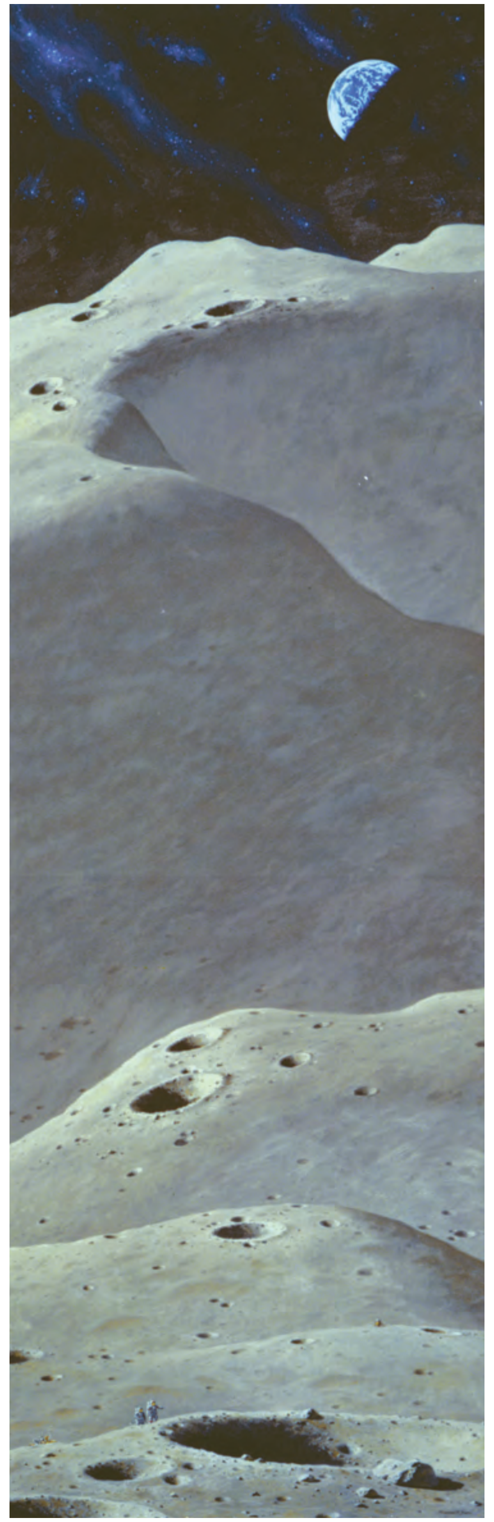

Artist Pierre Mion's painting of "A Speck of Dust." Explorer astronauts are dwarfed by the immense size of craters and mountains on the lunar surface. Size 120 in. x 40 in. (Image number: 79-HC-14)

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2008

Exploring the Unknown

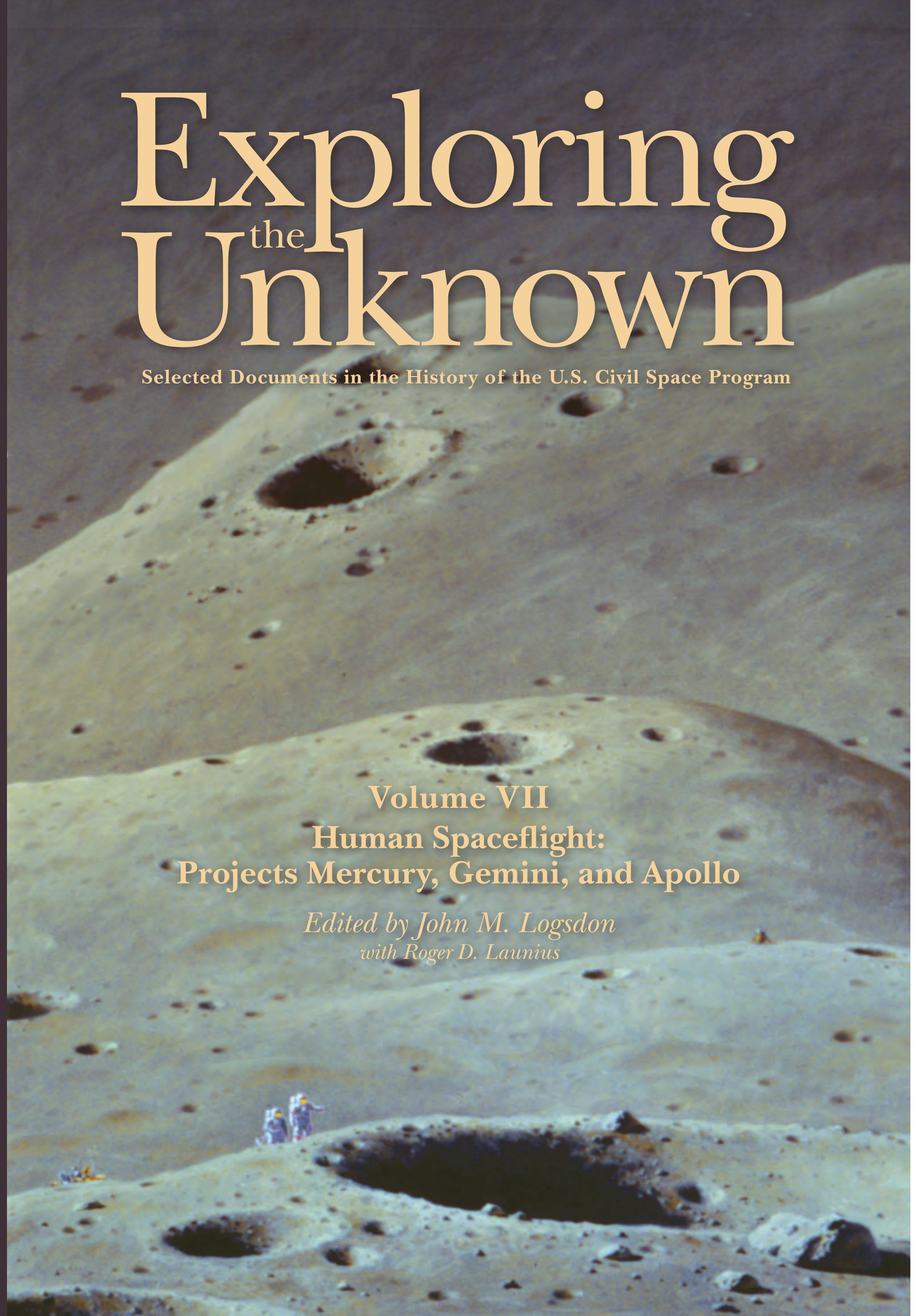
Selected Documents in the History of the U.S. Civil Space Program

Volume VII: Human Spaceflight: Projects Mercury, Gemini, and Apollo

John M. Logsdon
Editor

with
Roger D. Launius

NASA SP-2008-4407



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Dedicated to the Pioneers of Human Spaceflight:
George Low, Robert Gilruth, and the members of the Space Task Group

Contents

Chapter Two

Documents

Acknowledgments

This volume is the seventh in a series that had its origins almost two decades ago. The individuals involved in initiating the series and producing the initial six volumes have been acknowledged in those volumes [Volume I—*Organizing for Exploration* (1995); Volume II—*External Relationships* (1996); Volume III—*Using Space* (1998); Volume IV—*Accessing Space* (1999); Volume V—*Exploring the Cosmos* (2001); Volume VI—*Space and Earth Science* (2004)]. Those acknowledgments will not be repeated here.

We owe thanks to the individuals and organizations that have searched their files for potentially useful materials, and for the staffs at various archives and collections who have helped us locate documents, especially Shelley Kelly at the University of Houston Clear Lake Library. Graduate students Chirag Vyas, Eric Dickinson, Daphne Dador, Angela Peura, and Audrey Schaffer provided essential assistance in the preparation of the volume.

My thanks go to all those mentioned above, and again to those who helped get this effort started and who have been involved along the way.

John M. Logsdon
George Washington University

****

Numerous people at NASA associated with historical study, technical information, and the mechanics of publishing helped in myriad ways in the preparation of this documentary history. In the NASA History Division, Stephen J. Garber oversaw much of the editorial and production work. Nadine J. Andreassen provided key administrative support for this project. Intern Matthew Barrow capably researched and wrote the entries for the biographical appendix and Amelia Lancaster assisted with the final production. Archivists Jane Odom, Colin Fries, and John Hargenrader also helped in a number of ways. In addition, the staffs of the NASA Headquarters Library, the Scientific and Technical Information Program, and the NASA Document Services Center provided assistance in locating and preparing for publication the documentary materials in this work.

On the production end in the NASA Headquarters Communications Support Services Center, Stacie Dapoz oversaw the careful copyediting of this volume. Shelley Kilmer-Gaul laid out the book and designed the dust jacket. Gail Carter-Kane and Cindy Miller assisted in the overall process. Printing specialists Hanta Ralay and Tun Hla expertly oversaw this critical final stage.

Thanks are due to all these fine professionals.

Steven J. Dick
NASA Chief Historian

Introduction

One of the most important developments of the twentieth century has been the movement of humanity into space with machines and people. The underpinnings of that movement—why it took the shape it did; which individuals and organizations were involved; what factors drove a particular choice of scientific objectives and technologies to be used; and the political, economic, managerial, and international contexts in which the events of the Space Age unfolded—are all important ingredients of this epoch transition from an Earthbound to a spacefaring people. This desire to understand the development of spaceflight in the United States sparked this documentary history series.

The extension of human activity into outer space has been accompanied by a high degree of self-awareness of its historical significance. Few large-scale activities have been as extensively chronicled so closely to the time they actually occurred. Many of those who were directly involved were quite conscious that they were making history, and they kept full records of their activities. Because most of the activity in outer space was carried out under government sponsorship, it was accompanied by the documentary record required of public institutions, and there has been a spate of official and privately written histories of most major aspects of space achievement to date. When top leaders considered what course of action to pursue in space, their deliberations and decisions often were carefully put on the record. There is, accordingly, no lack of material for those who aspire to understand the origins and evolution of U.S. space policies and programs.

This reality forms the rationale for this series. Precisely because there is so much historical material available on space matters, the National Aeronautics and Space Administration (NASA) decided in 1988 that it would be extremely useful to have easily available to scholars and the interested public a selective collection of many of the seminal documents related to the evolution of the U.S. civilian space program. While recognizing that much space activity has taken place under the sponsorship of the Department of Defense and other national security organizations, the U.S. private sector, and in other countries around the world, NASA felt that there would be lasting value in a collection of documentary material primarily focused on the evolution of the U.S. government's civilian space program, most of which has been carried out since 1958 under the Agency's auspices. As a result, the NASA History Division contracted with the Space Policy Institute of George Washington University's Elliott School of International Affairs to prepare such a collection. This is the seventh volume in the documentary history series; one additional volume containing documents and introductory essays related to post-Apollo human spaceflight will follow.

The documents collected during this research project were assembled from a diverse number of both public and private sources. A major repository of primary source materials relative to the history of the civil space program is the NASA Historical Reference Collection of the NASA History Division located at the Agency's Washington headquarters. Project assistants combed this collection for the "cream" of the wealth of material housed there. Indeed, one purpose of this series from the start was to capture some of the highlights of the holdings at Headquarters. Historical materials housed at the other NASA installations, at institutions of higher learning, and Presidential libraries were other sources of documents considered for inclusion, as were papers in the archives of individuals and firms involved in opening up space for exploration.

Copies of the documents included in this volume in their original form will be deposited in the NASA Historical Reference Collection. Another complete set of project materials is located at the Space Policy Institute at George Washington University. These materials in their original forms are available for use by researchers seeking additional information about the evolution of the U.S. civil space program, or wishing to consult the documents reprinted herein in their original form.

The documents selected for inclusion in this volume are presented in two chapters: one covering the Mercury and Gemini projects and another covering Project Apollo.

Volume I in this series covered the antecedents to the U.S. space program, and the origins and evolution of U.S. space policy and of NASA as an institution. Volume II dealt with the relations between the civilian space program of the United States and the space activities of other countries; the relations between the U.S. civilian and national security space and military efforts; and NASA's relations with industry and academic institutions. Volume III provided documents on satellite communications, remote sensing, and the economics of space applications. Volume IV covered various forms of space transportation. Volume V covered the origins of NASA's space science program and its efforts in solar system exploration and astrophysics and astronomy. Volume VI covered space and Earth science. As noted above, one more future volume will cover post-Apollo human spaceflight.

Each section in the present volume is introduced by an overview essay. In the main, these essays are intended to introduce and complement the documents in the section and to place them in a chronological and substantive context. Each essay contains references to the documents in the section it introduces, and also contains references to documents in other volumes in this series. These introductory essays are the responsibility of their individual authors, and the views and conclusions contained therein do not necessarily represent the opinions of either George Washington University or NASA.

The documents included in each section were chosen by the project team in concert with the essay writer from those assembled by the research staff for the overall project. The contents of this volume emphasize primary documents or long-out-of-print essays or articles and material from the private recollections of important actors in shaping space affairs. The contents of this volume thus do not comprise in themselves a comprehensive historical account; they must be supplemented by other sources, those both already available and to become available in the future. The documents included in each section are arranged chronologically, with the exception that closely related documents are grouped together. Each document is assigned its own number in terms of the section in which it is placed. Thus, the first document in the second section of this volume is designated "Document II-l." Each document or group of related documents is accompanied by a headnote setting out its context and providing a background narrative. These headnotes also provide specific information about people and events discussed. We have avoided the inclusion of explanatory notes in the documents themselves and have confined such material to the headnotes.

The editorial method we adopted for dealing with these documents seeks to preserve spelling, grammar, paragraphing, and use of language as in the original. We have sometimes changed punctuation where it enhances readability. We have used the designation **[not included, or omitted]** to note where sections of a document have not been included in this publication, and we have avoided including words and phrases that had been deleted in the original document unless they contribute to an understanding of what was going on in the mind of the writer in making the record. Marginal notations on the original documents are inserted into the text of the documents in brackets, each clearly marked as a marginal comment. Except insofar as illustrations and figures are necessary to understanding the text, those items have been omitted from this printed version. Page numbers in the original document are noted in brackets internal to the document text. Copies of all documents in their original form, however, are available for research by any interested person at the NASA History Division or the Space Policy Institute of George Washington University.

We recognize that there are certain to be quite significant documents left out of this compilation. No two individuals would totally agree on all documents to be included from the many we collected, and surely we have not been totally successful in locating all relevant records. As a result, this documentary history can raise an immediate question from its users: why were some documents included while others of seemingly equal importance were omitted? There can never be a fully satisfactory answer to this question. Our own criteria for choosing particular documents and omitting others rested on three interrelated factors:

- Is the document the best available, most expressive, most representative reflection of a particular event or development important to the evolution of the space program?

- Is the document not easily accessible except in one or a few locations, or is it included (for example, in published compilations of presidential statements) in reference sources that are widely available and thus not a candidate for inclusion in this collection?

- Is the document protected by copyright, security classification, or some other form of proprietary right and thus unavailable for publication?

As general editor of this volume, I was ultimately responsible for the decisions about which documents to include and for the accuracy of the headnotes accompanying them. It has been an occasionally frustrating but consistently exciting experience to be involved with this undertaking; I and my associates hope that those who consult it in the future find our efforts worthwhile.

John M. Logsdon
Director
Space Policy Institute
Elliott School of International Affairs
George Washington University

Biographies of Volume VII Editors

Roger D. Launius is a member of the space history department of the Smithsonian Institution's National Air and Space Museum and is the former NASA Chief Historian. He has produced many books and articles on aerospace history, including *Innovation and the Development of Flight* (Texas A&M University Press, 1999); *NASA & the Exploration of Space* (Stewart, Tabori, & Chang, 1998); *Frontiers of Space Exploration* (Greenwood Press, 1998); *Organizing for the Use of Space: Historical Perspectives on a Persistent Issue* (Univelt, Inc., AAS History Series, Volume 18, 1995), editor; *NASA: A History of the U.S. Civil Space Program* (Krieger Publishing Co., 1994); *History of Rocketry and Astronautics: Proceedings of the Fifteenth and Sixteenth History Symposia of the International Academy of Astronautics* (Univelt, Inc., AAS History Series, Volume 11, 1994), editor; *Apollo: A Retrospective Analysis* (Monographs in Aerospace History, Vol. 3, 1994); and *Apollo 11 at Twenty-Five* (electronic picture book issued on computer disk by the Space Telescope Science Institute, Baltimore, MD, 1994).

John M. Logsdon is Director of the Space Policy Institute of George Washington University's Elliott School of International Affairs, where he is also Professor Emeritus of Political Science and International Affairs. He holds a B.S. in physics from Xavier University and a Ph.D. in political science from New York University. He has been at George Washington University since 1970, and previously taught at The Catholic University of America. He is also a faculty member of the International Space University. He is the author and editor of numerous books and articles on space policy and space history. He is an elected member of the International Academy of Astronautics and a former member of the board of The Planetary Society. He is a member of the NASA Advisory Council and served during 2003 on the Columbia Accident Investigation Board. Dr. Logsdon has lectured and spoken to a wide variety of audiences at professional meetings, colleges and universities, international conferences, and other settings, and has testified before Congress on numerous occasions. He is frequently consulted by the electronic and print media for his views on various space issues. He has twice been a Fellow at the Woodrow Wilson International Center for Scholars and was the first holder of the Chair in Space History of the National Air and Space Museum. He is a Fellow of the American Association for the Advancement of Science and the American Institute of Aeronautics and Astronautics.

Chapter 1

First Steps into Space: Projects Mercury and Gemini

by Roger D. Launius

Introduction

Humanity has dreamed of traveling into space for centuries, but in the twentieth century, scientific and technical capabilities converged with this dream for the first time. From the work of Robert H. Goddard through the heroic era of spaceflight into the 1960s, the modern age of rocketry signaled a beginning that would eventually lead to human flights beyond Earth to the Moon.[1] All of these enthusiasts believed humanity would soon explore and eventually colonize the solar system. And many of them worked relentlessly to make that belief a reality. They successfully convinced a large majority of Americans of spaceflight's possibility. Through their constant public relations efforts during the decade following World War II, they engineered a sea change in perceptions, as most Americans went from skepticism about the probabilities of spaceflight to an acceptance of it as a near-term reality.[2]

This is apparent in the public opinion polls of the era. In December 1949, Gallup pollsters found that only 15 percent of Americans believed humans would reach the Moon within 50 years, while 15 percent had no opinion, and a whopping 70 percent believed that it would not happen within that time. In October 1957, at the same time as the launching of Sputnik I, only 25 percent believed that it would take longer than 25 years for humanity to reach the Moon, while 41 percent believed firmly that it would happen within 25 years, and 34 percent were not sure. An important shift in perceptions had taken place, and it was largely the result of well-known advances in rocket technology coupled with a public relations campaign that emphasized the real possibilities of spaceflight.[3]

Indeed, by the end of World War II, all the technical assessments suggested that it was only a matter of a few years before the United States would be able

1. Robert H. Goddard. "R. H. Goddard's Diary," 16–17 March 1926 in Esther C. Goddard, ed., and G. Edward Pendray, assoc. ed., *The Papers of Robert H. Goddard* (New York: McGraw-Hill Book Co., 1970), 2: pp. 580–581; Milton Lehman, *This High Man* (New York: Farrar, Straus, 1963), pp. 140–144; David A. Clary, *Rocket Man: Robert H. Goddard and the Birth of the Space Age* (New York: Hyperian, 2003), pp. 120–122.

