHAPTER 2

VON BRAUN AND THE PRE-NASA PLANNERS

The Mars Project

Without a doubt, the most influential figure in the history of human Mars mission planning is Wernher Magnus Maximilian von Braun. During World War II, von Braun was a key member of the Peenemünde rocket team that developed the V-2 rockets which Nazi Germany used to bomb England. In spite of his loyal service on the project, von Braun was arrested by the Gestapo and accused of secretly working on spaceflight. As the war in Europe drew to a close, a group of German rocket scientists, including von Braun, surrendered to American troops to avoid capture by Soviet troops. Under the auspices of "Operation Paperclip," Wernher von Braun and his associates emigrated to the United States to continue their work. While working for the Army at Fort Bliss, Texas, von Braun began work on what would become the most influential book on planning human missions to Mars.[8]

In January 1947, von Braun was invited to speak to the El Paso Rotary Club about rockets and the future of spaceflight. Encouraged by the enthusiastic response of his first American public audience, he seized every opportunity possible to share his enthusiasm for space transportation. He realized that large projects such as the exploration of space would require popular support to be successful. In addition to his public "campaign" for spaceflight, von Braun used his spare time at Fort Bliss to pursue a lifelong interest – planning a human expedition to Mars. During 1948 and 1949, he completed the manuscript for his first book, *The Mars Project*. The essay originally was published in 1952 as *Das Marsprojekt*, a special 90-page issue of the German journal *Weltraumfahrt*. An English translation was published the following year by the University of Illinois Press.[9]

In his introduction to *The Mars Project*, von Braun stressed to the reader that, unlike popular science-fiction stories about a single heroic inventor building a rocket ship, interplanetary travel would require governmental support. "Since the development of the long-range liquid rocket, it has been apparent that true space travel cannot be attained by any back-yard inventor, no matter how ingenious he might be. It can only be achieved by the coordinated might of scientists, technicians, and organizers belonging to nearly every branch of modern science and industry." Von Braun then explained that a mission to Mars would require a fleet of ships, noting that if Columbus had sailed with only one ship rather than a fleet of three ships he might never had made it back to Spain with news of his discoveries. "So it is with interplanetary exploration: it must be done on a grand scale."[10]

The goal of *The Mars Project* was to prove that human missions to Mars were possible using conventional chemical propellants. While von Braun recognized that nuclear propulsion had the potential to propel interplanetary spacecraft, he believed that it would take at least 25 years before the cost of nuclear propulsion could compete with the use of chemical rockets. Though he allowed that his essay substantiated the "technical possibility" of a human Mars program, he

cautioned that *The Mars Project* dealt only with the mechanical problems involved with such a mission and could not be considered the final word on the subject. In his introduction, he noted that a number of topics omitted from the study would have to be addressed before the project could proceed: the eccentric orbit of Mars, development of space vehicles, interplanetary astronavigation, meteor hazards, and the ability of humans to survive in space for 3 years (psychological effects, radiation, weightlessness, etc.).[11]

Von Braun began his mission plan with a description of the ferry vessels that would be required to carry the components of a Mars fleet to Earth orbit where the spacecraft were to be assembled. He provided an entire section describing the mechanical details required to build the ferry fleet. The description of the vehicles was similar to the space shuttle, as originally planned, in that "its first and second stages can be salvaged and reused, and that its third stage can make a normal glider landing." The vehicle fleet itself would be required to carry a substantial payload to orbit – the total weight required to construct the Mars fleet was estimated at 37,000 tons. Von Braun, by assuming that each ferry vessel could carry an average of 39.4 tons to orbit, determined that the Mars Project would require 950 ferry flights to complete the assembly phase of the mission. He envisioned a total shuttle fleet of 46 vehicles completing a round-trip to and from orbit every 10 days. With such a turnaround time, the ferries could complete the required flights in 8 months even if six vehicles were continuously out of commission.[12]

As the size of the ferry fleet indicated, von Braun's ambitious Mars Project indeed was to be done "on a grand scale." He envisioned a flotilla of 10 interplanetary vessels carrying a crew of at least 70 humans. Seven of the ships were to be designed specifically as passenger spacecraft to carry the crew to Mars and back. The remaining three "cargo" craft would carry the landing boats required for the crew to descend to the surface of the Red Planet. The voyage to Mars was scheduled to take 260 days. Once the spacecraft had achieved Mars orbit, the majority of the crew would descend to the Martian surface in three landers, possibly equipped with wings to take advantage of the Martian atmosphere. The landing party would conduct scientific investigation on the surface during the 449-day "waiting period" required for Earth and Mars to reach the proper alignment for a return trip. After abandoning one lander and any unnecessary equipment on the surface, the landing party would lift off from the surface and rendezvous with crewmates aboard the seven orbiting passenger spacecraft. They would then abandon the cargo vessels and remaining landers in Mars orbit to begin their 260-day return trip to Earth.[13]

Throughout his imaginative description of this mission, von Braun provided detailed calculations and diagrams to support his ideas. His was the first serious work to demonstrate the technological feasibility of human missions to Mars. He inspired a number of engineers and scientists to pursue studies relevant to human Mars missions; and, through this book and other scaled-down versions of his plan, he greatly influenced NASA's overall long-term plan for human interplanetary missions. Basic elements of von Braun's Mars Project – such as the use of reusable shuttle-like ferry vessels, orbital assembly, and multiple spacecraft to reach Mars – continue to show up in proposals for human journeys to the Red Planet. Having succeeded in

demonstrating to the scientific and engineering community that it could be done, von Braun next turned his attention to the general public to convince them that it should be done.[14]

Collier's and Disney's Man in Space Series

Ironically, von Braun was not in attendance at the pivotal event that eventually gave him access to the average American. For Columbus Day on October 12, 1951, New York City's Hayden Planetarium hosted its first annual Symposium on Space Travel. A panel of experts in rocketry, astronomy, aerospace medicine, and even international law delivered papers on the technical challenges associated with human spaceflight. Panelists there included Robert P. Haviland, a research engineer on General Electric's Project Hermes; Fred L Whipple, chairman of Harvard's Astronomy Department; Heinz Haber, an expert in space medicine from the Air Force School of Aviation Medicine at Randolph Air Force Base in San Antonio, Texas; Oscar Schachter, Deputy Director of the United Nations Legal Department; and Willy Ley, a science-fiction writer and founding member of the German Society for Space Travel. The audience of 250 scientists, engineers, military officers, and members of the press included several members of the editorial staff of *Collier's*, one of the nation's most popular magazines. It was the *Collier's* staff that convinced their managing editor, Gordon Manning, that human spaceflight would be of interest to the general public. Manning, who decided to follow up on the idea, sent associate editor Cornelius Ryan to a space medicine conference held several weeks later in San Antonio.[15]

During that conference, which was held at the Air Force School of Aviation Medicine from November 6-9, 1951, Ryan met with Wernher von Braun and several other scientists who shared their enthusiasm for human spaceflight with him. Upon his return to New York, Ryan convinced Manning that the magazine should do a series of articles on the subject. *Collier's* editors invited von Braun, Whipple, Haber, Ley, Schachter, UCLA professor of physics Joseph Kaplan, and others to participate in an internal symposium on man in space. Artists Chesley Bonestall, Fred Freeman, and Rolf Klep were recruited for the project to help the scientists illustrate their ideas. While all of these men contributed to the eight-issue series, it was von Braun who seized the opportunity to introduce the public to his grand blueprint for the human conquest of space: a reusable space vehicle, an Earth-orbiting space station, human exploration of the Moon, and eventually a human mission to Mars.[16]

The first *Collier's* articles appeared in the March 22, 1952, issue, the cover of which declared "Man Will Conquer Space **Soon**." Associate editor Ryan introduced the symposium and the participants. The magazine then presented several space station concepts and other issues related to humans in space in articles written by the scientists, as well as an article on international space law by Schachter. In conclusion, the issue included a question-and-answer session in which the scientists addressed some of the most intriguing questions that had been raised during the symposium. When the question "Is interplanetary travel possible?" was asked, it was von Braun who stepped forward to give the answer. He explained that the easiest planet for humans to visit would be Mars, "since either of its two moons is close enough to serve as a space station for the return voyage." Two years and eight space issues later, von Braun presented the readers of

Collier's with his concept of how humans could carry out the Mars Project.[17] In the April 30, 1954, issue of *Collier's*, the general public first read about von Braun's Mars Project. In this issue, von Braun explained that the journey would last over 2½ years – 8 months to reach Mars, over a year spent on the surface waiting for Earth and Mars to reach a favorable position, and an 8-month return trip to Earth. Like the fleet in his book, a flotilla of 10 large spacecraft would carry 70 scientists and crewmembers to the Red Planet. However, von Braun cautioned that it would be nearly a century before man would be ready to make the journey. He explained that over the next 25 years, humans would gain much of the necessary knowledge to make the journey as they constructed a space station and carried out the human exploration of the Moon. Unlike the book *The Mars Project*, the *Collier's* articles delved into a detailed discussion of the hazards that astronauts might face during a journey to Mars. Von Braun explained that the human was "the unknown quantity, the weak spot that makes a Mars expedition a project for the far distant, rather than the immediate, future." He discussed the health hazards associated with an interplanetary voyage such as muscle atrophy due to prolonged weightlessness and the dangers of radiation exposure from cosmic rays. He also explained the danger of meteor impact with a spacecraft and described how, by using space suits and handheld rocket guns, crewmembers could abandon a disabled vehicle and transfer to another ship in the fleet. Finally, von Braun considered the psychological problems that might occur when people live together in an enclosed area for long periods of time. A solution, he suggested, might be to place crewmembers into a state of hibernation. The article ended with a look at how the travelers would reach Mars and activities that could be conducted on the Martian surface. Von Braun concluded that no one can know what humans will find when they land on Mars – "all that can be said with certainty is this: the trip can be made and will be made … someday."[18]

It is difficult to gauge the impact of the *Collier's* article on public support for human spaceflight. At the time, the magazine produced over 3,000,000 copies and, if these copies were read by 4 or 5 people as the editors claimed, as many as 15,000,000 people may have read the series. In 1953, Cornelius Ryan edited an expanded version of the first issue and published it in book form under the title *Across the Space Frontier*. Like the articles, the book was met by popular enthusiasm. The *Collier's* articles also generated interest in human spaceflight among the broadcast media who requested interviews with the scientists involved in the project. Von Braun appeared on NBC's "Camel News Caravan," NBC's "Today" show, and CBS's "Garry Moore Show." It is estimated that, through interviews and appearances on radio and television, von Braun may have reached an additional 15,000,000 people with his ideas about the future of humans in space. If the Hayden Planetarium symposium opened the door to public discussion of a piloted space program, the *Collier's* articles ensured that the door stayed open and von Braun would have additional opportunities to continue his public campaign. The next opportunity was a direct result of his success with *Collier's*.[19]

In the early 1950s, Walt Disney developed a television show to finance the construction of Disneyland. This show echoed the organization of the theme park: Adventureland, Fantasyland, Frontierland, and Tomorrowland. For the Tomorrowland segment, Disney turned to Ward Kimball, one of the animation supervisors for the animated film *Snow White and the Seven*

Dwarfs and other Disney feature films. Kimball, who had been following the articles in *Collier's*, suggested that something similar would be great to represent Tomorrowland. Using the articles as a guide, he and his staff prepared their tentative screen treatments and showed them to Disney on April 17, 1954. Walt Disney approved the project, which was to have three episodes: "Man in Space," "Man on the Moon," and "Mars and Beyond." Kimball contacted Willy Ley, Wernher von Braun, and Heinz Haber, who had been part of the original *Collier's* panel, and recruited them to act as technical consultants for the program. The goal was to provide "a factual scientific presentation" of what a human space program might be like. Von Braun provided technical details and guided the Disney crew in constructing accurate models of the launch vehicle, a space station, the lunar spacecraft, and the Mars vehicles. He also appeared in all three of the films.[20]

"Man in Space" premiered on March 9, 1955, and was rerun on June 15, 1955, reaching an estimated total audience of 42,000,000. The first episode in the series featured all three scientists: Ley started with a brief history of rockets, Haber discussed the human factors related to human missions, and von Braun described the Earth-to-orbit vehicle and how it would be launched. The second show, "Man on the Moon," also aired in 1955. It used detailed models of a space station and a lunar spacecraft to show how a human mission around the Moon could be executed. Because very little was known about the surface of the Moon and the producers wanted to avoid speculation, the show did not cover a human lunar landing. The final episode, "Mars and Beyond," shown on December 4, 1957, presented a different approach for a human Mars mission than was used in the *Collier's* article. For this episode, von Braun recruited his associate Ernst Stuhlinger, who had proposed that human missions to the Red Planet could use electric propulsion. Stuhlinger's spacecraft was designed to generate electrical power from the use of a nuclear-electric generator. An electric field was used to accelerate a flow of ions to a high exhaust velocity, thus providing thrust for the vehicle. As with the lunar mission, the Disney show limited the human mission to Mars to an orbital mission – again avoiding speculation about the planetary surface. Von Braun and the other scientists involved in the Disney project were quite pleased with the results. Together with the *Collier's* articles and the books, it allowed them to demonstrate to the general public that human space travel was not only technologically feasible but also could be an exciting program for the nation to pursue.[21]

Other Human Mars Mission Proposals of the 1950s

Stuhlinger's electronic propulsion concept was one of several alternatives to von Braun's Mars Project that were published in the 1950s. While none of these was as detailed as von Braun's plan, nor as influential, they might be of interest to current human Mars mission planners. The first of these appeared in the *Journal of the British Interplanetary Society* (BIS) in May 1951. This article reported on a paper presented by Kenneth W. Gatland to the BIS in January of that year. Gatland noted that his intent was "not to produce a 'design' for a spaceship but merely to throw into perspective the major limitations which confront us in this early formative period of astronautics." The article proposed using a "composite vehicle;" a crew section that used chemical propellants and an interplanetary section powered by a nuclear reactor. Gatland's

concept required that each vehicle be launched to orbit independently, with the atomic rocket perhaps being assembled in orbit. Once the two vehicles were linked together, nuclear power would propel the spacecraft through interplanetary space. When the linked vehicle reached orbit around the destination planet, the crew compartment would separate and proceed to the surface. Upon completion of their surface mission, the crew would return to orbit, rendezvous with the nuclear spacecraft, and begin their return trip home. While Gatland concentrated primarily on a lunar flight, he stressed that his concept could be applied to interplanetary missions such as a human mission to Mars as well.[22]

Another BIS member addressed the use of nuclear power for interplanetary travel. Eric Burgess published the book *Rocket Propulsion: With an Introduction to the Idea of Planetary Flight* in 1952, and then published a revised second edition in 1954. In his book, Burgess examined the orbital mechanics of interplanetary flight. He concluded that human flights to Mars could be more easily accomplished by using Earth's Moon or the Martian moons, Phobos and Deimos, as way stations for the mission. Burgess also noted that the costs of such a mission would be prohibitive for any single nation, making international cooperation a necessity for any human Mars mission. Through his use of numerous calculations, Burgess believed he had demonstrated the impracticality of a human mission to the Red Planet employing only chemical propellants. In the final chapter of the book, he showed how nuclear power could be used to generate more thrust with less fuel, thus making human missions to Mars more achievable and reducing the travel time required for the mission.[23]

Ernst Stuhlinger, who worked with von Braun on Disney's "Mars and Beyond" program, presented his first paper on electrical propulsion to the 5th International Astronautical Federation Congress held in Innsbruck, Austria, in August 1954. Stuhlinger, a member of von Braun's team at Fort Bliss, became interested in electrical propulsion after reviewing the work of Hermann J. Oberth. In Oberth's paper, "Possibilities of Electrical Space Ship Propulsion," Stuhlinger noted that Oberth asserted that all components for an interplanetary spacecraft had to be launched into Earth orbit prior to the mission. Stuhlinger suggested that spacecraft could be designed that would get the same thrust as chemical rockets but would consume less fuel. Such a spacecraft, he reasoned, would make the mission more economical. The paper addressed the idea that lower fuel consumption could be achieved by using electrical fields to accelerate propellant particles, rather than by using heat energy as chemical rockets do. Unlike Oberth's work, Stuhlinger's paper looked at how the required electrical power could be generated in space. Stuhlinger suggested that the energy to power an electrical field could come from either solar energy or an internal power plant in the spacecraft. This power source also would provide the power necessary to ionize the propellant particles prior to their acceleration. Stuhlinger included a detailed discussion of the electrical thrust chamber, ion source, primary power source, and performance data for his electrically propelled spacecraft. He concluded that the mass of an interplanetary spacecraft could be significantly reduced by using an electrical propulsion system instead of chemical propellants. Stuhlinger's ideas, as well as those of other early Mars mission planners, have resurfaced throughout the history of human Mars mission planning and have been updated as new technology has been developed.[24]

The Exploration of Mars

Von Braun's ideas for complex, staged missions were revised in 1956 when he and Ley published a book titled *The Exploration of Mars*. In the first four chapters, the authors provided a detailed history of the astronomy of the Red Planet. They then discussed developments in rocketry and logical steps for the human exploration of space: construction of an Earth orbital space station, the human exploration of the Moon, and a human mission to Mars. The authors cautioned that "the expedition to Mars should be considered the ultimate achievement of a gradual and often painful step-by-step development of manned space flight which may take many decades to accomplish." Although they knew that technology would have to advance significantly before a human Mars mission could be initiated, Ley and von Braun explained that it was a worthwhile exercise to demonstrate that it could be done with the technology of their day. They reviewed the orbital mechanics of such a flight and proceeded to describe every aspect of their proposed human mission to Mars.[25]

The Mars mission described in *The Exploration of Mars* was somewhat similar to von Braun's Mars Project. Total mission duration was to be 2 years and 239 days – 260 days to reach Mars, a 449-day stay on the surface, and 260 days to return to Earth. While the basic mission design is similar to von Braun's earlier proposal, the most important difference is found in the scale of the mission. The crew size, rather than being at least 70 as in *The Mars Project*, was described as being limited to only 12. This reduction in crew size also translated into a reduction in the fleet from the 10 ships in von Braun's first plan to only 2 spacecraft – 1 passenger ship and 1 cargo ship, each weighing 1,870 tons at the time of departure. The largest payload to be carried in the cargo craft was the 177-ton landing craft designed to carry nine people to the surface of Mars and to sustain them during their stay. The landing craft, looking similar to a large airplane, would glide through a Martian atmosphere that is much thinner than that of Earth. To return to orbit, the crew would separate the ship's wings and landing gear and raise the ship to a vertical position. After all unnecessary equipment had been abandoned on the surface, the landing craft with its nine crewmembers would weigh only 76 tons at liftoff. After rendezvous with the orbiting crew vehicle, the landing craft and the cargo vehicle would be left in Martian orbit and the crew would return to Earth.[26]

Another similarity to the mission proposed by von Braun in 1952 was the large "space lift" effort required to carry all components of the Mars mission to Earth orbit prior to the mission. By using three-stage, robotic shuttles with an 11-ton payload capacity, the authors estimated that it would take approximately 335 flights just to carry the spacecraft components (which would be assembled in orbit) and the propellant for the voyage to orbit. The entire operation described by Ley and von Braun would require 400 shuttle flights, including the 28 piloted flights needed to rotate the assembly crew and carry the Mars astronauts to their completed spacecraft. Assuming a launch rate of two flights every 24 hours, the authors contended that the entire Earth-to-orbit portion of the Mars mission could be completed in about 7 months. Ley and von Braun further discussed the shuttle spacecraft, shuttle operations, and launch base that would be required to carry out the ferry missions.[27]

The remainder of the book covered the human aspects of a piloted Mars expedition and described how the mission might proceed. According to Ley and von Braun, the astronauts selected for the mission would have to be in good physical condition, would have to be at least in their late twenties, and would likely be "quietly competent, with an outstanding capacity to learn, an exceptional ability of adaptation, and a preference for working in and as a team." In addition, they would need a good sense of humor and would have to be practical people but also have good imaginations. They would be carefully trained and would be able to perform vital tasks outside of their fields of expertise, thus providing backups in case crewmembers became unable to fulfill their duties. In the final chapter, Ley and von Braun provided an imaginative account of the mission as it might unfold.[28]

Ley and von Braun's book was intended for a more public audience than *The Mars Project*. *The Exploration of Mars*, using illustrations by Chesley Bonestell who illustrated the *Collier's* articles, was much less technical than the earlier von Braun plan and there was much more emphasis placed on the human side of the mission. This work was von Braun's last book specifically addressing a human Mars mission. However, von Braun continued to include a Mars expedition in his plans for the future of the space program. Throughout his busy career with the Army Ballistic Missile Agency and NASA, von Braun achieved a great deal, but he always took advantage of opportunities to campaign for what he thought would be the ultimate achievement of the human space program. To von Braun, his concept of an integrated space program would lead to one ultimate goal – a human landing on the Red Planet. His influence on human Mars mission planning even continued after his death. During the years of the Space Exploration Initiative, engineers working to plan a Mars expedition looked to von Braun's *The Mars Project* and to the *Collier's* articles for inspiration to show that, from the early years of spaceflight planning, humans on Mars has been the logical goal for a human spaceflight program.[29]

CHAPTER 3

EMERGENCE OF NASA

Introduction to Outer Space

Von Braun's dreams of space travel came closer to reality when the Soviet Union launched the first artificial satellite, Sputnik 1, on October 4, 1957. The launch of Sputnik 1 deserves a place in history for reasons other than its status as the first artificial satellite. The immediate effects of the launch were to startle the American public and to create a sense of panic that our nation was falling behind the Soviet Union. Congressional hearings and public discussions sought to discover the reason for our first loss in the space race, and Americans began to question the nation's ability to compete in nonmilitary arenas such as education. Sputnik had several long-term consequences in the United States: the creation of the position of Assistant to the President for Science and Technology and of the President's Science Advisory Committee (PSAC), the reorganization of the Department of Defense (DOD), passage of the National Aeronautics and Space Act (the Space Act), and passage of the National Defense Education Act (NDEA).[30]

Of the long-term consequences of Sputnik, the most important for human spaceflight was the creation of NASA. On February 4, 1958, President Dwight D. Eisenhower announced that his science advisor, James R. Killian, had appointed (at the President's request) a PSAC panel, led by Nobel laureate Edward M. Purcell, to make recommendations on the outlines of a space program and an organization to manage it. Purcell's panel studied the programs of the National Advisory Committee for Aeronautics (NACA); the programs of the Army, Air Force, and the DOD's Advanced Research Projects Agency (ARPA);[31] as well as reports such as that of the Technical Panel on the Earth Satellite Program of the U.S. National Committee for the International Geophysical Year; and they relied on consultants such as NACA's Robert R. Gilruth. The team's report, entitled "Introduction to Outer Space," identified four reasons for the nation to have a space program: (1) "the compelling urge of man to explore and discover;" (2) "the defense objective for the development of space technology;" (3) "national prestige;" and (4) the fact that "space technology affords new opportunities for scientific observation and experiment which will add to our knowledge and understanding of the earth, the solar system, and the universe." Eisenhower was so impressed by the report that he used it as a basis for a press conference on March 26, 1958, where he asked the press to widely disseminate it to the American people.[32]

The Purcell Panel's report sought to answer fundamental questions about the nature of space exploration. It addressed satellites, rocketry, lunar exploration, and the exploration of Mars. Among other things, the Outer Space report first discussed robotic exploration, noting that the cost of human exploration would be much higher. However, the report recognized that, "since man is such an adventurous creature, there will undoubtedly come a time when he can no longer resist going out and seeing for himself." No attempt was made to establish a timeline for the space exploration – "so much will depend on how rapidly we want to expand and accelerate our

program." However, the report did included a basic outline of scientific objectives categorized under broad headings: "'Early' – physics, geophysics, meteorology, minimal moon contact, experimental communications, [and] space physiology; 'Later' – astronomy, extensive communications, biology, scientific lunar investigation, minimal planetary contact, [and] human flight in orbit; 'Still Later' – automated lunar exploration, automated planetary exploration, [and] human lunar exploration and return; 'And Much Later Still' – human planetary exploration." The PSAC report was the first known government document to proclaim human interplanetary exploration as a legitimate goal of the space program, but it was not the last. And while later documents did not always mention human exploration of the Moon and Mars specifically, they did discuss human spaceflight. Those within the space planning community always have considered Mars the ultimate destination for a human exploration program[33]

NASA and Early Planning

On April 2, 1958, President Eisenhower sent a special message to Congress requesting legislation for the creation of NASA. Eisenhower, citing the Purcell Panel's rationale for a space program, recommended that the "aeronautical and space science activities sponsored by the United States be conducted under the direction of a civilian agency, except for those projects primarily associated with military requirements." He further stressed that establishing a civilian setting for the administration of space activities would "emphasize the concern of our Nation that outer space be devoted to peaceful and scientific purposes."[34] Eisenhower's message to Congress included the following recommendations: that NACA be absorbed into NASA; that a National Aeronautics and Space Board, which included a DOD representative, be created; and that some of the space programs of the DOD be transferred to the new space agency.[35] Eisenhower signed the National Aeronautics and Space Act on July 29, 1958, and he appointed T. Keith Glennan, president of the Case Institute of Technology in Cleveland, Ohio, to be the first Administrator of NASA.[36]

The Space Act did not outline specific goals for the civilian space program, nor did it directly mention human spaceflight. However, it did place aeronautical and space activities, except those related to defense, under the jurisdiction of NASA. Among the objectives for the new Agency were "the expansion of human knowledge of phenomena in the atmosphere and space," and "the development and operation of vehicles capable of carrying instruments, equipment, supplies and living organisms through space." Human spaceflight was addressed in greater detail in the Eisenhower Administration's "Preliminary U.S. Policy on Outer Space" that was adopted by the National Security Council on August 18, 1958. While neither document addressed the specific subject of human Mars missions, it was recognized that humans would venture into space. When NASA was officially established on October 1, 1958, these two documents provided the initial guidance for the Agency's activities. More recommendations for the new Agency were offered in the form of a report that was issued several weeks later. On January 12, 1958, NACA Director James Doolittle created The Special Committee on Space Technology to provide recommendations for the new civilian space program. The committee's report, entitled "Recommendations to the NASA Regarding a National Civil Space Program," was published on October

28, 1958. While, as in the previous documents, the report did not mention human Mars missions specifically, it did note that "exploration of the solar system in a sophisticated way will require a human crew."[37]

In early 1959, the U.S. House Select Committee on Astronautics and Space Exploration published a report titled "The Next Ten Years in Space: 1959-1969." Although the document was not specifically a plan for a space program, it is valuable because it represented the views of a number of space experts from the government and private sectors. Over a period of several months, the committee had contacted scientists, engineers, and other space authorities in a number of countries to ask what space achievements might be possible before the year 1969, including whether or not humans would be able to land on the planet Mars. Consensus among those surveyed was that human landings on the Red Planet were not likely to occur during the 1960s. Wernher von Braun admitted that he did not believe that either the U.S. or the U.S.S.R. would be able to develop the required technology during the decade, but that he was certain that the first probes would be launched to Mars by 1969. NASA scientists responding to the survey agreed with von Braun, but they believed that "an active program should be underway" during that period for a human orbital mission to Mars and back. This mission would be a precursor to a human landing mission. The purpose of the report was to educate members of Congress about possible space programs. However, committee chairman Overton Brooks indicated that there was also a large public demand for copies of the publication. Several months later, in April 1959, NASA's Wolfgang E. Moeckel of the Lewis Research Center (LeRC) testified before the Senate Committee on Aeronautical and Space Sciences about the possibility of piloted Mars missions. Moeckel reported on preliminary work performed at LeRC concerning interplanetary spacecraft propulsion and stated that he believed that a human expedition to the Red Planet could be accomplished using a spacecraft assembled in Earth orbit. Despite the work reported by Moeckel and some preliminary work being conducted by von Braun's team at the Army Ballistic Missile Agency under the direction of Heinz H. Koelle and Ernst Stuhlinger, there was no clear indication until later that year that NASA included human Mars missions as a goal of the Agency.[38]

By the end of 1959, NASA published its own plan – the *Long Range Plan of the National Aeronautics and Space Administration* – which was released on December 16, 1959. Unlike the previous guidance documents prepared by other organizations, NASA's plan was quite clear about the Agency's long-term goal – "the manned exploration of the moon and the nearby planets." The document explained that "the rate of progress could be improved by an increased funding level," thus placing the responsibility for the plan's success squarely on the shoulders of the nation's decision makers. Goals identified in the document that were relevant to a human expedition to Mars were: 1962, first [robotic] launching to the vicinity of Venus and/or Mars; and 1964, first reconnaissance of Mars and/or Venus by a robotic vehicle. The human Mars mission, while not listed, was apparently intended to occur some time "beyond 1970" after a piloted flight to the Moon. When NASA's Office of Program Planning and Evaluation produced a *Proposed Long Range Plan* on November 4, 1960, the issue of a human Mars mission was mentioned as one rationale for a piloted space station to study the effects of extended stays in

space on astronauts. NASA's goal of placing a human on the Moon, let alone on Mars, did not receive the full support of the Eisenhower Administration, however. The President asked his science advisor, George Kistiatowsky, to evaluate the Agency's plans for human spaceflight, particularly the goals, missions, and costs of such a program. On December 16, 1960, the PSAC issued the *Report of the Ad Hoc Panel on Man-In-Space*. The panel concluded that "the NASA program is well thought through, and we believe that the mission, schedules and costs are as realistic as possible at this time." Regarding human exploration of Mars, the panel recognized that propulsion requirements and human factors (life support and radiation shielding) would require great advances in technology; and panel members concluded that "manned trips to the vicinity of Venus or Mars are not yet foreseeable."[39]

Kennedy's Challenge

The election of John F. Kennedy in November 1960 did not clarify the future of human missions to Mars. Kennedy's position on human spaceflight had yet to be revealed. Shortly after his election, Kennedy appointed Jerome B. Wiesner of the Massachusetts Institute of Technology to chair the transition team charged with assessing the nation's space program. The Wiesner Report, released on January 10, 1961, was highly critical of NASA's management of Project Mercury and did not seem to indicate that the new Administration was likely to support a vibrant human space effort such as a lunar landing or a voyage to Mars. Although Wiesner's team recognized that such a mission was the ultimate goal of a human space program, they voiced concern that a rush to place the first astronaut in orbit could be the source of severe national embarrassment if the crewmember was killed or lost in orbit. The final recommendation of the report was that Project Mercury should not be allowed to continue unaltered and that the importance of the program should be diminished so as not to imply that it was the nation's premier goal in space.[40]

Whether or not Kennedy agreed with the Wiesner report, events of April 1961 influenced the direction of his Administration's space policy much in the way that Sputnik influenced that of Eisenhower's Administration. As America prepared to launch the first Mercury astronaut, the Soviet Union announced that it had not only successfully launched and retrieved a piloted spacecraft, but it also had completed the first orbital human flight. Yuri Gagarin's historic flight on April 12, 1961, represented another Soviet space victory and prompted Kennedy to find an appropriate response.[41]

Eight days after Gagarin's flight, Kennedy asked Vice President Lyndon B. Johnson to conduct an assessment of the U.S. civil space program. The President's memorandum, dated April 20, asked Johnson to determine whether the United States could beat the Soviet Union with a program such as a space station, a robotic lunar mission, or a piloted lunar mission, or if there was "any other space program which promises dramatic results in which we could win?" During the review, Johnson and the National Aeronautics and Space Council consulted officials from NASA and the DOD, as well as scientists and engineers from government and private sectors. The first evaluation was delivered to the President on April 28, 1961. It indicated that, while the

