Trajectory Design for Small-Satellite Missions to Near-Earth Objects

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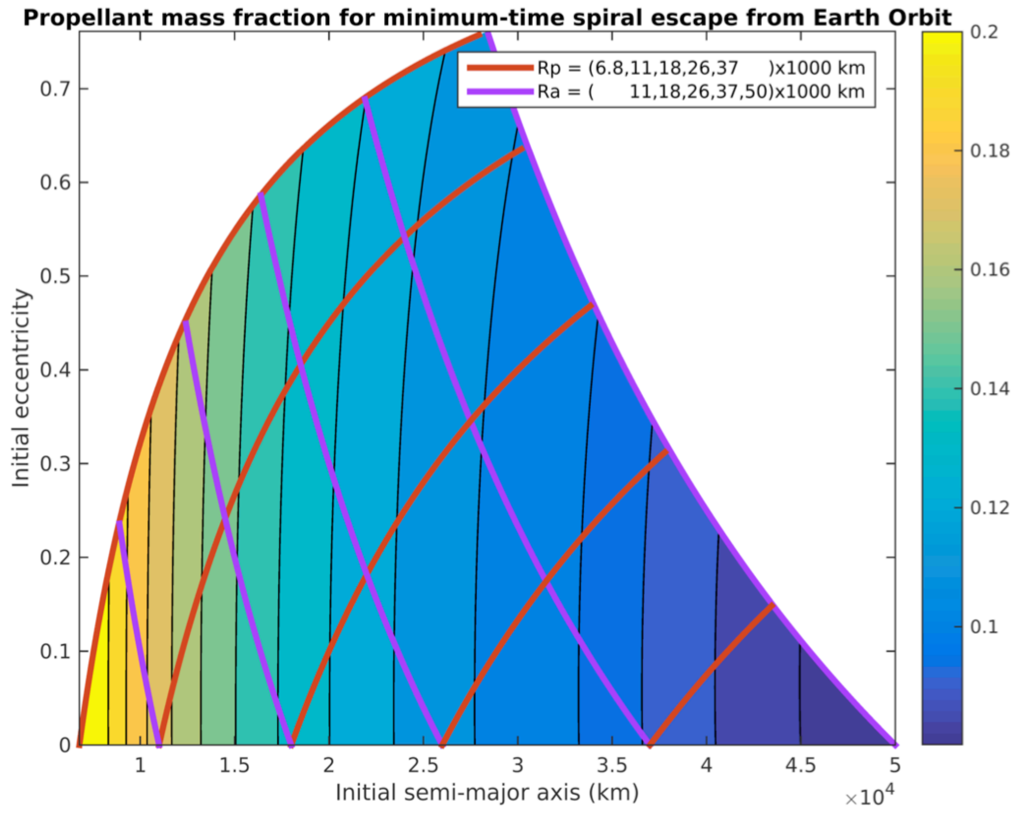
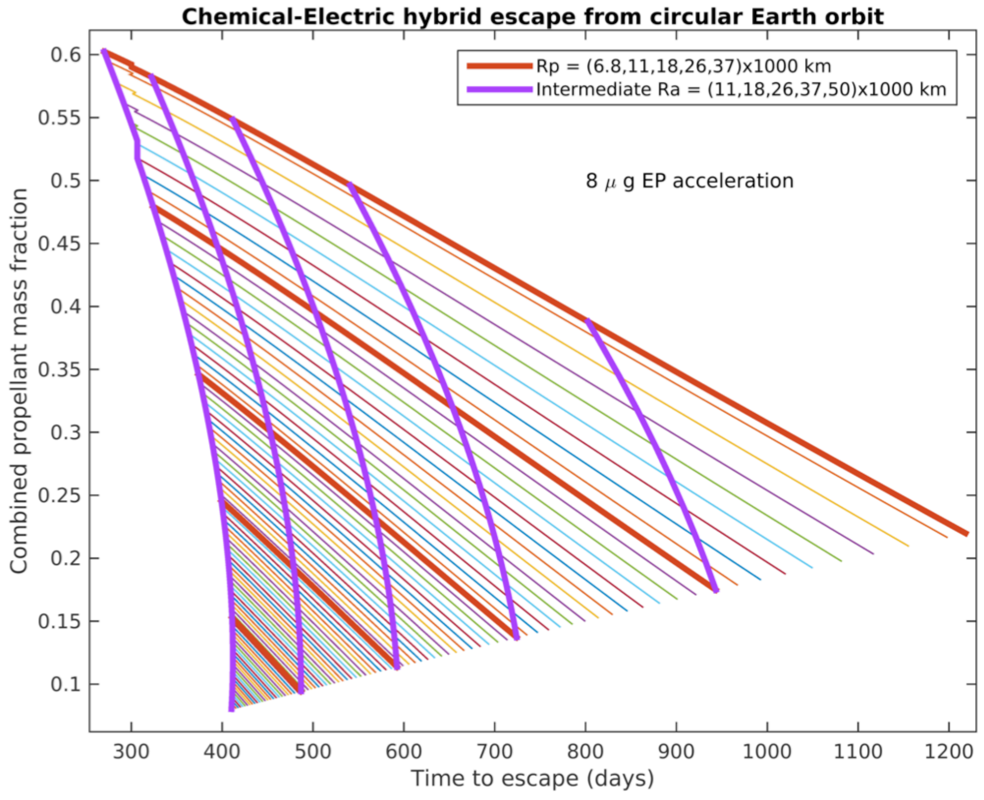
Overview of Possible Small Satellite Missions

