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Realizing the Dream of Flight

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Godfather to the Astronauts

Robert Gilruth and the Birth of Human Spaceflight

ROGER LAUNIUS

ROBERT R. GILRUTH WAS A LONGTIME NACA ENGINEER WORKING AT THE LANGLEY AERONAUTICAL LABORATORY WHEN HE BECAME ITS GURU OF SPACEFLIGHT. He had been Chief of Langley's Pilotless Aircraft Research Division from 1946 to 1952, developing the technologies necessary for reaching space, and his Space Task Group at Langley had been exploring the possibility of human spaceflight even before NASA was created in 1958. Because of this, he became the head of Project Mercury from 1959 to 1963 and served as the first Director of the Manned Spacecraft Center in Houston, Texas, retiring in 1972 after the successful completion of Project Apollo.

Gilruth, perhaps more than any other NASA official, served as the godfather of human spaceflight in the United States. Under his direction, NASA successfully completed Projects Mercury, Gemini, and Apollo. His organization recruited, trained, and oversaw the astronauts and the human spaceflight program throughout the heroic age of spaceflight. Yet, his name is much less well known than many others associated with these projects. He was a contemporary on a par with Wernher von Braun and a host of other NASA officials, and he certainly contributed as much to human spaceflight as any of them, yet his name is rarely invoked as a key person. He is a representative of the engineering entrepreneur, a developer and manager of complex technological and organizational systems, accomplishing remarkably difficult tasks through excellent oversight of the technical, fiscal, cultural, and social reins of the effort. Johnson Space Center Director George W. S. Abbey appropriately commented at the time of his death in 2000, "Robert Gilruth was a true pioneer in every sense of the word and the father of human spaceflight. His vision, energy, and dedication helped define the American space program. His leadership turned the fledgling Manned Spacecraft Center into what it is today, the leader in humanity's exploration of outer space."[1] This essay discusses the career of Robert Gilruth as an engineering entrepreneur who oversaw the vast human spaceflight effort for NASA during the "glory days" of the 1960s.

A MIDWESTERN CHILDHOOD

Robert Rowe Gilruth enjoyed a happy, tranquil boyhood in the small town of Nashwauk, Minnesota, a mining town in the Mesabi Range of northern Minnesota. Born on 8 October 1913, Gilruth's parents were both educators of Cornish/Scottish ancestry. His father, Henry Augustus Gilruth, was the Nashwauk superintendent of schools, and his mother, Francis Marian Rowe Gilruth, was an ex-school teacher. Gilruth recalled in an interview in 1986:

> My father was born in Davenport, Iowa, and my mother was born in Bessemer, Michigan. My mother was the daughter of a mining captain. They called them mining captains in those days if they became officials in the mine and had worked their way up from the pit, so to speak. He was born in England, was a Cornishman—you know there are a lot of mines in Cornwall—and he came to America because he heard they needed expert iron geologists. They didn't call them geologists; they called them mining captains. He was a self-educated geologist, and he could tell the men where to dig in order to get the rich iron ore.[2]

Gilruth and his older sister, Jean Marian Gilruth, enjoyed their experience in upper Minnesota.

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1 JSC Press Release J00-49, "Statement By Johnson Space Center Director George W. S. Abbey Marking the Death of Dr. Robert R. Gilruth" (17 August 2000), NASA Headquarters Historical Reference Collection, Washington, DC.

2 Robert Gilruth Oral History Interview (OHI) No. 1 by David DeVorkin and Martin Collins (21 March 1986), Glennan-Webb-Seamans Project, National Air and Space Museum, Washington, DC.

His parents provided Gilruth not only with the necessities of life, but also encouraged his innate curiosity about the world around him. He started to carve wooden models of ships, grew intensely interested in the history and lore of the local Native American tribes, and gained an interest in airplanes and flight while in Nashwauk. At an early age, he began reading magazines such as *American Boy*, which reinforced his interest in making model airplanes from the sketches it carried. He soon moved on to *Popular Mechanics*, with its more advanced articles on model planes. Later he built telescopes to observe the planets and stars. Two constants remained in his life from his earliest years, his love of flight and his deep affection for the sea and sailing. "I've liked boats very much in my lifetime," he recalled, "and I've spent a lot of time building my own sail and power boats, and so on and so forth. I did also have a very good interest in a hydrofoil company with hydrofoil-fitted boats."[3]

Three of the four Apollo 13 flight directors applaud the successful splashdown of the Command Module Odyssey while Dr. Robert R. Gilruth, Director, Manned Spacecraft Center (MSC), and Dr. Christopher C. Kraft, Jr., MSC Deputy Director, light up cigars (upper left). The flight directors are (from left to right): Gerald D. Griffin, Eugene F. Kranz, and Glynn S. Lunney. Photo taken on 17 April 1970. (GRIN database number GPN-2000-001313)

3 Ibid.; and Pearce Wright, "Robert Gilruth: Rocket Engineer Who Put Americans into Space," in the *Guardian* (London, England: 21 August 2000).

As a young boy, Gilruth suffered from chronic bronchitis. He said, "I had missed so much school due to my bronchitis that I had as a younger chap that I just didn't do all that well." He never showed stellar grades in school until he reached the University of Minnesota as a junior in 1933.[4]

As a boy of almost eight years old, Gilruth moved with his family from Nashwauk to Hancock, Michigan, when his father accepted another education position. They did not stay long there, however, as his father ran afoul of the schoolboard over funding allocated to the system. Gilruth recalled:

> Hancock was a poor copper mining town in Michigan, and it was having tough going. The mines were just breaking even, and lots of men were out of work. They mined copper, and they had a refinery there called the Smelts. The copper came out of the ground as native copper. They had to crush the rock away from it and then melt it and put it in ingots. All those industries around there were just barely staying alive. It was hard for the school . . . . He led an effort to get a bond issue for a new school, and that was the end of his career with the Board of Education.[5]

By mutual agreement in 1922, Henry Gilruth left his position in Hancock and moved his family to Duluth, where he worked as a teacher in the local school system.

While in Duluth, about the age of 12, Gilruth entered a model airplane contest sponsored by the local newspaper, the *Duluth News Tribune*, which put the contest details on the front page to generate the greatest interest. "They gave people publicity who did well," Gilruth recalled, "and they got a lot of the boys there in Duluth to become interested in building models." He added, "I cared very little about whether it looked like a World War I airplane or Lindbergh's airplane, although I did build a model of Lindbergh's airplane. I did a little of both. When I made a model of Lindbergh's airplane, then I tried to make it look very much like his airplane." In addition to his model airplane building, Gilruth also built radios and other electronics. Indeed, his interest in things technical took root early and stayed with him throughout his life.[6]

While his parents thought Gilruth could spend his time more productively on other activities, he had caught the aviation bug by the time of Lindbergh's flight and decided to make it his life's work. Reading *American Boy, Popular Science,* and *Popular Mechanics* reinforced this decision.[7] So did reading the *Saturday Evening Post*, where he first heard

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4 Gilruth OHI No. 1 by DeVorkin and Collins.

5 Ibid.

6 Ibid.

7 The importance of these periodicals for aspiring aerospace leaders before the dawn of the space age deserves sustained attention. Many of the first generation of NASA officials confess to reading these publications as children, and an analysis of their influence should be undertaken.

about the National Advisory Committee for Aeronautics (NACA), the government entity with laboratories dedicated to pursing the problems of flight, in the words of Hugh L. Dryden, "to separate the real from the imagined."[8] He sent away to the NACA for information about airfoils, an early research effort of the organization, and Gilruth used this data to help improve his model aircraft.[9]

Gilruth finished high school at Duluth in 1931, a bright but not particularly engaged student. In part because of this, he went to the local Duluth Junior College for two years. He also attended there because it was the height of the Great Depression, and his parents did not have the money to send him to the state university. He pursued his interest in aviation while at the junior college, but he also led the chess club on the campus and became an avid tennis player, both hobbies he pursued the rest of his life. At college he fell under the spell of Lewis A. Rodert, a recent graduate of the University of Minnesota and later a colleague of Gilruth's at the NACA. Gilruth recalled that Rodert "became a fast friend of mine," opening a world of discovery about aeronautics in his "Principles of Flight" course at the junior college. "Rodert was a good teacher," recalled Gilruth. "He was a good disciplinarian. There were only, I think, three of us that were taking the course," so Gilruth received considerable individual attention.[10]

When he transferred to the University of Minnesota for his junior year, his academic career, already taking off, accelerated even more. The university offered one of the few courses of study then available in aeronautical engineering, and Gilruth found a challenging and invigorating niche for his interests.[11] As he prepared for graduation in 1935, he had already decided that he wanted to work for the NACA. He commented, "I continued to take special note of anything I ever read about NACA, and my interest grew to such an extent that the only thing I wanted was to gain my aeronautical degree, hoping that I could then go to work with the group."[12]

With no positions available at the NACA because of the Great Depression, Gilruth decided to pursue graduate education and completed a master of science degree in aeronautical engineering in 1936, writing a thesis on "The Effect of Wing-Tip Propellers on

8 Michael H. Gorn, *Hugh L. Dryden's Career in Aviation and Space* (Washington, DC: NASA Monographs in Aerospace History No. 5, 1996).

9 Edgar S. Gorrell and H. S. Martin, *Aerofoils and Aerofoil Structural Combinations* (NACA Technical Report 13, 1918); Max M. Munk, *General Theory of Thin Wing Sections* (NACA Technical Report 142, 1922); Max M. Munk and Elton W. Miller, *Model Tests with a Systematic Series of 27 Wing Sections at Full Reynolds Number* (NACA Technical Report 221, 1927); and Virginius E. Clark, *Design Your Own Airfoils* (Langley Field, VA: Langley Memorial Aeronautical Laboratory, 1927).

10 Gilruth OHI No. 1 by DeVorkin and Collins; and Glenn E. Bugos, "Lew Rodert, Epistemological Liaison, and Thermal De-Icing at Ames," in *From Engineering Science to Big Science: The NACA and NASA Collier Trophy Research Project Winners*, ed. Pamela E. Mack (Washington, DC: NASA SP-4219, 1998), pp. 29–58.

11 Gilruth OHI No. 1 by DeVorkin and Collins.

12 Shirley Thomas, *Men of Space: Profiles of the Leaders in Space Research, Development, and Exploration,* vol. 4 (Philadelphia, PA: Chilton Company, 1962), p. 48.

the Aerodynamic Characteristics of a Low Aspect Ratio Wing."[13] Working as a graduate assistant at $50 a month, he helped the department chair build a hot air "barrage balloon" that used a ground-power generator to send electricity up a tether where it powered a space heater that kept the air in the balloon hot. The project proved ineffective and ended without a successful test. About this effort Gilruth recalled, "It was a job that I got paid for, so I did the best I could with it, but I certainly didn't think it was a good job to be doing. I was not interested in it. I didn't think it was a good thing for the university to do."[14] More interesting, Gilruth participated in a project with French high-altitude balloonist Jean Piccard, who had recently joined the University of Minnesota's faculty, to make a valve that could ensure constant pressure inside an aircraft's cockpit. Piccard told him that this work was necessary because the higher the aircraft could fly, the greater the possibilities for speed.[15]

Jean Piccard had an important early influence on Gilruth, but one that was more practical and less inspirational than Rodert's. "I learned many things from him," Gilruth commented, "ways of looking at problems. He had a way of simplifying things, in talking about [how components worked]." Gilruth said that he tried to remember how Piccard would break down an engineering problem into the smallest possible components and then tackle each in order, gradually working through an entire issue to achieve a meaningful solution. These might not be the most elegant resolutions of problems, but they worked, and a technical problem solved with a minimum of effort was often better than an elegant resolution requiring considerable expenditure of resources. Piccard practiced a form of KIS (keep it simple) before the name arose. Gilruth came back to it many times in his career as he worked to place Americans first in orbit and then on the Moon.[16]

Gilruth had some unique opportunities while attending graduate school. His advisor, John Akerman, received a contract from air showman Roscoe Turner to undertake technical work on an air racer of Turner's design, later christened the *Laird-Turner Meteor*.[17] Gilruth remarked:

> Roscoe Turner gave a contract to Akerman and Bud Barlow, assistant head of the department, to design this airplane. I think I had an input into just about every part of it. A small staff and I ran the wind tunnel tests, I designed the size of the tail, the wing,

13 Robert R. Gilruth, "The Effect of Wing-Tip Propellers on the Aerodynamic Characteristics of a Low Aspect Ratio Wing," (master's thesis, University of Minnesota, 1936).