Soviets had a lead in the race to a human space station, a mission to send astronauts to the Moon was one area in which the U.S. conceivably could take the lead over the U.S.S.R. No mention was made of a human mission to Mars.[42]

Among those consulted during the review was Wernher von Braun, Director of NASA's Marshall Space Flight Center (MSFC). In his letter dated April 29, 1961, von Braun emphasized that he had been asked to participate as an individual and that he did not represent the position of NASA or of MSFC. Von Braun's recommendations concurred with the first evaluation that the Soviets most likely would launch the first space station, while Americans could possibly win the race to the Moon. While Kennedy's memo left open the discussion of a human Mars mission with the question about other space programs, von Braun did not mention such a mission in his recommendations. It is unclear whether this omission was due to von Braun's vision of an integrated space program with a set progression of programs, or whether it was the result of an analysis that a human mission to the Red Planet was an unrealistic goal at the time. Either way, it is consistent with von Braun's earlier assessments that such a mission would not occur in the near future.[43]

By May 8, 1961, NASA Administrator James E. Webb and Secretary of Defense Robert S. McNamara forwarded their *Recommendations for Our National Space Program: Changes, Policies, Goals* to Vice President Johnson for his consideration. The primary human space program proposed in the document was the human exploration of the Moon within the decade. This recommendation became the central element of Kennedy's speech on "Urgent National Needs," which he delivered before a joint session of Congress on May 25, 1961. The President's challenge that the 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 earth" spawned the massive Apollo Program in which NASA set out to land a human on our planet's nearest celestial neighbor.[44]

CHAPTER 4

ECLIPSED BY THE MOON: PLANNING IN THE EARLY 1960S

Early Human Mars Studies

As NASA mobilized most of its resources to complete Projects Mercury and Gemini and to meet Kennedy's challenge, the Agency's advanced mission planners looked ahead to what would follow the Apollo lunar program. Two focal points of these activities were the Marshall Space Flight Center (MSFC) in Huntsville, Alabama, and the new Manned Spacecraft Center (MSC) in Houston, Texas. Initially, these Centers conducted in-house studies using a small number of personnel to do the research. One such study was conducted by the Space Task Group (STG)[45] in the summer of 1961. In this STG study, NASA planners examined launch vehicle requirements for sending crews on planetary missions and contrasted those with requirements for the Apollo Program. Another important study, initiated in 1961, was performed by Lockheed Missiles and Space Company (Sunnyvale, California) as part of a 2½ year contract (number NAS8-2469[46]) with MSFC. The Lockheed study examined all trajectories for interplanetary missions among the Earth, Mars, and Venus using high-velocity vehicles. The end result was a planetary flight handbook entitled *Interplanetary Flight Trajectories*, which included trajectory data essential to scheduling and planning human Mars missions for the period 1965 through 1999. As an MSC internal note dated February 1965 recalled, the handbook became "the standard reference source for interplanetary trajectories, and NASA study contractors [were] directed to use it as such."[47]

At the time the Lockheed study was still under way, a number of other significant studies were awarded by NASA to aerospace contractors. Robert B. Merrifield, a Johnson Space Center (JSC) historian, estimated that in the period from 1961 to 1966 approximately 60 contracts, valued at over $7.5 billion, were awarded to industry for studies related to human interplanetary missions. Merrifield classified the studies into two distinct categories:

> (1) broad conceptual studies to aid in defining the overall program and delineating information required from unpiloted planetary mission feasibility;
>
> (2) more detailed studies to ensure mission feasibility; to determine the use of existing or planned hardware; and to define the technological, economic, and timing aspects of human planetary exploration.[48]

While the Lockheed trajectory study fit into Merrifield's first category, some of the most extensive studies performed in the early 1960s fit into the second category. Some of these were the EMPIRE [Early Manned Planetary-Interplanetary Roundtrip Expedition] studies contracted by MSFC, studies conducted for the Ames Research Center (ARC), the planetary spacecraft design studies directed by MSC, and the UMPIRE studies initiated by MSFC.[49]

Project EMPIRE

In May 1962, MSFC awarded three contracts for work on human planetary missions. Known as Project EMPIRE, these studies addressed the human exploration of Mars and Venus. Each company that took part was awarded a $250,000 contract for a 6-month study incorporating 6,000 work-hours. The three EMPIRE contractors were Ford's Aeronutronic Division, General Dynamics/Astronautics, and the Lockheed Missiles and Space Company. All studies were based upon the assumption that the Saturn V vehicle being developed for Apollo could be used to launch Mars missions to Earth orbit and that nuclear propulsion systems, also in the development stage at the time, would be available for the interplanetary portion of the journey.[50]

Aeronutronic's study was conducted under NASA contract NAS8-5025. The work, directed by Ford project manager Franklin P. Dixon, considered a dual-planet flyby of Venus and Mars. The results were published in two reports: (1) "EMPIRE, A Study of Early Manned Interplanetary Missions" (December 21, 1962) and (2) "The EMPIRE Dual Planet Flyby Mission," released in 1963. These reports provided details of a "symmetric" flyby,[51] named for the symmetry between the Earth-launch and Earth-arrival positions relative to Mars at the midpoint of the interplanetary trajectory. A crew of six would be launched from Earth orbit during the launch window of July 19 through August 16, 1970. The journey would last from 613-631 days, or about 21 months, and would be divided into three mission segments – the trip from Earth to Venus (100 days), travel from Venus to Mars (200 days), and the return trip from Mars to Earth (310-340 days). During the mission, the crew would conduct scientific observations and experiments, which were to be defined in a later study.[52]

The Aeronutronic group considered three launch vehicles that NASA was studying at the time: the Saturn V, the Nova, and the Super Nova. This group determined that these launch vehicles could be used in conjunction with a nuclear injection stage and chemical maneuvering systems to propel a spacecraft. Once the interplanetary portion of the mission was under way, artificial gravity could be generated by rotating a spacecraft at a rate of 3 revolutions per minute. Finally, the study considered three types of vehicles for Earth reentry: an Apollo-type capsule, a spacecraft incorporating a drag brake, and a spacecraft incorporating high lift-to-drag technology for reentry. The team chose the latter as offering the best options for returning a crew to Earth. Cost of the mission, according to the Aeronutronic group, would be $12.6 billion plus the cost of launch vehicle development and scientific instrumentation.[53]

General Dynamics/Astronautics conducted its EMPIRE study under the direction of Krafft A. Ehricke, who had been a member of the German rocket team at Peenemünde. At least four reports were produced as a result of the initial contract (NAS8-5026) and of a follow-up study: (1) "A Study of Early Manned Interplanetary Missions" (January 31, 1963); (2) "Methodology of Mission and Systems Synthesis of Manned Planetary Flights with Particular Emphasis on Venus and Mars as Target Planets" (July 1, 1963); (3) "A Study of Early Manned Interplanetary Missions (EMPIRE Follow-on)" (January 28, 1964); and (4) "A Study of Early Manned Interplanetary Missions" (6 volumes, dated between January 31, 1964 and July 1, 1964).

While the General Dynamics team considered both flyby and capture missions involving orbital operations around Mars, it was the latter proposals that offered the most interesting mission scenarios. Although crew sizes discussed in the approximately 30 missions studied ranged from 2 to 16, most options considered a crew of 8 to be ideal. The missions were planned for the period 1973 to 1975, when the relative positions of Earth and Mars were most favorable. By using nuclear vehicles, it was believed that the mission duration could be reduced to 400-450 days, including a stay in Mars orbit of 30-50 days. Like the Aeronutronic proposals, those missions included in the General Dynamics study would achieve scientific objectives yet to be defined. However, mission plans also included scenarios for sample return missions and human excursions to the surface of the Red Planet.[54]

The team noted that it would require the launch of eight Saturn V vehicles and completion of seven orbital rendezvous operations in Earth orbit to assemble the interplanetary spacecraft. In contrast, the team found that the proposed Post-Saturn Earth Launch Vehicle, with a payload capacity of 400 tons, could do the job with only one launch. Development of this vehicle was believed to be highly desirable for human Mars missions. In addition, assumptions were also made that the development of the nuclear engines required for the interplanetary phase of the mission would be achieved through the NERVA [nuclear engine for rocket vehicle application] and Phoebus nuclear rocket programs that were under way at the time.[55]

General Dynamics looked at missions incorporating either a combined vehicle or two separate spacecraft – a crew ship and a service vehicle. In the two-vehicle scenario, the crew portion would include three distinctive elements: (1) the command module, which would be staffed by three crewmembers at all times, (2) the mission modules, and (3) the Earth-entry vehicle. Mission modules were divided into two groups. The first group consisted of three internal modules that would house the ecological life support system for the voyage to Mars, provide storage space for food, and contain a repair shop. Four external modules made up the second group. These included the service shop and storage for auxiliary vehicles and special "space taxis," which could be used to travel between spacecraft or as towing vehicles. The service spacecraft held a backup Earth-entry vehicle as well as emergency crew quarters. According to the mission plan, the crew would abandon the command and mission modules in Mars orbit, returning to Earth with only the Earth-entry vehicle.[56]

There were seven types of auxiliary vehicles in the General Dynamics plan. These included surface landing vehicles and robotic scientific vehicles. "Lander" vehicles were designed for landings to collect data about the surface of Mars. "Returner" vehicles were similar to the "Landers," except that "Returner" vehicles had the capability to return soil and air samples to the orbital spacecraft. The last of the surface landing vehicles, the manned excursion module, could be used to transport a crew of one or two to the surface of the Red Planet. Robotic scientific vehicles included an orbital "Mapper" spacecraft and three orbital environmental satellites designated "Marens;" a series of "Floater" vehicles designed to hover at different altitudes to collect atmospheric data; and two spacecraft called "Phepro" and "Deipro" intended for impact missions on the Martian moons.[57]

As part of this study, the General Dynamics team expended a great amount of effort into considering crew composition for the mission. Eight-person crew plans required a mixture of engineers and scientists, each with a number of skills and responsibilities. The commander and deputy commanders, respectively, were imagined as a mechanical engineer and an electrical engineer who not only commanded the mission but also were responsible for maintaining the ship's structure, mechanical equipment, and electrical systems. Another crewmember, preferably a nuclear engineer and physicist, would monitor the nuclear systems and work with the flight surgeon to ensure the crew was protected from radiation during the mission. Two electronic engineers, one with skills as an astronomer and the other with training in physics, would be responsible for communications, navigation and guidance, and data processing. The mission designers designated that one of the three non-command engineers would participate in the piloted excursion to the Martian surface and would serve as excursion commander if more than one astronaut participated in the landing mission. Another team, composed of a physicist/ geophysicist and an astronomer/geologist, would share the task of conducting scientific observations in space physics, planetology, meteorology, and geophysics. The final member of the crew, a physician and biologist who would serve as flight surgeon, would monitor and maintain the physical and mental health of the crew and would conduct biological and astroclinical research.[58]

In the report, General Dynamics indicated that there were four categories of costs involved with the mission: (1) direct development costs of the EMPIRE spacecraft; (2) costs for test facilities and test operations; (3) launch vehicle costs for flight and operational testing; and (4) costs associated with modifications of the Saturn V or development of the Post-Saturn Earth Launch Vehicle. According to the study, direct development costs would be $18.5 billion over the period from 1965 to 1975. In addition, General Dynamics predicted that scientific studies, which would benefit the Mars program as well as other programs, could be expected to cost $6 billion.[59]

Lockheed Missiles and Space Company, the third EMPIRE contractor, conducted its study under initial contract (NAS8-5024) and as part of an extension through the end of 1964. Efforts were directed by Lockheed project manager Benjamin P. Martin. Among the reports produced as part of the Lockheed contracts were "Early Manned Interplanetary Mission Study" (March 1963) and "Manned Interplanetary Missions, Follow-on Study" (February 28, 1964). Lockheed's study examined both flyby and orbital capture missions. Unlike the Aeronutronic study, flyby flights to the planets were planned as separate missions. Scenarios studied included 3-, 6-, 9-, and 12-person crews. Launch for the Mars mission was scheduled for September 24, 1975, with the flight duration planned to last 670 days. Lockheed's missions were designed to provide reconnaissance for later human landings on the Martian surface.[60]

While conducting the study, the Lockheed team produced mission profiles based upon Saturn V and NERVA technology. The team attempted to design a spacecraft that could be launched using only two Saturn V vehicles and one orbital rendezvous operation. Escape from Earth orbit would be achieved by using either chemical or nuclear propulsion systems. The designers also proposed producing artificial gravity of 0.4g by slowly rotating the vehicle during the interplanetary phase

of the mission. Crew sections of the spacecraft were to be divided into two parts. The command module, based upon the Apollo capsule, would have an internal volume of only 8.5 cubic meters. In contrast, the mission modules would offer 113 cubic meters of living space including the crew quarters, a dining and recreation area, the environmental control system, and the crew's food and water stores.[61]

While none of the EMPIRE missions ever moved beyond the initial design phase, they are significant for those interested in human Mars mission planning. For the first time since *The Mars Project*, detailed appraisals of what it would take to accomplish a human voyage to Mars were conducted and shared with others in the space community. Details on launch vehicle requirements, orbital assembly, interplanetary transfer, spacecraft design, and crew composition were examined as part of the project. Combined with studies conducted for ARC and for MSC during the same period, the results of these contractor studies convinced many in NASA that human missions to the Red Planet were feasible.

Ames Research Center Contractor Studies

The work on human Mars mission planning that took place at various NASA Centers did not occur in a vacuum. Managers and engineers involved in human Mars mission planning consulted with their counterparts at other NASA Centers throughout the duration of the studies conducted in the early 1960s. On September 28, 1962, two MSC employees traveled to NASA's ARC to discuss research of mutual interest to both Centers. At the time, the MSC team found that studies at ARC were concerned primarily with robotic spacecraft for precursor missions to Mars.[62]

However, by May 1963, two contractor studies were initiated by ARC to examine human missions to Mars. The purpose of the contracts was to determine whether such missions were feasible and, if so, to recommend what the scope of a human flight to Mars should be. Contractors were asked to compare different types of mission profiles as well as technological requirements for each. Finally, the studies were supposed to identify areas where more research was required to prepare for human Mars missions. Each contract was valued at $100,000 for a 9-month study.[63]

TRW Space Technology Laboratories, one of the companies selected by ARC, performed its work under contract number NAS2-1409 directed by TRW project manager Robert L. Sohn. The TRW team first reported their findings at the Manned Mars Mission Symposium held at MSFC on January 28-30, 1964. They then produced a multivolume report dated March 28, 1964 and titled "Manned Mars Landing and Return Mission." TRW's report focused on Mars stopover missions culminating in a human landing on the planet. It emphasized that such a mission would be a "direct follow on to the Apollo project" and specified that human participation was essential to the exploration to Mars because the complexities of the mission would exceed the capabilities of robotic spacecraft. Crew sizes for the TRW scenarios ranged from 3 to 12 astronauts with the ideal number being 6 astronauts. For direct missions to Mars and back, mission dates ranged from 1971 to 1986. In addition, the study examined return trips that included a Venus flyby

during the period 1971 to 2000. Trip duration ranged from 419 to 440 days, depending on mission profile, and included 10 to 60 days spent in the vicinity of the Red Planet. Mission plans called for two crewmembers to descend to the surface for a landing on Mars. The mission study emphasized that the definition of scientific objectives for the trip to Mars should drive the design of the mission, and it urged that the space science mission should be studied in depth before mission planning proceeded any further.[64]

The TRW study did not dwell on the subject of launch vehicles. It did recommend that the Saturn V should be upgraded to reduce the number of launches required for a human Mars mission. In addition, the report suggested that Nova-class vehicles should also be considered. Interplanetary flight, according to TRW, could be achieved using either chemical propulsion or nuclear power, but it was found that the latter had the potential to reduce the gross weight of the spacecraft by up to 40%. TRW's main spacecraft consisted of several sections. The command module included spacecraft communications, navigation, and guidance equipment. A central mission module, 260 inches in diameter, contained the crew quarters. Additional crew space was available in the Apollo-like Earth entry module and in the Mars excursion module (MEM). The MEM was designed to support two astronauts for a 5- or 6-day surface excursion. This mission plan also included provisions to create artificial gravity during the interplanetary portion of the journey. Finally, the TRW report offered conclusions about how different mission elements affected the overall system requirements and made recommendations for future studies.[65]

The second contractor, North American Aviation, completed its study under contract NAS2-1408. North American presented its findings to ARC in April 1964. The mission plan considered a human landing on the Martian surface. Crew sizes examined in the study ranged from 3 to 10, with 6 considered to be the most ideal. The missions, scheduled for launch opportunities occurring in the 1970s and 1980s, were designed to last 12 to 18 months including a stay around Mars of 7 to 60 days.[66]

Launch vehicles considered by North American included both Saturn V and post-Saturn systems. For the interplanetary portion of the mission, the report considered both chemical and nuclear propulsion methods. It was noted that a decision to use the Saturn V and chemical systems would enable the process of program planning to move forward immediately. However, if the planners chose to use post-Saturn launch vehicles and nuclear propulsion systems, the report suggested that planning should be delayed awaiting further definition of these new systems. In conclusion, the North American study recommended that human exploration of Mars should progress through a series of missions that built upon each other. These missions included planetary flyby missions, planetary orbital missions, and, finally, a human planetary landing.[67]

While the ARC studies emphasized mission concepts over hardware design, they were important contributions to the evolution of human Mars mission planning. In some cases, they reinforced the findings of the earlier EMPIRE studies. There were also important additions to the growing collection of mission concepts. For example, the TRW study proposed a different purpose for the add-on Venus flyby segment included in some of the EMPIRE reports. This study was the

first to propose using the gravity of Venus as a method to decelerate a spacecraft during the Earth-return portion of the mission.[68]

Manned Spacecraft Center Planetary Spacecraft Design Studies

Shortly after ARC awarded contracts to North American Aviation and TRW, two new sets of studies were initiated by MSC and MSFC. Those contracted by MSC were direct follow-ons to the EMPIRE studies launched a year before at MSFC. The three spacecraft elements identified by the EMPIRE contractors – the Mars mission module (MMM), the MEM, and the Earth entry module (EEM) – were each examined as part of MSC's planetary spacecraft design studies. In May 1963, articles published in *Missiles and Rockets* and in *Aviation Week & Space Technology* reported that requests for proposal (RFPs) had been issued to study each of the three Mars mission spacecraft. Mission specifications called for a crew of six to make the journey during the 1970-1975 time period. Mission duration ranged from 420 to 440 days. For the 420-day mission, 140 days would be required for the journey to the Red Planet, 40 days would be spent in Mars orbit, and the return trip to Earth would take 240 days. Time required for the return trip was greater than that for the trip to Mars because Earth and Mars would be moving apart during that phase of the mission. The overall goal of the mission was a human landing on the Martian surface. Throughout the study period, all three contractors were instructed to exchange information on their portion of the mission so that the end product would be designs for a fully integrated spacecraft system.[69]

The contract for the MMM study was awarded to North American Aviation's Space and Information Systems Division. They were funded with $100,000 under contract NAS9-1748 for a 6-month study to look at the primary living space for the human Mars mission. Their report, "Study of Subsystems Required for a Mars Mission Module," was released on February 2, 1964. There were three basic purposes for the study. One was to examine the subsystem requirements of the mission module. The second was to analyze spacecraft designs for aerobraking – using the Martian atmosphere to slow down and achieve orbit. The third was to provide a basic design which integrated the MEM and the EEM with the MMM to provide a complete design for an aerobraking and landing mission.[70]

Philco's Aeronutronic Division received the contract for the human MEM. Their MEM study, performed under contract NAS9-1608, was directed by Franklin P. Dixon who also had overseen the EMPIRE study for MSFC. The MEM final report, entitled "Study of a Manned Mars Excursion Module," was dated December 20, 1963; and a "Summary Report: Study of a Manned Mars Excursion" was published on May 13, 1964. Aeronutronic also presented their findings to the aerospace industry at the American Institute of Aeronautics and Astronautics' (AIAA's) third Manned Space Flight Conference held in Houston, Texas, in November 1964. NASA's statement of work for the contract specified that the primary objective was "the preliminary design of a Mars Excursion Module (MEM) for transporting personnel and scientific equipment from a space vehicle in Mars orbit to the Mars surface and return to the space vehicle in Mars orbit." Other tasks assigned under the contract were the study of Mars orbital operations and surface

operations, a definition of crew size and tasks, and the definition of all major subsystems for the MEM.[71]

Aeronutronic's findings indicated that a Mars landing could be achieved only 9 years after NASA awarded the hardware contracts. This was possible because its design was heavily based upon technology being created for the Apollo Program, even though the spacecraft differed significantly from the lunar module (LM). The Mars landing vehicle was designed to separate from the MMM in orbit in preparation for a 40-day excursion to the surface of the Red Planet. Unlike the LM, the MEM was designed in a half-cone lifting-body configuration. During the descent phase of the mission, parachutes would be deployed to slow the spacecraft in preparation for landing. In the final phase of the landing, the parachutes were to be jettisoned and the descent engines were to be used to complete the landing.[72]

The study also examined the surface activities that would occupy the crew during their sojourn on the surface. A thorough examination of the Martian environment was considered an essential activity for this phase of the mission. Following the surface stay, the ascent module would blast off from the MEM and launch the crew for an orbital rendezvous with the main spacecraft. It was then time for the crew to begin the return to Earth.[73]

Following the interplanetary flight, the crew was to transfer to the EEM for reentry and landing. The contract for this spacecraft element was awarded to Lockheed Missiles and Space Company. Its study, directed by Lockheed project manager D. J. Shapland, was performed under NASA contract NAS9-1702. The EEM, designed to carry the crew during the last 8 hours of the mission, was to be used for the approach to Earth, atmospheric reentry, and landing in either the water or on land. Like the Apollo module, the spacecraft was to use parachutes to slow the descent to Earth in preparation for landing.[74]

These MSC studies contributed detailed designs for the spacecraft elements introduced by earlier mission plans. They examined the interactions among different spacecraft modules as well as the systems and subsystems necessary for the mission. It was also this study series that provided a design for an aerobraking spacecraft that NASA could contrast with those produced as part of the EMPIRE studies. The studies conducted for MSC also encouraged planners to think of human Mars missions as projects with a similar design period to that of the Apollo Program. By its use of the technology under development for Apollo, Lockheed determined that the EEM could be developed in only 7½ years. Even more surprising, it was estimated that the MEM would be mission ready a mere 9 years after NASA awarded the hardware contracts. While these studies increased NASA's confidence in the practicality of human missions to Mars, a set of concurrent studies conducted for MSFC expanded the window of opportunity for such missions into the unfavorable period.[75]

UMPIRE Studies

One of the findings of the EMPIRE studies was that missions occurring between 1975 and 1985 were not as simple as those conducted at other times. Flights during this period would require

more radiation protection due to a projected increase in solar activity. In addition, capabilities for much greater velocities would be required compared to human Mars missions planned for other periods because of the position of Mars relative to that of Earth during this period. While MSC was initiating its planetary spacecraft design studies, MSFC awarded two contracts to examine the "unfavorable" period, to examine mission profiles associated with it, and to see how the chances of mission success could be increased. These contracted efforts became known as the UMPIRE studies.[76]

Douglas Aircraft Company's Missile and Space Systems Division published its UMPIRE report, "Manned Mars Exploration in the Unfavorable Time Period (1975-1985)," in January 1964. This work was completed under NASA contract NAS8-11005. The company was awarded $91,901 for the 7-month study. The mission examined by the Douglas team called for a crew of six to make the interplanetary journey using nuclear propulsion. Mars stay time depended on the type of mission with a 20-day stay for opposition-class missions and a 300-day stay for conjunction-class missions. The key to planning missions during the unfavorable period, according to the Douglas study, was to keep the initial launch mass as low as possible.[77]

The second UMPIRE contractor, General Dynamics, worked under NASA contract NAS8-11004. Their report, "A Study of Manned Mars Exploration in the Unfavorable Time Period (1975-1985)," was released on February 15, 1964. In it, General Dynamics made several important observations about life support systems for human Mars missions. They found that, while the general concept for the system would not be affected by changes in crew size or mission duration, these factors would have a significant impact on the overall mass of the system. Therefore, it was important to establish these variables before designing the system. The report also determined that the life support system would account for a significant portion of the overall vehicle mass, making this a key system that would affect the overall mission design. In addition to the required presentation to MSFC, the General Dynamics group presented their preliminary findings – such as system mass definition and trajectory analysis, as well as an analysis on reliability and mission success – to personnel at MSC on September 13, 1963.[78]

Like the other studies of the period, the UMPIRE reports confirmed the belief of many at NASA that human missions to Mars were feasible without significant technological developments beyond those already under way at the time. This helped reaffirm the position among many NASA planners that human interplanetary expeditions would be the logical sequel to the Apollo lunar landing missions. During the fiscal year (FY) 1965 NASA authorization hearings held in February and March 1964, NASA officials explained to Congress that they were spending $22 million in FY 1964 on advanced mission planning, including human expeditions to the planets. They suggested that a piloted flyby of Mars could be launched as early as August 1973. Mission duration was estimated to range from 500 to 700 days. Human landings on the Red Planet were projected for the early 1980s. Two types of landing missions were described – opposition-class missions of 300 to 500 days, and conjunction-class missions of 750 to 950 days, including up to 500 days spent in orbit or on the surface. In earlier hearings, NASA officials had only

alluded to human planetary missions as long-range goals. This was one of the first incidences where human Mars missions were described in detail to Congress.[79]

Early Interplanetary Mission Meetings and Conferences

Throughout the duration of the studies, NASA employees, NASA contractors, and other proponents of human Mars missions met to discuss the progress of their work and the implications for the next step in program planning. All of the aforementioned contractor studies produced formal written reports of their findings; these now serve as a permanent record for those interested in previous human Mars mission planning efforts. However, before the reports were published, the primary conduit for communications between those involved in the studies was a variety of NASA meetings and the aerospace conferences of the period. NASA's Office of Advanced Research and Technology (OART) sponsored the Manned Planetary Mission Technology Conference, the first NASA inter-Center conference to focus on the topic. The meeting was organized "to explore the possibilities and problems of manned planetary space flight." On May 21-23, 1963, participants from all over NASA gathered at the Lewis Research Center (LeRC) in Cleveland, Ohio, to discuss the results of relevant in-house studies[80] and to encourage additional research in the area of human interplanetary space exploration. Sessions at the conference covered subjects such as the space and planetary environments; life support; spacecraft technology and design problems; atmospheric entry and gas thermodynamics; guidance, control, and communications; propulsion and power generation; trajectories and mission analysis; and mission examples.[81]

The American Astronautical Society (AAS) sponsored an industry conference, the AAS Symposium on the Exploration of Mars, during the following month. This conference was held on June 6-7, 1963, in Denver, Colorado. Papers presented at the meeting discussed the rationales for exploring the Red Planet, advanced propulsion methods that could be used including nuclear propulsion, the human requirements for piloted Mars missions, and the scientific issues relevant to such missions. Meeting papers were published later that year under the title *Exploration of Mars: Proceedings of the American Astronautical Society Symposium on the Exploration of Mars*. Comments from the meeting were also reported in the *New York Times* and in *Aviation Week & Space Technology*. The articles focused on the technology required for a journey to Mars and what life might be like for a crew making the trip.[82]

An internal NASA meeting of the Planetary Mission Study Group was convened on July 30, 1963, in Washington, D.C. It was chaired by Douglas R. Lord, Acting Assistant Director for Planetary Mission Studies in the NASA Headquarters Office of Manned Space Flight (OMSF). Lord described the meeting as the "first effort to assemble those persons primarily concerned with study of manned interplanetary missions for an exchange of information and views on that subject." Participants included NASA personnel from OMSF, OART, LeRC, MSC, MSFC, and ARC. They discussed the objectives and status of in-house studies and contractor studies under way throughout the Agency.[83]

AIAA held its first AIAA Manned Planetary Mission Conference in Palo Alto, California, in October 1963. Participants from NASA and industry met to present papers discussing the engineering problems associated with human exploration of the planets. H. H. Koelle, Director of the Future Projects Office at MSFC, told those at the meeting that he did not expect startup money to become available until FY 1967. He, therefore, predicted that the first human landing on Mars would be delayed until the mid-1980s. Koelle also warned conference participants that human planetary exploration would have to compete with other programs for a portion of the NASA budget. This thought was reemphasized by George M. Low, NASA's Deputy Associate Administrator for Manned Space Flight, who commented that he believed the human program to follow the Apollo Program would be an orbital space station.[84]

Some specific outlines for human planetary excursions became clear during 1964-1965. NASA's second Symposium on Manned Interplanetary Mission Studies was held at MSFC in Huntsville, Alabama, in January 28-30, 1964. The purpose of this meeting was to share the results of studies under way during the previous year. In November 1964, the AIAA held its third Manned Space Flight Conference in Houston, Texas, home of MSC. Like the meetings and symposiums before it, this conference provided NASA engineers and scientists, as well as those employed in the aerospace industry, to exchange ideas and results of their work related to human Mars missions. It gave Mars mission planners an opportunity to learn from each other and to build upon each other's work. This allowed the planning effort to continue evolving as new ideas were introduced.[85]

Whether through conferences on the topic or through completion of detailed studies of mission scenarios, the legitimacy of human Mars missions as a viable goal for the U.S. space program appeared to have been established by the mid-1960s. Proponents of such missions felt confident that work in the area was proceeding at a pace that would allow full-scale planning to begin as soon as the Agency committed itself to the goal. Many felt that it would be quite logical to initiate a human Mars program as the follow-on to the Apollo Moon landings and that they need only wait for the word to set their plans in motion. They seemed confident that the monetary support for their planning efforts would be equal to that applied to Apollo. It is also possible that they felt that, once research and development funds were no longer necessary for the lunar landings, these funds would be redirected towards sending humans to Mars.

