ASEN 6060
ADVANCED ASTRODYNAMICS
Creating Transfers in GMAT/STK

Objectives:

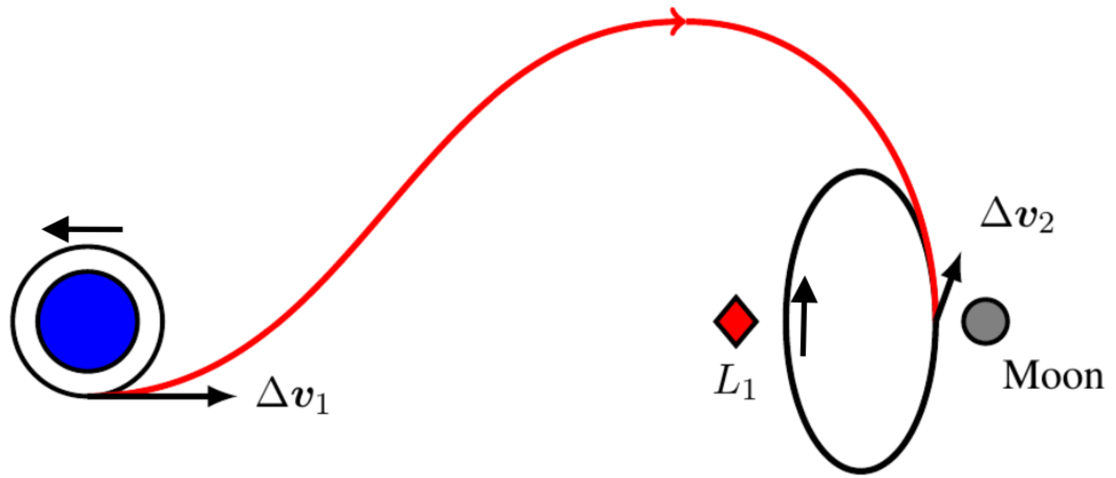
- Briefly summarize approach used to generate transfers in an ephemeris model from LEO to a motion resembling a periodic orbit

Follows the example in this document:

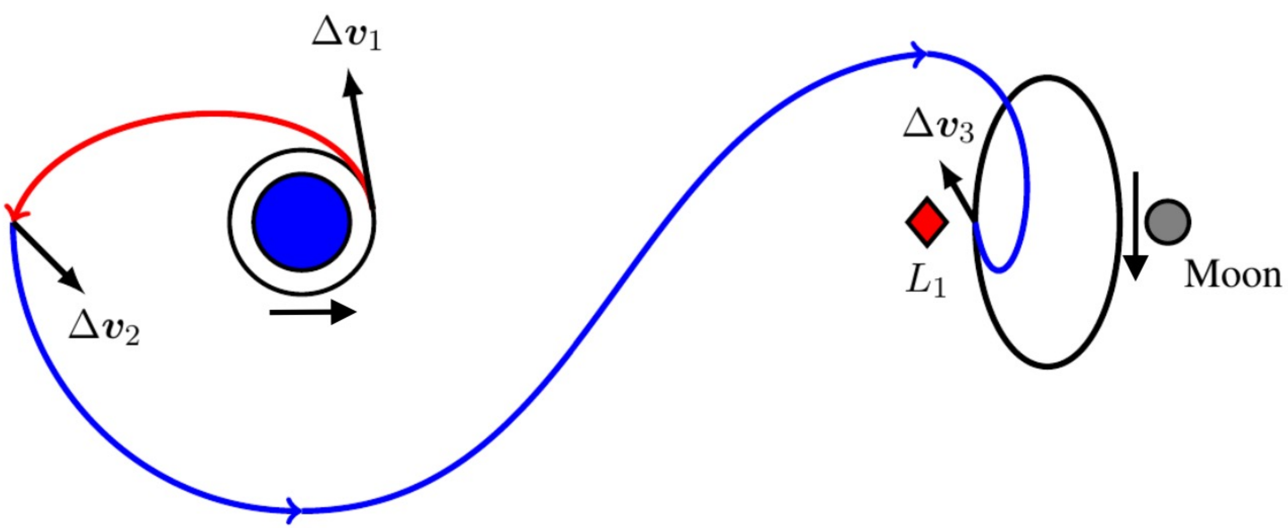
"Folta, D.; Bosanac, N.; Elliott, I.L.; Mann, L.; Mesarch, R.; Rosales, J., 2022, "Astrodynamics Convention and Modeling Reference for Lunar, Cislunar, and Libration Point Orbits (Version 1.1)", NASA/TP–20220014814"