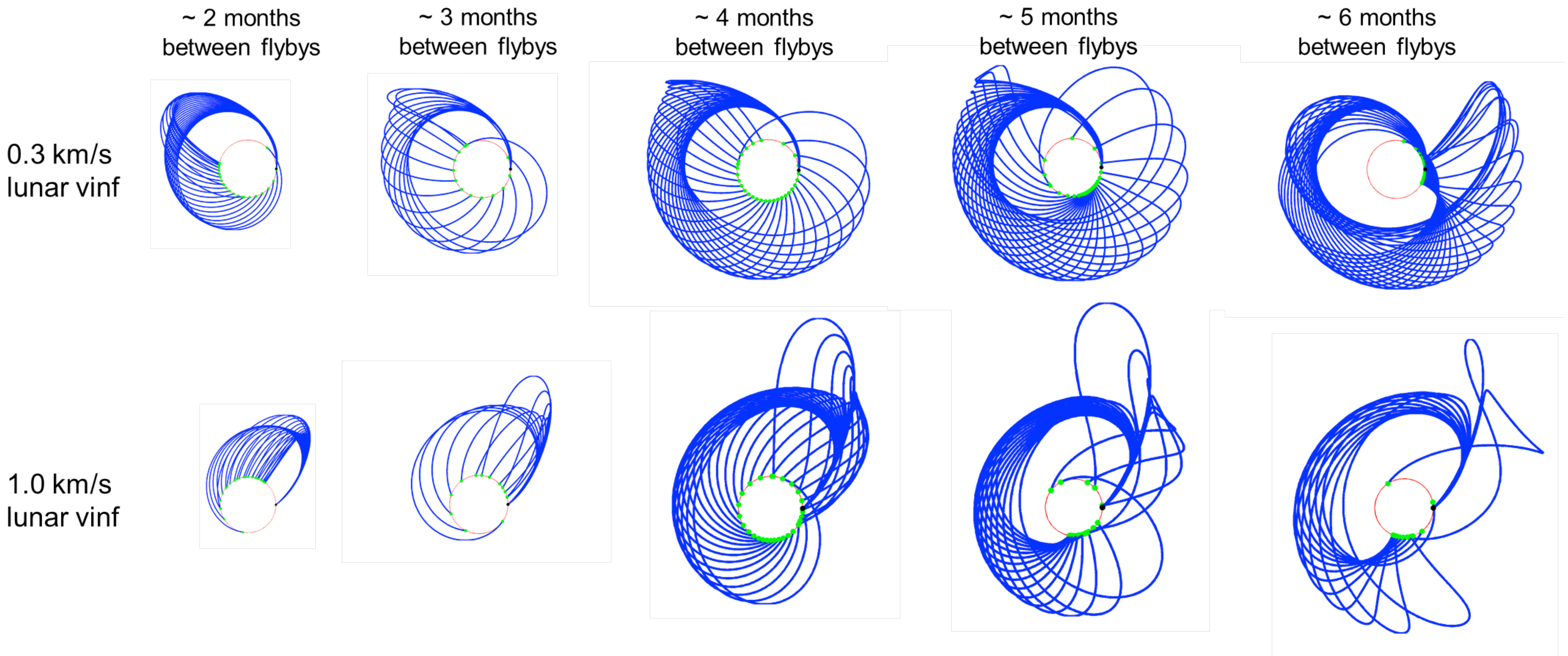
- Assumptions
- Constraints
- Possible missions
- Our approach – divide and conquer
  - Departure from Earth orbit
  - Use of Sun-Earth dynamics to set the stage
  - Use of multiple lunar flybys to escape the system
  - Straightforward transfer to the target