14 Gilruth OHI No. 1 by DeVorkin and Collins.

15 David H. DeVorkin, *Race to the Stratosphere: Manned Scientific Ballooning in America* (New York: Springer-Verlag, 1989), pp. 234–246.

16 Gilruth OHI No. 2 by DeVorkin, Collins, and Linda Ezell (14 May 1986).

17 Carroll V. Glines, *Roscoe Turner: Aviation's Master Showman* (Washington, DC: Smithsonian Institution Press, 1995).

> did the stability and control work, and also a fair amount of the structural analysis. So, during the summer of 1935, I got a liberal course in airplane design by actually doing the work, which was invaluable because both Akerman and Barlow are very good aeronautical engineers. What we built was faster than anything else in the skies. I think it went a little over 400 miles an hour, which was at that time the world's speed record.[18]

This aircraft made it possible for Turner to win the National Air Races in 1938 and the Thompson Trophy Race in 1939.[19]

While in graduate school, Gilruth met and married Jean Barnhill, a fellow aeronautical engineering student and pilot who had flown in cross-country races. A friend of Amelia Earhart, Jean Gilruth claimed membership in the flying group she helped found, the 99s. They wed in the Episcopal Cathedral in Washington, DC. It proved a longlasting union, Jean outliving Gilruth. Jean gave up her flying when they had a daughter, but remained interested in aviation the rest of her life.[20]

REACHING THE NACA

Just as Gilruth finished his master of science degree in December 1936, the NACA offered him a position as an aeronautical engineer at its Langley Memorial Aeronautical Laboratory in Hampton, Virginia.[21] The NACA had been established in 1915 to foster aviation in the United States at a time when the nation lagged far behind the technological capabilities of Western Europe. Established via a rider to the Naval Appropriations Act of 1915, Congress established the NACA "to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions."[22] This became an enormously important government research and development organization for the next half of a century, materially enhancing the development of aeronautics. All research projects undertaken by the NACA sought to pursue investigations that promised the compilation of fundamental aeronautical knowledge applicable to all flight, rather than working on a specific type of aircraft design because it smacked of catering to a particular aeronautical firm. Most

18 Thomas, *Men of Space,* p. 49.

19 Roger Huntington, *Thompson Trophy Races* (Osceola, WI: Motorbooks International, 1989).

20 Thomas, *Men of Space,* pp. 49–50.

21 Robert R. Gilruth Bio-Data Sheet (20 August 1970), NASA Headquarters Historical Reference Collection, Washington, DC.

22 From Public Law 271, 63rd Congress (approved 3 March 1915).

NACA research was accomplished "in house" by scientists or engineers on the federal payroll. The results of these activities appeared in more than 16,000 research reports of one type or another, which were distributed widely for the benefit of all. As a result of this work, the NACA received the coveted Robert J. Collier Trophy given annually for "great" achievement in aeronautics and astronautics in America a total of five times between 1929 and 1954.[23]

The NACA's research was conducted in government facilities, and its government scientists and engineers developed a strong technical competence, a commitment to collegial in-house research conducive to engineering innovation, and a definite apolitical perspective. While it never had more than about 8,000 employees and an annual budget of $100 million, the NACA maintained a small Washington Headquarters staff, three major research laboratories—the Langley Aeronautical Laboratory established in 1917, the Ames Aeronautical Laboratory activated near San Francisco in 1939, and the Lewis Flight Propulsion Laboratory built in Cleveland, Ohio in 1940—and two small test facilities at Muroc Dry Lake in the high desert of California and at Wallops Island, Virginia. This organization remained a significant entity until transformed into NASA in 1958.[24]

Gilruth reported to mother Langley, as its employees affectionately called it, in January 1937, newly graduated from the University of Minnesota. As he recalled:

> I reported for duty there, and after getting finger printed and everything like that, I went to see the head of the Aerodynamics Division. There were really three divisions at the NACA at that time. There was the Aerodynamics Division, which is sort of self-explanatory, there was the Wind Tunnel and Flight Research Section and so on, and there was the Hydro Division, which was the towing basin. Then there was the Engine Lab, which was what it says. I was obviously an aeronautical engineer with an aviation background, so I was sent to the Aerodynamics Division.

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23 Alex Roland, *Model Research: The National Advisory Committee for Aeronautics, 1915–1958*, vol. 1 (Washington, DC: NASA SP-4103, 1985). For a discussion of the Collier trophy and the NACA/NASA research projects that received it, see Mack, ed., *From Engineering Science*.

24 On these centers, see Roland, *Model Research*, pp. 283–303; James R. Hansen, *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917–1958* (Washington, DC: NASA SP-4305, 1987); Elizabeth A. Muenger, *Searching the Horizon: A History of Ames Research Center, 1940–1976* (Washington, DC: NASA SP-4304, 1985); Virginia P. Dawson, *Engines and Innovation: Lewis Laboratory and American Propulsion Technology* (Washington, DC: NASA SP-4306, 1991); Richard P. Hallion, *On the Frontier: Flight Research at Dryden, 1946–1981* (Washington, DC: NASA SP-4303, 1984); Lane E. Wallace, *Flights of Discovery: 50 Years at the NASA Dryden Flight Research Center* (Washington, DC: NASA SP-4309, 1996); and Glenn E. Bugos, *Atmosphere of Freedom: Sixty Years at NASA Ames Research Center* (Washington, DC: NASA SP-2000-4314, 2000).

The head of that division then looked at Gilruth's vita and said, "Well, your experience in stress analysis and airplane design will make you particularly valuable in flight research." He then sent him to Flight Research.[25]

Gilruth found a Center fabled both for its collegiality and cutting-edge aeronautical research. Almost with the opening of the Langley Center, the NACA had recruited Max Munk, a gifted student of Ludwig Prandtl. Munk—who had earned two doctorates, one in engineering and another in physics from Göttingen University—had reoriented the lab's efforts toward aerodynamics through the construction of a revolutionary Variable Density Tunnel that began operation in 1922. This instrument, and other later wind tunnels, transformed the Langley laboratory into a major research facility on par with the best of those anywhere in the world. As historian Deborah G. Douglas concluded, "By the late 1920s, the NACA's Langley Aeronautical Laboratory had begun to earn an international reputation, largely due to the construction of a trio of pioneering wind tunnels (the Variable Density Tunnel that became operational in 1922, the Propeller Research Tunnel in 1927, and the Full Scale Tunnel in 1931)."[26]

Because of this, Langley became a mecca for bright, young aeronautical engineers who wanted to make a difference in the progress of aircraft technology in the United States. As historian Roger E. Bilstein wrote, "Langley managed to attract the brightest young aeronautical engineers in the country because they knew that their training would continue to expand by close and comradely contact with many senior NACA engineers on the cutting edge of research."[27] This feature of the Langley Center and the whole of the NACA would become a hallmark of its technical success. Even though the organization grew more formal over the years, all agreed that it remained a place where uniquely creative individuals undertook remarkable research and made significant contributions to knowledge about the practical aspects of flight.[28]

While Gilruth found such an environment invigorating, he also found it competitive. The best aeronautical engineers in the world worked at Langley, with more arriving every day. Notwithstanding this, Gilruth rose to the occasion and soon became one of the premier researchers at the lab. His principal work revolved around the field of aircraft stability, control, and vehicle-handling qualities.[29] Throughout the war, the NACA aero-

25 Gilruth OHI No. 2 by DeVorkin, Collins, and Ezell.

26 Deborah G. Douglas, "Three-Miles-A-Minute: The National Advisory Committee for Aeronautics and the Development of the Modern Airliner," in *Innovation and the Development of Flight*, ed. Roger D. Launius (College Station: Texas A&M University Press, 1999), p. 156.

27 Roger E. Bilstein, *Orders of Magnitude: A History of the NACA and NASA, 1915–1980* (Washington, DC: NASA SP-4406, 1989), p. 5.

28 Ibid., pp. 1–14; and Michael H. Gorn, *Expanding the Envelope: Flight Research at NACA and NASA* (Lexington: University Press of Kentucky, 2001), pp. 9–96.

29 NASA Manned Spacecraft Center Release, "Robert R. Gilruth Biographical Data" (May 1968), NASA Headquarters Historical Reference Collection, Washington, DC.

nautical research program continued as it had in earlier years, but at a heightened pace. Requests for answers to specific problems came into the Committee and were then parceled out to laboratories for resolution. Researchers such as Gilruth worked closely with those seeking the information to ensure that they received what they needed on a timely basis. No fewer than 40 technical reports, notes, or other studies bore Gilruth's name as author or coauthor between his arrival at Langley and the end of WWII.[30]

The NACA expressed justifiable pride in its contributions in terms of both applied and fundamental research during WWII.[31] These related to research on the shape of wings and bodies, devices to improve engine power and propeller thrust, measures to safeguard stability and control, and apparatus to protect the planes against ice and other natural hazards. These involved all types of experiments at all of the NACA research institutions. The NACA periodically issued statements about its general work for the war. A January 1944 issue of *Aviation* described in proper patriotic fashion the Agency's efforts and urged support for it:

> How much is it worth to this country to make sure we won't find the Luftwaffe our superiors when we start that "Second Front"? We spend in one night over Berlin more than $20,000,000. The NACA requires—now—$17,546,700 for this year's work. These raids are prime factors in winning the war. How can we do more towards victory than by spending the price of one air raid in research which will keep our Air Forces in the position which the NACA has made possible?[32]

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30 The following are representative NACA reports, which can be found in the NASA Langley Research Center Historical Reference Collection, Hampton, VA: Warren D. Reed and Robert R. Gilruth, "Results of Landing Tests with a Curtiss XF13C-3 Airplane" (12 August 1937); Gilruth, "Results of Landing Tests of Kellett TG-1 Autogiro" (15 November 1937); Gilruth, "Measurements of the Flying Qualities of the Martin B-10B Airplane" (11 January 1938); Gilruth, "An Investigation of the Lift and Thrust Theoretically Available from the Angular Momentum of a Propeller Wake" (19 February 1938); Gilruth and Melvin N. Gough, "Stalling Characteristics of a Douglas B-18 Airplane" (31 May 1938); Gilruth and Gough, "Stalling Characteristics of a Boeing B-17 Airplane" (14 October 1938); Gilruth and Gough, "Stalling Characteristics of the Boeing XB-15 Airplane" (14 November 1938); Gilruth and Gough, "Measurements of the Flying Qualities of a Douglas B-18 Airplane" (11 January 1939); Gilruth and Gough, "Measurements of the Fly Qualities of the Boeing B-17 Airplane" (14 April 1939); Gilruth and Gough, "Measurements of the Fly Qualities of the Boeing XB-15 Airplane" (31 July 1939); Gilruth, Gough, and William Gracey, "Measurements of the Flying Qualities of a Piper Cub Airplane (Model JSL-50)" (19 March 1940); Gilruth, Gough, and Gracey, "Measurements of the Fly Qualities of the Taylorcraft Airplane (Model 30-65)" (29 April 1940); Gilruth and Gough, "Modifications and Tests of Curtiss P-40 Airplane for Improvement of Ground Handling Characteristics" (1 July 1940); Gilruth and William N. Turner, "Longitudinal Stability and Maneuverability Characteristics of Republic XP-41 Airplane with Center of Gravity of 25 Percent M.A.C." (19 September 1940); Gilruth and Floyd L. Thompson, "Notes on the Stalling of Vertical Tail Surfaces and on Fin Design" (October 1940); Gilruth, "Requirements for Satisfactory Flying Qualities of Airplanes" (April 1941); Gilruth and Turner, "Lateral Control Required for Satisfactory Flying Qualities Based on Flight Tests of Numerous Airplanes" (1941); Gilruth, "Measurements of the Aileron Control Characteristics of a Republic P-47B Airplane" (22 March 1942); Gilruth, "Preliminary Trials of a Means for Testing Aerodynamic Bodies in the Transonic Speed Range" (September 1944); and Gilruth and Joseph R. Wetmore, "Preliminary Tests of Several Airfoil Models in the Transonic Speed Range" (May 1945).

31 Many of these activities have been detailed in George W. Gray, *Frontiers of Flight: The Story of NACA Research* (New York: Alfred A. Knopf, 1948). "Research and Air Supremacy," *New York Times* (3 April 1945).

32 "NACA: The Force Behind Our Air Supremacy," *Aviation* (January 1944): 22–23.