Transfers to Mission Orbit

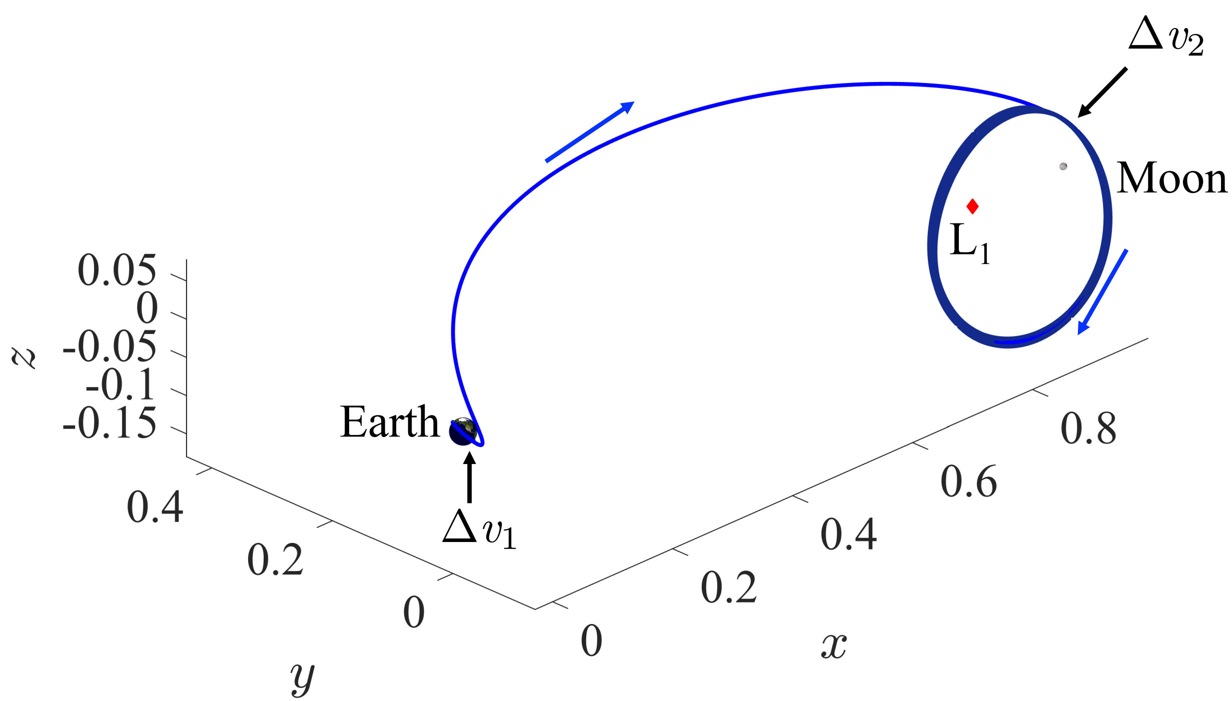
Direct Transfer



Indirect Transfer



Transfer Design Problem



Our goal: Calculate Earth departure and orbit insertion maneuvers producing a transfer with two impulsive maneuvers that, in **backward** time, reaches the desired low Earth orbit from a fixed state that lies along the **desired mission orbit at a specific epoch**.