2. This is the core argument of Howard E. McCurdy, *Space and the American Imagination* (Washington, DC: Smithsonian Institution Press, 1997).

3. George H. Gallup, *The Gallup Poll: Public Opinion, 1935–1971* (New York: Random House, 1972), 1: pp. 875, 1152.

to place a satellite in orbit around Earth and, ultimately, to place a human in a capsule for orbital activities. In 1946, for instance, the forerunner of the Rand Corporation completed an engineering analysis of an Earth satellite vehicle for the Army Air Forces, finding important military support functions possible ranging from weather forecasting to secure global communications to strategic reconnaissance.[4] Later, military analysts thought there might be a role for piloted military missions in space, and that, along with the exploration imperative, drove efforts to make human spaceflight a reality. By the middle part of the 1950s, the spaceflight advocacy community was actively advocating, as later ensconced in the NASA long-range plan of 1959, "the manned exploration of the Moon and nearby planets." They called for the "first launching in a program leading to manned circumlunar flight and to a permanent near-Earth space station" that would make a human mission to the Moon possible.[5]

The von Braun Paradigm

All of the prospective futures for the near term contemplated by spaceflight pioneers ended with a human expedition to Mars. Without question, the most powerful vision of spaceflight since the early 1950s has been that articulated by Wernher von Braun, one of the most important rocket developers and champions of space exploration during the period between the 1930s and the 1970s. Working for the German Army between 1934 and 1945, von Braun led the technical effort to develop the V-2, the first ballistic missile, and deliberately surrendered to the Americans at the close of World War II because he said he desired to work for a rich and benevolent uncle, in this case Uncle Sam. For 15 years after World War II, von Braun worked with the U.S. Army in the development of ballistic missiles. Von Braun became one of the most prominent spokesmen of space exploration in the U.S. in the 1950s. In 1952 he gained note as a participant in an important symposium dedicated to the subject and he gained notoriety among the public in the fall of 1952 with a series of articles in *Collier's*, a popular weekly periodical of the era. He also became a household name following his appearance on three Disney television shows dedicated to space exploration in the mid-1950s.[6] Indeed, no one became more significant as an advocate for space

4. Douglas Aircraft Company, Inc., "Preliminary Design of an Experimental World-Circling Spaceship," Report No. SM-11827, 2 May 1946. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

5. Office of Program Planning and Evaluation, "The Long Range Plan of the National Aeronautics and Space Administration," 16 December 1959, document III-2 in James M. Logsdon, gen. ed., with Linda J. Lear, Jannelle Warren Findley, Ray A. Williamson, Dwayne A. Day, *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I, Organizing for Exploration* (Washington, DC: NASA Special Publication 4407, 1995), pp. 403–407.

6. See Erik Bergaust, *Wernher von Braun* (Washington, DC: National Space Institute, 1976); Ernst Stuhlinger, Frederick I. Ordway, III, *Wernher von Braun: Crusader for Space*, 2 vols. (Malabar, FL: Krieger Publishing Co., 1994). See Michael J. Neufeld, *Wernher von Braun: Dreamer of Space, Engineer of War* (New York: Alfred A. Knopf, 2007). Also see the *Collier's* series of articles conveniently reprinted in Cornelius Ryan, ed., *Across the Space Frontier* (New York: Viking Press, 1952); and Cornelius Ryan, ed., *Conquest of the Moon* (New York: Viking Press, 1953). The three Disney programs have recently been

exploration in the first part of the Space Age than von Braun, whose ideas influenced millions and charted the course of space exploration in the U.S. Central to von Braun's ideas was the human exploration of space; there was virtually no room in his vision for robotic spaceflight.

From the 1950s on, this German émigré called for an integrated space exploration plan centered on human movement beyond this planet and involving these basic steps accomplished in this order:

1. Earth orbital satellites to learn about the requirements for space technology that must operate in a hostile environment (initially soft-pedaled by von Braun but later embraced in such missions as Explorer 1).
2. Earth orbital flights by humans to determine whether or not it was possible to explore and settle other places.
3. A reusable spacecraft for travel to and from Earth orbit, thereby extending the principles of atmospheric flight into space and making routine space operations.
4. A permanently inhabited space station as a place both to observe Earth and from which to launch future expeditions. This would serve as the base camp at the bottom of the mountain or the fort in the wilderness from which exploring parties would depart.
5. Human exploration of the Moon with the intention of creating Moon bases and eventually permanent colonies.
6. Human expeditions to Mars, eventually colonizing the planet.

This has become known over time as the von Braun paradigm for the human colonization of the solar system. This approach would lead, von Braun believed, in the establishment of a new and ultimately perfect human society elsewhere in the solar system.

This integrated plan has cast a long shadow over American efforts in space for over 50 years. It conjured powerful images of people venturing into the unknown to make a perfect society free from the boundaries found on Earth. As such, it represented a coherent and compelling definition of American ideals in space. In many respects, von Braun's vision of space exploration has served as the model for U.S. efforts in space through the end of the 20th century.[7] His vision was constrained by the time in which he lived, for without a coherent vision of the rise of electronics, he failed to perceive the role of robotic explorers. As John H. Gibbons, Assistant to the President for Science and Technology during the Clinton administration, said in 1995:

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released in DVD as *Tomorrow Land: Disney in Space and Beyond* (Burbank, CA: Buena Vista Home Entertainment, 2004).

7. Dwayne A. Day, "The Von Braun Paradigm," *Space Times: Magazine of the American Astronautical Society* 33 (November to December 1994): pp. 12–15; "Man Will Conquer Space Soon," *Collier's* (22 March 1952): pp. 23–76ff; Wernher von Braun, with Cornelius Ryan, "Can We Get to Mars?" *Collier's* (30 April 1954): pp. 22–28.

> The von Braun paradigm—that humans were destined to physically explore the solar system—which he so eloquently described in *Collier's* magazine in the early 1950's was bold, but his vision was highly constrained by the technology of his day. For von Braun, humans were the most powerful and flexible exploration tool that he could imagine. Today we have within our grasp technologies that will fundamentally redefine the exploration paradigm. We have the ability to put our minds where our feet can never go. We will soon be able to take ourselves—in a virtual way—anywhere from the interior of a molecule to the planets circling a nearby star—and there exclaim, "Look honey, I shrunk the Universe!"[8]

Most important, von Braun's integrated approach to space exploration was ensconced in the NASA long-range plan of 1959, and, with the exception of a jump from human orbital flights to a lunar (Apollo) mission driven by political concerns, the history of spaceflight has followed this paradigm consistently. Following the Apollo missions, NASA returned to the building of winged reusable spacecraft (the Space Shuttle), and a space station (*Freedom*/International Space Station) and, in 2004, embarked on human lunar and Mars expeditions. This adherence to the paradigm is either a testament to the amazing vision of Wernher von Braun or to a lack of imagination by NASA leaders, but the best guess suggests that it lies somewhere between the two.

The NACA and Spaceflight Research

During the latter part of World War II, leaders of the National Advisory Committee for Aeronautics (NACA), the predecessor to NASA, had become interested in the possibilities of high-speed guided missiles and the future of spaceflight. It created the Pilotless Aircraft Research Division (PARD), under the leadership of a young and promising engineer at the Langley Research Center in Hampton, Virginia, Robert R. Gilruth. In early 1945, NACA asked Congress for a supplemental appropriation to fund the activation of a unit to carry out this research, and a short time later the NACA opened the Auxiliary Flight Research Station (AFRS), which was later redesignated the name by which it gained fame, PARD, with Gilruth as Director.[9]

Established at Wallops Island as a test-launching facility of Langley on 4 July 1945, PARD launched its first test vehicle, a small two-stage, solid-fuel rocket to

8. John H. Gibbons, "The New Frontier: Space Science and Technology in the Next Millennium," Wernher von Braun Lecture, 22 March 1995, National Air and Space Museum, Smithsonian Institution, Washington, DC, available online at *http://clinton4.nara.gov/textonly/WH/EOP/OSTP/other/space.html*, accessed 2 October 2008.

9. James M. Grimwood, *Project Mercury: A Chronology* (Washington, DC: NASA SP-4001, 1963), Part 1A, p. 1; Joseph Adams Shortall, *A New Dimension: Wallops Island Flight Test Range, the First Fifteen Years* (Washington, DC: NASA Reference Publication [RP]-1028, 1978). At first, only part of the land on Wallops Island was purchased; the rest was leased. In 1949 NACA purchased the entire island.

check out the installation's instrumentation. Beyond a series of exploratory flight tests of rocket models, Gilruth's PARD advanced the knowledge of aerodynamics at transonic and, later, hypersonic speeds. They did so through exhaustive testing, which some at Langley considered excessive and overly expensive, launching at least 386 models between 1947 and 1949, leading to the publication of NACA's first technical report on rocketry, "Aerodynamic Problems of Guided Missiles," in 1947. From this, Gilruth and PARD filled in tremendous gaps in the knowledge of spaceflight. As historian James R. Hansen writes: "the early years of the rocket-model program at Wallops (1945–1951) showed that Langley was able to tackle an enormously difficult new field of research with innovation and imagination."[10]

The NACA leadership believed that human spaceflight could be achieved within a decade after 1952, and Gilruth served as an active promoter of the idea within the organization. He helped to engineer the creation of an interagency board to review "research on spaceflight and associated problems" with an end to advancing the cause of human spaceflight (I-1).[11] For example, while Gilruth was interested in orbiting an artificial satellite, it did not capture his imagination. As he recalled, "When you think about putting a man up there, that's a different thing. That's a lot more exciting. There are a lot of things you can do with men up in orbit."[12] This led to concerted efforts to develop the technology necessary to make it a reality. In 1952, for example, PARD started the development of multistage, hypersonic, solid-fuel rocket vehicles. These vehicles were used primarily in aerodynamic heating tests at first and were then directed toward a reentry physics research program. On 14 October 1954, the first American four-stage rocket was launched by PARD, and in August 1956 it launched a five-stage, solid-fuel rocket test vehicle, the world's first, that reached a speed of Mach 15.[13]

At the same time, H. Julian Allen at NACA's Ames Research Center began research on recovery of objects from orbit. In the early 1950s, he found that a blunt-nose body experienced less heating and dissipated it more quickly than a pointed body during the reentry; the pointed body was likely to burn up before reaching Earth's surface. Allen's work fundamentally shaped the course of spaceflight research and provided the basis for all successful reentry vehicles. It became the standard technology used in reconnaissance, warhead, and human reentry missions from the;1950s to the present. Based upon this research, in 1955 General Electric (GE) engineers began work on the Mark 2 reentry vehicle. While an overall success, GE adopted a heat-sink concept for the Mark 2 vehicle, whereby the heat

10. Robert R. Gilruth, "Aerodynamic Problems of Guided Missiles," NACA Report, draft, 19 May 1947, Gilruth Papers, Special Collections, Carol M. Newman Library, Virginia Polytechnic Institute and State University, Blacksburg, VA; James R. Hansen, *Spaceflight Revolution: NASA Langley Research Center from Sputnik to Apollo* (Washington, DC: NASA SP-4308, 1995), p. 270.

11. H. J. E. Reid, Director, NACA, to NACA, "Research on Spaceflight and Associated Problems," 5 August 1952. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

12. Third oral history interview of Robert R. Gilruth, by Linda Ezell, Howard Wolko, Martin Collins, National Air and Space Museum, Washington, DC, 30 June 1986, pp. 19, 44.

13. NASA Space Task Group to NASA Headquarters, 5 July 1960. Folder 18674, NASA Historical Reference Collection, NASA Hisotry Division, NASA Headquarters, Washington, DC; Eugene M. Emme, *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915–1960* (Washington, DC: National Aeronautics and Space Administration, 1961), p. 76; House Rpt. 67, 87th Cong., 1st Sess., p. 27.

of reentry was conducted from the surface of the vehicle to a mass of material that could soak it up quickly. The key was to dissipate the heat away from the surface fast enough so that it did not melt. By 1956, Allen and other researchers had noticed that reinforced plastics had proven more resistant to heating than most other materials. They proposed coating the reentry vehicle with a material that absorbed heat, charred, and either flaked off or vaporized. As it did so, these "ablative" heatshields took away the absorbed heat (I-2).[14]

While Gilruth experimented with launch technology, and Allen worked on spacecraft recovery, both became very interested in the prospects for human spaceflight. They became aware of the *Collier's* series of articles on space, the first of which appeared on 22 March 1952. In it readers were asked by Wernher von Braun, "What Are We Waiting For?" and urged to support an aggressive space program.[15] Clearly the *Collier's* series helped to shape the perceptions of many at NACA that spaceflight was something that was no longer fantasy. Gilruth recalled of von Braun and his ideas: "I thought that was fascinating. He was way ahead of all of us guys . . . everybody was a space cadet in those days. I thought a space station was very interesting."[16]

In more than 12 years NACA made some significant strides in the development of the technology necessary to reach orbital flight above the atmosphere. Clearly, PARD held the lion's share of knowledge in NACA about the nascent field of astronautics. And it enjoyed renewed attention and funding once the Soviet Union launched the world's first satellite, Sputnik I, on 4 October 1957. "I can recall watching the sunlight reflect off of Sputnik as it passed over my home on the Chesapeake Bay in Virginia," Gilruth commented in 1972. "It put a new sense of value and urgency on things we had been doing. When one month later the dog Laika was placed in orbit in Sputnik II, I was sure that the Russians were planning for man-in-space."[17]

In the aftermath of the Sputnik crisis, NACA proceeded with efforts to advance human spaceflight even as plans were underway in 1958 to transform it into a new space agency. NACA engineers developed plans for a human space-

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14. H. Julian Allen, NACA, to A. J. Eggers Jr., NACA, "Research Memorandum: A Study of the Motion and Aerodynamic Heating of Missiles Entering the Earth's Atmosphere at High Supersonic Speeds," 25 August 1953. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; H. Julian Allen and Alfred J. Eggers Jr. "A Study of the Motion and Aerodynamic Heating of Ballistic Missiles Entering the Earth's Atmosphere at High Supersonic Speeds," NACA Technical Report 1381, *Forty-Fourth Annual Report of the NACA—1958* (Washington, DC: 1959), pp. 1125–1140; H. Julian Allen, "Hypersonic Flight and the Reentry Problem," *Journal of the Aeronautical Sciences* 25 (April 1958): pp. 217–230; Alfred J. Eggers Jr., "Performance of Long Range Hypervelocity Vehicles," *Jet Propulsion* 27 (November 1957): pp. 1147–1151; Loyd S. Swenson, James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington, DC: NASA SP-4201, 1966), pp. 55–82; David K. Stump, *Titan II* (Fayetteville, AR: University of Arkansas Press, 2000), pp. 56–63.

15. "Man Will Conquer Space Soon" series, *Collier's*, 22 March 1952, pp. 23–76ff.

16. Robert Gilruth Oral History No. 6 by David DeVorkin and John Mauer, 2 March 1987, Glennan-Webb-Seamans Project, National Air and Space Museum.

17. NASA Press Release H00-127, "Dr. Robert Gilruth, an Architect of Manned Spaceflight, Dies," 17 August 2000. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

flight proposal during the spring of the year.[18] As a part of this effort they considered the best method for reaching space. At a series of meetings to discuss planning for human-in-space program approaches being developed by U.S. industry in January–February 1958, NACA officials found:

> Proposals fell into two rough categories: (a) a blunt-nose cone or near-spherical zero-lift high-drag vehicle of a ton to a ton-and-a-half weight, and (b) a hypersonic glider of the ROBO or Dyna-Soar type. The first category of vehicles used existing ICBM vehicles as boosters; the second used more complex and arbitrary multiplex arrangements of existing large-thrust rocket engines. A number of contractors looked at the zero-lift high-drag minimum weight vehicle as the obvious expedient for beating the Russians and the Army into space. Others, notably Bell, Northrup, and Republic Aviation, set this idea aside as a stunt and consequently these contractors stressed the more elaborate recoverable hypersonic glider vehicle as the practical approach to the problems of flight in space (I-3).[19]

By April 1958, NACA engineers had concluded that the first of these options should become the basis for NACA planning for an initial human spaceflight (I-4).[20]

It soon became obvious to all that an early opportunity to launch human spacecraft into orbit would require the development of blunt-body capsules launched on modified multistage intercontinental ballistic missiles (ICBMs). Robert Gilruth recalled one of these decisions:

> Because of its great simplicity, the non-lifting, ballistic-type of vehicle was the front runner of all proposed manned satellites, in my judgment. There were many variations of this and other concepts under study by both government and industry groups at that time. The choice involved considerations of weight, launch vehicle, reentry body design, and to be honest, gut feelings. Some people felt that man-in-space was only a stunt. The ballistic approach, in particular, was under fire since it was such a radical departure from the airplane. It was called by its opponents 'the man in the can,' and the pilot was termed only a 'medical specimen.' Others thought it was just too undignified a way to fly.[21]

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18. Abe Silverstein, Associate Director, NACA, to Langley, "Review of Prospective Langley Report Entitled "Preliminary Study of a Manned Satellite" by Maxime A. Faget, Benjamine E. Garland, and James J. Buglia, 7 March 1958; Paul E. Purser, Aeronautical Research Engineer, NACA, Memorandum for Mr. Gilruth, "Langley Manned-Satellite Program," 11 April 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

19. Adelbert O. Tischler, Head, Rocket Combustion Section, NACA, Memorandum for Associate Director, NACA, "Minimum Man-In-Space Proposals Presented at WADC, January 29, 1958 to February 1, 1958," 10 April 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

20. Silverstein to NACA, "Review of Prospective Langley Report," 7 March 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

21. Robert R. Gilruth, "Memoir: From Wallops Island to Mercury; 1945–1958," paper, Sixth

While initially criticized as an inelegant, impractical solution to the challenge of human spaceflight, the ballistic spacecraft concept gained momentum as NACA engineers, led by Maxime A. Faget, championed the approach. At a meeting on human spaceflight held at Ames on 18 March 1958, a NACA position emerged on this approach to human spaceflight, reflecting Faget's ideas.[22] By April 1958, NACA had completed several studies "on the general problems of manned-satellite vehicles," finding that they could build in the near term "a basic drag-reentry capsule" of approximately 2,000 pounds and sufficient volume for a passenger.[23]

In August 1958, Faget and his designers developed preliminary specifications that then went to industry, especially the McDonnell Aircraft Corporation, for a ballistic capsule. Faget and his colleagues emphasized the simplicity, if not the elegance, of a ballistic capsule for the effort:

> The ballistic reentry vehicle also has certain attractive operational aspects which should be mentioned. Since it follows a ballistic path there is a minimum requirement for autopilot, guidance, or control equipment. This condition not only results in a weight saving but also eliminates the hazard of malfunction. In order to return to Earth from orbit, the ballistic reentry vehicle must properly perform only one maneuver. This maneuver is the initiation of reentry by firing the retrograde rocket. Once this maneuver is completed (and from a safety standpoint alone it need not be done with a great deal of precision), the vehicle will enter Earth's atmosphere. The success of the reentry is then dependant only upon the inherent stability and structural integrity of the vehicle. These are things of a passive nature and should be thoroughly checked out prior to the first man-carrying flight. Against these advantages the disadvantage of large area landing by parachute with no corrective control during the reentry must be considered.[24]

The Mercury spacecraft that flew in 1961 to 1963 emerged from these early conceptual studies by NACA engineers (I-9).

