

Chapter 2

PROJECT APOLLO: AMERICANS TO THE MOON

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Project Apollo, the remarkable U.S. space effort that sent twelve astronauts to the surface on the Earth's Moon between July 1969 and December 1972, has been extensively chronicled and analyzed.¹ This essay will not attempt to add to this extensive body of literature. Its ambition is much more modest: to provide a coherent narrative within which to place the various documents included in this compendium. In this narrative, key decisions along the path to Moon will be given particular attention.

Origins of Apollo

When it began operations on October 1, 1958, NASA had already been tasked by the Eisenhower administration with the initial U.S. human space flight effort, soon to be designated Project Mercury. NASA also inherited a number of robotic missions that had been planned by various elements of the Department of Defense and was given an agenda of desired missions by the Space Science Board of the National Academy of Sciences. NASA spent much of 1959 integrating these missions into a Long-Range Plan; to do so, it also recognized the need to identify its long-range goals for human space flight and the steps needed achieve those goals. To undertake this task, NASA in spring 1959 created a Research Steering Committee on Manned Space Flight. This Committee was chaired by Harry Goett, then of NASA's Ames Research Center but soon to become the Director of the new Goddard Space Flight Center. The Committee held its first meeting on May 25-

26, 1959. Its members included senior representatives from the NASA field centers and the agency's Washington Headquarters.

At this meeting, Bruce Lundin from the Lewis Research Center argued that “the ultimate objective is manned interplanetary travel and our present goal should be for a manned lunar landing and return.” Engineer and spacecraft designer Maxime Faget of the Space Task Group of the Langley Research Center “endorsed selecting lunar exploration as the present goal of the Committee although the end objective should be manned interplanetary travel.” George M. Low, then in charge of human space flight at NASA headquarters, suggested that the Committee adopt the lunar landing mission as NASA's present long range objective with proper emphasis on intermediate steps “because this approach will be easier to sell.” Others at the meeting suggested a more modest objective, human flight around the Moon without a landing attempt, be adopted as NASA's stated goal. (II-1)

There was no agreement at this point, but by the Committee's next meeting in late June, after George Low had lobbied the group, the Committee decided that indeed a lunar landing should be selected as the long-range goal for human space flight, with an orbiting space station and circumlunar flight as intermediate steps. The NASA Long Range Plan, published in December 1959, thus identified as objectives for the 1965-1967 time period the first launches “in a program leading to manned circumlunar flight and to [a] permanent near-earth space station.” The objective of “manned flight to the moon” was identified, but only in the “beyond 1970” period. (Volume I, III-2) While Low and some of his associates would have preferred a faster paced effort, at least NASA, after only

fifteen months of operation, was on record as intending to head to the Moon, if only they could get the White House and Congress to agree.

In mid-1960, NASA's thinking about the intermediate steps in human space flight had matured to the point that the space agency called together representatives of the emerging space industry to share that thinking. At a "NASA-Industry Program Plans Conference" held in Washington on July 28-29, 1960, George Low told the audience "at this point it should be stated that official approval of this program has not been obtained. Rather, this presentation includes what we now believe to be a rational and reasonable approach to a long-range development program leading to the manned exploration of outer space." He added "our present planning calls for the development and construction of an advanced manned spacecraft with sufficient flexibility to be capable of both circumlunar flight and useful earth-orbital missions. In the long range, this spacecraft should lead toward manned landings on the moon and planets, and toward a permanent manned space station. This advanced manned space flight program has been named 'Project Apollo.'" (II-2).

The name Apollo had been suggested by Low's boss, NASA's Director for Space Flight Programs Abe Silverstein, in early 1960. Silverstein had also chosen the name for Project Mercury, and he wanted to establish a tradition of naming NASA's projects after Greek gods.²

NASA, and particularly George Low, in the second half of 1960 continued to move forward in planning Apollo and the lunar landing mission that was its long-term goal. On October 17, he informed Silverstein "it has become increasingly apparent that a preliminary program for manned lunar landings should be formulated. This is necessary

in order to provide a proper justification for Apollo, and to place Apollo schedules and technical plans on a firmer foundation.” To undertake this planning, Low formed a small working group of NASA Headquarters staff. (II-3)

That NASA was planning advanced human spaceflight missions, including one to land people on the Moon, soon came to the attention of President Eisenhower and his advisors as NASA submitted a budget request that included funds for industry studies of the Apollo spacecraft. This request was not approved, and the president asked his science adviser, Harvard chemist George Kistiakowsky, to organize a study of NASA’s plans by the President’s Science Advisory Committee; to carry out such a study, Kistiakowsky established an “Ad Hoc Committee on Man-in-Space” chaired by Brown University professor Donald Hornig. The Hornig Committee issued its report on December 16, 1960. The report called Project Mercury a “somewhat marginal effort,” and noted “among the reasons for attempting the manned exploration of space are emotional compulsions and national aspirations. These are not subjects which can be discussed on technical grounds.” The Committee estimated the cost of Project Apollo at \$8 billion, and suggested that a program to land humans on the Moon would cost an additional \$26-38 billion. (Volume I, III-3) When President Eisenhower was briefed on the report, he found these projected costs well beyond what he thought reasonable. When a comparison was made to Queen Isabella’s willingness to finance the voyages of Christopher Columbus, Eisenhower replied that “he was not about to hock his jewels” to send men to the Moon.³

George Low’s working group on a manned lunar landing presented its interim findings to a meeting of NASA’s Space Exploration Program Council in early January

1961; the Council decided that Low should continue his planning effort. However, outgoing NASA Administrator T. Keith Glennan reminded Low that such a program would require presidential approval, and that approval had not been forthcoming. Indeed, as President Dwight D. Eisenhower left office on January 20, 1961, the future of NASA's program of human spaceflight was extremely uncertain. There were no funds in the President's final budget proposal to support Project Apollo, and it was known that the incoming President, John F. Kennedy, was receiving advice skeptical of the value of launching humans in space. There certainly was no sense that Kennedy would within four months decide to send Americans to the Moon.

The Decision to Go to the Moon⁴

As he entered the White House, John Kennedy was aware that he would be faced with decisions that would shape the future of U.S. space efforts. One of his top advisers during the period between the election and his taking office, Harvard professor Richard Neustadt, told Kennedy in December 1960 that the United States had been in a race for dramatic space achievements, a race that the Soviet Union was winning because of their superior space lift capability. Neustadt asked "if we are behind and are likely to stay behind in the race for 'Sputnik-type firsts,' should we get out of the race and divert the resources now tied up in it to other uses which have tangible military, scientific or welfare value?" Neustadt was skeptical of the value of the Saturn rockets,⁵ which he noted were needed "only in order to put a man on the moon" before Russia, but he did support the development of a very large rocket motor (the F-1). He asked Kennedy "in

the longer run, what proportion of Government resources, for what span of years, should go into developing the technology of space travel?" (Volume I, III-4)

Kennedy also appointed during the transition an "Ad Hoc Committee on Space," which was chaired by the man who would become his science adviser, MIT Professor Jerome Wiesner. This committee recognized that "manned exploration of space will certainly come to pass and we believe that the United States must play a vigorous role in this venture," but that "because of our lag in the development of large boosters, it is very unlikely that we shall be first in placing a man into orbit." However, the committee believed that too much emphasis had been placed on Project Mercury in comparison to its actual scientific and technological payoffs, and recommended that "we should stop advertising MERCURY as our major objective in space activities. . . . We should find effective means to make people appreciate the cultural, public service and military importance of space activities other than [human] space travel." (Volume I, III-5)

In his Inaugural Address, delivered on a wintry Washington afternoon, President John F. Kennedy suggested to the leaders of the Soviet Union that "together let us explore the stars."⁶ In his initial thinking about space policy, Kennedy favored using space activities as a way of increasing the peaceful interactions between the United States and its Cold War adversary. Soon after he came to the White House, Kennedy directed his science adviser to undertake an intensive review to identify areas of potential U.S.-Soviet space cooperation, and that review continued for the first three months of the Kennedy administration, only to be overtaken by the need to respond to the Soviet launch of Yuri Gagarin on April 12. Soviet-U.S. cooperation in space was a theme that Kennedy was to return to in subsequent years.

A first order of business was to select someone to head NASA. After a number of candidates indicated that they were not interested in the position, on the advice of his Vice President, Lyndon B. Johnson, powerful Oklahoma Senator Robert Kerr, incoming chairman of the Senate Committee on Aeronautical and Space Sciences, and his science adviser Jerome Wiesner, Kennedy on January 31 turned to James E. Webb. The NASA position was one of the last top-level jobs to be filled by the new administration. Webb was from North Carolina, trained as a lawyer, and veteran of both the Congressional staff and senior executive branch positions during the Truman administration as well as business experience working for one of Kerr's companies in Oklahoma.⁷ Webb agreed to take the NASA job, but only after meeting with the President, who told Webb that he wanted "someone who understands policy. This program involves great issues of national and international policy." Webb got assurances from the President that respected scientist and manager Hugh Dryden would be allowed to stay on as NASA's Deputy Administrator. Webb also decided to retain Associate Administrator Robert Seamans, who served as the agency's general manager. Seamans was a Republican, and Webb wanted to present NASA as not being influenced by partisan politics. Webb was sworn in as NASA Administrator on February 14.⁸

John Kennedy's closest advisor, Theodore Sorenson, was later to comment that "Webb was not what we would call a Kennedy type individual. He was inclined to talk at great length, and the President preferred those who were more concise in their remarks. He was inclined to be rather vague, somewhat disorganized in his approach to a problem, and the President preferred those who were more precise." However, according to

Sorenson, "I don't know that the President ever regretted his appointment of Webb, or wished that he had named someone else." (II-43)

Once Webb arrived at NASA, a first task was to review the agency's proposed budget for Fiscal Year 1962 that had been prepared by the outgoing Eisenhower administration. In doing so, Webb and his associates came to the conclusion that NASA's planning had been too conservative, and that the milestones included in the agency's ten-year plan should be accelerated. One input into this conclusion was the February 7 final report of Low's Working Group, which concluded that "the present state of knowledge is such that no invention or breakthrough is believed to be required to insure the over-all feasibility of safe manned lunar flight," that "manned landings on the moon . . . could be made in the 1968-1971 time period," and that it would be possible to carry out a lunar landing program for a total cost of \$7 billion. (II-4)

Based on this and other analyses, NASA requested a 30 per cent increase in its FY1962 budget over what had been proposed by President Eisenhower. The Bureau of the Budget reacted negatively to such a large increase, and on March 22, 1961 Webb, Dryden, and Seamans met with President Kennedy and his staff to discuss how best to proceed. At that meeting, NASA noted that President Eisenhower had eliminated from the NASA budget all funds related to human flight after Project Mercury, including the Apollo spacecraft and heavier lift boosters and rocket motors. Webb told the President that "the Soviets have demonstrated how effective space exploration can be as a symbol of scientific progress and as an adjunct of foreign policy. . . . We cannot regain the prestige we have lost without improving our present inferior booster capability."

Kennedy had at this point not made up his own mind about the future of human space flight, and so he was unwilling to approve NASA's request to restore funds for the Apollo spacecraft; the sense is that decisions on this issue would come during the preparation of the FY1963 NASA budget at the end of 1961. Support for the importance of human space flight, as the President deliberated on its future, came from the Space Sciences Board of the National Academy of Sciences. The chairman of that Board, Lloyd Berkner, was a long-time friend of James Webb, and on March 31 he sent Webb and Kennedy's science adviser Jerome Wiesner a letter reporting that the Board had agreed that "from a scientific standpoint, there seems little room for dissent that man's participation in the exploration of the Moon and planets will be essential, if and when it becomes technologically feasible to include him." (II-5)

Kennedy and his advisers did agree that the United States, for a variety of reasons, needed to approve its space lift capabilities, and so he approved an additional \$114 million for launch vehicle development. These matters were planned to rest until NASA was successful in its initial flights of Project Mercury, planned for later in 1961, and it came time to formulate the NASA budget for FY1963.

Events forced the President's hand much earlier than he had anticipated. In the early morning hours of April 12, word reached the White House that the Soviet Union had successfully orbited its first cosmonaut, Yuri Gagarin, and that he had safely returned to Earth. The Soviet Union was quick to capitalize on the propaganda impact of the Gagarin flight; Nikita Khrushchev boasted, "Let the capitalist countries catch up with our country!" In the United States, both the public and the Congress demanded a response to the Soviet achievement.

President Kennedy called a meeting of his advisers for the late afternoon of April 14 to discuss what that response might be. Kennedy also agreed to an interview the same afternoon with Hugh Sidey, a top reporter for *Life* and *Time* magazines and someone on friendly terms with the President (as were many journalists). In preparation for that interview, Sidey prepared a set of questions and transmitted them to Presidential Press Secretary Pierre Salinger. Wiesner then prepared a background memorandum for the President's use in responding to Sidey. (II-6, II-7)

Rather than meet separately with Sidey, the President decided to let him join the meeting with Webb and Dryden and Kennedy's top advisers; Sidey later described the meeting in a book about Kennedy. Dryden told the President that to catch up with the Russians might require a crash program on the order of the Manhattan Project that developed the atomic bomb; such an effort might cost as much as \$40 billion. After hearing the discussions of what might be done, according to Sidey, Kennedy's response was "when we know more, I can decide if it's worth it or not. If someone can just tell me how to catch up. . . . There's nothing more important."⁹

While Kennedy considered his course of action, other events reinforced his need to get something positive in place. On the morning of April 17, CIA-trained Cubans were landed at the Bay of Pigs in Cuba in an attempt to foment an uprising that would result in forcing Fidel Castro to give up his leadership position. During the following two days, Kennedy and his advisers decided not to offer U.S. military support to this failing invasion; as a result, the United States looked weak and vacillating to much of the rest of the world.

Kennedy had decided in December to give his Vice-President, Lyndon Johnson, lead responsibility for advising him on space as the Chairman of the existing National Aeronautics and Space Council. That Council had been set up as part of the 1958 Space Act, with the President as Chair. Thus legislative action was needed to give the chairmanship to the Vice President. The President signed the legislation making this change on April 20, and on that same day wrote a historic memorandum to the Vice-President, asking him “as Chairman of the Space Council to be in charge of making an overall survey of where we stand in space.” In particular, Kennedy asked, “Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or by a rocket to go to the moon and back with a man. Is there any other space program which promises dramatic results in which we could win?” (II-8)

Vice-President Johnson quickly organized the review that the President requested. On April 21, he received a first input from the Department of Defense, which suggested that “dramatic achievements in space . . . symbolize the technological power and organizing capability of a nation” and “major achievements in space contribute to national prestige.” (Volume I, III-7) NASA’s response came a day later; the space agency told the President that “there is a chance for the U. S. to be the first to land a man on the moon and return him to earth if a determined national effort is made. . . . It is doubtful that the Russians have a very great head start on the U.S. in the effort required for a manned lunar landing. Because of the distinct superiority of U.S. industrial capacity, engineering, and scientific know-how, we believe that with the necessary national effort, the U. S. may be able to overcome the lead that the Russians might have

up to now.” NASA added “a possible target date for the earliest attempt for a manned lunar landing is 1967, with an accelerated U.S. effort.” NASA told the Vice-President that to carry out the overall NASA ten-year plan at a pace that would allow a first attempt at a lunar landing in 1967 would cost \$33.7 billion through 1970. (II-9)

Lyndon Johnson consulted not only government agencies, but also individuals whom he respected, as he carried out his review. One of those individuals was Wernher von Braun, who told Johnson “we have an excellent chance of beating the Soviets to the *first landing of a crew on the moon* (including return capability, of course) [emphasis in original].” He added, “The reason is that a performance jump by a factor 10 over their present rockets is necessary to accomplish this feat. While today we do not have such a rocket, it is unlikely that the Soviets have it. Therefore, we would not have to enter the race toward this obvious next goal in space exploration against hopeless odds favoring the Soviets.” Von Braun suggested “with an all-out crash program I think we could accomplish this objective in 1967/68.” (II-10)

By April 28, Johnson could report to the President “the U.S. can, if it will, firm up its objectives with a reasonable chance of attaining world leadership in space during this decade.” In particular, he added, “manned exploration of the moon, for example, is not only an achievement with great propaganda value, but it is essential as an objective whether or not we are first in its accomplishment – and we may be able to be first.” (Volume I, III-8)

Johnson continued his review, consulting with leading members of the Congress. (Volume I, III-10) The review took place as NASA was preparing to launch the first suborbital flight in Project Mercury, and there was debate within the White House

regarding whether to televise the event live, given the chance of a catastrophic failure. The decision was made to do so, and on May 5 Alan Shepard became the first American to enter space on a fifteen-minute journey. During the same week, President Kennedy asked Johnson to travel to Southeast Asia to get a sense of the situation there and whether direct U.S. military intervention was required. Johnson wanted to get his final recommendations on space to the President before he left Washington on Monday, May 8; this meant that those preparing the basis for those recommendations would have to work over the weekend.

