# Lunar Prospector Description

## Mission Overview

The Lunar Prospector (LP) Mission consisted of a spin-stablized orbiter spacecraft designed to perform continuous mapping of the Moon from a circular polar orbit. LP was selected as the third mission in NASA’s Discovery program in February, 1995. The spacecraft was designed and built in about 2 years by Lockheed Martin Missiles and Space in Sunnyvale, CA. It was delivered for launch in late 1997 (Binder et al., 1998). The LP spacecraft was launched on January 7, 1998  
(UTC). The primary mapping mission began on January 16, 1998 and lasted for one year. During most of the mapping mission, the spacecraft mapped the surface from a 118-minute, circular, polar orbit 100 km above the moon’s surface (Binder et al., 1998). Starting on 12/19/98  
the spacecraft was maneuvered into a 40 km orbit as a transition into a low altitude extended mission orbit. The transition orbit was used to collect gravity data in order to verify the moon’s gravity model in preparation for conducting the extended mission orbit.

The extended mission began on January 16, 1999. The objective of the extended mission was to provide higher resolution mapping from a circular, polar orbit averaging 30 km above the moon’s surface. The spacecraft was maneuvered in its 30 km extended mission orbit starting  
on January 29, 1999. The Lunar Prospector mission ended on July 31, 1999 when the spacecraft was intentionally impacted into a crater near the south pole. The impact site was targeted for one of the hydrogen deposits detected by Lunar Prospector’s Neutron Spectrometer. The  
intent of the impact event was to generate a plume of dust and vapor from the deposit to try to confirm the presence of water through a series of earth-based and space-based spectral observations. The impact of Lunar Prospector occurred at 9:52 UTC on July 31, 1999. There was no evidence of a dust plume, a water vapor plume, or an OH plume.

The science goals of the Lunar Prospector Mission were to map the Moon’s surface composition and its magnetic and gravity fields, and to determine the frequency and location of gas release events. Special emphasis was placed of the search for polar ice deposits.

To meet these science goals the LP spacecraft carried five science instruments mounted on three booms. The instrument package included a Gamma Ray Spectrometer (GRS), a Neutron Spectrometer (NS), an Alpha Particle Spectrometer (APS), a Magnetometer (MAG), and an Electron Reflectometer (ER). A sixth science investigation was a Doppler Gravity Experiment (DGE) that used tracking data for mapping the gravity field. The gravity data was derived from tracking the LP spacecraft with the NASA Deep Space Network (DSN) with ground stations  
in California, Spain, and Australia (Konopliv et al., 1998).

The LP science team consisted of the PI, Alan Binder, and five Co-I’s, and was divided into three groups. The Spectrometer Group consisted of William Feldman and Binder. The Magnetics Group consisted of Robert Lin, Mario Acuna, and Lon Hood. The Gravity Group consisted of  
Alexander Konopliv.  
   
Mission Phases

Lunar Prospector Launch  
The Lunar Prospector spacecraft was launched on January 7, 1998 at 2:28:44 UTC on a Lockheed Martin Launch Vehicle 2 (Athena 2) from the Spaceport Florida commercial pad (Pad 46) at Cape Canaveral, Florida. After about 1/2 of an orbit around the Earth, a 64 second burn by the spacecraft’s Trans Lunar Injection stage sent LP on a 105 hour cruise to the moon. The spacecraft was turned on at 56.5 minutes after launch.  
   
 Spacecraft Id: LP  
 Target Name: MOON  
 Mission Phase Start Time: 1998-01-07  
 Mission Phase Stop Time: 1998-01-07  
 Spacecraft Operations Type: ORBITER  
   
Lunar Prospector Cruise  
The Lunar Prospector spacecraft was inserted into a translunar trajectory after reaching a parking orbit around Earth. The Cruise Phase to the moon lasted about 105 hours. The three spacecraft booms were deployed starting about 5 hours after launch. All five science  
instruments were turned on during cruise and collected science data for instrument check out and calibration. The MAG/ER was activated at about 1.33 hours after launch and the APS at about 3.5 hours after launch. The GRS and NS needed to degas and were not turned until  
about 24 hours after launch. Two trajectory correction maneuvers were performed during the Cruise Phase.  
   
 Spacecraft Id: LP  
 Target Name: MOON  
 Mission Phase Start Time: 1998-01-07  
 Mission Phase Stop Time: 1998-01-11  
 Spacecraft Operations Type: ORBITER  
  
Lunar Prospector Orbit Insertion  
The Lunar Prospector spacecraft was inserted into orbit by an initial Lunar Orbit Insertion (LOI) engine burn at 11:45 UTC on January 11, 1999. The initial capture orbit had a 11.8 hour period. Three additional engine firings put the spacecraft into its mapping orbit, which was a 100 +/- 20 km circular polar orbit with a 118 minute period. All five science instruments were operating and collecting data during the Orbit Insertion Phase.  
   
 Spacecraft Id: LP  
 Target Name: MOON  
 Mission Phase Start Time: 1998-01-11  
 Mission Phase Stop Time: 1998-01-16  
 Spacecraft Operations Type: ORBITER  
   
Lunar Prospector Primary Mission  
The Lunar Prospector Primary Mission lasted for one year as originally planned. The nominal mapping orbit during the Primary Mission had an altitude of 100 km above the moon’s surface. Orbit maintenance maneuvers were required every 56 days to correct for changes in the  
mapping orbit due to lunar gravity anomalies.