International History of Astronautics Symposium, Vienna, Austria, 13 October 1972, pp. 31–32.

22. Swenson et al., *This New Ocean*, p. 86; James M. Grimwood, *Project Mercury: A Chronology* (Washington, DC: NASA SP-4001, 1963), p. 17; "How Mercury Capsule Design Evolved," *Aviation Week*, 21 September 1959, pp. 52–53, 55, and 57.

23. Paul E. Purser, Aeronautical Research Engineer, NACA, Memorandum for Mr. Gilruth, "Langley Manned-Satellite Program," 11 April 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

24. Maxime A. Faget, Benjamine J. Garland, and James J. Buglia, Langley Aeronautical Laboratory, NACA, "Preliminary Studies of Manned Satellites," 11 August 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; Grimwood, *Project Mercury: A Chronology,* pp. 19–24; Gilruth, "Memoir: From Wallops Island to Mercury," pp. 34–37.

Man-in-Space Soonest

At the same time that NACA was pursuing its studies for a human spaceflight program, the U.S. Air Force (USAF) proposed the development of a piloted orbital spacecraft under the title of "Man-in-Space Soonest" (MISS).[25] Initially discussed before the launch of Sputnik I in October 1957, afterwards the Air Force invited Dr. Edward Teller and several other leading members of the scientific/technological elite to study the issue of human spaceflight and make recommendations for the future. Teller's group concluded that the Air Force could place a human in orbit within two years and urged that the department pursue this effort. Teller understood, however, that there was essentially no military reason for undertaking this mission and chose not to tie his recommendation to any specific rationale, falling back on a basic belief that the first nation to do so would accrue national prestige and advance, in a general manner, science and technology.[26] Soon after the new year, Lieutenant General Donald L. Putt, the USAF Deputy Chief of Staff for Development, informed NACA Director Hugh L. Dryden of the intention of the Air Force to aggressively pursue "a research vehicle program having as its objective the earliest possible manned orbital flight which will contribute substantially and essentially to follow-on scientific and military space systems." Putt asked Dryden to collaborate in this effort, but with NACA as a decidedly junior partner.[27] Dryden agreed; however, by the end of the summer he would find the newly created NASA leading the human spaceflight effort for the United States, with the Air Force being the junior player.[28]

Notwithstanding the lack of clear-cut military purpose, the Air Force pressed for MISS throughout the first part of 1958, clearly expecting to become the lead agency in any space program of the U.S. Specifically, it believed hypersonic space planes and lunar bases would serve national security needs in the coming decades well. To help make that a reality, it requested $133 million for the MISS program and secured approval for the effort from the Joint Chiefs of Staff.[29] Throughout this period, a series of disagreements between Air Force and NACA officials rankled both sides. The difficulties reverberated all the way to the White House, prompting a

25. The MISS program called for a four-phase capsule orbital process, which would first use instruments, to be followed by primates, then a pilot, with the final objective of landing humans on the Moon. See David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson Air Force Base, CO: Air Force Space Command, 1997), p. 75; Swenson et al., *This New Ocean*, pp. 33–97.

26. Swenson et al., *This New Ocean*, p. 73–74.

27. Lt. Gen. Donald L. Putt, USAF Deputy Chief of Staff, Development, to Hugh L. Dryden, NACA Director, 31 January 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

28. NACA to USAF Deputy Chief of Staff, Development, "Transmittal of Copies of Proposed Memorandum of Understanding between Air Force and NACA for joint NACA-Air Force Project for a Recoverable Manned Satellite Test Vehicle," 11 April 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

29. The breakdown for this budget was aircraft and missiles, $32M; support, $11.5M; construction, $2.5M; and research and development, $87M. See Memorandum for ARPA Director, "Air Force Man-in-Space Program," 19 March 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

review of the roles of the two organizations (I-5, I-6, I-7).[30] The normally staid and proper Director of NACA, Hugh L. Dryden, complained in July 1958 to the President's science advisor, James R. Killian, of the lack of clarity on the role of the Air Force versus NACA. He asserted that "the current objective for a manned satellite program is the determination of man's basic capability in a space environment as a prelude to the human exploration of space and to possible military applications of manned satellites. Although it is clear that both the National Aeronautics and Space Administration and the Department of Defense should cooperate in the conduct of the program, I feel that the responsibility for and the direction of the program should rest with NASA." He urged that the President state a clear division between the two organizations on the human spaceflight mission (I-8).[31]

As historians David N. Spires and Rick W. Sturdevant have pointed out, the MISS program became derailed within the Department of Defense (DOD) at essentially the same time because of funding concerns and a lack of clear military mission:

> Throughout the spring and summer of 1958 the Air Force's Air Research and Development Command had mounted an aggressive campaign to have ARPA convince administration officials to approve its Man-in-Space-Soonest development plan. But ARPA [Advanced Research Projects Agency] balked at the high cost, technical challenges, and uncertainties surrounding the future direction of the civilian space agency.[32]

Dwight D. Eisenhower signed the National Aeronautics and Space Act of 1958 into law at the end of July and, during the next month, assigned the USAF's human spaceflight mission to NASA. Thereafter, the MISS program was folded into what became Project Mercury.[33] By early November 1958, the DOD had acceded to the President's desire that the human spaceflight program be a civil-

30. Maurice H. Stans, Director, Bureau of the Budget, Memorandum for the President, "Responsibility for "Space" Programs," 10 May 1958; Maxime A. Faget, NACA, Memorandum for Dr. Dryden, 5 June 1958; Clotaire Wood, Headquarters, NACA, Memorandum for files, "Tableing [*sic*] of Proposed Memorandum of Understanding Between Air Force and NACA For a Joint Project For a Recoverable Manned Satellite Test Vehicle," 20 May 1958, with attached Memorandum, "Principles for the Conduct by the NACA and the Air Force of a Joint Project for a Recoverable Manned Satellite Vehicle," 29 April 1958; Donald A. Quarles, Secretary of Defense, to Maurice H. Stans, Director, Bureau of the Budget, 1 April 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

31. Hugh L. Dryden, Director, NACA, Memorandum for James R. Killian Jr., Special Assistant to the President for Science and Technology, "Manned Satellite Program," 19 July 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

32. David N. Spires and Rick W. Sturdevant, "'. . . to the very limit of our ability . . .': Reflections on Forty Years of Civil-Military Partnership in Space Launch," in Roger D. Launius and Dennis R. Jenkins, eds., *To Reach the High Frontier: A History of U.S Launch Vehicles* (Lexington, KY: University Press of Kentucky, 2002), p. 475.

33. For an overall discussion of the early military human program see Dwayne A. Day, "Invitation to Struggle: The History of Civilian-Military Relations in Space," in John M. Logsdon, with Dwayne A. Day and Roger D. Launius, eds., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume II, External Relationships* (Washington, DC: NASA SP-4407, 1996), 2: pp. 248–251.

ian effort under the management of NASA. For its part, NASA invited Air Force officials to appoint liaison personnel to the Mercury program office at Langley Research Center, and they did so.[34]

Beginning Project Mercury

Everyone recognized that time was of the essence in undertaking the human spaceflight project that NASA would now lead. Roy Johnson, director of ARPA for the DOD, noted in September 1958 that competition with the Soviet Union precluded taking a cautious approach to the human spaceflight initiative and advocated additional funding to ensure its timely completion. As he wrote to the Secretary of Defense and the NASA Administrator:

> I am troubled, however, with respect to one of the projects in which there is general agreement that it should be a joint undertaking. This is the so-called "Man-in-Space" project for which $10 million has been allocated to ARPA and $30 million to NASA. My concern over this project is due 1) to a firm conviction, backed by intelligence briefings, that the Soviets next spectacular effort in space will be to orbit a human, and 2) that the amount of $40 million for FY 1959 is woefully inadequate to compete with the Russian program. As you know our best estimates (based on some 12–15 plans) were $100 to $150 million for an optimum FY 1959 program.
>
> I am convinced that the military and psychological impact on the United States and its Allies of a successful Soviet man-in-space "first" program would be far reaching and of great consequence.
>
> Because of this deep conviction, I feel that no time should be lost in launching an aggressive Man-in-Space program and that we should be prepared if the situation warrants, to request supplemental appropriations of the Congress in January to pursue the program with the utmost urgency (I-10).[35]

Johnson agreed to transfer a series of space projects from ARPA to NASA but urged more timely progress on development of the space vehicle itself. Two weeks later, ARPA and NASA established protocols for cooperating in the aggressive development of the capsule that would be used in the human spaceflight program (I-11).[36]

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34. Memorandum for Dr. Silverstein, "Assignment of Responsibility for ABMA Participation in NASA Manned Satellite Project," 12 November 1958; Abe Silverstein to Lt. Gen. Roscoe C. Wilson, USAF Deputy Chief of Staff, Development, 20 November 1958; Hugh L. Dryden, Deputy Administrator, NASA, Memorandum for Dr. Eugene Emme for NASA Historical Files, "The 'signed' Agreement of April 11, 1958, on a Recoverable Manned Satellite Test Vehicle," 8 September 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

35. Roy W. Johnson, Director, ARPA, DOD, Memorandum for the Administrator, NASA, "Man-in-Space Program," 3 September 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

36. Roy W. Johnson, Director, ARPA, DOD, Memorandum for the Admistrator, NASA, "Man-in-Space Program," 19 September 1958, with attached Memorandum of Understanding,

To aid in the conduct of this program, ARPA and NASA created a panel for Manned Spaceflight, also referred to as the Joint Manned Satellite Panel, on 18 September 1958. Holding its first meeting on 24 September, the panel established goals and strategy for the program. Chaired by Robert Gilruth and including such NASA leaders as Max Faget and George Low, the panel focused on a wide range of technical requirements necessary to complete the effort. Under this panel's auspices, final specifications for the piloted capsule emerged in October 1958, as did procurement of both modified Redstone (for suborbital flights) and Atlas (for orbital missions) boosters (I-12, I-13, I-14).[37]

Just six days after the establishment of NASA on 1 October 1958, NASA Administrator T. Keith Glennan approved plans for a piloted satellite project to determine if human spaceflight was possible, and on 8 October he established the Space Task Group at Langley Research Center under Robert Gilruth. Thirty-five key staff members from Langley, some of whom had been working the military human spaceflight plan, were transferred to the new Space Task Group, as were 10 others from the Lewis Research Center near Cleveland, Ohio (I-15, I-16).[38] These 45 engineers formed the nucleus of the more than 1,000-person workforce that eventually took part in Project Mercury, so named on 26 November 1958 (I-17, I-18).[39] On 14 November, Gilruth requested the highest national priority procurement rating for Project Mercury, but that did not come until 27 April 1959 (I-23).[40] As Glennan recalled, "the philosophy of the project was to use known technologies, extending the state of the art as little as necessary, and relying on the unproven Atlas. As one looks back, it is clear that we did not know much about what we were doing. Yet the Mercury program was one of the best organized and managed of any I have been associated with."[41] Throughout

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"Principles for the Conduct by NASA and ARPA of a Joint Program for a Manned Orbital Vehicle," 19 September 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

37. Minutes of Meetings, Panel for Manned Spaceflight, 24 and 30 September, 1 October 1958; NASA, "Preliminary Specifications for Manned Satellite Capsule," October 1958; Paul E. Purser, Aeronautical Research Engineer, NASA, to Mr. R. R. Gilruth, NASA, "Procurement of Ballistic Missiles for use as Boosters in NASA Research Leading to Manned Spaceflight," 8 October 1958, with attached, "Letter of Intent to AOMC (ABMA), Draft of Technical Content," 8 October 1958. Folder 18674, all in NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

38. S. B. Batdorf, ARPA, Memorandum for File, "Presentation of MIS Program to Dr. Glennan," 14 October 1958; Robert R. Gilruth, Project Manager, NASA, Memorandum for Associate Director, NASA, "Space Task Group," 3 November 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

39. Abe Silverstein, Director of Spaceflight Development, NASA, Memorandum for Administrator, NASA, "Code Name "Project Mercury" for Manned Satellite Project," 26 November 1958; George M. Low, NASA, Memorandum for Dr. Silverstein, NASA, "Change of Manned Satellite Project name from "Project Mercury" to "Project Astronaut," 12 December 1958. Folder 18674, both in NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; Linda Ezell, *NASA Historical Data Book: Volume II: Programs and Projects 1958–1968* (Washington, DC: NASA SP-4012, 1988), pp. 102, 139–140; James M. Grimwood, *Project Mercury: A Chronology* (Washington, DC: NASA SP-4001, 1963), pp. 31–32.

40. George M. Low, NASA, Memorandum for House Committee on Science and Astronautics, "Urgency of Project Mercury," 27 April 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

41. T. Keith Glennan, *The Birth of NASA: The Diary of T. Keith Glennan*, J. D. Hunley, ed. (Washington, DC: NASA SP-4105, 1993), p. 13.

the fall of 1958, therefore, NASA leaders worked to press the Mercury program through to flight initially conceived as possible before the end of 1959 (I-19).[42]

The Role of the Mercury Seven Astronauts

As an important step in moving forward with Project Mercury, NASA selected and trained the astronaut corps.[43] Although NASA at first intended to hold an open competition for entry into the astronaut corps, over the 1958 Christmas holiday, President Dwight D. Eisenhower directed that the astronauts be selected from among the armed services' test pilot force. Indeed, NASA Administrator T. Keith Glennan visited the White House over Christmas of 1958. "When he came back to NASA," NASA Chief Historian Eugene Emme wrote in 1964, "Project Mercury was to possess classified aspects and the astronauts were to be military test pilots."[44] Although this had not been NASA leadership's first choice, this decision greatly simplified the selection procedure. The inherent riskiness of spaceflight, and the potential national security implications of the program, pointed toward the use of military personnel. It also narrowed and refined the candidate pool, giving NASA a reasonable starting point for selection. It also made good sense in that NASA envisioned the astronaut corps first as pilots operating experimental flying machines, and only later as working scientists.[45]

As historian Margaret Weitekamp has concluded in a recent study:

> From that military test flying experience, the jet pilots also mastered valuable skills that NASA wanted its astronauts to possess. Test pilots were accustomed to flying high-performance aircraft, detecting a problem, diagnosing the cause, and communicating that analysis to the engineers and mechanics clearly. In addition, they were used to military discipline, rank, and order. They would be able to take orders. Selecting military jet

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42. George M. Low, Memorandum for Administrator, "Status of Manned Satellite Program," 23 November 1958; George M. Low, Program Chief, Manned Spaceflight, NASA, Memorandum for Administrator, NASA, "Status Report No. 1, Manned Satellite Project," 9 December 1958; Abe Silverstein, Director of Spaceflight Development, NASA, Memorandum for Administrator, NASA, "Schedule for Evaluation and Contractual Negotiations for Manned Satellite Capsule," 24 December 1958; Message from NASA to Commanding General, Army Ordnance Missile Command, 8 January 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

43. See Allan C. Fisher Jr., "Exploring Tomorrow with the Space Agency," *National Geographic*, July 1960, pp. 48, 52–89; Kenneth F. Weaver, "Countdown for Space," *National Geographic*, May 1961, pp. 702–734.

44. George M. Low to NASA Administrator, "Pilot Selection for Project Mercury," 23 April 1959; Eugene M. Emme to Mae Link and James Grimwood, "Military Status of Mercury Astronauts," 23 March 1964. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

45. This was in striking contrast to the Soviet Union's cosmonauts, whom space program leaders believed were essentially passengers without complex tasks to perform. See Slava Gerovitch, "Trusting the Machine: The Technopolitics of Automation in the Soviet Space Program," paper presented at Society for History in the Federal Government annual meeting, 10 October 2003, copy in possession of author.

> test pilots as their potential astronauts allowed NASA to choose from a cadre of highly motivated, technically skilled, and extremely disciplined pilots.[46]

In addition, since most NASA personnel in Project Mercury came out of the aeronautical research and development arena anyway, it represented almost no stretch on the Agency's part to accept test pilots as the first astronauts. (It also guaranteed, as Weitekamp notes, that all of the original astronauts would be male.) After all, NACA had been working with the likes of them for decades and knew and trusted their expertise. It also tapped into a highly disciplined and skilled group of individuals, most of whom were already aerospace engineers, who had long ago agreed to risk their lives in experimental vehicles.[47]

NASA pursued a rigorous process to select the eventual astronauts that became known as the Mercury Seven. The process involved record reviews, biomedical tests, psychological profiles, and a host of interviews.[48] In November 1958, aeromedical consultants working for the Space Task Group at Langley had worked out preliminary procedures for the selection of astronauts to pilot the Mercury spacecraft. They then advertised among military test pilots for candidates for astronauts, receiving a total of 508 applications (I-20).[49] They then screened the service records in January 1959 at the military personnel bureaus in Washington and found 110 men that met the minimum standards established for Mercury:

1. Age—less than 40
2. Height—less than 5'11"
3. Excellent physical condition
4. Bachelor's degree or equivalent
5. Graduate of test pilot school
6. 1,500 hours total flying time
7. Qualified jet pilot

This list of names included 5 Marines, 47 Navy aviators, and 58 Air Force pilots. Several Army pilots' records had been screened earlier, but none was a graduate of a test pilot school.[50] The selection process began while the possibility

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46. Margaret A. Weitekamp, "The Right Stuff, The Wrong Sex: The Science, Culture, and Politics of the Lovelace Woman in Space Program, 1959–1963," Ph.D. Diss., Cornell University, 2001, p. 98. Dr. Weitekamp's dissertation has been published as *Right Stuff, Wrong Sex: America's First Women in Space Program* (Baltimore, MD: Johns Hopkins Press, 2004).

47. In some cases this was literally the case. The best example is Neil A. Armstrong, who worked with the NACA and NASA as a civilian research pilot on the X-15 program at its Flight Research Center in the Mojave Desert prior to selection for astronaut training in 1962. For an excellent account of flight research at NACA/NASA see Michael H. Gorn, *Expanding the Envelope: Flight Research at NACA and NASA* (Lexington, KY: University Press of Kentucky, 2001).