Committee Executive Director John F. Victory remarked: "The employees of the NACA have a big and important job to do. They are at war with similar research organizations in Germany, Japan, and Italy. It is their responsibility, and they are using their technical knowledge and skill to make sure that the airplanes that are given to American and allied flyers are better and more efficient instruments of war than those flown by enemy airmen."[33]

Gilruth soon earned a central role in the flight research efforts at Langley, demonstrated by the large number of reports he wrote and the increasing stature that he enjoyed at the laboratory. Working in flight research proved a real opportunity for Gilruth. "Although I didn't realize it at the time," he commented in 1986, "if I had gone to a wind tunnel or some other place, I probably would not have gotten the background that was to make it possible for me to do the things I did both in aviation and space. I was working with the actual airplanes, with test pilots, and, somehow or other, I found that the people that came out of Flight Research had a better chance for grasping the big picture than the people that were buried in wind tunnel work." Some pathbreaking studies emerged from his research, studies he chose to highlight more than 40 years later as the best of his early career, such as the following:

- "Notes on the Stalling of Vertical Tail Surfaces and on Fin Design," NACA Technical Report No. 778, 1940.
- "Analysis and Prediction of Longitudinal Stability of Airplanes," NACA Report No. 711, 1941.
- "Lateral Control Required for Satisfactory Flying Qualities, Based on Flight Tests of Numerous Airplanes," NACA Report No. 715, 1941.
- "Requirements for Satisfactory Flying Qualities in Airplanes," NACA Report No. 755, 1943.
- "Analysis of Vertical Tailoads and Rolling Pullout Maneuvers," NACA Confidential Bulletin L4H14, August 1944.[34]

Despite his productivity, these reports read like telephone books, and, despite a lifetime effort at communicating via the written word, he always wrote in the passive voice using dense engineering jargon. One example will suffice. In a 1942 report on ice detectors, he wrote:

33 John F. Victory, "National Advisory Committee for Aeronautics" (24 June 1942), pp. 2–3, John F. Victory Papers, Special Collection, United States Air Force Academy Library, Colorado Springs, CO. See also "NACA Research and the Nation's War Planes: A Brief History of the Efforts of the NACA To Improve the Performance of Military Airplanes" (9 September 1942), Record Group 255, National Archives and Records Administration, Archives II, College Park, MD.

34 Gilruth OHI No. 2 by DeVorkin, Ezell, and Collins.

> An ice detector, which served as a basis for a rate-of-icing indicator, has been developed and tested recently by the National Advisory Committee for Aeronautics . . . . The present investigation has disclosed two important characteristics of this instrument, either of which can be utilized in measuring the rate of icing. It has been found that a) the time required for the pressure to drop from any given level to another given level is inversely proportional to the icing rate, and b) the maximum rate of change of pressure or the average rate of change of pressure is proportional to the rate of icing.[35]

Gilruth will not win any writing awards for this, or other, similar studies. But the level of writing skill proved less important for engineering than the analysis, and there he excelled.

Gilruth quickly proved his capabilities, and, with the opportunities afforded by WWII, he soon found himself in charge of a number of other researchers. W. Hewitt Phillips, who would himself soon prove a leading aerodynamicist, recalled that "on starting work with NACA at Langley Field in July 1940, I was assigned to the Flight Research Division." He commented:

> The next few years, during the period of World War II, proved to be [an] exciting time. I was working under Dr. Robert R. Gilruth, who had undertaken the task of studying requirements for the flying qualities of airplanes. During that time, a new military airplane was produced practically every month, and many of these airplanes were assigned to Langley for study and improvement of their flying qualities.[36]

Phillips reported that in conducting this research Gilruth followed a set approach. An airplane would be fitted with recording instruments to measure "relevant quantities such as control positions and forces, angular velocities, linear accelerations, airspeed, altitude, etc." He then developed with his team of engineers and their research pilots, especially Melvin N. Gough, "a program of specified flight conditions and maneuvers . . . . After the flight, the data was transcribed from the flight records and plotted to show the relevant information, and the results were correlated with pilot opinion." They then undertook analysis of every aspect of the flight data, and Gilruth prepared reports on the individual studies. The ultimate study by Gilruth came in 1943, "Requirements for Satisfactory Flying Qualities of Airplanes." This major study involved research on tests of 16 different

35 Robert R. Gilruth, J. A. Zalovik, and A. R. Jones, "Flight Investigation of an NACA Ice-Detector Suitable for Use as a Rate-of-Icing Indicator," Wartime Report L-364 (November 1942), p. 1, NASA Langley Research Center Historical Reference Collection, Hampton, VA.

36 W. Hewitt Phillips, "Flying Qualities from Early Airplanes to the Space Shuttle," *Journal of Guidance* 12 (July–August 1989): 289.

airplanes of all types, ranging from light airplanes to the Boeing XB15.[37] As Phillips recalled, "this report formed the basis of subsequent military specifications for stability and control characteristics of airplanes."[38]

LEADING THE PILOTLESS AIRCRAFT RESEARCH DIVISION (PARD)

After nearly eight years as a "dirty hands" engineer at Langley, Gilruth made the most of a chance to lead his own organization, the Pilotless Aircraft Research Division (PARD). On 9 December 1944, Gilruth participated in a meeting at the Langley Memorial Aeronautical Laboratory to discuss the formation of an organization that would devote its efforts to the study of stability and maneuverability of high-speed weapons, especially guided missiles. From the outset, however, he understood that this work would point toward supersonic flight research, which was something he believed represented the cutting edge of flight activities in the postwar era. In early 1945, the NACA asked Congress for a supplemental appropriation to fund the activation of this unit, and a short time later the NACA opened the Auxiliary Flight Research Station (AFRS), soon redesignated the Pilotless Aircraft Research Division, with Gilruth as Director.[39]

The AFRS was established on 7 May 1945 at Wallops Island as a test-launching facility of Langley. Under Gilruth's direction on 4 July 1945, it launched its first test vehicle, a small two-stage, solid-fuel rocket to check out the installation's instrumentation. Also, by 1946 the PARD had begun testing rocket-launched X-2 models at Wallops to gather stability and control data. Additional tests helped NACA and Bell engineers design a pilot escape system for the X-2. Intended originally only to test rocket-powered models of aircraft and missiles at transonic and higher velocities to obtain aerodynamic data, under Gilruth's tutelage it also began pioneering work on supersonic inlets and ramjets. For example, Maxime E. Faget, one of PARD's staff, designed a compact (6½-inch diameter) ramjet engine and a supersonic flight-test vehicle that was powered by two of these ramjets.

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37 Robert R. Gilruth, "Requirements for Satisfactory Flying Qualities of Airplanes," NACA Technical Report No. 755, 1943, NASA Langley Research Center Historical Reference Collection, Hampton, VA.

38 Phillips, "Flying Qualities," p. 294. The seminal nature of this report is attested to in "Specification for Stability and Control Characteristics of Airplanes," Bureau of Aeronautics, U.S. Navy, Washington, DC, SR-119A (April 1945); "Stability and Control Characteristics of Airplanes," Army Air Force Specification R-1815A (April 1945); and W. Hewitt Phillips, "Appreciation and Prediction of Flying Qualities," NACA Technical Report No. 927, 1948, NASA Langley Research Center Historical Reference Collection, Hampton, VA.

39 James M. Grimwood, *Project Mercury: A Chronology* (Washington, DC: NASA SP-4001, 1963), part 1A, p. 1; and 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, the NACA purchased the entire island.

During a flight test in 1950, this vehicle accelerated under ramjet power in a climbing flight achieving an altitude of 65,000 feet and a velocity of M=3.2, setting unofficial speed and altitude records for vehicles powered by air-breathing engines.[40]

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 between 1947 and 1949 at least 386 models, leading to the publication of Gilruth's first technical report on rocketry, "Aerodynamic Problems of Guided Missiles," in 1947. From this, Gilruth and the PARD filled in tremendous gaps in the knowledge of high-speed flight. 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."[41]

The NACA leadership promoted Gilruth to serve as the Assistant Director of Langley Memorial Aeronautical Laboratory in 1952. Thereafter, in addition to his administrative responsibilities, he worked on several of the ballistic missiles, but was deeply troubled by the advent of nuclear destruction. He said, "I felt that things had really gotten out of hand." He also was aware of the discussion of orbiting an artificial satellite, but at first paid little attention to its potential. On the other hand, he said, "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."[42]

Meantime, the PARD continued to advance its work on rockets and missiles. In 1952, the PARD started the development of multistage, hypersonic-speed, 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 the 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.[43]

Also during 1956, Gilruth's engineers in PARD originated the idea of one of the most successful programs in NASA history—the small, inexpensive sounding rocket, Scout. Led by William E. Stoney, Jr., this team also included Max Faget, who would gain fame as the original designer of the Mercury capsule, Joseph G. Thibodaux, Jr., and Robert O.

40 Christopher C. Kraft, Jr., *Robert R. Gilruth, 1913–2000: A Biographical Memoir* (Washington, DC: National Academy of Sciences, 2000); Gilruth OHI No. 1 by DeVorkin and Collins; Robert L. Rosholt, *An Administrative History of NASA, 1958–1963* (Washington: NASA SP-4101, 1966), pp. 48, 81, fig. 3-1, and appendix B; and Glen Golightly, "Spaceflight Pioneer Maxime Faget Hospitalized," *http://www.space.com*.

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

42 Robert Gilruth OHI No. 3 by Linda Ezell, Howard Wolko, and Martin Collins (30 June 1986), pp. 19, 44.

43 Letter from NASA Space Task Group to NASA Headquarters (5 July 1960), NASA Headquarters Historical Reference Collection, 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; and House Report 67, 87th Congress, 1st Session, p. 27.

Piland, who put together the first multistage rocket to reach the speed of Mach 10. Gilruth accepted that while the PARD had originated as an organization that collected data for transonic, supersonic, and eventually hypersonic speeds on aircraft models, it naturally evolved toward the design of rockets and missiles. Scout emerged as a logical outgrowth of the development of this expertise, as these individuals developed a multi-stage, solid-propellant rocket that could reach orbital speeds of Mach 18.[44]

In 1957, this group explored with the Aerojet Corporation how best to advance solid-rocket motor technology to achieve orbital velocity. Their most interesting attempt involved converting the Jupiter rocket, developed by Wernher von Braun's rocket team at the Army Ballistic Missile Agency in Huntsville, Alabama, to a solid-propellant missile for use aboard naval vessels. They called it the "Jupiter Senior," and its solid-propellant motor measured 30 feet long, 40 inches in diameter, and could provide a thrust of 100,000 pounds. From its first firing in March 1957, Jupiter Senior amassed a record of 13 static tests and 32 flights without a failure, proving the technology that made possible the Polaris and Minuteman intercontinental ballistic missiles that could be placed in a silo or on a submarine and launched reliably with a minimum amount of preparation. The PARD team then went on to argue for, but failed to receive, support to develop a four-stage launcher with the Jupiter Senior as the first stage; a plethora of launchers were developed in the latter 1950s in response to the need to create an intercontinental ballistic missile capability in the Cold War.[45]

While Gilruth ran PARD, he slowly became enamored with the prospects of human spaceflight. In 1952, German émigré Wernher von Braun burst on the broad public stage with a series of articles in *Collier's* magazine about the possibilities of spaceflight. The first issue of *Collier's* devoted to space appeared on 22 March 1952. In it readers were asked "What Are We Waiting For?" and were urged to support an aggressive space program. An editorial suggested that spaceflight was possible, not just science fiction, and that it was inevitable that humanity would venture outward. Von Braun led off the *Collier's* issue with an impressionistic article describing the overall features of an aggressive spaceflight program. He advocated the orbiting of an artificial satellite to learn more about spaceflight followed by the first orbital flights by humans, development of a reusable spacecraft for travel to and from Earth orbit, building a permanently inhabited space station, and finally human exploration of the Moon and planets by spacecraft launched from the space station. Willy Ley and several other writers then followed with elaborations on various aspects of spaceflight ranging from technological viability to

44 Hansen, *Spaceflight Revolution*, pp. 197–200, chapter 11; Shortal, *A New Dimension*, pp. vii, 533–534; T. Keith Glennan, *The Birth of NASA: The Diary of T. Keith Glennan*, ed. J. D. Hunley (Washington, DC: NASA SP-4105, 1993), p. 328; and Lloyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington, DC: NASA SP-4201, 1966), p. 65. On the history of Wallops, see Harold D. Wallace, Jr., *Wallops Station and the Creation of an American Space Program* (Washington, DC: NASA SP-4311, 1997), although it has far less material relevant to Scout than Shortal's older study.