The Uses of Low Thrust

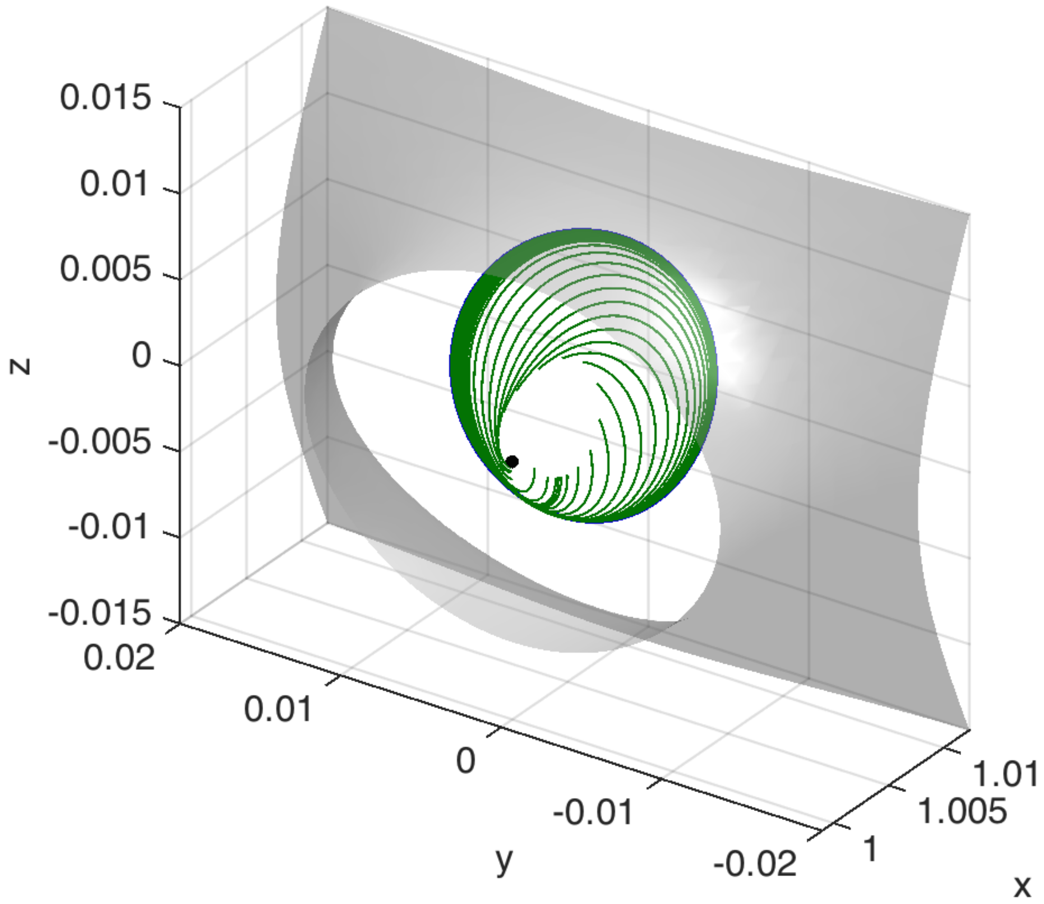




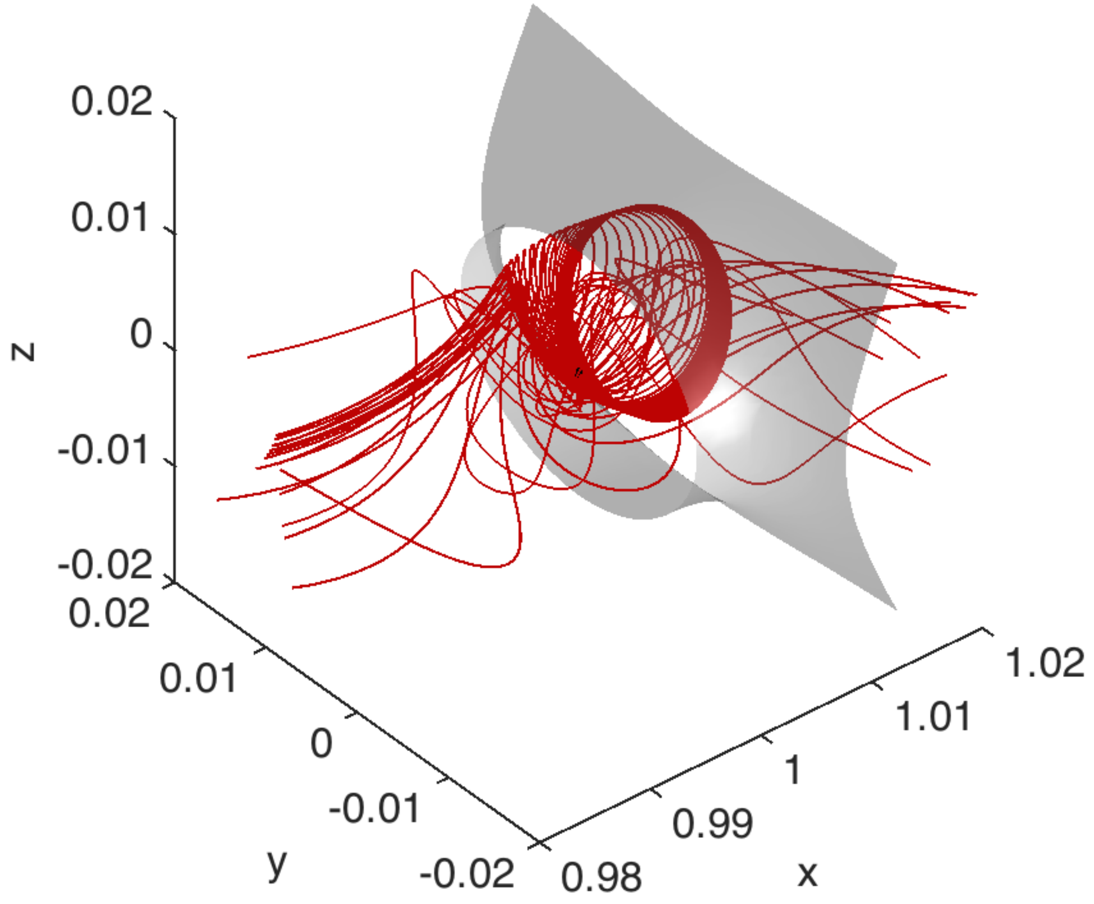
The Uses of Lunar Gravity Assists



