Design and Analysis of Weak Stability Boundary Transfer Orbits for Artemis Mission

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Image adapted from JAXA

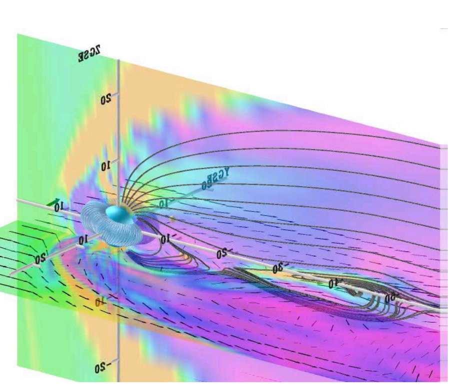
Abstract

This project will validate the current orbit plans while increasing fidelity of the models. These orbit designs take advantage of 4-body dynamics to raise the satellites to the Moon while minimizing delta-v. The transfer for P1 includes two lunar fly-bys and use of weak stability boundaries, while P2 utilizes only one lunar fly-by. Once the satellites reach the Moon they will insert into lissajous orbits around LL1 and LL2. This will be the first time a satellite has been placed in these orbits, thus providing very important information about orbit maintenance for future missions. Both satellites will then depart these lissajous orbits and transfer to elliptical lunar orbits. Once this transfer orbit design has been validated using NASA's General Mission Analysis Tool (GMAT) statistical error analysis will be done to insure potential orbital correction maneuvers do not exceed the available delta-v budget.

THEMIS

Time **H**istory of **E**vents and **M**acroscale **I**nteractions During **S**ubstorms (THEMIS)

Five satellites in various elliptical orbits are currently measuring solar sub storms and space weather.



Prime mission ends in 2009. Two satellites will be unable to continue mission due to extreme shadows and orbit decay.

Artemis

Acceleration, **R**econnection, **T**urbulence and **E**lectrodynamics of the **M**oon's **I**nteraction with the **S**un

Scientific Objectives
- -Electron Acceleration in Shocks
  - Tail and Lunar Environment
- -Tail Reconnection
  - Onset Mechanism, Effects, Response
- -Lunar Wake
  - Make up of Plasma Waves
  - Measurements of Electric Fields

Other Benefits
- -Navigation and stability data
  - First Earth-Moon lissajous orbits
- -Continued presence at the Moon
  - Lunar orbit data
  - Environmental awareness

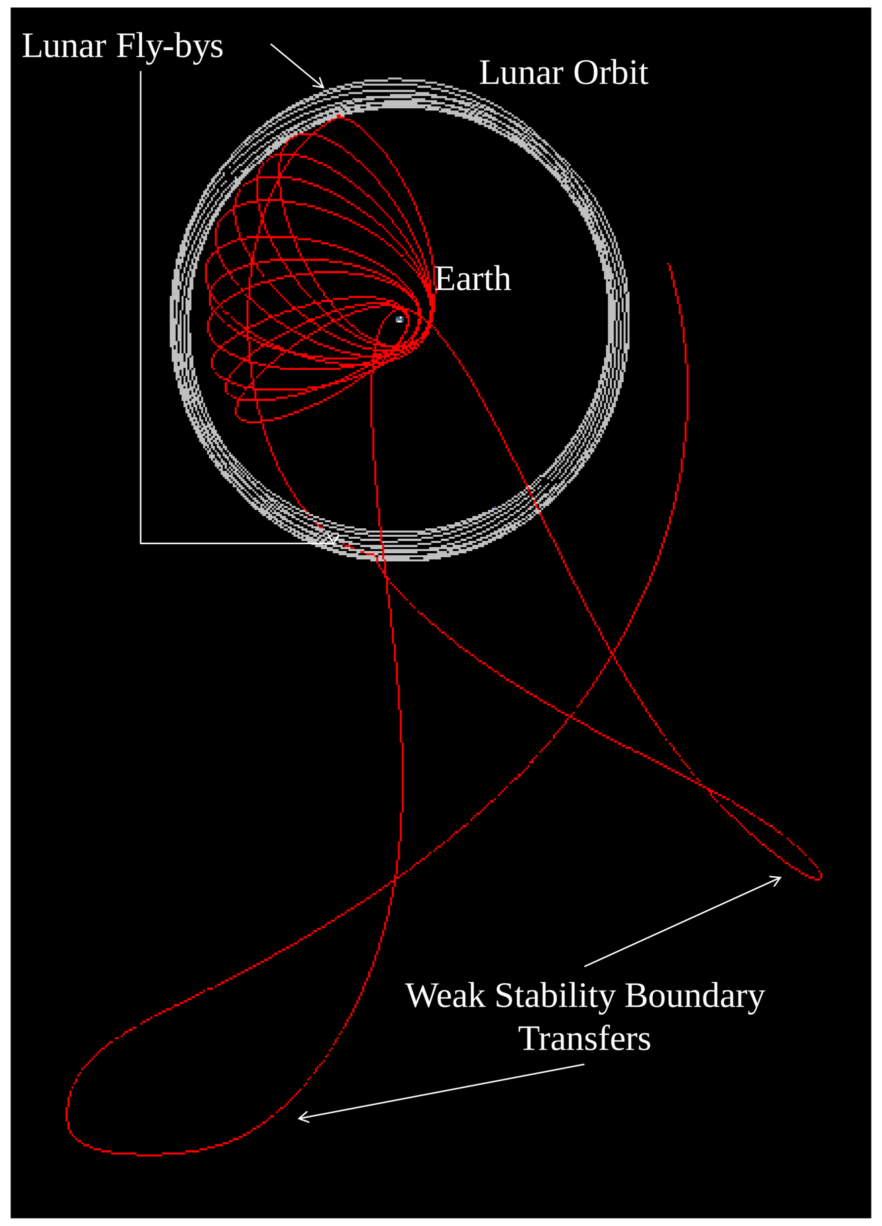
Possible LL1 & LL2 Uses

Communications
- -Data relay for orbiters and rovers
- -Contact with far side of the Moon operations
- -Support of future manned missions/outpost