CHAPTER 5

PLANNING IN THE MID-1960S

Program Reviews and Continued Planning

Throughout the Kennedy Administration, the goals of the U.S. space program were reexamined several times. While advanced human spaceflight and interplanetary exploration were mentioned during these reexaminations, little emphasis was placed on human missions to Mars. On October 30, 1964, 2 months after the assassination of President Kennedy, President Lyndon B. Johnson asked NASA Administrator James Webb about future objectives for the space program. After a year of work, in February 1965 NASA forwarded the report of the Future Programs Task Group to the President. This report reflected the Administrator's hesitance to proclaim any long-range goals for the Agency without a guarantee of political support. There was no schedule for the evolution of the program beyond the Apollo missions. Instead, the report reiterated previous NASA statements recommending that the nation pursue a balanced space program in all areas, without specifying in any detail what those programs should be. Human exploration of Mars was mentioned, although there was no timetable set for accomplishing this goal. Very briefly, the report outlined the basic steps of a human Mars mission and noted such a mission's potential to be "possibly the most challenging long-term goal of the entire space program."[86]

Work on human Mars mission planning continued at the Center level during 1965. One such study was performed in-house by the Future Projects Office at the Marshall Space Flight Center (MSFC). The report of this work – *Manned Planetary Reconnaissance Mission Study: Venus/Mars Flyby* – was published on February 5, 1965. Harry O. Ruppe, author of the work, explained that the purpose of the study was two-fold: (1) to determine the feasibility of human flyby missions to Mars and Venus using existing hardware, and (2) to expand the in-house capability in interplanetary mission planning. The MSFC team determined that a crew of three astronauts could be flown around Mars as early as 1979. A mission duration of 661 to 691 days would allow the crew to make the round-trip journey and to perform the planetary reconnaissance tasks that would enable planners to design a later piloted landing mission to the Red Planet.[87]

Ruppe justified a piloted flyby mission using several arguments. He noted that individual programs such as Apollo, a lunar base, or a space station were not the ultimate goals of the space program. Instead, he considered them just steps in the "logical and systematic overall exploration of space." The human exploration of Mars would, therefore, also be a step in the expansion of humans outwards from Earth. Because the mission would be based upon Apollo technology, the MSFC study concluded that it would provide an excellent way to exploit the capability developed for the Moon landing and prepare for future programs. The report noted that a piloted Mars landing mission most likely would require the use of a solid-core nuclear propulsion system, or some other system, that would not be human-rated until the 1980s. Ruppe explains that one of the most important justifications for a flyby mission would be to help NASA retain public support for human spaceflight during the 10- to 15-year period between the lunar landing and a human landing on the Red Planet.[88]

New Capabilities and Discoveries

While the lack of a clear mandate may have been disappointing for those planning piloted Mars missions, the year 1965 was an exciting one for all involved in piloted and robotic space exploration. NASA's Gemini Program was progressing as planned, and development of the Apollo spacecraft was moving the Agency closer to achieving Kennedy's goal of a human lunar landing by the end of the decade. While the Soviet Union succeeded in performing the first extravehicular activity (EVA) with Aleksei Leonov's historic spacewalk on March 18, 1965, the United States demonstrated that it also had this capability. During the Gemini IV flight, Edward White II not only became the first American to perform an EVA, but he also became the first to test a small handheld propulsion device during his spacewalk. Demonstrated progress in the human spaceflight program was essential to those designing piloted Mars missions because it showed that the human capability to live and work in space would expand so that piloted landing missions on Mars would be possible.

In addition, progress in robotic exploration was also vital to the piloted Mars planning effort. While the Soviet Union appeared to have a lead in the human arena, the United States proved that it had more reliable technology and emerged as the early leader in robotic exploration of the Red Planet. After four unsuccessful launches of what were believed to be Mars probes in 1960 and 1962, the Soviets had successfully flown a spacecraft within 120,000 miles of Mars on June 19, 1964. Unfortunately, a communications failure several months before the flyby prevented the spacecraft from sending any data to Earth. Of the two American spacecraft launched to Mars in 1964, only one successfully found its way to its intended target. On July 15, 1965, Mariner 4 flew within 6,118 miles of Mars. Mariner 4 returned 22 close-up photographs that showed lunar-style craters on the Martian surface. Data returned also included measurements of Mars' ionosphere and atmosphere, as well as surface temperature readings. As a result of these probes, the atmospheric exploration of Mars as a vital precursor to human missions had begun. The findings from Mariner 4 provided the data necessary to develop more detailed plans for subsequent human missions.[89]

Space Science Board Study

During this summer of discovery, interest in human Mars missions moved beyond the traditional groups of the NASA Centers and aerospace contractors. The Space Science Board of the National Academy of Sciences, encouraged by discussions with NASA the previous fall, convened a summer study session in June and July 1965 for scientists to discuss the future of space research. Two sessions of 2 weeks each were held at Woods Hole, Massachusetts. From June 20 through July 3, 1965, working groups met to discuss astronomy, physics, medicine and physiology, and biology. The July 5-16 session was devoted to a working group on planetary and lunar exploration. There were three objectives to the Woods Hole sessions: "first, to develop a program of planetary exploration and to recommend priority within it; second, to determine the need of astronomy in space; and, third, to consider the role of man in space research."[90]

The Space Science Board recommended that, in the period following the Apollo Program, the space goals of the nation should be directed toward planetary exploration. In the opinion of Board members, this area would offer "the most rewarding scientific objective for the 1970-1985 period." They ranked possible targets for exploration based upon target relevance to three scientific questions: "the origin of the solar system, the origin of life, and the understanding of the Earth." Using these criteria, the planet Mars was considered the most important to explore, with the Moon and Venus ranked second and third.[91]

Scientific questions for the investigation of the Red Planet were divided into six areas. Exobiology was one of the most intriguing of these, as most scientists believed that if any other body in the solar system could have supported life it was Mars. The questions posed by the biologists included the possible existence of life either in the Martian present or in the Martian past. If life had evolved on the planet, scientists wondered how it differed from that on Earth. Geologists asked questions in three different areas – differentiation, activity, and composition. They wanted to know if Mars, like Earth, was differentiated into a core, mantle, and crust. In addition, they needed data about the geologic activity of Mars including seismic, volcanic, and tectonic movement. The final area of geologic interest was Mars' chemical, physical, and mineralogical composition. A fifth area of scientific inquiry concerned the planetary history of Mars. Scientists hoped to compare events in the development of Mars with that of Earth to learn more about both planets. Finally, investigators wished to know more about the atmospheric dynamics of Mars. These questions, according to the Space Science Board, were what made the planet a primary target for scientific investigation. Board members envisioned an integrated program of exploration incorporating both robotic and piloted spacecraft.[92]

Unlike NASA, the Space Science Board did not recognize the distinction between robotic and piloted programs as an important one. Its report emphasized that scientific objectives should be used to define the nature of the mission. Therefore, representatives from all interest areas were brought together into the Working Group on the Role of Man in Space Research, which met on July 6-7 to discuss the advantages and justification for a human presence in space. The group suggested that, whenever possible, humans should be included in the exploration of the planets. Members recognized that a crew could contribute to the flexibility of a Mars mission by making scientific judgments and by carrying out multiple investigations during the course of the mission. The scientists also understood that astronauts could extend the duration of a Mars mission by monitoring, maintaining, and repairing scientific equipment.[93]

The work of the Space Science Board at Woods Hole in 1965 and their *Space Research: Directions for the Future*, published in the following year, were significant in the development of Mars exploration as a potential goal for the nation. The Board, independent of the aerospace community and NASA, reaffirmed the assertion that Mars was the next logical step after the exploration of the Moon. External support for human missions to the Red Planet had been lacking prior to the publication of this report. The prestige and objectivity of the National Academy of Sciences lent some element of legitimacy to work on such missions using scientific

rationale as justification. This may have been the support that was needed for NASA to elevate piloted Mars mission planning from the Center level up to the Agency level.

Continued Planning in 1965

While members of the Space Science Board were discussing possible human excursions to the Red Planet, several contractors issued reports on their human Mars mission plans for NASA. One such report was on the "MAVES" study conducted by General Dynamics/Convair for MSFC under contract NAS8-11327. This report, *Manned Mars and Venus Exploration Study*, published on June 8, 1965, described the project as an extension of previous studies on the topic. The report compared flyby and capture missions and a number of mission models for sending a crew of eight to Mars some time in the period from 1973 through 1990. For the study's reference mission, departure from Earth orbit was scheduled for January 17, 1982. Launch windows occurring in 1984, 1986, 1988, and 1990 were also considered. It was estimated that, based upon the 1982 departure date, the crew would arrive at Mars on July 27, 1982. Following a month in the vicinity of the Red Planet, the astronauts would depart for Earth on August 25, 1982, and arrive home on February 24, 1983. Mission duration for the longest mission considered in the study was not to exceed 1,000 days. Launch vehicles proposed for the missions included the Saturn V, a modified Saturn V, and a post-Saturn launch vehicle that was expected to be available after 1981. The report also included cost estimates for the hardware associated with mission scenarios that were considered during the study.[94]

Another study completed in June 1965 was conducted by North American Aviation's Space and Information Systems Division for the Manned Spacecraft Center (MSC). Directed by North American project manager M. W. Jack Bell, this flyby mission systems study was performed under contract NAS9-3499. The report, *Manned Mars and/or Venus Flyby Vehicle Systems Study*, described the systems necessary for a 4-person interplanetary mission using only minor changes to the Apollo command module. Mission dates considered during the study ranged from 1973 to 1979, with the primary Mars mission scheduled for launch on September 5, 1975. Based upon this launch date, the crew would take 150 days to reach Mars on February 2, 1976. The return trip would last 550 days, with the crew scheduled for return to Earth on August 5, 1977. Overall, mission duration for this scenario was estimated at 700 days.[95]

Practical work on Mars missions continued at the Center level as interest expanded throughout the Agency and beyond. Stories on the studies appeared in aerospace journals and technology magazines. Many in the space community believed that the preparatory work under way would prove productive once a plan emerged beyond Apollo for the space program. Dr. Harry O. Ruppe, an advanced planner at MSFC, explained in an interview to *Aviation Week & Space Technology* that a flyby mission to Mars could be achieved by 1979 if funding started by 1968. Following this schedule, Ruppe believed that the first human landing mission would occur in 1982. It seemed as if it was only a matter of time until the Agency would adopt a human Mars mission as its next major goal beyond a Moon landing.[96]

Despite the optimism among those involved in planning a human Mars mission, NASA managers testifying in the Congressional authorization hearings for fiscal year (FY) 1966 did not actively promote a mission to Mars as the next major goal for the nation. During the House hearings held in March 1965, the Agency introduced the idea of human planetary exploration as a possible follow-on to Apollo and suggested that, using technology developed for the Apollo Program, they could send a crew to the Red Planet as early as the mid-1970s. NASA managers explained briefly that a human Mars mission would last about 400 days, with 200 days required to reach Mars and 40 days spent in the vicinity of the planet. They then noted that, if they used nuclear rockets, mission time could be reduced to about 350 days.[97]

At the Senate hearings held the following August, a different picture of the mission emerged. NASA managers explained that extended use of Apollo hardware through the mid-1970s would cost more than $3 billion per year. However, as the costs of Apollo would be reduced as the program proceeded into the development and operations phase,[98] those representing the space agency suggested that the costs could be covered by leaving the NASA budget at $5.25 billion and shifting the excess funds from Apollo to the Apollo Applications Program (AAP) and to advanced missions. Not all witnesses shared this optimistic view. Donald F. Hornig, President Johnson's science advisor, cautioned that a human mission to Mars could cost $100 billion – five times the estimated cost of the Apollo Program. In addition, he was concerned that the longest Apollo mission was scheduled to last 14 days, while a Mars mission could last from 400 to 600 days. He suggested that more work should be done in extended missions before NASA attempted a trip of that length. Hornig also explained that the cost of space programs had to compete with other government programs in the federal budget process. His recommendation was that there were "a number of national objectives that seem more urgent." The dream of sending humans to Mars would have to wait until the nation could accept the cost without sacrificing other important programs.[99]

Von Braun's Modest Proposal

While a human Mars mission had not received the type of Congressional support necessary to establish it as the next major space program, there were still many who promoted this goal. In November 1965, Wernher von Braun reemerged as a supporter of human missions to the Red Planet. "The Next 20 Years of Interplanetary Exploration," an article published in *Astronautics & Aeronautics*, presented those in the aerospace industry with an update of von Braun's vision – a vision that had been influenced by the planning efforts of the early 1960s. In the article, von Braun discussed four planetary missions: (1) a three-person flyby of Venus in 1975, (2) a three-person flyby of Mars in 1978, (3) an eight-person mission including a human Mars landing in 1982, and (4) a short-term Mars base some time in the future.[100]

All missions discussed in the von Braun article were designed to take advantage of Apollo-based technology including a Saturn V descendant that he referred to as the MLV-3 launch vehicle. The 1978 flyby of Mars, which assumed the use of nuclear propulsion for the interplanetary journey, would take 682 days. Only two Saturn V launches would be necessary to prepare for this mission.

The Mars landing mission, on the other hand, would require 10 launches to Earth orbit and a 90-day orbital operation to prepare for departure. Spacecraft modules discussed in earlier studies – such as the Mars mission module, the Mars excursion module (MEM), and the Earth entry module – were all vital elements for the mission. The entire mission was expected to last 456 days. During the Mars stopover, four members of the eight-person crew would descend to the surface for a 20-day sojourn on the surface of the Red Planet. After 20 days, they would ascend to orbit to be reunited with their crewmates for the flight back to Earth[101].

While the first two Mars missions discussed in von Braun's article were quite similar to previously mentioned studies, the final mission scenario represented a dramatic departure from those comparatively conservative plans. To establish an extended human presence on the surface of the Red Planet, von Braun suggested that it might be easiest to use a high-risk approach. His idea was to replace the weight needed for an Earth-return capability with the logistical supplies required to support a crew of 8 to 12 people on the Martian surface for up to a year and a half. While this strategy would allow NASA to establish a base on Mars with the same number of launches as the 1982 landing mission, it would essentially mean stranding crewmembers on Mars with only the hope that Congress would fund a follow-up mission to retrieve them and transport them home. Von Braun envisioned "a little village on Mars," with six MEMs serving as crew living quarters, a laboratory, and cargo carriers. Once the retrieval mission had been approved and the interplanetary spacecraft had reached Mars orbit, the astronauts would ascend in two of the MEMs to rendezvous with their return vehicle.[102]

It is difficult to imagine that such a risky mission would have been proposed by NASA or approved by Congress. For von Braun, however, the scenario demonstrated how an extended human presence on Mars could be achieved at a cost similar to that of the Apollo Program. The tradeoff for a comparatively low-cost Mars base was to increase the risk factor. Clearly, von Braun was confident that, once the astronauts had embarked on their mission, Congress would have no other choice but to approve a retrieval mission. Needless to say, while von Braun's enthusiasm for a Mars mission was shared by many within NASA, this particular plan was never part of an official Agency plan. At the time the article was published, the future of human spaceflight beyond Apollo was still undefined.[103]

Planetary Joint Action Group

As the year 1966 began, there was still no long-range plan to guide NASA programs after Apollo. During the FY 1967 authorization hearings, held in March 1966, NASA managers offered several program alternatives as possible futures for the American space program. These included two that would have a human landing on the planet Mars as the ultimate goal. NASA's "Planetary Exploration Program" would emphasize early planetary landings with a piloted flyby of Mars in 1978 and a human landing on the Red Planet in the early 1980s. An alternative was the "Maximum Effort Program," which would emphasize "preeminence in Earth orbital, lunar, and planetary activities." In this program, the human Mars landing goal would be reached through a progression of programs: a space station, which would be operational by 1972; a lunar

base, which would be operational by 1974; piloted flybys of Venus and Mars, which would be achieved in the early 1970s; an Earth-orbital research and applications facility, which would be operational by the late 1970s; and a human landing on Mars, which would be achieved in 1980. NASA managers then reviewed the findings of mission requirements studies and system studies that had been completed in preparation for a human planetary program. They concluded by recommending to the Congress that a decision should be made as soon as possible as to which option would be adopted for the next major objective in space. An early decision would allow maximum use of the technologies and facilities developed for the Apollo Program.[104]

At this time, the Agency was already planning the AAP to extend the use of technology developed for the Moon landing. Those interested in human interplanetary expeditions sought to expand the scope of the AAP to enhance the opportunities for human missions beyond the Earth-Moon system. In several letters to Dr. George E. Mueller, Associate Administrator for Manned Space Flight, MSC Director Robert R. Gilruth expressed concern that the AAP, as planned, lacked any link to "a definite goal or direction for the future of manned space flight." Gilruth recommended that the Agency adopt the goals of establishing a permanent, piloted space station and of achieving a human landing on Mars. He then reasoned that the AAP could be redesigned so as to contribute to these goals. Otherwise, the only purpose of the program would be simply to use Apollo-era technology. In April, Dr. Robert Seamans, NASA Associate Administrator, directed the formation of a focus group of advanced planners from NASA Headquarters, MSC, MSFC, and the Kennedy Space Center (KSC). This group was given the assignment of conducting a feasibility study to determine future missions for consideration.[105]

The group divided into several subgroups, each geared toward a specific advanced program. Topical groups included the AAP Mission Planning Task Force and the Space Station Joint Action Group (JAG). Both of these groups were interested in activities within the Earth-Moon system. Two other groups focused on interplanetary missions. They were the Interplanetary Trajectory Coordination Committee and the Planetary JAG. Throughout the spring and summer of 1966, the Planetary JAG worked to design an interplanetary mission that NASA could consider for the first human expedition to the Red Planet.[106]

Initially, the Planetary JAG considered six different missions, four of them involving human missions to Mars. The first mission considered was intended for launch in September 1975. In this flyby mission, a crew of four would spend 670 to 680 days on their round-trip. Another four-person flyby, lasting 670 to 695 days, was considered for launch in November 1977. The third mission of interest to the JAG was a dual-planet flyby of both Venus and Mars. Based upon a launch date in November 1978, the crew of four would pass around the Red Planet in October 1979. The entire mission would last approximately 510 days. Finally, a human Mars landing mission including a Venus swing-by was discussed by the group. In this scenario, a crew of eight would launch in January 1982 for a mission of about 567 days. The crew would use nuclear propulsion to arrive at Mars in September 1982. During their Mars stay, four of the eight crewmembers would descend to the surface where they would remain for 28 days.[107]

By the beginning of the summer, members of the Planetary JAG agreed to pursue planning of the 1975 flyby mission. While it was understood that this mission would not be included in NASA's 1968 budget request so as not to detract from the AAP, participants were optimistic that the flyby would be defined in a formal project development proposal (PDP) by August. The group also agreed to defer planning of the human Mars landing mission to a later JAG, while emphasizing that such a mission would be the follow-on to the flyby and, thus, would define the goals of their mission. Not everyone in NASA was pleased with this decision. When the preliminary PDP was distributed in August 1966 to the Center directors for comment, MSC's Robert R. Gilruth voiced objections. In his letter to Dr. George E. Mueller, Gilruth cautioned against the promotion of a "flyby project as a goal in itself." His rationale was that a flyby, because it could be achieved with only minor technological advances beyond those of the Apollo Program, would not stimulate the development of the new technology necessary for a robust human space program. He argued that landing a crew on Mars was the type of mission that should be emphasized as the long-term goal of the program. Included with Gilruth's letter was a proposed addition to the document. This addition, entitled "Long-Range Program Evolution," defined three goals for NASA's human space program: (1) a permanent Earth-orbiting space station, (2) a lunar base, and (3) human exploration of the surface of Mars. The proposed section concluded by defining the AAP as "the transition between Apollo and all three future goals for manned spaceflight."[108]

When members of the Planetary JAG issued their summary report on October 3, 1966, they outlined an integrated planetary exploration program eventually leading to a human landing on the Red Planet. This report, entitled *Planetary Exploration Utilizing a Manned Flight System*, linked the group's flyby mission proposal directly to expected advances in human Earth-orbital operations and robotic exploration of the planets, as well as to the follow-on human Mars landing mission. Their plan cited the recommendations of the National Academy of Science's Space Science Board that NASA should use a combination of robotic and piloted missions and that the primary target for exploration should be the planet Mars. Besides the scientific objectives and technological benefits of such a mission, the report also noted another potential benefit from pursuing the human exploration of Mars – an increase in national prestige. JAG team members suggested that the first piloted mission to the Red Planet would be a good addition to America's bicentennial celebration.[109]

Launch windows for the type of low-energy flyby mission described in the report appeared every 25 months. The mission planned by the Planetary JAG was scheduled for launch during the window beginning on September 5, 1975, and running through October 3, 1975. If the crew followed this schedule, they would pass within 300 to 400 km of Mars in late January or early February 1976. The entire mission would last between 670 to 683 days, and would return to Earth in July 1977.[110]

Four launches of upgraded Saturn V vehicles would be needed to assemble the spacecraft in Earth orbit. The crew portion of the ship was designed to use a modified Apollo command module supported by a command service module. Three Saturn IVB stages were to be used to boost the spacecraft into its interplanetary trajectory. During the journey to Mars, the crew was

to conduct a number of astronomical observations – including the study of the Sun. When they reached the vicinity of Mars, they would also study the Martian moons, Phobos and Deimos. A number of robotic probes were to be carried by the spacecraft to enhance data-gathering capabilities once the crew arrived at Mars. Aerodynamic drag probes were to be used to test atmospheric entry systems, and an orbiter probe was included to photograph the surface of the planet. The plan also included two probes designed to land on Mars. One probe, designated the lander probe, was intended to photograph the landscape and relay information about weather on the Red Planet. The other probe, a Mars surface sample return probe, was to be used to collect Martian soil and to return the soil to the crew in orbit.[111]

To follow the 1975 mission, the report recommended additional flyby missions of Mars or of Venus. The team indicated that, by the 1980s, NASA would have gained experience in interplanetary flight and would have developed the technology necessary to attempt a human Mars landing mission. They estimated that this mission could be completed in fewer than 600 days, including up to 60 days in orbit and 10 to 40 days spent on the surface of the Red Planet.[112]

Of all the mission scenarios and reports generated before 1967, the work of the Planetary JAG was one of the most significant. It was the first human Mars mission study conducted as part of an Agency-wide effort. The team was composed of representatives from NASA Headquarters and from the three Centers responsible for human spaceflight – MSC, MSFC, and KSC. Other Centers were consulted when their expertise was required for the effort. The advantage of this approach was that the team was able to achieve a balance between the interests of the different NASA Centers and, thus, provide a more comprehensive view of what an integrated planetary exploration program would look like. Copies of the report were forwarded to the President's Science Advisory Committee (PSAC) Space Science and Technology Panels, and the findings were presented to the National Academy of Sciences Space Science Board. Details of the proposed mission were described to the public in an article published in the November 28, 1966, issue of *Technology Week*. Following release of the report, the JAG team continued to meet to refine their findings and to provide input for the budget hearings scheduled for May 1967.[113]

Report of the President's Science Advisory Committee

By the end of 1966, NASA had completed both the Mercury and Gemini Programs and had demonstrated the capability for two spacecraft to rendezvous and dock in orbit. Progress on the Apollo Program indicated that NASA would have no trouble meeting Kennedy's challenge within the prescribed time frame. The PSAC Panel for Space Science and the PSAC Panel for Space Technology, to plan for the post-Apollo period, met to conduct a joint study on what space goals should be considered for the 1970s. The panels received input from a number of sources including the reports of the National Academy of Sciences Space Science Board and NASA's JAG.

One of these reports, *The Space Program in the Post-Apollo Period*, published in February 1967, suggested that U.S. space activities in the next decade would fall into two categories: "practical

uses of space, and space exploration, including space science." Of the two areas, exploration was seen as the primary rationale for the nation's space program. The panels echoed the Space Science Board by presenting three questions for investigation – (1) the search for extraterrestrial life, (2) the origin and evolution of the universe, and (3) the study of the other planets in the solar system. They agreed with the Space Science Board that a combination of robotic and piloted spacecraft would be required to discover answers to these questions. In addition, they asserted that human exploration of the planets would be an appropriate long-range goal for the U.S. space program.[114]

As they considered new goals for the American space program, panel members acknowledged that a single project such as a human Mars mission might be comparable to the Apollo challenge. However, they also recognized that much had changed since President Kennedy outlined the nation's space program for the 1960s. The panels concluded that, for the next decade, it would be more appropriate to pursue a balanced program of multiple goals, all leading toward the long-term goal of a human Mars mission. First, their recommendations suggested that the lunar exploration program should be expanded to build upon the capabilities developed for the Apollo missions. Second, the panels called for a program of robotic planetary exploration designed as precursor missions for eventual human planetary activities. Third, they recommended the development of the capability for long-duration human spaceflight such as the one that would be involved in piloted flights to the planets. Fourth, they urged that the nation's space capabilities should be exploited for national security purposes and for economic and social gains. Finally, panel members, in their report, listed the objective of exploiting the near-Earth environment, including the Moon, for the advancement of the sciences, including astronomy.[115]

In a detailed discussion of planetary exploration, the panels noted that the lack of a NASA-integrated exploration plan created confusion about the future of planetary exploration. After comparing NASA's plans for the robotic Voyager[116] mission – designed to land a spacecraft on the Red Planet in the mid-1970s – and the JAG proposal for a human flyby mission during the same period, panelists questioned how the presence of a crew would contribute to the mission. They felt that the mission designed by the JAG lacked a significant role for astronauts in the scientific investigation of Mars. For this reason, the report recommended that NASA's resources for the study of the Red Planet during the 1970s should be used for the Voyager Program instead. They also suggested that NASA should immediately develop an integrated planetary exploration plan that included an effective role for humans in planetary missions. They emphasized that their skepticism about the role of a crew in a flyby mission should not be interpreted as opposition to human planetary exploration. Instead, they emphasized that piloted missions should be planned to compliment robotic missions, using human crews to achieve scientific aims that could not be met using robotic spacecraft.[117]

CHAPTER 6

THE AGE OF APOLLO

Loss and Disappointment

The President's Science Advisory Committee (PSAC) report received little attention in the press. Shortly after President Johnson signed his letter of introduction to the report, a catastrophe stuck the Apollo Program and placed the future of NASA's human spaceflight program in jeopardy. During a preflight test, the crew of the first Apollo mission was killed as they sat on the launch pad when fire erupted in the command module. NASA immediately began a full investigation of the incident under the direction of Floyd L. Thompson, Director of the Langley Research Center (LaRC). As the public and the press wondered about the cause of the tragedy, space committees in both the House and Senate allowed the NASA investigation board time to complete its work. The board's findings revealed a number of oversights and errors that, combined with the pure oxygen atmosphere used in the command module, appeared to be an accident waiting to happen. Throughout the months that followed the fire, NASA and contractor engineers examined every system associated with the Apollo command module. By the time Thompson and other NASA officials briefed the House Space Committee on their findings in April 1967, NASA's image had been severely tarnished. Congressional investigations of the accident followed, and NASA Administrator James Webb found Congressional support for NASA to be significantly damaged. The PSAC report had been nearly forgotten by the aerospace news media.[118]

As Thompson and his team investigated the Apollo 1 fire, authorization hearings for fiscal year (FY) 1968 started in the House of Representatives. Dr. George E. Mueller, Associate Administrator for Manned Space Flight, explained the importance of the Apollo Applications Program (AAP) to the House Committee on Science and Astronautics, citing it as a way to keep the momentum of technology development going after the Apollo Program. He also discussed briefly the possibilities for human spaceflight beyond AAP, such as human planetary missions. Above all, he recited the "party line" that NASA's objective was to maintain a balanced program of robotic and human spaceflight and exploration. Mueller stressed that, just as the Apollo missions relied on data from early lunar probes such as the Lunar Orbiter and Surveyor spacecraft, robotic missions such as the planned Voyager Mars landing mission would be vital to the future human exploration of the Red Planet.[119]

While Mueller was cautious about promoting to Congress a human mission to Mars, it was well known that he wanted such a mission to be included in NASA's planning for the future. Other key managers who supported Mueller's position were Franklin P. Dixon and Edward Z. Gray, who both managed advanced mission studies for the Agency. Dixon and Gray, who had worked on earlier contractor studies for human missions to Mars, continued to push for the human Mars program to be elevated to a top Agency goal. They insisted that human exploration of the Red Planet would be the logical follow-on to the Apollo Program and would benefit greatly from the projects of the AAP. In addition, they stressed that initial funding for such a mission would have to begin by FY 1969 if they were to take advantage of the capabilities developed for Apollo.