45 Shortal, *A New Dimension*, pp. 706–707.

space law, to biomedicine.[46] The series concluded with a special issue devoted to Mars, in which von Braun and others described how to get there and predicted what might be found based on recent scientific data.[47]

Clearly the *Collier's* series helped to shape Gilruth's perception of spaceflight as 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."[48] Gilruth confessed that he did not know von Braun well during that period:

> I had met him at the Pentagon one or two times when he was working for the Army. I think the first time I was with him was during some meetings that were held in connection with early reentry studies that they were doing using the Redstone rockets and some things that the Army was doing on reentry technology. I was there as one of the people in the government that was interested in that sort of thing and who was knowledgeable in the guided missile business.[49]

Gilruth claimed a working relationship with the spaceflight propagandist but not a friendship. They had similar objectives and worked diligently to achieve them.

Gilruth worked to close the gap between public perceptions of spaceflight and its near-term reality with the technological developments. The convincing of the American public that spaceflight was possible was one of the most critical components of the space policy debate of the 1950s. For realizable public policy to emerge in a democracy, people must both recognize the issue in real terms and develop confidence in the attainability of the goal. It was present by the mid-1950s, and without it NASA and the aggressive piloted programs of the 1960s could never have been approved.[50]

In a little more than 12 years, PARD 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 the NACA above rocketry and the nascent field of astronautics. This organization enjoyed renewed attention and funding once the Soviet Union launched the world's first satellite, Sputnik, 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 recalled 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."[51]

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46 "Man Will Conquer Space *Soon*" series, *Collier's* (22 March 1952): 23–76 ff.

47 Wernher von Braun with Cornelius Ryan, "Can We Get to Mars?" *Collier's* (30 April 1954): 22–28.

48 Robert Gilruth OHI No. 6 by David DeVorkin and John Mauer (2 March 1987).

49 Ibid.

50 Howard E. McCurdy, *Space and American Imagination* (Washington, DC: Smithsonian Institution Press, 1997), pp. 29–52.

51 NASA Press Release H00-127, "Dr. Robert Gilruth, an Architect of Manned Space Flight, Dies" (17 August 2000), NASA Headquarters Historical Reference Collection, Washington, DC.

THE SPACE TASK GROUP AND PROJECT MERCURY

The launch of Sputnik 1 in October 1957, and especially the successful flight of Sputnik 2 a month later, set the United States in crisis mode, kicking off an intensely competitive space race in which two superpowers locked in a Cold War sought to outdo each other for the world's accolades. Nothing seemed too much, no opportunity too small, to move toward that singular goal. At a fundamental level, NASA emerged because of pressures during the Cold War with the Soviet Union, a broad contest over the ideologies and allegiances of the nonaligned nations of the world in which space exploration emerged as a major area of contest. Sputnik had a "Pearl Harbor" effect on American public opinion, creating an illusion of a technological gap and providing the impetus for increased spending for aerospace endeavors, technical and scientific educational programs, and the chartering of new federal agencies to manage air and space research and development.[52]

Sputnik led directly to several critical efforts aimed at "catching up" to the Soviet Union's space achievements, which included the following:

- a wide-ranging review of the civil and military space programs of the United States (scientific satellite efforts and ballistic missile development);
- establishment of a Presidential Science Advisor in the White House who had responsibility for overseeing the activities of the federal government in science and technology;
- beginning the Advanced Research Projects Agency in the Department of Defense and consolidating several space activities under centralized management;
- creation of the National Aeronautics and Space Administration to manage civil space operations for the benefit "of all mankind" by means of the National Aeronautics and Space Act of 1958; and
- passage of the National Defense Education Act of 1958 to provide federal funding for education in scientific and technical disciplines.[53]

More immediately, the United States launched its first Earth satellite on 31 January 1958 when Explorer 1 documented the existence of radiation zones encircling Earth. Shaped by Earth's magnetic field, what came to be called the Van Allen Radiation Belt partially dictates the electrical charges in the atmosphere and the solar radiation that

52 See Rip Bulkeley, *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space* (Bloomington: Indiana University Press, 1991); Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (New York: Oxford University Press, 1993); and Paul Dickson, *Sputnik: The Shock of the Century* (New York: Walker and Co., 2001).

53 Roger D. Launius, "National Aeronautics and Space Act of 1958," in Donald C. Bacon, et al., eds., *The Encyclopedia of the United States Congress* (New York: Simon and Schuster, 1994), pp. 1,437–1,438; and Alison Griffith, *The National Aeronautics and Space Act: A Study of the Development of Public Policy* (Washington, DC: Public Affairs Press, 1962).

reaches Earth. The United States also began a series of scientific missions to the Moon and planets in the latter 1950s and early 1960s.[54] As a direct result of this crisis, NASA began operations on 1 October 1958, absorbing the National Advisory Committee for Aeronautics intact—its 8,000 employees, an annual budget of $100 million, three major research laboratories (Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, and Lewis Flight Propulsion Laboratory), and two smaller test facilities. NASA quickly incorporated other organizations into the new Agency. These included the space science group of the Naval Research Laboratory in Maryland, the Jet Propulsion Laboratory managed by the California Institute of Technology for the Army, and the Army Ballistic Missile Agency in Huntsville, Alabama, where Wernher von Braun's team of engineers was engaged in the development of large rockets. Eventually NASA created several other Centers; by the early 1960s, there were 10 located around the country.[55]

Just six days after the establishment of NASA, Gilruth's Space Task Group received approval from NASA Administrator T. Keith Glennan for a piloted satellite project to determine if it was possible for human spaceflight. On 8 October 1958, NASA established the Space Task Group at Langley Research Center. On 5 November 1958, Gilruth received his appointment as Project Manager, and Charles J. Donlan, Technical Assistant to the Director of the Langley Laboratory, became Assistant Project Manager. Thirty-five key staff members from Langley, many of whom had worked on a military man-in-space plan, were transferred to the new Space Task Group, as were 10 others from the Lewis Research Center in Cleveland, Ohio. These 45 persons formed the nucleus of the more than 1,000-person workforce that eventually became a part of Project Mercury. On 14 November, Gilruth requested the highest national priority procurement rating for this project, but it did not come until 27 April 1959. On 26 November 1958, NASA officially designated the program "Mercury," and by early 1959 it had contracted with the McDonnell Aircraft Corporation's bid to build the vehicle.[56] 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."[57]

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54 James A. Van Allen, *Origins of Magnetospheric Physics* (Washington, DC: Smithsonian Institution Press, 1983).

55 Roger D. Launius, *NASA: A History of the U.S. Civil Space Program* (Malabar, FL: Krieger Pub. Co., 1994), chapter 3.

56 Linda Neuman Ezell, *NASA Historical Data Book: Volume II: Programs and Projects, 1958–1968* (Washington, DC: NASA SP-4012, 1988), pp. 102, 139–140; and James M. Grimwood, *Project Mercury: A Chronology* (Washington, DC: NASA SP-4001, 1963), pp. 31–32.

57 T. Keith Glennan, *The Birth of NASA*, chapter 1. On Project Mercury, see Loyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington, DC: NASA SP-4201, 1966).

Gilruth received two responsibilities in one: 1) Project Manager of the Space Task Group and 2) Assistant Director of a new NASA "space projects center" to be located near Greenbelt, Maryland, which became the Goddard Space Flight Center. This facility, as Glennan believed, would serve as the operations control center for all NASA spaceflight activities. Until that new installation came on line, however, Gilruth's group would remain at Langley. This changed within three years, as it became apparent that the scope, size, and support for human spaceflight necessitated an entirely separate center, and politics decreed that it would be established in Houston, Texas.[58]

The Space Task Group, under Gilruth's tutelage, turned its attention to beginning the program as soon as Mercury received approval. From his mind sprang the astronaut corps needed to accomplish it. He firmly believed that humanity's future lay beyond this planet, and he intended to start society down that challenging and hopeful path. Concurrent with the decision to move forward with Project Mercury, NASA selected and trained the Mercury astronaut corps.[59] President Dwight D. Eisenhower directed that the astronauts be selected from among the armed services' test pilot force. Although this had not been the NASA leadership's first choice, this decision greatly simplified the selection procedure. The inherent risk of spaceflight, and the potential national security implications of the program, pointed toward the use of military personnel. It narrowed and refined the candidate pool, giving NASA a reasonable starting point for selection. It also made imminent sense in that NASA envisioned this astronaut corps first as pilots operating experimental flying machines and only later as scientists. As historian Margaret Weitekamp has concluded:

> 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 test pilots as their potential astronauts allowed NASA to choose from a cadre of highly motivated, technically skilled, and extremely disciplined pilots.[60]

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

58 On the formation of the Manned Spacecraft Center (renamed the Lyndon B. Johnson Space Center in 1973), see Henry C. Dethloff, *"Suddenly Tomorrow Came . . .": A History of the Johnson Space Center* (Washington, DC: NASA SP-4307, 1993).

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

60 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. dissertation, Cornell University, 2001), p. 98.

Agency's part to accept test pilots as the first astronauts. After all, they 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.[61]

From a total of 508 service records screened in January 1959 by NASA at the military personnel bureaus in Washington, they found 110 men that met the minimum standards established for Mercury. These standards were as follows:

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. Total flying time of 1,500 hours

7. Qualified jet pilot

This list of names included 5 Marines, 47 Navy men, and 58 Air Force pilots. Several Army pilots' records had been screened earlier, but none was a graduate of a test pilot school.[62] The selection process began while the possibility of piloted Mercury/Redstone flights late in 1959 still existed, so time was a critical factor in the screening process; although, launch before the end of the year later proved impossible.[63]

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. 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 12 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.

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61 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 Mohave Desert prior to selection for astronaut training in 1962.

62 On this process, see Swenson, Grimwood, and Alexander, *This New Ocean*, pp. 155–165; and 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.

63 Ibid., pp. 18, 43–45.

> 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.[64]

Every one of the first 10 pilots interrogated on 2 February agreed to continue through the elimination process. The next week, a second third of the 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 amazingly elaborate set of environmental studies, physical endurance tests, and psychiatric studies conducted at the Aeromedical Laboratory of the Wright Air Development Center in 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 were all part of the Dayton experience.[65]

Finally, without conclusive results from these tests, late in March 1959 Gilruth'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. "We looked for real men and valuable experience," said Donlan, and he pressed Gilruth to select the epitome of American masculinity.[66] Gilruth 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 errantly became the personification of NASA to most Americans.[67]

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64 Quoted in Swenson, Grimwood, and Alexander, *This New Ocean*, p. 161.

65 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 in time. 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); and John A. Pitts, *The Human Factor: Biomedicine in the Manned Space Program to 1980* (Washington, DC: NASA SP-4213, 1985).

66 Quoted in Swenson, Grimwood, and Alexander, *This New Ocean*, p. 163. The masculine ideal has been analyzed in Susan Faludi, *Stiffed: The Betrayal of the American Male* (New York: HarperCollins, 1999), pp. 451–468.

67 See Tom Wolfe, "The Last American Hero," in *The Kandy-Kolored Tangerine-Flake Streamline Baby*, ed. Tom Wolfe (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: University of Alabama Press, 1994), pp. 68–92; and Mark E. Byrnes, *Politics and Space: Image Making by NASA* (Westport, CT: Praeger, 1994), pp. 25–46.

Despite the wishes of Gilruth and others within the NASA leadership, the fame of the astronauts quickly grew beyond all proportion to their assignments. Perhaps it was inevitable that the astronauts were destined for premature adulation considering the enormous public curiosity about them, the risk they took in spaceflight, and their exotic training activities, but the power of commercial competition for publicity and the pressure for political prestige in the space race also whetted an insatiable public appetite for this new kind of celebrity. Walt Bonney, a public information officer, foresaw the public and press attention, asked for an enlarged staff, and laid the guidelines for public affairs policy in close accord with that of other government agencies.[68]

Bonney's foresight proved itself in 1959 only a week before the cherry blossoms bloomed along the tidal basin in Washington, DC, drenching the city with spectacular spring colors. NASA had chosen to unveil the first Americans 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 was 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 with 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, and it was the central one for men like Gilruth, 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.[69]

At the same time, Gilruth had enormous respect for the astronauts. He was genuinely impressed with all of them and enjoyed working with them. These individuals, he realized, embodied the deepest virtues of the United States. They strode the Earth as latter-day saviors whose purity coupled with noble deeds would purge this land of the evils of communism by besting the Soviet Union on the world stage. John Glenn, perhaps intu-

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68 Walter T. Bonney (1909–1975) was NASA's first Director of the Office of Public Information (1958–1960). From 1949 to 1958, he had worked for the National Advisory Committee for Aeronautics. For more information on Bonney, see Walter T. Bonney Biographical File, NASA Headquarters Historical Reference Collection, Washington, DC.

