RICE UNIVERSITY'S
BAKER INSTITUTE
FOR PUBLIC POLICY

ISSUE BRIEF 06.11.19

50th Anniversary of Apollo 11: America's Race to the Moon

George W.S. Abbey, Senior Fellow in Space Policy

In October 1957, the Soviet Union startled the world by launching the first man-made satellite into orbit, Sputnik. This event created great concern in the United States and the Western world, as it demonstrated the Soviets had unexpectedly advanced its technological capabilities—technologies that could, in turn, lead to very capable intercontinental ballistic missiles. The Soviets subsequently achieved further firsts in space, launching another satellite with a passenger, a dog called Laika, as a first step toward launching humans into space. The United States suddenly found itself in a space race in which they were behind and trying to catch up.

This report traces events that were set into motion in the U.S. by the Soviets' successful launch of the Sputnik satellite and their subsequent launch of the first human in space, Yuri Gagarin. Among the most notable of these events was President John F. Kennedy's address to a joint session of Congress on May 25,1961, when he challenged the nation to land a man on the moon before the end of the decade. Subsequently, the U.S. successfully completed the Mercury and Gemini programs and worked relentlessly and tirelessly to enable astronaut Neil Armstrong to step on the lunar surface on July 21, 1969, eight years after Kennedy's speech.

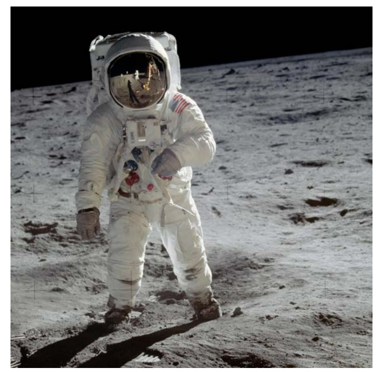
As the 50th anniversary of that historic achievement approaches, NASA has pledged to again return to the moon. If it is to be successful in this endeavor, it will require the commitment of the necessary funds and resources and a major redirection of NASA's ongoing activities to focus on returning to the moon. And it should be a cooperative effort, building on the foundation of the International Space Station partnerships, in order to achieve success.

NASA IS ESTABLISHED AND KENNEDY SETS A GOAL

In October 1958, President Dwight Eisenhower and the Congress established the National Aeronautics and Space Administration (NASA), a civilian space organization formed to further America's exploration of space with both manned and unmanned spacecraft. In December 1958, the newly formed NASA announced the Mercury program with the intent to send a human into space.

November 1960 brought the election of a new president, John Fitzgerald Kennedy. One of the major talking points of his campaign was to imply that Eisenhower had allowed the U.S. to fall behind the Soviets in the production of intercontinental ballistic missiles, thereby creating a so-called missile gap. Kennedy, inaugurated on January 20, 1961, declared the U.S. could not afford to be second to the Soviet Union in any area.

On April 12, 1961, less than three months after Kennedy took office, cosmonaut Yuri Gagarin lifted off on a rocket launched from the Baikonur Cosmodrome in Kazakhstan to become the first human to orbit the Earth. The adverse reaction in the U.S. to the Soviet Union's spectacular achievement exceeded



As the 50th anniversary of Apollo 11 approaches, NASA has pledged to again return to the moon. To be successful, this endeavor will require the necessary and funds and resources, and a major redirection of NASA's ongoing activities.

the negative response to the orbiting of Sputnik in 1957 and brought forth an admission by Kennedy at a press conference: "We are behind."

Only days after Gagarin's flight, a group of Cuban exiles armed and trained by the Central Intelligence Agency (CIA) attempted an invasion of Castro-led Cuba that was a dismal failure. It was another major embarrassment for the young president's administration.

Kennedy felt he had to respond with a bold step in response to Gagarin's flight and the failed CIA-backed assault on Cuba. He asked Vice President Lyndon Johnson, head of the newly formed Space Council, to recommend a challenge of historic proportions, one whose successful accomplishment would clearly demonstrate to the world the technological superiority of the United States.