48. This process is well told in Swenson et al., *This New Ocean*, pp. 140–164.

49. "Invitation to Apply for Position of Research Astronaut-Candidate, NASA Project A, Announcement No. 1," 22 December 1958. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

50. See Swenson et al., *This New Ocean*, pp. 155–165; Joseph D. Atkinson, Jr. and Jay M. Shafritz, *The Real Stuff: A History of NASA's Astronaut Recruitment Program* (New York: Praeger Publishing, 1985), pp. 8–12.

of piloted Mercury/Redstone flights late in 1959 still existed, so time was a critical factor is the screening process.[51]

A grueling selection process began in January 1959. Headed by the Assistant Director of the Space Task Group, Charles J. Donlan, the evaluation committee divided the list of 110 arbitrarily into three groups and issued invitations for the first group of 35 to come to Washington at the beginning of February for briefings and interviews (I-22).[52] Donlan's team initially planned to select 12 astronauts, but as team member George M. Low reported:

> During the briefings and interviews it became apparent that the final number of pilots should be smaller than the twelve originally planned for. The high rate of interest in the project indicates that few, if any, of the men will drop out during the training program. It would, therefore, not be fair to the men to carry along some who would not be able to participate in the flight program. Consequently, a recommendation has been made to name only six finalists.[53]

Every one of the first 10 pilots interrogated on 2 February agreed to continue through the elimination process. The next week a second group of possible candidates arrived in Washington. The high rate of volunteering made it unnecessary to extend the invitations to the third group. By the first of March 1959, 32 pilots prepared to undergo a rigorous set of physical and mental examinations.

Thereafter each candidate went to the Lovelace Clinic in Albuquerque, New Mexico, to undergo individual medical evaluations. Phase four of the selection program involved passing an elaborate set of environmental studies, physical endurance tests, and psychiatric studies conducted at the Aeromedical Laboratory of the Wright Air Development Center, Dayton, Ohio. During March 1959 each of the candidates spent another week in pressure suit tests, acceleration tests, vibration tests, heat tests, and loud noise tests. Continuous psychiatric interviews, the necessity of living with two psychologists throughout the week, an extensive self-examination through a battery of 13 psychological tests for personality and motivation, and another dozen different tests on intellectual functions and special aptitudes—these were all part of the Dayton experience (I-29).[54]

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51. Atkinson and Shafritz, *The Real Stuff*, pp. 18, 43–45.

52. George M. Low, Program Chief, Manned Spaceflight, NASA, Memorandum for Administrator, NASA, "Pilot Selection for Project Mercury," 23 April 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

53. Quoted in Swenson et al., *This New Ocean*, p. 161.

54. Charles L. Wilson, Captain, USAF, WADC Technical Report 59-505, "Project Mercury Candidate Evaluation Program," December 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC. Although depicted as comic relief in the film version of *The Right Stuff* (1982), the battery of physiological tests were the most sophisticated designed up to that point. On these examinations see W. Randall Lovelace II, "Duckings, Probings, Checks That Proved Fliers' Fitness," *Life*, 20 April 1959; Mae Mills Link, *Space Medicine in Project Mercury* (Washington, DC: NASA SP-4003, 1965); John A. Pitts, *The Human Factor: Biomedicine in the Manned Space Program to 1980* (Washington, DC: NASA SP-4213, 1985).

Finally, without conclusive results from these tests, late in March 1959 NASA's Space Task Group began phase five of the selection, narrowing the candidates to 18. Thereafter, final criteria for selecting the candidates reverted to the technical qualifications of the men and the technical requirements of the program, as judged by Charles Donlan and his team members. NASA finally decided to select seven. The seven men became heroes in the eyes of the American public almost immediately, in part due to a deal they made with *Life* magazine for exclusive rights to their stories, and without NASA quite realizing it, they became the personification of NASA to most Americans.[55]

NASA unveiled the Mercury Seven in the spring of 1959, a week before the cherry blossoms bloomed along the tidal basin in Washington, DC, drenching the city with spectacular spring colors. NASA chose to announce the first Americans who would have an opportunity to fly in space on 9 April 1959. Excitement bristled in Washington at the prospect of learning who those space travelers might be. Surely they were the best the nation had to offer, modern versions of medieval "knights of the round table" whose honor and virtue were beyond reproach. Certainly they carried on their shoulders all of the hopes and dreams and best wishes of a nation as they engaged in single combat the ominous specter of communism. The fundamental purpose of Project Mercury was to determine whether or not humans could survive the rigors of liftoff and orbit in the harsh environment of space. From this perspective, the astronauts were not comparable to earlier explorers who directed their own exploits. Comparisons between them and Christopher Columbus, Admiral Richard Byrd, and Sir Edmund Hillary left the astronauts standing in the shadows.[56]

NASA's makeshift Headquarters was abuzz with excitement. Employees had turned the largest room of the second floor of Dolly Madison House facing Lafayette Park near the White House, once a ballroom, into a hastily set-up press briefing room. Inadequate for the task, print and electronic media jammed into the room to see the first astronauts. One end of the room sported a stage complete with curtain and both NASA officials and the newly chosen astronauts waited behind it for the press conference to begin at 2:00 p.m. The other end had electrical cable strewn about the floor, banks of hot lights mounted to illuminate the stage, more than a few television cameras that would be carrying the event live, and movie cameras recording footage for later use. News photographers gathered at the foot of the stage and journalists of all stripes occupied seats in the

55. See Tom Wolfe, "The Last American Hero," in *The Kandy-Kolored Tangerine-Flake Streamline Baby* (New York: Farrar, Straus, and Giroux, 1965); Atkinson and Shafritz, *The Real Stuff*, pp. 8–12; James L. Kauffman, *Selling Outer Space: Kennedy, the Media, and Funding for Project Apollo, 1961–1963* (Tuscaloosa, AL: University of Alabama Press, 1994), pp. 68–92; Mark E. Byrnes, *Politics and Space: Image Making by NASA* (Westport, CT: Praeger, 1994), pp. 25–46.

56. On this dynamic, see Roger D. Launius, "Project Apollo in American Memory and Myth," in Stewart W. Johnson, Koon Meng Chua, Rodney G. Galloway, and Philip J. Richter, eds., *Space 2000: Proceedings of the Seventh International Conference and Exposition on Engineering, Construction, Operations, and Business in Space* (Reston, VA: American Society of Civil Engineers, 2000), pp. 1–13; Harvey Brooks, "Motivations for the Space Program: Past and Future," in Allan A. Needell, ed., *The First 25 Years in Space: A Symposium* (Washington, DC: Smithsonian Institution Press, 1983), pp. 3–26; Perry Miller, "The Responsibility of a Mind in a Civilization of Machines," *The American Scholar* 31 (Winter 1961–1962), pp. 51–69; Thomas Park Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970* (New York: Viking, 1989), p. 2.

gallery. Since the room was inadequate for the media, NASA employees brought in more chairs and tried to make the journalists as comfortable as possible in the cramped surroundings.[57]

Many of the Mercury Seven astronauts have recorded their recollections of this singular event and all expressed the same hesitation and dread that Glennan experienced. They also expressed irritation at the huge and unruly audience assembled for the press conference. Alan Shepard and Donald 'Deke' Slayton had a brief conversation as they sat down at the table behind the curtain and contemplated the event ahead:

> "Shepard," Deke leaned toward him. "I'm nervous as hell. You ever take part in something like this?"
>
> Alan grinned. "Naw." He raised an eyebrow. "Well, not really. Anyway, I hope it's over in a hurry."
>
> "Uh huh. Me, too," Deke said quickly.[58]

When the curtain went up NASA Public Affairs Officer par excellence Walter Bonney announced:

> Ladies and gentlemen, may I have your attention, please. The rules of this briefing are very simple. In about sixty seconds we will give you the announcement that you have been waiting for: the names of the seven volunteers who will become the Mercury astronaut team. Following the distribution of the kit—and this will be done as speedily as possible—those of you who have p.m. deadline problems had better dash for your phones. We will have about a ten- or twelve-minute break during which the gentlemen will be available for picture taking.[59]

Like a dam breaking, a sea of photographers moved forward and popped flashbulbs in the faces of the Mercury Seven astronauts. A buzz in the conference room rose to a roar as this photo shoot proceeded. Some of the journalists bolted for the door with the press kit to file their stories for the evening papers; others ogled the astronauts.

Fifteen minutes later Bonney brought the room to order and asked Keith Glennan to come out and formally introduce the astronauts. Glennan offered a brief welcome and added, "It is my pleasure to introduce to you—and I consider

57. "Press Conference, Mercury Astronaut Team," transcript of press conference, 9 April 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

58. See Donald K. Slayton and Alan B. Shepard, *Moonshot: The Inside Story of America's Race to the Moon* (New York: Turner Publishing, Inc., 1994), p. 62; Roger D. Launius and Bertram Ulrich, *NASA and the Exploration of Space* (New York: Stewart, Tabori, and Chang, 1998), pp. 35–43; Donald K. "Deke" Slayton with Michael Cassutt, *Deke! U.S. Manned Space from Mercury to Shuttle* (New York: Forge Press, 1994), pp. 73–74.

59. "Press Conference, Mercury Astronaut Team," transcript of press conference, 9 April 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.; also quoted in Launius and Ulrich, *NASA and the Exploration of Space*, pp. 40–41.

it a very real honor, gentlemen—Malcolm S. Carpenter, Leroy G. Cooper, John H. Glenn, Jr., Virgil I. Grissom, Walter M. Schirra, Jr., Alan B. Shepard, Jr., and Donald K. Slayton . . . the nation's Mercury Astronauts!" These personable pilots faced the audience in civilian dress, and many people in the audience forgot that they were volunteer test subjects and military officers. Rather, they were a contingent of mature, middle-class Americans, average in build and visage, family men all, college-educated as engineers, possessing excellent health, and professionally committed to flying advanced aircraft.[60]

The reaction was nothing short of an eruption. Applause drowned out the rest of the NASA officials' remarks. Journalists rose to their feet in a standing ovation. Even the photographers crouched at the foot of the stage rose in acclamation of the Mercury Seven. A wave of excitement circulated through the press conference like no one at NASA had ever seen before. What was all of the excitement about?

The astronauts asked themselves the same question. Slayton nudged Shepard and whispered in his ear, "They're applauding us like we've already done something, like we were heroes or something." It was clear to all that Project Mercury, the astronauts themselves, and the American space exploration program were destined to be something extraordinary in the nation's history.[61]

The rest of the press conference was as exuberant as the introduction. At first the newly selected astronauts replied to the press corps' questions with military stiffness, but led by an effervescent and sentimental John Glenn, they soon warmed to the interviews. What really surprised the astronauts, however, was the nature of the questions most often asked. The reporters did not seem to care about their flying experience, although all had been military test pilots, many had combat experience and decorations for valor, and some held aircraft speed and endurance records. They did not seem to care about the details of NASA's plans for Project Mercury. What greatly interested them, however, were the personal lives of the astronauts. The media wanted to know if they believed in God and practiced any religion. They wanted to know if they were married and the names and ages and gender of their children, they wanted to know what their families thought about space exploration and their roles in it, and they wanted to know about their devotion to their country. God, country, family, and self, and the virtues inherent in each of them became the theme of the day.[62]

It was thus an odd press conference, with the reporters probing the characters of the pilots. But the motivation was never to dig up dirt on the astronauts, as has so often been the case with the media since, and was certainly something they could have profitably done with these men; instead, it was just the opposite. The reporters wanted confirmation that these seven men embodied the best virtues of the U.S. They wanted to demonstrate to their readers that the Mercury Seven strode Earth as latter-day saviors whose purity coupled with noble deeds

60. The Astronauts Themselves, *We Seven* (New York: Simon and Schuster, 1962); William Leavitt, "First American into Orbit," *Space Digest*, March 1959, pp. 62–65.

61. Slayton and Shepard, *Moonshot*, chapter 1.

62. "Space Voyagers Rarin' to Orbit," *Life*, 20 April 1959, p. 22

would purge this land of the evils of communism by besting the Soviet Union on the world stage. The astronauts did not disappoint.

John Glenn, perhaps intuitively or perhaps through sheer zest and innocence, picked up on the mood of the audience and delivered a ringing sermon on God, country, and family that sent the reporters rushing to their phones for rewrite. He described how Wilbur and Orville Wright had flipped a coin at Kitty Hawk in 1903 to see who would fly the first airplane and how far we had come in only a little more than 50 years. "I think we would be most remiss in our duty," he said, "if we didn't make the fullest use of our talents in volunteering for something that is as important as this is to our country and to the world in general right now. This can mean an awful lot to this country, of course." The other astronauts fell in behind Glenn and eloquently spoke of their sense of duty and destiny as the first Americans to fly in space. Near the end of the meeting, a reporter asked if they believed they would come back safely from space, and all raised their hands. Glenn raised both of his.[63]

The astronauts emerged as noble champions who would carry the nation's manifest destiny beyond its shores and into space. James Reston of the *New York Times* exulted in the astronaut team. He said he felt profoundly moved by the press conference, and even reading the transcript of it made one's heartbeat a little faster and step a little livelier. "What made them so exciting," he wrote, "was not that they said anything new but that they said all the old things with such fierce convictions. . . . They spoke of 'duty' and 'faith' and 'country' like Walt Whitman's pioneers. . . . This is a pretty cynical town, but nobody went away from these young men scoffing at their courage and idealism."[64]

These statements of values seem to have been totally in character for what was a remarkably homogeneous group. They all embraced a traditional lifestyle that reflected the highest ideals of the American culture. The astronauts also expressed similar feelings about the role of family members in their lives and the effect of the astronaut career on their spouses and children. In a recent study by sociologist Phyllis Johnson, analyzing several Apollo-era astronaut autobiographies, she found that the public nature of what the astronauts did meant that their family and work lives were essentially inseparable, often taking a toll on those involved in the relationship. She concluded:

> The data on these early astronauts need to be interpreted in light of the work-family views of the time: men were expected to keep their work and family lives compartmentalized. Their family life was not supposed to interfere with work life, but it was acceptable for work life to overlap into their family time. In high level professions, such as astronauts, the wife's support of his career was important; rather than 'my' career, it became 'our' career. The interaction between work and family is an

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63. John Glenn with Nick Taylor, *John Glenn: A Memoir* (New York: Bantam Books, 1999); "Space Voyagers Rarin' to Orbit," *Life*, 20 April 1959, p. 22.

64. John H. Glenn, "A New Era: May God Grant Us the Wisdom and Guidance to Use It Wisely," *Vital Speeches of the Day*, 15 March 1962, pp. 324–326; Dora Jane Hamblin, "Applause, Tears and Laughter and the Emotions of a Long-ago Fourth of July," *Life*, 9 March 1962, p. 34; Launius and Ulrich, *NASA and the Exploration of Space*, p. 43.

important aspect of astronaut morale and performance, which has been neglected by researchers.[65]

The media, reflecting the desires of the American public, depicted the astronauts and their families at every opportunity. The insatiable nature of this desire for intimate details prompted NASA to construct boundaries that both protected the astronauts and projected specific images that reinforced the already present traditional and dominant structure of American society. NASA, for obvious reasons, wanted to portray an image of happily married astronauts, not extramarital scandals or divorce. Gordon Cooper, one of the Mercury Seven, recalled that public image was important to some inside NASA because "marital unhappiness could lead to a pilot making a wrong decision that might cost lives—his own and others."[66] That might have been part of it, but the Agency's leadership certainly wanted to ensure that the image of the astronaut as clean-cut, all-American boy did not tarnish.

Sometimes the astronauts caused NASA officials considerable grief, and they sometimes had to rule them with an authoritarian hand. More often, however, they were benevolent and patriarchal toward the astronauts. Often this had to do with what rules they needed to follow and the lack of well-understood guidelines for their ethical conduct. For example, when the Space Task Group moved to Houston in 1962, several local developers offered the astronauts free houses. This caused a furor that reached the White House and prompted the involvement of Vice President Lyndon B. Johnson. (In this case, the head of the Manned Spacecraft Center, Robert R. Gilruth, had to disallow an outright gift to the astronauts.)[67] Gilruth's boys also got into trouble over what they could and could not do to make additional money on the outside. NASA had facilitated the Mercury Seven to sell their stories to *Life* magazine. This had raised a furor, and NASA policies were changed thereafter, but in 1963, Forrest Moore complained to Johnson that the second group of astronauts was seeking to do essentially the same thing. Gilruth had to intervene and explain that any deals for "personal stories" would be worked through the NASA General Counsel and would only take place in a completely open and legal manner.[68] Gilruth also defended the astronauts to the NASA leadership when they accepted tickets to see the Houston Astros season opener baseball game in the new Astrodome in

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65. Phyllis J. Johnson, "Work-Family Linkages in the Lives of Astronauts," presentation at 55th International Astronautical Congress, 6 October 2004, Vancouver, British Columbia, Canada.

66. Gordon Cooper and Barbara Henderson, *Leap of Faith: An Astronaut's Journey into the Unknown* (New York: HarperCollins, 2000), p. 26.

67. Edward Welsh to Lyndon B. Johnson, "Gift of Houses to Astronauts," 2 April 1962, VP Papers, LBJ Library, box 182, University of Texas, Austin, Texas; Robert Gilruth Oral History No. 6 by David DeVorkin and John Mauer, 2 March 1987, Glennan-Webb-Seamans Project, National Air and Space Museum, Washington, DC.

68. Robert C. Seamans, Jr., Associate Administrator, NASA, Memorandum for Robert R. Gilruth, Director, Manned Spaceflight, NASA, "Astronaut Activities," 30 August 1962. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; LBJ to Forrest Moore, President, Rominger Advertising Agency, 14 June 1963, VP Papers, LBJ Library, box 237, University of Texas, Austin, Texas.

1965, although he reprimanded several for poor judgment. While he told his superiors that he saw no reason why the astronauts should not enjoy the experience, he ensured that this type of media problem did not repeat itself. He also privately chastised, but publicly defended, John Young over the famous corned beef sandwich episode during Gemini III. He took the licks for these actions from the NASA Administrator:

> If this were a military operation and this kind of flagrant disregard of responsibility and of orders were involved, would not at least a reprimand be put in the record? . . . The only way I know to run a tight ship is to run a tight ship, and I think it essential that you and your associates give the fullest *advance* consideration to these matters, rather than to have them come up in a form of public criticism which takes a great deal of time to answer and which make the job of all of us more difficult.[69]

None of this suggests that NASA officials let the astronauts run amuck. They tried to maintain order through more patriarchal means than military ones, but on occasion—as in the case of the Apollo 15 stamp cover sales by the crew—they could be enormously stern.[70] Gilruth later said he tried to keep issues in perspective. These men put their lives on the line and deserved some leniency when minor problems arose. After all, they rose to the challenge repeatedly in conducting Mercury, Gemini, and Apollo.

The bravery of the astronauts touched emotions deeply seated in the American experience of the 20th century. Even their close associates at NASA remained in awe of them. The astronauts put a very human face on the grandest technological endeavor in history and the myth of the virtuous, no-nonsense, able, and professional astronaut was born at that moment in 1959. In some respects it was a natural occurrence. The Mercury Seven were, in essence, each of us. None were either aristocratic in bearing or elitist in sentiment. They came from everywhere in the nation, excelled in the public schools, trained at their local state university, served their country in war and peace, married and tried to make lives for themselves and their families, and ultimately rose to their places on the basis of merit. They represented the best the country had to offer and, most importantly, they expressed at every opportunity the virtues ensconced in

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69. James E. Webb to Robert R. Gilruth, 15 April 1965, James E. Webb Papers, Box 113, NASA-Astronaut Notes, Truman Library, Independence, Missouri.