They believed that the first human flyby of Mars could be achieved in 1975 with very little new technology required. The only impediment to the program was the need for NASA to persuade Congress to fund the effort. Despite their appeals, NASA Administrator James Webb was not convinced, and NASA policy continued to be that the direction of America's human space program would be determined by the White House and the Congress.[120]

White House support was elusive. Dr. Nicholas E. Golovin of the President's Office of Science and Technology suggested that at least 7 years of work would be necessary before a human Mars commitment could be made. Golovin believed that information on the atmosphere and surface of Mars must be obtained before the Agency could define clearly the requirements for a landing mission. This data would not be available until after the planned 1973 Voyager lander reached the Red Planet. Both flyby and landing missions would have to wait until more was learned about the psychological and physiological effects of extended spaceflights on humans. It was obvious that longer flights would have to occur before that data could be collected. Opposition also came from Dr. Edward C. Welsh, executive secretary of the National Aeronautics and Space Council. Welsh noted that the situation was different from what it had been when Kennedy issued his lunar challenge. He also asserted that the space program would continue moving in the right direction even without a new goal such as placing a human on Mars.[121]

By August 1967, it became clear that Congress was not going to provide a mandate or funding for a human expedition to Mars. Budgetary problems caused by the escalating war in Southeast Asia and urban unrest, plus a lack in confidence in NASA's capabilities after the Apollo fire, all created an environment where funding for a new, expensive space program was difficult to justify. Not only was funding denied for new programs, the Agency's budget was reduced by $234 million. The Voyager landing mission to Mars was among the programs eliminated by Congress. That program, plagued by cost overruns, was a prime target for cancellation. This was a definite blow to those counting on this precursor mission to provide the data necessary to define a future human landing mission on the Red Planet. Ironically, the efforts of these planners may have contributed to the loss of Congressional support that NASA suffered at this time.[122]

One example of lost support was the case of Representative Joseph E. Karth. Karth, a Democrat from Minnesota, had defended the Voyager Program even when others on Capitol Hill wanted to cancel it. However, as the estimated costs of the program escalated, he warned NASA to improve management of their programs and program planning. Congress also warned the Agency not to start any new programs without Congressional approval. In late summer of 1967, Karth was infuriated when the Manned Spacecraft Center (MSC) issued a request for proposals (RFP) from industry for a study of piloted Mars and Venus spacecraft. Congressman Karth criticized planning for human missions to the Red Planet as a waste of the taxpayers' money. He declared that, "very bluntly, a manned mission to Mars or Venus by 1975 or 1977 is now and always has been out of the question – and anyone who persists in this kind of misallocation of resources at this time is going to be stopped." MSC withdrew the RFP, but the damage had been done – NASA had alienated even its own supporters. Congress, which was determined to cut the budget and bring advanced mission planning under control, not only cut funding to NASA that

could have been used to plan future human Mars missions, but also funding for the robotic precursor mission as well.[123]

Studies in 1967 and 1968

Despite Karth's admonition, a number of studies already under way began to reach conclusion during 1967. The appearance of these studies kept the debate alive throughout the aerospace community. Offices at MSC and other NASA Centers continued working on the Joint Action Group's (JAG's) mission planning project, and some studies already in progress before the Congressional restriction were completed by NASA contractors. One contractor study completed in 1967 compared different Mars and Venus flyby mission concepts based upon Apollo and Saturn technology to determine which were the best options. This study, performed by North American Aviation for the Marshall Space Flight Center (MSFC) under contract NAS8-18025, also showed that the presence of a crew on a flyby mission would contribute significantly to the science and engineering data collected during a mission. The study team, working under the direction of North American project manager A. L. Jones, produced a report titled *Study of Manned Planetary Missions Based on Saturn/Apollo Systems: Final Report* in August 1967.[124]

During the study, the North American team examined 6 multi-planet and 10 single-planet flyby opportunities which would occur in the 1975-1982 period. They noted that, for a mission to be launched during the 1975 and 1976 launch windows, funding and hardware procurement would be necessary by 1969 and by 1970. This factor influenced their decision to select missions for the late 1970s. While crew sizes of three to six astronauts were considered, they recommended that a crew of four astronauts would be ideal. Their initial target mission was to be a 1976 dual-planet flyby mission. This mission would launch from Earth on October 27, 1976. Venus flyby was scheduled for June 16, 1977, and Mars flyby would take place on December 21, 1977. The crew would return to Earth on October 13, 1978, after 716 days in space. An alternative for the first flyby mission was also included in their recommendations. This alternate scenario, a three-planet flyby, would launch on February 26, 1977. The flight would reach Venus on June 20, 1977, pass by Mars on December 22, 1977, and have a second flyby of Venus on August 28, 1978. After 676 days, the crew would return to Earth on January 3, 1979. Finally, North American's report recommended a second flyby mission that would launch on December 8, 1978. After a Venus flyby on May 17, 1979, and a flyby of Mars on January 12, 1980, the astronauts would arrive back on Earth on September 19, 1980, after a 651-day mission.[125]

Launch vehicles considered for the missions included the Saturn V developed for the Apollo Program as well as modified Saturn concepts. The North American team examined a number of spacecraft configurations including some that were designed to generate artificial gravity. They also discussed scientific, biological, and engineering experiments that could be performed by the crew during the interplanetary portions of the journey. Once in the vicinities of Venus and Mars, the astronauts would study the planets and release specially designed probes to gather detailed data. For those interested in human Mars landing missions, the most significant probe would be the Mars surface sample return (MSSR) spacecraft – a robotic spacecraft that would descend

to the surface, guided by the crew who could make last-minute corrections during the landing process. Once on the surface, the MSSR would collect surface data and samples that would be returned to the waiting astronauts. During the return trip to Earth, the crew would perform preliminary analysis on the samples.[126]

Early in 1968, several studies related to human Mars mission planning came to a conclusion. One was a 14-month project to determine what types of human missions to Venus and Mars could be completed by using common flight hardware and to define the hardware requirements and capabilities. This work was conducted by Boeing for LaRC under contract NAS1-6774. Boeing's final report, entitled *Integrated Manned Interplanetary Spacecraft Concept Definition*, considered Mars missions for the period 1975 though 1990. The study team found that it was feasible to conduct a variety of human planetary missions using common hardware and recommended that NASA should adopt a policy of integrated program planning to ensure that spacecraft designs were developed with alternate uses in mind. Another finding reported by Boeing was that the lack of an overall exploration plan for the Agency created a problem for those involved in advanced human mission planning. They recommended that the Agency develop such a plan as soon as it was reasonable to do so.[127]

Another study, initiated in October 1966, surfaced in January 1968. This study examined experimental tests for a piloted Mars excursion module (MEM). Work on the study was conducted by North American Rockwell's Space Division between October 1966 and August 1967 under the direction of Rockwell project manager G. S. Canetti. The final report, *Definition of Experimental Tests for a Manned Mars Excursion Module*, was published on January 12, 1968. This work was performed under contract NAS9-6464 for MSC. During the study, the Rockwell team examined a landing spacecraft for a human Mars mission during the 1980s. This was the first study to incorporate the data on the Martian atmosphere collected by the Mariner 4 spacecraft. Because the atmosphere of the Red Planet was found to be much thinner than was assumed during earlier studies, this team reexamined and updated earlier work performed to define the MEM. They considered a mission for two astronauts to descend to the surface for a 4-day stay, but determined that a four-person crew and a 30-day duration on Mars was the most advantageous. The objectives of their study were to develop conceptual designs for the module and test requirements for qualifying the spacecraft for flight. They did not consider the launch vehicles for the mission or the interplanetary portion of a human mission to Mars.[128]

The Rockwell report indicated that the MEM could be made operational for a 1982 Mars landing provided that Phase D (development and operations) of the program was initiated in 1974. For this mission to be feasible, additional robotic missions to acquire additional data on the surface and atmosphere would have to be launched by 1977. Development on the engines and other subsystems would have to begin as early as 1970 to make the 1982 deadline. The cost of the spacecraft, according to the report, could range from $4.1 to $5.6 billion depending on the final spacecraft design.[129]

Several articles published about the study noted that it would likely be the last human Mars study conducted for some time. These articles discussed the political climate and noted that human missions to Mars, although technologically feasible, remained a project for the future due to the social and economic problems facing the United States. During Congressional budget hearings for FY 1968, held in February 1968, Dr. George Mueller again emphasized the AAP for future mission funding. While Mueller mentioned interplanetary missions and discussed what had been learned from the studies conducted during the 1960s, he assured the Congressmen that "In view of the information presently available in this area and the decrease in available resources, there will be little or no Manned Planetary Mission study effort during Fiscal Year 1969."[130]

Changes in Direction

While 1968 was the last year for human Mars mission contractor studies to be completed, it was also a turning point for NASA planning efforts. Planners at MSC considered contributions that the Center could make to support robotic planetary exploration missions. In addition, some at MSC began working on a draft advanced planning program for the Center. Their conclusion was that significant future planning on a programmatic level could take place only at NASA Headquarters. Another problem, according to the report, was that each office in NASA conducted its own planning efforts with no coordination among them to develop an overall Agency plan.[131]

Several events in late 1968 changed the Agency's direction on long-range planning. NASA Administrator James E. Webb was disheartened by the failure of the White House and Congress to provide for the future of the Agency. He had been concerned that the lack of a mandate for the Agency would jeopardize NASA's ability to retain the capabilities developed for the Apollo Program. This fear was realized when, in August 1968, he had no other choice but to disapprove a contract for the "long lead time items" that would be required to continue the Saturn launch vehicle assembly process. This action insured there would be no more than 15 Saturn V vehicles produced. On October 8, Webb retired from NASA. He had been an opponent of long-range planning, so his resignation created an opportunity for those who believed that the Agency should be more active in this area. His successor was Deputy Administrator Thomas O. Paine, who was named Acting Administrator. Paine was an open proponent of advanced mission planning at the Agency level. Shortly after Webb's resignation, the first human flight of an Apollo spacecraft using the Saturn IB launch vehicle occurred on October 11, 1968. With the Apollo 7 mission, the human program was back on track and once again it looked as if Kennedy's deadline would be reachable. In November 1968, the election of Richard M. Nixon as President of the United States appeared to signal a new era of planning for the future of the human space program. Many proponents of human Mars missions hoped that the new Administration would be more receptive to the idea of human exploration of the Red Planet.[132]

Prior to his inauguration, President-elect Nixon appointed a transition task force on space similar to that appointed by President-elect Kennedy. The purpose of the review was to provide recommendations on the future of the nation's space program. Nixon chose Nobel Laureate

Charles Townes of the University of California at Berkeley to head the 13-member team. The group's report was sent to the President-elect but, unlike the Wiesner Report, was never released to the press or to the public. This *Report of the Task Force on Space*, dated January 8, 1969, recommended against a commitment to a future planetary flight such as a piloted mission to Mars. They warned that such a commitment would endanger the Agency's ability to achieve a balance between piloted and robotic programs. However, they did advise that the nation continue the human spaceflight program through the AAP and continued lunar exploration.[133]

Space Task Group Formed

Shortly after the new President's inauguration, it became clear that a decision had to be made on the future of the space program after Apollo. Initially, it seemed that a review effort would be the responsibility of Lee DuBridge, Nixon's new Science Advisor. However, because DuBridge had clashed with James Webb in the past, NASA made it clear to the President that it opposed placing the fate of the Agency in DuBridge's hands. As a compromise, Nixon assigned the task to Vice President Spiro T. Agnew who, as chair of the National Aeronautics and Space Council, seemed the logical choice. In a memo dated February 13, 1969, Nixon asked Agnew to work with the Secretary of Defense, the Acting Administrator of NASA, and the Science Advisor to develop a coordinated program and budget proposal by September 1, 1968.[134]

While his predecessor would have been comfortable with the concept of an independent commission determining the future of NASA, Thomas Paine believed that the Agency should do its own long-rang planning. Accordingly, on February 26, he sent a memorandum directly to the President detailing what he thought were the priorities for human spaceflight. He pushed for a permanent piloted space station and suggested that Nixon could instruct the Space Task Group (STG) to include proposals on what the best program could be for achieving that goal. President Nixon was not swayed by Paine's appeal and responded that determination of space goals would wait until after he received the report of the STG in September.[135]

Integrated Program Planning

In the meantime, planning activities at NASA Headquarters continued. During 1968, Associate Administrator Homer Newell had initiated an Agency-wide planning effort that used a decentralized approach. This endeavor was continued in 1969 with 12 topical planning panels engaged in the activity. Each panel addressed an aspect of NASA's work such as planetary exploration, lunar exploration, or human spaceflight in Earth orbit. Membership was drawn from personnel assigned to NASA Headquarters and all relevant field Centers. The work of all of the panels was coordinated by a planning steering group (PSG) made up of Headquarters employees. A planning review committee – which included the Agency's Associate Administrators, selected Headquarters staff, and the directors of each NASA Center – oversaw the entire effort. The goal of Newell's planning venture was to develop a "long-range planning prospectus" by the end of the year as well as interim planning recommendations to be used in FY 1971 budget proposals.[136]

By May 1969, the PSG was working to compile the input from the panels into both a long-range plan and several alternative short-term plans. When they briefed NASA Administrator Thomas Paine on May 27, they offered him two options: (1) a "maximum effort" plan, including all of the challenging programs that were suggested by the panels, and (2) a PSG reference plan. Paine was disappointed by the plans. He instructed the group to develop a core program that would guide the Agency through the next decade and beyond. After a month of work, the planners presented Paine with a proposal that included significant goals for the human space program for the 1970s. These included construction of several space stations, development of the space shuttle, and establishment of a lunar base.[137]

Paine finally had a plan that included all of the elements he had asked for, but he was not yet satisfied with the way the programs related to one another. He turned to an integrated planning approach initiated by George Mueller in March 1969 as an alternative approach to Newell's effort. Mueller's method merged robotic and piloted programs into an integrated plan that gave a comprehensive view of the space program. Integrated planning allowed the Agency to show the interrelationships between missions that, when viewed as a whole, made up an ambitious program of solar system exploration. The plan emphasized the need for commonality among spacecraft systems designs and for flight operations among all NASA programs.[138]

An Integrated Program of Space Utilization and Exploration for the Decade 1970 to 1980 was the result of Mueller's planning activities. This report emphasized that any future NASA program "must represent the results of a deliberate assessment of the national contributions to be made by the total Agency program and of the role to be fulfilled by the various program elements." In justifying the space program, the plan noted that the Agency contributed to the nation's preeminence, national defense, economy, technological innovation, and advancement of science. Eight post-Apollo program elements were identified for the approaching decade. Several of these were relevant to developing the capabilities for a future human Mars mission: robotic exploration of the planets as a precursor to eventual human planetary missions, extension of human spaceflight for long-duration missions, reduction of operational costs, and the development of space technology.[139]

The plan showed the progression through the AAP to the development of new hardware such as a space station, a space tug, and space vehicles – all elements that von Braun had identified decades earlier as contributing technologies to enable a human expedition to Mars. Robotic precursor missions to Mars identified in the plan included two Mars-Mariner flyby missions, launched in early 1969; two Mars-Mariner orbiter missions, scheduled for 1971; two Viking soft-lander missions that the Agency wanted to send to Mars in 1973; and a Mars rover mission planned for 1979. By the end of the 1970s, the planners expected to have enough data on the Red Planet that they could implement a human landing on Mars in the 1980s.[140]

However, the report recommended against one specific mission as the goal of the planetary exploration program. The Planetary Exploration Planning Panel suggested a broader goal – "to understand the origin and evolution of the solar system, the origin and evolution of life, and the

dynamic processes that shape man's terrestrial environment." They then stated an objective toward meeting this goal that would "utilize the unique capabilities of man for *in situ* exploration of the planets." Within the context of this objective, the Agency was to develop all of the capabilities required to send humans to the surface of Mars.[141]

NASA planners, in developing an integrated plan, hoped to avoid the type of criticism that they had received for previous planning efforts. The report emphasized that NASA should pursue a balanced program of both robotic and piloted exploration with broad goals, rather than another Apollo-type goal. Citing the recommendations of NASA's Science and Technology Advisory Committee (STAC),[142] the integrated plan concluded that during the next decade the Agency could develop the nation's spaceflight capabilities, while maintaining the balanced program recommended by the STAC. The plan, combined with the results of Newell's formal planning effort, provided a basis for NASA's input to the STG.[143]

Man on the Moon and Other Achievements

The summer of 1969 saw the realization of Kennedy's dream and an increase in the expectations of those involved in planning future missions. Several Apollo missions flown earlier in the year had completed the testing of the Apollo system, and the stage was set for a Moon landing. Vice President Agnew took advantage of the Apollo 11 launch to proclaim his support for a human Mars mission. He addressed the press gathered to watch the beginning of the first lunar landing mission on July 16, 1969, and suggested that a human landing on the Red Planet should be the next long-range goal for the U.S. space program. "It is my individual feeling that we should articulate a simple, ambitious, optimistic goal of a manned flight to Mars by the end of this century," Agnew said. He stressed that he did not speak for the Administration and that it was not certain that the President would support such a goal. Four days later, on July 20, 1969, the entire world seemed to pause to watch the first human beings set foot on the Moon. Astronauts Neil Armstrong and Edwin "Buzz" Aldrin demonstrated that humans could land and explore other bodies in the solar system, and the successful splashdown of the crew proved that it could be done safely.[144]

Other events focused attention on possible Mars efforts. In addition to the successful human Moon landing, two robotic spacecraft successfully flew past Mars and returned a wealth of data to scientists on Earth. The two Mariner spacecraft, launched in February and March 1969, added a great deal to what was known about the Red Planet. As Mariner 6 passed within 3,431 km (2,131 mi.) of Mars on July 31, 1969, it photographed the surface and took measurements on the environment of Mars. Mariner 7 flew by the Red Planet on August 5, 1969, passing within 3,430 km (2,130 mi.) of the planet. Together the Mariner spacecraft returned several hundred photographs and took close-ups of 20% of the Martian surface. They also measured the daytime and nighttime temperatures on the surface, and reported on the composition of the atmosphere.[145]

August 1969

During August 1969, discussion of human missions to Mars increased on several levels. NASA Administrator Thomas O. Paine started the debate by announcing that the U.S. could place a human on Mars by 1982, noting that such a mission would only require the will of the nation to do it. When Paine met with the other members of the STG on August 4, 1969, he explained that NASA had already established that a human landing on Mars could be achieved in the early 1980s. He then introduced Dr. Wernher von Braun, who presented his vision of a human mission to the Red Planet to members of the group. Von Braun explained that the integrated program for the 1970s, which NASA had recently presented to the STG, would provide the technology and capabilities necessary to launch a human crew to Mars on November 12, 1981. Following a 270-day interplanetary flight, the crew would enter orbit around Mars on August 9, 1982. During 80 days spent in obit, they would send a robotic sample-return spacecraft to the surface to retrieve samples. After analysis of the samples determined that it was safe for a human landing, a portion of the crew would descend to the surface of the Red Planet in the MEM. Once the landing team had rendezvoused with crewmates in orbit, the spacecraft would begin its return trip on October 28, 1982. During the flight home, the crew would swing by Venus and launch a probe towards that planet. Earth arrival was scheduled for August 14, 1983, nearly 2 years after the mission began. When von Braun presented the same mission to the Senate Committee on Aeronautical and Space Sciences the next day, he was careful to explain that the dates given in the briefing were for program planning purposes and should not be construed as a "hard sales proposal" for a 1982 mission. He also suggested that the mission could be conducted using either one or two 6-crew spacecraft so that the total crew size would either be 6 or 12 astronauts. The 2-ship option provided the best chance for success, because one ship could return all 12 crewmembers to Earth in the event that one ship was disabled. Launch vehicles for the mission would be based upon the Saturn V, and interplanetary propulsion would use the NERVA [nuclear engine for rocket vehicle application] engine under development.[146]

When NASA Associate Deputy Administrator Willis H. Shapley tried to set up a similar von Braun briefing to the House committee, he found the reception to be less than enthusiastic. In a memo to Paine on August 7, Shapley reported that "Chairman Miller's attitude seems to be basically that we are making a big mistake in even talking about manned flight to Mars at this time and may stand to lose on what we might otherwise gain out of the success of Apollo 11." As the discussion of future missions continued on the floor of the House of Representatives, Committee Chairman George P. Miller (D-Calif.) stated that he did not oppose a future mission to the Red Planet, but felt that it would be premature to set a timetable for such a mission. He recommended that the nation should pursue a "well-chosen set of intermediate steps and give the Mars goal a great deal more study before we decide if, how and when we should take the next great leap forward for mankind." Other Congressmen were more critical of the human Mars goal, suggesting that the mission was inappropriate even as a long-term goal when other national priorities were taken into consideration.[147]

Congressmen were not the only critics to voice objection to a human Mars landing mission. A number of prominent scientists publicly stated that it was too early to establish such a goal. Among these were Dr. Eugene Shoemaker and Dr. Bruce Murray of the California Institute of Technology. Both scientists suggested there was no reason why a human landing on Mars should be an immediate goal. They recommended that the space program should instead pursue scientific objectives closer to Earth and that the human Mars landing should be deferred to a later date.[148]

America's Next Decade in Space

NASA's report to the STG, delivered to Vice President Agnew on September 8, 1969, was unaffected by criticism of human Mars missions. Entitled *America's Next Decade in Space: A Report for the Space Task Group*, the report outlined three options for the nation's future in space. The ultimate goal of all three programs was to be "the exploration of the solar system, with men and machines." The Agency's report suggested that the goal of human expeditions to the planets in the 1980s should be used to focus the space program during the 1970s. Many familiar elements were to be included in the plan: a permanent piloted space station, a low-cost space transportation system, extended human exploration of the Moon, continued robotic exploration of the solar system, and a human expedition to Mars as early as 1981. Above all, the report recommended that the nation pursue "the kind of course that will both keep America at the forefront of space exploration and development, and also provide a steady flow of returns in science, applications, and technology from our national investments in space."[149]

The report offered three viable program options for the STG to consider. For comparison, it also included a "maximum rate" schedule that showed what could be achieved with unlimited funding. This schedule showed the first space station in 1975, as well as an Earth-to-orbit space shuttle. Initial human exploration of Mars was believed possible in 1981. The three programs which NASA recommended contained the same elements, but allowed for different rates of development to meet major goals. Program I was the most vigorous, placing the station and shuttle in 1976 and scheduling the human mission to Mars in 1983. Programs II and III delayed the station and shuttle until 1977. However, while Program II set a date of 1986 for a human Mars mission, Program III left this an open-ended goal. NASA's plans as described in this report formed the nucleus of the STG's recommendations to the President.[150]

The Post-Apollo Space Program

On September 15, 1969, the STG presented its report to President Nixon. In *The Post-Apollo Space Program: Directions for the Future*, the group offered several options for a balanced space program after Apollo. The STG recommended that the United States should "accept the basic goal of a balanced manned and unmanned space program conducted for the benefit of all mankind." To achieve this goal, the group recommended program objectives in five areas: (1) expansion of the space applications program; (2) enhancement of the defensive posture of the U.S. through space technology; (3) extension of human knowledge of the universe;

(4) development of new systems and technology which emphasize commonality, reusability, and economy; and (5) promotion of international cooperation in space.[151]

In this report, the STG acknowledged that phasing out human spaceflight would be the only way to significantly reduce the size of the NASA budget over a long period. However, they "concluded that a forward-looking space program for the future for this Nation should include continuation of manned space flight activity." The group stressed that there was a high degree of public interest in the human space program. There were also other benefits to using humans in the exploration of space – "the presence of man in space, in addition to its effect upon public interest in space activity, can also contribute to mission success by enabling man to exercise his unique capabilities, and thereby enhance mission reliability, flexibility, ability to react to unpredicted conditions, and potential for exploration."[152]

Not only did the STG recommend the continuation of NASA's human spaceflight program, they also suggested the adoption of a new long-range goal through which the Agency could focus the human program. They noted that NASA had demonstrated the ability to land an astronaut on Mars within 15 years. In their report they therefore advocated that the United States should adopt a long-range goal of sending humans to the Red Planet by the end of the century. However, unlike the Kennedy challenge that started the Apollo Program, this goal would not be the single focus of the space program. Rather, the STG recommended that the Mars goal should be part of a balanced program of space exploration and utilization using both robotic and piloted spacecraft.[153]

The report offered five program options for the future space program. While the goals and objectives presented in most of these options were basically the same, there were significant differences in the level of commitment to the programs. At one extreme was the "upper bound" effort limited only by technology. This scenario, following the assumption that with unlimited resources the only constraint would be the rate of technological development, showed that NASA could have a space station and an Earth-to-orbit space shuttle by 1975, and could send the initial human expedition to Mars by 1981; but this program plan was included in the report only for comparison purposes. There were three viable options put forward by the STG. The first, Program I, showed the space station and space shuttle in 1976 and the initial Mars mission in 1983. Programs II and III both placed the same emphasis on the station and shuttle programs, scheduling them for 1977 – only 2 years later than the maximum pace plan. However, Program II placed the human Mars goal for 1986, while Program III left this an open-ended goal. Finally, the report offered a "low level" program that would end the human space program after the completion of the Apollo Program and the AAP. As with the "upper bound" option, this last option was included for comparison purposes and was not recommended by the STG. In conclusion, the STG report suggested that any of the three programs would be appropriate for the future U.S. space program. Beyond this, the group did not recommend which plan the President should select.[154]

When President Nixon met with the STG on September 15, 1969, he concurred with their suggestion to reject the two extreme options – a crash program to go to Mars or the complete elimination of the human spaceflight program. However, he did not immediately endorse one of the three options. Nevertheless, the press interpreted Nixon's acceptance of the report as an endorsement of a human Mars goal at least for the distant future. Those in the aerospace industry anticipated that the NASA budget would soon reflect the President's support, ensuring that the Agency would begin developing the integrated space program that would eventually lead to a human expedition to the Red Planet. One article reported that a human Mars landing, planned over a 12-year period, could be accomplished for approximately $16.46 billion – less than the $21.1 billion cost of the Apollo 11 Moon landing.[155]

As the press speculated about the space budget, President Nixon received advice from several sources about how he should proceed. NASA Administrator Thomas Paine sent a letter to the President on September 19, 1969. In it, Paine recommended that Nixon select Option 2 – "a balanced and challenging program which includes as major objectives the earth-orbiting space station, space shuttle and nuclear stage in the 1970s, leading to a manned mission to Mars in the 1980s." Budget Director Richard P. Mayo did not agree with Paine's recommendation, however. In a memorandum dated September 25, 1969, Mayo noted shortcomings in the STG report and suggested that Nixon should not make his decision based upon the report alone. Among the failings identified by Mayo was the emphasis on human spaceflight, a lack of comparison of the space program to other national priorities, and the absence of any economic context within which the program would occur. He cautioned the President that the report had been written so that choosing any of the three options would imply a commitment to a new major human space project. Finally, Mayo suggested that the cost figures provided by the STG had seriously underestimated the cost of the future space program.[156]

During the months following the release of the STG report, Nixon consulted with other advisors about his course of action. It is possible that the President was influenced in his final decision by a public opinion poll that was published in the October 6, 1969, issue of *Newsweek*. In a memorandum to the President, Presidential Advisor Peter Flanigan noted that the poll indicated there was little public support for space spending. The numbers showed that 56% of the American public believed that the nation should spend less on space exploration, while only 10% supported an increase in the space budget.[157]

In March 1970, the PSAC forwarded their recommendations to President Nixon. The report, *The Next Decade in Space*, emphasized practical applications of space technology. According to the PSAC report, the human exploration of Mars was a logical follow-on to the Apollo Program. However, the report recommended against proceeding with such an expensive project immediately after Apollo. The committee saw a number of other priorities for the space program during the 1970s. In addition, the decade would allow NASA to develop the technologies and capabilities that would be necessary before a human mission to Mars would be practical. Therefore, the PSAC recommended that the Mars goal be delayed until a later date.[158]

By the time President Nixon made a public announcement of his decision regarding the STG report on March 7, 1970, the future of the human space program was already clear. NASA's budget had been reduced, leaving little doubt that the human Mars mission would be tabled until a later date. In choosing this, the President explained that there were a number of national priorities that took precedence over an ambitious space program. He therefore recommended a balanced program emphasizing exploration, scientific knowledge, and practical applications of space technology. The level of space effort would be kept in balance with other national objectives. Nixon's statement listed six objectives for the program: (1) continuing lunar exploration, (2) exploring the planets and the universe, (3) reducing the cost of space operations (through development of the space shuttle), (4) extending the human ability to live and work in space, (5) expanding practical applications of space, and (6) encouraging international space ventures. Human missions to Mars were mentioned, but only as an eventual part of the effort to explore the planets. Essentially, Nixon had put an end to the speculation of the future of human spaceflight. The shuttle would become the dominant program, while plans for Mars expeditions would be filed away for the distant future.[159]

CONCLUSION

The human fascination with the planet Mars began by looking at a distant red light in the night sky. As technology and science allowed humans to learn more about Earth's celestial neighbor, imaginations soared over speculation that the Red Planet might host an extraterrestrial civilization. Science-fiction writers concocted wild stories that fueled enthusiasm about spaceflight to other planets. It was these stories that inspired men such as Robert Goddard and Wernher von Braun to wonder whether such a journey may actually be possible.

While Goddard never seriously worked on plans to go to Mars, von Braun adopted the idea of placing a human on the Red Planet as the ultimate goal of his integrated space program. According to von Braun's plans, human spaceflight would progress through activities in low-Earth orbit to the human exploration of the Moon and Mars. During the 1950s, von Braun seized every opportunity to share his dream. He prepared both technical and popular versions of his Mars plan to spread enthusiasm for the human exploration of outer space.

With the creation of NASA in 1958, von Braun and others recognized that an infrastructure had been constructed to support an endeavor such as human spaceflight. As plans were under way for NASA's first human space program, Project Mercury, the nation was shocked when the Soviet Union succeeded in launching the first human into space. President John F. Kennedy responded by challenging the United States space program to place a man on the Moon by the end of the 1960s. Many within NASA saw the human exploration of the Moon as but the first step in von Braun's ultimate planetary exploration plan and began working on preliminary studies to prepare the Agency to reach for Mars after the completion of the Apollo lunar landing program.

By the mid 1960s, the initial piloted Mars studies had been completed. Results from projects such as the EMPIRE studies, the Ames Research Center studies, the Manned Spacecraft Center's planetary spacecraft design studies, and the UMPIRE studies seemed to confirm that human missions to Mars would be possible – perhaps as early as the 1970s. NASA's Administrator James Webb did not share the enthusiasm for spaceflight beyond the Moon, however, and he discouraged any long-range planning within the Agency. Human Mars mission planning thus continued at a slow pace, funded only through discretionary funding for advanced mission planning. One estimate has been that, in the period 1962 through 1966, NASA was only able to devote $3.9 million to human Mars contract studies. After 1967, the Agency was forbidden to spend any money on such studies.[160]

As the end of the late 1960s approached , it became clear that a direction must be chosen for the post-Apollo space program. The election of President Richard M. Nixon and the appointment of Thomas O. Paine to the position of NASA Administrator seemed to signal that the time might be right to establish a national goal of sending humans to Mars during the 1980s. Human Mars mission proponents hoped that the new Administration would select the Red Planet as the next goal for the human spaceflight program. Vice President Spiro Agnew added his endorsement to

the project, but his enthusiasm was not shared by the Congress, the public, or the President. In the end, Mars planners had to settle for an acknowledgment that one day humans would travel to Mars, but they received no firm commitment that work would continue to plan for such a project. By early 1970, the dream of a human expedition to Mars seemed no closer to reality than it had when Wernher von Braun started writing about it in the 1950s.

While the nation appeared to have the technical capability to achieve such a feat, there was an absence of will on the part of the country's leadership to commit resources to another large human exploration program. It is important to understand why the support was lacking if anything is to be learned from the human Mars mission planning efforts that concluded with Nixon's announcement of March 1970. There were several factors that contributed to Nixon's decision, and there has been much discussion about what went wrong.

For example, some writers have attributed the premature death of the human Mars program to NASA's failure to develop a master plan for future missions. Arnold S. Levine, in his book *Managing NASA in the Apollo Era*, criticized NASA's failure to develop a viable long-term plan during the 1960s. However, in the forward to Levine's book, former NASA Administrator James E. Webb explained that there was a great deal of opposition in the public and private sectors to the human spaceflight program. Webb contended that extensive long-term planning geared towards expensive programs to follow the Apollo Program would have further alienated NASA critics and could have jeopardized the funding required to complete Apollo. In addition, Webb explained that it was important to complete the Apollo Program before planning the next piloted program. By doing that, Webb felt that the lessons from Apollo could have been fully integrated into the goals and objectives of future human programs. In an article entitled "How NASA Lost the Case for Mars in 1969," Stephen Baxter justified Webb's hesitance to pursue long-term planning as the product of Webb's experience with and understanding of the political environment of his day. Baxter concludes that Webb's astute management and deliberate policy of avoiding long-term planning was key to retaining political support for the Apollo Program long enough to achieve Kennedy's goal of placing a man on the Moon before the end of the decade.[161]

Another view explains the demise of the human Mars goal by discussing the persistence of the "von Braun Paradigm." According to Dwayne A. Day of the Space Policy Institute, this paradigm has influenced NASA advanced plans and also played a role in the Space Task Group's decision to include three variations of the same program in their report, rather than distinctive choices for the future space program. Day believed the paradigm was rooted in the "belief that the country needs an integrated space plan centered upon human exploration of the solar system" and that certain paradigm elements must be "accomplished in this order: (1) an Earth-orbital space station serviced by a reusable space vehicle; (2) a lunar base; and (3) a human mission to Mars." While it is true that these elements from von Braun's early plans have continued to surface throughout the Agency's advanced planning efforts, whether the paradigm has adversely affected NASA's ability to gain support for the human Mars mission is difficult to determine. It is possible that the "all or nothing" options presented in the report made it difficult for Nixon to endorse completely any of the

plan's recommendations. It is also likely that Nixon's decision was more heavily influenced by a lack of public support for the space program.[162]

The *Newsweek* poll of October 6, 1969, was not the first indication that public support for the space program was declining. A Gallup poll from July 1969 had shown that only 39% of those questioned supported funding a human expedition to the Red Planet. The 53% that opposed such a mission clearly reflected a trend that was seen immediately following the Apollo 11 Moon landing. While it has been estimated that 94% of all households with televisions tuned in to watch astronauts Neil Armstrong and Buzz Aldrin walk on the Moon on July 20, 1969, public and media interest in the space program declined significantly once that goal had been achieved. This was probably due to increased social problems such as urban unrest and opposition to the Vietnam War. Other national priorities were seen as more important, and the budget strain caused by increased government spending seemed to indicate that the space program was an area that could be reduced. While only one-third of the U.S. populace opposed increased space spending in 1965, by 1969 the number who objected to an increase in the NASA budget had passed one-half of the population.[163]

Congressional opinion tended to echo that of their constituents. By the end of 1969, many decision makers who had previously supported NASA programs found themselves no longer able to champion NASA owing to the high costs of extensive human spaceflight programs. An article published in *Space/Aeronautics* in February 1970 noted that cost was the major barrier to acceptance of the Mars goal. According to the article, NASA's human Mars studies during the previous 7 years had produced cost estimates ranging from $12 to $32 billion. A memorandum produced by D. D. Wyatt, NASA's Assistant Administrator for Program Plans and Analysis, for Associate Administrator Homer Newell in July 1969 estimated that the cost of a human Mars expedition would range between $30-40 billion. The author of the *Space/Aeronautics* article speculated that, when converted into 1967 dollars, the cost could be as high as $50 billion. Regardless of the exact cost, the total was too high for the political leadership of the country to accept. As previously mentioned, cost overruns associated with the robotic Voyager mission to Mars eroded confidence in NASA's ability to estimate the cost of major programs. This severely complicated the cost issue. If any one factor were to be selected as the key to the failure of human Mars mission planning during NASA's first decade, it would most certainly be the issue of cost. Until NASA can find a way to achieve the goal of placing a human on the Red Planet at a cost that is considered reasonable within the context of the national budget, the dream of Wernher von Braun and the others will remain just a vision of a possible future for mankind's exploration of space.[164]

BIBLIOGRAPHIC ESSAY

Historical Papers on Human Mars Mission Planning

While there are currently no comprehensive histories of all human Mars mission planning efforts, there are several brief histories or summaries of studies conducted during the 1960s, as well as several articles concerning the demise of the Space Exploration Initiative (SEI). A brief description of each work has been included to provide a guide for those interested in these sources.