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

itively or perhaps through sheer zest and innocence, understood this better than most others and delivered on numerous occasions ringing sermons on God, country, and family that melted the souls of all who heard him. He called upon the memory of how Wilbur and Orville Wright flipped a coin at Kitty Hawk in 1903 to see who would fly the first airplane and how far we had come since. "I think we would be most remiss in our duty," he said at the press conference where the Mercury Seven were unveiled by NASA in 1959, "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." Other astronauts proved just as eloquent and spoke of their sense of duty and destiny as the first Americans to fly in space. 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*, a newspaper with a history of pooh-poohing spaceflight going back to a criticism of Robert Goddard in 1920, exulted the astronaut team. He said he felt profoundly moved by the press conference, and even reading the transcript of it made one's heart beat 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."[70]

The astronauts put a very human face on the grandest technological endeavor in history, and the myth of the virtuous astronaut was born at that moment in 1959. In some respects, it was a natural occurrence. The Mercury Seven were, as Gilruth perceived, surrogates for 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 we had to offer, and, most importantly, they expressed at every opportunity the virtues ensconced in the democratic principles of the republic.

The astronauts, of course, were the "main architects" of their image.[71] But they appeared at a time when NASA desperately needed to inspire public trust in its ability to

70 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): 324–326; Dora Jane Hamblin, "Applause, Tears, and Laughter and the Emotions of a Long-Ago Fourth of July," *Life* (9 March 1962): 34; and Roger D. Launius and Bertram Ulrich, *NASA and the Exploration of Space* (New York: Stewart, Tabori, and Chang, 1998), chapter 2.

71 Letter from Don A. Schanche to P. Michael Whye (28 December 1976), NASA Headquarters Historical Reference Collection, Washington, DC.

carry out the nation's goals in space. Rockets might explode, but the astronauts shined. The astronauts seemed to embody the personal qualities in which Americans of that era wanted to believe: bravery, honesty, love of God and country, and family devotion. How could anyone distrust a government agency epitomized by such people? The trust that the public placed in the astronauts spread through NASA and to the government as a whole. As one of the *Life* reporters summarized, "*Life* treated the men and their families with kid gloves. So did most of the rest of the press. These guys were heroes, most of them were very smooth, canny operators with all of the press. They felt that they had to live up to a public image of good, clean, all-American guys, and NASA knocked itself out to preserve that image."[72]

Gilruth understood that the astronauts were critical to the success of the program. Early on he made astronauts an important part of the organizational structure, inviting them into the inner councils of NASA and into the decision-making process. Gilruth recalled in 1987, "They certainly had every right to sit in and listen to things that were going on in the design of the spacecraft. They certainly had every right to make an input." In essence, Gilruth put the astronauts to work for him, co-opting them on behalf of his larger ideals.

Despite the success of motivating the public with Gilruth's astronauts, stubborn problems arose with Project Mercury at seemingly every turn. The first spaceflight of an astronaut, made by Alan B. Shepard, had been postponed for weeks so NASA engineers could resolve numerous details; it finally took place on 5 May 1961, less than three weeks before the Apollo announcement. The second flight, a suborbital mission like Shepard's, launched on 21 July 1961, had problems as well. The hatch blew off prematurely from the Mercury capsule, *Liberty Bell 7*, and it sank into the Atlantic Ocean before it could be recovered. In the process, astronaut "Gus" Grissom nearly drowned before being hoisted to safety in a helicopter. These suborbital flights, however, proved valuable for NASA technicians who found ways to solve or work around literally thousands of obstacles to successful spaceflight.[73]

As these issues were being resolved, NASA engineers began final preparations for the orbital aspects of Project Mercury. In this phase, NASA planned to use a Mercury capsule capable of supporting a human in space for not just 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

72 Letter from Dora Jane Hamblin to P. Michael Whye (18 January 1977), NASA Headquarters Historical Reference Collection, Washington, DC.

73 Swenson, Grimwood, and Alexander, *This New Ocean*, pp. 341–379.

capsule, but the biggest complication was a debate among NASA engineers over its propriety for human spaceflight.[74]

When Atlas was first conceived in the 1950s, many believed that it was a high-risk proposition because to reduce its weight Convair engineers, under the direction of Karel J. Bossart, a pre-WWII immigrant from Belgium, designed the booster with a very thin, internally pressurized fuselage instead of massive struts and a thick metal skin. The "steel balloon," as it was sometimes called, employed engineering techniques that ran counter to a conservative engineering approach used by Wernher von Braun for the V-2 and the Redstone at Huntsville, Alabama.[75] Von Braun, according to Bossart, needlessly designed his boosters like "bridges" to withstand any possible shock. For his part, von Braun thought the Atlas was too flimsy to hold up during launch. He considered Bossart's approach much too dangerous for human spaceflight, remarking that the astronaut using the "contraption," as he called the Atlas booster, "should be getting a medal just for sitting on top of it before he takes off!"[76] The reservations began to melt away, however, when Bossart's team pressurized one of the boosters and dared one of von Braun's engineers to knock a hole in it with a sledge hammer. The blow left the booster unharmed, but the recoil from the hammer nearly clubbed the engineer.[77]

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, the final test flight took place with the chimpanzee Enos occupying the capsule for a two-orbit ride before being successfully recovered in an ocean landing. Not until 20 February 1962, however, could NASA get ready for an orbital flight with an astronaut. On that date, John Glenn became the first American to circle Earth, making three orbits in his *Friendship 7* Mercury spacecraft. The flight was not without problems, however; Glenn flew parts of the last two orbits manually because of an autopilot failure and left his normally jettisoned retrorocket pack attached to his capsule during reentry because of a loose heatshield.

Glenn's flight provided a healthy 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

74 Wernher von Braun, "The Redstone, Jupiter, and Juno," in *The History of Rocket Technology: Essays on Research, Development, and Utility*, ed. Eugene M. Emme (Detroit: Wayne State University Press, 1964), pp. 107–122.

75 Richard E. Martin, *The Atlas and Centaur "Steel Balloon" Tanks: A Legacy of Karel Bossart* (San Diego, CA: General Dynamics Space Systems Division, 1989).

76 Interview with Karel J. Bossart by John L. Sloop (27 April 1974), quoted in John L. Sloop, *Liquid Hydrogen as a Propulsion Fuel, 1945–1959* (Washington, DC: NASA SP-4404, 1978), pp. 176–177.

77 Martin, *The Atlas and Centaur*, p. 5.

learned much about the power the astronauts had in swaying public opinion. The NASA leadership made Glenn available to speak at some events, but he 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.[78]

Three more successful Mercury flights took place during 1962 and 1963. Scott Carpenter made three orbits on 20 May 1962, and, on 3 October 1962, Walter Schirra flew six orbits. The capstone of Project Mercury was the 15–16 May 1963 flight of Gordon Cooper, who circled Earth 22 times in 34 hours. The program had succeeded in accomplishing its purpose: to successfully orbit a human in space, explore aspects of tracking and control, and learn about microgravity and other biomedical issues associated with spaceflight.[79]

MANAGING PROJECT APOLLO

In May 1961, Robert Gilruth's life changed forever. After President John F. Kennedy announced the decision on 25 May that the United States would land an American on the Moon by the end of the decade, Apollo consumed NASA's every effort. It required significant expenditures, costing $24.5 billion in 1960s dollars over the life of the program (more than $110 billion in 2004 dollars) to make it a reality. Only the building of the Panama Canal rivaled the Apollo program's size as the largest nonmilitary technological endeavor ever undertaken; only the Manhattan Project was comparable in a wartime setting. Even NASA leaders expressed concern that it might prove too daunting a challenge. When Kennedy made his speech, Gilruth was flying to a meeting in Tulsa. He recalled that he was "aghast" at the lunar landing goal and what it would portend for the future. After all, he reasoned, his organization now had to accomplish it. Rising to the challenge, project participants exhibited single-minded devotion to it for a decade.[80]

In 1986, Gilruth talked about the decision-making process leading up to Kennedy's speech on 25 May. He commented on the intense technical and political review and how government officials reached closure on the initiative. He recalled:

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78 Swenson, Grimwood, and Alexander, *This New Ocean*, pp. 422–436.

79 Ibid., pp. 446–503.

80 By far the most influential study making this case is the seminal work of John M. Logsdon, *The Decision to Go to the Moon: The Space Program and the National Interest* (Cambridge, MA: MIT Press, 1970). There are several ways to view the decision. These have been analyzed in Stephen J. Garber, "Multiple Means to an End: A Reexamination of President Kennedy's Decision to Go to the Moon," *Quest: The History of Spaceflight Quarterly* 7 (Summer 1999): 5–17.

> I told President Kennedy when he said, "I want to go to the Moon," I said, "Well, that's very hard to do." "But," I said, "I don't know that you can't." So that was fair and square. I didn't know that you couldn't. And it turned out, it was pretty straightforward. But how we ever did it, and all those things worked, with all those single-point failures in the sequence—there were some people who wanted to keep on flying those things, you know. A lot more of them—I said "Not me, you get another boy. You'll have to get another guy to handle it. You'll have to get another boy because I'm not going to stay around for it if you're going to keep doing it."[81]

President John F. Kennedy presents Dr. Robert R. Gilruth with the Medal for Distinguished Federal Civil Service. The ceremony took place on the White House lawn. In attendance were (foreground, left to right): astronauts Alan Shepard and John Glenn, Gilruth, NASA Administrator James Webb, and President John F. Kennedy. Photo taken on 1 August 1962. (GRIN database number GPN-2000-001681)

Gilruth agreed to take on the responsibility for managing the human element of the program, reluctant though he may have been.

Of course, Gilruth fully supported President Kennedy's decision, recognizing that he had correctly gauged the mood of the nation. This commitment captured the American imagination and enjoyed strong support during the days and weeks following the announcement. No one seemed concerned either about the difficulty or about the expense at the time. Congressional debate was perfunctory, and NASA found itself literally pressing to expend the funds committed to it during the early 1960s. Like most political decisions, at least in the U.S. experience, the decision to carry out Project Apollo was an effort to deal with an unsatisfactory situation (world perception of Soviet leadership in space and technology). As such, Apollo was a remedial action

81 Gilruth OHI No. 6 by DeVorkin and Mauer.

ministering to a variety of political and emotional needs floating in the ether of world opinion. Apollo addressed these problems very well and was a worthwhile action if measured only in those terms. In announcing Project Apollo, Kennedy put the world on notice that the United States would not take a back seat to its superpower rival. John Logsdon commented, "By entering the race with such a visible and dramatic commitment, the United States effectively undercut Soviet space spectaculars without doing much except announcing its intention to join the contest."[82] It was an effective symbol, just as Kennedy had intended.

Without question, Kennedy gave Gilruth an opportunity to shine by approving Apollo. He fully recognized that the lunar landing was so far beyond the capabilities of either the United States or the Soviet Union in 1961 that the early lead in space activities taken by the Soviets would not predetermine the outcome. It gave the United States a reasonable chance of overtaking the Soviet Union in space activities and recovering a measure of lost status. Gilruth recalled telling Kennedy the following:

> Well, you've got to pick a job that's so difficult that it's new, that they'll have to start from scratch. They just can't take their old rocket and put another gimmick on it and do something we can't do. It's got to be something that requires a great big rocket, like going to the Moon. Going to the Moon will take new rockets, new technology, and, if you want to do that, I think our country could probably win because we'd both have to start from scratch.[83]

Even though Kennedy's political objectives were essentially achieved with the decision to go to the Moon, there were other aspects of the Apollo commitment that required assessment. Those who wanted to see a vigorous space program, a group led by NASA scientists and engineers, obtained their wish with Kennedy's announcement. An opening was present to this group in 1961 that had not existed at any time during the Eisenhower administration, and they made the most of it. They inserted into the overall package supporting Apollo programs that they believed would greatly strengthen the scientific and technological return on the investment to go to the Moon. In addition to seeking international prestige, this group proposed an accelerated and integrated national space effort incorporating both scientific and commercial components.

