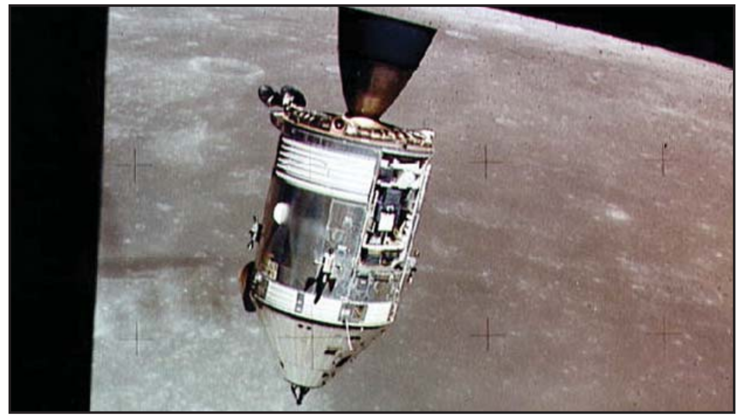
Project Apollo

When Apollo 11 commander Neil Armstrong stepped out of the lunar module and took "one small step" in the Sea of Tranquility, calling it "one giant leap for mankind," he fulfilled a dream as old as humanity. Project Apollo's goals, which went beyond landing Americans on the Moon and returning them safely to Earth, included establishing the technology to meet other national interests in space; achieving preeminence in space; carrying out a program of scientific exploration of the Moon; and, developing man's capability to work in the lunar environment. Six of the missions landed on the moon, where astronauts studied soil mechanics, meteoroids, seismic heat flow, lunar ranging, magnetic fields and solar wind. Apollos VII and IX tested spacecraft in Earth orbit; Apollo X orbited the moon as the dress rehearsal for the first landing.

Characteristics (Apollo Capsule)

Crew: Three
Crew Cabin Volume: 6.17 m³
Length: 3.47 m
Diameter: 3.90 m
Mass: 5,806 kg
Structure mass: 1,567 kg
Heat shield mass: 848 kg
RCS engine propellants: 75 kg
Drinking water capacity: 15 kg
Waste water capacity: 26.5 kg
Atmosphere cleanser: Lithium hydroxide
Odor absorber: Activated charcoal
Electric system batteries: three 40 ampere-hour silver zinc batteries and two 0.75 ampere-hour silver zinc pyrotechnic batteries
Parachutes: Two 5-m conical ribbon drogue parachutes, three 2.2-m ringshot pilot parachutes, three 25.45-m ringsail main parachutes



Highlights of Development Testing at AEDC

- **55,000 hours of test work in 25 different test facilities directly supporting the Apollo "man-on-the-moon" program, playing a crucial role in the nation's development of space flight vehicles**
- **Firings of Saturn V upper-stage engine and lunar ascent/decent motors**

AEDC played a major role in man's first landing on the moon in July 1969. From the first wind tunnel tests of a Saturn rocket model run in 1960 to more than 1,700 firings of the actual motors that made up the giant Saturn V launch vehicle in rocket test cells at simulated near-space conditions – AEDC was involved.

Just a little over nine years before Neil Armstrong's famous, "one small step for man and one giant leap for mankind" comments, the first aerodynamic test had been run on a scale model of a proposed Saturn launch configuration on June 6, 1960.

From 1960 to 1968, a total of 3,300 wind tunnel test hours – more than 35 percent of all the NASA Apollo program wind tunnel work – was completed at AEDC. In all, 25 of AEDC's 41 test facilities were involved in 55,000 hours of test work directly supporting the Apollo program.

In addition to determining flight characteristics of the launch configuration, tests conducted at AEDC provided data that helped NASA to program reentry parameters for the Apollo Command Module so that it would land within a mile or so of the recovery aircraft carrier. Reliability was proven for the launch abort/escape systems (which never had to be used), altitude start and operation of the Saturn IVB third stage, and the Service Propulsion System, which powered the Apollo Spacecraft.

