America’s Greatest Projects & Their Engineers-Vol. VIII
The Apollo Project-Part 2

Course Number: PM-05-111

PDH: 6

Approved for: AK, AL, AR, FL, GA, IA, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

State Board Approvals
Florida Provider # 0009553 License #868
Indiana Continuing Education Provider #CE21800088
Maryland Approved Provider of Continuing Professional Competency
New Jersey Professional Competency Approval #24GP00025600
North Carolina Approved Sponsor #S-0695
NYSED Sponsor #274

Course Author: Dom Perrotta, PE

How Our Written Courses Work
This document is the course text. You may review this material at your leisure before or after you purchase the course.
After the course has been purchased, review the technical material and then complete the quiz at your convenience.
A Certificate of Completion is available once you pass the exam (70% or greater).
If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained).
If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH Pro.com.

I. Plans to Land on the Moon Are Committed

A. Process Decisions Are Reconciled

Following President John F. Kennedy's challenge to a joint session of Congress on 25 May 1961 to land an American on the Moon and return him safely to Earth by the end of the decade, there were several critical decisions that had to be made by NASA (National Aeronautics and Space Administration). Key among these was to develop and insure that the actual procedure for doing this would be both successful and less expensive to the American taxpayers. As was noted in Part 1 of the Apollo Project, these were the options that confronted NASA:

Options and Evaluations

a. Direct flight from the Earth to the Moon
b. Earth Orbit Rendezvous (EOR)
c. Lunar Orbit Rendezvous (LOR)

a. The Space Task Group, which was responsible for Project Mercury and the Headquarters Office of Launch Vehicle Programs, favored using the huge Nova rocket for a direct flight from Earth to the Moon. Landing the entire spacecraft on the lunar surface, as would be necessary with a direct flight approach, would have required an increase in rocket thrust because of the much heavier load of fuel tanks and fuel.
b. Marshall Space Flight Center (MSFC) in Huntsville, Alabama advocated an Earth Orbit Rendezvous. This method would require the use of several smaller Saturn launch vehicles to rendezvous in a Low Earth Orbit LEO). One of the vehicles would then be refueled in orbit for the long flight to the Moon.
c. Key members of the Langley Research Center advocated the LOR. Its premise was to have one spacecraft launched from Earth, travel and orbit the Moon's surface, and detach a separate spacecraft, known as an LEM (Lunar Excursion Module), down to the Moon's surface. The LEM would then rendezvous and re-attach to the Moon-orbiting spacecraft.

To compound the early dilemma with the project, some in NASA did not think that the mission was possible, and many more had serious doubts the project would accomplish its goal by the end of the 60's. We do know that NASA authorized several serious studies on a direct landing method for the Apollo program, but dropped the ideas because they would require too big a rocket.

Decisions Made

After much review by NASA administrators and engineers, the LOR method was selected. The payload for the LOR was estimated to be just slightly over 45 tons, as opposed to more than 100 tons for a direct flight. In addition, the LOR method would require only one large booster instead of the two required for either of the other two options. At the time the decision to not need so big a rocket was very logical; the Atlas rocket for the Mercury Project was still in development, which had necessitated that the smaller Redstone rocket be used to launch the first American astronaut (Alan Shepard) into space for a suborbital flight in April 1961. Furthermore, the Titan I and Titan II rockets, which would eventually be used for the manned spaceflights of Project Gemini, were still on the drawing board at Aerojet General since the "bridge project" between Mercury (Gemini) and Apollo had yet to be announced. Even though this decision was not reached until July of 1962, this did allow NASA to proceed full speed ahead for a potential lunar landing.

B. Design Considerations and Equipment Are Established

1. Rockets – Launch Vehicles

The U.S. Army Ordnance Missile Command (AOMC), was established at Redstone Arsenal in Huntsville, Alabama in the early 1950's, and they were permitted by the ABMA (U. S. Army Ballistic Missile Agency) to develop a large space booster of approximately 1.5 million-pounds thrust using a cluster of available rocket engines. However, this booster was considered to be a Department of Defense (DOD) missile, and was not to be used in the U. S. Space Program. In early 1959, this vehicle was first designated as Saturn. However, the U.S. manned satellite space program was struggling, and had to use the Redstone rocket to launch the first American satellites as well as the first two suborbital flights of Project Mercury. There followed a typical political squabble over the next eighteen months, when the Air Force proposed a Super Nova rocket that would be better and cheaper than the Saturn. However, its development was barely in the design stage, whereas the Saturn had construction drawings and parts on the ground. NASA solved the infighting by absorbing the ABMA.

The ABMA, under the direction of Dr. Wernher von Braun, had begun to develop the Saturn I rocket in 1957. The unique first stage was composed of a cluster of eight Redstone booster rockets around a Jupiter tank. This clustering of smaller boosters, rather than manufacturing larger rockets, allowed the use of tooling from the Redstone and Jupiter missile programs. The first Saturn rocket to fly was the **Saturn I,** which had a thrust capacity of about 200,000 lbf, and was the first launch vehicle that was capable of carrying more than 20,000 pounds into outer space and propelling the load into a Low Earth Orbit (LEO). Designed specifically to launch larger payloads, most of the rocket's power came from a clustered lower stage consisting of boosters taken from older rocket designs strapped together to make a single large booster. Its design proved sound and very flexible. Although it served only for a brief period for NASA, ten Saturn I rockets were flown before it was replaced by the Saturn 1B, its successor, which featured a more powerful upper stage and improved instrumentation.

