Workshop on Science Associated with the Lunar Exploration Architecture - Earth Science Subcommittee

Theme: A Lunar-Based Earth Observatory

Science Observations from the Earth-Moon L1 Point

John L. West

Jet Propulsion Laboratory

Pasadena, CA 91109

February 28, 2007

Agenda

- Background
- The Concept
  - Description
  - Engineering/Technical Advantages
  - Potential Science Observations
- Proposed Funding and Schedule
- Acknowledgements

Background

- Concept developed by JPL in response to NASA Research Announcement (NRA) NNH06ZDA001N, Research Opportunities in Space and Earth Sciences (ROSES) Appendix E.4, Lunar Sortie Science Opportunities (LSSO) - 2006.

- Concept responds to NASA's goal of identifying how the new capabilities developed by the human exploration program can enable new opportunities to conduct high priority and compelling science investigations.

The Concept - Description

- Leverage the unique advantages that the Earth-Moon L1 vantage point offers, including continuous staring at the Earth, at the Moon, or at the celestial sphere during the Moon's periodic occultations of the celestial sphere, to perform compelling - and, very importantly, potentially substantially lower cost - science observations that complement those made on the lunar surface.

- Implement the concept using a small, instrumented, autonomous, "mini"-satellite, or instrument package, deployed by the astronauts from the crew transfer vehicle shortly after launch on the way to the Moon and subsequently stationed at the Earth-Moon L1 point.

The Concept - Description (Cont'd)

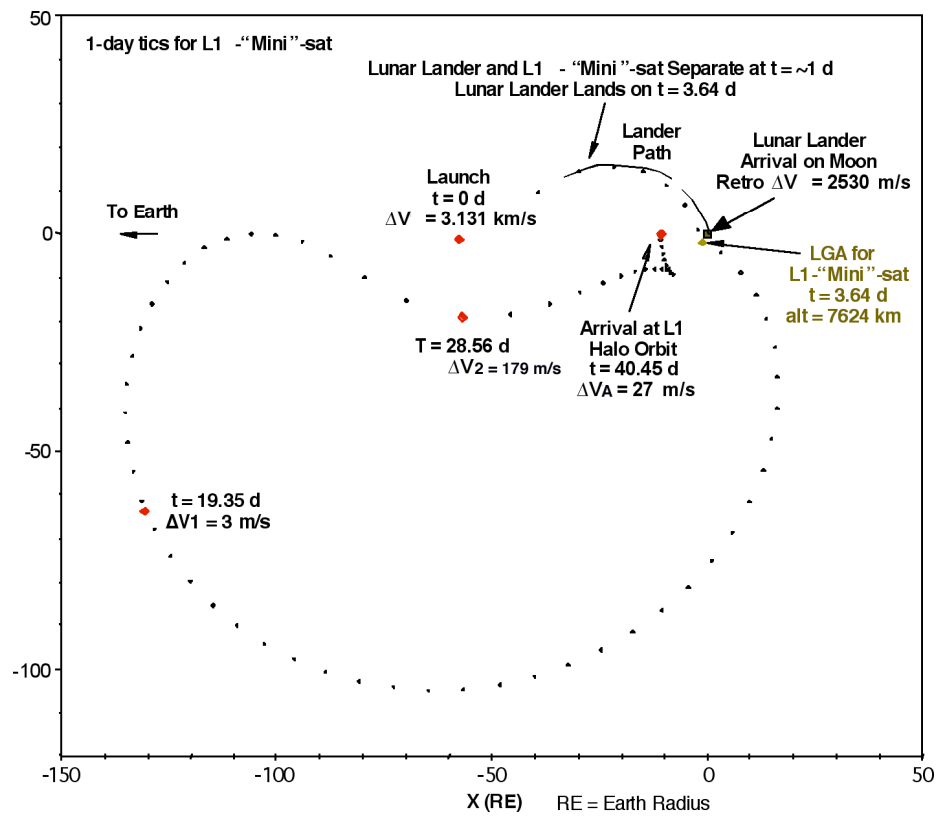
- Mini-satellite flies a trajectory displaced from that of the lunar-bound astronauts until, subsequent to a lunar gravity assist (LGA), it is captured into a halo orbit at the Earth-Moon L1 point one month later.

- Transfer requires three delta-V maneuvers with a total delta-V of 209 m/s. Final insertion into the L1 halo orbit requires 27 m/s.

- L1 halo orbit would have a period of 14 days, with the instrument package occupying a region of space 20-40 lunar radii (RM) above the lunar surface.