The first challenge Gilruth and other NASA leaders faced in meeting the presidential mandate was securing funding. While Congress enthusiastically appropriated funding for Apollo immediately after the President's announcement, NASA leaders rightly ques-

82 John M. Logsdon, "An Apollo Perspective," *Astronautics & Aeronautics* (December 1979): 112–117.

83 Quoted in Glen E. Swanson, ed., *"Before This Decade is Out . . ." Personal Reflections on the Apollo Program* (Washington, DC: NASA SP-4223, 1999), p. 68.

tioned if the momentary sense of crisis would subside and if the political consensus present for Apollo in 1961 would abate. They worked, albeit without much success, to lock the presidency and Congress into a long-term obligation to support the program. While they had made an intellectual commitment, NASA's leadership was concerned that they might renege on the economic part of the bargain at some future date. But they did err on the side of caution. While Apollo never enjoyed unlimited funding, there was always enough for the program because of this strategy. Additionally, after the assassination of Kennedy in November 1963, Gilruth and other NASA leaders used the slain President's commitment to the program as a means of convincing—some would say shaming—Congress into continuing to support the program with considerable public resources. Accordingly, the space agency's annual budget increased from $500 million in 1960 to a high point of $5.2 billion in 1965. The NASA funding level represented 3.3 percent of the federal budget in 1965.[84]

Out of the budgets appropriated for NASA each year, approximately 50 percent went directly to human spaceflight, most of it directly under the control of Gilruth and his leadership team at the Manned Spacecraft Center in Houston. For 11 years after Kennedy's Apollo decision, through the flight of Apollo 17 in December 1972, Robert Gilruth politicked, coaxed, cajoled, and maneuvered for the program. After Kennedy's assassination in 1963, moreover, he often appealed for continued political support for Apollo because it represented a fitting tribute to the fallen leader. In the end, through a variety of methods, he and Administrator James Webb built a seamless web of political liaisons that brought continued support for and resources to accomplish the Apollo Moon landing on the schedule Kennedy had announced.

In the immediate aftermath of the Apollo decision, NASA created the Manned Spacecraft Center (renamed the Lyndon B. Johnson Space Center in 1973) near Houston, Texas. It moved Gilruth's team from Hampton, Virginia, where Gilruth had lived since the latter 1930s, to this new facility. Gilruth hated that prospect. He loved the Virginia peninsula and had become an avid sailor. He had built a sailboat in his basement—which some of his underlings thought silly since he had to disassemble it to get it out of his basement—and was determined to sail it around the continent to Galveston. He took several weeks out of his work in 1962 to accomplish this voyage, traveling down the intercoastal waterway around Florida and across the Gulf. Later he built the first successful sailing hydrofoil system and participated in many hydrofoil projects. Upon reaching Houston, Gilruth set his team to work not only in settling into their new facility, but also in completing the design and development of the Apollo spacecraft and the launch plat-

84 As an example, see the 1963 letter in defense of Apollo by Vice President Lyndon B. Johnson to the President (13 May 1963), with attached report, John F. Kennedy Presidential Files, NASA Headquarters Historical Reference Collection, Washington, DC; Ezell, *NASA Historical Data Book,* pp. 122–123; and *Aeronautics and Space Report of the President, 1988 Activities* (Washington, DC: NASA Annual Report, 1990), p. 185.

form for the lunar lander. His Center also became the home of NASA's astronauts and the site of Mission Control.[85] The cost of the expansion of NASA's facilities, not only for the Manned Spacecraft Center, but also for other Apollo infrastructure, was great—more than $2.2 billion over the decade, with 90 percent of it expended before 1966.

Within its first few months in Houston, said 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."[86]

The mobilization of resources was not the only challenge facing those charged with meeting President Kennedy's goal. NASA had to meld disparate institutional cultures and approaches into an inclusive organization moving along a single unified path. Each NASA installation, university, contractor, and research facility had differing perspectives on how to go about the task of accomplishing Apollo.[87] To bring a semblance of order to the program, Gilruth employed a systems management concept borrowed from the military/industrial complex to oversee the Apollo capsule development effort. One of the fundamental tenets of the program management concept was that three critical factors—cost, schedule, and reliability—were interrelated and had to be managed as a group. Many also recognized these factors' constancy; if program managers held cost to a specific level, then one of the other two factors, or both of them to a somewhat lesser degree, would be adversely affected. This held true for the Apollo program. The schedule, dictated by the President, was firm. Since humans were involved in the flights, and since the President had directed that the lunar landing be conducted safely, the program managers placed a heavy emphasis on reliability. Accordingly, Apollo used redundant systems extensively so that failures would be both predictable and minor in result. The significance of both of these factors forced the third factor, cost, much higher than might have been the case with a more leisurely lunar program such as had been conceptualized in the latter 1950s. As it was, this was the price paid for success under the Kennedy mandate, and program managers made conscious decisions based on the knowledge of these factors.[88]

85 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).

86 *Space News Roundup* (11 July 1962), Lyndon B. Johnson Space Center, Houston, TX.

87 On the NASA organizational culture and Apollo, see Howard E. McCurdy, *Inside NASA: High Technology and Organizational Change in the U.S. Space Program* (Baltimore, MD: Johns Hopkins University Press, 1993); John M. Logsdon, moderator, *Managing the Moon Program: Lessons Learned from Project Apollo* (Washington, DC: NASA, Monographs in Aerospace History No. 14, 1999); and Stephen B. Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs* (Baltimore, MD: Johns Hopkins University Press, 2002).

88 Aaron Cohen, "Project Management: JSC's Heritage and Challenge," in *Issues in NASA Program and Project Management*, ed. Francis T. Hoban (Washington, DC: NASA SP-6101, 1989), pp. 7–16; C. Thomas Newman, "Controlling Resources in the Apollo Program," in *Issues in NASA Program*, pp. 23–26; and Eberhard Rees, "Project and Systems Management in the Apollo Program," in *Issues in NASA Program*, issue 2, pp. 24–34. For a full explication of the approach taken, see Johnson, *Secret of Apollo*.

Gilruth oversaw every aspect of this effort under his domain. He had excellent people working for him, and they read like a who's who of space history. Chris Kraft, Gene Kranz, John Aaron, and Glynn Lunney served in Mission Control. Joseph Shea and later George Low oversaw the Apollo spacecraft development effort. Aaron Cohen, Barouk el-Faz, Max Faget, Wendell Mendell, and others trained astronauts, developed subsystems, and worked scientific aspects of the program. These were the people who made the dreams of spaceflight real. There is a moving ballad in the filk (science-fiction folk song) community that captures the essence of this group. Written by Mary Jean Holmes in 1992, "Everyman" begins with the lament that these individuals will never leave the ground, but they enabled the astronauts to do so. The chorus states:

> For I'm the man who took up tools and laid out the designs.
> Of starships, I'm the one who built their sleek and burnished lines.
> I'm everyman who ever fashioned cold refined steel.
> Into the dreams of spaceflight, I'm the one who made them real.[89]

The program management concept was recognized as a critical component of Project Apollo's success in November 1968, when *Science* magazine, the publication of the American Association for the Advancement of Science, observed:

> In terms of numbers of dollars or of men, NASA has not been our largest national undertaking, but in terms of complexity, rate of growth, and technological sophistication, it has been unique . . . . It may turn out that [the space program's] most valuable spin-off of all will be human rather than technological: better knowledge of how to plan, coordinate, and monitor the multitudinous and varied activities of the organizations required to accomplish great social undertakings.[90]

Understanding the management of complex structures for the successful completion of a multifarious task was an important outgrowth of the Apollo effort.

Gilruth's organization orchestrated more than 200 contractors working on both large and small aspects of Apollo. These prime contractors, with more than 150 subcontractors, provided millions of parts and components for use in the Apollo spacecraft, all meeting exacting specifications for performance and reliability. Getting all of the personnel elements to work together challenged the program managers, regardless of whether or not

89 Mary Jean Holmes's "Everyman" lyrics are available online at *http://216.109.117.135/search/cache?va=filk+everyman&ei=UTF-8&n=20&fl=0&u=www.speculations.com/rumormill/index.php%3Fshow_all_topics%3D0%26t%3D211&w=filk+everyman&d=E96872EAB2&c=482&yc=6089&icp=1* (accessed 3 April 2004).

90 Dael Wolfe, Executive Officer, American Association for the Advancement of Science, editorial for *Science* (15 November 1968).

they were civil service, industry, or university personnel. There were various communities within NASA that differed over priorities and competed for resources. The two most identifiable groups were the engineers and the scientists. As ideal types, engineers usually worked in teams to build hardware that could carry out the missions necessary for a successful Moon landing by the end of the decade. Their primary goal involved building vehicles that would function reliably within the fiscal resources allocated to Apollo. Again as ideal types, space scientists engaged in pure research and were more concerned with designing experiments that would expand scientific knowledge about the Moon. They also tended to be individualists, unaccustomed to regimentation and unwilling to concede gladly the direction of projects to outside entities. The two groups contended with each other over a great variety of issues associated with Apollo. For instance, the scientists disliked having to configure payloads so that they could meet time, money, or launch vehicle constraints. The engineers, likewise, resented changes to scientific packages added after project definition because these threw their hardware efforts out of kilter. Both had valid complaints and had to maintain an uneasy cooperation to accomplish Project Apollo.[91]

The scientific and engineering communities within NASA, additionally, were not monolithic, and differences among them thrived. Add to these groups representatives from industry, universities, and research facilities, and competition on all levels to further their own scientific and technical areas was the result. The NASA leadership generally viewed this pluralism as a positive force within the space program, for it ensured that all sides aired their views and emphasized the honing of positions to a fine edge. Competition, most people concluded, made for a more precise and viable space exploration effort. There were winners and losers in this strife, however, and sometimes ill-will was harbored for years. Moreover, if the conflict became too great and spilled into areas where it was misunderstood, it could be devastating to the conduct of the lunar program. The head of the Apollo program worked hard to keep these factors balanced and to promote order so that NASA could accomplish the presidential directive.[92]

BRIDGING THE TECHNOLOGICAL GAP: FROM GEMINI TO APOLLO

Even as the Mercury program was underway and work took place developing Apollo hardware, Gilruth and his colleagues in the NASA leadership perceived a huge gap in the capability for human spaceflight between that acquired with Mercury and what would

91 To discipline the system, Gilruth had a sophisticated system of information flow to enable all to keep informed on the status of the program. As an example, every couple of days George M. Low sent him "Apollo Notes for Dr. Gilruth" (1 April 1967–5 November 1969), located in the Robert R. Gilruth Papers, Virginia Tech Special Collections, Blacksburg, VA.

92 McCurdy, *Inside NASA*, pp. 11–98.

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. Three major areas immediately arose where this was the case. The first was the ability in space to locate, maneuver toward, and rendezvous and dock with another spacecraft. The second was closely related—the ability of astronauts to work outside a spacecraft. The third involved the collection of more sophisticated physiological data about the human response to extended spaceflight.[93]

To gain experience in these areas before Apollo could be readied for flight, NASA devised Project Gemini. Hatched in the fall of 1961 by engineers at Gilruth's Space Task Group in cooperation with McDonnell Aircraft Corp. technicians, builders of the Mercury spacecraft, Gemini started as a larger Mercury Mark II capsule; it soon became a totally different proposition. 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 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 "dry" landings instead of a "splashdown" in water and recovery by the Navy. 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.

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 like the one used for Mercury. All of these difficulties shot an estimated $350-million program to over $1 billion. The overruns were successfully justified by the space agency, however, as necessities to meet the Apollo landing commitment.[94]

By the end of 1963, most of the difficulties with Gemini had been resolved, albeit at great expense, and the program was ready for flight. Following two unoccupied orbital test flights, the first operational mission took place on 23 March 1965. Mercury astronaut

93 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): 373–388; Barton C. Hacker, "The Genesis of Project Apollo: The Idea of Rendezvous, 1929–1961," in *Actes 10: Historic des techniques* (Paris: Congress of the History of Science, 1971), pp. 41–46; and Barton C. Hacker and James M. Grimwood, *On the Shoulders of Titans: A History of Project Gemini* (Washington, DC: NASA SP-4203, 1977), pp. 1–26.