70. On the stamp cover incident, in which the crew of Apollo 15 took collectibles with them to the Moon and then sold them after their return, see David Scott and Alexei Leonov, *Two Sides of the Moon: Our Story of the Cold War Space Race* (New York: Thomas Dunne Books, 2004), pp. 328–331. Jeff Dugdale, *Orbit* magazine, notes that "David Scott, the Commander, was famously dismissed from the Astronaut Corps on the first anniversary of his return from this mission as the Apollo 15 crew had smuggled 400 space covers with them. It was reported in newspapers in July 1972 that a West German stamp dealer had sold 100 of these at £570 each. Each of the three crew members had been expected to gain as much as £2,700 from the sale of covers. However they then declined to accept any money, acknowledging that their actions had been improper. Jim Irwin also resigned from the Astronaut Corps, and Worden was also moved out of the select group and made no more flights." See Jeff Dugdale, "Moonwalkers," available online at *http://www.asss.utvinternet.com/articles1/moonwalkers.htm*, accessed 11 October 2004.

the democratic principles of the republic. In many ways, the astronauts were the logical focal point of the space program because they were something that regular people could understand. Instead of mathematics, rockets, and acronyms, the astronauts served as an understandable entry point into a mysterious and elite world of science, technology, and exploration. In other words, the astronauts were the single most important element that made the space program something that resonated with the broader populace because of their (constructed to some degree) "everyman" status. They were not part of the technological elites that ran NASA, nor were they mechanical and alien like the machines they flew. They were quite aware of their status as national symbols and hoped to use that status to advance U.S. interests (I-28).[71]

The astronauts worked enormously hard to make Project Mercury a success, undergoing training far from their professional experience (I-21).[72] In December 1959, John Glenn described for a colleague some of the stress and strain of this effort:

> Following our selection in April, we were assigned to the Space Task Group, portion of NASA at Langley Field, and that is where we are based when not traveling. The way it has worked out, we have spent so much time on the road that Langley has amounted to a spot to come back to get clean skivvies and shirts and that's about all. We have had additional sessions at Wright Field in which we did heat chamber, pressure chamber, and centrifuge work and spent a couple of weeks this fall doing additional centrifuge work up at NADC, Johnsville, Pennsylvania. This was some program since we were running it in a lay-down position similar to that which we will use in the capsule later on and we got up to as high as 16 g's. That's a bitch in any attitude, lay-down or not (I-30).[73]

NASA kept the astronauts enormously busy training for future space missions. As Robert B. Voas of NASA's Space Task Group reported in May 1960: "The [training] program which has resulted from these considerations has allotted about one-half of the time to group activities and the other half to individually planned activities in each Astronaut's area of specialization" (I-31).[74]

When they were selected for Project Mercury in 1959, no one fully realized what would be the result of having highly skilled pilots involved in the effort.

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71. Mercury Astronauts, Memorandum For [Mercury] Project Director, NASA, "Exchange of visits with Russian Astronauts," 21 October 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

This is also the subject of Roger D. Launius, "Heroes in a Vacuum: The Apollo Astronaut as Cultural Icon," IAC-04-IAA.6.15.1.07, IAA History Session, International Astronautical Congress, Vancouver, British Columbia, Canada, 4–8 October 2004.

72. Among other things they undertook scientific training. See Dr. William S. Augerson, Human Factors Branch, NASA, Memorandum for Chief, Operations Division, NASA, "Scientific Training for Pilots of Project Mercury," 27 March 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

73. John Glenn, Mercury Astronaut, NASA, to Lt. Commander Jim Stockdale, USN, 17 December 1959. Folder 18674, NASA Historical Reference Collection (Doc. VII-I-31), NASA History Division, NASA Headquarters, Washington, DC.

74. Robert B. Voas, NASA Space Task Group, "Project Mercury Astronaut Training Program,"

Originally they had been viewed as minor participants in the flights by engineers developing Project Mercury at NASA's Langley Research Center in the winter of 1958 to 1959. Numerous skirmishes took place between engineers and astronauts in the development of the Mercury capsule, the "man-rating" of the launch vehicle, and in determining the level of integration of the astronaut into the system. Donald K. Slayton, who early took the lead for the Mercury Seven and later officially headed the astronaut office, emphasized the criticality of astronauts not as passengers but as pilots. In a speech before the Society of Experimental Test Pilots in 1959, he said:

> Objections to the pilot [in space] range from the engineer, who semi-seriously notes that all problems of Mercury would be tremendously simplified if we didn't have to worry about the bloody astronaut, to the military man who wonders whether a college-trained chimpanzee or the village idiot might not do as well in space as an experienced test pilot . . . I hate to hear anyone contend that present day pilots have no place in the space age and that non-pilots can perform the space mission effectively. If this were true, the aircraft driver could count himself among the dinosaurs not too many years hence.
>
> Not only a pilot, but a highly trained experimental test pilot is desirable . . . as in any scientific endeavor the individual who can collect maximum valid data in minimum time under adverse circumstances is highly desirable. The one group of men highly trained and experienced in operating, observing, and analyzing airborne vehicles is the body of experimental test pilots represented here today. Selection of any one for initial spaceflights who is not qualified to be a member of this organization would be equivalent to selecting a new flying school graduate for the first flight on the B-70, as an example. Too much is involved and the expense is too great.[75]

Slayton's defense of the role of the Mercury astronauts has found expression in many places and circumstances since that time.

Notwithstanding arguments to the contrary from some quarters, officials overseeing Project Mercury always intended that the astronauts should have control over the spacecraft that they flew in. Making these devices safe enough for humans took longer and exposed more doubts than NASA had expected and the astronauts themselves aided immensely in moving this integration forward. As the official history of Mercury reported in 1966:

> During the curiously quiet first half of 1960, the flexibility of the Mercury astronaut complemented and speeded the symbiosis of man

26 May 1960; U.S. Naval School of Aviation Medicine, "Proposed Schedule, Project Mercury (NASA) Astronauts Training Program, 28 March-1 April 1960," 11 February 1960. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

75. Donald K. Slayton, speech, annual meeting, Society of Experimental Test Pilots, Los Angeles, CA, 9 October 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

> and missile, of astronaut and capsule. Technology, or hardware, and techniques, or procedures—sometimes called "software" by hardware engineers—both had to be developed. But because they were equally novel, reliability had to be built into the new tools before dexterity could be acquired in their use.[76]

From the beginning, therefore, Project Mercury managers accepted the integral role of astronauts in controlling the spacecraft.

Christopher C. Kraft, Jr., Chief Flight Director for Mercury, made the case that many in NASA wanted a "go slow" approach to astronaut integration because "at the beginning, the capabilities of Man were not known, so the systems had to be designed to function automatically. But with the addition of Man to the loop, this philosophy changed 180 degrees since primary success of the mission depended on man backing up automatic equipment that could fail."[77] Kraft and his colleagues came to realize that the astronauts served an exceptionally useful purpose for enhancing the chances of success with Project Mercury. As an example, when the astronauts first visited the McDonnell Aircraft Corporation facilities in May 1959 they reviewed progress of the capsule they would fly with a sense for the human factors that would be necessary to make it work. They came up with several requests for alterations—including an observation window, manual reentry thruster controls, and an escape hatch with explosive bolts—and based on their recommendations NASA and McDonnell engineers went to work to overcome their concerns.[78]

One incident concerning the astronauts' desire for changes to the Mercury capsule has entered the public consciousness as a representation of conflicts between the fliers and the engineers. One key alteration the astronauts pressed for was the addition of an observation window for navigational purposes. In the feature film, *The Right Stuff*, this incident is depicted as a nasty confrontation that required the astronauts to threaten to appeal directly to the public through the media for their changes to be adopted. Only in the face of perceived embarrassment would the NASA and McDonnell engineers back down.[79] This adversarial approach to astronaut involvement made for sparks on the screen, but it bore little resemblance to what actually took place. The design engineers working on the spacecraft were exceptionally concerned about weight, and glass thick enough to

76. Swenson et al., *This New Ocean*, p. 167.

77. Christopher C. Kraft, Jr., "A Review of Knowledge Acquired from the first Manned Satellite Program," MSC fact sheet No. 206, p. 1, Mercury Files, Special Collections, University of Houston-Clear Lake, Texas.

78. Minutes, "Mock-Up Review," 12–14 May 1959, with enclosure addressed to C. H. Zimmerman and George M. Low, 23 June 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

79. *The Right Stuff* (Los Angeles: Warner Bros., 1983). Feature film directed by Philip Kaufman and produced by Irwin Winkler and Robert Chartoff, screenplay by Chartoff. A cast of unknown actors at the time depicted the development of aeronautics and astronautics from 1947 through the time of the Mercury program. Scott Glenn, cast as Alan Shepard, played the astronaut perfectly, and Ed Harris as John Glenn captured the essence of being an astronaut. A box office hit, the film also won an Academy Award for special effects.

withstand the harsh environments of launch, spaceflight, and reentry would weigh quite a lot. As Maxime A. Faget, designer of the Mercury spacecraft, remarked in an interview on 1 February 1991: "When we started off, we thought the Atlas could put about 2,000 pounds into orbit. So our design weight at the initiation of the program was 2,000 pounds. That was our goal. We had to build it at 2,000 pounds, and it was very challenging." To save weight Faget had only two portholes in the spacecraft and he thought that was good enough, but the astronauts pressed their point and got their navigation window. In the process of this and other changes, the Mercury capsule grew to a weight of about 2,700 pounds. Faget concluded, "Fortunately, as the Atlas was developed, we improved its performance, so it didn't have any trouble carrying the full weight. I think a great number of changes to the Mercury capsule would not have happened if the Atlas had not been improved." He added, "The astronauts were involved in the program decisions from the time they came on board. I think it was the right way to do it."[80]

Edward Jones made his point about human involvement even more succinctly in a paper delivered before the American Rocket Society in November 1959. He suggested that the astronaut was virtually necessary to the successful operation of Mercury missions. He commented:

> Serious discussions have advocated that man should be anesthetized or tranquillized or rendered passive in some other manner in order that he would not interfere with the operation of the vehicle. . . . As equipment becomes available, a more realistic approach evolves. It is now apparent with the Mercury capsule that man, beyond his scientific role, is an essential component who can add considerably to systems effectiveness when he is given adequate instruments, controls, and is trained. Thus an evolution has occurred . . . with increased emphasis now on the positive contribution the astronaut can make.[81]

The result of these efforts led to the development of a Mercury spacecraft that allowed considerable, but not total, control by the astronaut.

As Gordon Cooper recalled: "We weren't just mouthpieces or pilots milling around a hangar waiting to fly. We were involved in all aspects of the program, and there was a job for everybody." Of the Mercury Seven, Scott Carpenter took on communication and navigation, Alan Shepard handled worldwide tracking and capsule recovery, John Glenn worked on cockpit layout and design of the instrument panel in the spacecraft, Wally Schirra worked on spacesuits and life-support, Gus Grissom worked to develop automatic and manual control systems, Deke Slayton oversaw systems integration with the Mercury capsule and the Atlas

80. Interview with Maxime A. Faget and Alan B. Shepard, 1 February 1991, Hall of Science and Exploration, Academy of Achievement: A Museum of Living History, available online at *http://www.achievement.org/autodoc/page/she0int-2*, accessed 7 November 2004.

81. Edward R. Jones, "Man's Integration into the Mercury Capsule," paper presented at the 14th annual meeting of the American Rocket Society, Washington, DC, 16–19 November 1959, pp. 1–2. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

rocket, and Gordon Cooper served as liaison with the rocket team developing the launch systems.[82] When problems arose during MA-4, an unpiloted flight of the Mercury-Atlas system in September 1961, Robert Gilruth commented that had an astronaut been aboard he could have diagnosed and overcome the malfunctions of the automated system. That was why they were present, he asserted. In the end, Mercury as a system worked, but not without flaws, and the program successfully flew six humans in space between 5 May 1961 and 15 to 16 May 1963.[83]

Building the Mercury Capsule

The Mercury spacecraft flown by the first astronauts was the product of a genius incarnate in the form of a diminutive Cajun by the name of Dr. Maxime A. Faget, an engineering graduate of Louisiana State University and submarine officer in World War II. Working at the Langley Research Center in Hampton, Virginia, he was one of the most innovative and thoughtful engineers working on Mercury. While everyone thinking about spaceflight in the 1950s was obsessed with rocket planes, Faget realized that space was an entirely different environment and could effectively be accessed using an entirely different type of vehicle.[84]

During November and December 1958, the Space Task Group energetically pursued the development of the ballistic capsule flown by the astronauts. Faget became the chief designer of the Mercury spacecraft, and on 7 November 1958, held a briefing for 40 aerospace firms to explain the requirements for bidding on a NASA contract to build the capsule according to Faget's specifications. A week later, after 20 firms had indicated an interest, Faget's team mailed out requests for proposals. They received 11 proposals on 11 December and worked over the Christmas holidays to complete an evaluation. The Source Evaluation Board, convened under Faget's direction, recommended that the McDonnell Aircraft Corporation of St. Louis, Missouri, serve as the prime manufacturer for this system. The NASA leadership accepted this decision and announced the contract award on 9 January 1959. In the end NASA procured one dozen capsules at an estimated cost of $18.3 million—plus an award fee of $1.5 million—but the actual costs almost immediately spiraled upwards, causing considerable concern among senior government officials even as they made the funds avail-

82. Cooper with Henderson, *Leap of Faith*, pp. 20–22. See also Donald K. "Deke" Slayton with Michael Cassutt, *Deke! U.S. Manned Space from Mercury to the Shuttle* (New York: Forge, 1994), pp. 78–79.

83. John Catchpole, *Project Mercury: NASA's First Manned Space Programme* (Chichester, UK: Springer Praxis, 2001), p. 310. Before the astronauts flew, however, NASA launched primates into space to test the system. See George M. Low, Program Chief, Manned Spaceflight, NASA Memorandum for Mr. R. R. Gilruth, Director, Project Mercury, NASA, "Animal Payloads for Little Joe," 19 June 1959, with attached Memorandum from T.K.G to George M. Low, 15 June 1959; NASA, Information Guide for Animal Launches in Project Mercury, 23 July 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

84. "Maxime A. Faget," biographical file, NASA Historical Reference Collection.

able to complete the effort (I-26).[85] This two-month procurement process, from start to contract award, deserves special notice as something of a speed record with respect to the convoluted manner in which the federal government buys everything from paperclips to nuclear powered aircraft carriers. In the end, the Mercury project would cost approximately $350 million for research and development as well as operations.[86]

McDonnell's Mercury team, under the leadership of John F. Yardley, immediately began wrestling with Faget's requirements. It had a good start on the capsule from work done the year before for the Air Force, but Yardley was unprepared for the difficulties encountered when actually building the spacecraft. First and most important, Yardley's team struggled with strict weight requirements so that the capsule could be launched atop the Atlas rocket. NASA's specifications for the capsule had been 2,000 pounds placed in orbit. McDonnell's bid had proposed a 2,400-pound spacecraft, plus or minus 25 percent. The minus side allowed a capsule of 1,800 pounds, perfect for the capability of the Atlas, but anything over 2,000 pounds could not be put into orbit by the envisioned launcher. A combination of paring the capsule design down to the lightest weight possible and increasing the thrust of the Atlas finally made successful launches in Project Mercury attainable, but it was a difficult task and the capability margins were always stretched. Everyone was keenly aware of this and other problems in building the spacecraft. Wernher von Braun wrote a friendly letter to Robert Gilruth about McDonnell's performance. "It has come to my attention that one of our ball carriers has his shoelaces untied and doesn't know it," he wrote. "If he trips and falls we may all lose the game and our astronaut his life. So I feel that I must pass along to you what has been brought to my attention, at the risk of making a few people sore" (I-27).[87] In response to such concerns, teams of NASA engineers swarmed over contractors in an effort to keep the program on track.

For the next year the NASA/McDonnell engineering team worked through the critical components of the spacecraft. They focused on the four major elements of any flying machine:

- Aerodynamics/stability and control
- Avionics/electronics
- Propulsion
- Materials

In addition, they had the critical area of human factors to oversee in the development of this entirely new type of spacecraft.[88] One of the McDonnell engi-

85. Cost had long been an issue, even before the McDonnell contract. See A. J. Goodpaster, Brigadier General, USA, Memorandum of Conference with the President, 29 September 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

86. President's Science Advisory Committee, "Report of the Ad Hoc Panel on Man-in-Space," 14 November 1960 (final report 16 December 1960). Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

87. Wernher von Braun, Director, Development Operations Division, NASA, to Robert R. Gilruth, Space Task Group, NASA, 9 October 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

88. George M. Low, Program Chief, Manned Spaceflight, NASA, Memorandum for Administrator, NASA, "Status Report No. 1, Manned Satellite Project," 9 December 1958. Folder 18674, NASA

neering team's important decisions was to use a pure oxygen atmosphere at 5 psi. This atmosphere would become the standard for American spacecraft until the Space Shuttle, but it had a fundamental drawback as a fire hazard, something that proved fatal in the Apollo 1 accident of 1967.[89]

The Mercury capsule that emerged from this process stood 115 inches high with a tapering cylinder from 74 inches at its base so that it appeared to all as an upside-down ice cream cone. The pressurized cockpit for the pilot was the largest portion of the capsule, with most other systems packed throughout the cramped interior. Indeed, the astronaut had very little room for movement, being placed in an individually fitted contour seat for the duration of the flight. A smaller cylinder at the top housed other electronics as well as a parachute for recovery. Attitude control jets allowed the astronaut to orient the spacecraft during flight. An ablative heatshield with a ceramic coating affixed to the capsule's base would protect the spacecraft during reentry. Designed to adhere to strict weight restrictions and maximum strength, much of the spacecraft was titanium, but heat-resistant beryllium made up the upper cone of the vehicle since, other than the heatshield, it would suffer the greatest heat during reentry. Underneath the heatshield a retrorocket pack of three solid rocket motors served to slow the vehicle down and return it to Earth. Each motor produced 1,000 pounds of thrust for only about 10 seconds. The Mercury spacecraft also had 3 smaller posigrade rockets that produced 400 pounds of thrust each for a second, used for separating the capsule from its booster. Atop the capsule stood a launch escape tower with solid rocket motors producing 52,000 pounds of thrust that could shoot the capsule away from the rocket during an emergency on the launchpad or during ascent. The capsule proved a spare but serviceable space vehicle.[90]

Adapting Launch Vehicles

During Project Mercury two different boosters proved their mettle in sending astronauts into space. The first was the Redstone, built by Wernher von Braun's rocket team at the Army Ballistic Missile Agency (ABMA) in Huntsville, Alabama, as a ballistic missile and retrofitted for human flights.[91] NASA Administrator T. Keith Glennan materially aided this effort by securing the transfer of ABMA

Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

89. This was discussed in "Report of the Ad Hoc Mercury Panel," 12 April 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

The report stated: "The idea of using a single gas, O_2, atmosphere, in both the suit and capsule to simplify the system appears to be reasonable from an engineering standpoint if it meets the biomedical requirements. The environmental control system is capable of operating completely automatically if required and still provide redundancy in many areas against failure. In the automatic mode the only single point of failure without backup appears to be with the emergency oxygen rate valve. However, with man functioning in the system, this valve can be manually operated."