By the morning of May 8, James Webb and Secretary of Defense Robert McNamara had signed a report titled “Recommendations for Our National Space Program: Changes, Policies, Goals.” They transmitted the report to the Vice President, saying “this document represents our joint thinking. We recommend that, if you concur with its contents and recommendations, it be transmitted to the President for his information and as a basis for early adoption and implementation of the revised and expanded objectives which it contains.” Johnson later that day did deliver the report to the President, without modification and with his concurrence; incidentally May 8 was the day on which Alan Shepard came to Washington to celebrate the success of his Mercury mission.

The Webb-McNamara report called for an across-the-board acceleration of the U.S. space effort aimed at seeking leadership in all areas, not only dramatic space achievements. As its centerpiece, the report recommended “our National Space Plan include the objective of manned lunar exploration before the end of this decade. It is our belief that manned exploration to the vicinity of and on the surface of the moon

represents a major area in which international competition for achievement in space will be conducted. The orbiting of machines is not the same as the orbiting or landing of man. It is man, not merely machines, in space that captures the imagination of the world.” A very expensive undertaking such as sending humans to the Moon was justified, according to Webb and McNamara, because “*this nation needs to make a positive decision to pursue space projects aimed at enhancing national prestige* [emphasis in original]. Our attainments are a major element in the international competition between the Soviet system and our own. The non-military, non-commercial, non-scientific but ‘civilian’ projects such as lunar and planetary exploration are, in this sense, part of the battle along the fluid front of the cold war.” (II-11)

After a quick review of the report’s recommendations by the White House staff, Kennedy approved them. He announced his decisions at the end of an address to a joint session of the Congress on May 25, 1961. He told the assemblage, and the nation, “I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth.” (Volume I, III-12)

The Congress quickly and without significant opposition approved the \$549 million addition to NASA’s FY1962 budget that was needed to get started on the accelerated program; this amount when added to the increase already approved in March represented an 89 percent increase of the previous year’s budget. With this initial approval in hand, NASA could begin to implement Project Apollo.

Getting Started

Locating the Facilities It was clear from the start of planning for Apollo that NASA would need a major new installation to manage the effort and new facilities for launch the Apollo missions. Prior to the Apollo decision, NASA had planned to move the Space Task Group, which was managing Project Mercury from its base at Langley Research Center in Hampton, Virginia, to the Goddard Space Flight Center in Greenbelt, Maryland. The thinking was that all NASA missions, human and robotic, could be managed by a single field center. But a project of the scope of Apollo would overwhelm other activities at Goddard, and there was high political interest in creating a new NASA center for Apollo. This meant that Governors, Congressmen and Senators, and business representatives from a number of locations around the United States pressured NASA to consider locating the new center in their area. In response, NASA set up a series of criteria that the new facility would have to meet, and a site survey team visited twenty-three potential locations. In particular, the Massachusetts political establishment put pressure on the President to consider a location in his home state, even though the proposed site did not meet all NASA's criteria, especially a climate that would permit year-round outdoor operations. (II-14)

On September 19, 1961, NASA announced that a new Manned Spacecraft Center would be located "in Houston, Texas, on a thousand acres to be made available to the government by Rice University."¹⁰ This decision may well have been pre-ordained. Even before President Kennedy announced his decision to go to the Moon, on May 23 James Webb had written a memorandum to Lyndon Johnson on his return from his inspection trip to Southeast Asia to bring the Vice President up to date on what had

happened in the two weeks he had been away from Washington. Webb noted that he had had several interactions with Representative Albert Thomas of Houston, who chaired the House appropriations subcommittee controlling NASA's budget, and that "Thomas has made it very clear that he and George Brown [Brown was head of the Houston-based construction company Brown & Root and a major political ally of Lyndon Johnson. Brown had been one of the outsiders consulted by Johnson in April as the space review was underway.] were extremely interested in having Rice University make a real contribution" to the accelerated space effort. (Volume II, III-7) Given the influence of Thomas over the NASA budget and the political links between Johnson and Brown, it would have been difficult to choose another location for the new center.

It was also clear to NASA that it would need to build new launch facilities for the large boosters needed for Apollo. At the time the decision to go to the Moon, NASA was already developing the Saturn 1 rocket, with first-stage thrust of 1.5 million pounds coming from a cluster of eight H-1 rocket engines, but it would not have sufficient power to launch human missions to the Moon. NASA in March had gotten White House permission to develop a more powerful Saturn 2 vehicle that added a second stage powered by engines using liquid hydrogen as their fuel. At the start of planning for lunar landing missions, NASA's thinking focused on a new, very large launch vehicle called Nova, which would cluster eight F-1 rocket engines, each with 1.5 million pounds of takeoff thrust, as a means of carrying a spacecraft directly to the lunar surface. As NASA planning moved forward during 1961 (this process is discussed below), variations of an advanced Saturn vehicle, using three, four, and ultimately five F-1 engines in its first stage were considered. While a Saturn 1 or Saturn 2 (which never got beyond the

preliminary design stage) could be launched from an existing launch pad on the Air Force-controlled Atlantic Missile Range at Cape Canaveral, Florida, that range could not accommodate the larger advanced Saturn or Nova boosters.

As a lunar landing decision appeared more and more likely in late April 1961, NASA Associate Administrator Robert Seamans had directed Kurt Debus, a von Braun associate who was in charge of NASA's launch operations at the Atlantic Missile Range, to begin to search for a site to launch much larger boosters. By August, Debus and his associates had examined eight possible locations, including three outside of the continental United States, and had concluded that Merritt Island, Florida, adjacent to Cape Canaveral, was the preferred site, with White Sands, New Mexico as second choice.¹¹ NASA on September 1 announced its intention to purchase 125 square miles of property on Merritt Island; on August 24, 1961, NASA and the Department of Defense had signed an interim agreement on the relationship between what called the Merritt Island Launch Area and the Atlantic Missile Range; that agreement was replaced by a more permanent agreement in January 1963. Anticipating a high launch rate for Saturn vehicles, NASA in 1962 decided to build what was to be called Launch Complex 39; the complex included a huge vertical assembly building where the launch vehicles would be assembled and checked out before being transported to one of two launch pads, designated 39A and 39B. While previously NASA's launch operations at Cape Canaveral had been managed by a division of the Marshall Space Flight Center in Huntsville, for Apollo NASA decided to create a separate Launch Operations Center reporting to NASA Headquarters and named Debus to head the facility.¹² (Volume IV, I-41 and I-42)

In addition to new launch facilities, NASA also needed a site for the assembly of the large first stage of the Saturn I and advanced Saturn vehicles. NASA selected a former ship, airplane, and tank factory located in the outskirts of New Orleans, Louisiana. The land had been granted by French King Louis XV in 1763 to a wealthy but eccentric recluse and junk dealer named Antoine Michoud for use as a plantation, and the plant built on the site almost two hundred years later was named after him. For testing the powerful F-1 engine, after considering 34 sites, NASA chose an isolated location in Hancock County, Mississippi, and christened it the Mississippi Test Facility. Site selection for both facilities was subject to political maneuvering as well as technical criteria.¹³

Finally, NASA also had to decide where to locate the control center to manage the Apollo missions once they were underway. The mission control center for Project Mercury was located at Cape Canaveral in Florida, and there was some thought of placing the Apollo control room there. By mid-1962, however, NASA decided that a new Mission Control Center should be created as part of the Manned Spacecraft Center in Houston. (II-25)

Building the Spacecraft As noted earlier, NASA had been thinking about an advanced spacecraft called Apollo since at least 1960. Thus the organization was able quickly to initiate the procurement of the vehicle, even before it was known exactly how it would be used for the lunar landing mission. By July 28, 1961 NASA had an approved procurement plan in place; twelve firms were identified as potential bidders. (II-13) Ultimately, only five bids for the contract were submitted. The competition for the Apollo spacecraft contract took place over the following four months; on November 28,

NASA announced that North American Aviation had been selected to build the vehicle. This turned out to be a controversial decision, particularly after problems with North America's performance became known and it was discovered that the NASA Source Evaluation Board had identified the Martin Company as its preferred choice, with North American Aviation as a "desirable alternative."¹⁴ (II-21)

Selecting the Launch Vehicle While the basic elements of the Apollo spacecraft, with a three-person crew and two elements, one housing the crew and the command center for the vehicle and the other housing propulsion and other systems, had been fixed since 1960, it took NASA until the end of 1961 to select the launch vehicle for the Apollo missions to the Moon. There were two reasons for this. One was that the "national space plan" contained in the May 8 Webb-McNamara memorandum had called for a collaborative NASA-Department of Defense effort to define a family of launch vehicles that could meet both agencies' requirements and advance the development of both liquid fuel and solid fuel propulsion systems. While NASA, and particularly its rocket development team headed by Wernher von Braun, had experience only with liquid-fueled boosters, the Department of Defense was interested in pushing the development of large solid-fuel rocket motors for various advanced military and intelligence uses. The focus of this planning effort was a "NASA-DOD Large Launch Vehicle Planning Group." The group was directed by Nicholas Golovin of NASA; its deputy director was Lawrence Kavanaugh of DOD. The group started work in July 1961, and by the fall had become bogged down in very detailed studies and deadlocked over the relative roles of liquid-fueled and solid-fueled boosters in the lunar landing program. Its final recommendations

attempted to satisfy both NASA and DOD, and ended up pleasing neither agency.

(Volume II, II-20)

In parallel with the Large Launch Vehicle study, NASA continued to carry out its own analyses of what kind of launch vehicles would be needed for Project Apollo. These analyses were hindered by a basic issue; NASA at the end of 1961 had not yet selected the approach – called the “mission mode” – which it would use to send crews to the Moon. (The process of making that decision is described in the following section.) This was the second reason for the delay in identifying the launch vehicles for Apollo; it was hard to define what kind of launch vehicle would be needed without knowing what requirements it would have to meet.

Still, there was a need as the end of the year approached to make some basic launch vehicle decisions. The NASA-DOD study had come out with a general set of recommendations that did not provide an adequate basis for NASA’s those decisions. So on November 6, Milton Rosen of NASA Headquarters organized a two-week study to recommend to the NASA leadership “a large launch vehicle program” which would “meet the requirements of manned space flight” and “have broad and continuing national utility.” (Volume IV, I-31) On November 20, Rosen reported that “to exploit the possibility of accomplishing the first lunar landing by rendezvous,” NASA should develop an “intermediate vehicle” that had five F-1 engines in the first stage, four or five J-2 engines in its second stage, and one J-2 in its third stage. (The J-2 was an engine powered by high energy liquid hydrogen fuel that would have the capability to stop and restart in orbit.) Since a direct flight to the Moon was at this point still NASA’s stated preference for the lunar landing missions, Rosen also recommended that “a NOVA

vehicle consisting of an eight F-1 first stage” should be developed on a “top priority basis.” He added “large solid rockets should not be considered as a requirement for manned lunar landing.” (Volume IV, I-32)

The recommendation for a five-engine first stage for the advanced Saturn launch vehicle, soon called the Saturn C-5 and ultimately the Saturn V, was quickly accepted by the NASA leadership. That decision, as will be seen below, soon became a key to NASA’s choice of how to get to the Moon.¹⁵

Choosing Apollo’s Managers From the time that Kennedy announced his decision to go to the Moon, it was clear that the responsibility for developing the Apollo spacecraft and training the astronauts to operate it would be assigned to the Space Task Group, which was headed by Robert Gilruth, a widely-respected veteran of the National Advisory Committee on Aeronautics, NASA’s predecessor. As soon as it was decided that NASA would build a new field center for Apollo and that it would be located in Houston, Gilruth and his team began both to move their base of operations to Houston and to hire the many additional staff who would be needed to carry out the spacecraft development, astronaut training, and flight operations. It was equally clear that Wernher von Braun and his German rocket team, now working for NASA in the new Marshall Space Flight Center in Huntsville, Alabama, would be the core of the group developing the launch vehicles for Apollo.

What NASA needed were highly qualified individuals to lead the overall Apollo program at its Washington Headquarters. After considering several other candidates from both inside and outside of the agency, Webb, Dryden, and Seamans settled on D.

Brainerd Holmes, who had managed the very large ballistic missile early warning project for RCA. Webb used his powers of persuasion to convince Holmes to join NASA. Holmes accepted the position, and came joined NASA in October 1961 in the new position of Associate Administrator for Manned Space Flight. One of Holmes first identified needs was to find someone to apply a “systems management” approach to the already sprawling Project Apollo; that person turned out to be a dynamic young engineer named Joseph Shea, who came to NASA at the very end of 1961.¹⁶ Over the following year, Holmes and Shea provided the energy and technical management skills to get Apollo started down a path to a lunar landing “before the decade is out,” although neither was with NASA by the time that first landing took place.

On the same day, November 20, that Rosen recommended development of a five-engine first stage Saturn vehicle, White House science adviser Jerome Wiesner prepared a memorandum for the President’s close associate Theodore Sorenson, summarizing the state of progress on Project Apollo. Wiesner noted “Six months have elapsed since the decision was announced to put man on the moon, yet none of these crucial hardware programs have progressed beyond the study phase. Lead times on these development and construction programs are of critical importance.” In particular, “Major decisions have not been announced as to what extent rendezvous will be employed, what Advanced Saturn vehicle will be built (probably C-4), and what will be the characteristics of the so-called Nova which could put man on the moon by direct ascent. The relative emphasis of rendezvous versus direct ascent is a key to the entire program.” (II-19) It would take almost a year before a decision on how to go to the Moon – by some form of rendezvous

or by a direct flight – was final; that decision, as Wiesner noted, was key to getting to the Moon before 1970.

*Finding a Way to the Moon*¹⁷

NASA Chooses The Way In early May 1961, when it appeared likely that President Kennedy would approve sending Americans to the Moon, NASA Associate Administrator Robert Seamans asked one of his senior staff members, William Fleming, to put together a task force to examine “in detail a feasible and complete approach to the accomplishment of an early manned lunar mission.” Seamans asked for a report within four weeks; the report was actually delivered in mid-June.¹⁸ The task force considered only one approach to the lunar mission, the “direct ascent” mode, in which the very large Nova launch vehicle would send a complete spacecraft to the lunar surface. This approach had been the basis of NASA’s early planning for a lunar landing. But Seamans also recognized that there were other approaches to the lunar landing that would involve rendezvous between two or more elements of a lunar spacecraft. So on the same day as President Kennedy announced the lunar landing goal, May 25, Seamans asked Bruce Lundin of the Lewis Research Center to head up another group that would examine various rendezvous approaches as a way of getting to the Moon.

Lundin and his associates conducted a rapid assessment of various rendezvous approaches and reported back to Seamans on June 10. They noted “mission staging by rendezvous has been the subject of much investigation at Marshall, Langley, Ames, Lewis, and JPL.” The group examined four rendezvous concepts: 1) rendezvous in earth orbit; 2) rendezvous in lunar orbit after take-off from the lunar surface; 3) rendezvous in

both earth and lunar orbit; 4) rendezvous on the lunar surface. They concluded “of the various orbital operations considered, the use of rendezvous in earth orbit by two or three Saturn C-3 vehicles (depending on estimated payload requirements) was strongly favored.” This approach was either the first or second choice of all members of the group.¹⁹ (II-12)

Based on this conclusion, Seamans formed yet another group, this one to examine rendezvous approaches in more depth than had been possible in the rapid Lundin study. This group was headed by Donald Heaton of NASA Headquarters. Following on Lundin’s report, the group considered only earth orbital rendezvous approaches. In its late August report, the group concluded “*rendezvous offers the earliest possibility for a successful manned lunar landing* [emphasis in original].”