The earliest account of early NASA piloted Mars planning was published in February 1965. This account, *An Introduction to the NASA Manned Planetary Mission Studies and a Brief Survey of the Study Results* – an internal report of the Manned Spacecraft Center (MSC) – was prepared by C. Howard Robins, Jr., and Roberto M. Villarreal. As employees of the MSC Advanced Spacecraft Technology Division's Mission Feasibility Branch, the authors presented a series of five 1-hour lectures in September 1964. The lectures and the report were conducted in anticipation of an increased human Mars planning effort that was expected once Project Gemini and the Apollo Program proceeded beyond the planning phase. Robins and Villarreal noted that their report was intended as a reference tool to introduce those involved to the results of previous Mars mission studies. The report included a brief history of the studies that will be discussed in Chapter 5: the Lewis Research Center (LeRC) trajectory studies, the Marshall Space Flight Center (MSFC) EMPIRE studies, the Ames Research Center (ARC) piloted Mars studies, the MSC Planetary Spacecraft Design Studies, and the MSFC UMPIRE studies. The remainder of the document included detailed discussions of target selection, mission classification, trajectory analysis, Mars and/or Venus flyby and capture missions, launch windows, Earth-entry and Mars-entry analyses, crew requirements, spacecraft subsystems and propulsion systems, mission modes, spacecraft design, and performance analysis.[165]

Another early history, titled *A Historical Note on the Genesis of Manned Interplanetary Flight*, was prepared just prior to the first human Moon landing on July 20, 1969. Robert B. Merrifield, a member of the history staff at NASA's MSC in Houston, Texas, presented this paper at the June joint national meeting of the American Astronautical Society and the Operations Research Society. The paper followed the development of interest in Mars from astronomical discoveries and fictional accounts through the development of the Apollo Program, particularly the work of Wernher von Braun. Merrifield discussed Mars mission planning at the time of the creation of NASA, contractor studies conducted in the early 1960s such as the Early Manned Planetary and Interplanetary Roundtrip Expeditions (EMPIRE) studies, various conferences concerning human planetary flight, and the activities of a NASA task force called the Joint Action Group (JAG).[166]

Ten years later, Dr. Edward Clinton Ezell built on Merrifield's work with a paper presented at the January 1979 annual meeting of the American Association for the Advancement of Science. Ezell, a contract historian, had been hired by NASA to prepare a history of the Viking Mars program. He was intrigued by NASA's unfulfilled vision of sending humans to Mars. Ezell's

work, *Man on Mars: the Mission that NASA Did Not Fly*, began with the astronomy of Mars, worked its way through the pre-NASA work such as that of von Braun, and discussed the NASA and contractor studies conducted during the 1960s. Ezell also touched on budgetary and political problems related to NASA's planetary and human spaceflight programs. Ezell contended that these problems, combined with the social unrest of the 1960s, did not create an environment conducive to the goal of sending humans to Mars. He illustrated his point with the failure of the Space Task Group (STG)[167] of 1969 to impact Congressional policy on human interplanetary programs, despite the full backing of Vice President Spiro Agnew.[168]

A decade passed before others examined the history of human Mars mission planning. President George H. W. Bush's announcement for a new national goal to return to the Moon and continue on to Mars, which he voiced on the 20th anniversary of the Apollo 11 Moon landing, launched the SEI and renewed interest in sending humans to Mars. Franklin P. Dixon, who had been a participant in the EMPIRE studies, presented a paper the following October to the International Astronautical Federation on the studies conducted during the 1960s. His paper, "Manned Planetary Mission Studies From 1962 to 1968," covered not only the EMPIRE studies but also other work including the activities of the Interplanetary-Planetary JAG. Dixon also discussed budgetary issues as well as the influence of advisory committees such as the President's Science Advisory Committee (PSAC).[169]

A variety of other studies also reflected the continuing fascination with Mars flights. For example, a paper, presented to the 24th Symposium on the History of Astronautics at the 41st International Astronautical Congress in October 1990 summarized the EMPIRE studies. "EMPIRE – Background and Initial Dual-Planet Mission Studies" was the work of Frederick I. Ordway, III, and Mitchell R. Sharpe of the Alabama Space and Rocket Center and Ronald C. Wakeford of the U.S. Army Corps of Engineers Technical Committee. In this paper, the authors followed early fascination with Mars through the pre-NASA activities of Wernher von Braun. The most notable aspect of their paper was the presentation of the EMPIRE studies including detailed discussions of the work and reports of the three contractors selected to participate in EMPIRE: Ford's Aeronutronic Division, General Dynamics/Astronautics, and the Lockheed Missiles and Space Company. The authors showed how the EMPIRE studies established the foundation upon which other studies of the period were based.[170]

A subsequent study by Ordway, "Mars Mission Concepts: the Von Braun Era," focused on the role that Wernher von Braun played in early Mars mission planning. Ordway traced early fascination with Mars through the popularity of the canal theory and discussed how this piqued von Braun's fascination with the Red Planet. The paper covered von Braun's works on human missions to Mars including *The Mars Project* (1952), the *Collier's* articles (1952-1954), and *The Exploration of Mars* (1956), which von Braun wrote with Willy Ley. Finally, Ordway examined the period beginning with the EMPIRE studies and concluding with the 1969 report of the STG. Another discussion of von Braun's participation in the *Collier's* articles was presented by Randy Liebermann to the 20th History Symposia of the International Academy of Astronautics in Innsbruck, Austria (1986). Liebermann discussed the initiation of the *Collier's* project prior

to von Braun's involvement and then showed how the series of eight feature articles provided von Braun with a forum to introduce his concept of an integrated human spaceflight program to the general public.[171]

In another review of NASA's human Mars mission planning efforts of the 1960s, Stephen Baxter, a science-fiction writer, probed management contradictions in the June 1996 issue of *Spaceflight*. "How NASA Lost the Case for Mars in 1969" addressed the roles of two NASA Administrators, James Webb and Thomas Paine. Webb, a career manager aware of the dangers of asking for too much, discouraged long-term planning and was especially cautious about openly planning for human Mars missions. In contrast, his successor, Paine, was a Mars enthusiast who encouraged planning for extensive future programs. Baxter discussed the post-Apollo planning efforts associated with the STG of 1969. The group's report, with the support of Vice President Spiro Agnew, proposed a human Mars mission as the next planetary goal for the U.S. space program. Eventually, President Richard Nixon relegated the mission to the position of "long-term goal" and failed to gain any type of Congressional support to ensure the execution of the program. Baxter's article was an interesting account of the STG activity and offered an interesting insight into the type of administration that could get NASA to Mars based upon his assessment of Webb and Paine.[172]

The death of the SEI prompted Dwayne A. Day of the Space Policy Institute at George Washington University to consider reasons for its failure. In "Doomed to Fail: the Birth and Death of the Space Exploration Initiative," published in 1995, Day briefly discussed the early ideas of von Braun and the STG (1969) and the reemergence of interest in human exploration that took root in the 1980s. Day also discussed the work of former NASA Administrator Thomas O. Paine and the National Commission on Space (1986), as well as the study led by astronaut Sally K. Ride which followed up on the Commission's findings the following year. Day then followed the progression of SEI through Bush's speech, NASA's 90-Day Study, and the work of the Synthesis Group. Finally, he examined the final days of the SEI and offered insight into what caused the death of the program.[173]

Two other articles by Day offered a more controversial conclusion for the failure of SEI. "The Von Braun Paradigm," published in the *Space Times* in 1994, and "Paradigm Lost," published in *Space Policy* the following year, presented Day's belief that NASA has been handicapped by the paradigm of an integrated space program proposed by Wernher von Braun. The "Von Braun Paradigm," according to Day, required these elements to be achieved in this order: a space station in Earth orbit serviced by a reusable space shuttle, a crewed lunar base, and finally a human mission to Mars. Day traced the paradigm from its inception through the key reports related to human exploration and concluded that this "all or nothing" approach has alienated the space community from those who control national policies and the federal budget. Day's second article prompted a response from Harry O. Ruppe, a colleague of von Braun. Ruppe contended that if the goal is a permanent human space program, von Braun's integrated program contained the "nucleus of any possible all-round and consistent plan." Ruppe blamed not the space

community but rather the political leadership for their failure to provide consistent support to human spaceflight activities.[174]

World Wide Web Resources

In addition to printed resources on the history of human Mars mission planning, there are also resources available on the Internet. One of the most significant has been an annotated bibliography which is the work of David S. F. Portree, a former employee in the JSC History Office and an experienced NASA contract writer. In it, Portree has endeavored to compile a comprehensive bibliography of materials relating to human exploration of the Moon and Mars. "Romance to Reality: Moon [and] Mars Expedition [and] Settlement Plans" (http://members.aol.com/dsfportree/explore.htm) was designed as an annotated bibliography divided into several chronological periods: "Tomorrowland" (1950-1960),"The Age of Heroes" (1961-1969), "The End of the Beginning" (1970-1979), "The Shuttle Era" (1980-1988), "Space Exploration Initiative I" (1989-1992), and "A New World" (1993-present). True to the nature of works on the World Wide Web, this site has continued to evolve and change. Additional access to entries by subject and document title has been added to allow multiple methods of accessing the material. Portree, in his original introduction, explained that his bibliography was created to "make widely available ideas engineers and scientists have developed for exploring [and] settling the moon [and] Mars; [to] educate people about the challenges and opportunities of exploring and settling the moon and Mars; [and to] help in a small way to return us to the moon and send us onward to Mars." While some information on the World Wide Web is difficult to evaluate because the sources of information are largely unknown, Portree's acknowledgment page featured an impressive list of many key players from the SEI and others with an interest in exploration and space history. Other factors which have made the site particularly useful to historians and those interested in human Mars mission planning are the detailed annotations provided for works covered and the frequent updates.[175]

NASA History Series

For many years, NASA has been hiring contract historians to prepare official histories. The NASA History Program assures its historians "full academic freedom of research and expression," and thus has produced many unbiased, detailed histories of all aspects of the space program. While many of the works in the NASA History Series were consulted during this research, two volumes were essential for the study of human Mars mission planning.

Exploring the Universe: Selected Documents in the History of the U.S. Civil Space Program, volume 1: "Organizing for Exploration," brought together, for the first time, the key documents related to the establishment and planning of NASA's human spaceflight program. Edited by John M. Logsdon, Director of the Space Policy Institute at George Washington University, the work was divided into four chapters with each covering a different period. The chapters were preceded by historical essays authored by Roger D. Lanius, NASA's chief historian; R. Cargill Hall, Chief of the Contract Histories Program at the Center for Air Force History; Logsdon; and

Sylvia Katherine Kramer, a senior director of NASA's Office of Policy and Plans and former Director of NASA's History Office. Most documents were printed in their entirety, and their significance has been identified in a brief introductory section. Before publication of this work, access to many of the documents could only be attained by traveling to various archives located around the country.[176]

The other NASA history which was invaluable to this research concerned the robotic exploration of Mars. Edward Clinton Ezell and Linda Newman Ezell published NASA's official history of the Viking Program in 1984. *On Mars: Exploration of the Red Planet, 1958-1978*, is an excellent history of U.S. robotic exploration of Mars which climaxed with the landing of Vikings 1 and 2 in 1976. While the emphasis was on robotic spacecraft, this book has been important to the study of human Mars mission planning for several reasons. The chapter entitled "Why Mars?" presented a brief history of fascination with Mars, science fiction related to the Red Planet, and early planning efforts including those of Wernher von Braun. It also addressed early NASA planning for goals in space. As the Ezells examined the history of both unsuccessful and successful robotic Mars missions, they touched on many of the budgetary issues that also affected planning for human Mars missions. Especially useful was the chapter that described the planning failures and cancellation of the Voyager Mars exploration mission. Besides being a useful starting point for any study of Mars, the book was also a wealth of information on the Red Planet and contained many useful appendices.[177]

Getting Started in Mars Research

While the works listed above are some of the most important for the history of human Mars mission planning, researchers in any area of Mars exploration should take advantage of the excellent bibliographic databases covering space exploration. NASA RECON and Dialog's Aerospace Database (a commercial spinoff which includes much of the information in RECON) are essential for any research on the Red Planet. The databases contain citations and abstracts of NASA publications, contractor reports, conference papers, journal articles, and other publications relevant to the space program from the days of the National Advisory Committee for Aeronautics (NACA) to the present. In addition, NASA employees and contractors should search any local databases maintained by individual NASA Centers. Several NASA Centers have History Offices or special history collections that can also be valuable for research into previous planning efforts. Unfortunately, budget cuts have caused some Centers to close their History Offices or to limit access to them to NASA personnel and contractors. For this research, the author was fortunate to have access to the collection of the former JSC History Office, which at the time was kept in the Center's Scientific and Technical Information Center.

Applying History to Planning for Future Human Mars Missions

This study was prepared as a starting point for future mission planning. It presents a chronological account of major planning documents and identifies many of the planning efforts conducted between 1952 and 1970. It is recommended that those conducting human Mars

mission planning familiarize themselves with the documentation prepared during previous planning efforts. In addition, readers will benefit from the appendices which document major advances in the robotic exploration of Mars as well as the history of human Mars expedition planning. Most importantly, future planners must share the dream of von Braun and the other early planners that one day astronauts will leave their footprints in the iron-rich soil of the Red Planet.

This bibliographic essay was written in 1999. Since then, another significant history has been published relevant to human Mars mission planning. Below is a description of the work, written by the NASA History Office.

Humans to Mars: Fifty Years of Mission Planning. 1950-2000 (NASA SP-2001-4521) is Monograph in Aerospace History Number 21. *Humans to Mars* was written by David S.F. Portree. Mars has long held a fascination for those interested in astronomy and spaceflight; and over the last half century, a great number of plans have been devised to send astronauts to Mars. Daunting logistical and physical problems still remain, however. How long would it take to get to Mars? How would we carry the necessary supplies? After surviving a long journey, what would astronauts do once they arrived on Mars? In addressing such important questions, Portree looks at a representative sampling of the many humans to Mars plans.

APPENDIX A

MARS HUMAN EXPLORATION CHRONOLOGY

1947

January — Wernher von Braun spoke to the El Paso Rotary Club about his vision of human spaceflight. This was his first public talk in the U.S. and the warm reception that he received encouraged him to seek out opportunities to take his message to the public.

1948-1949 — Von Braun used his spare time at Fort Bliss to write his first book, *The Mars Project*.

1950

March 3 — Von Braun presented a paper titled "Multi-stage Rockets, Artificial Satellites and Interplanetary Travel" at a symposium on space medicine held by the University of Illinois.

Summer — Von Braun's rocket group moved from Fort Bliss, Texas, to the Redstone Arsenal located near Huntsville, Alabama.

1951

May — In an article published in the *Journal of the British Interplanetary Society*, Kenneth W. Gatland proposed a concept for a spacecraft that could be applied to interplanetary missions such as a human mission to Mars

October 12 — Two reporters from *Collier's* magazine attended a Space Travel Symposium held at the New York Museum of Natural Science's Hayden Planetarium in New York City. Their report spurred their editor's interest in space travel.

November 6-9 — *Collier's* associate editor Cornelius Ryan attended a conference on space medicine held in San Antonio, Texas. He met with von Braun and other leaders in the space field. Ryan encouraged his editor to organize an internal *Collier's* symposium on space which led to the publication of eight feature articles over a 2-year period.

1952 — Von Braun published *Das Marsprojekt* in a special issue of the magazine *Weltraumfahrt.* The work was republished in the United States in 1953 as *The Mars Project*.

Eric Burgess published *Rocket Propulsion: With an Introduction to the Idea of Planetary Flight* in 1952 (revised second edition in 1954). In his book, Burgess examined the orbital mechanics of interplanetary flight.

March 22 — *Collier's* magazine published "What Are We Waiting For?," the first in an eight-issue series about human space exploration.

1953 — Cornelius Ryan edited an expanded version of the first *Collier's* issue and published it in book form under the title *Across the Space Frontier*.

1954

April 30 — *Collier's* magazine published "Can We Get to Mars?," the last in an eight-article series about human space exploration.

August — Ernst Stuhlinger presented his first paper on electrical propulsion for interplanetary spacecraft to the 5th International Astronautical Federation Congress.

1955

March 9	Disney's weekly television series aired "Man in Space," the first of three programs on space inspired by the *Collier's* articles. The program reached an estimated audience of 42 million.
July 29	The United States committed itself to launching a satellite during the International Geophysical Year. The announcement was made at a White House press conference which included representatives of the National Science Foundation and the National Academy of Science.
1956	Von Braun and Willy Ley published *The Exploration of Mars*.
1957-1960	Teams at NASA's Lewis Research Center (LeRC) in Cleveland, Ohio, conducted studies on the feasibility of planetary missions. Concurrently, teams at the Army Ballistic Missile Agency, located at the Redstone Arsenal near Huntsville, Alabama, were working on propulsion systems for planetary missions.

1957

June	Beginning of International Geophysical Year (June 1957-December 1958).
October 4	The Soviet Union launched Sputnik 1, the first artificial satellite.
November 3	The Soviet Union launched Sputnik 2 which contained a dog named Laika.
November 7	President Eisenhower addressed the nation on Science in National Security, naming James R. Killian, Jr., to the new position of Special Assistant for Science and Technology.
December 4	Disney aired "Mars and Beyond," the final of three television shows inspired by the *Collier's* articles.
December 6	The first U.S. attempt to launch a satellite using a Vanguard rocket failed when the launch vehicle exploded as it left the pad. The press dubbed the satellite "flopnik" and "kaputnik."

1958

January 12	NACA Director James Doolittle created a space committee to provide recommendations for the new civilian space program.
January 31	The first U.S. satellite, Explorer 1, was launched by von Braun's team.
February 4	President Eisenhower announced the creation of a President's Science Advisory Committee (PSAC) panel (the Purcell Panel) to make recommendations on the outlines of a space program and an organization to manage it.
March 26	The PSAC released its report, *Introduction to Outer Space*, which outlined the reasons for, and proposed projects for, a national space program.
April 2	President Eisenhower sent a message to Congress requesting legislation for the creation of NASA.
July 29	President Eisenhower signed the National Aeronautics and Space Act of 1958, establishing NASA.
August 7	T. Keith Glennan began his appointment as Administrator of NASA.
October 1	NASA was formally created.

October 8	NASA Administrator T. Keith Glennan authorized the formation of a Space Task Group (STG) at the Langley Research Center (LaRC) in Hampton, Virginia, to implement a human space program. The group, under the leadership of Robert R. Gilruth, formed the nucleus of the Manned Space Center (MSC) (now the Johnson Space Center (JSC) when they moved to Houston, Texas, in November 1961. This STG should not be confused with that initiated by President Nixon to determine a direction for the post-Apollo space program.
October 28	NACA's Special Committee on Space Technology published their report, *Recommendations to the NASA Regarding a National Civil Space Program*. In it, they noted that "exploration of the solar system in a sophisticated way will require a human crew."
August 18	The National Space Council adopted the "Preliminary U.S. Policy on Outer Space."
1959	LeRC conducted an in-house study "to define nuclear propulsion system requirements through a determination of the velocity requirements for orbit-to-orbit roundtrip planetary missions."
February 3	The U.S. House Select Committee on Astronautics and Space Exploration published a report titled *The Next Ten Years in Space: 1959-1969*. NASA scientists responding to the Committee's survey expressed their opinions that "an active program should be underway" during that period for a human orbital mission to Mars and back.
April	NASA selected its first seven astronauts.
April	NASA's Wolfgang E. Moeckel of LeRC testified before the Senate Committee on Aeronautical and Space Sciences about interplanetary studies conducted at LeRC since 1957. Moeckel suggested to the Committee that a vehicle assembled in Earth orbit could be used for human Mars missions.
December 16	NASA's Office of Program Planning and Evaluation published its plan, the "Long Range Plan of the National Aeronautics and Space Administration," which stated the Agency's long-term goal – "the manned exploration of the moon and the nearby planets."
1960	Von Braun and his team were transferred from the Army Ballistic Missile Agency to NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama.
May	President Eisenhower learned of NASA's plans for a human lunar landing program. He asked George Kistiatowsky, his Science Advisor, to study "the goals, the missions, and the costs" of NASA's human spaceflight program.
November 4	The NASA Office of Program Planning and Evaluation published an internal document, "A Proposed Long Range Plan," which alluded to human missions to Mars. The document was classified "secret."
December 16	The PSAC issued the "Report of the Ad Hoc Panel on Man-In-Space." The panel recognized that propulsion requirements and human factors (life support and radiation shielding) would require great advances in technology, and concluded that "manned trips to the vicinity of Venus or Mars are not yet foreseeable."
1961	
January 20	John F. Kennedy took office as the 35th President of the United States.
January 20	T. Keith Glennan ended his term as NASA Administrator.
January 31	Kennedy named James E. Webb to the office of NASA Administrator
February 14	James E. Webb took office as NASA Administrator

April 12	Soviet cosmonaut Yuri Gagarin became the first human in space. He completed one orbit before returning safely to Earth.
April 20	President John F. Kennedy asked Vice President Lyndon B. Johnson to find a "space program which promises dramatic results in which we can win." The announcement of the program was made on May 25.
May 5	U.S. astronaut Alan B. Shepard, Jr., became the first American astronaut in space.
May 25	President John F. Kennedy, before a joint session of Congress, challenged the nation to land a man on the Moon by the end of the decade.
Summer	MSC initiated its first in-house studies on human planetary missions.
Fall	MSFC contracted with Lockheed Missiles and Space Company (Sunnyvale, Calif.) for a 2½-year study of trajectories for high-velocity missions among Earth, Mars, and Venus for the period 1965-1999. An MSC internal note dated February 1965 called the handbook "the standard reference source for interplanetary trajectories."
November 1	The STG for the implementation of a human space program moved to MSC (now JSC) in Houston, Texas, from NASA's LaRC.

1962

February 20	John Glenn became the first American to orbit the Earth.
May	NASA's MSFC selected three contractors to conduct the Early Manned Planetary-Interplanetary Roundtrip Expedition (EMPIRE) studies. The contractors selected were Ford's Aeronutronic Division, General Dynamics/Astronautics, and Lockheed.
June 2	Lockheed Missiles and Space Company (Sunnyvale, California) published "Interplanetary Flight Trajectories" (Report 3-17-62-1; NASA Contract NAS8-2469) and "A Study of Interplanetary Transportation Systems" (NASA Contract NAS8-2469). Both reports were issued as part of a contract initiated in Fall 1961 with MSFC.
July	MSC issued a statement of work for a "Study of Manned Scientific Missions to Mars and Venus."
August 1	MSC's Spacecraft Research Division initiated an in-house study of human planetary missions to Mars and Venus. An MSC memorandum stated the purpose of the study was "to define in preliminary form the manned spacecraft system missions to Mars."
Fall	MSC's Instrumentation and Electronic Systems Division, Communications Systems Section conducted an in-house study on Mars-Venus Mission Communication. The effort was part of a broader study of human planetary missions by the Spacecraft Research Division.
September 28	Two MSC personnel traveled to Ames Research Center (ARC), Moffett Field, California, to discuss studies under way related to Mars and Venus exploration.
October 4	Lockheed Missiles and Space Company published their "Study of Early Manned Interplanetary Missions -- EMPIRE" (NASA Contract NAS8-5024).
October 15	MSC's Flight Vehicle Integration Branch, Aeronautics Section initiated an in-house human Mars landing study.
November	NASA's LeRC published "Spaceflight Beyond the Moon: A Study of Advanced Propulsion Systems for Interplanetary Flight."
December 21	Ford's Aeronutronic Division published a report titled *EMPIRE: A Study of Early Manned Interplanetary Missions*, (NASA Report CR-51709; NASA Contract NAS8-5025).

1963

January	MSC Spacecraft Technology Division's Flight Vehicle Integration Branch issued a statement of work for a Mars excursion module (MEM).
January 31	General Dynamics/Astronautics (Advanced Studies Office) published a report on their EMPIRE work titled *A Study of Early Manned Interplanetary Missions*, Final Summary Report (GC/A AOK63-0001; NASA-CR-51364; NASA Contract NAS8-5026).
February 11	MSC's Instrumentation and Electronic Systems Division, Physical Measurements Branch completed an in-house "Preliminary Study of Instrumentation Requirements for a Manned Mars-Venus Mission."
March	Lockheed Missiles and Space Company published "Early Manned Interplanetary Mission Study" (Report NASA CR-51297; NAS8-5024).
Mid 1963	ARC initiated two contractor studies to estimate the scope and feasibility of human missions to Mars. Contractors were North American Aviation and TRW Space Technology Laboratories.
May 6	The *Sunday Star* (Washington, D.C.) reported on an MSC plan for a human expedition to Mars. The mission, said to be launchable in 1971, 1973 or 1975, would send a crew of six on a 400-day trip that would include a 40-day stay on the Martian surface.
May 20	*Aviation Week & Space Technology* reported on the requests for proposal (RFPs) issued by NASA field Centers for work related to Mars mission planning. MSC studies mentioned were "Mars Landing And Reconnaissance Mission Environmental Control and Life Support System Study," "Mars Mission-Module Subsystems Study," and "Mars-Mission Earth Reentry Module." "Mars Exploration In The Unfavorable (1975-1985) Time Period," a study for MSFC, was also mentioned in the discussion of RFPs. The article noted that two contract studies related to human Mars missions were under way for ARC.
May 21-23	NASA Headquarter's Office of Advanced Research and Technology sponsored the first NASA-wide Manned Planetary Mission Technology Conference. The meeting was held at NASA's LeRC. The purpose of the conference was "to explore the possibilities and problems of manned planetary space flight" (*Missiles and Rockets*, May 13, 1963).
Summer	MSFC initiated studies of human Mars missions during the unfavorable period (1975-1985). UMPIRE contractors were General Dynamics (Fort Worth) and Douglas' Missile and Space Systems Division.
June 6-7	The American Astronautical Society sponsored the Symposium on the Exploration of Mars in Denver, Colorado. According to a NASA news release, objectives of the symposium were "to establish the effort required for manned exploration of the planet, review planning and state-of-the-art for the mission, estimate a timetable and define the scientific value of the Mars mission."
June 12	*Space News Roundup*, JSC's newspaper, reported on Philco's Aeronutronic Division's study on requirements for an MEM. The article noted that the purpose of the study was to establish a body of knowledge that could be used when NASA initiated a project to send astronauts to Mars.
June 16	Valentina Tereshkova, Soviet cosmonaut, became the first woman in space.
July 1	Ford's Aeronutronic Division, one of the EMPIRE contractors, was placed under Ford's subsidiary, the Philco Corporation.
July 1	General Dynamics/Astronautics published a report on their EMPIRE work titled *Methodology of Mission and Systems Synthesis of Manned Interplanetary Flights with Particular Emphasis on Venus and Mars as Target Planets* (NASA Report CR-55409).

July 30	NASA's Planetary Mission Study Group met to discuss the status of human interplanetary mission planning efforts including contractor studies and in-house field Center studies. This was the first internal effort to bring together the appropriate personnel from different NASA Centers for an exchange of information.
August 6	Lockheed Missiles and Space Company gave their first presentation on their "Early Manned Interplanetary Mission Study" (Technical Report No. 8-32-63-2).
October	Grumman's Research Department published "Some General Consideration on the Manned Mars Mission" (Grumman Research Department Memorandum RM-224).
October	The American Institute of Aeronautics and Astronautics (AIAA) held its first conference on human planetary missions in Palo Alto, California.
October 2	Lockheed Missiles and Space Company gave their second presentation on their "Early Manned Planetary Mission Study" (Technical Report No. 8-32-63-3).
November 22	President Kennedy was assassinated. Lyndon B. Johnson was sworn in as the 36th President of the United States.
December 20	Philco's Aeronutronic Division published their "Mars Excursion Module Final Report" (Publication No. C-2379, NASA Contract NAS9-1608).
n.d.	Philco's Aeronutronic Division published a report titled *The EMPIRE Dual Planet Flyby Mission*, (NASA Report CR-25677, NASA Contract NAS8-5025). The work was conducted under contract to MSFC.

1964

January	Douglas Aircraft's Missile and Space Systems Division published a report on their UMPIRE study, "Manned Mars Exploration in the Unfavorable (1975-1985) Time Period" (NASA Contract NAS8-11005).
January 7	Lockheed Missiles and Space Company gave their final presentation on "Preliminary Design of a Mars-Mission Earth Reentry Module" (NASA Contract NAS9-1702).
January 16	NASA's Office of Manned Space Flight released a statement of Work for a contractor study, "Conjunction Class Manned Mars Trips" (NASA Contract NASw-1028).
January 28	General Dynamics published "A Study of Early Manned Interplanetary Missions (EMPIRE Follow-On)" (Report GD/A-AOK-64-002; NASA Contract NAS8-5026).
January 28-30	NASA's MSFC hosted a NASA/industry conference, The Symposium of Manned Interplanetary Mission Studies Performed by Industry for NASA in 1963. Work performed as part of the EMPIRE studies, as well as other research projects, was discussed.
January 28-30	TRW Space Technology Laboratory presented their *Summary of Manned Mars Mission Study* to NASA's ARC (Report 8572-6009-RU-000; NASA Contract NAS2-1409).
January 31	General Dynamics/Astronautics (Advanced Studies Office) published a report on their EMPIRE follow-on work titled *A Study of Manned Interplanetary Missions* (Report GD/A AOK64-006; NASA Contract NAS8-5026).
February 2	North American Aviation's Space and Information Systems Division published their "Study of Subsystems Required for a Mars Mission Module (NASA Contract NAS9-1748).
February 15	General Dynamics published a report on their UMPIRE study, "A Study of Manned Mars Exploration in the Unfavorable Time Period (1975-1985)" (NASA Contract NAS8-11004).