The Uses of Low-Energy Trajectories

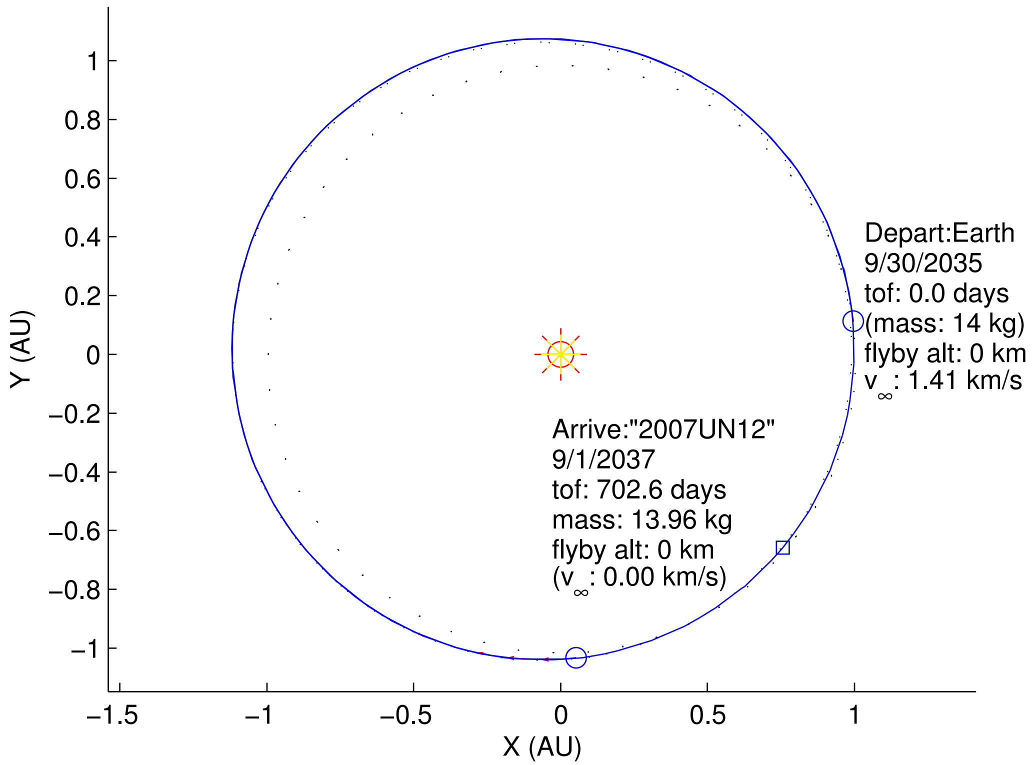


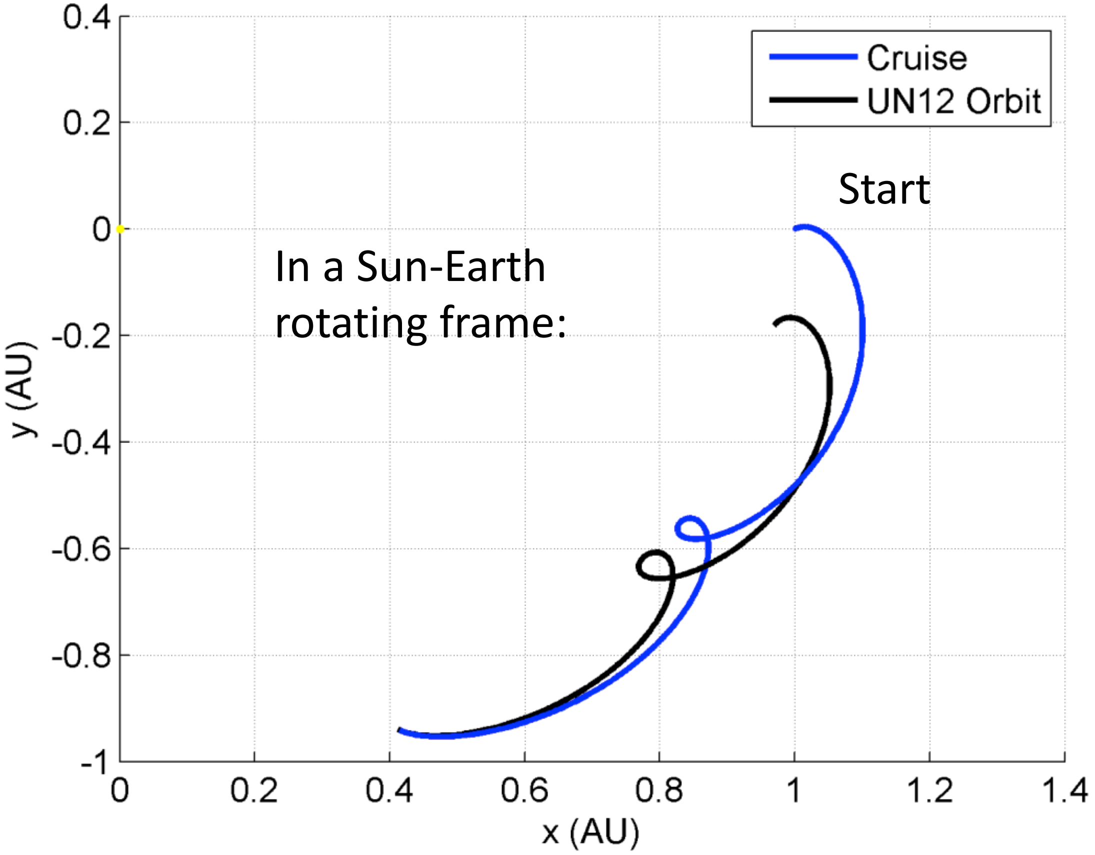
