The Lunar Prospector Mission:
Final Results of Trajectory Design, Quasi-Frozen Orbits, Extended Mission Targeting, and the Lunar Topography and Potential Models

David Folta & Mark Beckman
Guidance, Navigation, and Control Center
Goddard Space Flight Center, NASA
and
David Lozier & Ken Galal
Space Projects Division
Ames Research Center, NASA

Abstract:

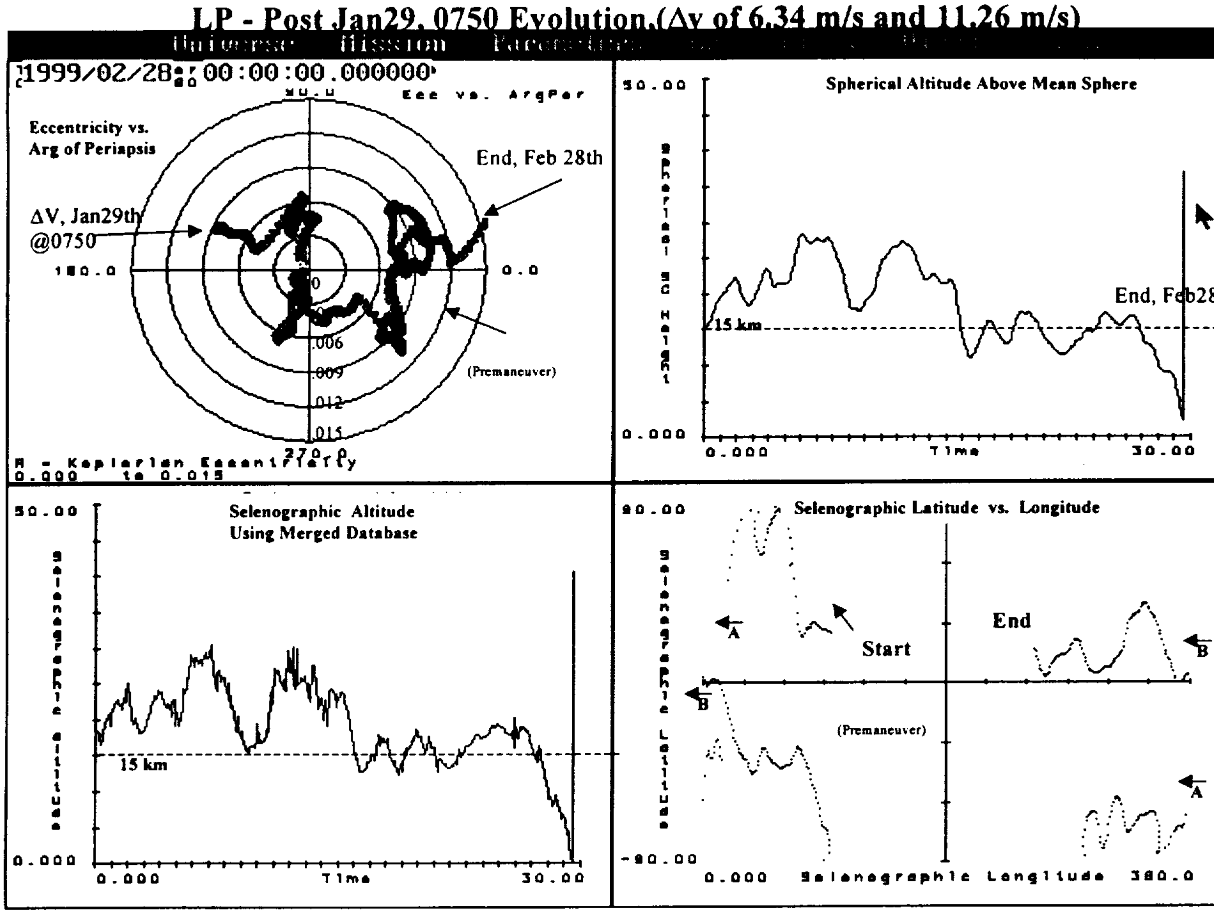
The National Aeronautics and Space Administration (NASA) selected Lunar Prospector as one of the discovery missions to conduct solar system exploration science investigations. The mission was NASA's first lunar voyage to investigate key science objectives since Apollo and was launched in January 1998. In keeping with discovery program requirements to reduce total mission cost and utilize new technology, Lunar Prospector's mission design and control will focus on the use of innovative and proven trajectory analysis programs. As part of this effort, the Goddard Space Flight Center and the Ames Research Center became partners in the Lunar Prospector trajectory team to provide the trajectory analysis and orbit determination support.

At the end of 1998, Lunar Prospector completed its one-year primary mission at 100-km altitude above the lunar surface. On December 19, 1998, Lunar Prospector entered its extended mission phase. The mission orbit was lowered from 100 km to a mean altitude of 40 km. Due to lunar potential effects, the altitude of Lunar Prospector varied from 25 to 55 km above the mean lunar geoid. After one month at 40 km, the lunar potential model was updated based upon the new tracking data at 40 km. On January 15, 1999, the altitude was lowered again to a mean altitude of 30 km. The spherical altitude varied between 15 km and 45 km above the mean lunar geoid while the topographical altitude varied between 10 km and 50 km. Various means were employed to get accurate lunar surface elevation including Clementine altimetry and LOS analysis. Based upon the best available terrain maps, Lunar Prospector reached actual altitudes of 8 km above lunar mountains in the southern polar region. This extended mission phase of six months will enable LP to obtain science data up to 3 orders of magnitude better than at the mission orbit. At the end of the operations mission, LP was targeted for impact at a chosen location that allowed optical observation of the lunar ejecta as LP ended its mission at 1.6 km/sec.

This paper details the trajectory design and orbit determination planning and actual results of the Lunar Prospector nominal and extended mission including maneuver design, eccentricity vs. argument of perigee evolution, topographical altitude estimation, and lunar potential modeling. This paper provides understanding of the quasi-frozen orbit design of the LP mission, the optimization process of lunar orbit targets, the impacts that the selected lunar potential models play, and discusses the feasibility of meeting the mission goals. Observed evolution of the Keplerian orbit elements are compared to the theoretical predictions using the latest lunar potential model available which incorporates the Lunar Prospector Doppler data. Mapping orbit maintenance maneuver design along with results of the actual maneuvers to maintain the orbital requirements are also presented.

The figure below presents recent results of orbital maintenance and the parameters considered in selected targets. The polar plot shows the w vs. eccentricity evolution that is a constant form.

LP - Post Jan29, 0750 Evolution,(Δv of 6.34 m/s and 11.26 m/s)



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NOTE:

A '5' minute movie of the entire mission is proposed for presentation during the paper or as an additional exhibition. This movie is a high quality movie with both orbit and science information provided.