90. A description of the Mercury spacecraft may be found in Swenson et al., *This New Ocean*, pp. 223–262; Linda Ezell, *NASA Historical Data Book: Volume II*, pp. 134–139.

91. See Wernher von Braun, "The Redstone, Jupiter, and Juno," in Eugene M. Emme, ed., *The History of Rocket Technology* (Detroit, MI: Wayne State University Press, 1964), pp. 107–121.

to NASA thereby facilitating the tapping of expertise from the builders of the Redstone rocket.[92] In addition to a large number of other modifications, NASA engineers worked to lengthen the Redstone tanks and scrapped the original fuel, Hydyne, for alcohol. Hydyne proved too toxic and difficult to work with. In all, NASA's rocketeers made some 800 changes to the Redstone to prepare it for human spaceflight.[93]

Then there was the problem with the reliability of the Atlas rocket, envisioned as the launcher of choice for the Mercury orbital missions. A converted ICBM, the Atlas had been undergoing an on-again, off-again development since 1946. Canceled once and underfunded thereafter, the Air Force had been unable until the Sputnik crisis to secure sufficient resources to make serious progress on it. Because of this difficulty, its designers at the Convair Corp. had accepted, as a given, a 20 percent failure rate. In fact, the rate proved much higher in the early going. As 1959 began, seven out of eight launches had failed. Sometimes the Atlas blew up on the pad and sometimes it veered off course in flight only to be destroyed by the range safety officer. Instead of 80 percent reliability, still not acceptable for human flight, the Atlas had an 80 percent failure rate.[94] That would most assuredly not do with astronauts aboard. Robert Gilruth testified to Congress about this problem a few months after the creation of the Space Task Group. "The Atlas . . . has enough performance . . . and the guidance system is accurate enough, but there is the matter of reliability. You don't want to put a man in a device unless it has a very good chance of working every time." Gilruth urged time and money to test the hardware under actual flight conditions without people aboard. "Reliability is something that comes with practice," he said.

Ever so incrementally, Atlas project engineers improved the performance of the launch vehicle. They placed a fiberglass shield around the liquid oxygen tank to keep the engines from igniting it in a massive explosion, a rather spectacular failure that seemed to happen at least half the time. They changed out virtually every system on the vehicle, substituting tried and true technology wherever possible to minimize problems. They altered procedures and developed new telemetry to monitor the operations of the system. Most important, they developed an abort sensing system

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92. T. Keith Glennan to the President, "Responsibilities and Organization for Certain Space Activities," 2 November 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

93. Swenson et al., *This New Ocean*, p. 181; NASA Office of Congressional Relations, "Mercury-Redstone III," p. 5-1; William M. Bland, Jr., Space Task Group, Memorandum for Project Director, "Second Coordination Meeting Concerning Project Mercury with NASA, ABMA, and MAC Representatives Held 20 March 1959, at NASA, Space Task Group, Langley Field, Virginia," 27 March 1959; T. Keith Glennan, NASA Administrator, to Neil H. McElroy, Secretary of Defense, 14 July 1959. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

94. For able histories of the Atlas, see Dennis R. Jenkins, "Stage-and-a-Half: The Atlas Launch Vehicle," in Roger D. Launius and Dennis R. Jenkins, eds., *To Reach the High Frontier: A History of U.S. Launch Vehicles* (Lexington, KY: University Press of Kentucky, 2002), pp. 102–170; John Lonnquest, "The Face of Atlas: General Bernard Schriever and the Development of the Atlas Intercontinental Ballistic Missile, 1953-1960," Ph.D. Diss., Duke University, 1996; Davis Dyer, "Necessity is the Mother of Invention: Developing the ICBM, 1954–1958," *Business and Economic History* 22 (1993): pp. 194–209. Although dated, a useful early essay is Robert L. Perry, "The Atlas, Thor, Titan, and Minuteman," in Eugene M. Emme, ed., *History of Rocket Technology*, pp. 143–155.

(labeled ASS by everyone but the people involved in developing it) to monitor vehicle performance and to provide early escape of the Mercury capsule if necessary.[95]

Suborbital Flights

The first Mercury test flight took place on 21 August 1959, when a capsule carrying two rhesus monkeys was launched atop a cluster of Little Joe solid-fuel rockets (I-24). Other tests using both Redstone and Atlas boosters and carrying both chimpanzees and astronaut dummies soon followed (I-25). The first flight of a Mercury-Redstone combination took place on 21 November 1960 (Mercury-Redstone 1), but only with a "simulated man" in its capsule. It pointed out serious problems with the system. The rocket rose only 3.8 inches off the pad, and then it settled back on its fins. The parachutes deployed and fell to the launchpad while the capsule remained in place on the booster. The episode proved embarrassing, but NASA soon found that faulty grounding on electrical circuitry had caused a short in the system. They repaired the problem and the next test flight, Mercury-Redstone 1A, flown on 19 December 1960, went somewhat better but still experienced problems. The rocket boosted the capsule higher and at greater G forces than expected, pushing it some 20 miles downrange beyond the target area. This led to the 31 January 1961, Mercury-Redstone 2 launch with Ham the chimpanzee aboard on a 16-minute, 39-second flight. Again, the booster overperformed and carried him 42 miles higher and 124 miles further downrange than planned. In the process, Ham suffered about 17 g's going up and some 15 during reentry. NASA made one more test flight, on 24 March 1961, and this time the mission took place as planned.[96]

With these tests, NASA was prepared to move on to the piloted portion of the suborbital Mercury program. As preparations for this flight progressed throughout the spring, on 12 April 1961, the Soviet Union suddenly launched Yuri Gagarin into orbit, counting coup on the U.S. space effort one more time.[97] This spaceflight gave greater impetus to rescue national honor in the early launch of an astronaut in the U.S.'s Mercury program. Interestingly, the leaders of the program took extraordinary efforts to prepare for the release of public information about the mission. They kept the name of the astronaut assigned to fly the mission secret until only a short time before the scheduled launch.

Presidential science advisor Jerome B. Wiesner also expressed concern that the media should be prevented from making the flight "a Hollywood production, because it can jeopardize the success of the entire mission." Wiesner, concerned

95. "Report of the Ad Hoc Mercury Panel," 12 April 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

96. Swenson et al., *This New Ocean*, pp. 293–318; Linda Ezell, *NASA Historical Data Book,* Volume II, pp. 134–143; NASA News Release, "Mercury Redstone Booster Development Test," 22 March 1961, NASA Historical Reference Collection (Doc. IV-I-24); Richard J. Wisniewski, for Warren J. North, Head, Manned Satellites, to Director of Spaceflight Programs, "Mercury Status as of March 2, 1961," 3 March 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

97. Swenson et al., *This New Ocean,* pp. 332–335; Thomas A. Heppenheimer, *Countdown: A History of Spaceflight* (New York: John Wiley & Sons, Inc., 1997), pp. 189–192.

with NASA's preparations for the mission, chartered a panel of the Presidential Scientific Advisory Committee to conduct an independent review of the program; that panel gave a qualified endorsement to NASA's plans to launch the first U.S. astronaut (I-32, I-33, I-34).[98]

Alan Shepard made that first suborbital Mercury flight on 5 May 1961, in the process establishing that the U.S. could send an individual into space and return him to Earth. At 9:34 a.m., about 45 million Americans sat tensely before their television screens and watched a slim black-and-white Redstone booster, capped with a Mercury spacecraft containing Shepard, lift off its pad at Cape Canaveral and go roaring upward through blue sky toward black space. At 2.3 seconds after launch, Shepard's voice came through clearly to Mercury Control; minutes later the millions heard the historic transmission: "Ahh, Roger; lift-off and the clock is started. . . . Yes, sir, reading you loud and clear. This is *Freedom 7*. The fuel is go; 1.2 g; cabin at 14 psi; oxygen is go . . . *Freedom 7* is still go!" Reaching a speed of 5,146 miles per hour and an altitude of about 116.5 miles, well above the 62-mile international standard for the minimum altitude for spaceflight, Shepard's suborbital flight lasted only 15 minutes and 22 seconds and he was weightless only a third of that time. *Freedom 7* landed 302 miles downrange from the Cape Canaveral in the Atlantic Ocean (I-35). It was an enormously significant event for the U.S. The flight made Shepard a national hero, and his stoical persona and public countenance also served to solidify his stature among Americans as a role model. In the following months, how best to capitalize for propaganda purposes on the astronauts' experiences without distorting them became a matter of policy concern (I-37).[99]

NASA officials were euphoric in the aftermath of the Alan Shepard flight, and some even offered proposals for expansive follow-on missions such as a circumlunar flight using the Mercury hardware (I-36).[100] Those schemes went nowhere,

98. Abe Silverstein, Director of Spaceflight Programs, NASA, Memorandum for Administrator, NASA, "Astronaut Selection Procedure for Initial Mercury-Redstone Flights," 14 December 1960; Jerome B. Wiesner, The White House, Memorandum for Dr. Bundy, "Some Aspects of Project Mercury," 9 March 1961; James E. Webb, Administrator, NASA, to James C. Hagerty, Vice President, American Broadcasting Company, 1 June 1961; Abe Silverstein, Director of Spaceflight Programs, NASA, Memorandum for Administrator, "Use of a Television System in Manned Mercury-Atlas Orbital Flights," 6 September 1961; Wernher von Braun, Memorandum, "Sensitivity of Mercury Launching Dates," 3 March 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

99. NASA MR-3 Technical Debriefing Team, "Debriefing," 5 May 1961; James E. Webb, Administrator, NASA, to James C. Hagerty, Vice President, American Broadcasting Company, 1 June 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; Alan B. Shepard, Jr., "A Pilot's Story," *National Geographic* 130 (September 1961): pp. 432–444; The Astronauts Themselves, *We Seven* (New York: Simon and Schuster, 1962), Shepard wrote three sections, "The Urge to Pioneer," pp. 65–69, "What to do Until the Ship Comes," pp. 164–167, and "A Range Around the World," pp. 285–299; Alan B. Shepard Jr., "The Astronaut's Story of the Thrust into Space," *Life*, 19 May 1961; "Shepard's Space Saga," *Naval Aviation News* 42 (June 1961): pp. 20–23; Roger D. Launius, "Alan B. Shepard Jr.," in *Research Guide to American Historical Biography* (Washington, DC: Beacham Publishing, 1991), 5: pp. 2742–2748.

100. Joachim P. Kuettner, Chief, Mercury-Redstone Project, NASA, to Dr. von Braun, 18 May 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

and a second Mercury flight on 21 July 1961 proved less successful.[101] After landing the hatch blew off prematurely from the Mercury capsule, *Liberty Bell 7*, and it sank into the Atlantic Ocean before it could be recovered. As Grissom noted about the incident:

> I was just waiting for their call when all at once, the hatch went. I had the cap off and the safety pin out, but I don't think that I hit the button. The capsule was rocking around a little but there weren't any loose items in the capsule, so I don't see how I could have hit it, but possibly I did. I had my helmet unbuttoned and it wasn't a loud report. There wasn't any doubt in my mind as to what had happened. I looked out and saw nothing but blue sky and water starting to ship into the capsule. My first thought was to get out, and I did. As I got out, I saw the chopper was having trouble hooking onto the capsule. He was frantically fishing for the recovery loop. The recovery compartment was just out of the water at this time and I swam over to help him get his hook through the loop. I made sure I wasn't tangled anyplace in the capsule before swimming toward the capsule. Just as I reached the capsule, he hooked it and started lifting the capsule clear. He hauled the capsule away from me a little bit and didn't drop the horsecollar down. I was floating, shipping water all the time, swallowing some, and I thought one of the other helicopters would come in and get me. I guess I wasn't in the water very long but it seemed like an eternity to me. Then, when they did bring the other copter in, they had a rough time getting the horsecollar to me. They got in within about 20 feet and couldn't seem to get it any closer. When I got the horsecollar, I had a hard time getting it on, but I finally got into it. By this time, I was getting a little tired. Swimming in the suit is difficult, even though it does help keep you somewhat afloat. A few waves were breaking over my head and I was swallowing some water. They pulled me up inside and then told me they had lost the capsule (I-38).[102]

Some suspected that Grissom had panicked and prematurely blown the capsule's side hatch into the water—and a panicked Grissom is how most people routinely remember him today because of a graphic misrepresentation of the incident in the movie *The Right Stuff*—but he became a national hero because of that flight, and appropriately so.[103] Despite this problem, these suborbital flights proved valuable for NASA technicians who found ways to solve or work around

101. This mission is recorded in Swenson et al., *This New Ocean*, pp. 341–379.

102. MR-4 Technical Debriefing Team, Memorandum for Associate Director, NASA, "MR-4 Postflight Debriefing of Virgil I. Grissom," 21 July 1961, with attached, "Debriefing." Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

103. Tom Wolfe, *The Right Stuff* (New York: Farrar, Straus, Giroux, 1979), pp. 280–296. See also William J. Perkinson, "Grissom's Flight: Questions," *Baltimore Sun*, 22 July 1961, which suggests that NASA had miscalculated in its rocketry and forced Grissom into the unenviable position of being outside the recovery area, thereby increasing the time it took to reach the spacecraft. Grissom had personally performed well, Perkinson noted.

literally thousands of obstacles to successful spaceflight. The success of these two missions led to the cancellation of any more Mercury-Redstone flights, although two more had been planned (I-39).[104]

Achieving Orbit

Even as these suborbital flights reached completion, NASA began final preparations for the orbital aspects of Project Mercury (I-40, I-41). In this phase, NASA planned to use a Mercury capsule capable of supporting a human in space not just for a few minutes, but eventually for as much as three days. As a launch vehicle for this Mercury capsule, NASA used the more powerful Atlas instead of the Redstone. But this decision was not without controversy. There were technical difficulties to be overcome in mating it to the Mercury capsule, to be sure, but most of the differences had been resolved by the first successful orbital flight of an unoccupied Mercury/Atlas combination in September 1961. On 29 November 1961, the final test flight took place, this time with the chimpanzee Enos occupying the capsule for a two-orbit ride before being successfully recovered in an Atlantic Ocean landing.[105]

Not until 20 February 1962, after several postponements, did NASA launch an astronaut on an orbital flight. After repeated delays, including a nationally televised 27 January 1962 scrub just 20 minutes before liftoff, John Glenn became the first American to circle Earth on 20 February, making three orbits in his *Friendship 7* Mercury spacecraft.[106] The flight had several difficulties, and Glenn proved the worth of a pilot in the spacecraft. During his first orbit, Glenn's spacecraft drifted out of proper orbit attitude, yawing to the right and not being corrected by the low-rate attitude thrusters. When it reached a 20-degree alteration, high-rate thrusters fired to correct the problem, but this was an inappropriate use of these thrusters. Glenn took control and manually corrected for the yaw throughout much of the remainder of the mission using the low-rate attitude control jets. It was an excellent object lesson in the advantage of having an astronaut step in to control the spacecraft in the event of a malfunction. Virtually every Mercury mission would require a similar type of action on the part of the astronaut, and with every demonstration, all those associated with the program became more comfortable with human/machine interaction. Even more significant, Glenn experienced a potentially disastrous event when he learned that

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104. Richard J. Wisniewski, Memorandum for Administrator, "Mercury Redstone 4 Mission," 24 July 1961; Robert R. Gilruth, Director, Space Task Group, NASA, to Marshall, NASA, (attention: Dr. Wernher von Braun), "Termination of Mercury Redstone Program," 23 August 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; Swenson et al., *This New Ocean*, pp. 328–330; Linda Ezell, *NASA Historical Data Book, Volume II,* pp. 143–144.

105. Von Braun, "The Redstone, Jupiter, and Juno," in Eugene M. Emme, ed., *History of Rocket Technology*, pp. 107–122.

106. "Month's Delay for Glenn Seen," *Washington Star,* 31 January 1962; Art Woodstone, "Television's $1,000,000 (When & If) Manshoot; Lotsa Prestige & Intrigue," *Variety,* January 24, 1962; Swenson et al., *This New Ocean*, pp. 419–436.

on the back side of his *Friendship 7* Mercury pressure shell, a landing bag, programmed to inflate a few seconds before splashdown to help cushion the impact, had possibly inflated in orbit. The landing bag was located just inside the heatshield, an ablative material meant to burn off during reentry, and was held in place in part by a retropack of three rocket motors that would slow the capsule down and drop it from orbit. Because of this apparent problem, Glenn had to return to Earth after only three orbits, instead of a planned seven, and leave the retropack in place during his fiery reentry, hoping that it would hold the heatshield in place. It did, and Glenn returned safely to Earth (I-42, I-43).[107]

Glenn's flight provided a welcome increase in national pride, making up for at least some of the earlier Soviet successes. The public, more than celebrating the technological success, embraced Glenn as a personification of heroism and dignity. Hundreds of requests for personal appearances by Glenn poured into NASA Headquarters, and NASA learned much about the power of the astronauts to sway public opinion. The NASA leadership made Glenn available to speak at some events but more often substituted other astronauts and declined many other invitations. Among other engagements, Glenn did address a joint session of Congress and participated in several ticker-tape parades around the country. NASA discovered, in the process of this hoopla, a powerful public relations tool that it has employed ever since. It also discovered that there was a need to control the activities of the Mercury astronauts so that they did not become a source of political or public embarrassment (I-44).[108]

Three more successful Mercury flights took place during 1962 and 1963. Scott Carpenter made three orbits on 20 May 1962 (I-45), and on 3 October 1962, Wally Schirra flew six orbits. The capstone of Project Mercury came on the flight of Gordon Cooper, who circled Earth 22 times in 34 hours from 15 to 16 May 1963. The program had succeeded in accomplishing its purpose: to successfully orbit a human in space, explore aspects of tracking and control, and to learn about microgravity and other biomedical issues associated with spaceflight.[109]

As the Mercury program made strides toward enabling the U.S. to move on to a lunar landing, as promised by President John F. Kennedy in May 1961, the

107. Dr. Robert B. Voas, Training Officer, NASA, Memorandum for Astronauts, "Statements for Foreign Countries During Orbital Flights," 7 November 1961; Telegram, NASA—Manned Spacecraft Center, Port Canaveral, FL, to James A. Webb; "MA-6 Postlaunch Memorandum," 21 February 1962; R. B. Voas, NASA, Memorandum for Those Concerned, "MA-6 Pilot's Debriefing," 22 February 1962, with attached, John Glenn, NASA, "Brief Summary of MA-6 Orbital Flight," 20 February 1962; NASA Manned Spacecraft Center, "Postlaunch Memorandum Report for Mercury-Atlas No. 6 (MA 6)," 5 March 1962. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; The Astronauts Themselves, *We Seven*, pp. 310–312; Roger D. Launius, *NASA: A History of the U.S. Civil Space Program* (Malabar, FL: Krieger Pub., Co., 2000 ed.), chapter 11.