Sun-Earth L2 Lyapunov Stable Manifold



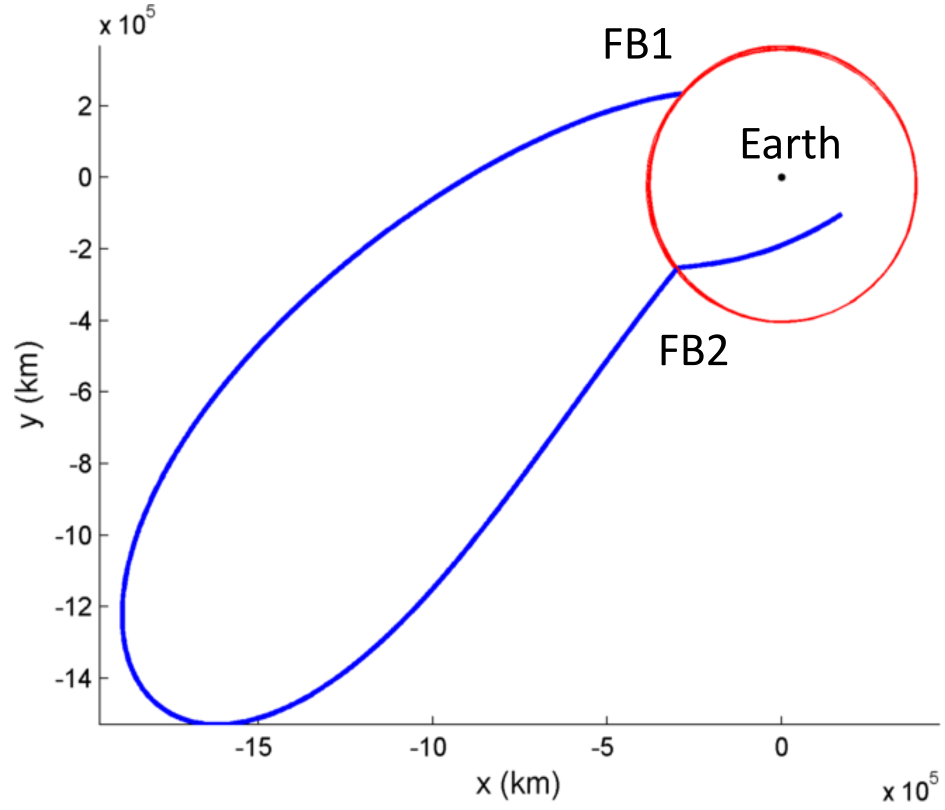
Sun-Earth L2 Lyapunov Unstable Manifold

A Sample Mission to Asteroid 