February 28	Lockheed Missiles and Space Company published "Manned Interplanetary Missions Follow-On Study, Final Report" (Technical Report No. 8-32-63-2; NASA-CR-56821 - NASA-CR-56823; NASA Contract NAS8-5024).
March	Lockheed Missiles and Space Company published their "Preliminary Design of a Mars-Mission Earth Reentry Module" (NASA Contract NAS9-1702).
March 23	MSC issued a statement of work for "Interplanetary Mission Support Requirements."
March 28	TRW Space Technology Laboratory published *Manned Mars Landing and Return Mission* (Vol. 1: Summary, Report 8572-6011-RU-000, NASA Contract NAS2-1409) for ARC.
April	North American Aviation's Space and Information Systems Division gave their final presentation on a "Manned Mars Landing and Return Mission Study," reporting on work performed for ARC (NASA Contract NAS2-1408).
April 30	MSC issued an RFP for the *Study of Interplanetary Mission Support Requirements* (RFP Number MSC 64-1284P).
April 30	Lockheed Missiles and Space Company published a report titled *Study of Interplanetary Transportation Systems*, Phase III, Final Report No. 3-17-64-1 (NASA Report CR-56856, NASA Contract NAS8-2469).
May 13	Philco's Aeronutronic Division published a report titled "Summary Report: Study of a Manned Mars Excursion Module (U)" (Publication Number U-2530, NASA Contract NAS9-1608).
July 1	General Dynamics published "A Study of Manned Interplanetary Missions" (Report GD/A-AOK-64-006-i - iv; NASA Contract NAS8-5026).
July 24	Martin Company's Baltimore Division initiated a "Study on Spacecraft Propulsion for Manned Mars and Venus Studies for the NASA Headquarters Office of Manned Space Flight" (NASA Contract NASw-1053).
November	Philco's Aeronutronic Division presented the results of their MEM study to the AIAA 3rd Manned Space Flight Conference in Houston, Texas.
November 16	Philco's Aeronutronic Division study on the MEM was reported in *Aviation Week & Space Technology*.
1965	LeRC published *Space Flight Beyond the Moon*. The report was revised in May 1965.
January	NASA's Future Programs Task Group published a summary report in response to the Johnson Administration's request for programs to follow those already approved for the 1960s. The report was included in the documentation for the NASA Authorization for Fiscal Year 1966. Human planetary exploration was listed as one of the long-term goals that might be considered for the future.
February 5	MSFC published *Manned Planetary Reconnaissance Mission Study: Venus/Mars Flyby* (NASA TM X-53204). The report summarized the results of an in-house study.
March	TRW Space Technology Laboratory published *Mission Oriented Advanced Nuclear System Parameters Study*, a final report for MSFC (Report 8423-6005-RU-000; NASA Contract NAS8-5371).
March 18	Soviet Cosmonaut Aleksei Leonov became the first human to perform an extravehicular activity (EVA) or spacewalk.
May	NASA's LeRC published "Spaceflight Beyond the Moon" (revised edition).

June	North American Aviation published their final report *Manned Mars and/or Venus Flyby Vehicle Systems Study* (Accession #07360-65, SID 65-761-1, NASA Contract NAS9-3499).
June	Douglas Missile and Space Systems Division published a report titled "Study of Conjunction Class Manned Mars Trips," which presented the results of a 9-month study conducted for NASA's Office of Manned Space Flight (Douglas Aircraft Company Reports No. SM-48661 and No. SM-48662; NASA Contract NASw-1028).
June 3	Edward White II became the first American to perform an EVA.
June 8	General Dynamics/Convair published *Manned Mars and Venus Exploration Study* (Report #GD/C AOK 65-002-1, Contract NAS8-11327) for MSFC.
July 24	Martin Company's Baltimore Division presented their final briefing on "A Study on Spacecraft Propulsion for Manned Mars and Venus Studies" for the NASA Headquarters Office of Manned Space Flight (NASA Contract NASw-1053).
July 5-16	The National Academy of Sciences Space Science Board Working Group on Planetary and Lunar Exploration met at Wood's Hole, Massachusetts. They heard a presentation on human planetary missions.
July 15	The Mariner 4 robotic spacecraft flew within 6,118 miles of Mars. It returned the first close-up photographs of the Martian surface. The 22 images showed lunar-style craters on the surface, and the spacecraft's instruments indicated that carbon dioxide was the major component of the atmosphere.
August	In hearings before the Senate Space Committee, NASA officials stated their conclusion that decisions on human Mars missions should wait until a later date (*Aviation Week & Space Technology*, August 30, 1965).
August	The NASA-Air Force Conference on Mars-Venus Exploration was held at the Virginia Polytechnic Institute.
August 25	Dr. Donald F. Hornig, President Johnson's Science Advisor, testified to a Senate panel that a mission to place American astronauts on Mars would probably cost $100 billion. He expressed his conclusion that there were a number of national objectives that were more urgent than a human Mars mission.
August 28	The Manned Planetary Missions Planning Group held a preliminary meeting to discuss the development of a human planetary exploration program.
September 27	MSC issues a statement of work for "Integrated Manned Planetary Spacecraft Concept Definition."
November	Von Braun published an article titled "The Next 20 Years of Interplanetary Exploration."
1966	The National Academy of Sciences published *Space Research: Directions for the Future: Report of a Study by the Space Science Board, Woods Hole, Massachusetts, 1965* (Publication 1403).
February 1	MSC issued a statement of work for "Definition of Experimental Tests for a Manned Mars Excursion Module."
February 25	MSC issued an RFP for "Definition of Experimental Tests for a Manned Mars Excursion Module" (RFP BG721-12-6-434P).
March 16	Gemini 8 became the first piloted spacecraft to dock with another spacecraft in orbit. The target vehicle was a robotic Agena rocket stage.

April	NASA established a Planetary Joint Action Group (JAG) to focus on missions and technology for an interplanetary program.
August 15	MSC Director Robert R. Gilruth sent a memo to Dr. George E. Mueller, Associate Administrator for Manned Space Flight, expressing concern about the Agency's lack of long-term goals for the human space program. Gilruth suggested that a Mars landing mission or a flyby mission should be adopted as an in-house goal,.
August 19	*Space News Roundup*, MSC's newspaper, reported that MSFC had awarded a $400,000 contract to North American's Space Division to study Mars/Venus flyby missions.
May 3-4	Second meeting on planetary studies of the Planetary JAG was held at MSC.
June 29-30	Meeting of the Planetary JAG was held at the Kennedy Space Center (KSC) in Cape Kennedy (now Cape Canaveral), Florida.
Fall	Planetary JAG conferees concluded their study and submitted their report to the Associate Administrator of Manned Space Flight at NASA Headquarters.
October 3	NASA's Office of Manned Space Flight (OMSF)published *Planetary Exploration Utilizing a Manned Flight System*, a report labeled "For Internal Use Only." The report presented the results of an OMSF JAG Study.
November 28	*Technology Week* reported on MSC's plans for a 1975 piloted Mars flyby mission. The 4-person crew would launch in September 1975 for a 683-day mission, returning to Earth in July 1977. Mission elements included a robotic Mars soil sample return probe that would return samples to the spacecraft for analysis by scientist-astronauts during the flight.

1967

January	The Planetary Missions JAG met.
January 27	A launch pad fire during an Apollo 204 (Apollo 1) training session resulted in the deaths of three astronauts. The accident cast doubt on NASA's ability to safely send a crew to the Moon and back, and also placed the need for advanced mission planning in doubt.
February	The PSAC published a report titled *The Space Program in the Post-Apollo Period*.
February 16	Meeting of the Planetary JAG was held at KSC.
February 24	MSC's Advanced Spacecraft Technology Division's Planetary Missions Office published *Information Book on Their Planetary Missions Study, Task T2A600: Mars/Venus Manned Missions (Phase II).*
March 16	Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, was quoted in *Space Daily* as saying that "no major engineering breakthroughs are necessary for the accomplishment of a Mars/Venus reconnaissance in 1975." Mueller commented that such a mission could be launched in September 1975.
March 20	Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, testified before the House Committee on Science and Astronautics Subcommittee on Manned Space Flight. He presented a profile of a typical human mission to Mars. A report published 4 days earlier in *Space Daily* noted that Mueller's outline showed such a mission could be accomplished by 1975 using Saturn/Apollo technology.
March 22	The Planetary Missions JAG met.
April 12	The Planetary Missions JAG met.

April 7 — *Space Business Daily* reported that Dr. Nicholas E. Golovin, of the President's Office of Science and Technology, believed that it would be 5 to 7 years before a decision could be made on the development of major systems for a human Mars mission.

August — North American Aviation published their final report, *Study of Manned Planetary Flyby Missions Based on Saturn/Apollo Systems* (Report SID 67-549-1, NAS8-18025).

August 3 — MSC issued an RFP for a study of "Spacecraft for Manned Planetary Encounter/Retrieval Missions" (RFP BG721-18-7-557P).

August 3 — MSC sent out an RFP for a "Planetary Surface Sample Return Probe Study for Manned Mars/Venus Reconnaissance/Retrieval Missions" (RFP BG721-28-7-528P). Initiation of new studies angered Representative Karth, who had been battling in Congress to save the Voyager (Mars) Program.

August 29 — NASA canceled the Voyager Mars probe program (not to be confused with the later Voyager Program to visit the outer planets). Problems with Voyager Program costs further discredited human Mars mission planning efforts.

December — MSC Advanced Spacecraft Technology Division's Planetary Missions Office published *A Study of Spacecraft Design and Operations for Manned Planetary Encounter Missions* (Report MSC-EA-R-67-1).

1968

January — Boeing's Aerospace Group published their final report, *Integrated Manned Interplanetary Spacecraft Concept Definition*. This work was performed under contract to LaRC (Report D2-113544-1, NASA CR-66558, NASA Contract NAS1-6774).

January 12 — North American Rockwell Corporation's Space Division published their final report, *Definition of Experimental Tests for a Manned Mars Excursion Module*, in which they summarized work performed for MSC (Report SD 67-755-1, NASA Contract NAS9-6464).

January 15 — Boeing presented their "Study of an Integrated Manned Interplanetary Spacecraft Concept Definition," reporting on work performed under contract to LaRC (Report Number D2-113544-1, NASA Contract NAS1-6774).

January 31 — Thomas O. Paine was appointed Deputy Administrator of NASA.

October 8 — James E. Webb retired from his position as NASA Administrator. Deputy Administrator Thomas O. Paine was named Acting Administrator of NASA.

October 11 — Launch of Apollo 7, the first piloted flight of the Apollo spacecraft, using a Saturn IB launch vehicle.. After over a week in Earth orbit, the crew splashed down on October 22, 1968.

November — Richard M. Nixon won the U.S. Presidential election.

November — President-elect Richard M. Nixon established a task force (the Townes Task Force) to provide advice on the post-Apollo space program.

December 21 — First piloted launch of a Saturn V launch vehicle. The Apollo 8 flight was the first circumlunar mission. After completing 10 orbits of the Moon, the crew returned to Earth on December 27.

1969

January — The Townes Task Force recommended against new, costly space endeavors.

January 20 — Richard M. Nixon was sworn in as the 37th President of the United States.

February	President Nixon established the STG under Vice President Spiro Agnew to develop recommendations for America's future in space.
February 10	A NASA contractor report entitled "An Analysis of the Allocation of Federal Budget Resources as an Indicator of National Goals and Priorities" (report No. BMI-NLVP-TR-69-1, NASA Contract NASw-1164) predicted that an increase in the space budget was unlikely, and that the growth of the human spaceflight portion was likely to be well below the average compared to other research and development programs.
March 5	Thomas O. Paine was nominated to the position of NASA Administrator. He was confirmed by the Senate on March 20.
July 10	NASA published "An Integrated Program of Space Utilization and Exploration for the Decade 1970 to 1980 (Summary)."
July 16	NASA published "An Integrated Program of Space Utilization and Exploration for the Decade 1970 to 1980."
July 20	Apollo 11 astronauts Neil A. Armstrong and Edwin E. "Buzz" Aldrin landed on the Moon, becoming the first humans to set foot on another planetary body.
July 22	A NASA internal memorandum (D. D. Wyatt, Assistant Administrator for Program Plans and Analysis, to Dr. Homer Newell, Associate Administrator) stated that NASA could achieve a piloted Mars landing launched within either 1979 or 1981. The total cost of the program was estimated at $30-40 billion.
July 31	The Mariner 6 spacecraft flew within 2,131 miles of Mars. The robotic spacecraft returned surface photographs and data about the environment of Mars including surface temperatures and information about the atmosphere.
August 4	NASA Administrator Dr. Thomas O. Paine was quoted by *Space Business Daily* as saying that a human Mars mission could be achieved in 1982.
August 4	Dr. Wernher von Braun gave a presentation on a human Mars landing to the STG.
August 5	Von Braun presented information on human Mars missions to the Senate Committee on Aeronautical and Space Sciences.
August 5	Mariner 7 spacecraft flew within 2,130 miles of Mars. The robotic spacecraft returned surface photographs and environmental data.
August 7	Representative Joe L. Lewis of Tennessee submitted an editorial from the *Nashville Banner* into the *Congressional Record* opposing a human Mars mission.
August 13	Representative Hamilton Fish, Jr., of New York submitted an editorial from the *Washington Post* into the *Congressional Record*. The editorial recommended that NASA should pursue basic scientific research rather than committing to placing a human on Mars.
August 15	Deadline for the written report of the Manned Planetary Working Group.
August 18	*Aviation Week & Space Technology* reported that NASA's plan for a human Mars mission had received "sharp criticism" in Congress. Among the critics was Representative George P. Miller (D-Calif.), Chairman of the House Committee on Science and Astronautics. Although Miller supported human exploration of Mars as a long-term goal, he believed that planning for a 1981 mission was premature. Another Congressional critic noted in the article was Representative Joseph E. Karth (D-Minn.).
September	NASA issued *America's Next Decades in Space: A Report for the Space Task Group*.

September 15 — President Nixon met with his STG to discuss plans for a human Mars mission. The President accepted the group's recommendation that NASA should have a goal for a human landing in the period 1980-2000, but he rejected an expensive mission achieved at the expense of a balance space program.

September 16 — The STG released *The Post-Apollo Space Program: Directions for the Future – Space Task Group Report to the President.*

September 19 — NASA Administrator Thomas O. Paine sent a letter to the White House recommending that the President select "Option 2" from the STG's report.

October 1 — Representative Olin Teague, chairman of the House Manned Space Flight Subcommittee, predicted that President Nixon could get Congressional approval for a 1983 human landing on Mars (*Houston Chronicle*, October 1, 1969).

October 29 — *Space Daily* reported that William A. Anders, Executive Secretary of the National Space Council, had predicted that a human Mars landing will "inevitably take place before the end of this century.

1970

January 4 — NASA announced cancellation of the Apollo 20 mission.

January 12 — Robert F. Allnutt, Assistant Administrator for Legislative Affairs, responded to an inquiry about human Mars mission costs from Representative Joseph E. Karth, Chairman of the House Committee on Science and Astronautics Subcommittee on Space Science and Applications. Allnutt estimated the costs at $14-19 billion, not including the price of "a space station, nuclear shuttle, and earth-to-orbit shuttle" which were considered to be "elements of an integrated manned space flight program."

January 14 — NASA announced suspension of Saturn V production after completion of the 15th booster. This decision left the Agency without the capability to produce a heavy-lift launch vehicle.

March — Office of Science and Technology. PSAC. Space Science and Technology Panel. *The Next Decade in Space: A Report of the Space Science and Technology Panel of the President's Science Advisory Committee.*

Appendix Sources: Roger E. Bilstein, Orders of Magnitude: A History of the NACA and NASA, 1915-1990, NASA SP-4406 (Washington, D.C.: NASA, 1989); William David Compton, Where No Man Has Gone Before: A History of Apollo Lunar Exploration Missions, NASA SP-4214 (Washington, D.C.: 1989); Bruce M. Cordell, "Manned Mars Mission Overview (Invited Paper)," AIAA-89-2766, presented to the AIAA/ASME/SAE/ASEE 25th Joint Propulsion Conference, Monterey, California, July 10-12, 1989; Dwayne A. Day, "Doomed To Fail: The Birth And Death Of The Space Exploration Initiative," *Spaceflight* 37 (March 1995) : 79-83; Dwayne A. Day, "Paradigm Lost," Space Policy 11 (August 1995) 153-159; Franklin P. Dixon, "Manned Planetary Mission Studies from 1962 To 1968," IAA-89-729, Presented to the 40th Congress of the International Astronautical Federation, October 7-12, 1989, Málaga, Spain; Edward C. Ezell, "Man On Mars: The Mission That NASA Did Not Fly," Presented to the American Association for the Advancement of Science Annual Meeting, Houston, Texas, January 3-8, 1979 (located in the JSC History Collection); Logsdon, John M., ed. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, volume 1: Organizing for Exploration, NASA SP-4218. (Washington, D.C.: NASA, 1995); Robert B. Merrifield, "A Historical Note on the Genesis of Manned Interplanetary Flight," Presented to the Joint National Meeting of the American Astronautical Society (15th Annual) and the Operations Research Society, June 17-20, 1969 (located in the JSC History Collection, JSC Files, Manned Mars Mission Studies, Box 14); NASA Headquarters History Office (Washington, D.C.): Folder 009025 - "Manned Mars Landing/Flight Documents," Folder 009029 - "Mars Symposia/AAS/June 1963, Denver, CO," Folder 009030 - "Von Braun Long-Range Planning Presentation," Folder 009031 - "Mars Exploration – Early concepts," Folder 009032 - "To Mars 1958-1970," Folder 009034 - "To Mars 1971 to 1987," Folder 009035 - "To Mars (1988-1991)," Folder 009036 - "Manned Mars Mission (Cost), Folder 009039 - "Mission to Mars (1990-1991)," Folder 009040 - "Mission to Mars (1987-1989)," and Folder 009041 - "Project Mars (Manned Flight);" Johnson Space Center (Houston, TX) Scientific and Technical Information Center, Historical Collection, JSC Center Series: Advanced Program Planning Subseries (Boxes 1-2, 5-6), Manned Mars Mission Studies Subseries (Boxes 1-4, 6-8, 12-16), and Planetary Missions - Silveira Files Subseries (Boxes 1-3); Frederick I. Ordway, III, Mitchell R. Sharpe, and Ronald C. Wakeford, "EMPIRE: Background and Initial Dual-Planet Mission Studies," IAA-90-632, Presented To The 41st International Astronautical Congress, 24th Symposium on the History of Astronautics, Dresden, October 11, 1990; C. Howard Robins, Jr., "An Introduction to the NASA Manned Planetary Mission Studies and a Brief Survey of the Study Results," MSC Internal Note No. 65-ET-7 (Houston, Tex.: NASA MSC, February 1965), Located in the JSC History Collection, Center Files, Planetary Missions-Silveira Files, Box 1: 1962-1965.

APPENDIX B

MARS ROBOTIC EXPLORATION CHRONOLOGY

1960

October	U.S.S.R. launched Korabl 4 (10/10) and Korabl 5 (10/14). Believed to have been Mars probes, both spacecraft failed in Earth orbit. Reportedly, Soviet Premier Nikita Krushchev had timed his arrival for the United Nation's opening session to coincide with the launches and had carried models of the spacecraft in his luggage. When the missions failed, no mention of the launch attempts was made by the Soviets. The failures were announced by the U.S. in 1962.

1962

October	U.S.S.R. launched Korabl 11 on 10/24. The spacecraft failed to leave Earth orbit and reentered on 10/29.
November	U.S.S.R. launched Mars 1 (11/1). Korabl 13, launched 3 days later (11/4), failed in Earth orbit and reentered on 11/5.

1963

March	Mars 1 experienced communications failure on 3/21.
June	Mars 1 passed within 193,000 km (120,000 mi.) of Mars on 6/19.

1964

November	U.S. launched Mariner 3 Mars probe on 11/5. The vehicle experienced a launch failure and entered solar orbit. U.S. launched Mariner 4 on 11/28.
	U.S.S.R. launched Zond 2 on 11/30.

1965

May	Zond 2 experienced communications failure.
July	Mariner 4 flew by Mars on 7/15.
	U.S.S.R. launched Zond 3 on 7/18.
August	Zond 2 passed within 1,500 km of Mars on 8/6.

1969

February	U.S. launched Mariner 6 on 2/24.
March	U.S.S.R. launched an unannounced spacecraft on 3/27. The spacecraft, believed to be a Mars probe, may have experienced a launch failure.
	U.S. launched Mariner 7 on 3/27.
July	Mariner 6 flew within 3,431 km of Mars on 7/31.
August	Mariner 7 flew within 3,430 km of Mars on 8/5.

Appendix Sources: Norman L. Baker, *Soviet Space Log: 1957-1967* (Washington, D.C.: Space Publications, Inc., 1967), pp. 33-34; Nicholas L. Johnson, *Handbook of Soviet Lunar and Planetary Exploration* (San Diego:

Univelt, 1979), pp. 243-244; Joe Heyman, *Spacecraft Tables 1957-1990* (San Diego: Univelt, 1991), p. 25, 26, 79, 81; Douglas Hurt, *Encyclopedia of Soviet Spacecraft* (New York: Exeter Books, 1987), pp. 68-74; "Soviet Space Failures are Disclosed," *Missiles and Rockets* 11 #11 (Sept. 10, 1962), p. 12.

APPENDIX C

MARS ROBOTIC SPACECRAFT DATA (BY SPACECRAFT NAME)

Note: The information in this appendix was compiled from a number of sources. It was not possible to obtain the same data for all spacecraft. Where both metric and English Standard measurements are given, they were found in original sources (no attempt was made to calculate conversions). Where conflicting figures were found, those provided by official sources or occurring most frequently were used.

Definitions:
Apicenter: Point on orbit furthest from the primary (i.e., apogee for Earth orbit, apihelion for solar orbit, and apares for Mars orbit)
Pericenter: Point on orbit closest to the primary (i.e., perigee for Earth orbit, perihelion for solar orbit, and periares for Mars orbit)

Korabl 4 (U.S.S.R.) [aka Mars-1960A]
Objective: Mars flyby mission
Launched: October 10, 1960 Launch Vehicle: A-2-e (Molniya)
Mass: 850 kg?
Results: Third stage failed and spacecraft failed to reach Earth orbit
Notes: First use of larger booster and of Earth parking orbit; failure was announced by the U.S. in 1962

Korabl 5 (U.S.S.R.) [aka Mars-1960B]
Objective: Mars flyby mission
Launched: October 14, 1960 Launch Vehicle: A-2-e (Molniya)
Mass: 850 kg?
Results: Failed to reach Earth orbit
Notes: Failure was announced by the U.S. in 1962

Korabl 11 (U.S.S.R.) [aka Mars-1962A]
Objective: Mars flyby mission
Launched: October 24, 1962 Launch Vehicle: A-2-e (Molniya)
Mass: 894 kg?
Apogee: 217 km Perigee: 196 km
Inclination: 65° Period: 89 min.
Results: Failed to leave Earth orbit and reentered on 10/29

Korabl 13 (U.S.S.R.) [aka Mars-1962B]
Objective: Mars flyby mission
Launched: November 4, 1962 Launch Vehicle: A-2-e (Molniya)
Mass: 894 kg?
Apogee: 158 km Perigee: 136 km
Inclination: 65° Period: 87.7
Results: Failed to leave Earth orbit and reentered on 11/5

Mariner 3 (U.S.)
Objective: Mars flyby
Launched: November 5, 1964 Launch Vehicle: Atlas-Agena D
Mass: 261 kg
Aphelion: 0.8155 AU Perihelion: 1.6150 AU
Inclination: 0.524° Period: 448.7 days

Results: Experienced booster failure when the shroud did not jettison and ceased functioning soon after launch (unable to open solar panels to receive energy). Drifted into solar orbit and the battery power failed 8 hr. 43 min. after launch.

Mariner 4 (U.S.)

Objective: Mars flyby
Launched: November 28, 1964 Launch Vehicle: Atlas-Agena D
Mass: 261 kg
Apogee: 184.2 km Perigee: 172.2 km
Inclination: 28.3°
Trans-Mars Interval: 228 days
Mars Flyby: 7/15/65 Distance: 9,844 km (6,118 mi.)
Description: Main body consisted of a 138.4 cm-diameter, 45.7 cm-high octagonal magnesium frame. Seven compartments contained electronics and an eighth compartment contained the 220 N hydrazine course correction system. A high-gain dish antenna was mounted atop the base, and a low-gain antenna was mounted on top of an aluminum tube. Attitude jets were mounted on the solar panel tips. Overall spacecraft height was 2.89 m.
Power: Provided by four solar arrays, spanning 6.88 m, and a 1,200 W-hr silver-zinc battery.
Scientific payload: Meteoroid detector (0.95 kg), cosmic ray telescope (1.2 kg), ionization chamber (1.3 kg), magnetometer (3.1 kg), trapped radiation detector (1.0 kg), solar plasma probe (2.9 kg)
Other equipment: TV system (5.1 kg) consisting of a single TV camera on a scan platform with an f/8, 30.5 cm-focal-length Cassegrain telescope
Results: First successful Mars flyby. Returned the first close-up photographs of the Martian surface (22 total). Discovered lunar-style craters on the surface, measured the ionosphere and atmosphere, and determined that carbon dioxide was the major constituent of the atmosphere. Indicated that the surface pressure on Mars was 5 mb (scientists had expected anything up to 80 mb), found that the daytime temperature on the surface was around 100°C, and determined that the magnetic field was about 0.1% that of Earth.

Mariner 6 (U.S.)

Objective: Mars Flyby
Launched: February 24, 1969 Launch Vehicle: Atlas-Centaur
Mass: 413 kg
Trans-Mars Interval: 156 days
Mars Flyby: 7/31/69 Distance: 3,431 km (2,131 mi.)
Description: Main body consisted of a 138.4 cm-diameter, 45.7 cm-high octagonal magnesium frame. Seven compartments contained electronics and an eighth contained the 220 N hydrazine course correction system. A high-gain dish antenna was mounted atop the base, and a low-gain antenna was mounted on top of an 2.23 m tube. Attitude jets were mounted on the solar panel tips. Overall spacecraft height was 3.34 m.
Power: Provided by four solar arrays, spanning 5.79 m, and a 1,200 W-hr silver-zinc battery.
Scientific payload: Infrared radiometer, infrared spectrometer, ultraviolet spectrometer (total instrument mass: 59 kg)
Other equipment: TV system consisting of wide- (52 mm) and narrow- (508 mm) angle TV cameras carried on a scan platform. The platform moved to 70° in elevation and 215° in azimuth and was controlled by a reprogrammable computer.
Results: Successful Mars flyby and photography. Acquired data on Mars using a visual imager, ultraviolet spectrometer, and temperature sensors. The radiometer recorded surface temperatures at the equator that were -73°C at night with a low temperature of –125°C at the southern pole. Data returned recorded a surface pressure of 6-7 mb and indicated that CO_2 comprised 98% of the Martian atmosphere.
Notes: First Mariner launched using Atlas-Centaur launch vehicle.

Mariner 7 (U.S.)

Objective: Mars Flyby
Launched: March 27, 1969 Launch Vehicle: Atlas Centaur
Mass: 413 kg
Trans-Mars Interval: 133 days
Mars Flyby: 8/5/69 Distance: 3,430 km (2,130 mi.)
Description: Main body consisted of a 138.4 cm-diameter , 45.7 cm-high octagonal magnesium frame. Seven compartments contained electronics and an eighth contained the 220 N hydrazine course correction system. A high-gain dish antenna was mounted atop the base, and a low-gain antenna was mounted on top of an 2.23 m tube. Attitude jets were mounted on the solar panel tips. Overall spacecraft height was 3.34 m.
Power: Provided by four solar arrays, spanning 5.79 m, and a 1,200 W-hr silver-zinc battery.
Scientific payload: Infrared radiometer, infrared spectrometer, ultraviolet spectrometer (total instrument mass: 59 kg)
Results: Successful Mars flyby and photography
Notes: Together, Mariner 6 and Mariner 7 returned 143 analog pictures on their approaches to Mars. They returned 58 photos during flyby, and made close-up photos of 20% of the surface; and they measured daytime and nighttime surface temperatures and confirmed the presence of CO_2, ionized CO_2, atomic hydrogen, and slight traces of molecular oxygen.

Mars 1 (U.S.S.R.)

Objective: Mars Flyby, primarily intended to photograph the planet from a distance of 11,000 km. Also designed to record and transmit measurements on the planet's magnetic field, radiation field, cosmic radiation, and micrometeroid impacts.
Launched: November 1, 1962 Launch Vehicle: A-2-e (Molniya)
Mass: 893.5 kg
Apogee: 238 km Perigee: 157 km
Inclination: 65° Period: 88.4 min.
Aphelion: 1.604 AU Perihelion: 0.924 AU
Inclination: 2.68° Period: 519 days
Mars Flyby: 6/19/63 Distance: 193,000 km
Description: Cylindrical “bus” 3.3 meters (10.89 ft.) long and a maximum width of 1.0 m; modification of the Venera-type spacecraft; carried a parabolic dish communication antenna (1.7 m in diameter); the experiment module was cylindrical (1.0 m diameter, 0.6 m deep) and was located at the base
Power: Supplied by solar panels (1.1 m high and 0.9 m across) on either side of the spacecraft
Scientific payload: Equipped with a spectroreflexometer designed to look for indications of organic compounds on the planet. Also designed for radiowave probing of the atmosphere and the Martian surface.
Other Equipment: Carried a television system
Mission Results: Communications failed on 3/21/63, possibly due to attitude control problems. However, spacecraft broke Mariner 2’s communications distance record (Mars 1 communicated from 106,760,000 km away). No pictures or data were received. Guidance systems continued to function and Mars 1 was the first spacecraft to fly within 193,000 km of Mars

Zond 2 (U.S.S.R.)

Objective: Designed to land or impact on Mars
Launched: November 30, 1964 Launch Vehicle: A-2-e (Molniya)
Mass: 907 kg? (assumption based on Mars 1)
Apogee: 191 km Perigee: 174 km
Inclination: 65° Period: 88.15 min.
Mars Flyby: 8/6/65 Distance: 1,500 (1,497 km/930 mi.)
Description: Equipped with a set of six experimental plasma (electronic ion) engines designed to assist in attitude control
Results: Experienced a communications failure in early May 1965

Zond 3 (U.S.S.R.)
Objective: Believed to be a Mars probe
Launched: July 18, 1965
Mass: 960 kg
Apogee: 209 km Perigee: 163.5 km
Inclination: 64.78° Period: 88.42 min.
Scientific Payload: ultraviolet spectrograph (2,500-3,500 Å), ultraviolet and infrared spectrograph (1,900-2,700 Å, 3-4 μm), meteoroid detectors, radiation sensors (cosmic rays, solar wind), magnetometer, ion thrust test, radiotelescope
Results: Designed as a systems test vehicle, the spacecraft was still communicating when it passed through the orbit of Mars, but it was too distant from the planet to record data; Successfully photographed the lunar far side; included experiments to determine magnetic field properties, infrared studies of the Moon's surface, micrometeorite size and frequency, and cosmic ray properties.