Logistics
- -Space station placement
- -Orbital depots

Science
- -Deep space monitoring from far side
- -Earth/Moon remote sensing

Orbit Designs

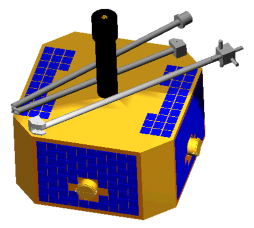


Satellite P1:

2 – Lunar Approaches
2 – Lunar Fly-bys
2 – Deep Space Legs
1 – Earth Fly-by

Total ΔV=188.2 m/s

541 Days to LOI

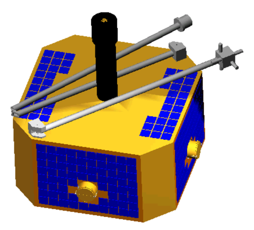


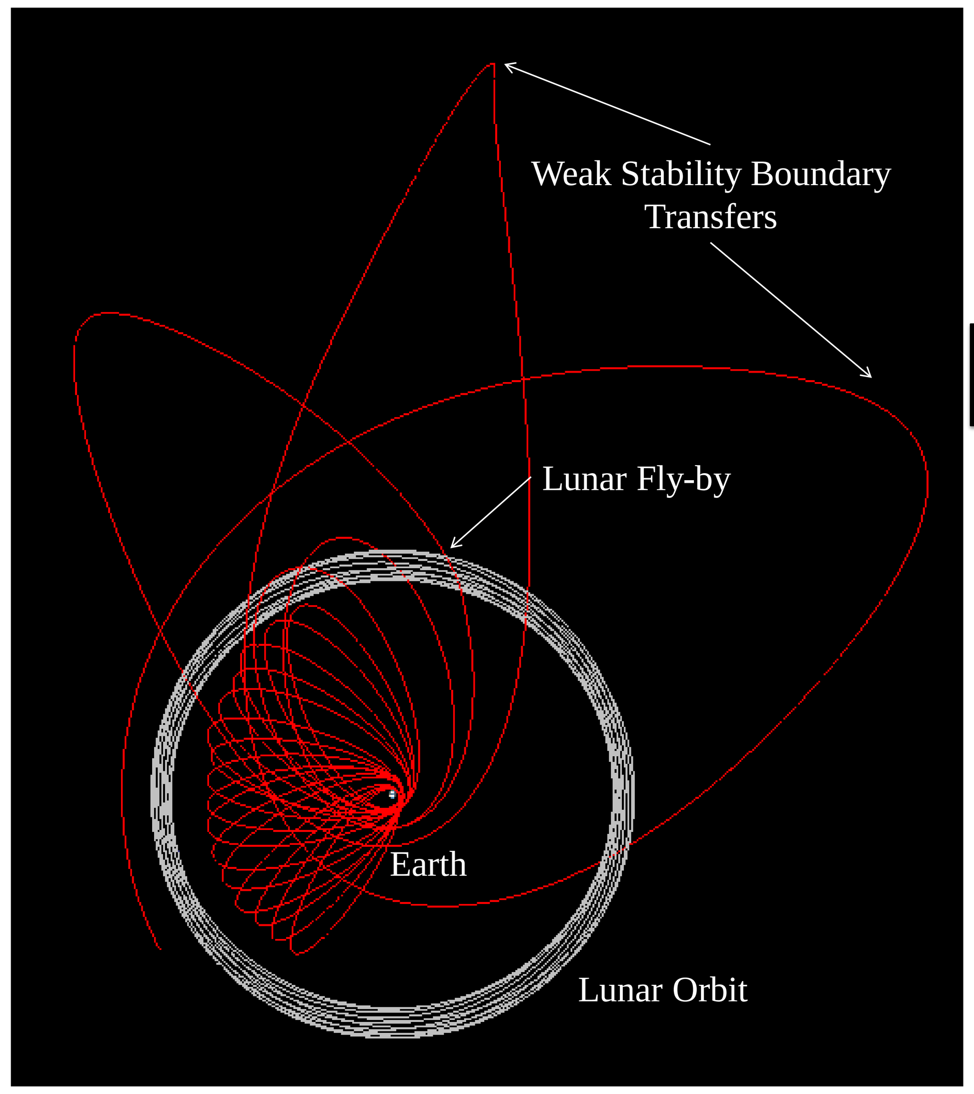
Satellite P2:

4 – Lunar Approaches
1 – Lunar Fly-by
3 – Deep Space Legs

Total ΔV=311.7 m/s

551 Days to LOI





Future Work

Orbit design validation
- -Confirm feasibility of chosen design

Increase fidelity of orbital model
- -Include more complex force models

Error analysis
- -Evaluate thrust and orbit determination errors
- -Use Monte Carlo sampling to model errors
- -Insert trajectory correction maneuvers
- -Optimize placement of TCMs
- -Confirm TCMs fit within ΔV budget

Tools

General Mission Analysis Tool (GMAT)
- -Primary software used to validate design
- -Will also be used for error analysis

Astrogator
- -Utilized for model verification

MATLAB
- -Used for data collection and error analysis

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