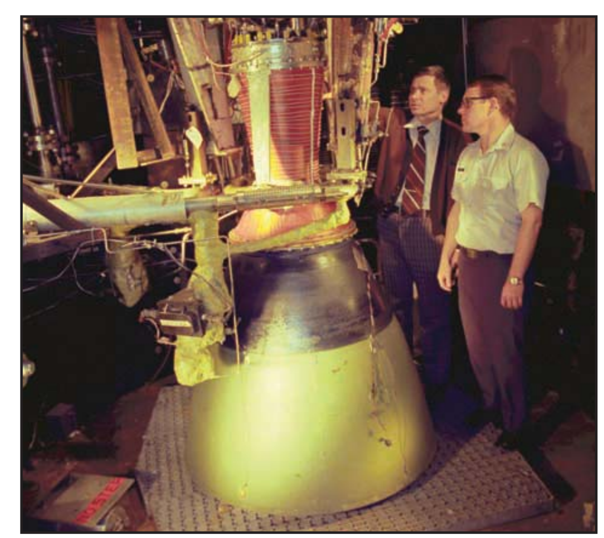
The first wind tunnel tests of models of the Apollo spacecraft ran in June 1962, in the von Kármán Gas Dynamics Facility's (VKF) 50-inch Mach 10 wind tunnel.

The first propulsion system test involved base heating studies on a proposed Saturn launch vehicle configuration in January 1961. Initial activity in support of the propulsion systems for the Apollo spacecraft modules involved an exploratory program using a 1/3-scale rocket engine.

The tests were run in a simulated space environment for the Service Module – the propulsion unit for the spacecraft that remained in orbit around the moon while two astronauts in the Lunar Excursion Module (LEM) explored the moon's surface. Results of these tests helped NASA in selection of a thrust chamber assembly and also led to the selection of an optimum nozzle configuration. In August 1963, a series of tests started using the full-scale Service Module primary (rocket) propulsion system to flight-qualify this 21,000-pound-thrust engine for its lunar mission throughout the various possible firing cycles.

In May 1964, an accelerated development test program began on the 3,500-pound-thrust LEM ascent engine under simulated space conditions. The engine lifted the lunar vehicle off the moon to return the astronauts to the orbiting Service Module. This program evaluated the design of the thrust chamber; evaluated the prototype flight-weight engine to define ballistic performance and structural integrity; and simulated the launch of the LEM ascent stage from the descent stage on the lunar surface.

Preparation for development of the 10,000-pound-thrust LEM descent engine, which decelerated the two-man capsule to a soft landing on the moon, began in May 1965. AEDC also did extensive altitude testing of the reaction control (course correction) system motors for both the Service and Command Modules. This included, among other work, development of test techniques for firing these rocket motors at a simulated altitude of nearly 80 miles. Wind tunnel aerodynamic tests refined the Saturn V launch configuration. A wealth of data produced in these tests contributed immeasurably to the design of the Saturn V launch vehicle as well as the Apollo Spacecraft and its emergency abort capsule escape system. The overall test program at AEDC was designed by NASA to obtain data on aerodynamic heating, stability during reentry, reentry heat ablation, interaction between separating components during escape operations, and aerodynamic loading throughout the flight regime – as well as to help solve related problems that arose during development. The aerodynamic tests provided information that was critically important in solving hundreds of problems and tasks associated with Apollo spacecraft development.



A three-month test program examining the performance of several proposed improvements to the liquid-fueled transtage rocket motor was completed in the same test cell in which the original study was conducted.

AEDC engineers performed detailed tests on a number of facets of NASA's Apollo program, including aerodynamic testing of this scale model of the Apollo three-man capsule with its escape tower in 1962. Later tests established the need for canard control surfaces at the apex of the escape rocket.

The biggest Apollo tests conducted at the center were firings of the Saturn IVB engine in an altitude rocket test cell. The complete engine was fired at simulated altitude conditions of more than 100,000 feet. The Saturn IVB was the second stage of the smaller Saturn IB rocket, which was used on the first suborbital Apollo flights. It was also used as the third stage of the Saturn V. Five J-2 engines made up the second stage of the Saturn V. The J-2 engine in this stage generated 200,000 pounds of thrust, using liquid hydrogen and liquid oxygen as the propellant. The second stage was 22.75 feet in diameter, 58.5 feet tall and weighed 70 tons. The value of testing this engine in an altitude test cell was proven when an over-temperature problem developed that had not shown up in sea-level tests performed by the manufacturer. The cause of the problem was identified and corrected at AEDC, and the engine fired successfully under all probable starting conditions in subsequent tests and actual flights.

From May 1963 to June 1968, tests were run on the Service Propulsion Engine. Results helped confirm that the Apollo XVI mission flown by John Young, Charles Duke and Ken Mattingly could safely continue when a wobble in the engine was discovered in flight. Also tested were the four 5,000-pound-thrust retrorockets that ensured proper separation of the Saturn IVB stage from the Service Command and Lunar Excursion Modules, which continued on to the moon.