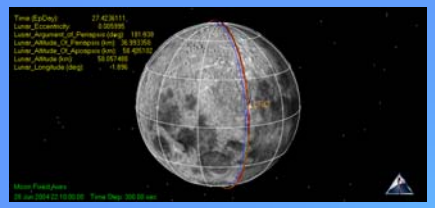
Orbital Maintenance for the Lunar Reconnaissance Orbiter



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Mission Motivation

The Lunar Reconnaissance Orbiter (LRO) mission fulfills NASA's goal of sending robotic missions to the moon by 2008 in preparation for future space exploration.

Project Goals

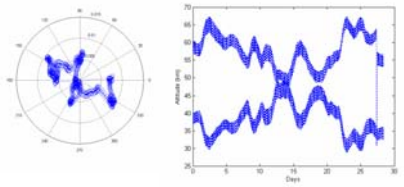
- Determine the effects of the Moon's gravity field on a satellite
- Find the orbit that minimizes divergence from the mean altitude
- Develop a periodic corrective thrust sequence to maintain a desired orbit
- Develop a MATLAB script that controls the simulation software

Centering the Pattern and Correcting the Orbit

- When the orbit evolves to a high eccentricity, the altitude of the satellite can move outside of the conditions specified for the mission, and the satellite could crash
- Executing a burn sequence after one longitudinal revolution puts the satellite back into its initial orbit and lets the satellite repeat its path

28-day mission with initial conditions: ε=0.006, ω=180°

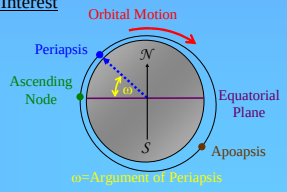
Satellite executes burn sequence at 27.3 days



Conclusions from the Centering and Targeting Simulations

- Centering the pattern improves the trajectory evolution
- The mean orbital altitude after the targeting drops undesirably

Elements of Interest



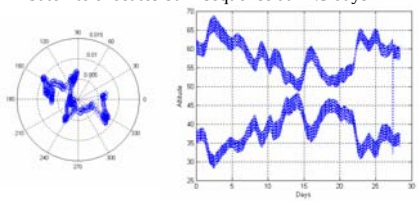
- Periapsis marks the satellite's closest distance from the Moon's center
- The ascending node is the location where the satellite crosses the lunar equatorial plane while moving Northward
- The argument of periapsis (ω) is the angle in the orbital plane between the ascending node and periapsis
- Eccentricity (ε) is a dimensionless measure of the orbit shape

Matching Eccentricity

Executing the burn from the same altitude as the initial state better centers the pattern, and avoids a large mean altitude drop

28-day mission with initial conditions: ε=0.007, ω=180°

Satellite executes burn sequence at 27.3 days



Conclusions from the Eccentricity Matching Simulations

Matching the initial and final eccentricity reduces the post-burn altitude loss significantly

Gravity Models of the Moon

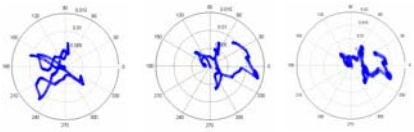
The LRO mission simulations employed three different lunar gravity models:

- The GLGM2 model data from early lunar missions
- The LUN75A model data from the Clementine mission
- The LP100K model data from the Lunar Prospector mission

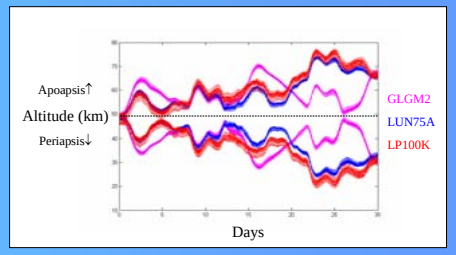
For any given altitude band, the eccentricity and argument of periapsis evolve in a pattern that repeats itself once per longitudinal revolution (27.3 days), and that pattern depends on the gravity model employed in the simulation

30-day mission with initial conditions: ε=0.0001, ω=0°

ε is the radial coordinate, ω is the angular coordinate



GLGM2 LUN75A LP100K



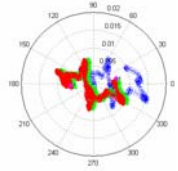
Conclusions from the Gravity Model Comparison Simulations

- The LUN75A and LP100K models generate similar results, and they are quite different from the GLGM2 model results
- LP100K will be used to simulate the LRO mission
- An orbit with less altitude deviation needs to be found

Automating the Changes

A MATLAB script that can center and match eccentricities completes the procedure with one keystroke

27.3-day mission with original condition ε=0.0001 ω=0 °



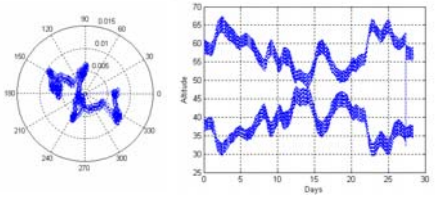
Original orbital evolution pattern (28 days)

Geometrically centered pattern

Initial and final eccentricity matched

28-day mission with new initials: ε=0.0064, ω=184.2 °

Satellite executes burn sequence at 27.3 days



Conclusions and Ongoing Work

- Need to improve the automated condition finder, possibly by repeating its procedure two or three times
- The setup, simulations, and results processing needs to be accomplished with one MATLAB script for user ease