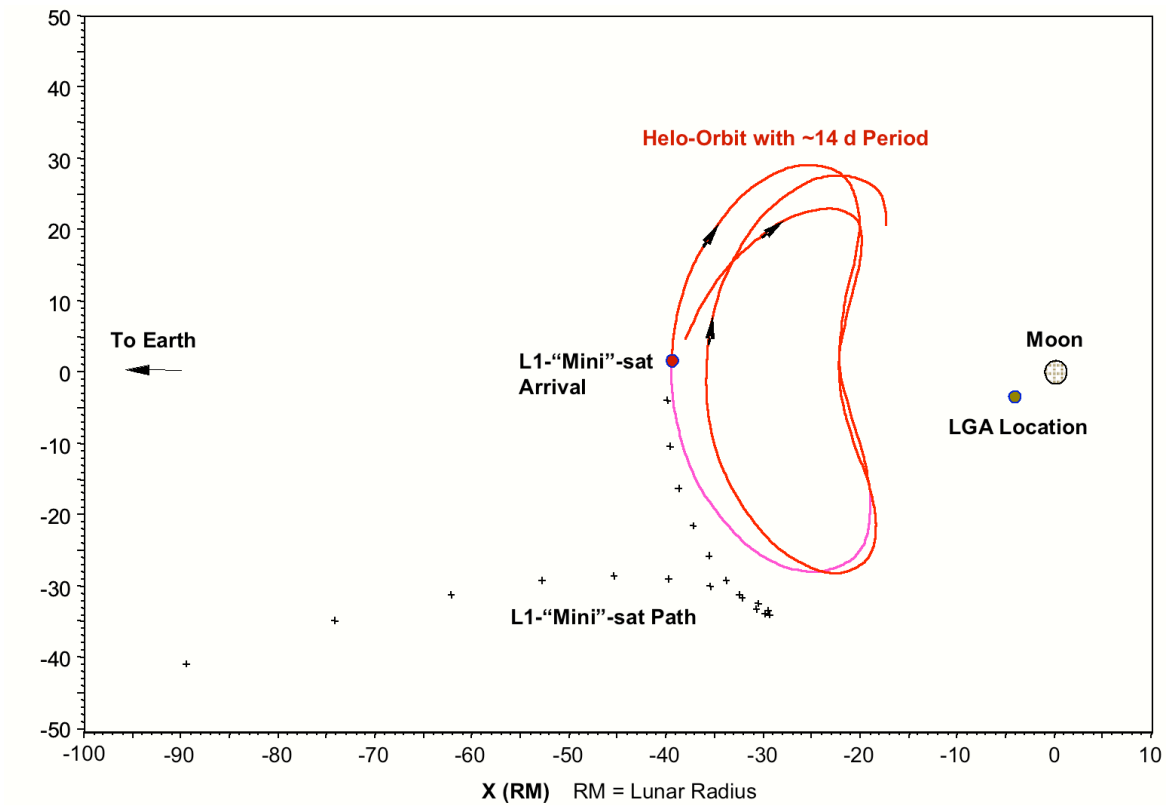
Workshop on Science Associated with the Lunar Exploration Architecture - Earth Science Subcommittee

The Concept - Description (Cont'd)



200-km Low-Earth-Orbit (LEO) to Earth-Moon L1 Halo Orbit Transfer Trajectory.
Earth-Moon Fixed Bi-polar Plot.

The Concept - Description (Cont'd)



The Concept - Engineering/Technical Advantages

- Minimizes Downmass.
  - Downmass is the mass delivered to the lunar surface. **Downmass is expensive** (engineering resources, $).
    - Performing the same science investigation on the lunar surface requires a delta-V of 2,530 m/s compared to 209 m/s, plus an allowance of several 10's of m/s for station keeping, at the L1 point.
    - Extra delta-V translates into a substantially higher downmass (as well as, potentially, higher launch mass to carry the extra required fuel) to perform the same experiment on the lunar surface.
- Simplifies Instrument Design.
  - Lunar surface is a hostile environment (contamination, thermal, etc). Space environment may permit less costly instrument design, longer life.

The Concept - Potential Science Observations

- Candidate observations may include any that may benefit from the capability to:
  - Observe the whole Earth and its limb continuously over its diurnal cycles for a duration limited only by instrument package life.
  - Observe the Moon continuously and for a duration limited only by instrument life from an unusual, close-up, fixed vantage point (20-40 lunar radii).

and/or

  - Benefit from operation in a space - as opposed to surface - environment.
  - Be too expensive (engineering resources & $ for delivery to and data acquisition on/from the lunar surface) to justify selection.
  - Be able to provide useful data that might complement that acquired in situ at the Earth or Moon (e.g., fill in data gaps, support interpretation/calibration of data acquired from other sources, provide data for comparison with ground truth measurements).

Proposed Funding and Schedule

- Funding: $150K.
- Schedule: January 1, 2007-September 30, 2007.

Acknowledgements

- The research described herein was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. The research was performed for the Earth Science Research and Advanced Concepts Office by personnel from the Engineering and Science Directorate.

- The author wishes to gratefully acknowledge the sponsorship of T. Freeman and counsel of T. Cwik of the of the Earth Science Research and Advanced Concepts Office. In addition, the author wishes to thank C. Yen of JPL's Systems and Software Division for developing the mission design concept.