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

Grissom commanded the mission, with John W. Young, a Naval aviator chosen as an astronaut in 1962, accompanying him. The next mission, flown in June 1965, stayed aloft for four days, and astronaut Edward H. White II performed the first extravehicular activity (EVA) or spacewalk. Eight more missions followed through November 1966. Despite problems great and small encountered on virtually all of them, the program achieved its goals. 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. Gilruth always believed that Gemini represented the fundamental point at which NASA demonstrated its abilities to surpass the Soviets in human spaceflight.[95]

THE APOLLO SPACECRAFT

Gilruth had his Space Task Group working to develop a spacecraft capable of taking astronauts to the Moon even before the announcement by JFK. What they came up with was a three-person command module capable of sustaining human life for two weeks or more in either Earth orbit or in a lunar trajectory; a service module holding oxygen, fuel, maneuvering rockets, fuel cells, and other expendable and life-support equipment that could be jettisoned upon reentry to Earth; a retrorocket package attached to the service module for slowing to prepare for reentry; and finally a launch escape system that was discarded upon achieving orbit. The teardrop-shaped command module had two hatches—one on the side for entry and exit of the crew at the beginning and end of the flight, and one in the nose with a docking collar for use in moving to and from the lunar landing vehicle.[96]

Production work on the Apollo spacecraft stretched from 28 November 1961, when the prime contract for its development was let to North American Aviation, to 22 October 1968, when the last test flight took place. In between there were various efforts to design, build, and test the spacecraft both on the ground and in suborbital and orbital flights. For instance, on 13 May 1964, Gilruth's team tested a boilerplate model of the

95 Reginald M. Machell, ed., *Summary of Gemini Extravehicular Activity* (Washington, DC: NASA SP-149, 1968); *Gemini Summary Conference* (Washington, DC: NASA SP-138, 1967); Ezell, *NASA Historical Data Book*, pp. 149–170; and Gilruth OHI No. 6 by DeVorkin and Mauer.

96 A lengthy discussion of the development of the Apollo spacecraft can be found in Ivan D. Ertal and Mary Louise Morse, *The Apollo Spacecraft: A Chronology, Volume I, Through November 7, 1962* (Washington, DC: NASA SP-4009, 1969); Mary Louise Morse and Jean Kernahan Bays, *The Apollo Spacecraft: A Chronology, Volume II, November 8, 1962–September 30, 1964* (Washington, DC: NASA SP-4009, 1973); Courtney G. Brooks and Ivan D. Ertal, *The Apollo Spacecraft: A Chronology, Volume III, October 1, 1964–January 20, 1966* (Washington, DC: NASA SP-4009, 1973); and Ivan D. Ertal and Roland W. Newkirk, with Courtney G. Brooks, *The Apollo Spacecraft: A Chronology, Volume IV, January 21, 1966–July 13, 1974* (Washington, DC: NASA SP-4009, 1978). A short developmental history is in Ezell, *NASA Historical Data Book*, pp. 171–185.

Apollo capsule atop a stubby Little Joe II military booster, and another Apollo capsule actually achieved orbit on 18 September 1964 when it was launched atop a Saturn I. By the end of 1966, NASA leaders declared the Apollo command module ready for human occupancy. The final flight checkout of the spacecraft prior to the lunar flight took place on 11–22 October 1968 with three astronauts.[97]

As these development activities were taking place, tragedy struck the Apollo program. On 27 January 1967, Apollo-Saturn (AS) 204, scheduled to be the first spaceflight with astronauts aboard the capsule, was on the launch pad at Kennedy Space Center, Florida moving through simulation tests. The three astronauts to fly on this mission—"Gus" Grissom, Edward White, and Roger B. Chaffee—were aboard running through a mock launch sequence. At 6:31 p.m., after several hours of work, a fire broke out in the spacecraft, and the pure oxygen atmosphere intended for the flight helped it burn with intensity. In a flash, flames engulfed the capsule, and the astronauts died of asphyxiation. It took the ground crew 5 minutes to open the hatch. When they did so, they found three bodies. Although three other astronauts had been killed before this time—all in plane crashes—these were the first deaths directly attributable to the U.S. space program.[98]

Shock gripped NASA and the nation during the days that followed. As the nation mourned, NASA appointed an eight-member investigation board, chaired by longtime NASA official and Director of the Langley Research Center, Floyd L. Thompson. It set out to discover the details of the tragedy: what happened, why it happened, could it happen again, what was at fault, and how could NASA recover? The members of the board learned that the fire had been caused by a short circuit in the electrical system that ignited combustible materials in the spacecraft fed by the oxygen atmosphere. They also found that it could have been prevented and called for several modifications to the spacecraft, including a move to a less oxygen-rich environment. Changes to the capsule followed quickly, thanks to the efforts of a dedicated team of engineers under Gilruth's and others' direction. Within a little more than a year, it was ready for flight.[99]

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97 Ezell, *NASA Historical Data Book,* pp. 182–185.

98 On this subject, see "The Ten Desperate Minutes," *Life* (21 April 1967): 113–114; Erik Bergaust, *Murder on Pad 34* (New York: G. P. Putnam's Sons, 1968); Mike Gray, *Angle of Attack: Harrison Storms and the Race to the Moon* (New York: W. W. Norton and Co., 1992); Erlend A. Kennan and Edmund H. Harvey, Jr., *Mission to the Moon: A Critical Examination of NASA and the Space Program* (New York: William Morrow and Co., 1969); Hugo Young, Bryan Silcock, and Peter Dunn, *Journey to Tranquillity: The History of Man's Assault on the Moon* (Garden City, NY: Doubleday, 1970); and Brooks, Grimwood, and Swenson, *Chariots for Apollo*, pp. 213–236.

99 United States House, Committee on Science and Astronautics, Subcommittee on NASA Oversight, *Investigation into Apollo 204 Accident, Hearings, Ninetieth Congress, First Session* (Washington, DC: Government Printing Office, 1967); United States House, Committee on Science and Astronautics, *Apollo Program Pace and Progress; Staff Study for the Subcommittee on NASA Oversight, Ninetieth Congress, First Session* (Washington, DC: Government Printing Office, 1967); United States House, Committee on Science and Aeronautics, *Apollo and Apollo Applications: Staff Study for the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, U.S. House of Representatives, Ninetieth Congress, Second Session* (Washington, DC: Government Printing Office, 1968); and Robert C. Seamans, Jr., and Frederick I. Ordway III, "Lessons of Apollo for Large-Scale Technology," in *Between Sputnik and the Shuttle: New Perspectives on American Astronautics*, ed. Frederick C. Durant III (San Diego: Univelt, 1981), pp. 241–287.

GODFATHER TO THE ASTRONAUTS

The Apollo fire shook Gilruth personally, for he had served since the beginning of the Mercury program as leader and mentor to the young men selected to fly the Apollo missions, whether they set foot on the Moon or performed a less visible but no less significant role. Gilruth included the astronauts in the decision-making process at the Manned Spacecraft Center, not only for crew systems, but also for the larger Apollo technical requirements. Gilruth held weekly meetings with his senior staff, including the astronaut corps. "We'd spend the morning talking about all of our problems," he recalled, "and this was a pretty effective thing to do. Sometimes it would maybe take 1 or 2 hours, and sometimes it would take all morning." Gilruth added, "It was obvious they should report to the Director's office, to me. They shouldn't report to the people designing the spacecraft, because if they disliked something the spacecraft designers were doing they ought to be able to bitch about it."[100] Gilruth had enormous respect for them, sometimes calling them his boys. This seems fully in keeping with this philosophy of leadership, with an older visionary overseeing the stupendous accomplishments of young and virile heroes. It is one of the most powerful conceptions in myth and human history—Merlin/King Arthur, Obi-Wan Kenobi/Luke Skywalker, Gandalf/Frodo Baggins, Lincoln/Union Army, FDR/G.I. generation—with the greybeard prophet teaching and motivating the young civic-minded heroes who accomplish great tasks under that guidance. That certainly took place in the context of the relationship between the older Gilruth and the young astronauts who went to the Moon. Gilruth was a prophet, possessing vision, values, and ideals concerning a future for America in space. As heroes, the astronauts possessed community, affluence, and technology. They made a powerful team, accomplishing the task required. NASA eventually landed six sets of astronauts on the Moon between 1969 and 1972. The first landing mission, Apollo 11, succeeded on 20 July 1969 when astronaut Neil Armstrong first set foot on the lunar surface, telling millions of listeners that it was "one small step for [a] man—one giant leap for mankind." Five more landing missions followed Apollo 11 at approximately six-month intervals through December 1972.[101]

The astronauts were in too many instances rambunctious boys, as Gilruth called them. They roughhoused and drank and drove fast and got into sexual peccadilloes. Rumors swirled around several of the Apollo astronauts, especially Gus Grissom, whom Gilruth considered a consummate professional in the cockpit and an incorrigible adolescent whenever off duty. Everyone laughed, including Gilruth, when Grissom said, "There's a certain

100 Gilruth OHI No. 6 by DeVorkin and Mauer.

101 For a stimulating discussion of this dynamic in American history, see William Strauss and Neil Howe, *The Fourth Turning* (New York: Broadway Books, 1996); and William Strauss and Neil Howe, *Generations: The History of America's Future, 1584 to 2069* (New York: William Morrow, 1992).

Dr. Robert R. Gilruth's official portrait while he was serving as Director of the Manned Spacecraft Center in Houston, TX. 1965. (Center number S87-26820)

kind of small black fly that hatches in the spring around the Space Center south of Houston. Swarms of the bugs can splatter [on] 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 fucking—and they do them at the same time." For years thereafter, the insects were known as "Grissom Bugs" to local residents.[102] 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, certainly Gilruth understood it.[103]

Sometimes the astronauts caused Gilruth grief, and he could rule with an authoritarian hand. More often, however, he was 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, Gilruth had to disallow an outright gift to the astronauts.[104] 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 in selling their stories to *Life* magazine. This had raised a furor, and NASA policies were changed thereafter. However, in 1963 Forrest Moore complained to LBJ that the new astronauts were 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.[105] Gilruth also defended the astronauts to the NASA leadership when they accepted tickets to see the Houston Astros season opener baseball game in the

102 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 the letter from 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, TX.

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

104 Letter from Edward Welsh to Lyndon B. Johnson, "Gift of Houses to Astronauts" (2 April 1962), VP Papers, LBJ Library, Box 182; and Gilruth OHI No. 6 by DeVorkin and Mauer.

105 Letter from LBJ to Forrest Moore, President, Rominger Advertising Agency (14 June 1963), VP Papers, LBJ Library, Box 237.

new Astrodome in 1965, although he reprimanded several for poor judgment. While he told his superiors that he saw no reason why they should not enjoy the experience, he ensured that this type of media problem did not repeat itself. He also disliked and privately chastised, but publicly defended, Gus Grissom over the famous corned beef sandwich episode during Gemini III. He took licks such as the following 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.[106]

None of this suggests that Gilruth let the astronauts run amuck. He 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—he could be enormously stern. Gilruth 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.

At a fundamental level, moreover, he basked in the reflected glory of the astronauts. He enjoyed being with them and loved their humor and passion for life. He said, "People used to tell me that I had no control over the astronauts. I'll tell you, those boys were wonderful." He took seriously the selection of the best crews and worked with them personally to ensure success. He worked with Deke Slayton to establish the most effective crews. Slayton "would just tell me who he thought would be the best for the next crew. I'd ask him the questions I had to ask about why, what he based it on. If there was something that I knew about this young man, where he might have had some problem, physical problems or something, was he all better from those? Of course he wouldn't have been picked if he hadn't been. As you say, they were all very high-caliber people, and all would have done a good job."[107] These men were his charges. They carried with them his and the entire nation's best wishes. Gilruth agreed with the sentiments expressed by Cynthia McQuillin in her 1983 poem "Star Fire" about the Apollo astronauts:

106 Letter from James E. Webb to Robert R. Gilruth (15 April 1965), James E. Webb Papers, Box 113, NASA-Astronaut Notes, Truman Library, Independence, MO.

107 Gilruth OHI No. 6 by DeVorkin and Mauer.

Ten thousand hands to build the shining shell.
    It took a dozen years and love to build it well.