Chrysler Corporation had opened a Huntsville operation in the 1950's, which was designated as their Space Division. It became Marshall Space Flight Center's prime contractor for the first stage of both the Saturn 1 and Saturn 1B rocket versions. The design, based on this cluster of boosters from the Redstone as well as the Jupiter missiles, was actually the first nuclear-tipped, medium-range ballistic missile (MRBM). Chrysler built them for the early Apollo program at their huge Michoud Assembly Plant, one of the largest manufacturing plants in the world, in East New Orleans. Between October 1961 and July 1965, all of Chrysler's missiles and boosters were successful and NASA never suffered a launch failure.

Saturn V Chosen

On 10 January 1962 NASA announced plans to build the **C-5**, a three-stage rocket consisting of the S-IC first stage, the S-II second stage, and the S-IVB third stage. The C-5 would be designed for a 90,000-pound (45 ton) payload capacity, capable of carrying American astronauts to the Moon. This was to be the largest production model of the Saturn family of rockets, and was already in the process of being designed at the Marshall Space Flight Center in Huntsville under the direction of Dr. von Braun. He and his team had been working on greatly improving rocket thrust in Huntsville since the early 1950's and had created a less complex operating system, designing better mechanical systems. During these revisions the decision to reject the single engine of the V-2's design had come about, and the team moved to a multiple-engine design. **Arthur Rudolph**, an integral part of the V-2 rocket team coordinated by von Braun, was the assistant director under von Braun at the Marshall Space Flight Center.

Saturn V Design

The Saturn V's size and payload capacity dwarfed all other previous rockets which had successfully flown at that time. With the Apollo spacecraft on top, Saturn V had an overall height of 363 feet and was slightly more than 33 feet in diameter, including guidance fins. Fully fueled, the Saturn V weighed nearly 6.5 million pounds, and had a thrust capability of 7.5 million lbf. Its Low Earth Orbit capacity was originally estimated at 261,000 pounds, and it was designed to send at least 90,000 pounds to the Moon, including the third stage (S-IVB), necessary fuel, the Command Service Module (CSM) and the Lunar Excursion Module (LEM). The stages were designed by the Marshall Space Flight Center (MSFC) in Huntsville, and numerous outside contractors were chosen for the construction. By late 1962, NASA had finalized its plans to proceed with von Braun's Saturn designs, and the Apollo space program gained speed. The C-5 was confirmed as NASA's choice for the Apollo Program in early 1963, and was renamed the **Saturn V** and used by NASA between 1967 and 1973. It would be a three-stage, heavy-lift launch vehicle, human-rated and liquid-fueled but expendable. The Saturn V was designed and manufactured to be a vehicle capable of launching a manned spacecraft on a trajectory to the Moon. In addition to Saturn V being used for human exploration of the Moon, it was later used to launch Skylab, the first American space station.

A total of fifteen flight-capable Saturn V vehicles were built, and it was the launch vehicle from the Kennedy Space Center in Florida for thirteen missions, never losing a manned crew or a payload. As of this day the Saturn V remains the tallest, heaviest, and most powerful rocket ever brought to operational status, and holds records for the heaviest payload launched and largest payload capacity ever placed into Low Earth Orbit (LEO). The weight of the lunar expedition system, which included the third stage and propellant necessary for translunar navigation as well as the Command Service Module and the Lunar Module, exceeded 160,000 tons. With the configuration of Saturn V finalized, NASA turned its attention to procedural missions for the translunar flights. Despite much controversy, the lunar orbit rendezvous combined with a lunar module had been chosen over an Earth orbital rendezvous or direct landing. Issues such as type of fuel injections, the needed amount of fuel for such a trip, and rocket manufacturing processes were ironed out, and the designs for the Saturn V were accelerated.

2. Spacecraft

Once the decision was made to adopt the lunar orbit rendezvous, this meant that two astronauts would remain in lunar orbit and control the CSM, while a lunar module (LM) with the other astronaut would descend to the Moon's surface. Many other aspects of the mission were significantly based on this fundamental design decision. Realizing that space rendezvous would be an integral part of any Moon landing, NASA inaugurated Project Gemini, a bridge project between the Mercury and Apollo programs, which would focus on spacecraft rendezvous and docking techniques. They also chose the second group of American astronauts in 1962, known as the New Nine, primarily to command and fly in the Gemini program.

The **Apollo spacecraft** was composed of several parts designed to accomplish the Apollo program's goal of landing American astronauts on the Moon by the end of the 1960s and returning them safely to Earth. The partially expendable (single-use) spacecraft consisted of a combined Command and Service Module (CSM) and a Lunar Module (LM). Two additional components complemented the spacecraft stack for space vehicle assembly. The first was the Spacecraft Lunar Module Adapter (SLA) designed to shield the LM from the aerodynamic stress of launch and to connect the CSM to the third stage (S-IVB) of the Saturn. It also included the Launch Escape System (LES), originally developed at the Langley Research Center for the Mercury Project, to carry the crew in the Command Module safely away from the launch vehicle in the event of a launch emergency. The LES was jettisoned during launch upon reaching the point where it was no longer needed, and the SLA remained attached to the launch vehicle's upper stage.

The change to lunar orbit rendezvous, plus several technical obstacles encountered in some subsystems (such as environmental controls internal to the CSM), soon made North American Aviation aware that substantial redesign would be required. Per an agreement with Faget, North American's project team determined that the most time-saving and efficient way to keep the program on track was to proceed with the development of the CSM in two versions. Thus, Block I and Block II came into being.