The basic mapping strategy during the Primary Mission was for the science instruments to collect data continuously. The data were downlinked to Earth immediately and simultaneously transferred to a solid state recorder and then downlinked 53 minutes later. These delayed data frames were interleaved into the real-time data stream. The purpose of the delayed stream was to receive data acquired on the lunar farside when communications with the Earth were blocked by the moon. Late in the Primary Mission as the spacecraft batteries began to degrade and eclipses limited recharge time by the solar panels, the spacecraft transmitter was cycled off and on to conserve power. The transmitter was switched off when the spacecraft was on the lunar farside and communications with the Earth were not possible. This transmitter cycling began on September 16, 1998 and continued periodically throughout the rest of the Primary Mission and into the Extended Mission.

At the start of the Primary Mission the LP spacecraft attitude as measured by the spin axis direction (+Z, which is perpendicular to the top of the spacecraft bus and in the direction of the omni antenna) was pointed to within a few degrees of north ecliptic pole. In October 1998, the spacecraft orientation was flipped by 180 degrees so that the spin axis pointed toward the south ecliptic pole. The reorientation was done so that the APS instrument could collect data that it missed due to an anomaly on one of its faces and to test for any asymmetries in the response of the other spectrometers. The maneuver was initiated on October 5, 1998 with the spacecraft turning 90 degrees (spin axis parallel to the ecliptic). This intermediate orientation provided calibration data for the GRS instrument. On October 7, 1998, the spacecraft turned the final 90 degrees. The spacecraft maintained the ecliptic south orientation for the rest of the mission except for special procedures. On November 15, 1998, the spacecraft was turned by 80 degrees to avoid possible damage to the solar panels due to dust from Leonids meteor shower. This orientation minimized the cross sectional area of the solar panels in the direction of the shower. On November 19, 1998, the spacecraft was turned back to the attitude with the spin axis nearly parallel to the ecliptic south pole. There was no apparent damage to the spacecraft  
from the shower.  
   
 Spacecraft Id: LP  
 Target Name: MOON  
 Mission Phase Start Time: 1998-01-16  
 Mission Phase Stop Time: 1999-01-16  
 Spacecraft Operations Type: ORBITER  
   
Lunar Prospector Extended Mission  
The Lunar Prospector Extended Mission started on January 16, 1999 and continued until July 31, 1999. The nominal mapping orbit during the Extended Mission had an average altitude of 30 km above the moon’s surface.

Near the start of the Extended Mission, noise in the Alpha Particle Spectrometer instrument started to affect the Neutron Spectrometer causing the NS instrument to saturate. As a result, the APS was turned off on February 8, 1999 to allow the NS to collect clean data. The APS instrument was turned on again on April 21, 1999 and was collecting good data without noise. However, noise from the APS again began affecting the NS in mid-May 1999. As a result, the APS was turned off on May 24, 1999 and it remained off for the remainder of the mission.

During the final week of the Lunar Prospector mission a number of events took place in preparation for the final impact event. On July 26, 1999, a small orbit correction maneuver raised periselene up about 5 km to maintain the spacecraft’s circular orbit. In preparation for a lunar eclipse on July 28, 1999 where the spacecraft could not fully recharge the battery between nighttime passes, all non-critical subsystems were turned off. The three spectrometer instruments were powered off before the eclipse and they remained off for the last three days of the mission. On July 29, 1999, the spacecraft was spun up to 23.7 rpm (from the nominal 12 rpm). This was in preparation for later maneuvers that targeted the spacecraft for impact. On July 30, 1999 aposelene was raised to put the spacecraft into a more elliptical orbit. This was done so that the impact approach was as steep (about 6.3 deg) as possible to hit the crater floor. On July 31, the final maneuver occurred to lower periselene beneath the lunar surface such that the spacecraft impacted the target point of -87.7 deg latitude, 42 deg longitude. The impact occurred at 09:52 UTC.  
   
 Spacecraft Id: LP  
 Target Name: MOON  
 Mission Phase Start Time: 1999-01-16  
 Mission Phase Stop Time: 1999-07-31  
 Spacecraft Operations Type: ORBITER  
  
Mission Objectives

The overall goal of the Lunar Prospector (LP) Mission was to perform global mapping of the Moon in order to better understand the Moon’s origin, evolution, current state, and resources. Specifically, LP mapped the surface abundances of key elements (U, Th, K, O, Si, Mg, Fe, Ti, Ca, Al, Gd, Sm, and H). As part of the elemental abundance mapping, LP determined that water ice exists in permanently shadowed areas near the lunar poles. LP made high-resolution measurements of the near-side crustal gravity field and measured long-wavelength gravity anomalies for the entire Moon. LP provided global measurements of lunar crustal magnetic fields and the induced dipole moment. LP also attempted to determine the frequency and location of gas release events, as one of the major sources of the thin lunar atmosphere.   
  
References

Binder, A.B., Lunar Prospector: Overview, Science, 281, 1475-1476, 1998, doi:10.1126/science.281.5382.1475.   
  
Binder, A.B., W.C. Feldman, G.S. Hubbard, A.S. Konopliv, R.P. Lin, M.H. Acuna, and L.L. Hood, Lunar Prospector searches for polar ice, a metallic core, gas release events, and the moon's origin, Eos, Trans. AGU, 79, 97, 1998, doi:10.1029/98EO00061.   
  
Konopliv, A. S., A. B. Binder, L. L. Hood, A. B. Kucinskas, W. L. Sjogren, and J. G. Williams, Improved gravity field of the moon from Lunar Prospector, Science, 281, 1476-1480, 1998, doi:10.1126/science.281.5382.1476.