2007 UN12: Design from the End and Work to the Front

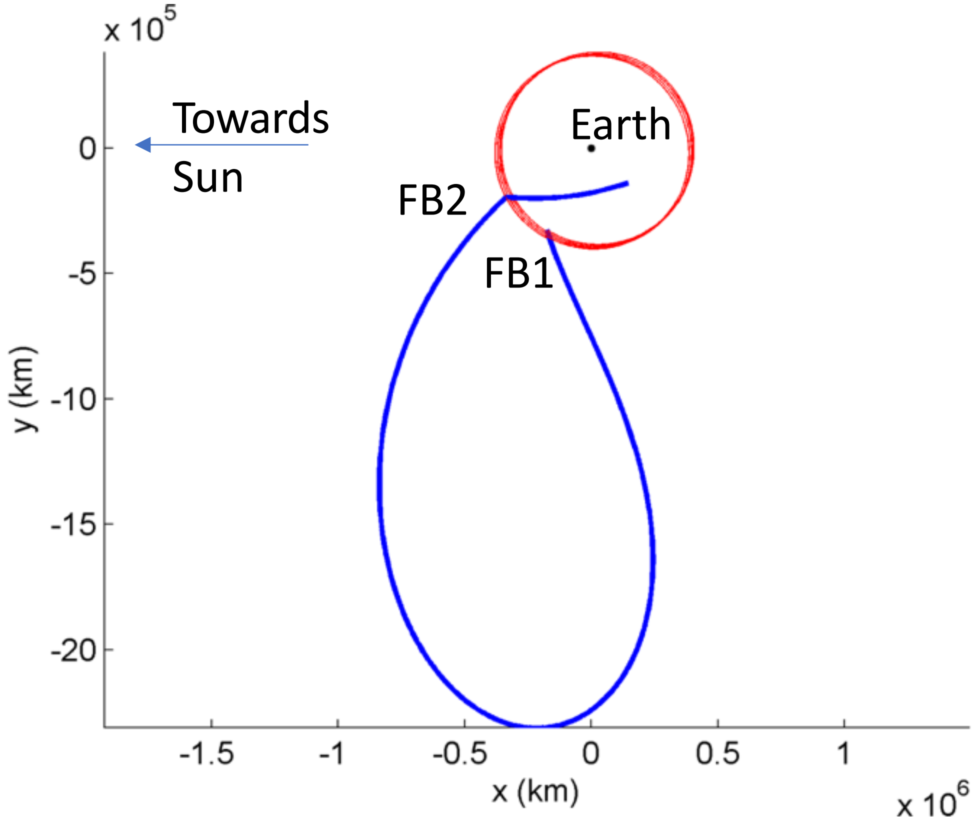




Find Lunar Flybys That Give Our Departure:

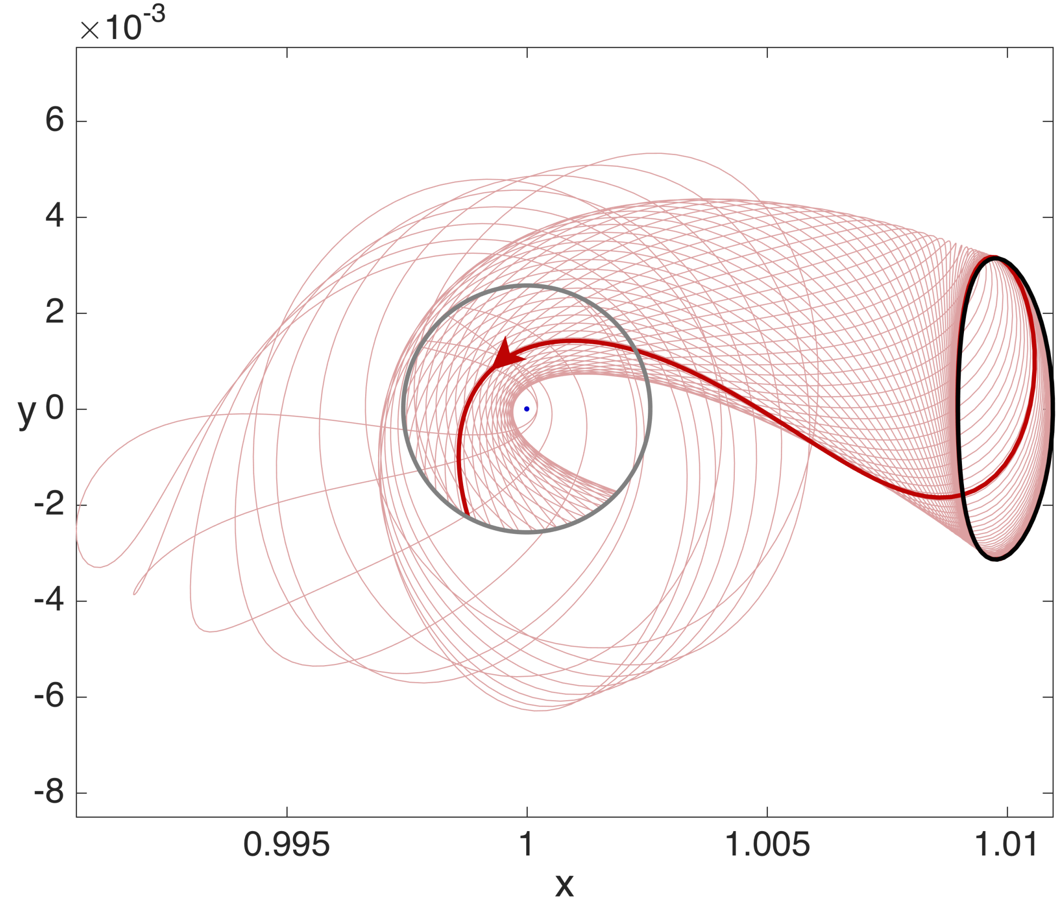


J2000 Frame

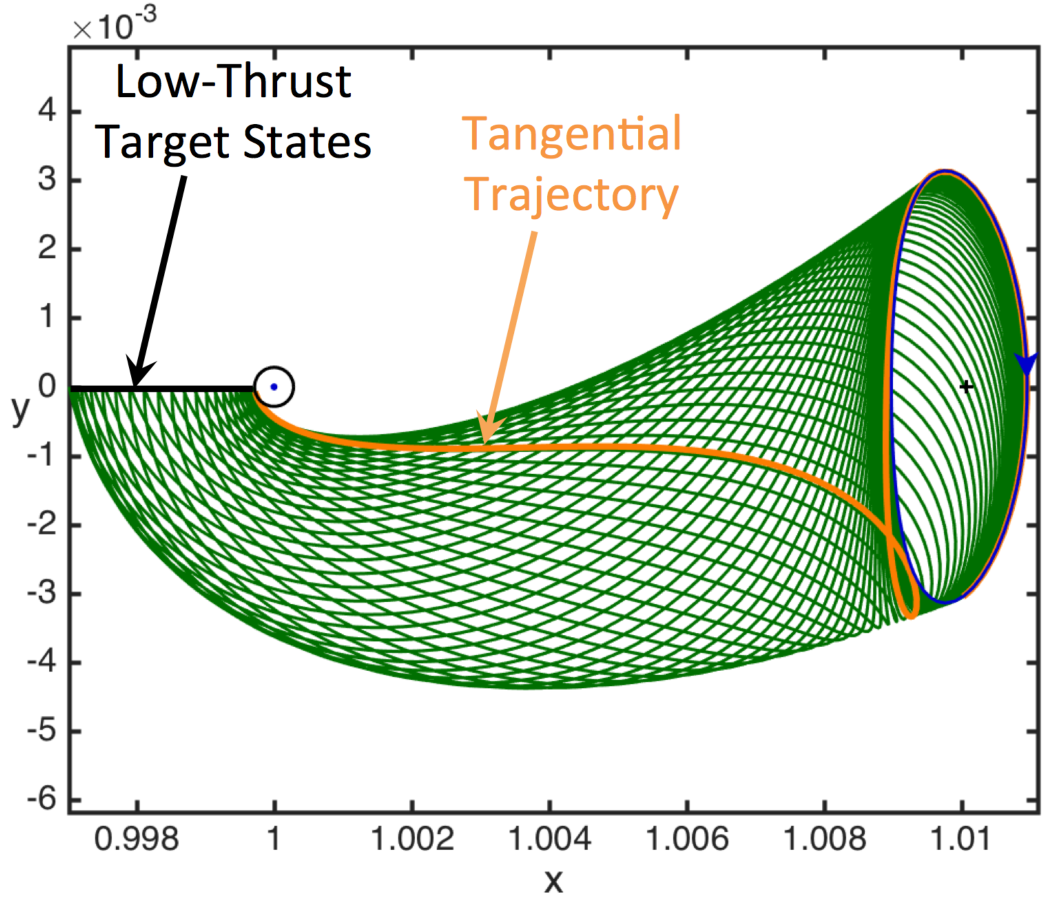


Rotating Frame

Use Sun-Earth Dynamics to Set Up Flyby 1

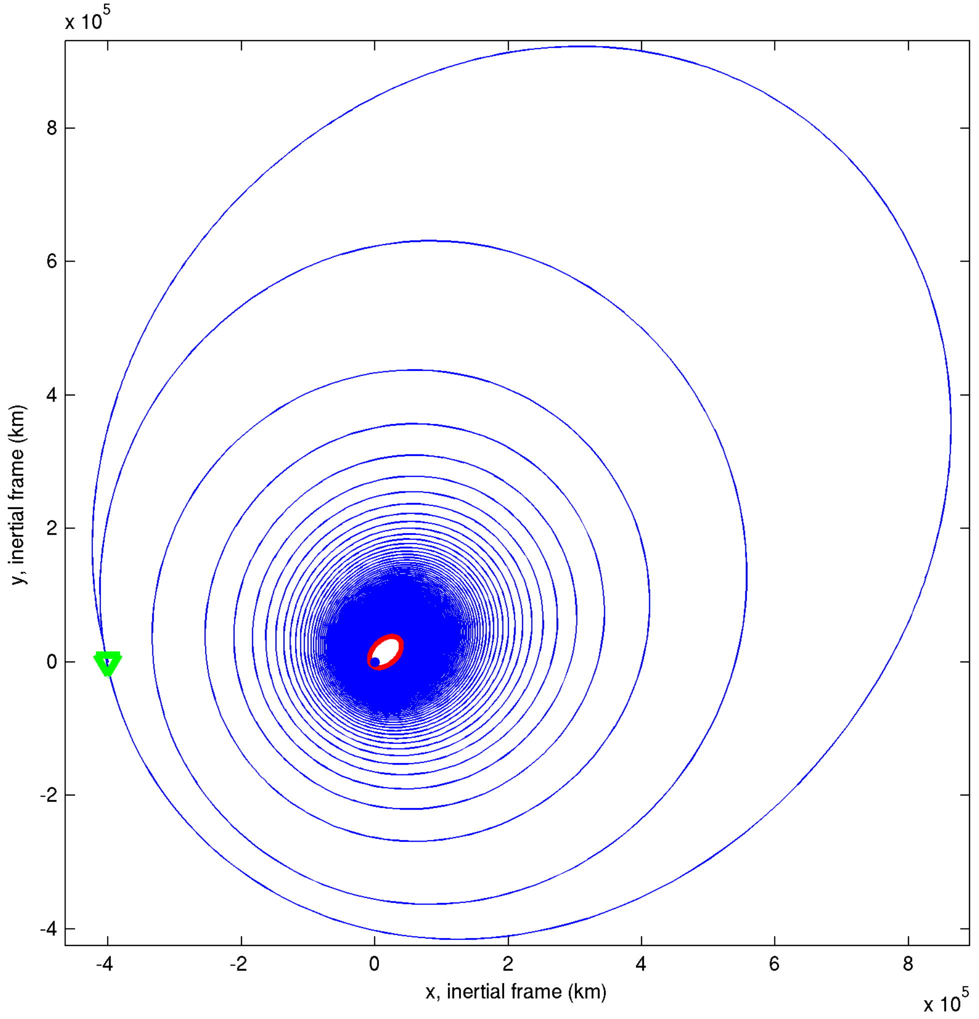


Lyapunov to Flyby 1



Earth Orbit to Lyapunov

Spiral from Earth Orbit to Stable Manifold



Putting it Together

- This is an effective strategy for designing small satellite missions to deep space from Earth orbit:
  - Do the design in stages from the end state to the beginning
  - Reverse the design stages to see the end-to-end trajectory
- In the example shown, the entire trajectory takes about 1.04 kg of propellant in the low-thrust system for an initial total mass of 14 kg.