Everyone who touched its birth,
    Though they be bound on Earth,
Will be with the astronauts that in her dwell.[108]

Gilruth, and everyone who met them, was fascinated by the apparent willingness of these young men to risk their lives for the good of a national cause. Tom Wolfe captured the method of this imagery some 20 years later in *The Right Stuff*. He wrote: "The astronauts were not brave in a stupid, unknowing way. Any fool could throw his or her life away. No, the idea here . . . seemed to be that a man should have the ability to go up in a hurling piece of machinery and put his hide on the line and then have the moxie, the reflexes, the experience, the coolness to pull it back in the last yawning moment—and then to go up again *the next day*."[109] The bravery of the astronauts touched emotions deeply seated in the American experience of the 20th century, felt by Gilruth perhaps most of all. He remained friends with them—but also in awe of them—his entire life.[110]

GILRUTH AND THE LEGACY OF APOLLO

Between 1968 and 1972, Apollo achieved its goals. Gilruth, approaching retirement, recognized that with the end of the Apollo program nothing would be the same. He spent 10 years as the Director of the Manned Spacecraft Center (1961–1971) directing 25 human spaceflights, including Alan Shepard's first Mercury flight in May 1961, the first lunar landing by Apollo 11 in July 1969, the dramatic rescue of Apollo 13 in 1970, and the Apollo 15 mission in July 1971. In January 1972, as Apollo was wrapping up, he served as Director of Key Personnel Development at NASA Headquarters in Washington, DC, retiring from federal service in December 1973. At that point, he devoted himself full time to building the boat of his dreams, one in which he could circumnavigate the world. He completed a 52-foot multi-hull boat, sailed it to his retirement home in Virginia, but never felt his nautical skills matched his astronautical ones; so he never sailed around the world. His close associate in Houston, George Low, said of him, "There

108 Cynthia McQuillin, "Star Fire," on *To Touch the Stars* (Sunnyvale, CA: Prometheus Music, 2004).
109 Tom Wolfe, *The Right Stuff* (New York: Farrar, Straus, and Giroux, 1979), p. 24.
110 Richard Slotkin, *Gunfighter Nation* (New York: Atheneum, 1992).

is no question that without Bob Gilruth there would not have been a Mercury, Gemini, or an Apollo program. He built in terms of what he felt was needed to run a manned spaceflight program . . . it is clear to all who have been associated with him that he has been the leader of all that is manned spaceflight in this country."[111]

Gilruth was justifiably proud of his role in Project Apollo. He commented on several key legacies from it. First, the Apollo program was successful in accomplishing the political goals for which it had been created. Kennedy had been dealing with a Cold War crisis in 1961 brought on by several separate factors—the Soviet orbiting of Yuri Gagarin and the disastrous Bay of Pigs invasion only two of them—that Apollo was designed to combat. At the time of the Apollo 11 landing, Mission Control in Houston flashed the words of President Kennedy announcing the Apollo commitment on its big screen. Those phrases were followed with these: "TASK ACCOMPLISHED, July 1969." When Gilruth lit up his characteristic cigar in Mission Control when Apollo 11 touched down, he understood that no greater understatement could probably have been made. It became more obvious with every passing year that any assessment of Apollo that did not recognize the accomplishment of landing an American on the Moon and safely returning before the end of the 1960s was incomplete and inaccurate, for that was the primary goal of the undertaking, and Gilruth and the other individuals who worked on the effort deserved recognition for making this dream a reality.[112]

Second, Project Apollo was a triumph of management in meeting the enormously difficult systems engineering and technological integration requirements. Gilruth always believed that Apollo was much more a management exercise than anything else and that the technological challenge, while sophisticated and impressive, was also within grasp. More difficult was ensuring that those technological skills were properly managed and used.[113] Through the decade of the 1960s, the space program provided one of the leading examples of a government technological program that worked. It inspired public confidence in the ability of government to accomplish great feats. Even as other government initiatives failed, civilian spaceflights continued to succeed. Actor Carroll O'Connor perhaps said it best in an episode of *All in the Family* in 1971. Portraying the character of Archie Bunker, the bigoted working-class American whose perspectives were more common in our society than many observers were comfortable with, O'Connor summarized well how most Americans responded to the culture of competence that Apollo engendered. He observed that he had "a genuine facsimile of the Apollo 14 insignia. That's

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111 NASA Press Release H00-127, "Dr. Robert Gilruth, An Architect of Manned Space Flight, Dies" (17 August 2000), NASA Headquarters Historical Reference Collection, Washington, DC; and Pearce Wright, "Robert Gilruth: Rocket Engineer Who Put Americans into Space," *Guardian* (London, U.K., 20 August 2000).

112 John Pike, "Apollo—Perspectives and Provocations," Cold War History Symposium (11 May 1994), Ripley Center, Smithsonian Institution, Washington, DC.

113 See Arnold S. Levine, *Managing NASA in the Apollo Era* (Washington, DC: NASA SP-4102, 1982); and Sylvia D. Fries, *NASA Engineers and the Age of Apollo* (Washington, DC: NASA SP-4104, 1992).

the thing that sets the U.S. of A. apart from . . . all them other losers."[114] In very specific terms, Archie Bunker encapsulated for everyone what set the United States apart from every other nation in the world—success in spaceflight. At a basic level, Gilruth and Apollo provided the impetus for the perception of NASA as a culture of competence, one of the great myths emerging from the lunar landing program. This contention was true beyond all bounds, and subsequent tragedies have failed to demonstrate this level of continuing excellence shown throughout the Apollo era.

Third, by sheer serendipity Apollo taught humanity about itself and in the process altered our perception of the world in which we live. Apollo 8 was critical to this fundamental change, as it treated the world to the first pictures of Earth from afar. For example, Anne Morrow Lindbergh suggested in *Earthshine* (1969) that humanity gained a "new sense of awe and mystery in the face of the vast marvels of the solar system." She added, "Man had to free himself from Earth to perceive both its diminutive place in the solar system and its inestimable value as a life-fostering planet." The poet Archibald MacLeish said it this way: "To see the Earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the Earth together, brothers on that bright loveliness in the eternal cold—brothers who know now that they are truly brothers."[115] The modern environmental movement was galvanized in part by this new perception of the planet and the need to protect it and the life that it supports.[116]

Finally, Gilruth would agree that the Apollo program, while an enormous achievement, left a divided legacy for NASA and the aerospace community. The perceived "golden age" of Apollo created for the Agency an expectation that the direction of any major space goal from the President would always bring NASA a broad consensus of support and provide it with the resources and license to dispense them as it saw fit. Something most NASA officials did not understand at the time of the Moon landing in 1969, however, was that Apollo had not been a normal situation and would not be repeated. The Apollo decision was, therefore, an anomaly in the national decision-making process. The dilemma of the "golden age" of Apollo has been difficult to overcome, but moving beyond the Apollo program to embrace future opportunities has been an important goal of the Agency's leadership in the recent past. Exploration of the solar system and the universe remains as enticing a goal and as important an objective for humanity as it ever has been. Project Apollo was an important early step in that ongoing process of exploration.[117]

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114 "Carroll O'Connor Obituary," *Morning Edition*, National Public Radio (22 June 2001). This report by Andy Bowers is available online at *http://www.npr.org* (accessed 2 July 2001).

115 Oran Nicks, ed., *This Island Earth* (Washington, DC: NASA SP-250, 1970), p. 3.

116 R. Cargill Hall, "Project Apollo in Retrospect" (20 June 1990), pp. 25–26, R. Cargill Hall Biographical File, NASA Headquarters Historical Reference Collection, Washington, DC.

117 As an example, see the argument made in George M. Low, Team Leader, to Mr. Richard Fairbanks, Director, Transition Resources and Development Group, "Report of the NASA Transition Team" (19 December 1980), NASA Headquarters Historical Reference Collection, Washington, DC, which advocated for strong presidential leadership to make everything right with the U.S. space program.

CONCLUSION

Gilruth wrote several reflective essays on the method of accomplishment and the meaning of Apollo.[118] He commented, "In thinking back over the flights of Apollo, I am impressed at the intrinsic excellence of the plan that had evolved. I have, of course, somewhat oversimplified its evolution, and there were times when we became discouraged, and when it seemed that the sheer scope of the task would overwhelm us in some areas there were surprises, and other areas proceeded quite naturally and smoothly." He added:

> The most cruel surprise in the program was the loss of three astronauts in the Apollo fire, which occurred before our first manned flight. It was difficult for the country to understand how this could have occurred, and it seemed for a time that the program might not survive. I believe that the self-imposed discipline that resulted, and the ever-greater efforts on quality, enhanced our chances for success, coming as they did while the spacecraft was being rebuilt and final plans formulated . . . .
>
> The flights came off almost routinely following Apollo 8 on through the first lunar landing and the flight to the Surveyor crater. But Apollo 13 was to see our first major inflight emergency when an explosion in the service module cut off the oxygen supply to the command module. Fortunately, the LM was docked to the CSM, and its oxygen and electric power, as well as its propulsion rocket, were available. During the four-day ordeal of Apollo 13, the world watched breathlessly while the LM pushed the stricken command module around the Moon and back to Earth. Precarious though it was, Apollo 13 showed the merit of having separate spacecraft modules, and of training of flight and ground crews to adapt to emergency. The ability of the flight directors on the ground to read out the status of flight equipment, and the training of astronauts to meet emergencies, paid off on this mission.
>
> Apollo surely is a prototype for explorations of the future when we again send men into space to build a base on the Moon or to explore even farther away from Earth.[119]

His last sentence is an understatement—something he fully realized as the years passed and America did not return to the Moon.

Robert Gilruth died on 17 August 2000, and the spaceflight community mourned. He was 86 years old by then and had suffered from Alzheimer's disease for a number of years. He never enjoyed the public stature of Wernher von Braun or James Webb. He certainly

118 See, for example, Robert R. Gilruth, "To the Moon and Beyond," *The Aeronautical Journal* 75 (January 1971): 1–17.

119 Robert R. Gilruth, "I Believe We Should Go to the Moon," in *Apollo Expeditions to the Moon,* ed. Edgar M. Cortright (Washington, DC: NASA SP-350, 1975), p. 39.

Wearing special germ-free clothing, Dr. Robert R. Gilruth, right, inspects lunar samples collected during the Apollo 17 mission, NASA's final Apollo flight in 1973. (Center number S73-34103)

never enjoyed the adulation of the astronauts. But he may be seen in innumerable film and photographs standing beside—or more often slightly behind—those people at some public event. He was decorated for his efforts by Kennedy and Johnson, and he specifically was singled out for recognition with a Robert J. Collier Trophy in 1971 "as representative of the engineering genius of the manned spaceflight team culminating in Apollo 15—man's most prolonged and scientifically productive lunar mission."[120] He was an unsung leader in the race to the Moon.

I believe Gilruth would agree that Apollo represented the unique creation and operation of technological systems that accounted for the perceptions of the U.S. as a people who master machines. We are a technological and an organizational people, and the structures we created to carry out Apollo are not just the so-called hardware of the system, but also the management structure, the organizations, the processes and procedures of operation, the people assigned, and the transportation and information networks that interconnect everything. In NASA, these technological systems included not just the spacecraft, but also the organizations, people, communications, manufacturing components, and even the political structure. It is the task of the modern makers of systems to direct the values of order, system, and control that are embedded in the machines of modern technology. The real legacy of Apollo for the modern American should probably be to understand the system and how to control it so that order will emerge sufficiently to make the success of the endeavor a reality. That, coupled with the dreams of the possible and the unwillingness to believe the experts when they say it cannot be done, might be the greatest lesson of Apollo for the modern

120 NASA Press Release H00-127, "Dr. Robert Gilruth"; JSC Press Release J00-49, "Statement by Johnson Space Center Director George W. S. Abbey Marking the Death of Dr. Robert R. Gilruth" (17 August 2000); and W. Henry Lambright, "Managing America to the Moon: A Coalition Analysis," in *From Engineering Science*, ed. Mack, pp. 193–211.

nation. Who knows what might happen when we fail to listen to those who say, "It can't be done." We might be able, as we once were, to promise the Moon and to deliver.

He would not have enjoyed this lament for what the United States has lost with the end of the Apollo program captured in the following poem entitled "Legends," by Bill Roper:

Once upon a time,
You could hear the Saturn's roar
As it rose upon its fiery tail to space.
And once upon a time, the men that we sent out
Landed in a strange and alien place.

And as I watched them walk upon the Moon,
I remembered Icarus,
Who flew too close to the Sun.

Once upon a time, they tore the gantries down
And the rockets flew no longer to the Moon.
And once upon a time,
We swore that we'd return,
But it doesn't look like we'll be back there soon.

And as the Moon shines down
On the shattered launching ground,
I remember Apollo,
Who flew the chariot of the Sun.
And I wonder of the legends they will tell
A thousand years from now.[121]

He would have applauded the announcement made by President George W. Bush on 14 January 2004 that the United States would return to the Moon between 2015 and 2020. With sufficient diligence and resources, Gilruth always believed that virtually anything humans can imagine in spaceflight may be achieved. He would have been concerned, however, that neither sufficient diligence nor resources would be available for this great initiative.[122]

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121 Bill Roper, "Legends" (1980), *To Touch the Stars* (Sunnyvale, CA: Prometheus Music, 2004).

122 White House Press Release, "Fact Sheet: A Renewed Spirit of Discovery" (14 January 2004), available online at *http://www.whitehouse.gov/news/releases/2004/01/20040114-1.html* (accessed 4 April 2004).