108. Swenson et al., *This New Ocean*, pp. 422–436.

109. W. J. North, Senior Editor, Manned Spacecraft Center, NASA, "MA-7/18 Voice Communications and Pilot's Debriefing," 8 June 1962. Folder 18674, NASA Historical Reference Collection (Doc. VII-I-47), NASA History Division, NASA Headquarters, Washington, DC; NASA Manned Spacecraft Center, *Mercury Project Summary Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963* (Washington, DC: NASA SP-45, 1963); Swenson et al., *This New Ocean*, pp. 446–503.

human spaceflight program found itself in turmoil over the relocation of the Space Task Group from Langley Research Center to a new Manned Spacecraft Center in Houston, Texas. A decision taken in September 1961 as it became apparent that the scope, size, and support for human spaceflight necessitated an entirely separate center, the new human spaceflight center rested on land granted from Rice University.[110] Upon reaching Houston, the Space Task Group set to work not only settling into their new facility, but also in completing the design and development of their next projects. The center also became the home of NASA's astronauts and the site of mission control.[111] Within its first few months in Houston, said Robert Gilruth in June 1962, "the Manned Spacecraft Center has doubled in size; accomplished a major relocation of facilities and personnel; pushed ahead in two new major programs; and accomplished Project Mercury's design goal of manned orbital flights twice with highly gratifying results."[112]

The early astronauts were, in too many instances, rambunctious men, as many had recognized during the Mercury program. They roughhoused and drank and drove fast and got into sexual peccadilloes. Rumors swirled around several of the astronauts, especially Gus Grissom, whom NASA officials considered a consummate professional in the cockpit and an incorrigible adolescent whenever off-duty. Everyone laughed when Grissom said:

> There's a certain kind of small black fly that hatches in the spring around the space center south of Houston. Swarms of the bugs can splatter windshields, but their real distinction is that male and female catch each other in midair and fly along happily mated. Grissom told a *Life* magazine reporter that he envied those insects. "They do the two things I like best in life," he said, "flying and ****ing—and they do them at the same time." For years thereafter, the insects were known as Grissom Bugs to local residents.[113]

Several memoirs have recounted these and other anecdotes of the astronauts, many of which are the stuff of legend. It should come as no surprise to anyone that many astronauts had a wild, devil-may-care side to their personalities, the alter ego of the professional who faces danger and death in his or her daily work.[114]

Project Mercury had been formally established just after the birth of NASA in 1958 and completed in a little less than five years at a cost of $384 million. It

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110. James C. Webb, NASA Administrator, Memorandum for the President, 14 September 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

111. On the creation of this center see Henry C. Dethloff, *"Suddenly Tomorrow Came . . .": A History of the Johnson Space Center* (Washington, DC: NASA SP-4307, 1993).

112. *Space News Roundup* (Houston, TX), 11 July 1962.

113. Quoted in James Schefter, *The Race: The Uncensored Story of How America Beat Russia to the Moon* (Garden City, NY: Doubleday and Co., 1999), p. 72. LBJ also had great confidence in Grissom. See Lyndon B. Johnson to Gus Grissom, 21 July 1961, LBJ Papers, Vice Presidential Papers, box 116, January–July 1961, Space and Aero File, LBJ Library, University of Texas, Austin, Texas.

114. See Guenter Wendt and Russell Still, *The Unbroken Chain* (Burlington, Ontario, Canada: Apogee Books, an imprint of Collector's Guide Publishing Ltd., 2001).

may have been the best bargain ever in human spaceflight, in no small measure because its goals were so simple. Although lagging behind the original schedule, it had succeeded in proving the possibility of safe human space exploration and in demonstrating to the world U.S. technological competence during the Cold War rivalry with the Soviet Union. At the conclusion of the Mercury effort, Walter C. Williams noted that "in the period of about 45 months of activity, some 25 flights were made which was an activity of a major flight in something less than every 2 months." He then commented on what NASA learned in the context of completing Mercury:

> I think we learned . . . a lot about spacecraft technology and how a spacecraft should be built, what its systems should be, how they should perform, where the critical redundancies are that are required. I think we learned something about man-rating boosters, how to take a weapons system development and turn it into a manned transportation system. I think, in this area, we found primarily, in a nutshell, that this was a matter of providing a malfunction detection system or an abort system, and, also, we found very careful attention to detail as far as quality control was concerned. I think that some of the less obvious things we learned—we learned how to plan these missions and this takes a lot of detail work, because it's not only planning how it goes, but how it doesn't go, and the abort cases and the emergency cases always took a lot more effort than the planned missions. . . . We learned what is important in training crews for missions of this type. When the crew-training program was laid down, the program had to cover the entire gamut because we weren't quite sure exactly what these people needed to carry out the missions. I think we have a much better focus on this now. We learned how to control these flights in real time. This was a new concept on a worldwide basis. I think we learned, and when I say we, I'm talking of this as a National asset, not NASA alone, we learned how to operate the world network in real time and keep it up. And I think we learned a lot in how to manage development programs of this kind and to manage operations of this kind (I-47).[115]

As Christopher C. Kraft, senior flight controller, concluded, Mercury "changed quite a few concepts about space, added greatly to our knowledge of the universe around us, and demonstrated that Man has a proper role in exploring it. There are many unknowns that lie ahead, but we are reassured because we are confident in overcoming them by using Man's capabilities to the fullest" (I-48).[116]

115. Dr. Walter C. Williams, Deputy Director, NASA Manned Spacecraft Center, NASA, "Project Review," 3 October 1963. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

116. Christopher C. Kraft, Jr., "A Review of Knowledge Acquired from the First Manned Satellite Program." Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

Bridging the Technology Gap: Project Gemini

Even as the Mercury program was underway and Apollo hardware was beginning development, NASA program managers recognized that there was a huge gap in the capability for human spaceflight between that acquired with Mercury and what would be required for a lunar landing. They closed most of the gap by experimenting and training on the ground, but some issues required experience in space. Several major areas immediately arose where this was the case. These included the following major mission requirements, as defined in the Gemini crew familiarization manual:

A. Accomplish 14-day Earth orbital flights, thus validating that humans could survive a journey to the Moon and back to Earth.
B. Demonstrate rendezvous and docking in Earth orbit.
C. Provide for controlled land landing as the primary recovery mode.
D. Develop simplified countdown techniques to aid rendezvous missions (lessens criticality of launch window).
E. Determine man's capabilities in space during extended missions (I-52).[117]

These major initiatives defined the Gemini program and its 10 human spaceflight missions conducted in the 1965 to 1966 period.[118]

NASA conceived of Project Gemini first as a larger Mercury "Mark II" capsule, but soon it became a totally different vehicle. It could accommodate two astronauts for extended flights of more than two weeks. It pioneered the use of fuel cells instead of batteries to power the ship, and it incorporated a series of modifications to hardware. Its designers also toyed with the possibility of using a paraglider being developed at Langley Research Center for land landings instead of a "splashdown" in water and recovery by the Navy.[119] The whole system was to be powered by the newly developed Titan II launch vehicle, another ballistic missile developed for the Air Force. A central reason for this program was to perfect techniques for rendezvous and docking, so NASA appropriated from the military some Agena rocket upper stages and fitted them with docking adapters to serve as the targets for rendezvous operations.

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117. NASA Flight Crew Operations Division, "Gemini Familiarization Package," 3 August 1962. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

118. The standard work on Project Gemini is Barton C. Hacker and James M. Grimwood, *On Shoulders of Titans: A History of Project Gemini* (Washington, DC: NASA SP-4203, 1977). See also David M. Harland, *How NASA Learned To Fly in Space: An Exciting Account of the Gemini Missions* (Burlington, ON, Canada: Apogee Books, 2004).

119. Barton C. Hacker, "The Idea of Rendezvous: From Space Station to Orbital Operations, in Space-Travel Thought, 1895–1951," *Technology and Culture* 15 (July 1974): pp. 373–388; Barton C. Hacker, "The Genesis of Project Apollo: The Idea of Rendezvous, 1929–1961," *Actes 10: Historic des techniques* (Paris: Congress of the History of Science, 1971), pp. 41–46; Barton C. Hacker and James M. Grimwood, *On Shoulders of Titans: A History of Project Gemini* (Washington, DC: NASA SP-4203, 1977), pp. 1–26.

The Gemini program emerged full-blown in October 1961 from a working group of NASA and McDonnell engineers. They developed a detailed project development plan that incorporated the following philosophy as central to the effort (I-49):

> In general, the philosophy used in the conception of this project is to make maximum use of available hardware, basically developed for other programs, modified to meet the needs of this project. In this way, requirements for hardware development and qualification are minimized and timely implementation of the project is assured.
>
> Another fundamental concept is that in the design of the spacecraft, all systems will be modularized and made independent of each other as much as possible. In this way, an evolutionary process of product improvement and mission adaptation may be implemented with a minimum of time and effort. Thus, it will be possible to use equipment of varying degrees of sophistication as it becomes available and as the mission requirements are tightened. It is important that a minimum of lead time can be obtained by making use of the latest hardware developments. This concept will make possible the attainment of mission and permits reasonable compromises to be made in the face of difficulties rather than excessive delays that otherwise might be required to meet the full objectives.
>
> This project will provide a versatile spacecraft/booster combination which will be capable of performing a variety of missions. It will be a fitting vehicle for conducting further experiments rather than be the object of experiments. For instance, the rendezvous techniques developed for the spacecraft might allow its use as a vehicle for resupply or inspection of orbiting laboratories or space stations, orbital rescue, personnel transfer, and spacecraft repair.[120]

It took only a little longer for the Gemini name to be attached to the program; by early January 1962 the new program received its official moniker, chosen because of its reference to classical mythology and the "twins," which D. Brainerd Holmes, NASA's Director of Manned Spaceflight, thought most appropriate for the two-person spacecraft. Associate Administrator Robert Seamans presented a bottle of Scotch whiskey to the first person to suggest Gemini as the project's name, engineer Al Nagy (I-50, I-51).[121]

The Gemini spacecraft was a marked improvement on the Mercury capsule. It was 19 feet long (5.8 meters), 10 feet (3 meters) in diameter, and weighed about

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120. NASA Manned Spacecraft Center, "Project Development Plan for Rendezvous Development Utilizing the Mark II Two Man Spacecraft," 8 December 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

121. Al Nagy, NASA, to George Low, NASA, 11 December 1961; D. Brainerd Holmes, NASA Director of Manned Spaceflight Programs, Memorandum for NASA Associate Administrator, "Naming Mercury-Mark II Project," 16 December 1961; D. B. Holmes, Director of Manned Spaceflight, NASA, Memorandum for the Associate Administrator, NASA, "Naming the Mercury Mark II Program," 2 January 1961. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

8,400 pounds (3,810 kilograms)—twice the weight of Mercury. But it had only 50 percent more cabin space for twice as many people, and was extremely cramped for the long-duration missions envisioned. Ejection seats replaced Mercury's escape rocket and more storage space was added for the longer Gemini flights. The long-duration missions also used fuel cells instead of batteries for generating electrical power, an enormously significant development in the methodology of generating power for the spacecraft.[122] An adapter module fitted to the rear of the capsule (and jettisoned before reentry) carried on-board oxygen, fuel, and other consumable supplies. Engineering changes, such as systems that could be removed and replaced easily, simplified maintenance. Since extra-vehicular activities (EVAs) were an essential part of these missions, the spacesuit became a crucial piece of equipment, the suit providing the only protection for astronauts in the extremely hostile environment of space.[123] By January 1964, NASA had developed a preliminary plan for one astronaut to conduct an EVA at some point during Gemini (I-53). To make EVAs possible, NASA redesigned the Gemini's mechanical hatch to permit astronauts to leave the spacecraft in orbit. As early as July 1964, Gemini Deputy Manager Kenneth Kleinknecht suggested that NASA might attempt an EVA during Gemini IV, but some were opposed to doing this on the second crewed mission of the program, and astronauts James McDivitt and Edward White, the primary crew for Gemini IV, had to lobby to make it a reality the next year. The demonstration of the EVA proved to be one of the huge successes, both from a public relations and a knowledge-advancement viewpoint, of the whole Gemini program.[124]

Problems with the Gemini program abounded from the start. The Titan II had longitudinal oscillations called the "pogo" effect because it resembled the behavior of a child on a pogo stick. Overcoming this problem required engineering imagination and long hours of overtime to stabilize fuel flow and maintain vehicle control. The fuel cells leaked and had to be redesigned, and the Agena reconfiguration also suffered costly delays. NASA engineers never did get the paraglider to work properly and eventually dropped it from the program in favor of a parachute system and ocean recovery, similar to the approach used for Mercury. All of these difficulties increased an estimated $350 million program cost to over $1 billion. The overruns were successfully justified by the Agency, however, as necessities to meet the Apollo landing commitment.[125]

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122. Linda Carrette, K. Andreas Friedrich, and Ulrich Stimming, "Fuel Cells: Principles, Types, Fuels, and Applications," *ChemPhysChem* 1 (2000): pp. 162–193; Brian Cook, *An Introduction to Fuel Cells and Hydrogen Technology* (Vancouver, British Columbia, Canada: Heliocentris, April 2002), pp. 5–6; M. L. Perry and T. F. Fuller, "A Historical Perspective of Fuel Cell Technology in the 20th Century," *Journal of The Electrochemical Society*, 149 no. 71 (2002): S59-S67.

123. On EVAs and spacesuits, see David S.F. Portree and Robert C. Treviño, *Walking to Olympus: An EVA Chronology* (Washington, DC: Monographs in Aerospace History Series No. 7, 1997); David Shayler, *Walking in Space: Development of Space Walking Techniques* (Chicester, UK: Springer-Praxis, 2003); Gary L. Harris, *The Origins and Technology of the Advanced Extravehicular Space Suit* (San Diego, CA: Univelt, Inc., 2001).

124. Charles W. Mathews, Manager, Gemini Program, "Program Plan for Gemini Extravehicular Operation," 31 January 1964. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

125. James M. Grimwood and Ivan D. Ertal, "Project Gemini," *Southwestern Historical Quarterly*,

By the end of 1963, most of the difficulties with Gemini had been resolved, albeit at great expense, and the program was approaching its first test flights. As they took place, NASA officials considered the possibility of reconfiguring the Gemini spacecraft for a circumlunar mission in the 1966 time frame. With continued pressures from the Soviet Union, examining the possibility of an early circumlunar flight as a contingency for the future appeared appropriate. The initial review in the spring of 1964 showed promise and Edward Z. Gray, Director of NASA's Advanced Manned Missions Program, recommended: "I believe that a study should be initiated to more thoroughly investigate the Gemini circumlunar mode, utilizing the Saturn IB with a Centaur as the injection stage, in either a direct ascent or an Earth orbit rendezvous trajectory. . . . The purpose of such a study would be to more accurately determine the capability of each configuration, the key technical problems, relative costs, development schedules and key decisions points to provide a basis for possible contingency-type decisions in the 1965–66 time period" (I-54).[126]

Further study the next year yielded a decision not to pursue this option. Eldon Hall, Director of Gemini Systems Engineering, commented:

> I think the proposal is feasible, but not within the time and effort indicated. The equipment and mission are too marginal to absorb changes and additions that will be required without extensive redesign and testing. . . . I personally would prefer to see us advance our Earth orbital capability. With the same or fewer modifications to the spacecraft advocated in this proposal and additional Agena payloads, we could attain a significant lead in the design and operation of Earth-orbital space stations (I-55).[127]

In his typically convoluted "adminispeak" style, NASA Administrator James E. Webb communicated this perspective to Representative Olin E. Teague (D-Texas) in September 1965, adding, "I do not believe a decision not to make the substantial investment that would be required by a modified Gemini lunar fly-by will change the posture which our program has had for a number of years" (I-56).[128]

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81 (January 1968): pp. 393–418; James M. Grimwood, Barton C. Hacker, and Peter J. Vorzimmer, *Project Gemini Technology and Operations* (Washington, DC: NASA SP-4002, 1969); Robert N. Lindley, "Discussing Gemini: A 'Flight' Interview with Robert Lindley of McDonnell," *Flight International*, 24 (March 1966): pp. 488–489.

126. Edward Z. Gray, Director, Advanced Manned Missions Program, Office of Manned Spaceflight, NASA, to Director, Gemini Program, NASA, "Gemini Lunar Mission Studies," 30 April 1964. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

127. Eldon. W Hall, Director, Gemini Systems Engineering, NASA, to Deputy Director, Gemini Program, NASA, "Circumlunar Missions," 29 June 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

128. James E. Webb, NASA Administrator, to Olin E. Teague, Chairman, Subcommittee on NASA Oversight, Committee on Science and Astronautics, House of Representatives, 10 September 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

At the same time, confident that Gemini's major technological challenges were being overcome, NASA moved out on mission planning for the human-piloted portion of the program. LeRoy E. Day, the Gemini Program's Deputy Director, outlined the missions in a 25 June 1964 memorandum:

> Flights 4, 5, and 7 will provide experience in long duration orbital flight . . . Many measurements and experiments will be performed to assess the effects of orbital weightless flight on man and machine for periods up to 14 days—more than adequate for the Apollo lunar expedition. Among the medical experiments, for example; M-1, Cardiovascular Reflex, will determine the feasibility of using inflatable cuffs to prevent cardiovascular deterioration—evidence of which was noted in Project Mercury flights MA-8 and MA-9. . . . In addition to these experiments, we also plan to conduct extravehicular activity to evaluate man's performance outside the spacecraft.
>
> With Flight No. 6, we will establish the feasibility of rendezvous and provide experience for the visual manual docking mode, which is common to both Gemini and Apollo . . . Whereas radar computer guidance will be the primary onboard mode for the terminal rendezvous phase of Flight No. 6; the radar optical and optical guidance modes will be primary for Flights 8 and 9 respectively.
>
> By Flights 10 and 11, or earlier, we plan to flight test the feasibility of the LEM lunar orbit direct rendezvous mode in Earth orbit if possible. In this mode, the catch up or parking orbits are essentially by-passed and terminal rendezvous is initiated near first apogee. . .
>
> For Flight No. 12, we plan to simulate LEM abort maneuvers; either abort from an equiperiod transfer orbit (I-57).[129]

Eldon Hall followed in July 1964 with another set of mission profiles that offered not only the already agreed-upon Gemini mission objectives, but also such proposals as tests of propellant transfer, rendezvous with an empty Apollo Command Module, rendezvous with a Lunar Module, using Gemini as a minimum space station, a joint NASA/Air Force Manned Orbiting Laboratory (MOL) using Gemini spacecraft, satellite recovery on-orbit, and a one-astronaut Gemini mission with a telescope mounted in the other seat of the spacecraft. Of course, these missions did not come to pass (I-58).[130]

129. L. E. Day, Deputy Director, Gemini Program, NASA, Memorandum for William C. Schneider, Deputy Director, Apollo Program, NASA, "Gemini Support of Apollo," 25 June 1964. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

130. John L. Hammersmith, Director, Gemini Systems Engineering, NASA, Memorandum for Deputy Director, Gemini Program, NASA, "List of Missions," 17 July 1964. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