Unannounced spacecraft (U.S.S.R.) [aka Mars-1969A]
Objective: Believed to be a Mars probe
Launched: March 27, 1969 Launch Vehicle: D-1-e (Proton)
Mass: 3,500 kg?
Results: May have experienced a booster failure

Unannounced spacecraft (U.S.S.R.) [aka Mars-1969B]
Objective: Believed to be a Mars probe
Launched: April 14, 1969 Launch Vehicle: D-1-e (Proton)
Mass: 3,500 kg?
Results: May have experienced a booster failure

Appendix Sources: Norman L. Baker, *Soviet Space Log: 1957-1967* (Washington, D.C.: Space Publications, Inc., 1967), pp. 33-34; California Institute of Technology, Jet Propulsion Laboratory, *Mariner-Mars 1964: Final Project Report*, NASA SP-139 (Washington, D.C.: NASA, 1967), pp. 133; Edward Clinton Ezell and Linda Newman Ezell, *On Mars: Exploration of the Red Planet, 1958-1978*, NASA SP-4212 (Washington, D.C.: NASA, 1984); Joe Heyman, *Spacecraft Tables 1957-1990* (San Diego: Univelt, 1991), p. 25, 26, 79, 81; Douglas Hurt, *Encyclopedia of Soviet Spacecraft* (New York: Exeter, 1987), pp. 68-74; Steven J. Isakowitz, *International Reference Guide to Space Launch Systems*, 1991 ed. (Washington, D.C.: AIAA, 1991), p. 106; Nicholas L. Johnson, *Handbook of Soviet Lunar and Planetary Exploration* (San Diego: Univelt, 1979), pp. 243-244; Larry Klaes, "The Rocky Soviet Road to Mars," *Spaceflight* 32 #8 (Aug. 1990), pp. 273-282; Saunders B. Kramer, "A Retrospective Look at the Soviet Union's Efforts to Explore Mars," AAS-81-250, *The Case For Mars: Proceedings of a Conference Held April 29-May 2, 1981 at the University of Colorado, Boulder, CO* (San Diego: Univelt, 1984), pp. 269-279; "Soviet Space Failures are Disclosed," *Missiles and Rockets* 11 #11 (Sept. 10, 1962), p. 12; Andrew Wilson, *Solar System Log* (New York: Jane's, 1987).

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NOTES

Chapter One: Fascination With Mars

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[3] Everett F. Bleiler, *Science-Fiction: The Early Years* (Kent, Oh.: Kent State University Press, 1990), 163-164.

[4] Bleiler, 51, 95-100, 146, 173, 248, 280, 295-296, 347-348, 434.

[5] Bleiler, 20-23, 93-94, 312, 422-423, 605-606, 626, 665; Ezell and Ezell, p. 3-4. An interesting discussion of the influence of Kurd Lasswitz and *Auf Zwei Planeten* can be found in Mark R. Hillegas' Afterword to the 1971 English translation, *Two Planets*. Kurd Lasswitz *Two Planets*, trans. Hans H. Rudnick (Carbondale, Ill.: Southern Illinois University Press, 1971), 397-405.

[6] Bleiler, 5-6, 14-15, 31, 168-169, 197, 201-203, 213, 239-240, 252, 281-283, 300-301, 386, 396, 459-461, 474, 483-484, 510, 529, 633, 641, 644, 740-742, 753, 817-818.

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[8] Ernst Stuhlinger and Frederick I. Ordway III, *Wernher von Braun: Crusader for Space; A Biographical Memoir* (Malabar, Florida: Krieger Publishing Co., 1994) foreword, 75, 108; Ernst Stuhlinger and Frederick I. Ordway III, *Wernher von Braun: Crusader for Space; An Illustrated Memoir* (Malabar, Florida: Krieger Publishing Co., 1994), xvi-xvii. These books, based upon interviews with von Braun's associates, offer an interesting look at the life of von Braun. For more information on the von Braun team's surrender and immigration to the U.S., see Walter A. McDougall, *Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc, 1985), Chapter 2, 41-44.

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[10] Wernher von Braun, *The Mars Project* (Urbana, Ill.: University of Illinois Press, 1953), 1-2.

[11] Von Braun, *The Mars Project*, 2-3, 5-7.

[12] Von Braun, *The Mars Project*, 9-36, 75-76.

[13] Von Braun, *The Mars Project*, 3, 39-40, 61-62, 65-66.

[14] *The Mars Project* has always fascinated NASA's advanced missions planners. An article published in JSC's newspaper, *Space News Roundup*, on November 16, 1979, summarized the mission described in the book. It was also a frequently-requested item at the New Initiatives Office/Exploration Programs Office library while work was under way for the SEI. "The Mars Project," *Space News Roundup* 18 #23 (November 16, 1979), p. 4.

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SP-4218 (Washington, D.C.: NASA, 1995)., 17-18; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 112; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; An Illustrated Memoir*, xvii, 115; Randy Liebermann, "Wernher von Braun and Collier Magazine's Man in Space Series," AAS-92-344, in *History of Rocketry and Astronautics*, ed. Lloyd H. Cornett, Jr., AAS History Series, vol. 15, IAA History Symposia, vol. 9 (San Diego, Ca.: American Astronautical Society/Univelt, 1993), p. 236; Randy Liebermann, "The Collaboration of Wernher von Braun and Fred Freeman," (paper presented at the Twenty-Third Symposium of the International Academy of Astronautics, Málaga, Spain) in John Becklake,ed., *History of Rocketry and Astronautics: Proceedings of the Twenty-Second and Twenty-Third History Symposia of the International Academy of Astronautics*, AAS History Series, vol. 17, IAA History Symposia, vol. 10 (San Diego, Ca.: American Astronautical Society/Univelt, 1995), 37; "What Are We Waiting For?," *Collier's* 129 (March 22, 1952) 23.

[16] Lanius, "Prelude to the Space Age," in *Organizing for Exploration*, 17-18; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 112-115; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; An Illustrated Memoir*, 115; Liebermann, "Wernher von Braun and Collier Magazine's Man in Space Series," 236-242; Liebermann, "The Collaboration of Wernher von Braun and Fred Freeman," 37-39; "What Are We Waiting For?," *Collier's* 129 (March 22, 1952) 23.

[17] "What Are We Waiting For?," *Collier's* 129, no. 12 (March 22, 1952): 23. An issue-by-issue inventory of the articles in *Collier's* Man in Space series demonstrates the depth of coverage concerning the subject. The first magazine, *Collier's* 129, no.12 (March 22, 1952), was an introductory issue and included "What Are We Waiting For?" (p. 22-23); "Crossing the Last Frontier," by Wernher von Braun, (p. 24-29, 72, 74); "A Station in Space," by Willy Ley (p. 30-31); "The Heavens Open," by Fred Whipple (p. 32-33); "This Side of Infinity," by Joseph Kaplan (p. 34); "Can We Survive in Space," by Heinz Haber (p. 35, 65-67); "Who Owns the Universe?," by Oscar Schachter (p. 36, 70-71); and "…Space Quiz (p. 38-39). The second installment, *Collier's* 130, no. 16 (October 18, 1952) concerned human lunar missions and included "Man on the Moon" (p. 51); "Man on the Moon: the Journey," by Wernher von Braun (p. 52-60); and "Inside the Moon Ship," by Willy Ley (p. 56). The third issue, *Collier's* 130, no. 17 (October 25, 1952) continued the lunar theme with "Man on the Moon: the Exploration," by Fred L. Whipple and Wernher von Braun (p. 38-48) and "Inside the Lunar Base," by Willy Ley (p. 46). *Collier's* 131, no. 9 (February 28, 1953), the fourth installment, concerned the human element and included part one of "Man's Survival in Space," edited by Cornelius Ryan (p. 40-41) – "Picking the Men, (p. 42-48). Issue five in the series, *Collier's* 131, no. 10 (March 7, 1953), continued with part two of "Man's Survival in Space," entitled "Testing the Men" (p. 56-63). Part three of "Man's Survival in Space," *Collier's* 131, no. 11 (March 14, 1953), covered the dangers of space travel with an article titled "Emergency!" (p. 38-44). The seventh issue, *Collier's* 131, no. 26 (June 27, 1953), included the article "Baby Space Station," by Wernher von Braun with Cornelius Ryan (p. 33-40). *Collier's* 133 (April 30, 1954), the final installment, concerned the exploration of the Red Planet and included two articles: "Is There Life on Mars?" by Fred L. Whipple (p. 21) and "Can We Get to Mars?," by Wernher von Braun with Cornelius Ryan (p. 22-29).

[18] Wernher von Braun with Cornelius Ryan, "Can We Get to Mars?," *Collier's* 133 (April 30, 1954): 22-29; Ezell and Ezell, p. 8.

[19] Lanius, "Prelude to the Space Age," in *Organizing for Exploration*, 18, 176-177; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 114-115; Liebermann, "Wernher von Braun and Collier Magazine's Man in Space Series," 240; Cornelius Ryan, ed., *Across the Space Frontier* (New York: Viking Press, 1953) acknowledgment.

[20] Lanius, "Prelude to the Space Age," in *Organizing for Exploration*, 19; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 115-117.

[21] Lanius, "Prelude to the Space Age," in *Organizing for Exploration*, 19; Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 115-117. Stulinger and Ordway, in their book, suggested that the Disney film may have influenced Eisenhower's decision to launch a satellite during the International Geophysical Year (IGY) (June 1957-Dec. 1958). They relay a story told by David R. Smith, director of the Walt Disney Productions archives. According to Smith, President Eisenhower borrowed the film of the first episode to show to his military advisors. Six weeks later, the United States announced that it intended to launch a satellite as part of the IGY. Lanius suggested that the linking of Disney's "Man in Space" to the U.S. announcement was "an overstatement." Stuhlinger and Ordway, *Wernher von Braun: Crusader for Space; A Biographical Memoir*, 116; Lanius, "Prelude to the Space Age," in *Exploring the Unknown*, 19.

[22] Kenneth W. Gatland, "Orbital Rockets: Some Preliminary Considerations," *Journal of the British Interplanetary Society* 10, no. 3 (May 1951): 97-107. John Pike , Director of Space Policy and Cyber Strategy

Projects for the American Federation of Scientist, noted that, while there was much written on human Mars missions during the period 1939-1960, very few authors looked at the subject in any detail. The criteria used by Pike were that the work had to have "at least a picture of what the spacecraft would look like, backed up by rough mass/energy budget calculations." The combination of vehicle concept and calculations seemed a good indication that the work was indeed a mission study. This current study used Pike's criteria to select the concepts discussed in this chapter. John Pike, Message posted to AEROSP-L Aerospace History Internet Newsgroup, September 30, 1995.

[23] Eric Burgess, *Rocket Propulsion: With an Introduction to the Idea of Interplanetary Travel* (London: Chapman and Hall, 1954) 5-6, 166-228; John Pike,. Message posted to AEROSP-L Aerospace History Internet Newsgroup, September 30, 1995.

[24] Virginia P. Dawson, *Engines and Innovation: Lewis Laboratory and American Propulsion Technology*, NASA SP-4306 (Washington, D.C.: NASA, 1991) 154; E. Stuhlinger, "Possibilities of Electrical Space Ship Propulsion," *Proceedings of the V International Astronautical Federation Congress, Innsbruck, Austria, 5-7 August 1954*, 100-119; John Pike,. Message posted to AEROSP-L Aerospace History Internet Newsgroup, September 30, 1995. Hermann J. Oberth, in his *Wege zur Raumschiffahrt* (Ways to Spaceflight), discussed the possibility of a human flight to Mars. While he did not propose a specific mission profile, he noted the possibility of using Martian resources to manufacture fuel for the return trip. In-situ resource utilization, while only a passing thought in Oberth's day, has since become a popular solution to the logistics problems inherent to a human Mars mission. Hermann Oberth, *Ways to Spaceflight*, translation of *Wege zur Raumschiffahrt*, NASA Translation, NASA TT F-622 (Munich-Berlin: R. Oldenbourg Verlag, 1929): 532-547.

[25] Willy Ley and Wernher von Braun, *The Exploration of Mars* (New York: Viking Press, 1960) 88, 97-98.

[26] Ley and von Braun, 108-111.

[27] Ley and von Braun, 121-130.

[28] Ley and von Braun, 131-165.

[29] Ordway, Sharpe, and Wakeford, 5-7; Ordway, "Mars Mission Concepts: the von Braun Era," 77-78.

Chapter Three: Emergence of NASA

[30] These four areas are identified by President Dwight D. Eisenhower in his memoirs written in 1965. Dwight D. Eisenhower, *The White House Years: Waging Peace, 1956-1961* (Garden City, NY: Doubleday, 1965), 239. Another effect of Sputnik was to increase public awareness of, and interest in, space. The satellite launch triggered a wave of news articles and public interviews with space experts such as Wernher von Braun. In an interview with *U.S. News and World Report*, von Braun discussed possible space program objects. During his discussion of a space station, he emphasized that a station was necessary as a "jump-off" point for expeditions to Mars. "Interview with Top Rocket Expert Dr. Wernher von Braun – Space Travel: When it is Coming … What it Will be Like," *U.S. News and World Report* (October 18, 1957): 36-42. For a thorough discussion of Sputnik, see Robert A. Divine, *The Sputnik Challenge* (New York: Oxford University Press, 1993) or Chapter 7 of McDougall.

[31] The DOD established the Advanced Research Projects Agency (ARPA) in 1958-59 to conduct high-technology research that was not specific to any of the service branches. ARPA's original project assignments were in the areas of military space technology, ballistic missile defense, and solid propellant chemistry. T. Keith Glennan, *The Birth of NASA: The Diary of T. Keith Glennan* (Washington, D.C.: NASA, 1993) 9 (footnote 7).

[32] James R. Killian, Jr., *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology*. (Cambridge, Mass.: MIT Press, 1977) 122-125, Divine, 97-107; John M. Logsdon, *Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge, Ma: M.I.T. Press, 1970), 18-20. The panel was made up of General James Doolittle, Edwin Land, Herbert York, and Edward Purcell. Killian notes that the scientific community was generating a number of proposals for a space program. Among the organizations making recommendations were the U.S. National Committee for the IGY (February 1958); and the American Rocket Society and the Rocket and Satellite Research Panel of the National Academy of Sciences, which began work on a joint report prior to the launch of Sputnik 1 (submitted to the president in January 1958). Killian, 125. "Introduction to Outer Space," in Killian, 289.

[33] "Introduction to Outer Space," full text in Killian, 288-299 and partial text in *Exploring the Unknown*, 332-334; Logsdon, *Decision to Go to the Moon*, 18-20.

[34] According to Robert Divine, Eisenhower agreed to a civilian space agency only after much convincing by Killian and Vice President Richard M. Nixon. Divine, 101. Logsdon calls Eisenhower's creation of a civilian

agency "perhaps the most important and lasting impact of the Eisenhower space policy." Logsdon, *Decision to Go to the Moon*, 20.

[35] Dwight D. Eisenhower, "Special Message to the Congress Relative to Space Science and Exploration, April 2, 1958," in *Public Papers of the Presidents of the United States: Dwight D. Eisenhower; Containing the Public Messages, Speeches, and Statements of the President, January 1 to December 31, 1958* (Washington, D.C.: Government Printing Office, 1959), 270; Killian, 125-144. Eisenhower's memo stated that the factors identified in the Purcell Report "have such a direct bearing on the future progress as well as on the security of our Nation that an imaginative and well-conceived space program must be given high priority and a sound organization provided to carry it out. Such a program and the organization which I recommend should contribute to (1) the expansion of human knowledge of outer space and the use of space technology for scientific inquiry, (2) the improvement of the usefulness and efficiency of aircraft, (3) the development of vehicles capable of carrying instruments, equipment and living organisms into space, (4) the preservation of the role of the United States as a leader in aeronautical and space science and technology, (5) the making available of discoveries of military value to agencies directly concerned with national security, (6) the promotion of cooperation with other nations in space science and technology, and (7) assuring the most effective utilization of the scientific and engineering resources of the United States and the avoidance of duplication of facilities and equipment." Eisenhower, "Special Message to the Congress Relative to Space Science and Exploration, April 2, 1958," 270; Killian, 125-144. The Army Ballistic Missile Agency (ABMA), part of the Redstone Arsenal in Huntsville, Alabama, was transferred to NASA on July 1, 1960, and was renamed the George C. Marshall Space Flight Center (MSFC). ABMA's rocket scientists included Wernher von Braun's team, which had designed and built the German V-2 ballistic missiles as well as the Jupiter C launch vehicle. Von Braun's group was instrumental in designing the Redstone launch vehicle used in the Mercury Program and the massive Saturn V launch vehicle used to send the first American astronauts around the Moon in 1968 (Apollo 8). Glennan, 9 (footnote 8), 363; Roger E. Bilstein, *Flight in America: From the Wrights to the Astronauts* (Baltimore: Johns Hopkins University Press, 1984), 205-213, 275.

[36] Eisenhower, "Special Message to the Congress Relative to Space Science and Exploration, April 2, 1958," 270; Killian, 125-144. When he signed the Space Act, Eisenhower proclaimed that "the enactment of this legislation is an historic step, further equipping the United States for leadership in the space age. ... The enactment of the law establishing the NACA in 1915 proved a decisive step in the advancement of our civil and military aviation. The Aeronautics and Space Act of 1958 should have an even greater impact on our future." Dwight D. Eisenhower, "Statement by the President Upon Signing the National Aeronautics and Space Act of 1958, July 29, 1958," in *Public Papers of the Presidents of the United States: Dwight D. Eisenhower; Containing the Public Messages, Speeches, and Statements of the President, January 1 to December 31, 1958* (Washington, D.C.: Government Printing Office, 1959). Killian gives an account of the genesis of NASA in his memoirs (Killian, 125-144). The "Birth of NASA" is recorded in the diary of the first NASA Administrator, T. Keith Glennan, which is based upon Glennan's daily appointment cards and dictations that he made each evening that recounted the day's activities (T. Keith Glennan, *The Birth of NASA: The Diary of T. Keith Glennan*). The early administrative history of NASA is discussed in Robert L. Roshalt, *An Administrative History of NASA, 1958-1963*, NASA SP-4101 (Washington, D.C.: NASA, 1966).

[37] "National Aeronautics and Space Act of 1958 [unamended]," Public Law 85-568, 72 Stat., 426, Signed by the President on July 29, 1958, in *Organizing for Exploration*, 334-345, and available on the World Wide Web at http://www.hq.nasa.gov/office/pao/History/spaceact.html (located October 25, 1995); U.S. National Security Council, "Preliminary U.S. Policy on Outer Space," NSC 5814/1, August 18, 1958, in *Organizing for Exploration*, p. 345-361; John M. Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, 377-378; and Special Committee on Space Technology, "Recommendations to the NASA Regarding a National Civil Space Program," October 28, 1958, in *Organizing for Exploration*, 394-403, available on the World Wide Web at http://www.hq.nasa.gov/office/pao/History/report58.html (located October 25, 1959).

[38] U.S. House of Representatives, Select Committee on Astronautics and Space Exploration, *The Next Ten Years in Space: 1959-1969*, House Document No. 115 (Washington, D.C.: USGPO, 1959) iv, 1, 5-7, 211-212; Merrifield, p. 8; Ezell, "Man on Mars," p. 5-6.

[39] NASA, *The Long Range Plan of the National Aeronautics and Space Administration*, December 16, 1959, in *Organizing for Exploration*, 403-407, available on the World Wide Web at http://www.hq.nasa.gov/office/pao/History/report59.html (located October 25, 1995). NASA Office of Program Planning and Evaluation, "A Proposed Long Range Plan," November 4, 1960, p. 52 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 1). Logsdon, "The Evolution of U.S. Space Policy and

Plans," in *Organizing for Exploration*, 377-378; United States. Executive Office of the President, President's Science Advisory Committee, *Report of Ad Hoc Panel on Man-In-Space* (Washington, D.C.: the Committee, November 14, 1960), Located in the JSC History Collection, JSC Files, Manned Mars Mission Studies, Box 1 (also *Organizing for Exploration*, 408-412; Logsdon, *Decision to Go to the Moon*, 12-38. Panel members were: Donald F. Hornig (Chair), Malcolm H. Hebb, Lawrence A. Hyland, Donald P. Ling, Brockway McMillan, and J. Martin Schwarzschild. The panel's report, dated November 14, 1960, was released on December 16, 1960, and was presented to President Eisenhower 4 days later. A brief overview of early U.S. space policy can be found in Logsdon, *Decision to Go to the Moon*, 34-36.

[40] "Report to the President-Elect of the Ad Hoc Committee on Space," January 10, 1961, in *Organizing for Exploration*, p. 416-423; Logsdon, *Decision to Go to the Moon*, 71-75; Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, 379. Logsdon's *Decision to Go to the Moon* presents a detailed discussion of Kennedy's decision-making process that led up to the Apollo challenge. The Report of the Ad Hoc Committee is also available on the World Wide Web at http://www.hq.nasa.gov/office/pao/History/report60.html (accessed October 25, 1995).

[41] Logsdon, *Decision to Go to the Moon*, 81, 101-109.

[42] Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, p. 399; John F. Kennedy, "Memorandum for Vice President," April 20, 1961, in *Organizing for Exploration*, p. 423-424; "Memorandum for the President" on Evaluation of Space Program, April 28, 1961, in *Organizing for Exploration*, p. 427-429; Logsdon, *Decision to Go to the Moon*, 109-118. NASA has placed a number of key documents from this era on the World Wide Web. See "Key Documents from the Apollo Space Program," located at http://www.gsfc.nasa.gov/hqpao/Apollo_11/key_documents.html (accessed October 25, 1995).

[43] Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, p. 399; Wernher von Braun, letter to the Vice President of the United States, April 29, 1961, in *Organizing for Exploration*, p. 429-433.

[44] Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, p. 380-381; James E. Webb and Robert E. McNamara, "Recommendations for Our National Space Program: Changes, Policies, Goals," Memorandum to the Vice President, May 8, 1961, in *Organizing for Exploration*, p. 439-452; John F. Kennedy, "Urgent National Needs," speech before a joint session of Congress, May 25, 1961, excerpts, in *Organizing for Exploration*, p. 453-454; Logsdon, *Decision to Go to the Moon*, 125-130. For a history of the Apollo Program, see William David Compton, *Where No Man Has Gone Before: A History of Apollo Lunar Exploration Missions*, NASA SP-4214 (Washington, D.C.: 1989).

Chapter Four: Eclipsed by the Moon

[45] The Space Task Group (STG) was formed to implement NASA's human space program beginning with Project Mercury. Originally housed at Langley Research Center (LaRC) in Reston, Virginia, the group moved to Houston, Texas, in November 1961 to form the nucleus of the new Manned Spacecraft Center (MSC). MSC was renamed the Johnson Space Center (JSC) in 1973. For a thorough history of JSC, see Henry C. Dethloff, *Suddenly Tomorrow Came…: A History of the Johnson Space Center* (Houston, Tex.: NASA JSC, 1993). This STG should not to be confused with the STG of 1969, which was formed under the leadership of Vice President Spiro T. Agnew to determine the nature of the Post-Apollo space program.

[46] NASA contract number follows a system that identifies the contracting Center with the prefix "NAS" followed by a letter or number. For example, NASw indicates NASA Headquarters; NAS1 denotes LaRC; NAS2 designates Ames Research Center (ARC); NAS8 is used for contracts to Marshall Space Flight Center (MSFC); and NAS9 is used for MSC/JSC.

[47] Merrifield, p. 10; Ezell, "Man on Mars," p. 8-9; C. Howard Robins, Jr. and Roberto M. Villarreal, "An Introduction to the NASA Manned Planetary Mission Studies and a Brief Survey of the Study Results," MSC Internal Note No. 65-ET-7 (Houston, Tex.: NASA MSC, February 1965) (located in the JSC History Collection, Center Files, Planetary Missions-Silveira Files, Box 1), p. 4. H. O. Ruppe cited this work as an important extension of earlier work performed in the area of interplanetary trajectories. H. O. Ruppe, *Manned Planetary Reconnaissance Mission Study: Venus/Mars Flyby*, NASA TM X-53204 (Huntsville, Ala.: Marshall Space Flight Center, February 5, 1965), p. 4 (Located in the JSC History Collection, Center Files: Planetary Missions - Silveira Files, Box 1). Ezell lists the Lockheed studies on page 2 (footnote 11) of his footnotes: Lockheed Missiles and Space Co., "Interplanetary Flight Trajectories," by Stanley Ross et al., report 3-17-62-1, 2 June 1962, NAS8-2469;

Lockheed Missiles and Space Co., "A Study of Interplanetary Transportation Systems," by Ross et al., report 3-17-62-1, final report, contract NAS8-2469, 2 June 1962; and Lockheed Missiles and Space Co., "Study of Interplanetary Transportation Systems," by R. W. Farquhar et al., report 3-17-64-1, final report, contract NAS8-2469, 30 April 1964. Robins and Villarreal cite the study under the title "Planetary Flight Handbook" and lists 1963 as the publication date.

[48] Merrifield, p. 9; Ezell, "Man on Mars," p. 9.

[49] One report, not part of a contractor study, that might be of interest to Mars mission planners was William R. Mickelsen's *Spaceflight Beyond the Moon: A Story of Advanced Propulsion Systems for Interplanetary Flight.* Published by NASA's Lewis Research Center (LeRC) in November 1962, it discusses propulsion systems for missions to Mars and to other planets. This work was republished in May 1965 as *Spaceflight Beyond the Moon*. William R. Mickelsen's *Spaceflight Beyond the Moon: A Story of Advanced Propulsion Systems for Interplanetary Flight*, E-1962 (Cleveland, Oh.: Lewis Research Center, November 1962); cited in William R. Mickelsen's *Spaceflight Beyond the Moon* 1962 (Cleveland, Oh.: Lewis Research Center, May 1965) (Located in the JSC History Collection, JSC Files: Advanced Program Planning, Box 2).

[50] Ezell, "Man on Mars," p. 9-10; Merrifield, p. 10; Ordway, Sharpe, and Wakeford, p. 8-9; Robins and Villarreal, p. 3.

[51] Throughout various studies of interplanetary missions, two types of missions scenarios were identified: (1) flyby missions and (2) capture missions. Robins and Villarreal distinguish between the two categories by noting that capture missions involved a stopover at the target planet. Two subcategories of flyby missions identified in their report were single-planet flybys and dual-planet flybys. Within each subcategory, there were three variations – depending on whether the trajectory used a gravity turn, a propulsive-gravity turn, or an aerodynamic-gravity turn. Capture missions were divided into orbital reconnaissance missions and surface landing missions, each subdivided into opposition-class and conjunction-class missions. Opposition missions are those where a spacecraft arrives at Mars and departs from Mars when the planets are at opposition. This is a short period when the Earth is positioned between Mars and the Sun. Opposition-class missions are the shortest duration, lasting from 300 to 500 days. The disadvantage is that they require the most energy to accomplish. Conjunction-class missions involve the spacecraft arriving at Mars after opposition and departing the Red Planet before the next opposition. For mission planners, this mission offers the longest stay time of up to 500 days in Mars orbit. While the 750- to 950-day mission length requires more consumables for the crew, conjunction-class missions require the least amount of energy to achieve. Robins and Villarreal, p. 9-10; 13-21; U.S. House of Representatives, Eighty-Eighth Congress, Second Session, *1965 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 9641*, Part 2 [No. 1] (Washington, D.C.: USGPO, 1964), p. 610-611.

[52] Ordway, Sharpe, and Wakeford, p. 9-14.

[53] Ordway, Sharpe, and Wakeford, p. 9-14.

[54] Ordway, Sharpe, and Wakeford, p. 14-24.

[55] Ordway, Sharpe, and Wakeford, p. 14-24, Robins and Villarreal, p. 60.

[56] Ordway, Sharpe, and Wakeford, p. 14-24.

[57] Ordway, Sharpe, and Wakeford, p. 14-24.

[58] Ordway, Sharpe, and Wakeford, p. 14-24.

[59] Ordway, Sharpe, and Wakeford, p. 14-24, Robins and Villarreal, p. 12-21.

[60] Ordway, Sharpe, and Wakeford, p. 25-37; Alfred P. Alibrando, "Manned Venus-Mars Fly-by in 1970 Studied," *Aviation Week & Space Technology* 78 (March 4, 1963), p. 56.

[61] Ordway, Sharpe, and Wakeford, p. 25-37.

[62] Bruce G. Jackson, "Trip Report to Ames to Discuss Studies Relating to Mars and Venus Exploration, September 28, 1962," Memorandum for the Chief of the Spacecraft Research Division, October 3, 1962 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15); Smith J. DeFrance to William E. Stoney, Letter dated November 29, 1963 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[63] Robins, and Villarreal, p. 6-7; Irving Stone, "Mars Mission Equipment, Vehicles Studied," *Aviation Week & Space Technology* (May 20, 1963), p. 63.

[64] TRW Space Technology Laboratories, *Summary of Manned Mars Mission Study for NASA Ames Research Center*, Presented at the Manned Mars Mission Symposium, Marshall Space Flight Center, January 28-30, 1964, Report Number 8572-6009-RU-000, p. 1-3, 32-34; TRW Space Technology Laboratories, *Manned Mars Landing and Return Mission*, Volume 1 (Summary), Report Number 8572-6011-RU-000, March 28, 1964, p. 1-3,

5-6, 9; Willard E. Wilks, "Venus Swingby Would Permit Using Saturn Hardware on Manned Mars Trip," *Missiles and Rockets* (December 14, 1964), p. 24-28.

[65] TRW Space Technology Laboratories, *Summary of Manned Mars Mission Study for NASA Ames Research Center*, p. 23-26, 34; TRW Space Technology Laboratories, *Manned Mars Landing and Return Mission*, Volume 1 (Summary), p. 8-10; Wilks, "Venus Swingby Would Permit Using Saturn Hardware on Manned Mars Trip," *Missiles and Rockets*.

[66] North American Aviation, *Final Presentation (Condensed Summary): Manned Mars Landing & Return Mission Study*, Report Number PS 64-120, April, 1964.

[67] North American Aviation, *Final Presentation (Condensed Summary): Manned Mars Landing & Return Mission Study;* Robins and Villarreal, p. 62.

[68] Robins and Villarreal, p. 6-7, 29-31. An article in the May 4, 1964, issue of *Missiles and Rockets* reported that scientists at ARC suggested that a human Mars mission could be carried out using a single launch from Earth. Their presentation at the Society of Automotive Engineers' Air Transport and Space Meeting explained that such a mission would be possible using a Nova-class launch vehicle, nuclear propulsion for interplanetary travel, and aerobraking to achieve orbit around Mars. Crew size for the mission would be 10, with 7 of the crew descending to the surface of Mars. It is uncertain how this proposal related to the two contractor studies discussed in this paper, as no details were given identifying the study participants. "Ames Scientists Advocate Single Earth Launch Manned Mars Mission," *Missiles and Rockets* (May 4, 1964), p. 17-18.

[69] Robins and Villarreal, p. 4-5; Ezell, "Man on Mars," p. 10-11; Stone, "Mars Mission Equipment, Vehicles Studied," p. 59, 63; Warren Burkett, "NASA Planning Mars Expedition," *Missiles and Rockets* (May 13, 1963), p. 34, 36, 39; Manned Spacecraft Center, Spacecraft Technology Division, Flight Vehicle Integration Branch, "Statement of Work: Mars Excursion Module," January 1963 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15), p. [2]; Warren Burkett, "U.S. Beginning to Plan Manned Trip to Mars," *Sunday Star* (Washington, D.C.) (May 5, 1963) (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[70] Robins and Villarreal, p. 5, 32; Burkett, "NASA Planning Mars Expedition," p. 34; North American Aviation, Space and Information Systems Division, "Cost and Contractual Proposal for Manned mars Spacecraft Configuration Analysis for Aerodynamic Braking," Exhibit "A" of Enclosure (1) to NAA Ltr. 63 MA 8521, June 12, 1963 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15). The mission module was described as containing 4,500 cubic feet of living space and providing an artificial gravity environment for the crew. Weight of the module was estimated at 30,000 pounds.