On May 5, 1961, approximately three weeks after Yuri Gagarin's flight, astronaut Alan Shepard became the first American to fly in space. His Mercury capsule, launched on a Redstone rocket, did not orbit the Earth but reached an altitude of 116.5 miles, landing 302.8 miles downrange from the Florida launch site.

On May 25, not quite three weeks after Shepard's suborbital flight, Kennedy addressed a special joint session of Congress on the challenges facing the U.S. around the world. He spoke of the need to continue to build free market economies and to advance in science as means of promoting America's future.

He closed his 46-minute speech with a statement about space and a declaration of great significance. "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. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish." The room was silent. As the audience realized the significance of the technological and scientific challenge and the near impossibility of accomplishing it before the end of the decade—and what its accomplishment would mean—the applause grew. The Apollo program was born and the "Great Adventure" began.

INITIAL PLANS FOR A MOON LANDING

In May 1961, that goal seemed almost unattainable to those at NASA responsible for its achievement. John Glenn, the first American to orbit the Earth, did not fly until almost nine months later, on February 20, 1962. The Mercury program continued for another year with three more orbital flights. Mercury's last flight, piloted by Gordon Cooper, flew 22 orbits of the Earth in almost one and a half days. As the Mercury program proceeded, NASA struggled with various concepts for accomplishing the lunar landing. Three leading ideas were considered by NASA for the moon mission: direct ascent, Earth orbit rendezvous (EOR), and lunar orbit rendezvous (LOR). A direct ascent configuration required an extremely large rocket to send a three-man spacecraft that would land directly on the lunar surface. EOR would launch the direct-landing spacecraft in two smaller elements that would be assembled in Earth orbit. An LOR mission would involve a single rocket launching two spacecraft: a mother ship and a smaller, two-man landing module that would rendezvous with the main spacecraft in lunar orbit. The lander would be left in orbit around the moon and the mother ship would return home.

LOR was at first dismissed by NASA as too risky an approach, given that a space rendezvous had yet to be performed in Earth orbit, much less in lunar orbit. Langley Research Center engineer John Houbolt would not, however, let the advantages of LOR be ignored. As a member of the Lunar Mission Steering Group, Houbolt had been studying various technical aspects of space rendezvous since 1959, and he and several others at Langley were convinced that LOR was not only the most feasible way to make it to the moon before the end of the decade, but it was also the only way.

In November 1961, Houbolt, feeling the concept had not been fairly considered, wrote a letter directly to Robert C. Seamans, the associate administrator of NASA.

Seamans forwarded Houbolt's letter to D. Brainerd Holmes, recently hired by NASA as the director of the Office of Manned Space Flight. Holmes in turn forwarded the letter to George Low, NASA's chief of Manned Space Flight. After carefully considering Houbolt's recommended approach, Low felt it deserved further study.

In January 1962, Holmes hired a new deputy director for systems engineering, Joe Shea. Although Shea had a lengthy history in aerospace, he came to his new position with little knowledge about the great ongoing debate on concepts for accomplishing the lunar mission. Holmes sent Houbolt's letter to his new deputy. Holmes felt Shea would bring a fresh approach to the problem and help resolve the critical issue. Shea, as he took on his new position, found that NASA had not agreed on a concept to reach the moon, but thought that the final concept would probably require a rendezvous. Shea clearly gathered from Seamans that, based largely on the letter from Houbolt, the lunar orbit rendezvous deserved renewed consideration.

Over the next few months Shea worked with Houbolt and the leadership of the two major NASA centers involved in the decision to understand the advantages and disadvantages of the three concepts under consideration—LOR, EOR, and direct ascent. He was able to gain a consensus of all participants and the agreement of the two major center directors involved, Robert Gilruth of the Manned Spacecraft Center (MSC) and Werner von Braun of the Marshall Space Flight Center (MSFC), on the primary mode to be utilized for Apollo. On July 11, 1962, a formal announcement was made that NASA would base its planning program on the use of the advanced Saturn rocket (C-5 configuration) to accomplish the initial manned lunar landing and recovery using the lunar orbit rendezvous procedure as the prime mission mode. Shea would go on to become the Apollo spacecraft program manager working for Robert Gilruth at the Manned Spacecraft Center in Houston (later to become the Lyndon B. Johnson Space Center).

A large rocket booster was needed for the Apollo program and a number of booster configurations were being considered by von Braun and his team at the Marshall Space Flight Center. During 1961, various configurations were considered. Two rocket engines, the F-1 and J-2 engines, were believed to be the optimum choice, and the three-stage vehicle known as the Saturn V, utilizing these two engines, promised to be the optimum booster. Von Braun and his engineers made a firm commitment to the Saturn V by late 1961, and approval was given for its development on January 25, 1962. The approved three-stage vehicle would have five F-1 engines in the first stage, five J-2 liquid-hydrogen engines in the second stage, and one J-2 in the third stage. The Saturn V could lift a payload of 310,00 pounds to low Earth orbit and a payload of 107,100 pounds to a trans-lunar injection burn (a propulsive maneuver used to set a spacecraft on a trajectory to the moon).

With the LOR decision made in July 1962, two spacecraft were needed: The command and service module (CSM) to provide transportation to and from the Earth to the moon and the lunar module (LM) to land on the moon and carry the astronauts from the lunar surface to rendezvous with the orbiting CSM. Development was initiated on both spacecraft.

In addition to the rocket booster and the spacecraft, manufacturing, test, and launch facilities had to be designed and built. Two new NASA centers were created and built—the Manned Spacecraft Center in Houston and the Kennedy Space Center at Cape Canaveral—to test and launch the spacecraft and the new Saturn V rocket. All of these projects were begun as NASA continued to fly the Mercury spacecraft.

It also had become apparent that there was a need to develop systems beyond those flown in the Mercury spacecraft and to demonstrate capabilities well beyond those being achieved in Mercury's six-flight program in order to successfully accomplish Apollo. It was a "bridge too far" to proceed without a significant demonstration of the systems, techniques, and capabilities required for successful Apollo missions.

In a May 1961 speech to Congress, President Kennedy challenged the nation to put a man on the moon by the end of the decade. The room was silent as the near-impossibility accomplishing this—and the implications of success—sank in. Then the applause grew. The Apollo program was born and the "Great Adventure" began.

During this period, NASA was simultaneously developing, manufacturing, managing, and evaluating three major human space flight programs: Mercury, Apollo, and the rapidly evolving Gemini program.

THE GEMINI PROGRAM

Extensive new design work began after the president stated that a spacecraft beyond Mercury would be necessary to demonstrate the systems and capabilities that would enable Apollo. The new program, Gemini, was announced in early January 1962. The Gemini was a two-man spacecraft and was essentially an enlarged version of the Mercury capsule. It was the first manned spacecraft to include an onboard computer to facilitate the management and control of mission maneuvers. Unlike Mercury, the retrorockets, electrical power, propulsion systems, oxygen, and water were located in a detachable adapter module behind the crew's reentry module.

Gemini's objective was the development of space travel techniques to support the Apollo mission to land astronauts on the moon. It performed missions long enough for a trip to the moon and back, perfected the process of working outside the spacecraft (standup sessions and spacewalks), and pioneered the orbital maneuvers necessary to achieve space rendezvous and docking in Earth orbit. Other objectives included training both flight and ground crews; conducting experiments in space; active control of reentry to achieve a precise landing; and onboard orbital navigation.

With these new fundamental exploratory operations proven by Gemini, Apollo could pursue its prime mission. During this period, NASA was simultaneously developing, manufacturing, managing, and evaluating three major human space flight programs: Mercury, Apollo, and the rapidly evolving Gemini program. The last Mercury flight occurred in May 1963.

The 10 manned Gemini flights in 1965 and 1966 provided the essential preparation and experience needed to accomplish the subsequent Apollo missions. The first manned flight, Gemini 3, was flown on March 1965 and the last flight flew in November 1966.

THE APOLLO PROGRAM

As the Gemini missions were being flown, preparations were underway for the first Apollo mission. The first manned Apollo flight was to be launched in February 1967, approximately three months after the last Gemini flight. The crew assigned to the first flight included Virgil "Gus" Grissom, commander; Edward "Ed" White, command module pilot; and Roger Chafee, lunar module pilot.

A dress rehearsal of the launch countdown was scheduled approximately one month before the planned launch date. On January 27, 1967, a countdown demonstration test was held with the crew in the spacecraft with the hatch closed. Nylon Velcro had been placed throughout the interior of the spacecraft to assist in securing items in position during zero gravity. Other flammable material was also present in the spacecraft. There was a spark, probably caused by frayed wiring, resulting in a fire in the spacecraft. The crew frantically tried to open the inward-opening hatch but it proved to be too difficult and all three crewmen subsequently lost their lives through asphyxiation.

The tragic loss during the launch test was a major setback for the Apollo program and Kennedy's goal of a successful landing on the moon; that objective now seemed even more unattainable. In order to proceed, the cause of the fire had to be determined and corrective actions implemented. With an atmosphere of 100% oxygen inside the cabin, new fireproof material had to be developed, tested, and fabricated. A new outward, quick-opening hatch had to be designed and tested. The accident also led to a further evaluation of the spacecraft's basic design and systems, which led to additional design and reliability improvements. These efforts took place over a period of one and a half years. Apollo 7, the first manned flight of the redesigned spacecraft, was scheduled with a crew consisting of Wally Shirra as commander, Don Eisele as command module pilot, and Walt Cunningham as the lunar module pilot.

In late summer 1968, George Low, the Apollo spacecraft program manager, took a few days of a well-earned vacation, having worked almost seven days a week around-the-clock after becoming the program manager following the Apollo 1 fire. The lunar module was experiencing delays and he was quite concerned that if the current planned sequence of flights were followed, a successful lunar landing could not be achieved before the end of the decade—which, of course, was a primary goal. He came back to work with a new daring and courageous approach. If the planned October orbital flight of Apollo 7 was a complete success, he proposed taking the next flight two months later to the moon with just the Apollo command and service module. The Apollo 8 crew would only have to learn to fly one spacecraft and it would allow NASA to prove many of the systems, procedures, and much of the technology and equipment for a lunar landing without having to be concerned about a second spacecraft. Valuable deep space operational experience could be acquired while waiting for the delayed lunar module.

After reviewing his plan with Chris Kraft, the director of flight operations, and Deke Slayton, the director of flight crew operations, to obtain their assessment as to its feasibility, Low reviewed his proposal with center director Bob Gilruth and with his approval, successfully convinced NASA management on the merits of his plan. The NASA administrator, James Webb, agreed that if Apollo 7 was a success in October, he would consider approving Low's proposal to take Apollo 8 to the moon two months later in December 1968. However, there was another substantial obstacle that had to be overcome.

The Apollo 8 flight to the moon required a Saturn V. The Saturn V had flown two unmanned flights. Its first launch, Apollo 4, on November 9, 1967, was very successful. The second Saturn, Apollo 6, launched on April 4, 1968. Two minutes into the flight, the first stage experienced about 30 seconds of very violent vertical oscillations. During the second stage burn, two of the five engines shut down prematurely. When commanded to restart, the third stage engine, which was required to send the Apollo spacecraft on a trajectory to the moon, would not restart. In addition, the spacecraft lunar module adapter (SLA) that surrounded the lunar module came apart during the launch. All of these problems had to be understood and design changes made and tested before the next Saturn V flight scheduled for December, almost nine months later; this flight, Apollo 8, would be the new booster's first manned launch. 1967 and 1968 were periods of intense activity for both NASA's engineers and contractor teams.

All of the Apollo missions to the moon were flown from the mission control center at the Manned Spacecraft Center (later to become the Johnson Space Center) in Houston, Texas. The newly built Houston mission control center was first used in June 1965 for the flight of Gemini 4. The control center had two primary rooms known as mission operation control rooms. These two rooms controlled all the Gemini and Apollo flights. The two control rooms were identical in configuration. One could be used for simulated training for one mission while a flight was being flown utilizing the other room. The control room on the second floor of the control center was used for the first Apollo manned mission, Apollo 7. The control room on the third floor was used for all other the other Apollo flights.

Apollo 7's October 1968 flight of nearly 11 days was the first flight of the new Apollo command and service module. As noted earlier, its success was critical to ensuring a landing on the moon before the end of the decade. The fully successful pathfinding mission subsequently enabled Thomas Paine, the new NASA administrator, to announce on November 12, 1968, that Apollo 8 would be launched to the moon in December, one month later.

At 7:51 a.m. on Saturday, December 21, 1968, Apollo 8 lifted off from the Kennedy Space Center for its mission to the moon. After a successful launch, the crew of Apollo 8 and the third stage of the Saturn V completed almost two orbits of the Earth before restarting the third stage engine to perform the trans-lunar insertion (TLI) burn, sending humans for the first time beyond low Earth orbit; three days later they were orbiting the moon. A black-and-white television camera was carried on board the

As Apollo 8 orbited the moon, the crew saw its first Earth-rise. The beauty of the Earth with its rich colors were seen against the black void of space, with the stark lunar landscape in the foreground.

Apollo 8 spacecraft and as the astronauts orbited the moon on Christmas Eve 1968, the world saw a close-up view of the moon as the three astronauts read from the Bible—a very emotional event to all who viewed it on Earth. As they orbited the moon, they saw their first Earth-rise. Bill Anders took the photograph that has become quite famous and heightened the world's awareness of the significance of the Earth's environment. The beauty of the Earth with its rich colors can be seen against the black void of space, with the stark lunar landscape in the foreground. On December 27, Apollo 8 returned to Earth and landed successfully in the Pacific Ocean, and the crew and the spacecraft were recovered by the aircraft carrier USS Yorktown.

The Apollo command and service module (CSM) had now proven itself on two successive flights. However, landing on the moon required a proven lunar module (LM) as well. The next Apollo mission, Apollo 9, two months later would be on a Saturn V. The crew consisted of Commander James McDivitt, Command Module Pilot David Scott, and Lunar Module Pilot Rusty Schweickart. McDivitt and Schweickart had to learn to fly two spacecraft—the LM and the CSM. Apollo 9 was launched on March 3, 1969, for a 10-day mission in Earth orbit with a primary objective of an Earth-orbital engineering test of the first crewed lunar module.

Flying in the LM, McDivitt and Schweickart separated from Scott in the CSM and practiced separation and docking maneuvers. They flew the LM up to 111 miles from the CSM, using the engine on the descent stage; they then jettisoned the descent stage, and used the ascent stage to return and dock once again with the CSM. The flight was the first of a manned spacecraft that was not designed to reenter the Earth's atmosphere. Schweickart and Scott also performed an abbreviated EVA (extravehicular activity performed outside the spacecraft). Schweickart checked out the new Apollo spacesuit, the first to have its own life support system rather than being dependent on an umbilical connection to the spacecraft, while Scott filmed him from the command module hatch. The mission was a great success.

The next mission, Apollo 10, launched on a Saturn V, would take both the CSM and the LM to the moon, and while not landing, would be a dress rehearsal for the first lunar landing mission, Apollo 11. The flight was scheduled for May 1969, two months after the successful Apollo 9 flight.

The Apollo 10 crew were all veterans of spaceflight. Thomas P. Stafford, the commander, had flown on Gemini 6 and Gemini 9; John W. Young, the command module pilot, had flown on Gemini 3 and Gemini 10; and Eugene A. Cernan, the lunar module pilot, had flown with Stafford on Gemini 9. The mission included an eight-hour lunar orbit of the separated LM, flown by Stafford and Cernan, with a descent to about nine miles off the moon's surface before a rendezvous and docking with Young and the CSM in about a 70-mile circular lunar orbit. Data would be obtained in the landing rehearsal on the moon's gravitational effect to improve network-tracking techniques and to check out LM-programmed trajectories, radar, and lunar flight control systems. The mission launched on May 18, 1969, and landed in the Pacific Ocean on May 26, successfully achieving all the planned mission objectives.

Two months later, on July 16, Apollo 11 lifted off from the Kennedy Space Center with a crew consisting of Commander Neil Armstrong, Command Module Pilot Michael Collins, and Lunar Module Pilot Edwin "Buzz" Aldrin. Four days later, on July 20, 1969, Armstrong and Aldrin successfully landed on the moon—and the rest is history. The United States had achieved Kennedy's goal of landing a man on the moon and returning him safely to Earth before the end of the decade.

The goal having been achieved, the hectic schedule would be relaxed and the Apollo 12 mission to the moon, instead of being two months later, would not be flown until November 1969 with a crew consisting of Commander Charles (Pete) Conrad, Jr., Command Module Pilot Richard F. Gordon, and Lunar Module Pilot Alan L. Bean. The mission was planned to prove the ability to perform precision landings on the surface of the moon. The landing site selected was located in the southeastern portion of the Ocean of Storms and was within walking distance of the Surveyor III spacecraft, which had landed on the moon in April 1967. In addition to deploying surface experiments and gathering lunar samples, the astronauts planned to remove and return instruments from the Surveyor so that they might be examined to determine the effects of their long-term exposure to the lunar environment.

AFTER APOLLO 11

Apollo 12 launched on November 14, 1969, from the Kennedy Space Center, shortly after the passage of a cold front with some rain showers. Thirty-six and a half seconds after lift-off, the vehicle triggered a lightning discharge to the Earth through the Saturn's ionized plume. Protective circuits on the fuel cells in the service module detected overloads and all three fuel cells were taken offline, along with much of the instrumentation. A second strike at 52 seconds after launch took out the spacecraft's attitude indicator. The vehicle continued to fly on its planned trajectory, as the strikes had not affected the separate and independent instrument unit in the Saturn V.

The loss of all three fuel cells put the CSM entirely on batteries, which were unable to maintain the normal 75-ampere launch loads on the 28-volt DC bus, and one of the AC inverters dropped offline. Nearly every warning light on the spacecraft's control panel appeared to be lit.

At Mission Control Center in Houston, the flight controller responsible for monitoring the spacecraft's electrical system remembered the telemetry failure pattern from an earlier test when a power supply in the CSM signal conditioning electronics had failed. He made an immediate call to position a switch to a backup power supply. The fuel cells were put back online, and with telemetry restored, the launch continued successfully. Once in orbit, the spacecraft systems were carefully checked, and it was determined that the lightning strikes had caused no serious or permanent damage and a go was finally given for re-igniting the third stage engine for the trans-lunar injection burn.

The young flight controller's quick analysis and response and the redundancy provided by the Saturn V instrument unit allowed the mission to continue and achieve a precision landing on the moon. Apollo 12, successfully completing its planned mission, returned safely to Earth in the South Pacific on November 24.

Not one but two successful missions to the moon were achieved before the decade ended. During a chaotic decade of turmoil and dissension, Apollo demonstrated the nation's technological capabilities and brought hope and promise for the future—a bright and shining accomplishment amid a tumultuous time, and an achievement that could be the foundation for bettering life for all. In Neil Armstrong's words as he stepped upon the moon, "That's one small step for man, one giant leap for mankind."

The following year, 1970, brought Apollo 13, and the dramatic yet safe return of its three astronauts after an explosion in their service module 200,000 miles from Earth on the way to the moon. Four more successful lunar landings would be made during the next two years with the last mission, Apollo 17, returning safely to a landing in the Pacific in December 1972.

In December 2019 it will be 47 years, almost half a century, since a human last stepped on the lunar surface. It will be eight years this July since the space shuttle program was brought to a close and the United States last carried its astronauts to orbit. We have yet to again fly a spacecraft successfully carrying Americans to orbit, let alone back to the moon.

AUTHOR

George W.S. Abbey is the senior fellow in space policy at the Baker Institute. He served as the director of NASA Johnson Space Center from 1996 to 2001.

Rice University's Baker Institute for Public Policy
SPACE POLICY

Cover image courtesy of **NASA**

Cite as:
Abbey, George W.S. 2019. *50th Anniversary of Apollo 11: America's Race to the Moon.* Baker Institute Issue Brief no. 06.11.19. Rice University's Baker Institute for Public Policy, Houston, Texas.