Flying the Gemini Missions

Following two unoccupied orbital test flights, Gemini III, the first crew-carrying mission, took place on 23 March 1965; it was a three-orbit flight. (The mission was originally designated GT-3, for Gemini/Titan-3.) Mercury astronaut Gus Grissom commanded the mission, with John W. Young, a Naval aviator chosen as an astronaut in 1962, accompanying him. This mission proved to be a huge success for many reasons, serving "to flight qualify the crew-spacecraft combination as well as checkout the operational procedures." The system performed essentially as intended, although there were a few glitches in the technology that Mission Control and the astronauts aboard resolved satisfactorily. During this mission, as James Webb wrote to the President, "the two-man crew maneuvered their craft in orbit preparing the way for the rendezvous missions to follow. GT-3 also initiated the use of the Gemini spacecraft as an orbiting laboratory. Astronauts Grissom and Young also executed the first manned, controlled, lifting reentry" (I-66).[131]

Despite the success of Gemini III, or perhaps because of it, the White House became concerned about the possibility of losing a crew in Earth orbit during a future mission and questioned NASA and the DOD about plans for space rescue should they be stranded in orbit (I-59).[132] Both responded with analyses of the extremely low possibility of losing a crew because they were stranded in orbit, as well as by acknowledging the extremely risky nature of spaceflight. As Cyrus Vance told Bill Moyers, "It is possible we may strand an astronaut in orbit some day. It is very likely that astronauts will be killed, though stranding them is one of the less likely ways. The nation must expect such a loss of life in the space program. There have been several deaths already in our rocket development. We would be untruthful if we were to present any different image to our citizens" (I-60).[133] James Webb opined to President Lyndon B. Johnson, again in a masterpiece of indirect syntax, that:

> . . . in Gemini, we are building on all of the measures for safety that have come from our extensive experience in test flying and such advanced systems as the X-15—the measures which have also been instrumental in achieving our perfect record of astronaut safety thus far. The redundancy designed into the retro-system for return from orbit is optimized

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131. James E. Webb, Administrator, NASA, Cabinet Report for the President, "Significance of GT-3, GT-4 Accomplishments," 17 June 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

132. E.C. Welsh, National Aeronautics and Space Council, Executive Office of the President, Memorandum for the President, "Space Rescue," 21 May 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

133. Bill Moyers, Special Assistant to the President, The White House, Memorandum for James Webb, Administrator, NASA, and Robert McNamara, Secretary of Defense, 29 May 1965, with attached; Joseph A. Califano, Jr., Special Assistant to the Secretary and Deputy Secretary of Defense, Memorandum for Mr. Valenti/Mr. Busby, Special Assistants to the President, 29 May 1965, with attached; Cyrus Vance, Office of the Secretary of Defense, Memorandum for Mr. Bill Moyers, The White House, "Comments on Need for Space Rescue," 29 May 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

> for crew safety. The orbital parameters of the next Gemini mission are planned so that the orbit will decay to reentry within 24 hours after the planned termination of the flight, should all other provisions for initiating the de-orbiting landing sequence fail. . . . It is our judgment that the knowledge needed to begin the design of such a space rescue system is not yet available, but will come from our present developmental and flight program. You may be assured, Mr. President, that we shall continue to give first priority to considerations of astronaut safety (I-61).[134]

NASA has tended to follow this approach to crew safety to the present, relying on the development of the best possible technologies and processes to ensure safety and reliability rather than some type of space rescue capability. It also developed procedures in dealing with the necessity of informing the public about possible accidents and loss of astronauts, should that eventuality occur (I-71).[135]

Also in the aftermath of the successful Gemini III mission, NASA began planning how to honor the astronauts after their flights. For the Mercury program there had been considerable pomp and circumstances, usually involving medals awarded by the President and ticker-tape parades. But Gemini was different, argued Julian Scheer, NASA's Director of Public Affairs. "We are now entering a new phase of our program," he wrote. "The image that is, perhaps, best for this nation is that of a nation with this capability, a nation that goes about its work in an orderly and well-planned manner. We will fly these flights as best we can and put these flyers right back into the flight schedule for a future mission" (I-62, I-63).[136] Because of this desire to "routinize" spaceflight and in the process downplay the heroism of the astronauts, except in truly exceptional circumstances, the aftermath of the Gemini missions was more restrained than in Project Mercury. The Gemini III crew did visit the White House and received medals from President Johnson. In the case of the Gemini IV crew, President Johnson came to Houston to congratulate them and NASA Administrator James Webb sent them, at the request of the President, to the Paris International Air Show, where they met Soviet Cosmonaut Yuri Gagarin. Later missions were less pronounced in their public relations hoopla.[137]

Based on the success of Gemini III, NASA accelerated plans to fly the next mission, a 66-revolution, 4-day mission that began on 3 June and ended on 7 June

134. James E. Webb, Administrator, NASA, Memorandum to the President, "Space Rescue," 2 June 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

135. NASA, "Gemini Contingency Information Plan," 11 May 1966. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

136. Julian Scheer, Assistant Administrator for Public Affairs, NASA, Memorandum to Mr. Marvin Watson, The White House, 24 May 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

137. Marvin Watson, The White House, Memorandum for the President, 25 May 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC. On the "routinization" of power see Eric Hoffer, *The True Believer: Thoughts on the Nature of Mass Movements* (New York: Harper & Row, 1951), pp. 3–23, 137–155; Max Weber, "The Pure Types of Legitimate Authority," in *Max Weber on Charisma and Institution Building: Selected Papers*, S. N. Eisenstadt, ed. (Chicago: University of Chicago Press, 1968), p. 46.

1965 (I-67).[138] During that mission astronaut Edward H. White performed the first American EVA. During his 20 minutes outside Gemini IV, White remained connected to the spacecraft's life-support and communications systems by an "umbilical cord," and he used a hand-held jet thruster to maneuver in space. McDivitt remained inside the spacecraft during this event.[139] Although it turned out well, NASA leaders had debated intensely among themselves whether or not to allow the EVA on this mission. Those in favor emphasized the necessity of developing an EVA capability for the Apollo Moon landings and the necessity of haste because of the success of the Soviet efforts in space, including the first EVA by anyone, accomplished by Cosmonaut Alexey Leonov three months before the Gemini IV mission. Those opposed, who included NASA Deputy Administrator Hugh L. Dryden, argued that the EVA was premature, that it was risky, and that it looked like a direct response to Leonov's earlier spacewalk.

At a 24 May 1965 showdown at NASA Headquarters, Dryden raised the issue of "the element of risk to complete the 4-day Gemini flight because of EVA." The reply was that the added risk was simply having to depressurize the spacecraft, open the hatch, seal the hatch, and repressurize the spacecraft. This was not an insignificant set of concerns, Dryden countered. As the memorandum of the meeting recorded: "There was a strong feeling to ratify EVA for Gemini 4 in order to get the maximum out of the flight. There was unanimity in that EVA eventually would be carried out, but there was some reservation as to whether or not it was the best judgment to have EVA on Gemini 4 as a risk beyond that which has to be taken." Dryden, who was dying of cancer at the time and worked until his death on 2 December 1965, perhaps felt more keenly than others in the debate the weight of mortality and reflected this in his concern for the safety of the astronauts. No one could fault him for that concern, and everyone recognized the crew safety issue, but that had to be balanced against other factors that tipped the scales in favor of success. Calculating the risk and accepting the unknowns soon led NASA leaders to approve the EVA on Gemini IV. Since it turned out well, they looked like geniuses. Had it gone otherwise, they would have become scapegoats (I-64, I-65).[140] As James Webb wrote to the President: "It is significant that the first operational flight of Gemini, GT-4, has provided significant experience in each of the major mission areas of Gemini: long duration flight, rendezvous and docking, extra vehicular activity, and the conduct of experiments" (I-66).[141]

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138. NASA Program Gemini Working Paper No. 5038, "GT-4 Flight Crew Debriefing Transcript," n.d. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

139. Reginald M. Machell, ed., *Summary of Gemini Extravehicular Activity* (Washington, DC: NASA SP-149, 1968).

140. Robert C. Seamans, Jr., Associate Administrator, NASA, to The Administrator, "Extra Vehicular Activity for Gemini IV," 24 May 1965; W. Vogel, Executive Officer, Memorandum for the Record, "Top Management Meeting on Gemini 4 Extra-Vehicular Activity," 8 June 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

141. James E. Webb, Administrator, NASA, Cabinet Report for the President, "Significance of GT-3, GT-4 Accomplishments," 17 June 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

Eight more Gemini missions followed through November 1966. Despite problems great and small encountered on virtually all of them, the program achieved its goals. This especially was the case in the development of rendezvous and docking procedures necessary for the successful accomplishment of the lunar landing commitment. For example, Buzz Aldrin, selected in the third group of NASA astronauts in 1963, had a unique impact in this area, given his Ph.D. in astronautics from the Massachusetts Institute of Technology. Aldrin had written his dissertation on orbital rendezvous and he applied this knowledge to solving one of the principal riddles of the Gemini program: how to accomplish rendezvous and docking of two spacecraft in Earth orbit.[142] Acquiring the nickname "Dr. Rendezvous" from his fellow astronauts, Aldrin worked more than the others to develop the orbital maneuvers essential to the program's success. During Project Gemini, Aldrin became one of the key figures working on the problem of spacecraft rendezvous and docking in Earth or lunar orbit. Without solutions to such problems, Apollo could not have been successfully completed. Rendezvous techniques remained largely in the realm of theory until Aldrin began to work on the problem. In 1963 and 1964, Aldrin worked hard to convince flight operations leaders that a concentric rendezvous would work. In his estimation, a target vehicle could be launched in a circular orbit with the rendezvousing spacecraft in a closer orbit to Earth. It would then take less time to circle the globe, he argued, and then catch up for rendezvous. Aldrin and others worked together to develop the trajectories and maneuvers that would allow the spacecraft to intercept a target vehicle.[143]

Moreover, Aldrin argued that a closed-loop concept that relied more on machines than on astronauts could easily spell failure. Ground controllers wanted to use radar and computers to guide the two spacecraft together from the ground, making rendezvous essentially automatic. Should either the equipment or procedures fail, however, the mission would be lost. Aldrin argued for the astronauts as active participants in the process, even more involved than taking action should the equipment malfunction.[144]

Systematically and laboriously, Aldrin worked to develop procedures and tools necessary to accomplish space rendezvous and docking. He was also central in devising the methods necessary to carry out the astronauts' EVA. That, too, was critical to the successful accomplishment of Apollo. Techniques he devised have been used on all space rendezvous and docking flights since. Aldrin also significantly improved operational techniques for astronautical navigation star displays for these missions. He and a critical ally, Dean F. Grimm from the Manned Spacecraft Center's (MSC) Flight Crew Support Division, convinced their supe-

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142. See Edwin E. Aldrin Jr., "Line of Sight Guidance Techniques for Men in Orbital Rendezvous," Ph.D. Diss., Massachusetts Institute of Technology, 1964. Later Aldrin legally changed his first name to "Buzz."

143. Hacker and Grimwood, *On Shoulders of Titans*, pp. 266–268.

144. "Preflight Training Plan for Fourth Manned Gemini Flight Crew (GTA-6)," NASA Program Gemini working paper No. 5031, 23 August 1965. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; Hacker and Grimwood, *On the Shoulders of Titans*, p. 267.

riors at MSC and McDonnell Aircraft to build a simulator to test this possibility. They explored how astronauts responded to various situations with maneuvers leading to target interception. Astronauts mastered procedures for overcoming the failure of any one piece of equipment, and soon convinced everyone that the astronaut as active participant was critical to successful rendezvous and docking of the Gemini systems.[145]

What emerged was a combination system that relied on automated systems to get the Gemini spacecraft close enough to the target vehicle so that the crew could complete the rendezvous and docking process using the control handles, observing the pilot displays, and observing the optical targets through windows in the spacecraft. At some point in the approach, typically at about 60 meters separation, the rendezvous radar could no longer give an accurate estimate of range because of the closeness of the target. Then, visual observations of the docking targets by the crew were heavily relied upon. This approach worked flawlessly throughout the Gemini program. In all, Gemini astronauts completed successful rendezvous and dockings on Gemini VIII in March 1996, Gemini X in July 1966, Gemini XI in September 1966, and Gemini XII in November 1996.[146]

The first test of rendezvous in space occurred on the twin flights of Gemini VI and VII in December 1965. Gemini VI was initially intended to rendezvous with an Agena target spacecraft, but when the Agena failed during launch the mission was hastily modified to rendezvous with a piloted spacecraft (I-68). Consequently, Gemini VII, piloted by Frank Borman and James Lovell, was launched first on 4 December 1965 to become the rendezvous target for Gemini VI. When Gemini VI was launched on 15 December, piloted by Walter Schirra and Thomas Stafford, the two spacecraft rendezvoused and flew in formation for 5 hours. Their first test of rendezvous had been successful and proved the concept of human involvement in space rendezvous. Gemini VII remained aloft for 14 days to study the effects of long-duration flight. The 330 hours in space had no long-term harmful effects on the crew, but the flight turned into something of an endurance test for the two pilots, confined in their hot, cramped quarters. At the conclusion of the lengthy time cooped up together, Lovell joked to reporters that he and Borman were happy to announce their engagement. It was astronaut humor that said quite a lot about the masculine culture of the fliers (I-69).[147]

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145. Buzz Aldrin, "Apollo and Beyond," in Stephen J. Garber, ed., *Looking Backward, Looking Forward: Forty Years of Human Spaceflight Symposium* (Washington, DC: NASA SP-2002-4107, 2002), pp. 91–99; Roger D. Launius, *Frontiers of Space Exploration,* 2nd ed. (Westport, CT: Greenwood Press, 2004), pp. 83–84.

146. V. E. Jones, and J. E. Mangelsdorf, "Preliminary Rendezvous Experiments Definition and Design," Lockheed Missiles & Space Company, Sunnyvale, CA, p. 4-1; D. Chiarrappa, "Analysis and Design of Space Vehicle Flight Control Systems, Volume VIII—Rendezvous and Docking," NASA CR-827, prepared by General Dynamics Corp., San Diego, CA, for the NASA-Marshall Space Flight Center, Alabama, July 1967, p. 31; *NASA Pocket Statistics, 1997 Edition* (Washington, DC: NASA Headquarters Facilities and Logistics Management, 1998), pp. B-100–B-102.

147. "Summary of Telephone Conversations RE Gemini 7/6," 25–27 October 1965; "Gemini Program Mission Report, Gemini VI-A," January 1966. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; J. H. Latimer, "Observation of Gemini 6-GEMINI 7 Rendezvous," SAO Special Report #202 (Cambridge, MA: Smithsonian Astrophysical Observatory, 1966); J. R. Burton, "Rendezvous With the Gemini Spacecraft," *Proceedings*

It was perhaps the flight of Gemini VIII in the spring of 1966 that demonstrated more clearly than any other mission the capability of the program to accomplish rendezvous and docking in orbit. Gemini VIII had two major objectives, but was able to complete only one of them. The first objective involved completing the first ever on-orbit rendezvous and docking. Second, the crew was to accomplish an extended EVA. After launch on 16 March 1966, the crew of Neil Armstrong and David Scott approached their Agena target vehicle without difficulty. The crew then docked with it as had been planned. While undertaking maneuvers when attached to the Agena, the crew of Gemini VIII noticed that for some unexplained reason the spacecraft was in a roll. Armstrong used the Gemini's orbital maneuvering system to stop the roll, but the moment he stopped using the thrusters, it started again. They then turned off the Agena and this seemed to stop the problem for a few minutes. Then suddenly it started again. Scott then realized that the problem was with the Gemini capsule rather than the Agena. After transferring control of the Agena back to the ground, they undocked and with a long burst of translation thrusters moved away from the Agena. At that point, Gemini VIII began to roll about one revolution per second. They decided to turn off the orbital maneuvering system and try to regain control of the spacecraft with its reentry control system. If they failed to do so the accelerating rotation would eventually cause the crew to black out and for the mission to the lost, perhaps with loss of life. Even so, the use of the reentry control system would require Armstrong and Scott to return to Earth as soon as possible so as not endanger the mission any further. After steadying the spacecraft they tested each thruster in turn and found that Number 8 had stuck on. This had caused the roll. The mission then returned to Earth one orbit later so that it could land in a place that could be reached by the Navy.

There was no question that astronauts Armstrong and Scott had salvaged the mission, even if they did have to return to Earth earlier than expected. A review of the incident found no conclusive reason for the thruster sticking as it did. But it was obvious that the crew's presence allowed the diagnosis of the anomaly. Reviewers believed it was probably caused by an electrical short that caused a static electricity discharge. Even if the switch to the thruster was off, power could still flow to it. To prevent reoccurrence of this problem, NASA changed the system so that each thruster could be isolated (I-70).[148]

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of the Symposium on Space Rendezvous, Rescue, and Recovery, Volume 16, Part 2, American Astronautical Society, Edwards Air Force Base, CA, 10–12 September 1963, pp. 173–176.

148. "Gemini VIII Technical Debriefing," 21 March 1966. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; S.R. Mohler, A.E. Nicogossian, P.D. McCormack, and S.R. Mohler Jr., "Tumbling and Spaceflight: The Gemini VIII Experience," *Aviation and Space Environmental Medicine* 61 (January 1990): pp. 62–66; Bo J. Naasz, "Classical Element Feedback Control for Spacecraft Orbital Maneuvers," M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, 2002, pp. 1–2; M. E. Polites, *An Assessment of the Technology of Automated Rendezvous and Capture in Space* (Huntsville, AL: NASA/TP—1998–208528, 1998), pp. 3–9; H. J. Ballard, "Agena Target Vehicle for Gemini," *Proceedings of the Symposium on Space Rendezvous, Rescue, and Recovery*, Volume 16, Part 2, American Astronautical Society, Edwards Air Force Base, CA, 10–12 September 1963, pp. 177–187.

Conclusion

By the end of the Gemini program in the fall of 1966, orbital rendezvous and docking had become routine: astronauts could perform spacewalks; it seemed clear that humans could live, work, and stay healthy in space for several weeks at a time. Above all, the program had added nearly 1,000 hours of valuable spaceflight experience in the years between Mercury and Apollo, which by 1966 was nearing flight readiness. In every instance, NASA had enhanced the role of the astronauts as critical fliers of spacecraft, a role that would become even more significant in the accomplishment of the Moon landings between 1969 and 1972. Additionally, as a technological learning program, Gemini had been a success with 52 different experiments performed on the 10 missions. The bank of data acquired from Gemini helped to bridge the gap between Mercury and what would be required to complete Apollo within the time constraints directed by the President (I-72, I-73).[149]

149 Robert C. Seamans, Jr., Deputy Administrator, NASA, Memorandum for Associate Administrators, Assistant Associate Administrators, and Field Center Directors, NASA, "Gemini Program; Record of Accomplishments, Attached," 17 January 1967, with attached: "Project Gemini Summary"; George E. Mueller, Associate Administrator for Manned Space Flight, NASA, "Gemini Summary Conference," 1–2 February 1967. Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC; *Gemini Summary Conference* (Washington, DC: NASA SP-138, 1967); Linda Ezell, *NASA Historical Data Book, Vol. II*, pp. 149–170.