[71] Ezell, "Man on Mars," p. 10-11; Robins and Villarreal, p. 4-5; Harold D. Watkins, "Vehicle Study for Extended Mars Mission Calls for Advances in Varied Technologies," *Aviation Week & Space Technology* (April 20, 1964), p. 54-69; "Preliminary Studies Completed on 3-Man Mars Excursion Module," *Aviation Week & Space Technology* 81 (November 16, 1964), p. 7-9; "Ford Aeronutronic to Investigate 'Ferry' for Future Mars Mission," *Space News Roundup* 2 #17 (June 12, 1963), p. 3; "Electronic Equipment for MSC's Mission Control Center to be Provided by Philco," *Space News Roundup* 2 #26 (October 16, 1963), p. 5; "Statement of Work: Mars Excursion Module;" Philco Aeronutronic Division, *Summary Report: Study of a Manned Mars Excursion Module (U)*, Publication No. U-2530 (Newport Beach, California: Philco, May 13, 1964) (Located in the NASA HQ History Office Collection, Folder 009032); Temple W. Neumann, "Preliminary Design of a Mars Excursion Module," *Journal of Spacecraft and Rockets* 3 #1 (January 1966), p. 12-130.

[72] Philco Aeronutronic Division, *Summary Report: Study of a Manned Mars Excursion Module (U)*; "Ford Aeronutronic to Investigate 'Ferry' for Future Mars Mission;" Harold D. Watkins, "Vehicle Study for Extended Mars Mission Calls for Advances in Varied Technologies," *Aviation Week & Space Technology* (April 20, 1964), p. 54-69; "Preliminary Studies Completed on 3-Man Mars Excursion Module," *Aviation Week & Space Technology*; Neumann, "Preliminary Design of a Mars Excursion Module," *Journal of Spacecraft and Rockets*.

[73] Philco Aeronutronic Division, *Summary Report: Study of a Manned Mars Excursion Module (U)*; "Ford Aeronutronic to Investigate 'Ferry' for Future Mars Mission;" Harold D. Watkins, "Vehicle Study for Extended Mars Mission Calls for Advances in Varied Technologies," *Aviation Week & Space Technology* (April 20, 1964), p. 54-69; "Preliminary Studies Completed on 3-Man Mars Excursion Module," *Aviation Week & Space Technology*; Neumann, "Preliminary Design of a Mars Excursion Module," *Journal of Spacecraft and Rockets*.

[74] Robins and Villarreal, p. 5; "Design Submitted to MSC for Mars Return Vehicle," *Space News Roundup* 3 #7 (January 22, 1964), p. 1, 3; Lockheed Missiles & Space Company, "Final Presentation: Preliminary

Design of a Mars-Mission Earth Reentry Module," Report 4-57-63-2, January 7, 1964 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 2).

[75] Robins and Villarreal, p. 5; Ezell, "Man on Mars," p. 10; Lockheed Missiles & Space Company, "Final Presentation: Preliminary Design of a Mars-Mission Earth Reentry Module;" "Preliminary Studies Completed on 3-Man Mars Excursion Module," *Aviation Week & Space Technology*, p. 7. Not everyone in NASA agreed about the feasibility of early piloted Mars missions. An article in *Aviation Week & Space Technology* published on July 22, 1963 described the different opinions and challenges involved in such an effort. "Mars to be Next Space Goal After Moon," *Aviation Week & Space Technology* (July 22, 1963), 84-86. One proponent of NASA's piloted Mars effort was Maxime A. Faget, designer of the Mercury capsule. Faget and Paul E. Purser published an article in *Astronautics and Aerospace Engineering* in which they discussed progress in human spacecraft and possibilities for human missions to the Red Planet. Maxime A. Faget and Paul E. Purser, "From Mercury to Mars," *Astronautics and Aerospace Engineering* (February 1963), p. 24-28.

[76] Robins and Villarreal, p. 5-6; Stone, "Mars Mission Equipment, Vehicles Studied," p. 59, 63; "Astronaut Trip to Mars Studied," *Space News Roundup* 2 #20 (July 24, 1963), p. 7.

[77] Robins and Villarreal, p. 65-69; "Astronaut Trip to Mars Studied," *Space News Roundup*.

[78] Robins and Villarreal, p. 40, 42-43; O. O. Ohlsson, Head of Mars Mission Study, Advanced Projects Office, Memorandum dated September 9, 1963 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[79] U.S. House of Representatives, Eighty-Eighth Congress, Second Session, *1965 NASA Authorization: Hearings Before the Committee on Science and Astronautics on H.R. 9641*, Part 1 [No. 1] (Washington, D.C.: USGPO, 1964), p. 56; U.S. House of Representatives, Eighty-Eighth Congress, Second Session, *1965 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 9641*, Part 2 [No. 1] (Washington, D.C.: USGPO, 1964), p. 446-447, 609-615; U.S. House of Representatives, Eighty-Sixth Congress, First Session, *1960 NASA Authorization: Hearings Before the Committee on Science and Astronautics and Subcommittees Nos. 1, 2, 3, and 4 on H.R. 6512* [No. 17] (Washington, D.C.: USGPO, 1959), p. 170; ; U.S. House of Representatives, Eighty-Sixth Congress, Second Session, *1960 NASA Authorization: Hearings Before the Committee on Science and Astronautics and Subcommittees Nos. 1, 2, 3, and 4 on H.R. 10246* [No. 4] (Washington, D.C.: USGPO, 1960), p. 159, 168.

[80] A sampling of internal studies conducted at MSC in the early 1960s demonstrates that in-house work usually was concentrated on spacecraft systems rather than on complete spacecraft designs or mission scenarios. In August 1962, the Spacecraft Research Division initiated a study "to define in preliminary form the manned spacecraft system missions to Mars." The purpose of the study was to determine factors such as preliminary weights and spacecraft configuration -- information that could be used to set the basic design requirements for mission vehicles. Various divisions, branches, and sections at MSC contributed to the project. Smaller efforts such as the "Mars-Venus Mission Communication Study," conducted by the Communications Systems Section, and the "Preliminary Study of Instrumentation Requirements for a Manned Mars-Venus Mission," completed by the Physical Measurements Branch, are examples. Charles W. Mathews, Chief of the Spacecraft Research Division, Memorandum for Distribution: "Mars-Venus Mission Studies," August 1, 1962; Maxime A. Faget, Assistant Director for Research and Development, Memorandum for Distribution: "Study of Manned Scientific Missions to Mars and Venus," August 22, 1962; Richard C. Kennedy, AST of the Aerodynamics Section, Memorandum for Flight Vehicle Integration Branch: "Mars Manned Landing Study," October 15, 1962; George Hondros, AST for Measurement Instrument Systems, Memorandum for Spacecraft Technology Division: "Mars-Venus Mission Communication Study," November 29, 1962; William G. Davis, AST for Measurement Instrument Systems, Memorandum for Spacecraft Technology Division: "Preliminary Study of Instrumentation Requirements for a Manned Mars-Venus Mission," March 12, 1963; Maxime A. Faget, Assistant Director for Research and Development, Memorandum for Distribution: "Mars Project – Study of Space Vehicles and Systems Required for the Exploration of Mars (and Venus)," June 25, 1963 (All located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[81] Robins and Villarreal, p.7-8; Merrifield, p. 10. Raymond L. Bisplinghoff, "Schedule and Agenda for Manned Planetary Mission Technology Conference Plans," April 9, 1963; Raymond L. Bisplinghoff, "Manned Planning Mission Technology Conference Plans," March 5, 1963; "Manned Planetary Mission Technology Conference: Agenda," May 21-23, 1963 (All located in the JSC History Collection, Center Files, Planetary Missions – Silveira Files, Box 1).

[82] Merrifield, p. 11; Franklin P. Dixon, "Manned Planetary Mission Studies From 1962 to 1968," IAA-89-729, (paper presented to the 40th Congress of the International Astronautical Federation, October 7-12, 1989, Málaga, Spain); "Symposium to Discuss Exploration of Mars," NASA News Release 63-68 (Located in the NASA HQ History Collection, Folder 009029); "Manned Planetary Mission Studies From 1962 to 1968," p. 3; "Mars Exploration Seen Delayed to 1980s," *Aviation Week & Space Technology* 78 #25 (June 24, 1963), p. 85, 89; Walter Sullivan, "Travel to Mars Stirs Scientists," *New York Times* (June 16, 1963) (Article located in the NASA HQ History Collection, Folder 009029)..

[83] Douglas R. Lord, Memorandum on Planetary Mission Study Group Meeting of 30 July 1963, dated August 12, 1963 (Located in the NASA HQ History Collection, Folder 009025).

[84] Robins and Villarreal, p. 8; Harold D. Watkins, "First Manned Landings on Mars Now Seen Delayed Until mid-'80s," *Aviation Week & Space Technology* (October 14, 1963), p. 97, 100.

[85] Robins and Villarreal, p. 8; Merrifield, p. 11; Ezell, "Man on Mars," p. 10; "Tentative Agenda: Symposium of Manned Interplanetary Mission Studies," n.d., (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15). Merrifield calls the Huntsville conference "the Symposium on Manned Interplanetary Mission Studies Performed by Industry for NASA," while Robins and Villarreal use the word "planetary" instead of "interplanetary." Ruppe also refers to it as the Symposium on Manned Interplanetary Mission Studies. Ruppe, *Manned Planetary Reconnaissance Mission Study*, p. 4. There were several campaigns within NASA at this time to encourage communication among those involved in human Mars missions, as evidenced by memorandums preserved in NASA historical collections. For example, in January 1964, Homer E. Newell, of the Office of Space Science and Applications (OSSA), established an OSSA Ad Hoc Study Group on Planetary Exploration under the leadership of Donald P. Hearth. The group would be asked "to provide a rationale for the scientific exploration of planets, analyze the current OSSA planetary program and provide working papers that will aid in arriving at a coordinated unmanned and manned planetary program." He asked the Associate Administrator for Manned Space Flight to designate four members from the Office of Manned Space Flight (OMSF) for the group and the Associate Administrator for Advance Research to name one Office of Advanced Research and Technology (OAR)T representative. Homer E. Newell, "Establishment of an Ad Hoc Study Group on Planetary Exploration," [January 1964] (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15). In a memorandum dated March 19, 1964, Douglas R. Lord, Acting Director for OMSF Manned Planetary Mission Studies, indicated that he was calling a NASA working meeting on the topic for September 1964. Lord indicated that his objectives for the meeting were to "1. Aid in definition of an overall long-range plan for manned planetary exploration and to focus attention on critical areas requiring long lead times; 2. Motivate study efforts in FY '65 and beyond; 3. Enhance the capability of NASA Centers in planetary missions planning and related technology efforts; 4. Provide reliable funding estimates for advanced planning; [and] 5. Pinpoint technical areas of strong agreement and disagreement." Douglas R. Lord, "Meeting on Manned Interplanetary Exploration Planning," March 19, 1964 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15). In addition, Lord circulated a memorandum with a distribution list for all OMSF-supported reports on planetary mission studies. The list was meant to facilitate more efficient dissemination of study reports to those involved in mission planning. Douglas R. Lord, "Distribution of OMSF Supported Planetary Mission Study Reports," [1964] (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

Chapter Five: Planning in the Mid-1960s

[86] Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, p. 381-383; Director, Bureau of the Budget, "Memorandum for the President," draft, November 13, 1962, in *Organizing for Exploration*, p. 454-461; James E. Webb, Letter to the President, November 30, 1962, in *Organizing for Exploration*, p. 461-467; John F. Kennedy, "Memorandum for the Vice President," April 9, 1963, in *Organizing for Exploration*, p. 467-468; Lyndon B. Johnson, Letter to the President, May 13, 1963, in *Organizing for Exploration*, p. 468-473; NASA, *Summary Report: Future Programs Task Group*, in United States Senate, Committee on Aeronautical and Space Sciences, *NASA Authorization for Fiscal Year 1966: Hearings Before the Committee on Aeronautical and Space Sciences*, Part 3, Post Apollo Planning Documents and Information Relating to the Fiscal Year 1965 Authorization (Washington, D.C.: USGPO, 1965), p.1029-1102. Piloted Mars missions are specifically addressed on p. 1088. For more on the Future Programs Task Group, see Arnold S. Levine, *Managing NASA in the Apollo Era*, NASA SP-4102 (Washington, D.C.: NASA, 1982), p. 242-247. The excerpt of the Future Programs Task Group Summary Report included in *Organizing for Exploration* (p. 473-489) does not include the section

dealing with human Mars exploration. In his essay, "The Evolution of U.S. Space Policy and Plans," Logsdon discussed Administrator Webb's resistance to the elevation of the human space program at the expense of other NASA programs and his reluctance to present long-range plans without political consensus. Logsdon, "The Evolution of U.S. Space Policy and Plans," in *Organizing for Exploration*, p. 379-383. Webb's conservative views often conflicted with the visions of those planning advanced human missions, especially piloted Mars projects. An excellent example of this implied policy towards conservative planning can be found in the collection of piloted Mars landing and flight documents in the History Office at NASA Headquarters. In response to an MSC press release regarding a Lockheed Mars mission study, the following memo was produced by a member of Webb's staff: "Mr. Webb has frequently expressed his strong view that NASA should not play up far-out missions which give the impression that NASA is working on future expensive programs rather than tending to the hard job of succeeding in the present ones that are authorized. It seems to me that the attached release MSC 64-6 is almost deliberately written to provoke speculation and interest and emphasize the spectacular aspects of the Lockheed study. Maybe this release can be used as a specific example by Dr. Seamans to emphasize to the program office and the center director the NASA policy in this matter." R. P. Young, Letter to Mr. Williamson, Executive Officer, January 15, 1964 (Located in the NASA HQ History Collection, Folder 009025). Over a year later, the policy of cautious preparation for future missions was reiterated in a memo regarding planning for a human planetary capability. The Program Chief was advised that "discussion of this activity outside of NASA should be avoided." William T. O'Bryant, Manager of Advance Projects and Technology, Letter to Dr. Robert F. Fellows, Planetary Atmospheres Program Chief, May 21, 1965 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[87] Ruppe, *Manned Planetary Reconnaissance Mission Study*, p. 1-2.

[88] Ruppe, *Manned Planetary Reconnaissance Mission Study*, p. 5-8. There were also several relevant contractor studies completed during this period, including several contracted by NASA Headquarters. One was a 1-year contract, NASw-1053, which was initiated on July 24, 1964. The contract, performed by Martin, had as its object to examine spacecraft propulsion for human Mars and Venus missions. Another Headquarters contract, NASw-1028, was awarded to Douglas Missile and Space Systems Division. Their report, *Study of Conjunction Class Manned Mars Trip*, was published in June 1965. Douglas Missile and Space Systems Division, *Study of Conjunction Class Manned Mars Trip: Summary*, Douglas Report SM-48661, June 1965 (Located in the NASA HQ History Collection, Folder 009032); author unknown, letter referring to status of NASw-1053, April 29, 1965 and Franklin P. Dixon, memorandum on "Final Briefing on Study of Spacecraft Propulsion for Manned Mars and Venus Missions," June 10, 1965 (Both located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 2).

[89] Ezell and Ezell, *On Mars*, p. 74-80.

[90] Merrifield, p. 12; Dixon, "Manned Planetary Mission Studies From 1962 to 1968," p. 6; National Academy of Sciences, National Research Council, *Space Research: Directions for the Future; Report of a Study by the Space Science Board, Woods Hole, Massachusetts 1965* (Washington. D.C.: National Academy of Sciences – National Research Council, 1966), p. iii.

[91] *Space Research: Directions for the Future; Report of a Study by the Space Science Board, Woods Hole, Massachusetts 1965*, p. iii, 4-6; Compton, *Where No Man Has Gone Before*, p. 35-37.

[92] *Space Research: Directions for the Future; Report of a Study by the Space Science Board, Woods Hole, Massachusetts 1965*, p. 5, 12-13.

[93] *Space Research: Directions for the Future; Report of a Study by the Space Science Board, Woods Hole, Massachusetts 1965*, p. iv, 5, 623-628.

[94] General Dynamics/Convair, *Manned Mars and Venus Exploration Study*, Final Report Volume 1: Summary Technical Report, Report No. GD | C AOK 65-002-1, NASA Contract NAS8-11327, June 8, 1965, p. 1-4, 13, 37, 56, 60 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 4).

[95] North American Aviation, Space and Information Systems Division, *Manned Mars and/or Venus Flyby Vehicle Systems Study*, volume 1: Summary, SID 65-761-1, NASA Contract NAS9-3499, June 1965, p. 1-7 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 4). Representatives from MSC, MSFC, and NASA Headquarters were involved in the technical panel for this study. C. Howard Robins, Memorandum: "Technical Management Panel for Mars-Venus Flyby Vehicle Systems Study," March 3, 1964; W. E. Stoney, Jr., "Participation by Electromagnetic Systems Branch in the Technical Management of a Contracted Study of mars and/or Venus Flyby Vehicle Systems," March 10, 1964; W. E. Stoney, Jr., "MSFC Participation in Technical Management of Mars-Venus Flyby Vehicle Systems Study," April 3, 1964; and W. E. Stoney, Jr.,

"Technical Management Panel for Mars-Venus Flyby Vehicle Systems Study," May 11, 1964 (All located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[96] Donald E. Fink, "Manned Planetary 'Swing-bys' Proposed," *Aviation Week & Space Technology* (August 30, 1965), p. 30.

[97] U.S. House of Representatives, Eighty-Ninth Congress, First Session, *1966 NASA Authorization: Hearings Before the Subcommittee on Advanced Research and Technology of the Committee on Science and Astronautics on H.R. 3730*, Part 4 [No. 2] (Washington, D.C.: USGPO, 1965), p.245-247; U.S. House of Representatives, Eighty-Ninth Congress, First Session, *1966 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 3730*, Part 2 [No. 2] (Washington, D.C.: USGPO, 1965), p.9, 135, 141.

[98] NASA's human programs progress through four distinctive steps of the Phased Project Planning Method: (1) Phase A, Advanced Studies; (2) Phase B, Program Definition; (3) Phase C, Design; and (4) Phase D, Development and Operations. An explanation of this planning system was included in NASA's fiscal year (FY) 1967 presentation to the House Subcommittee on Manned Space Flight.

> Phase A: Advanced Studies is the first step in the process. During this phase feasibility studies are conducted covering various approaches to accomplish the future program mission objectives. Engineering assessments are made, research and technology requirements are identified and gross schedules and cost factors are determined. Favorable and unfavorable factors are analyzed and recommendations are made to proceed to the next Phase as a function of the analysis and decision making process activity contained in Phase A.
>
> Phase B: Program Definition is concerned with the assessment of total mission requirements for the program under study. An overall system analysis is made and selected concepts are refined. Preliminary design specifications are prepared, manufacturing and checkout assessments are made along with research, technology and advanced development requirements. Cost estimates and schedules are further defined and management and procurement approaches are evaluated. An analytical report is prepared and recommendations are made concerning the next phase.
>
> In the next phase, Phase C (Design or Final Program Definition) the finalized program concept is determined and a total systems analysis in conjunction with final design specification is prepared. Supporting development activities are initiated and plans for facilities, test operations and other resource requirements are prepared. A final Program Development Plan is issued and preparations for contractor selection are initiated.
>
> The last phase, Phase D is called Development and Operations. In this phase manufacturing and testing of system and subsystem occur, the flight vehicles are assembled, checked out and flight tested and finally mission operations flights are initiated.

U.S. House of Representatives, Eighty-Ninth Congress, Second Session, *1967 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 12718*, Part 2 [No. 4] (Washington, D.C.: USGPO, 1966), p. 402.

[99] "Cost of Mars Trip Figured at 100 Billion," *Chicago Tribune*, August 25, 1965 (Located at the NASA HQ History Collection, Folder 009032); "AES Costs Estimated at $3 Billion Annually," *Aviation Week & Space Technology* (August 30, 1965), p. 29.

[100] Wernher von Braun, "The Next 20 Years of Interplanetary Exploration," *Astronautics & Aeronautics* 3 (November 1965), p. 24-34.

[101] Wernher von Braun, "The Next 20 Years of Interplanetary Exploration," p. 28-33.

[102] Wernher von Braun, "The Next 20 Years of Interplanetary Exploration," p. 33-34.

[103] Wernher von Braun, "The Next 20 Years of Interplanetary Exploration," p. 33-34.

[104] U.S. House of Representatives, Eighty-Ninth Congress, Second Session, *1967 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 12718*, Part 1 [No. 4] (Washington, D.C.: USGPO, 1966), p. 137-146; U.S. House of Representatives, Eighty-Ninth Congress, Second Session, *1967 NASA Authorization: Hearings Before the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics on H.R. 12718*, Part 2 [No. 4] (Washington, D.C.: USGPO, 1966), p. 407-409.

[105] Merrifield, p. 13-14; Dixon, p. 9. Robert R. Gilruth, letter to Dr. George E. Mueller, March 25, 1966; Robert R. Gilruth, letter to Dr. George E. Mueller, April 15, 1966; J. P. Claybourne, "Minutes of Planetary Joint

Action Group Meeting at KSC, February 16, 1967," February 24, 1967 (All located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[106] Merrifield, p. 14; Director of Flight Operations to MSC Director, Memorandum: Information Staff Paper 49 - Reorientation of Planetary program Planning Objectives, October 30, 1967 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15).

[107] "Minutes, Conclusions and Actions of the Joint Action Group," (Located in the JSC History Collection, Center Files: Planetary Missions - Silveira Files, Box 2). Chief of the Advanced Spacecraft Planning, Memorandum: "Planetary Exploration Program Study – Request for Review and Comments on Systems Parameters," May 9, 1966;.Chief of the Planetary Mission Study Office, Memorandum: "Planetary Mission Specifications," May 11, 1966; Chief of the Advanced Spacecraft Technology Division, Memorandum: "Ground Rules for Mars Mission Study Report – Agreements Reached by JAG, June 9, 1966," June 10, 1966 (All located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15). "Notes on Planetary Studies: Meeting of ASTD Division Personnel on Friday, May 20, 1966," (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 6).

[108] "Notes on Planetary Studies: Meeting of ASTD Division Personnel on Friday, May 20, 1966," (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 6); "JAG Meeting at KSC on 29, 30 June and 1 July 1966," and "Minutes of Joint Action Group Meeting," July 8, 1966 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15); "JAG Configuration Study [Ground Rules], n.d. (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 16); Robert R. Gilruth, Letter to Dr. George E. Mueller, September 8, 1966, and "Comments on the Preliminary PDP for a Manned Planetary Exploration Program" (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 7); F. P. Dixon, "Meeting at JPL on Wednesday, June 15, 1966," June 7, 1966 and W. E. Stoney, Jr., "Ground Rules for Mars Mission Study Report – Agreements Reached by JAG, June 9, 1966," June 10, 1966 (Both located in the JSC History Collection, Center Files, Planetary Missions - Silveira Files, Box 2); [MSC Inputs to JAG Report], n.d. (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 12).

[109] National Aeronautics and Space Administration, Office of Manned Space Flight, *Planetary Exploration Utilizing a Manned Flight System* (Washington, D.C.: NASA, October 3, 1966), p. ii, 1-6, 11.

[110] *Planetary Exploration Utilizing a Manned Flight System*, p. 8-11.

[111] *Planetary Exploration Utilizing a Manned Flight System*, p. 11, 26-39.

[112] *Planetary Exploration Utilizing a Manned Flight System*, p. 9, 103, 110.

[113] Merrifield, p. 14; Glenn C. Miller, Memorandum: "First Iteration of the Planetary JAG," December 15, 1966 and J. P. Claybourne, "Minutes of Planetary Joint Action Group Meeting at KSC, February 16, 1967," February 24, 1967 (Both located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 15); George E. Mueller, Memorandum: "Results of OMSF Joint Action Group Study," October 11, 1966 (Located in the NASA HQ History Collection, Folder 009025); Jinx Mercer, "Manned Mars Trip, Space Station Sought," *Technology Week* (November 28, 1966), p. 56-60.

[114] President's Science Advisory Committee, *The Space Program in the Post-Apollo Period* (Washington, D.C.: White House, February 1967): 6-9; Levine, p. 252-253.

[115] *The Space Program in the Post-Apollo Period*, p. 13-14.

[116] The proposed Voyager Program to place a robotic lander on the surface of Mars should not be confused with the Voyager Program that successfully sent two spacecraft to explore the outer planets of the solar system in the late 1970s and throughout the 1980s. The Voyager Program to Mars was canceled by Congress in 1967. However, it was a predecessor to the Viking Mars Lander Program, which landed robotic spacecraft on Mars in 1976.

[117] *The Space Program in the Post-Apollo Period*, p. 17-19.

Chapter Six: The Age of Apollo

[118] Bilstein, p. 80-81; Compton, p. 91-94, 96-97. The crew of Apollo 1, or Apollo 204 as the flight was known within NASA, consisted of veteran astronauts Virgil I. "Gus" Grissom and Edward H. White II, as well as rookie astronaut Roger B. Chaffee. While these were not the first astronaut training fatalities, they were the first associated with spaceflight hardware.

[119] U.S. House of Representatives, Ninetieth Congress, Second Session, *1967 NASA Authorization: Hearings Before the Committee on Science and Astronautics on H.R. 4450, H.R. 6470*, Part 1 [No. 2] (Washington,

D.C.: USGPO, 1967), p. 139-179; Ezell, "Man on Mars," p. 12-13. While known by the unofficial name "Apollo 1," the spacecraft is known throughout NASA by its official designation -- "Apollo 204." Compton explained that flights of the Saturn IB launch vehicles were numbered in the 200s and this was to be the fourth flight of the Saturn IB configuration, so the mission was designated Apollo 204. Saturn V flights were given numbers in the 500s for internal use, but when Saturn launches resumed the numbering started with Apollo 4. Compton, p. 91.

[120] "War Casualty … $100 B Man-on-Mars Space Project," *Boston Globe* (January 4, 1967); "NASA Considers Manned Mars Flyby in 1975," *Space Business Daily* (March 16, 1967), p. 91-92 (Both located in the NASA HQ History Collection, Folder 009032). Hal Taylor, "NASA Pushing Mars Fly-by for Post-Apollo," *Technology Week* 20 #9 (February 27, 1967), p. 14-15; William J. Normyle, "Manned Mars Flights Studies for 1970s," *Aviation Week & Space Technology* 86 #13 (March 27, 1967), p. 62-67; Dixon, p. 10-11. Dixon outlined the steps involved in planning human planetary missions in a paper titled "Manned Interplanetary Program Planning." His goal was to discuss problems faced by advanced mission planners and to suggest possible solutions to these problems. Franklin P. Dixon, "Manned Interplanetary Program Planning," *AAS Science and Technology Series* 12 (1967), p. 27-52.

[121] "No Manned Mars Decision Before 1974," *Space Business Daily* 31 #28 (April 7, 1967), p. 216 (Located in the NASA HQ History Collection, Folder 009032); "New Era for NASA," *Aviation Week & Space Technology* 87 (August 7, 1967), p. 17; William J. Normyle, "Priority Shift Blocks Space Plans," *Aviation Week & Space Technology* 87 (September 11, 1967), p. 27.

[122] "New Era for NASA," *Aviation Week & Space Technology* 87 (August 7, 1967), p. 17; Normyle, "Priority Shift Blocks Space Plans," *Aviation Week & Space Technology*, p. 26-27; Ezell, "Man on Mars," p. 13-17; Merrifield, p. 15-16; Compton, p. 101-102.

[123] Ezell, "Man on Mars," p. 15-17; Normyle, "Priority Shift Blocks Space Plans," *Aviation Week & Space Technology*, 27. Levine noted that Webb complained about people at the Center level who were pushing for human planetary missions. Webb believed that their actions had damaged the Agency's image. Levine, p. 148.

[124] Manned Spacecraft Center, Advanced Spacecraft Technology Division, Planetary Missions Office, *Planetary Missions Study Task T2A600: Mars/Venus Manned Missions (Phase II) Information Book*, February 24, 1967 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 7); Manned Spacecraft Center, Advanced Spacecraft Technology Division, Planetary Missions Office, *A Study of Spacecraft Design and Operations for Manned Planetary Encounter Missons*, Volume IV: Missions and Mission Operations, MSC-EA-R-67-1 (Located in the JSC History Collection, JSC Files: Manned Mars Mission Studies, Box 12); North American Aviation, *A Study of Manned Planetary Flyby Missions Based on Saturn/Apollo Systems: Final Report*, Volume 1: Summary Report, SID 67-549-1, August 1967, p. 1-2, 6; "Study Contract Signed for Mars/Venus Flyby," *Space News Roundup* 5 #22 (August 19, 1966), p. 3.

[125] *A Study of Manned Planetary Flyby Missions Based on Saturn/Apollo Systems: Final Report*, p. 1, 10, 13.

[126] *A Study of Manned Planetary Flyby Missions Based on Saturn/Apollo Systems: Final Report*, p.7, 9, 19-25.

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asked the STG in their March 22 meeting if an Apollo-like goal such as a human Mars mission should be the basis for the post-Apollo space program. He also initiated discussion of the topic when the STG met with Congressional leaders on May 16. When the STG met on July 7 to hear from invited contributors, Logsdon says that it was again Agnew "who brought up manned Mars as a possible post-Apollo goal." Lodsdon explains that Agnew's statement at the Apollo 11 launch was "not a spontaneous reaction to the excitement of the occasion; it had been planned in advance. It reflected Agnew's willingness to lend support to an ambitious and bold space program, if only NASA would propose it." Logsdon, "From Apollo to the Shuttle," p. IV-39 - IV-40.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 2001	NASA Contractor Report

4. TITLE AND SUBTITLE
Eyes on the Red Planet: Human Mars Mission Planning, 1952-1970

5. FUNDING NUMBERS

6. AUTHOR(S)
Annie Platoff*

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Lyndon B. Johnson Space Center
Houston, Texas 77058

8. PERFORMING ORGANIZATION REPORT NUMBERS
S-873

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
CR-2001-208928

11. SUPPLEMENTARY NOTES
*Formerly of Arizona State University

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The history of human Mars mission planning from the early 1950s through the 1960s is examined. For centuries, Mars has been an object of fascination and, since the 1800s, science-fiction authors have imagined what it would be like for humans to travel to that planet. Space enthusiasts have shared this dream and as early as the 1950s were presenting feasible proposals for human missions to Mars. Since the creation of NASA, the Agency has maintained the idea of human Mars missions as an important long-term goal. Throughout its history, NASA has conducted studies aimed at landing an astronaut on Mars. NASA's current strategic plan still includes this goal. Therefore, it is important to look at previous planning efforts to see what work has been accomplished and to discover lessons that future planners can apply to their programs.

14. SUBJECT TERMS	15. NUMBER OF PAGES	16. PRICE CODE
manned spaceflight; histories; manned Mars missions; Mars probes; Mars environment; strategy; mission planning; Viking Mars Program; Mars probes	115	

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited