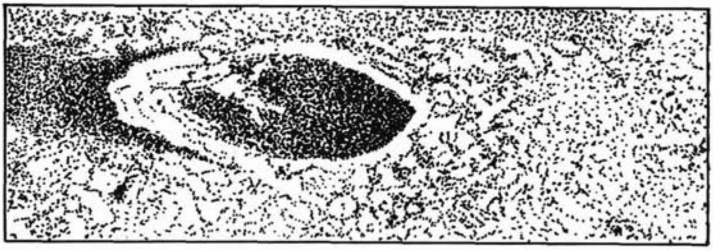


V. First Lunar Landing

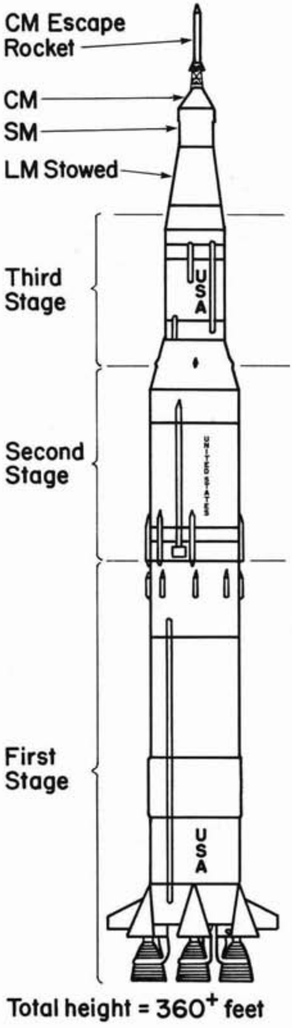
Based on the best guesses of various engineering managers, rumors around the space center were that Apollo 12 would be the first attempt to land on the Moon. After the extremely successful flights of Apollo missions 8, 9 and 10, however, "word" filtered down that the first lunar landing attempt might come on Apollo 11 if the mission went well. We notified some of our investigators to get their labs ready. One of the investigators I telephoned dropped the receiver when I told him, and I heard him shouting to his associates and lab techs, "We have to be ready for Apollo 11!" Our "countdown" calendar inside the front door of the LRL was a sobering sight. Each day's end meant we had one less day to get ready to receive lunar samples.

The new schedule for the lunar landing attempt caught the Soviet Union unprepared. Only three days before the Apollo 11 launch, the Russians launched a hastily assembled Luna 15 spacecraft designed to land on the Moon and return a small lunar sample. I have only rarely wished anyone ill luck with a space mission, but I was relieved to learn that the Russian spacecraft had crashed into the Moon. We would have been greatly disappointed if the Russian mission succeeded in returning a lunar sample to Earth before the Apollo program.

The southern edge of Mare Tranquillitatis was selected as the Apollo 11 landing site for two main reasons: 1) the area was relatively smooth and 2) the Surveyor V spacecraft landed there in September 1967. Surveyor V carried an alpha backscatter device to analyze the lunar surface. The analysis indicated the surface was basaltic, but a final refinement of the data, published by Dr. Tony Turkevich and his team just before the Apollo 11 launch, indicated the rocks were titanium-rich.[20] Turkevich's report was not anticipated. Many scientists ignored it, knowing that soon we would have samples for terrestrial laboratory analysis. Others privately expressed the opinion that the analysis was in error; after all, no theory of the Moon required that the rocks be rich in titanium. Later analyses of returned samples proved Turkevich and his co-workers had been exactly correct.

The immense stack of Apollo 11 hardware now dominated the Cape (Figures 4–6). The complete Saturn 5 assembly towered more than 360 feet above the launch pad. On July 16, 1969, at 8:32 a.m. EST, Apollo 11 lifted off the launch pad and began what geologists called "the big field trip in the sky." The check-out in Earth orbit, translunar injection, transposition and docking, spacecraft ejection, and translunar coast were virtually identical to those of Apollo 10. All systems were "go." Only one mid-course correction was required.

[20]A. L. Turkevich, E. J. Franzgrote, and J. H. Patterson, "Chemical Composition of the Lunar Surface in Mare Tranquillitatis," *Science*, vol. 165 (1969), 277–279.



Apollo Saturn 5

Figure 4. Scale drawing of the Apollo Saturn 5 launch stack showing the three rocket stages and the launch positions of the Command Module (CM), Service Module (SM), and the Lunar Module (LM). The first stage is composed of five F-1 engines which burn 4.6 million pounds of kerosene and liquid oxygen in 160 seconds to produce a combined thrust of 7.5 million pounds! The second stage burns liquid hydrogen and liquid oxygen in five J-2 engines for 6.5 minutes to produce a combined thrust of more than a million pounds. The third stage propulsion unit is a single J-2 engine that produces the final thrust required to achieve Earth parking orbit and another burn to gain trans-lunar injection. On top of this mighty stack of rocket engines is the LM, with its legs neatly folded under a large, smooth fairing; the SM; and the CM. The uppermost unit is a launch emergency escape system, including a modest rocket that could take the CM clear of a potential launch accident.

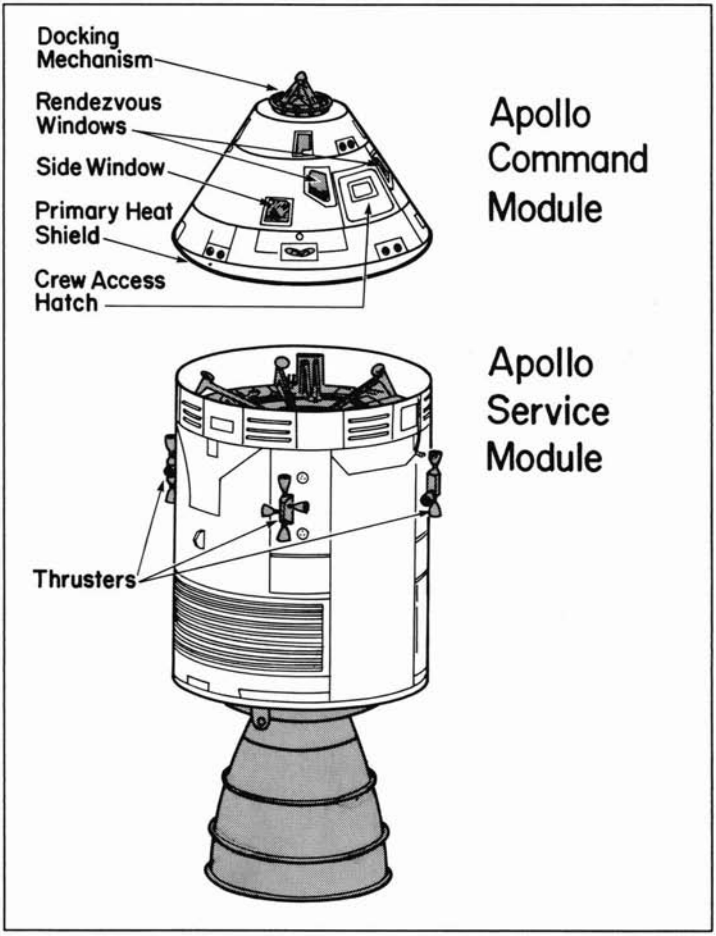


Figure 5. After trans-lunar insertion is accomplished with the third stage J-2 engine, the Command and Service Modules detach from the fairing covering the Lunar Module, turn around, dock with the hatch on top of the Lunar Module ascent stage, and pull the whole LM out of the expended third stage. The CM is the 12-foot, 10-inch diameter spacecraft with a heat shield for re-entry and all of the control panels. It houses the three-man crew except during lunar orbit, when the normal crew numbers only one. The SM contains the main propulsion engine for the CM and the SM. Together, the CM and SM are designated as the CSM until the SM is detached and abandoned just prior to re-entry. The SM is 24 feet, seven inches long and is the same diameter as the CM, so they fit together neatly.

The spacecraft braked into lunar orbit at approximately 76 hours ground elapsed time (g.e.t.), and a routine circularization of the orbit was made two revolutions later.[21] The check-out of the Lunar Module (LM) was nominal, and the crew took a planned rest period. Armstrong and Aldrin finally entered the LM. The LM and the Command and Service Module (CSM) undocked, and the descent to the lunar surface began at about 101.5 hours g.e.t. During powered descent to the lunar surface, the crew had to assume

[21]For a technical summary of the Apollo 11 mission activities, see "NASA Apollo 11 Mission Report," NASA SP-238 (1971). Also, see a less technical review of the Apollo missions by S. F. Cooper, Jr., *Apollo on the Moon* (New York: Dial Press, 1969).

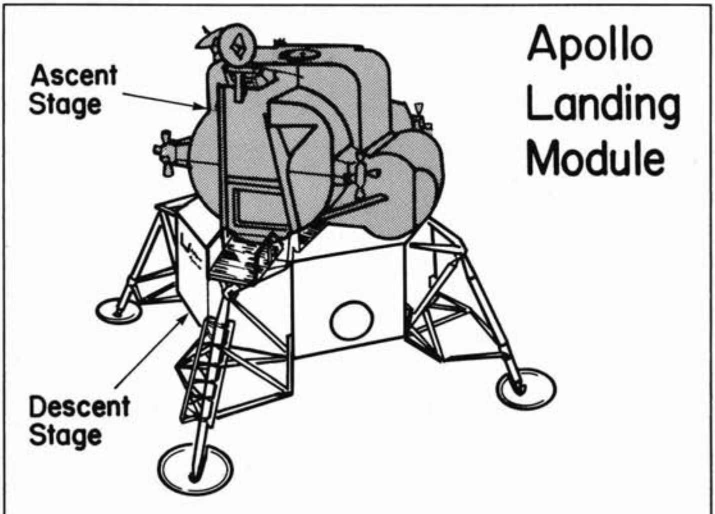


Figure 6. Apollo Lunar Landing Module (LM). The LM is divided into an ascent stage (shaded) and a descent stage (unshaded). The descent stage provides the liquid rocket engine for descent to the lunar surface from lunar orbit. With legs extended, the LM descent stage has a maximum diameter of 31 feet.The descent stage also serves as the launch platform for the ascent stage. The ascent stage contains the two-man crew and controls for the entire LM, as well as the small solid-fuel rocket for liftoff of the ascent stage from the lunar surface back to lunar orbit.

manual control of the descent path when it became clear that the automated flight path would place them in a boulder field near a fresh crater. This maneuver to avoid boulders took two and a half minutes and resulted in a down range translation of approximately 1,100 feet. The maneuver was costly in terms of descent stage fuel, and the Eagle touched down at Tranquility Base (Photo 45) with precious little descent stage fuel left! Nonetheless, the landing was successful.

After check-out of all LM systems and a meal, the crew decided to perform their Extra-Vehicular Activity (EVA) earlier than originally planned. Mission Commander Armstrong egressed first through the forward hatch and pulled a lanyard that deployed the Modularized Equipment Storage Assembly (MESA). Through the eye of a wide-angle television camera lens mounted on the MESA, we saw Armstrong take the first long step onto the lunar surface on July 20. We breathed a sigh of relief that the MESA deployed as it was supposed to, because the two rock boxes and most of the sample collection tools and bags were stored there.

The highest priority science activity was the collection of the "contingency sample." Armstrong had been provided with an extendable handle to hold a small teflon bag that enabled him to scoop up a few small rocks and store them in a pocket on his pressure suit—a small measure taken just to hedge our bets. If something went wrong and the crew had to leave the lunar surface prematurely, we wanted to be certain to have at least a small sample of Moon rocks. Armstrong accomplished the contingency sample collection and storage within his first minutes on the Moon, even before Aldrin egressed.

The most important scientific part of the mission was just beginning when President Nixon called to talk to the crew. The conversation lasted only two minutes, but it seemed like forever. Planting the U.S. flag was an activity we viewed with mixed emotions. We were proud to see "Old Glory" on the Moon, but the astronauts had a lot of important work to do. The crew soon got to it, though, and three major experiments were efficiently deployed: a passive seismometer, the laser ranging retroreflector, and a solar-wind composition experiment. The seismometer would detect "moonquakes" and meteoroid impacts and provide us with information on the internal structure and activity of the Moon. The laser ranging retroreflector was an array of optical corner reflectors that could reflect an incident light beam back exactly along its incident path,

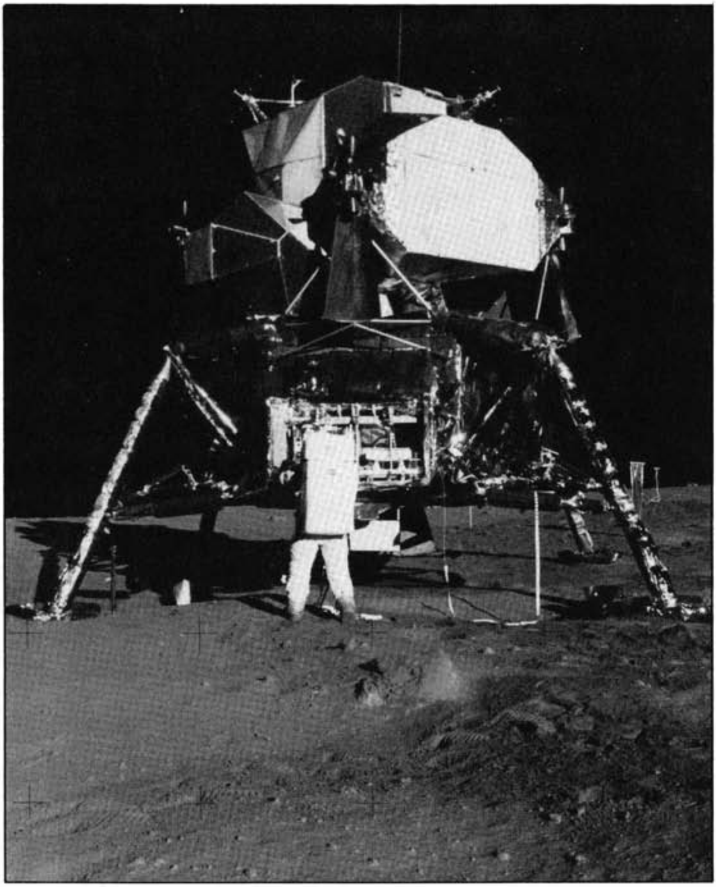


Photo 45. Tranquility Base. Astronaut Buzz Aldrin is unloading some of the lunar surface experiment apparatus for deployment. Note the lack of topography and smooth nature of the surface. (NASA photograph AS11-40-5927)

making it possible to determine exactly the distance from the light source to the reflector by precisely measuring the time it takes the light beam to make the two-way trip. The purpose of the solar-wind experiment was to collect solar ions implanted into clean aluminum foil—possible on the Moon because the surface is neither protected by an atmosphere nor a strong magnetic field. We referred to the solar-wind experiment as the "Swiss flag" because it was deployed like an aluminum window shade on a pole stabbed into the surface and the investigator was Dr. Johannes Geiss from Bern.

Our primary concern was for the astronauts to collect the main samples. Two aluminum rock sample boxes were stored on the MESA. The first box was called the "bulk sample" and was filled with the immediately available surface material. Collection of the bulk sample took more time than planned because the MESA was in a shadow which made sample collection more difficult. Armstrong remarked that using the sample scoop posed a problem because it was difficult to scoop material from the surface without throwing the sample out of the scoop. He tried to get at least one hard rock in each scoop and was careful to collect some samples away from the descent stage exhaust plume and propellant contamination. The box was sealed for later transfer to the LM ascent stage.

Two core tube samples were collected, although the crew had problems getting the core tubes to penetrate into the lunar soil more than about six inches even though a hammer was used to drive the tubes. The second rock box was designated as the "documented" sample, where the rocks on the surface were photographed before collection. Time ran short, however, and few samples were actually documented. Armstrong selected as wide a variety of rocks as possible for the second box during the remaining time. The second rock box was then vacuum sealed, after including the rolled-up aluminum foil from the solar-wind experiment, and was prepared for transfer to the LM ascent stage.

Meanwhile, Mike Collins continued monitoring the CSM in lunar orbit. Although he attempted to locate the LM on the lunar