NASA continued to consider both a direct ascent and earth orbital rendezvous approaches for the next several months. Then, on November 15, “somewhat as a voice in the wilderness,” John Houbolt, a NASA engineer at the Langley Research Center, bypassed several layers of management and wrote an impassioned nine-page letter to Robert Seamans, arguing that NASA was overlooking the best way to get to the Moon before 1970, lunar orbital rendezvous. He claimed that “the lunar rendezvous approach is easier, quicker, less costly, requires less development, less new sites and facilities” and that Seamans should “Give us the go-ahead, and C-3, and we will put men on the moon in very short order - and we don’t need any Houston empire to do it.” Houbolt told Seamans “it is conceivable that after reading this you may feel that you are dealing with a crank. Do not be afraid of this. The thoughts expressed here may not be stated in as diplomatic a fashion as they might be. . . . The important point is that you hear the ideas

directly, not after they have filtered through a score or more of other people.” (II-15)

Houbolt attached to his letter a report summarizing the results of work done by him and his associates at the Langley Research Center. (While Houbolt was only one of the originators of the lunar rendezvous concept, he was its primary spokesperson.) The report described the proposed mission plan: “A manned exploration vehicle is considered on its way to the moon. On approach, this vehicle is decelerated into a low-altitude circular orbit about the moon. From this orbit a lunar lander descends to the moon surface, leaving the return vehicle in orbit. After exploration the lunar lander ascends for rendezvous with the return vehicle. The return vehicle is then boosted into a return trajectory to the earth, leaving the lander behind.” The primary advantage of this approach was “the marked reduction in escape weight required; the reduction is, of course, a direct reflection of the reduced energy requirements brought about by leaving a sizable mass in lunar orbit, in this case, the return capsule and return propulsion system.” With less mass to carry to the Moon, Houbolt and his associates argued, a lunar landing mission could be accomplished by a single Saturn C-3 launch vehicle with two F-1 engines in its first stage. (II-16)

Houbolt had written an earlier letter directly to Seamans in May, and the first reaction was to discipline him for contacting Seamans outside of management channels. But George Low, now working for Brainerd Holmes at NASA Headquarters, told Holmes that despite its tone, “Houbolt’s message is a relatively sound one and I am forced to agree with many of the points he makes.” Robert Gilruth and his associates in Houston were also beginning to see the merits of designing two separate spaceships, one for the journey to lunar orbit and return to Earth, the other only to land on the Moon. They

began to do their own studies of the concept. By the end of January, Brainerd Holmes' deputy Joseph Shea, after being briefed by Houbolt on what was becoming known at the LOR concept, noted that "Brainerd and I agreed that LOR looks sufficiently attractive to warrant further study. He feels that the study should be run from OMSF, rather than either Center, to provide a measure of objectivity." He added "We are also concerned that MSFC will be especially negative with LOR because they have not studied it." ²⁰

(II-17)

Over the next four months, both the Manned Space Craft Center (MSC) at Houston and the Marshall Space Flight Center (MSFC) at Huntsville carried out detailed studies of alternative rendezvous approaches to getting to the Moon. The idea of developing a huge launch vehicle, Nova, to carry astronauts to the Moon had by now lost favor as a feasible approach, mainly because it seemed to be too large a jump to go from the launch vehicles with which NASA had experience to something so gigantic. In addition, the concept of designing a single spacecraft to carry out all phases of the mission, particularly the lunar landing and the return into the Earth's atmosphere, looked increasingly difficult as Maxime Faget and other designers at MSC gave detailed attention to that challenge. During the early months of 1962, Houston became convinced that some version of the lunar orbital rendezvous approach (LOR), which involved two separate spacecraft, one specialized only for landing on the Moon and one for the journey to and from lunar orbit, was indeed the best way to proceed. The combined weight of the two spacecraft would allow the mission to be launched with a single Saturn C-5 (Saturn V) booster, although there was very little margin for weight growth. They shared their

analyses and reasoning with their colleagues at MSFC, who were continuing to focus their efforts to various approaches to Earth orbital rendezvous (EOR).

A climactic meeting was held at MSFC on June 7. For most of the day, the Marshall staff presented their positive findings on EOR to Joseph Shea from NASA Headquarters. At the end of the day, MSFC Director Wernher von Braun provided concluding remarks. He shocked many of his associates by announcing that he had concluded that his first priority choice was the “Lunar Orbit Rendezvous Mode,” because “We believe this program offers the highest confidence factor of successful accomplishment within this decade.” Von Braun added “we agree with the Manned Spacecraft Center that the designs of a maneuverable hyperbolic re-entry vehicle and of a lunar landing vehicle constitute the two most critical tasks in producing a successful lunar spacecraft. A drastic separation of these two functions into two separate elements is bound to greatly simplify the development of the spacecraft system.” He noted “the issue of ‘invented here’ versus ‘not invented here’ does not apply to either the Manned Spacecraft Center or the Marshall Space Flight Center” because “both Centers have actually embraced a scheme suggested by a third.” Von Braun told Shea “personnel of MSC and MSFC have by now conducted more detailed studies on all aspects of the four modes than any other group. Moreover, it is these two Centers to which the Office of Manned Space Flight would ultimately have to look to ‘deliver the goods.’ I consider it fortunate indeed for the Manned Lunar Landing Program that both Centers, after much soul searching, have come to identical conclusions.” (II-18)

The White House Disagrees With this rather startling announcement, given that the two

centers with primary responsibilities for Apollo were now in agreement, NASA Headquarters had little choice but to accept LOR as its choice for getting Americans to the Moon, and scheduled a July 11 press conference to announce that decision. However, James Webb on July 3 learned that there were strong objections to LOR on the part of the President's science adviser, Jerome Wiesner, and his associates. Later that day, Webb called Joe Shea, saying "Jerry Wiesner just called me and he's in a highly emotional state; he thinks L.O.R. is the worst mistake in the world."²¹ NASA was allowed to go ahead with its July 11 press conference, but could only announce the LOR choice as tentative, with more studies to be conducted.

Wiesner spelled out his reservations about the LOR choice in a July 17 letter to James Webb. (II-27) Wiesner was worried that the spacecraft weight limitations imposed by using the Saturn C-5 launch vehicle provided no margins if additional radiation shielding or zero-gravity countermeasures were discovered to be needed. He suggested that "the matter of which mission mode is most consistent with the main stream of our national space program, and therefore the one most likely to be useful in overtaking and keeping ahead of Soviet space technology, is also one that I believe requires further consideration." Also, "the question of which mode is likely to be most suitable for enhancing our military capabilities in space, if doing so should turn out to be desirable, should be reviewed with care."

Wiesner's views were in substantial part based on the views of the Space Vehicle Panel of the President's Science Advisory Committee (PSAC), which was chaired by Brown University chemist Donald Hornig. Wiesner forwarded to NASA with his letter the Panel's preliminary July 11 report. (II-26) The Panel had concluded that a better

approach to the Moon mission was to send a two-person crew, rather than the three astronauts that NASA had been planning on since 1960, and to use either the EOR or direct ascent mode rather than LOR. The staff person supporting the PSAC Panel was none other than Nicholas Golovin, who had been replaced by Joseph Shea as Brainerd Holmes' deputy and soon left NASA, unhappy with how he had been treated. He was then hired by Wiesner as his space specialist. Golovin and Shea were both self-confident individuals, with diametrically different approaches to key aspects of their systems analysis work. It is not possible to judge how much Golovin's antagonism towards NASA figured in the NASA-White House dispute over the choice of mission mode, but it certainly was an element in the controversy that was to linger for several months.

James Webb replied to Wiesner on July 20, saying that NASA would indeed carry out the studies recommended by the Space Vehicle Panel and responding to some of Wiesner's criticisms. (II-28) In an attempt to smooth over the dispute, Webb concluded his letter by saying "this constructive criticism by eminently qualified men is of tremendous value, and I am looking forward to further discussions with you as the results of our present studies begin to crystallize."

However, this polite tone did not last. There were continuing tensions over the next few months between Wiesner and Golovin on one hand and Webb and his associates, particularly Joe Shea, on the other. On September 11, the dispute became public. President Kennedy on that day flew to Huntsville to be briefed on the progress being made on Apollo at the Marshall Space Flight Center. As the President toured the MSFC facilities accompanied by Wiesner, Webb, and von Braun, he had to intervene to

stop a heated discussion between those three people that had broken out within earshot of the accompanying press contingent over the wisdom of the LOR choice.

By October 24, James Webb had had enough of the White House interventions into what he considered NASA's authority to make its own technical decisions. In a letter to Wiesner, he attached a summary report of the reviews of the mission mode choice; that report noted that it was NASA's conclusion that "the lunar orbit rendezvous mode is the best choice for achieving a manned lunar landing mission before the end of the decade," and that "comparisons of the 2-man lunar mission capsules with the present LOR approach lead to the conclusion that LOR is the preferred mode on the basis of technical simplicity, scheduling and cost considerations." (II-29)

Webb in his letter implied that Wiesner, if he still disagreed with NASA's conclusions, would have to bring the matter before the President for resolution. He told Wiesner "my own view is that we should proceed with the lunar orbit plan, should announce our selection of the contractor for the lunar excursion vehicle, and should play the whole thing in a low key." He added, "If you agree, I would like to get before you any facts . . . you believe you should have in order to put me in position to advise Mr. O'Donnell [the President's appointment secretary] that neither you nor the Defense Department wishes to interpose a formal objection to the above. In that case, I believe Mr. O'Donnell will not feel it wise to schedule the President's time and that the President will confirm this judgment."

In early November, Webb and Wiesner "met in a tense confrontation" before the President. Webb "cast the issue in terms of who was in charge of getting to the moon." According to one account, Kennedy said "Mr. Webb . . . you're running NASA – you

make the decision.”²² On November 7, Kennedy’s National Security Adviser McGeorge Bundy asked Wiesner to write Webb a final time, telling Webb that “the President thinks the time is coming for a final recommendation and relies on Director Webb to review all the arguments and to produce that recommendation.” He added “what the President has in mind is that we should make Webb feel the responsibility for a definite decision and the importance of weighing all opinions, without trying to make his decision for him.” Wiesner was to ask Webb for a letter to be part of the President’s files that recorded NASA’s reasons for its recommendation. (II-30)

Bundy’s memorandum was a bit after the fact; on the same day, November 7, NASA called a press conference to announce that the choice of the lunar orbital rendezvous approach was final, and that NASA had selected the Grumman Aircraft Engineering Corporation to build the lunar landing spacecraft. Webb did write the requested letter, telling the President that “the decision to adopt the Lunar Orbit Rendezvous mode was based on major systems and engineering studies which involved over a million man-hours of effort on the part of government and contractor personnel.” He added “despite the very extensive study efforts, however, we are dealing with a matter that cannot be conclusively proved before the fact, and in the final analysis the decision has been based upon the judgment of our most competent engineers and scientists who evaluated the studies and who are experienced in this field.” Webb noted “The decision on the mode to be used for the lunar landing had to be made at this time in order to maintain our schedules, which aim at a landing attempt in late 1967.” (II-31)

Eighteen months after President John F. Kennedy had announced his decision to send Americans to the Moon, the plan for meeting that goal was now in place. The

choice of the “mission mode” was, as Wiesner had told Theodore Sorenson a year earlier, the “key to the entire program.”

The Science of Apollo

While NASA’s managers and engineers were deciding how to get to the Moon, there was a parallel activity focused on what scientific activities would take place on the lunar surface, and who would carry out those activities.²³ As a first step in linking scientific considerations to Apollo planning, NASA Headquarters in March 1962 established a working group to recommend what scientific tasks lunar explorers should perform. This group was headed by Charles P. Sonnett of NASA’s Lunar and Planetary Programs Office. The group held its first meeting on March 27; one immediate question is whether it would be desirable, perhaps even necessary, to include trained scientists on Apollo crews. After that meeting, Joseph Shea asked the relevant staff in the Office of Manned Space Flight: “Is there any fundamental reason which would prevent the use of one or more professional scientists as crew members?” and “What serious practical problems would result if such personnel were included in the selection training program?” (II-21)

There were no major objections raised to selecting scientists as Apollo astronauts, and over the next three years NASA worked together with the National Academy of Sciences to first set criteria for scientist-astronauts and then recruit a first group of individuals who met those criteria. For the first time in selecting astronauts, prior proficiency in piloting high-performance jet aircraft was not required to apply, although those selected would be required to undergo flight training. Over 1,000 applications were

sent to the National Academy of Sciences; after screening, the Academy recommended sixteen candidates to NASA. On June 28, 1965, NASA announced that it had selected six men as its first scientist-astronauts. (Of those six, only one, geologist Harrison H. “Jack” Schmitt, would fly an Apollo mission, although three others flew during the 1973 Skylab mission.)²⁴

Sonnett’s group completed its work in early July 1962. Its recommendations were then reviewed during a “Summer Study” of the National Academy’s Space Science Board, which was already underway at the University of Iowa. The study report endorsed most of the recommendations of Sonnett’s report, and they as modified by the Board’s review then became the basis for NASA’s planning regarding the scientific aspects of Apollo missions. (II-41 and Volume V, I-22, II-12, II-13)

Another pressing issue as the Apollo missions were being designed was how to obtain the needed information about the lunar environment, such as the radiation environment astronauts would experience on the journeys to and from the Moon, the physical properties of the lunar soil, and the topography of the Moon. Brainerd Holmes and his associates turned to previously approved robotic lunar science programs, Ranger and Surveyor, which were managed by the Jet Propulsion Laboratory, in hopes that they could provide much of this information. Ranger missions would make hard landings on the Moon, sending back images as the spacecraft approached the lunar surface; Surveyor missions would land softly on the lunar surface and send back detailed images and other information about the area surrounding their landing site.

Tensions between the original scientific objectives of these missions and NASA’s need for engineering information were inevitable. (II-22, Volume V, II-11) Later Ranger

missions and Surveyor missions were indeed modified to meet Apollo's needs, creating lasting resentment among some members of the scientific community with respect to the intervention of engineering concerns into the setting of scientific priorities for robotic missions. NASA also decided to add a third robotic lunar program, Lunar Orbiter, to obtain high-resolution imagery of the lunar surface. That program was managed by the Langley Research Center, which was less closely linked to the scientific community than was JPL; the program used a camera modified from its original highly classified intelligence satellite mission to obtain the images needed.

Even with all of this information, there was continuing controversy about the character of the lunar surface. One prominent astronomer, Thomas Gold of Cornell University, suggested that the smooth areas of the Moon were likely to be covered with a layer of fine dust several meters deep, raising the possibility that a lunar lander might sink into the dust or topple over after landing. Even after the first Surveyor spacecraft landed on the Moon without problems on June 2, 1966, Gold suggested that his views might still be valid. (II-46)

An early planning issue for NASA was the selection of the location on the Moon where Apollo would land. NASA did not want to restrict itself to a single location for even the first lunar landing attempt, and of course was planning more than one Apollo mission to the Moon. Engineering and trajectory considerations entered into play, making the choice of landing sites complex.(II-24) Ultimately NASA identified a number of potential landing sites on the near side of the Moon and close to the lunar equator; then the scientific community identified locations of highest scientific interest.²⁵

Because an explicit objective of Apollo was the safe return to Earth of astronauts and their spacecraft, and of the samples of the Moon they would collect during their stays on the lunar surface, NASA in its planning could not ignore the remote possibility that there could be living organisms on the Moon which, if brought to Earth, might have negative effects. The scientific community through the Space Science Board had pointed out this issue since the start of planning for missions to the Moon, and the Board's 1962 Summer Study recommended that NASA develop "appropriate quarantine and other procedures . . . when handling returned samples, spacecraft, and astronauts [in order to] make the risk as small as possible."²⁶ (Volume V, II-14) NASA did little in response to this recommendation, and in 1964 the Space Studies Board once again expressed its concerns. By 1965, NASA realized that it would have to develop elaborate Lunar Receiving Laboratory facilities at Houston for quarantining whatever had returned from the Moon and that measures to initiate that quarantine would have to be put in place for the period between when the astronauts and their spacecraft returned to Earth and they were placed in those facilities. NASA in 1966 also established an Inter-Agency Committee on Back Contamination to develop policies on the issue.²⁷

That Committee issued its report on the elaborate measures to be taken to prevent contamination of the Earth by alien organisms from the Moon in August 1967. (II-52) NASA also developed policies to minimize biological contamination to the Moon by the Apollo astronauts, their spacecraft, and the scientific experiments to be carried out on the lunar surface. (II-53)

As the Apollo 11 mission, the first attempt at a lunar landing, was imminent in March 1969, concerns were raised both through the National Academy of Sciences and in

representations to Congress that NASA was not being diligent enough in its application of the measures related to back contamination. (II-54, II-55, II-56) There was even some possibility that NASA might be forced to delay the Apollo 11 launch until it convinced the external scientific community that the way it was proceeding did not pose unacceptable risks. Ultimately, NASA was able to allay Congressional concerns, and the mission was launched on the planned date.

What Priority for Apollo?

As part of NASA's buildup for the Apollo project, James Webb on March 13, 1962 wrote to President Kennedy, asking him to assign the top government priority – called “DX” – to the lunar landing project. To be assigned such a priority, a program had to have objectives of key political, scientific, psychological or military import. Those programs with this priority had first call on the scarce resources needed to achieve their goals. The President approved this request upon the recommendation of the National Aeronautics and Space Council. (II-23)

One scarce resource not covered by the DX priority was money – specifically, funds within the overall NASA budget to be allocated to ensuring that Apollo would meet its goal of landing Americans on the Moon before 1970. And the man in charge of Apollo, Brainerd Holmes, by mid-1962 had come to believe that the project was receiving enough funds, and that with additional funds not only would a lunar landing by the end of 1967 (NASA's planning target at the time) be possible, but even might be accomplished earlier. As Robert Seamans observed, “by the summer of 1962, Jim

[Webb] and I knew we had a problem with Brainerd Holmes.” Holmes was a “very exciting person for the media. He had a way of expressing himself that made news.”²⁸ Indeed, the August 10 issue of *Time* magazine featured Holmes on its cover and dubbed him “Apollo czar.”

Holmes was seeking an additional \$400 million dollars for Apollo for the current Fiscal Year 1963. There were two ways to get these funds. One by transferring them from other NASA programs within the overall NASA budget provided by the Congress. The other was to request that amount in a supplemental appropriation from Congress. James Webb refused to approve either choice, angering Holmes. Apparently Holmes discussed the situation directly with President Kennedy, probably during the President’s inspection tour of the Apollo buildup on September 11-12, with a stress on an earlier date for the first landing attempt. The President then asked Webb whether there was indeed a possibility of making the lunar landing in 1966 rather than 1967. Webb responded in late October, telling Kennedy “the late 1967 target date is based on a vigorous and driving effort, but does not represent a crash program. A late 1966 target would require a crash, high-risk effort.” Webb added that NASA was “prepared to place the manned lunar landing program on an all-out crash basis aimed at the 1966 target date if you should decide this is in the national interest,” but substantial and immediate budget increases would be required. (II-32)

President Kennedy had asked his Bureau of the Budget during that summer to take a careful look at the actual situation with respect to the overall U.S. space program, focusing on two questions: “the pace at which the manned lunar landing should proceed” and “the approach that should be taken to other space programs in the 1964 budget.”

Director of the Budget David Bell sent the results of the review to the President on November 13. (Volume I, III-13) The review examined four options for Apollo. The first was the current NASA plan, with no supplemental budget request for FY1963 and a late 1967 target for the first lunar landing. Two examined the budget implications of an accelerated program along the lines being advocated by Holmes. The final option examined the impact of slipping the landing date target by a year. Bell told the President “I agree with Mr. Webb that alternative 1, the NASA recommendation, is probably the most appropriate choice at this time.”

Holmes remained unhappy. He was the apparent source for a second *Time* story that appeared on November 19, titled “Space is in Earthly Trouble.” The magazine’s editors had deleted from the story before it was published a Holmes quote saying that “The major stumbling block of getting to the moon is James E. Webb. He won’t fight for our program.”²⁹

Given the now-public controversy, President Kennedy scheduled a November 21 meeting in the Cabinet Room of the White House to discuss NASA’s plans for Apollo. Like a number of meetings while Kennedy was President, this meeting was tape-recorded; a transcript of the discussion provides a rare insight into the interactions between Kennedy and Webb. (II-33) During the meeting, Kennedy and Webb had the following exchange:

President Kennedy: Do you think this program [Apollo] is the top-priority of the Agency?

James Webb: No, sir, I do not. I think it is *one* of the top-priority programs, but I think it’s very important to recognize here...and that you have found what you could do with a rocket as you could find how you could get out beyond the Earth’s atmosphere and into space and make

measurements. Several scientific disciplines that are the very powerful are beginning to converge on this area.

President Kennedy: Jim, I think it is the top priority. I think we ought to have that very clear. Some of these other programs can slip six months, or nine months, and nothing strategic is gonna happen, it's gonna... But this is important for political reasons, international political reasons. This is, whether we like it or not, in a sense a race. If we get second to the Moon, it's nice, but it's like being second any time. So that if we're second by six months, because we didn't give it the kind of priority, then of course that would be very serious. So I think we have to take the view that this is the top priority with us.

Later in the meeting, the President and the NASA head continued their debate:

President Kennedy: Everything that we do ought to really be tied into getting onto the Moon ahead of the Russians.

James Webb: Why can't it be tied to preeminence in space?

President Kennedy: Because, by God, we keep, we've been telling everybody we're preeminent in space for five years and nobody believes it because they have the booster and the satellite. We know all about the number of satellites we put up, two or three times the number of the Soviet Union ... we're ahead scientifically.

President Kennedy: I do think we ought get it, you know, really clear that the policy ought to be that this is *the* top-priority program of the Agency, and one of the two things, except for defense, the top priority of the United States government. I think that that is the position we ought to take. Now, this may not change anything about that schedule, but at least we ought to be clear, otherwise we shouldn't be spending this kind of money because I'm not that interested in space. I think it's good; I think we ought to know about it; we're ready to spend reasonable amounts of money. But we're talking about these fantastic expenditures which wreck our budget and all these other domestic programs and the only justification for it, in my opinion, to do it in this time or fashion, is because we hope to beat them and demonstrate that starting behind, as we did by a couple years, by God, we passed them.

James Webb: I'd like to have more time to talk about that because there is a wide public sentiment coming along in this country for preeminence in space.

President Kennedy: If you're trying to prove preeminence, this is the way to prove your preeminence.

As he prepared to leave the meeting, the President asked Webb to prepare a letter stating his position on why space preeminence, and not just being first to the Moon, should be the country's goal: "I think in the letter you ought to mention how the other programs which the Agency is carrying out tie into the lunar program, and what their connection is, and how essential they are to the target dates we're talking about, and if they are only indirectly related, what their contribution is to the general and specific things possibly we're doing in space."

Webb's letter was sent to the President on November 30. (Volume I, III-14) In it, Webb said that in his view "the objective of our national space program is to become preeminent in all important aspects of this endeavor and to conduct the program in such a manner that our emerging scientific, technological, and operational competence in space is clearly evident." Webb emphasized that "the manned lunar landing program, although of highest national priority, will not by itself create the preeminent position we seek."

Webb's response apparently did not totally satisfy John F. Kennedy. As he visited the Los Alamos National Laboratory on December 8, he asked his science adviser Jerome Wiesner to again look into the possibility of accelerating the target date for the lunar landing. Wiesner replied on January 10, 1963, telling the President "that approximately 100 million dollars of the previously discussed 326 million dollar supplementary could have a very important effect on the schedule, but that to do so it would have to be available in the very near future." Such a funding increase, said Wiesner, should be used to make sure that the Saturn V launch vehicle (he still called it the C-5) would be available when it was needed. (II-34)

Overall, however, President Kennedy seems to have accepted the basic argument made by James Webb – that preeminence in space should be the guiding objective of the national space program. In a July 17, 1963 press conference, Kennedy responded to a press report that the Soviet Union was not planning to send its cosmonauts to the Moon, saying “The point of the matter always has been not only of our excitement or interest in being on the moon; but the capacity to dominate space, which would be demonstrated by a moon flight, I believe, is essential to the United States as a leading free world power. That is why I am interested in it and that is why I think we should continue.”³⁰

New Leadership and New Approaches for Apollo

As 1963 began, there were a number of technical problem areas in the Apollo program, particularly with the F-1 engine that would power the first stage of the Saturn V. (Volume IV, I-35, I-36, I-37) In addition, the strained relationship between NASA’s top leaders and Brainerd Holmes also was only becoming worse.³¹ On June 12, Holmes submitted his resignation. This meant that Apollo was losing the leader who in the public and media eyes had come to personify the effort.

It took NASA a little over a month to settle on a replacement for Holmes. The individual selected, George Mueller, was Vice President for Research and Development of Space Technology Laboratories; his selection was announced on July 23 and Mueller reported to NASA on September 1. At Space Technologies Laboratories, Mueller had excelled in applying a systems engineering approach to the management of the complex Minuteman ICBM program, and he brought the same approach to NASA. Unlike Holmes, who courted media attention, Mueller focused his attention on relationships

between NASA Headquarters, the NASA field centers, NASA's contractors, and the Congress. For example, he created a NASA-Industry Apollo Executives Group that brought together key NASA personnel working on Apollo and the leaders of the companies building Apollo hardware. One of the leading accounts of the Apollo program describes Mueller as a "brilliant," "intellectually arrogant," and "a complex man." Robert Seamans characterizes him as "tireless."³²

Soon after he entered NASA, the organization implemented a major reorganization in which the heads of the field centers working on Apollo reported to the Office of Manned Space Flight (i.e., Mueller), rather than directly to Seamans, the agency's Associate Administrator and general manager. By a combination of his force of will and this reorganization, Mueller "was the undisputed boss of manned space flight from the day he walked into the office in 1963 until he left six years later."³³

Mueller in the next several months made several key personnel moves. He assigned George Low and Joseph Shea – both of whom welcomed the assignments – to the Manned Spacecraft Center in Houston, Low to become Deputy Director under Robert Gilruth and Shea to head the Apollo Spacecraft Program Office. On December 31, 1963, Air Force Brigadier General Samuel Phillips took over the Apollo Program Office at NASA Headquarters. The team of Mueller and Phillips was to provide strong leadership as the Apollo program encountered both tragedy and triumph.

Soon after he came to NASA, Mueller asked two veteran NASA engineers not directly involved in Apollo, John Disher and Del Tischler, to conduct a discrete independent assessment of the situation within Apollo. They reported to Mueller on September 28 with the troubling conclusions that the "lunar landing cannot likely be

attained within the decade with acceptable risk” and that the “first attempt to land men on moon is likely about late 1971.” The two estimated that the “program cost through initial lunar landing attempt will approximate 24 billion dollars.” (II-36) Mueller had Disher and Tischler present their conclusions to Robert Seamans, who found the briefing “unsatisfactory.” According to some accounts, Seamans asked that the briefing material be destroyed to prevent its conclusions from becoming known inside and outside of NASA.³⁴

Clearly, bold steps were needed to get Apollo on a schedule that had a good chance of meeting President Kennedy’s goal of a lunar landing before 1970, and Mueller soon took them. First he canceled flights of the Saturn 1 booster so that attention could be shifted to the upgraded Saturn 1B, which would use the same upper stage as the Saturn V. At an October 29 meeting of his Management Council, with the senior leadership from Houston and Huntsville present, Mueller announced a new approach to getting ready for missions to the Moon that soon became known as “all-up testing.” Mueller “stressed the importance of a philosophical approach to meeting schedules which minimizes ‘dead-end’ testing, and maximized ‘all-up’ systems flight tests. He also said the philosophy should include obtaining complete systems at the Cape [emphasis in original].” (II-37) Two days later Mueller sent a teletype message to the Apollo field centers proposing a new, accelerated schedule of Apollo flights; in this message, he reiterated that his “desire that ‘all-up’ spacecraft and launch vehicle flights be made as early as possible in the program. To this end, SA-201 [the first flight of the Saturn 1B] and 501 [the first flight of the Saturn V] should utilize all live stages and should carry complete spacecraft for their respective missions.” (II-38)

The staff at Marshall Space Flight Center was “incredulous” when they first heard of Mueller’s dictate. It violated the step-by-step approach to rocket testing they had been following since their time in Germany. But they could not provide compelling counterarguments, particularly given the pressure to have the first lunar landing attempt come before the end of 1969. Von Braun wrote Mueller on November 8, saying that “We believe the philosophy of flying live all stages, modules, and systems, beginning with the first R&D launching, to be a worthy objective. There is no fundamental reason why we cannot fly ‘all-up’ on the first flight.” Von Braun hedged his response a bit, saying “Our practical application of this philosophy should recognize this objective, but with the important reservation that clear, alternative, ‘fall back’ positions are also formally recognized.”³⁵ Von Braun was later to agree “in retrospect it is clear that without all-up testing the first manned lunar landing could not have taken place as early as 1969.”³⁶ Mueller’s “all-up” decision thus joined the selection of lunar orbit rendezvous as keys to Apollo’s success. According to one account, “the crisis in Apollo leadership that had begun in 1962 with Holmes’ mutiny thus ended in 1963 with an astute new manned space flight director, a stronger overall Apollo management team, and decisive steps to get Apollo back on schedule.”³⁷

1963 – Also A Year of Uncertainty

Increasing Criticisms Even as internal steps were being taken to get Apollo on track to meet its “before the decade is out” goal, external to the space agency there were several developments that placed the future course of the program in some doubt.

After President Kennedy's May 25, 1961 speech announcing the lunar landing goal, the public and political reception to the President's initiative was in general very positive. Beginning in 1963, however, criticism of Apollo in the context of overall national priorities as well as scientific ones became much more widespread.³⁸ Much of this criticism was in the form of newspaper articles and editorials, but there were also the beginnings of dissent from the Apollo goal within the political system. On June 10-11, the Senate Committee on Aeronautical and Space Sciences, under its new Chairman, Senator Clinton Anderson of New Mexico (Robert Kerr had died on January 1, 1963), listened as ten scientists discussed Apollo. The majority complained about the priority that had been assigned to the lunar landing program, and provided dramatic examples of how the funds could otherwise be used. Philip Abelson, editor of the prestigious journal *Science*, reported that he had conducted a straw poll of "scientists not connected by self-interest to NASA," which had resulted in a 110 to 3 vote against the program. In his testimony, Abelson suggested that "manned space exploration has limited scientific value and has been accorded an importance which is quite unrealistic," and that the "diversion of talent to the space program is having or will have direct and indirect damaging effects on almost every area of science, technology, and medicine," and might "delay conquest of cancer and mental illness."³⁹ Liberal Senator William Fulbright (D-AK), chairman of the Committee on Foreign Relations, suggested "this allocation of priorities [to the lunar program] is a recipe for disaster." Former President Dwight D. Eisenhower, writing in the widely-read *Saturday Evening Post*, stated that "this racing to the moon, unavoidably wasting large sums and deepening our debt, is the wrong way to go about it."⁴⁰

In addition to these public declarations, there were private criticisms from senior members of the U.S. science and technology community. As one example, Vannevar Bush, a highly respected man who had headed the U.S. scientific effort during World War II and whose recommendations in his famous report *Science, the Endless Frontier*, had helped shape post-war government support of science, on April 11, 1963 wrote to James Webb, with whom he had worked when Harry Truman was President and whom he knew well, saying: “the difficulty is that the program, as it has been built up, is not sound. The sad fact is that the program is more expensive than the country can now afford; its results, while interesting, are secondary to our national welfare.” He added “while the scientific results of an Apollo program would be real, I do not think that anyone would attempt to justify an expenditure of 40 or 50 billion dollars to obtain them.” With respect to the argument that Apollo would enhance national prestige, Bush thought that “the courageous, and well conceived, way in which the President handled the threat of missiles in Cuba advanced our national prestige far more than a dozen trips to the moon. Having a large number of devoted Americans working unselfishly in undeveloped countries is far more impressive than mere technical excellence. We can advance our prestige by many means, but this way is immature in its concept.” Bush told Webb “as a part of lowering taxes and putting our national financial affairs in order, we should have the sense to cut; back severely, on our rate of expenditure on space. As a corollary they could remove all dates from plans for a trip to the moon; in fact, he could announce that no date will be set, and no decision made to go to the moon, until many preliminary experiments and analyses have rendered the situation far more clear than it is today.” (II-35)

Apollo Under Review In November 1962 President John F. Kennedy had identified beating Russia to the Moon as the country's highest priority in space. Less than five months later, there was some suggestion that the President might have been having second thoughts about that priority and about the impacts of the accelerated space program on the nation's economy and technical activities, although whether this indeed was the case is not clear from the historical record. On April 9, the President wrote Vice President Lyndon B. Johnson in his role as Chairman of the National Aeronautics and Space Council, saying that "in light of recent discussions, I feel the need to obtain a clearer understanding of a number of factual and policy issues relating to the National Space Program which seem to rise repeatedly in public and other contexts." Kennedy asked Johnson to carry out a quick review of the program to answer a number of specific questions.⁴¹ (Volume I, III-15)

Johnson's report came on May 13; NASA and DOD had been closely involved in its preparation. In addition to answering the specific questions posed by the President, the report noted "the space program is not solely a question of prestige, of advancing scientific knowledge, or economic benefit or of military development, although all of these factors are involved. Basically, a much more fundamental issue is at stake . . . the future of society." (Volume I, III-16)

To the Moon Together? If Kennedy was indeed question the wisdom of racing Russia to the Moon, one reason may have been the changed nature of U.S.-Soviet relations after the United States had forced the Soviet Union to withdraw its missiles from Cuba in October

1962. Kennedy seems to have concluded that the time was ripe to revisit a notion that had preceded his decision to enter the space race – that a flight to the Moon should be a cooperative U.S.-Soviet undertaking. According to Kennedy adviser Theodore Sorensen, “it is no secret that Kennedy would have preferred to cooperate with the Soviets” in manned missions to the Moon.⁴² In an interview shortly after Kennedy’s assassination, Sorenson expanded on this idea:

I think the President had three objectives in space. One was to ensure its demilitarization. The second was to prevent the field to be occupied to the Russians to the exclusion of the United States. And the third was to make certain that American scientific prestige and American scientific effort were at the top. Those three goals all would have been assured in a space effort which culminated in our beating the Russians to the moon. All three of them would have been endangered had the Russians continued to outpace us in their space effort and beat us to the moon. But I believe all three of those goals would also have been assured by a joint Soviet-American venture to the moon.

The difficulty was that in 1961, although the President favored the joint effort, we had comparatively few chips to offer. Obviously the Russians were well ahead of us at that time. . . . But by 1963, our effort had accelerated considerably. There was a very real chance we were even with the Soviets in this effort. In addition, our relations with the Soviets, following the Cuban missile crisis and the test ban treaty, were much improved – so the President felt that, without harming any of those three goals, we now were in a position to ask the Soviets to join us and make it efficient and economical for both countries. (II-43)

President Kennedy met Soviet leader Nikita Krushchev only once, on June 3-4, 1961. This was soon after Kennedy had made his speech announcing the lunar landing goal, but twice during the summit meeting, and the President’s initiative, Kennedy and Krushchev had discussed the possibility of cooperation in going to the Moon.⁴³ Krushchev reacted negatively to Kennedy’s proposal, and the matter was dropped for the next two years.

In mid-1963, the President began again to float the idea of a joint U.S.-Soviet mission to the Moon. One problem, however, was that there was no evidence from intelligence sources that the Soviet Union was in fact intending to send cosmonauts to the Moon.⁴⁴ In fact, it was reported that a leading British scientist, Bernard Lovell, had been told by his Soviet counterparts that there was no Russian program to send people to the Moon. Asked at a July 17 press conference on whether he favored a joint U.S.-Soviet lunar mission, Kennedy, for the first time in a public forum, said “we have said before to the Soviet Union that we would be very interested in cooperation.” However, he added, “the kind of cooperative effort which would be required for the Soviet Union and the United States to go to the moon would require a breaking down of a good many barriers of suspicion and distrust and hostility which exist between the Communist world and ourselves.” Kennedy concluded that he would “welcome” such cooperation, but that he “did not see it yet, unfortunately.”⁴⁵

By September, Kennedy had decided to publicly test the waters with respect to possible U.S.-Soviet cooperation in going to the Moon. During a September 18 meeting with James Webb, Kennedy for the first time told the NASA Administrator that he intended to make such a proposal in a September 20 speech to the General Assembly of the United Nations.(Volume II, I-41) In his September 20 speech, Kennedy said

in a field where the United States and the Soviet Union have a special capacity – in the field of space – there is room for new cooperation . . . I include among these possibilities a joint expedition to the moon. Why, therefore, should man’s first flight to the moon be a matter of national competition? . . . Surely we should explore whether the scientists and astronauts of our two countries – indeed of all the world – cannot work together in the conquest of space, sending some day in this decade to the moon not the representatives of a single nation, but representatives of all our countries.⁴⁶

Kennedy's proposal was greeted with dismay by many of those who had been Apollo's strongest supporters. For example, Congressman Albert Thomas sent a handwritten note to the President the day after the speech, saying that "the press and many private individuals seized upon your offer to cooperate with the Russians in a moon shot as a weakening of your former position of a forthright and strong effort in lunar landings." Thomas asked the President for "a letter clarifying your position with reference to our immediate effort in this regard."⁴⁷

Kennedy replied to Thomas on September 23. (II-39) He told Thomas "if cooperation is possible, we mean to cooperate, and we shall do so from a position made strong and solid by our national effort in space. If cooperation is not possible—and as realists we must plan for this contingency too—then the same strong national effort will serve all free men's interest in space, and protect us also against possible hazards to our national security."

There were suggestions in the aftermath of the President's speech that it was a public relations move or a way of justifying a withdrawal of the United States from a fast-paced lunar landing program. Countering these suggestions is the fact that in the weeks following the United Nations speech, the White House Office of Science and Technology examined ways to turn the President's proposal into reality, even as Nikita Krushchev on October 26 told a group of visiting journalists that the Soviet Union had no plans to send people to the Moon. For example, on October 29, Science Adviser Jerome Wiesner provided a memorandum for Kennedy proposing "a joint program in which the USSR provides unmanned exploratory and logistic support for the U.S. Apollo manned landing." (II-40) Wiesner suggested that such a plan be quickly offered to the Soviet

Union in light of Krushchev's statement. Wiesner noted "if the proposal is accepted we will have established a practical basis for cooperative program. If it is rejected we will have demonstrated our desire for peaceful cooperation and the sincerity of our original proposal." Following on Wiesner's suggestion, on November 12, President Kennedy signed a National Security Action Memorandum directing James Webb "to assume personally the initiative and central responsibility within the Government for the development of a program of substantive cooperation with the Soviet Union . . . including cooperation in lunar landing programs." (Volume II, I-42)

Uncertainties Resolved . . . In the Worst Possible Way On November 18, 1963, the Senate voted to cut \$612 million from NASA's budget request, leading *The New York Times* to question "whether the Administration can count on the budgetary support necessary to achieve a lunar landing by the 1969 deadline."⁴⁸ That was a good question, given what was happening within the White House budget staff. The Bureau of the Budget staff in November 1963 was completing a comprehensive review of the national space program that had been initiated in October; its draft report asked: "Should consideration be given at this time to backing off from the manned lunar landing goal? [Emphasis in original]." The budget office suggested "the review has pointed to the conclusion that in the absence of clear changes in the present technical or international situations, the only basis for backing off from the MLL [manned lunar landing] objective at this time would be an overriding fiscal decision either (a) that the budgetary totals in 1965 or succeeding years are unacceptable and should be reduced by adjusting the space program, or (b) that within present budgetary totals an adjustment should be made

shifting funds from space to other programs.”⁴⁹ (II-42) When Congress passed the NASA Fiscal Year 1964 appropriations bill, the space agency was allocated a \$5.1 billion budget, an increase of \$1.3 billion over FY1963 but a \$0.6 billion reduction from what the President had requested for NASA at the start of the year.

President Kennedy visited Cape Canaveral on November 16, and saw the progress being made on the facilities being developed for Apollo.⁵⁰ On November 21, Kennedy gave the space program a strong endorsement in a speech in San Antonio, where he had started a three-day political trip. That evening, the President attended a testimonial dinner for Albert Thomas in Houston, then flew to Dallas. The next day, Kennedy fell victim to an assassin’s gun.

With John F. Kennedy’s death and Lyndon B. Johnson becoming President, any chance of the United States “backing off” of the lunar landing program that Kennedy had initiated vanished; instead, the program became in a sense a memorial to the fallen president. Lyndon Johnson was far less interested in cooperating with the Soviet Union in space than had been Kennedy. NASA in January 1964 submitted the report requested by Kennedy’s November 12 national security directive (Volume II, I-43), but there had been no sign from Nikita Krushchev that he was interested in discussing cooperation, and President Johnson did not press the issue. For the next three years, while James Webb fought to maintain Congressional support for a budget adequate to meet Kennedy’s “before the decade is out” goal, the rest of NASA turned to getting the Apollo hardware ready to fly and the Apollo astronauts trained for lunar exploration.

Moving Ahead, But Losing Momentum

During the three year period 1964-1966, there was significant (though troubled, as will be discussed below) progress in the program aspects of Apollo, but during those same years, “NASA stopped growing, and [James] Webb sought to maintain momentum.”⁵¹ The NASA budget peaked at \$5.25 billion in Fiscal Year 1965 and then began a gradual decline. While Lyndon B. Johnson was strongly committed to completing Apollo, he found himself constrained by the budget demands of his Great Society programs and the war in Viet Nam, and was unwilling to provide significant financial support for major post-Apollo space initiatives. The Congress continued to question whether NASA needed all the resources it was requesting to complete Apollo, and was equally unwilling to support major new programs. By 1966, Webb was frustrated by what he perceived as lack of adequate political support from the White House as he battled to hold off Congressional attempts to slash the NASA budget. (Volume I, III-19)

NASA by this time was a very different organization than it had been just three years earlier, as the mobilization of human and financial resources needed to carry out Apollo peaked. The agency’s budget had increased by 89 per cent in the year after President Kennedy’s May 1961 speech, another 101 per cent in the following year, and then another 38 per cent as the budget approached its peak. The NASA staff had increased from 17,500 civil servants in 1961 to 34,300 at the end of 1965, and the related contractor force from 57,000 to 376,700.⁵² Apollo was truly a national effort.

On December 24, 1965, NASA Deputy Administrator Hugh Dryden succumbed to cancer. With his death, NASA loss a respected official and a key participant in the

management of the agency as it had gone through this rapid expansion. Dryden was not replaced; Robert Seamans took on the position of Deputy Administrator while continuing his role as the agency's general manager.

To the outside observer, all elements of the Apollo program appeared to be moving forward towards a lunar landing before the end of the decade, with the first flight of the Apollo spacecraft with a crew aboard scheduled for early 1967. During 1965 and 1966, a series of ten mainly successful Gemini launches demonstrated many of the capabilities, particularly rendezvous and docking, that would be needed for Apollo. Four Saturn 1 launches and the first Saturn 1B launch tested various aspects of the lunar mission; two of these launches carried Apollo command and service modules without a crew aboard. Technical problems with the F-1 engine that powered the first stage of the Saturn V appeared to have been resolved, and the mammoth booster was moving towards its first test flight.

The technical reality was rather different. There were major problems in the Apollo spacecraft program and the S-II second stage of the Saturn V launcher, both being developed by North American Aviation,⁵³ and the lunar module being developed by Grumman was running well behind schedule and was overweight.⁵⁴ By the end of 1966, Apollo's Washington managers were stressing publicly that it would be difficult to attempt an initial lunar landing mission until sometime in the second half of 1969. Thus Administrator James Webb was quite surprised to read an interview with Wernher von Braun that appeared in the December 12, 1966 issue of *U.S. News & World Report* headlines "A Man on the Moon in '68?" In the interview, von Braun suggested, with a number of caveats, that "there is a distinct possibility that, if everything really clicks and

we don't hit any major snags, it [the first landing attempt] may come off in '68," on the fourth flight of the Saturn V launcher.⁵⁵

In response to the interview, Webb fired off an annoyed memorandum to von Braun. (II-47) He told von Braun "there is certainly a very, very low possibility that complete Saturn V systems will be available for flights out as far as the Moon in 1968. Under these circumstances, it seems to me that you will need to be very careful in dealing with the press." Webb's concern was that NASA needed to "take account of all the difficulties we are likely to encounter in this very complex Saturn V-Apollo system, particularly as we are now so hemmed in, have so little room to make adjustments, and have no financial margins." He was also concerned that statements like von Braun's could "undermine the credibility of those of us who are working so hard to get the money to continue this program and to avoid having the vehicles now approved (15 Saturn V's) deleted from the program on the basis that they are not needed to accomplish the mission."

Soon after Lyndon Johnson became President, he had asked NASA to begin to identify post-Apollo options. NASA responded by January 1965 with a "laundry list" of future possibilities. (Volume I, III-18) But by that time, "Johnson did not want to hear about the possibilities, nor did he particularly want the Congress to hear them."⁵⁶ Recognizing that a second Apollo-like initiative was not in the offing, NASA focused its post-Apollo planning on an interim effort that became known as the Apollo Applications Program. The program initially was ambitious in scope, but never received significant funding. (II-45) Ultimately only one of the proposed Apollo Applications missions was flown; this was the 1973 Skylab, using an upper stage of a surplus Saturn V launch

vehicle as an interim space station. Lacking any additional missions for the Saturn V, Webb in August 1968 found himself forced to make the painful decision to begin the process of shutting down the production of the heavy lift booster, a decision that became final in 1972. (II-58)

Webb's biographer concludes that Webb's "strategies to maintain NASA, Apollo, and other programs had succeeded *and* failed in the 1964-1966 time frame." Webb had "kept up overall momentum for Apollo" but "NASA's budget was cut back . . . post-Apollo was delayed, and Webb saw his own power to persuade start to slip."⁵⁷

The Apollo 1 Fire

Despite these concerns, there was a fair degree of optimism as 1967 began, with the first crew-carrying flight of Apollo, an Earth-orbital test mission of the Apollo command and service modules designated Apollo 204, scheduled for launch on February 21. The crew included veteran astronauts Virgil "Gus" Grissom and Edward White and rookie Roger Chaffee. The spacecraft they were to fly was a "Block A" model, intended only for orbital flight.

At 1:00 p.m. on January 27, the crew was strapped into the spacecraft as it sat atop an unfueled Saturn 1B launcher on Pad 34 at Cape Canaveral for a lengthy countdown test. At 6:31, as the test neared its end, Roger Chaffee told the control room that "we've got a fire in the cockpit." Within less than a minute, the three astronauts were dead of asphyxiation as they inhaled toxic gases created by the fire within the still sealed spacecraft.⁵⁸

James Webb, Robert Seamans, and George Mueller learned of the fire soon

afterwards. Webb immediately notified President Johnson; later the three huddled at NASA Headquarters to decide how to proceed. They decided to ask the President to let NASA manage the accident investigation rather than have the White House appoint an external investigation board. While Webb worked to convince Johnson and Congressional leaders that NASA was best qualified to conduct the investigation, Seamans and Mueller identified the individuals who would compose the investigation board. Apollo program director Sam Phillips flew to Cape Canaveral (by then called Cape Kennedy) to take charge there. By the next day, the Apollo 204 Review Board had been named; it was to be chaired by Floyd Thompson, Director of NASA's Langley Research Center, and had eight other members from both within and outside of NASA. Seamans charged the Board to "review the circumstances surrounding the accident to establish the probable cause or causes of the accident" and to "develop recommendations for corrective or other action based upon its findings and determinations." (II-48)

The Review Board went about its work intensively. By February 25, its preliminary findings were ready to be made public, and James Webb issued a statement summarizing them. (II-39) In this statement, Webb noted that astronaut Frank Borman, a member of the Board, had told him that "he would not have been concerned to enter the capsule at the time Grissom, White and Chaffee did so for the test, and would not at that time have regarded the operation as involving substantial hazard. However, he stated that his work on the Board has convinced him that there were hazards present beyond the understanding of either NASA's engineers or astronauts."

The Apollo 204 Review Board submitted its final report to Administrator Webb on April 5. (II-50) The Board found that "the test conditions were extremely hazardous."

Once the fire started, “the crew was never capable of effecting emergency egress because of the pressurization before rupture and their loss of consciousness soon after rupture.”

With respect to the spacecraft, “deficiencies existed in Command Module design, workmanship and quality control.”

On February 27, the Senate Committee on Aeronautical and Space Sciences, chaired by Clinton Anderson of New Mexico, held the first Congressional public hearing since the accident. While he supported the space program, Anderson did not get along with James Webb, who had resisted Anderson’s attempts to exert influence over NASA activities, and was not willing to wait until the Review Board issued its final report to begin Congressional questioning. At the hearing, junior Minnesota Senator Walter Mondale asked Webb about a “Phillips Report” severely critical of North American Aviation’s management of its parts of the Apollo effort. Webb did not know what Mondale was referring to, and stonewalled the Senator’s inquiry. George Mueller told the committee that no such report existed. Later that day Webb became furious when he discovered that there was indeed such a document, in the form of a set of notes and a cover letter sent to North American Aviation President Leland Atwood after a late 1965 visit to North American by a NASA review team led by Apollo program director Sam Phillips. (II-44) In his cover letter, Phillips had told Atwood that “ I am definitely not satisfied with the progress and outlook of either program [the Apollo Spacecraft and S-II stage of the Saturn V]” and that “even with due consideration of hopeful signs, I could not find a substantial basis for confidence in future performance.”

Neither Seamans nor Mueller thought that what Phillips had prepared in 1965 constituted a “report,” but Webb saw immediately that semantic quibbling would not

extricate NASA from appearing to be withholding information from Congress. After discussing how best to give the Congress access to the material, NASA decided to have Sam Phillips present its contents to an open hearing of Andersen's committee. As he probed further, Webb discovered that there had been continuing criticism of North American's performance of which he had been unaware. Webb had a developing sense "that the men he trusted the most – his senior officials at headquarters – had let him down." In Webb's view, George Mueller "had deliberately presented a filtered picture of the situation, and Seamans had failed to press him on it." Determined to change this situation, Webb reasserted control of the Apollo program "with a vengeance."⁵⁹ One of his moves was to force North American to remove the senior manager of its Apollo efforts, Harrison Storms, from his position as head of the company's Space Division; if North American did not make such a move, threatened Webb, he would shift the Apollo contracts to another company.⁶⁰

Relations between Webb and Seamans became strained in the months following the fire, and Seamans submitted his resignation on October 2, 1967. Mueller stayed on; a change at the top of the manned space flight program would likely have resulted in unacceptable delays in fixing the problems revealed by the fire and getting NASA back on track. In Houston, Joseph Shea took the Apollo fire as a personal responsibility, and his associates began to worry about his physical and mental condition. He was persuaded to return to Washington as a deputy to George Mueller, but without significant Apollo responsibilities. By July 1967, Shea decided to leave NASA. In Shea's place in Houston, George Low took over the Apollo Spacecraft Program Office in addition to his duties as Deputy Center Director.

Not only were relations strained between Webb and his senior people within NASA; there were continuing tensions between him and members of Congress, and particularly Senator Clinton Anderson. Webb had always prided himself on maintaining a relationship of mutual trust and personal credibility with senior Congressmen, and now that relationship seemed at risk. He wrote Anderson in advance of a May 9 hearing, saying that “I am deeply troubled by your statement to me last Saturday that members of the Committee are not satisfied with our testimony on NASA's actions in follow-up of the deficiencies [sic] found by the management review team headed by General Phillips at North American Aviation in 1965.” He added “your statement that members of the Committee believe NASA is endeavoring to put a disproportionate part of the blame for the Apollo 204 accident on North American Aviation and avoid its proper acceptance of blame troubles me even more.” (II-51)

Eventually the furor over the accident quieted. There were no serious suggestions that the Apollo program be halted or the “before the decade is out” goal be abandoned. Under George Low’s close supervision, North American set about remedying the deficiencies in the Apollo spacecraft. Grumman was moving ahead with its work on the lunar module, but continuing to confront both schedule and weight problems. The Saturn V had its first test launch on November 9, 1967; all test objectives were met successfully. As 1968 began, there was increasing confidence that the first lunar landing attempt could come before the end of 1969.

Apollo Around the Moon

By the beginning of 1968, NASA was ready to schedule the first launch of the

redesigned Apollo Command and Service Modules; the date was finally set for October 7. That Earth-orbiting mission would be the first in a sequence of missions leading up to a lunar landing. The missions were designated by letters of the alphabet:

C- test of the Apollo Command and Service module in low Earth orbit

D – test of the Apollo Command and Service and Lunar Modules in low Earth orbit;

E- test of the Apollo Command and Service and Lunar Modules in a mission beyond Earth orbit, but not headed to the Moon;

F- test of all equipment in lunar orbit;

G- lunar landing mission.

It was not clear as the year began whether following this schedule would provide adequate assurance that the United States would reach the Moon before the Soviet Union. Throughout the 1960s, the Central Intelligence Agency had closely monitored the progress of the Soviet space program. In the years immediately following the 1961 Kennedy decision to go to the Moon, there was no indication that the Soviet Union was developing the facilities and equipment that would be required for a competitive lunar landing program. When Soviet scientists in mid-1963 said that there was no Soviet lunar landing program, they were correct. But earlier in 1963, U.S. satellites had detected what appeared to be the beginning of a large construction project at the main Soviet launch site, the Baikonur Cosmodrome in the Soviet republic of Kazakhstan. By 1964, construction of a large assembly building and two launch pads could be seen. It was during that year that the Soviet leadership finally approved a Soviet Moon program, but there were continuing bureaucratic battles inside of the Soviet space community that

slowed progress. The program also, it has been learned in retrospect, never received adequate funding. By mid-1965, the Intelligence Community had concluded that the Soviet Union did indeed have a lunar program, but that it was not proceeding on a pace that was competitive with Apollo. In December 1967, a U.S. satellite returned an image of a previously unseen large booster on one of the new launch pads.

Throughout this period, James Webb was regularly briefed on the status of the Soviet space effort. In 1964, and then with more frequency in 1966 and subsequent years, Webb said publicly that the Soviet Union was developing a launch vehicle with lifting capabilities larger than those of the Saturn V. The fact that the Soviet Union seemed to indeed be racing the United States to the Moon helped Webb politically as Apollo came under criticism in 1967 and 1968.⁶¹

In fact, the reality was that by 1967 the Soviet Union was conducting two lunar programs, one aimed at a lunar landing and a second, using a version of the proven Proton launch vehicle and a modified Soyuz spacecraft called Zond, aimed at flights around the Moon, without the capability to land. In April 1968, the Central Intelligence Agency issued an update of a 1967 assessment of the Soviet program. (II-57) The report said that “we continue to estimate that the Soviet manned lunar landing program is not intended to be competitive with the US Apollo program. We now estimate that the Soviets will attempt a manned lunar landing in the latter half of 1971 or in 1972, and we believe that 1972 is the more likely date.” However, added the CIA, “the Soviets will probably attempt a manned circumlunar flight both as a preliminary to a manned lunar landing and as an attempt to lessen the psychological impact of the Apollo program. In NIE 11-1-67 [the 1967 estimate], we estimated that the Soviets would attempt such a

mission in the first half of 1968 or the first half of 1969 (or even as early as late 1967 for an anniversary spectacular). The failure of the unmanned circumlunar test in November 1967 leads us now to estimate that a manned attempt is unlikely before the last half of 1968, with 1969 being more likely.” Senior Apollo managers could not help but have this intelligence estimate in the back of their minds as they moved toward the beginning of crew-carrying Apollo flights, although there is little direct evidence that it influenced their thinking.

In addition to getting Apollo hardware ready to fly, there was an immense amount of detailed effort required to actually design the lunar landing missions. That responsibility was assigned to a veteran NASA engineer named Howard W. (Bill) Tindall, who in August 1967 was named Chief of Apollo Data Priority Coordination, an opaque title that gave no indication of his sweeping responsibilities. Tindall had an exuberant personality and viewed Apollo “as one long stretch of fun that had by some miracle given to him instead of work.” One of the results of Tindall’s approach to his duties was a series of what became known as “Tindallgrams.” While dealing with the myriad of serious issues involved in getting ready to land on the Moon, these communications adopted a breezy, irreverent tone, and “became a sensation” around the Manned Spacecraft Center. As one example, Tindall told George Low in August 8 that “a rather unbelievable proposal has been bouncing around lately” - to delete the rendezvous radar on the lunar module as a weight saving measure. Tindall continued “because it is seriously ascribed to a high ranking official [George Mueller],” it was being taken seriously. He told Low, “I thought I’d write this note in hopes you could proclaim it to be a false alarm or if not, to make it one.”⁶² (II-59)

While the redesigned Apollo spacecraft seemed ready for a crewed launch, the same could not be said of the Saturn V or the lunar module. The second test launch of the Saturn V took place on April 4, 1968. In contrast to the almost perfect first test launch the preceding November, there were multiple problems with this flight. Each of the three stages of the vehicle had a separate failure. It took all of the skill and experience of the von Braun rocket team to diagnose the causes of the failures. This was essential, because NASA's planning called for the next flight of the Saturn V to carry three astronauts.⁶³

That mission, designated "D" in NASA's plans, was intended to carry a complete Apollo spacecraft, including both the command and service modules and the lunar module, for a test flight in low Earth orbit. Presuming success of the "C" mission in October, NASA hoped to launch the next flight before the end of the year.

However, there was a major obstacle to be overcome. The lunar module scheduled to be flown on the mission had arrived at the Kennedy Space Center with a number of problems to be solved, and as NASA attempted to address them it appeared increasingly unlikely that the module would be ready to fly in 1968, and indeed that the test flight might not be possible until February or March 1969. If that happened, the likelihood of landing on the Moon by the end of 1969 became remote. Faced with this situation, George Low began to consider an alternative flight sequence: "the possibility of a circumlunar or lunar orbit mission during 1968," using only the command and service modules launched by a Saturn V, "as a contingency mission to take a major step forward in the Apollo Program." By August 9, as problems with the lunar module persisted, he

took this idea to the Director of the Manned Spacecraft Center, Robert Gilruth, who immediately saw its benefits. The same morning, according to Low's notes:

I met with Gilruth, Kraft and Slayton. [Christopher Kraft was head of flight operations and Donald "Deke" Slayton was head of the astronaut office.] After considerable discussion, we agreed that this mission should certainly be given serious consideration and that we saw no reason at the present time why it should not be done. We immediately decided that it was important to get both von Braun and Phillips on board in order to obtain their endorsement and enthusiastic support. Gilruth called von Braun, gave him the briefest description of our considerations, and asked whether we could meet with him in Huntsville that afternoon. I called Phillips at KSC and also informed him of our activities and asked whether he and Debus could join us in Huntsville that afternoon. Both von Braun and Phillips indicated their agreement in meeting with us, and we set up a session in Huntsville for 2:30 p.m.

At the afternoon meeting in von Braun's office, "all present exhibited a great deal of interest and enthusiasm for this flight." The meeting ended "with an agreement to get together in Washington on August 14, 1968. At that time the assembled group planned to make a decision as to whether to proceed with these plans or not. If the decision was affirmative, Phillips would immediately leave for Vienna to discuss the plans with Mueller and Webb [at that time, Administrator Webb and manned spaceflight head Mueller would be attending a United Nations Conference on the Peaceful Uses of Outer Space], since it would be most important to move out as quickly as possible once the plan was adopted." (II-60)

With all of the key managers of the Apollo meeting agreed, it would be difficult for NASA's top officials to overturn Low's plan, but it turned out that they also were not willing to give it their total approval. The senior managers from Houston, Huntsville, Cape Kennedy and the NASA Headquarters Apollo program office met with the new NASA Deputy Administrator, Thomas Paine, on August 14 as planned. (Paine was a

newcomer to space; before he came to NASA he had been an executive of the General Electric Company, most recently the manager of GE's Center for Advanced Studies. He had assumed the number two position at NASA in January 1968, following the resignation of Robert Seamans.) At the August 14 meeting, Paine "congratulated the assembled group for not being prisoners of previous plans and indicated that he personally felt that this was the right thing for Apollo and that, of course, he would have to work with Mueller and Webb before it could be approved." There was a decision not to send Sam Phillips to Vienna because his sudden appearance there might compromise what still were secret plans. Instead, interactions with Webb and Mueller were by secure telephone and diplomatic couriers.

Webb was "shocked" when he first heard of what his staff was planning, but quickly both he and Mueller saw the logic of what was being proposed. However, they added a note of caution. While the Apollo managers could begin to plan for a lunar mission, they could not commit NASA to undertaking such a bold step until the October C mission, designated Apollo 7, was a success. Following this constrained approval of the plan, Apollo Program Director Sam Phillips on August 19 issued a directive announcing the revised program plan. (II-61) The new mission would be designated C' (C prime) and Apollo 8. Whether it would go to the Moon, stay in low Earth orbit, or follow some other mission plan would not be decided until the results of the Apollo 7 mission were available, said Phillips.

As Low noted, the implications of this tentative decision were dramatic in terms of when the first attempt at a lunar landing could be scheduled. At the August 14 meeting,

We also discussed the mission sequence to be followed after the proposed mission and proposed that the best plan would be to fly the D mission next, followed by an F mission, which, in turn, would be followed by the first lunar landing mission. In other words, the proposed mission would take the place of the E mission but would be flown before D. MSC also proposed that for internal planning purposes we should schedule the D mission for March 1, 1969; the F mission for May 15, 1969; and the G mission for July or August, 1969. However, dates two weeks later for D, one month later for F, and one month later for G should be our public commitment dates. (II-60)

Following Phillips' August 19 directive tentatively approving the C' mission, Low on August 20 issued his own directive to those working on the Apollo spacecraft and planning the Apollo missions. The launch date for the first attempt at a lunar landing was set for July 8, 1969. (II-66)

The Apollo 7 mission took place from October 11-22, 1968; aboard were astronauts Wally Schirra, Donn Eisle, and Walter Cunningham. All objectives of the flight were met, clearing the path for a decision to send the Apollo 8 mission into lunar orbit.

That decision would not be made by James E. Webb. On September 16, Webb had gone to the White House for a meeting with President Johnson to discuss a variety of issues, including how best to protect NASA and particularly Apollo during the transition to the next President. (Johnson had announced in March 1968 that he would not stand for re-election.) Webb knew that he was very unlikely to continue as NASA Administrator, whether Hubert Humphrey or Richard Nixon was elected. He and Humphrey did not get along, and as a committed Democrat he was even more unlikely to be retained by Nixon. Webb was weary after six and a half years running NASA at a frenetic pace, and had been a target of Congressional criticism since the Apollo fire. Webb thought that at some point in the fall he should step aside and let Thomas Paine, a non-political person, demonstrate that he was capable of running NASA at least through the first lunar landing.

To Webb's surprise, the President not only took up Webb's offer to resign, but decided that Webb should announce it immediately, even before he left the White House. Obediently, Webb told the White House press corps that he would leave NASA on October 7, his sixty-second birthday. Webb was not able to contact Paine or his wife before making the announcement.⁶⁴

Although momentum was great after the success of Apollo 7 to take Apollo 8 to lunar orbit, a final decision to undertake that bold step had not yet been made. In particular, George Mueller was worried about whether the overall program gains from the mission justified the fallout from a failure. A final review of the mission was scheduled for November 10-11; in advance of those meetings, Mueller wrote to Gilruth, saying "There are grave risks to the program as a whole, not just to the Apollo 8 mission, in embarking on a lunar orbit mission with the second manned flight of the CSM. We have to face the possibility that this type of mission could appear to the public, and to our peers in government, to be a precipitous, risky venture where the propaganda value is the only gain." Mueller was concerned that the enthusiasm within NASA for flying the mission might have had the effect of suppressing justified concerns about the risks. He told Gilruth "the risks from a purely technical aspect are probably reasonable and acceptable. If such a mission failed, however, the risks to the program as a whole could be significant." (II-62)

The November 10 meeting included the top executives of the companies involved in Apollo. After hearing a series of presentations by NASA managers, the executives were polled on their views of whether Apollo 8 should be approved as a lunar orbit mission. Although there were a few questions raised, according to George Low, "the

meeting was adjourned with the conclusion that a firm recommendation to fly the Apollo 8 mission to lunar orbit would be made the next day to the Acting Administrator.” (II-63) That recommendation came the next day in the form of a memorandum from Sam Phillips to George Mueller. (II-64) On November 11, there were a series of internal NASA meetings in which Thomas Paine heard the same briefings as had been given the previous day. In a first, large meeting, George Mueller continued to play the devil’s advocate. A second meeting involved Paine, Associate Administrator Homer Newell, who had been with NASA since its beginning and was respected for his judgment, Mueller, and the NASA Center Directors. A third meeting involved only Paine, Newell, and Mueller. At its conclusion, Paine announced that he had approved the plan to make Apollo 8 a mission to go into orbit around Moon. (II-65) The launch date was set for December 21, which meant that the Apollo spacecraft would go into lunar orbit on Christmas Eve.

As the launch preparations for Apollo 8 went forward, there was continuing concerns that the Soviet Union might still launch a flight around the Moon. Russia had modified its new Soyuz spacecraft so that it could carry cosmonauts in a flight around the Moon (but not into lunar orbit). They designated the modified spacecraft Zond. It would be launched on its circumlunar trajectory by a version of the Proton rocket. The original hope was that the first flight with cosmonauts aboard could occur on the fiftieth anniversary of the Bolshevik Revolution in October 1967, but a failure in April 1967 of the Earth-orbital version of the Soyuz spacecraft, resulting in the death of cosmonaut Vladimir Komarov, delayed testing of the Zond spacecraft into 1968. A September 1968 Zond-5 did go around the Moon and returned its passengers – turtles and insects – to

Earth, still alive. But a November Zond-6 mission had several failures; if there had been a crew aboard, they would have died. Even so, the cosmonauts scheduled to make the first crewed Zond mission asked permission from the Soviet Politburo to make an attempt at the next launch window in early December, but that permission was never given. The way was thus clear for Apollo 8 to be the first spacecraft to reach the Moon with humans aboard.⁶⁵

The five first stage engines of the Saturn V booster rumbled into action at 7:51 a.m. on December 21, lifting Frank Borman, James Lovell, and Bill Anders on their historic journey. Less than three hours later, the engine on the third stage of the launch vehicle fired, injecting the Apollo 8 spacecraft on a trajectory that would take it to the vicinity of the Moon three days later. Once it arrived at the Moon, the engine on its service module fired, placing the Apollo spacecraft into lunar orbit, where it remained for twenty hours.

The public highlight of the mission came on Christmas Eve, as the crew televised the view of the lunar surface from their spacecraft back to millions of people on Earth. Then, to the surprise of almost everyone, including the mission controllers back on Earth, the crew took turns reading the first verses from the Bible's Genesis account of the creation of the Earth. Frank Borman closed their broadcast by saying "goodnight, good luck, a Merry Christmas, and God bless you all – all of you on the good Earth."⁶⁶ (II-72)

In addition to this dramatic broadcast, the Apollo 8 crew when they landed on December 27 brought home with them the iconic photograph of the blue Earth rising above the desolate lunar landscape. In addition to its public impact, the successful mission demonstrated that NASA was ready to operate at the lunar distance. The path to

a lunar landing had been pioneered; “For many of the people in the Apollo Program, Apollo 8 was the most magical flight of all.”⁶⁷

Goal Met: Americans on the Moon

Two missions stood between Apollo 8 and, if they were successful, the first attempt at a lunar landing. On March 3, 1969, a Saturn V launched for the first time the full Apollo spacecraft – the command and service modules and the lunar module. That combination at the time at just over 292 thousand pounds was the heaviest payload ever put into orbit. The crew – James McDivitt, David Scott, and Rusty Schweickart – remained in Earth orbit. Over the course of the ten day mission, the lunar module spent six hours undocked from the command and service modules at distances up to 113 miles before rendezvous and re-docking, thereby demonstrating an essential element of the lunar orbital rendezvous approach. Both the descent and ascent engines of the lunar module were fired in a variety of modes. Schweickart performed a thirty-nine minute extra-vehicular activity to test the Apollo portable life support system that would be used for walking on the lunar surface. The mission was extremely complex, and all of its objectives were met successfully.

Apollo 10 would be a dress rehearsal for the lunar landing mission, carrying out all elements of that mission except for the final descent from 47,000 feet above the lunar surface. It was planned to follow the same time line as a landing mission attempt, with the same Sun angles and the same out-and-back trajectory. Some, most notably George Mueller, thought that the mission should actually attempt the landing; Mueller’s view was that to reduce risks the lunar landing should be achieved in the fewest possible

flights. But this idea was vetoed, both because the lunar module assigned to the mission was too heavy to actually land and because the crew and the mission managers in Houston argued successfully that they needed the experience of this mission under their belts to reduce the risks associated with the first landing attempt.⁶⁸

Once again, Apollo 10 met all of its test objectives. The lunar module undocked from the command and service modules by about 350 miles, and then successfully re-docked, once again demonstrating the feasibility of the approach that NASA had chosen in 1962. The mission was launched on May 18 and returned to a safe landing in the Pacific Ocean on May 26. The crew of Thomas Stafford, John Young, and Gene Cernan had demonstrated that NASA was ready to try to land on the Moon. Apollo 11 was next.

NASA, and particularly the top astronaut official Deke Slayton, had adopted an approach to flight crew assignment that resulted in the backup crew for a particular mission becoming the prime crew for a mission three flights down that line. That meant that the Apollo 11 flight assignment would go to the crew that had been the backup for Apollo 8 – Neil Armstrong, Edwin “Buzz” Aldrin, and Fred Haise. In reality, Haise was a replacement for the backup crew for Michael Collins, who had recently had back surgery. On January 6, 1969 Slayton informed Neil Armstrong that he would command the Apollo 11 mission, with Aldrin as his lunar module pilot. Collins had fully recovered from the surgery that had sidelined him for Apollo 8, and would serve as command module pilot.⁶⁹

NASA of course had been planning the lunar landing mission in detail for some months. (Indeed, the Sea of Tranquility had been identified as a possible site for the first landing in 1962.) Because the basic objective of the initial mission was to land on the

Moon's surface, get a few samples of lunar material, and return safely to Earth, that planning had been quite conservative. For example, Sam Phillips had proposed in October 1968 that the first landing mission should conduct only one extra-vehicular walk on the Moon's surface of no more than three hours, and that the astronauts should stay within 300 feet of the lunar module. An open item was whether both astronauts, or only one, should leave the lunar module for a walk on the Moon. After some controversy on whether it was feasible, Phillips also recommended that the mission should have the capability of televising the first steps on the Moon back to Earth. (II-67)

Once the Apollo 11 prime crew had been chosen, there followed almost seven months of intensive training to get them ready for the mission.⁷⁰ While they and their colleagues at the Manned Spacecraft Center focused on that training, NASA Headquarters considered how best to attend to the symbolic aspects of the mission. Richard Nixon had been elected President in November 1968, and as he took office he named Thomas Paine to continue to serve as Acting NASA Administrator; only after a number of others had turned the job down did he on March 5 nominate Paine to be Administrator. Paine was confirmed by the Senate on March 20 and was sworn in on March 21.

Paine during the spring appointed one of his top advisers, Associate Deputy Administrator Willis Shapley, to chair a Symbolic Activities Committee to recommend to him how best to recognize the historic character of the first lunar landing. Shapley was a veteran Washington bureaucrat and both Webb and Paine looked to him for advice on political, policy, and budgetary issues. By mid-April, the Committee had decided that "the intended overall impression of the symbolic activities and of the manner

in which they are presented to the world should be to signalize[sic] the first lunar landing as an historic forward step of all mankind that has been accomplished by the United States of America.” The primary way to indicate that the lunar landing was an American achievement would be “placing and leaving a U.S. flag on the moon in such a way as to make it clear that the flag symbolized the fact that an effort by American people reached the moon, not that the U.S. is ‘taking possession’ of the moon. The latter connotation is contrary to our national intent and would be inconsistent with the Treaty on Peaceful Uses of Outer Space.” (II-70, II-71)

In January 1969, some in NASA headquarters had interpreted Richard Nixon’s words in his inaugural address “as we explore the reaches of space, let us go to the new worlds together” as indicating that the White House might prefer that a United Nations flag, rather than the American flag, be placed on the Moon. When he heard of this suggestion, George Low told NASA Headquarters “my response cannot be repeated here. I feel very strongly that planting the United States flag on the moon represents a most important aspect of all our efforts.” (Volume II, I-12)

Another matter of concern was what might be said as the first man stepped onto the Moon. Julian Scheer, the top public affairs official at NASA Headquarters, heard a rumor that George Low was seeking advice on what might be said. Scheer wrote to Low, saying “we have not solicited comment or suggestions on what the astronauts might say. Not only do I personally feel that we ought not to coach the astronauts, but I feel it would be damaging for the word to get out that we were soliciting comment.” Scheer added “that the truest emotion at the historic moment is what the explorer feels within himself not for the astronauts to be coached before they leave or to carry a prepared text in their

hip pocket.” Low quickly responded, saying that there had been a misunderstanding; Low had sought advice on what should be carried to the Moon, not what should be said. He added, “I completely agree with you that the words said by the astronauts on the lunar surface (or, for that matter, at any other time) must be their own. I have always felt that way and continue to do so.” Low had made the point to Neil Armstrong, the Apollo 11 commander, that “whatever words are said must be his own words.” (II-68, II-69)

The first human mission to the Moon was launched at 9:32 a.m. EDT on July 16, 1969. Four days later, at 4:17 p.m., after a perilous descent, the lunar module came to rest on the lunar surface. A few seconds later, Armstrong radioed back “Houston, Tranquility Base here. The *Eagle* [the name assigned to the mission’s lunar module] has landed.”⁷¹

The mission plan that had been prepared for the Apollo 11 crew called for them to go to sleep between the time they landed and the time they exited the lunar module for the first Moon walk. (A decision had been made that both Armstrong and Aldrin would conduct an extra-vehicular activity, rather than have one astronaut stay in the lunar module as a safety measure.) But with the landing safely behind them and the lunar module in good condition, the keyed-up crew suggested that they begin their Moon walk five hours ahead of schedule, without the intervening sleep period. Permission was quickly granted. Getting ready to leave the lunar module went more slowly than had been planned, but finally, at 10:56 p.m. EDT, Neil Armstrong stepped off of the lunar module, saying, “that’s one small step for man, one giant leap for mankind.” (Armstrong meant to say “a man,” but the “a” got lost in the excitement of the moment.)

Aldrin followed Armstrong fourteen minutes later, and the two spent two and a

half hours carrying out their assigned tasks, including planting the U.S. flag on the lunar surface. During their Moon walk, President Richard Nixon called from the Oval Office, proclaiming it “the most historic telephone call ever made from the White House.”

The ascent stage of the *Eagle* performed as planned, and at 1:54 p.m. EDT on July 21 Armstrong and Aldrin were launched from the lunar surface to rendezvous with Michael Collins, who had been circling the Moon in the command and service module *Columbia*. The two spacecraft docked three hours later, and a little less than twelve hours later fired the service module engine to send them on a trajectory for a landing in the Pacific Ocean at 12:50 p.m. EDT on July 24. The crew, the command module, and the 44 pounds of precious lunar cargo were immediately placed in quarantine, where they were soon greeted by the President, who had flown to the recovery ship, the aircraft carrier *Hornet*, to greet them. The *Hornet* docked in Honolulu, Hawaii on the afternoon of July 26; from there, the crew flew back to Houston. (I-73)

The goal set by John F. Kennedy just over eight years earlier had been met; Americans had flown to the Moon and returned safely to Earth. Apollo 11 was a success, technically and politically. (II-81, II-74)

What Do You Do Next, Once You Have Been to the Moon?

Continuing Exploration There were a few within NASA, Robert Gilruth among them, who thought that there should be no additional flights to the Moon, given how risky they were and that the program’s fundamental goal had been achieved. But the momentum behind additional missions overrode these hesitations. As Apollo 11 concluded its mission in July 1969, there were nine additional flights to the Moon, through Apollo 20,

being planned. Apollo 12 through 15 would use the same basic equipment as had Apollo 11, but would land at different locations and stay for increasingly longer times on the lunar surface. Apollo 16-20 would carry a lunar rover, a small vehicle that would allow the astronauts to transverse the lunar surface, and could stay on the Moon for up to 78 hours.⁷²

Apollo 12, carrying Charles “Pete” Conrad, Alan Bean, and Richard Gordon, was launched during a thunderstorm on November 14, 1969. Lightning struck the spacecraft during its initial ascent and for a moment it appeared that the mission would have to be aborted. But this threat passed, and the lunar module made a precision landing within walking distance of the Surveyor III spacecraft that had landed on the moon in April 1967.

The next mission, Apollo 13, was launched on April 11, 1970. Its crew included James Lovell, Jack Swigert, and Fred Haise. Swigert was a last minute substitute for T.K. “Ken” Mattingly. There was concern that Mattingly had been exposed to measles and might become ill during the mission. More than two days away from Earth on the mission’s outbound journey, an oxygen tank in the service module exploded, placing the crew’s life in jeopardy. There would be no lunar landing, and it took heroic efforts by the crew and those on the ground to bring the crew back safely by using the lunar module as a life boat for most of the journey around the moon and back to Earth.

The intended landing site for Apollo 13 had been the Frau Mauro, a location of high scientific interest. When Apollo 14 was launched, on January 31, 1971, it was targeted to land at the same site. The crew – Alan Shepard, who had made the first U.S. spaceflight almost ten years earlier, Stuart Roosa, and Edgar Mitchell – carried out two

extended Moon walks. The mission became notorious when at the conclusion of the second walk Shepard used a piece of lunar equipment with an actual head of a six-iron golf club inserted in it to hit (after two misses) the first lunar golf shot.

The Apollo 14 crew was the last to be required to undergo quarantine after their return to Earth. The possibility of lifting the quarantine had been examined after the first two Apollo missions, but the Interagency Committee on Back Contamination refused to do so on the recommendation of a committee set up by the National Academy of Sciences to review the issue. Because Fra Mauro, the planned landing site for Apollo 13, was a very different type of location on the moon than the places where Apollo 11 and 12 had landed, and because the astronauts would take a deep core sample, “a majority [of the committee] recommend continuance of the 3-week lunar quarantine period. A minority favor discontinuance of quarantine.” (II-76) When there was no evidence of possible back contamination after Apollo 14 returned, the requirement for quarantine was lifted.⁷³

Missions Cancelled When Richard Nixon became President in January 1969, he was advised of the need for decisions on the character of the U.S. civilian space program once Apollo had reached the Moon. In February, he asked his Vice-President, Spiro Agnew, to chair a “Space Task Group” to provide him with recommendations on the future in space. The Task Group worked through the summer in the midst of the enthusiasm surrounding Apollo 11, and on September 15 submitted a bullish set of recommendations that called for the United States to accept “the long-range option or goal of manned planetary exploration with a manned Mars mission before end of this century as the first target.” (Volume I, III-25) As steps toward this goal, the Group recommended a series of

increasingly larger Earth-orbiting space stations launched by the Saturn V and continued exploration of the Moon. It also recommended the development of a lower cost Earth-to-orbit space transportation system, which soon became known as the Space Shuttle.

This type of recommendation was not at all what the Nixon administration had in mind; its top goal was reducing government spending. Between September 1969 and January 1970, the NASA budget went through a series of reductions from what had been proposed to get started on the recommendations of the Space Task Group, and George Low, who had become NASA Deputy Administrator in December 1969, announced on January 4, 1970 that NASA was canceling Apollo 20 and stretching out the remaining seven missions so that they would continue through 1974. Ten days later, faced with continuing budget cuts, Administrator Thomas Paine announced that production of the Saturn V would be suspended indefinitely once the fifteenth vehicle had been completed.⁷⁴ While NASA tried for several years to retain the option of restarting the Saturn V production line, by 1972 it decided that it had no choice but to give up this possibility. (Volume IV, I-46) Thus within six months of the first landing on the Moon, the United States had essentially abandoned the heavy-lift capability that had been so central to James Webb's vision of what Apollo could create.

Richard Nixon finally responded to the Space Task Group in a statement issued on March 7, 1970, saying, "space expenditures must take their proper place within a rigorous system of national priorities. What we do in space from here on in must become a normal and regular part of our national life and must therefore be planned in conjunction with all of the other undertakings which are important to us."⁷⁵ It was clear that there would be no more Apollo-like space goals set while Nixon was in office.

Nixon's intent to reduce the government budget continued to have an impact on Apollo through the rest of 1970, and even into 1971. Thomas Paine, frustrated by his lack of success in getting White House support for ambitious post-Apollo plans and eager to return to General Electric, announced his resignation on August 15, 1970; George Low became Acting Administrator. Low was almost immediately faced with a decision on whether to cancel two of the remaining six Apollo missions, recognizing that NASA could not both fly these missions, launch the Skylab space station in 1973, and begin its preferred new program, the Space Shuttle, within the budget being proposed for the next several years by the White House Office of Management and Budget. (II-77)

Reluctantly, Low agreed that NASA should cancel Apollo 15, the last limited capability mission, and Apollo 19. The remaining flights after Apollo 14 were then renumbered Apollo 15-17. The cancellation was announced on September 2.

Even after this announcement, there was continued White House pressure to reduce the NASA budget. There was a possibility that NASA would have to choose between canceling one or more of the remaining Apollo missions and flying Skylab. Low wrote Nixon's science adviser Edward Davis, Jr., on October 30, saying "on balance, the weight of evidence seems to favor Skylab over Apollo if a choice must be made." This was the case, said Low, because "the scientific returns from the single Skylab mission promise to be greater than those from a sixth Apollo lunar landing. We have already capitalized on our Apollo investment but not yet on that of Skylab; we will have more new options better developed stemming from Skylab than from Apollo; and, for this increased return, we risk less in earth orbit than at lunar distances." (II-78)

NASA was not forced to make this draconian choice in 1970, but the possibility

of canceling Apollo 16 and Apollo 17 was revived by the White House in 1971 as the NASA budget was being prepared; the space agency was also seeking White House permission to begin development of the Space Shuttle. James Fletcher, a former president of the University of Utah and industrial executive, had become NASA Administrator in May 1971. In November, he wrote the Deputy Director of the Office of Management and Budget, Caspar W. Weinberger, recommending “against the cancellation of Apollo 16 and 17 because these flights are scientifically important, and because much of the overall support for NASA's space program depends on our actions with respect to these flights.” In his letter, Fletcher listed a number of adverse consequences that could result. If, however, a decision to cancel the missions were made, said Fletcher, the rationale behind the decision should be that “in these times of pressing domestic needs, the manned space program should be earth-oriented instead of exploration and science-oriented.” (II-79)

In reality, it was the professional staff of the Office of Management and Budget, not Weinberger, who was pressing for the cancellations. In an August 12, 1971 memorandum to President Nixon, Weinberger had written that his office was proposing to cut the NASA budget “because it is cuttable, not because it is doing a bad job or an unnecessary one.” He added, “I believe that this would be a mistake” because “an announcement that we are canceling Apollo 16 and 17 . . . would have a very bad effect.” In Weinberger’s view, “it would be confirming in some respects, a belief that I fear is gaining credence at home and abroad: That our best years are behind us, that we are turning inward, reducing our defense commitments, and voluntarily starting to give up our super-power status, and our desire to maintain world superiority.” The memorandum

was returned by Nixon with a hand-written notation: "I agree with Cap."

It was a political rationale that initiated the Apollo program, and at least in part it was a political rationale that convinced the White House to continue the program. Apollo 16 and 17 would be launched.

The Scientists are Not Happy Tensions between those who saw Apollo as an opportunity to gather valuable scientific data and materials and those who saw it as primarily a challenging engineering enterprise intended to demonstrate U.S. technological and organization might had been present since the start of the program, and persisted through to its conclusion. For example, Donald Wise, the chief scientist of NASA's Apollo Lunar Exploration Office, left the agency in the immediate aftermath of Apollo 11, telling Associate Administrator Homer Newell that his office, with the responsibility for getting lunar science moving, "was largely wasting its time running in tight circles within the bureaucracy and the various competing elements of NASA." He felt that this situation would persist until the NASA leadership "determines that science is a major function of manned space flight." (Volume V, I-25) Echoing this concern, George Mueller wrote to Manned Spacecraft Center Director Robert Gilruth in September 1969, reminding Gilruth that after Apollo 11 "increased interest and direct participation of the scientific community in Apollo is taxing our capability to the limit. Despite this, we will certainly detract measurably from the success of Apollo 11, and the missions yet to be flown, unless we meet the challenge. Therefore, we must provide the support required in the science area." With respect to criticisms from the scientific community about the scientific aspects of Apollo, Mueller added "some members of the scientific community are impatient and as you know, are willing to air their views without necessarily relating

those views to what is practicable and possible. Public discussion aside, it is our policy to do the maximum science possible in each Apollo mission and to provide adequate science support.” (II-75)

There were some members of the scientific community who were excited by the potential scientific returns from Apollo, and were very upset as NASA in 1970 cancelled three Apollo missions. A letter from thirty-nine scientists protesting these cancellations was sent to Representative George Miller, Chairman of the House Committee on Science and Astronautics, soon after NASA announced the cancellation of the Apollo 15 and Apollo 19 missions. The scientists argued that “the Apollo lunar program is intended to supply not merely information of interest to scientists, but to give us finally a clear understanding of the origin of the earth-moon system and with this, an understanding of the origin and mode of construction of our earth.” “Because the structure of the Apollo program is one of increasing capabilities,” they stated, “the two cancelled missions represent much more than one third of the planned scientific program. With this curtailment, the program may fail in its chief purpose of reaching a new level of understanding.” (II-80)

The Final Missions

Pressure from the science community had one tangible result. On August 13, 1971 NASA announced that the crew for the last mission to the moon, Apollo 17, would include as lunar module pilot Harrison H. “Jack” Schmitt, a Ph.D geologist who had come to NASA as a scientist-astronaut in 1965 and had been deeply involved in planning the science to be done on the lunar missions. Assigning Schmitt to this mission meant

that the pilot-astronaut who had been part of the Apollo 14 backup crew together with Gene Cernan and Ron Evans, Joe Engle, would not have an opportunity to fly to the moon.⁷⁶

Schmitt's selection came on the heels of the scientifically most successful mission to date, Apollo 15, launched on July 26 with a crew of David Scott, Alfred Worden, and James Irwin. This was the first mission to carry the lunar roving vehicle, and Scott and Irwin used the vehicle to traverse almost 17 miles of the lunar surface, a distance much greater than that traveled by the previous three crews. They spent three days on the Moon, and conducted three extra-vehicular activities. Most significantly, they identified and brought back to Earth specimens of the primitive lunar crust, the first material that had solidified from the molten outer layer of the young moon; one of these samples was dubbed the "Genesis rock."⁷⁷

The penultimate Apollo mission, Apollo 16, was launched on April 16, 1972. The mission was commanded by John Young; other crew members were command module pilot Ken Mattingly, who had been bumped from the Apollo 13 mission, and lunar module Charles Duke. The mission was targeted to land in the lunar highlands, an area of the Moon that had not yet been explored. Apollo 16's objectives were similar to those of the preceding mission, with a focus on characterizing a region thought to be representative of much of the lunar surface.⁷⁸

All of the prior Apollo missions had been launched during daylight hours. After an almost three-hour delay, Apollo 17 lifted off at 12:33 a.m. EST on December 7, 1972. The vivid light from the Saturn V's five F-1 engines illuminated the night sky with an unreal brilliance. After they landed on the Moon on December 11, "for the next 75 hours

Cernan and Schmitt conducted the longest, and in many ways the most productive, lunar exploration of the Apollo program.”⁷⁹ As they prepared to leave the lunar surface for the last time, Cernan unveiled a plaque on the descent stage of the lunar module, which would remain on the Moon’s surface. It read “Here man completed his first explorations of the moon.” As he took a last look at the lunar landscape, Cernan added “As we leave the moon at Taurus-Littrow, we leave as we came, and, God willing, as we shall return, with peace and hope for mankind.” The lunar module *America* lifted off of the moon at 5:55 p.m. EST on December 14.

With its departure, a remarkable era in human history came to a close, at least for the next half-century. For the first time, human beings had left their home planet.

¹ Roger Launius, in his essay “Interpreting the Moon Landings: Project Apollo and the Historians,” *History and Technology*, Vol. 22, No. 3 (September 2006), has provided a comprehensive and thoughtful overview of many of the books written about Apollo. The bibliography accompanying this essay includes almost every book-length study of Apollo and also lists a number of articles and essays interpreting the feat. Among the books Launius singles out for particular attention are: John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge: MIT Press, 1970); Walter A. McDougall, . . . *the Heavens and the Earth: A Political History of the Space Age*, (New York: Basic Books, 1985); Vernon Van Dyke, *Pride and Power: the Rationale of the Space Program*, (Urbana, IL.: University of Illinois Press, 1964); W. Henry Lambright, *Powering Apollo: James E. Webb of NASA*, (Baltimore: Johns Hopkins University Press, 1995); Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles*, NASA SP-4206 (Washington, DC: Government Printing Office, 1980); Edgar M. Cortright, *Apollo Expeditions to the Moon*, NASA SP-350 (Washington, DC: Government Printing Office, 1975); Charles A. Murray and Catherine Bly Cox, *Apollo: The Race to the Moon*, (New York: Simon and Schuster, 1989); Stephen B. Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs*, (Baltimore: Johns Hopkins University Press, 2002); Norman Mailer, *Of a Fire on the Moon*, (Boston: Little, Brown, 1970); Michael Collins, *Carrying the Fire: An Astronaut’s Journeys*, (New York: Farrar, Straus, and Giroux, 1974); Andrew Chaikin, *A Man on the Moon: The Voyages of the Apollo Astronauts*, (New York: Viking, 1994); W. David Compton, *Where No Man Has Gone Before: A History of Apollo Lunar Exploration Missions*, NASA SP-4214 (Washington, DC: Government Printing Office, 1989); Don E. Wilhelms, *To A Rocky Moon: A Geologist’s History of Lunar Exploration*, (Tucson: University of Arizona Press, 1993); Donald A. Beattie, *Taking Science to the Moon: Lunar Experiments and the Apollo Program*, (Baltimore: Johns Hopkins University Press, 2001); Howard McCurdy, *Space and the American Imagination*, (Washington, DC: Smithsonian Institution Press, 1997); Marina Benjamin, *Rocket Dreams: How the Space Age Shaped Our Vision of a World Beyond*, (New York: Free Press, 2003); De Witt Douglas Kilgore, *Astrofuturism: Science, Race, and Visions of Utopia in Space*, (Philadelphia: University of Pennsylvania Press, 2003); and Andrew Smith, *Moondust: In Search of the Men Who Fell to Earth*, (New York: Fourth Estate, 2005). In addition to these accounts, a

number of Apollo astronauts, NASA managers and flight operations personnel, and managers from the aerospace industry have published memoirs about their engagement with Apollo. Of particular interest is Robert C. Seamans, Jr., *Aiming at Targets*, (Washington, DC: National Aeronautics and Space Administration Special Publication-4106, 1996), and *Project Apollo: The Tough Decisions*, NASA, Monographs in Aerospace History No. 37, SP-2005-4537, 2005. and Glen E. Swanson, “*Before This Decade is Out . . . : Personal Reflections on the Apollo Program*, (Washington, DC: National Aeronautics and Space Administration Special Publication-4223, 1999).

² Charles A. Murray and Catherine Bly Cox, *Apollo: The Race to the Moon*, (New York: Simon and Schuster, 1989), pp. 54-55.

³ John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge: MIT Press, 1970), pp. 34-35.

⁴ Most of the account of this decision is taken from Logsdon, *The Decision to Go to the Moon*. This study of the Kennedy decision, published in 1970, remains the accepted version of the events leading to Kennedy’s May 25, 1961 announcement that “we should go to the moon.”

⁵ At this point, Saturn was the name of the von Braun-led program to develop a larger booster than anything the United States was otherwise planning, but still far short in lifting power of what was ultimately developed as the Saturn V for the lunar landing program.

⁶ *Public Papers of The Presidents of the United States: John F. Kennedy, 1961* (Washington, DC: Government Printing Office, 1962), p. 2.

⁷ For a perceptive biography of James E. Webb, see W. Henry Lambright, *Powering Apollo: James E. Webb of NASA*, (Baltimore: Johns Hopkins University Press, 1995).

⁸ W. Henry Lambright, *Powering Apollo: James E. Webb of NASA*, (Baltimore: The Johns Hopkins Press, 1995), pp. 82-87.

⁹ Hugh Sidey, *Kennedy, President* (New York: Scribner, 1963), pp. 121-123.

¹⁰ Henry C. Dethloff, *Suddenly, Tomorrow Came . . . : A History of the Johnson Space Center* (Washington, DC: National Aeronautics and Space Administration Special Publication-4307, 1993), p. 40.

¹¹ Murray and Cox, *Apollo*, pp. 88-89.

¹² *Ibid*, pp. 90-99. See also Charles D. Benson and William Barnaby Faherty, *Moonport: A History of Apollo Launch Facilities and Operations* (Washington, DC: National Aeronautics and Space Administration Special Publication-4204, 1978).

¹³ For more on this selection, see Roger Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles* (Washington, DC: National Aeronautics and Space Administration Special Publication-4208, 1980).

¹⁴ For a history of the Apollo spacecraft, see Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson, Jr., *Chariots for Apollo: A History of Manned Lunar Spacecraft* (Washington, DC: National Aeronautics and Space Administration Special Publication-4205, 1979).

¹⁵ For more information on the origins and development of the Saturn launch vehicles, see Bilstein, *Stages to Saturn* and Ray Williamson, “Access to Space: Steps to Saturn V” in John M. Logsdon *et al.*, eds., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Program* (Washington, DC: National Aeronautics and Space Administration Special Publication-4407, Vol. IV, 1999).

¹⁶ Murray and Cox, *Apollo*, pp. 120-123; Robert C. Seamans, Jr., *Aiming at Targets* (Washington, DC: National Aeronautics and Space Administration Special Publication-4106, 1996), pp. 93-94. For a discussion of the application of systems management to Apollo, see Stephen B. Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs*, (Baltimore: Johns Hopkins University Press, 2002).

¹⁷ For more detailed discussions of the decision on what should be the preferred approach to a lunar landing, see John M. Logsdon, “NASA’s Implementation of the Lunar Landing Decision,” NASA HHN-81, September 1968; James R. Hansen, *Enchanted Rendezvous: John C. Houbold and the Genesis of the Lunar-Orbit Rendezvous Concept*. NASA Monograph in Aerospace History, No. 4, 1999; and Murray and Cox, pp. 113-143.

¹⁸ Barton C. Hacker and James M. Grimwood, *On the Shoulders of Titans: A History of Project Gemini* (Washington, DC: National Aeronautics and Space Administration Special Publication-4203, 1977), pp. 36-37.

¹⁹ *Ibid*, p. 38.

²⁰ Murray and Cox, *Apollo*, p. 120, 124-140.

- ²¹ *Ibid*, p. 141.
- ²² Lambright, *Powering Apollo*, p. 113.
- ²³ For the origins of scientific planning for lunar exploration, see W. David Compton, *Where No Man Has Gone Before: A History of Lunar Exploration Missions* (Washington, DC: National Aeronautics and Space Administration Special Publication-4214, 1989), Chaps. 2-3.
- ²⁴ *Ibid*, Chap. 5.
- ²⁵ *Ibid*, Chap. 6.
- ²⁶ Quoted in *Ibid*, p. 45.
- ²⁷ See *ibid*, Chapter 4, for a discussion of the approach taken to handling lunar samples.
- ²⁸ Seamans, *Aiming at Targets*, p. 103.
- ²⁹ Dwayne Day has provided a discussion of these issues which can be found at <http://history.nasa.gov/JFK-Webbconv/pages/backgnd.html> (accessed August 25, 2006).
- ³⁰ "News Conference 58," John F. Kennedy Library and Museum, http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Press+Conferences/003POF05Pressconference58_07171963.htm (accessed August 25, 2006).
- ³¹ Seamans, *Aiming at Targets*, p. 105.
- ³² Murray and Cox, *Apollo*, p. 158, 160; Seamans, *Aiming at Targets*, p. 110.
- ³³ Murray and Cox, *Apollo*, p. 160.
- ³⁴ *Ibid*, pp. 153-154.
- ³⁵ Wernher von Braun to George E. Mueller, November 8, 1963, NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, DC.
- ³⁶ Murray and Cox, *Apollo*, p. 162.
- ³⁷ Lambright, *Powering Apollo*, p. 118.
- ³⁸ Compton, *Where No Man Has Gone*, Chap. 3.
- ³⁹ Quoted in Logsdon, *Decision*, pp. 175-176.
- ⁴⁰ Fulbright and Eisenhower are quoted in Dodd L. Harvey and Linda Ciccoritti, *U.S.-Soviet Cooperation in Space*, (Miami: Center for Advanced International Studies, University of Miami, 1974), p. 113.
- ⁴¹ Compton, *Where No Man Has Gone*, Chap. 3.
- ⁴² Aleksandr Fursenko and Timothy Naftali, *One Hell of a Gamble: Khrushchev, Castro and Kennedy, 1958-1964* (New York: Norton, 1997), p. 121.
- ⁴³ John M. Logsdon, "To the Moon Together? John F. Kennedy and U.S. Soviet Space Cooperation," unpublished paper in author's files.
- ⁴⁴ The reality was that in 1963 the Soviet leadership had not yet decided to approve a lunar landing mission. See John M. Logsdon and Alain Dupas, "Was the Race to the Moon Real?" *Scientific American* 270, no. 6 (June 1994): 36.
- ⁴⁵ *Public Papers of the Presidents of the United States: John F. Kennedy, 1963*, (Washington, DC: Government Printing Office, 1964), pp. 567-568.
- ⁴⁶ *Ibid*, p. 695.
- ⁴⁷ Letter from Albert Thomas (signed only "Thomas"), September 21, 1963. National Security Files, Box 308, John F. Kennedy Presidential Library.
- ⁴⁸ Quoted in Murray and Cox, *Apollo*, p. 161.
- ⁴⁹ It is not clear from available sources whether this review was carried to completion. Document II-42 is a labeled draft, and contains only the thoughts of the Bureau of the Budget staff. Room was left for recommendations by various senior officials, but whether those recommendations were made in the aftermath of President Kennedy's assassination is not known.
- ⁵⁰ Seamans, *Aiming at Targets*, p. 113-115.
- ⁵¹ Lambright, *Powering Apollo*, p. 132.
- ⁵² Sylvia Kraemer, "Organizing for Exploration," in John M. Logsdon *et al.*, eds., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, (Washington, DC: National Aeronautics and Space Administration Special Publication-4407, Vol. I, 1995), p. 613.
- ⁵³ See Murray and Cox, *Apollo*, Chaps. 12-13, for a discussion of these problems.
- ⁵⁴ For an account of the development of the lunar module, see Thomas J. Kerlly, *Moon Lander: How We Developed the Apollo Lunar Module* (Washington: Smithsonian Institution Press, 2001)
- ⁵⁵ "A Man on the Moon in '68?" *U.S. News & World Report*, December 12, 1966, p. 63.

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- ⁵⁶ Lambright, *Powering Apollo*, p. 139.
- ⁵⁷ *Ibid*, p. 141.
- ⁵⁸ See Murray and Cox, *Apollo*, Chaps. 14-15 for a description of the fire and its aftermath.
- ⁵⁹ Lambright, *Powering Apollo*, p. 161. Lambright's book includes a thorough discussion of how Webb reacted to the Apollo fire and its aftermath.
- ⁶⁰ Murray and Cox, *Apollo*, p. 231. For an account of this situation sympathetic to Storms, see Mike Gray, *Angle of Attack: Harrison Storms and the Race to the Moon* (New York: W.W. Norton, 1992).
- ⁶¹ This account of what the United States knew at the time about the Soviet space program is based on Dwayne A. Day, "Webb's Giant," *The Space Review*, July 19, 2004, www.thespacereview.com/article/188, (accessed September 6, 2006), Dwayne A. Day, "The Secret at Complex J," *Air Force Magazine* 87, no. 7, (July 2004): 72-76 and Dwayne A. Day, "From the Shadows to the Stars: James Webb's Use of Intelligence Data in the Race to the Moon." *Air Power History* 51, no.4 (Winter 2004): 30-39. For a discussion of what was later learned about the Soviet lunar effort, see John M. Logsdon and Alain Dupas, "Was the Race to the Moon Real?"
- ⁶² For a discussion of Tindall's contributions and style, see Murray and Cox, *Apollo*, pp. 292-297.
- ⁶³ Bilstein, *Stages to Saturn*, pp. 360-363.
- ⁶⁴ For more on Webb's resignation, see Lambright, *Powering Apollo*, pp. 200-204 and Murray and Cox, *Apollo*, pp. 322-323.
- ⁶⁵ For more information on the failed Soviet circumlunar program, see Logsdon and Dupas, "Was the Race to the Moon Real?" and Marcus Lindroos, "The Soviet Manned Lunar Program," http://www.fas.org/spp/eprint/lindroos_moon1.htm (accessed September 10, 2006).
- ⁶⁶ Murray and Cox, *Apollo*, pp. 325-334, provide a vivid account of the Apollo 8 mission. See also Robert Zimmerman, *Genesis: The Story of Apollo 8*, (New York: Four Walls Eight Windows, 1998). This essay will not provide detailed accounts of the Apollo missions. For such accounts from the astronauts' perspective, see Andrew Chaikin, *A Man on the Moon: The Voyages of the Apollo Astronauts*, (New York: Viking, 1994).
- ⁶⁷ Murray and Cox, *Apollo*, p. 333.
- ⁶⁸ *Ibid*, pp. 338-339.
- ⁶⁹ For more on the Apollo 11 crew assignment process, see Chaikin, *A Man on the Moon*, pp. 136-140.
- ⁷⁰ For a discussion of this training, see *Ibid*, pp. 163-183.
- ⁷¹ For a vivid account of the landing and the rest of the Apollo 11 mission, see *Ibid*, pp. 184-227.
- ⁷² For a description of the various stages of lunar explorations, see Compton, *Where No Man Has Gone Before*, Chaps. 10-14.
- ⁷³ *Ibid*, p. 223.
- ⁷⁴ *Ibid*, pp. 195-196.
- ⁷⁵ Richard M. Nixon, "Statement About the Future of the United States Space Program," 7 March 1970, in U.S. President, *Public Papers of the Presidents of the United States: Richard Nixon, 1970* (Washington: Government Printing Office, 1971), p. 251.
- ⁷⁶ For more on Schmitt's selection, see Chaikin, *A Man on the Moon*, 448-451.
- ⁷⁷ Compton, *Where No Man has Gone Before*, pp. 231-242.
- ⁷⁸ *Ibid*, pp. 244-247.
- ⁷⁹ *Ibid*, p. 250.