Construct a Transfer in Backward Time

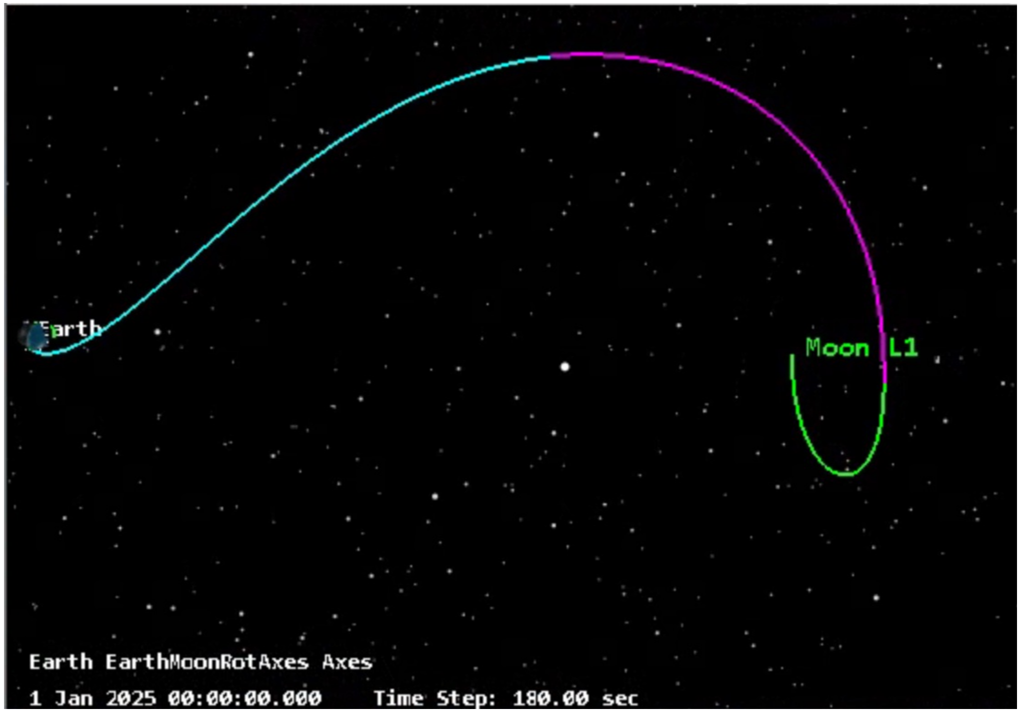
1. Define an initial state and epoch that produce a trajectory that resembles a periodic orbit until the next xz plane crosing
2. Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period
3. Apply impulsive maneuver $\Delta\bar{v}_2$ to depart the mission orbit in backwards time (or insert into it in forward time) near perilune
4. Integrate the spacecraft state backwards in time until perigee
5. Apply impulsive maneuver $\Delta\bar{v}_1$ to insert into a LEO in backward time (or depart it in forward time)

Blue = variables to calculate

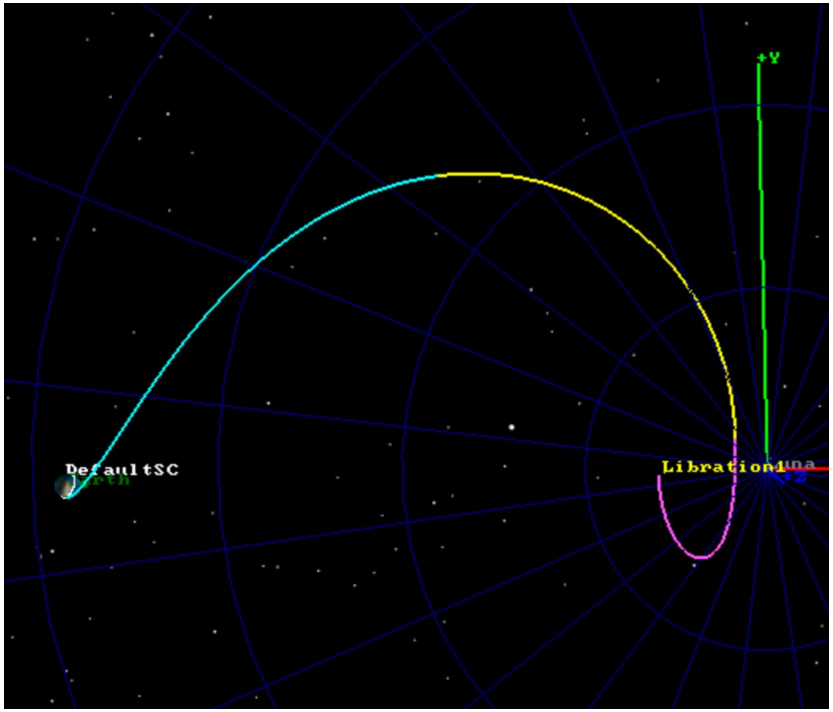
Construct a Transfer in Backward Time

Try implementing this approach on your own to generate direct transfers resembling the following:

STK:



GMAT:

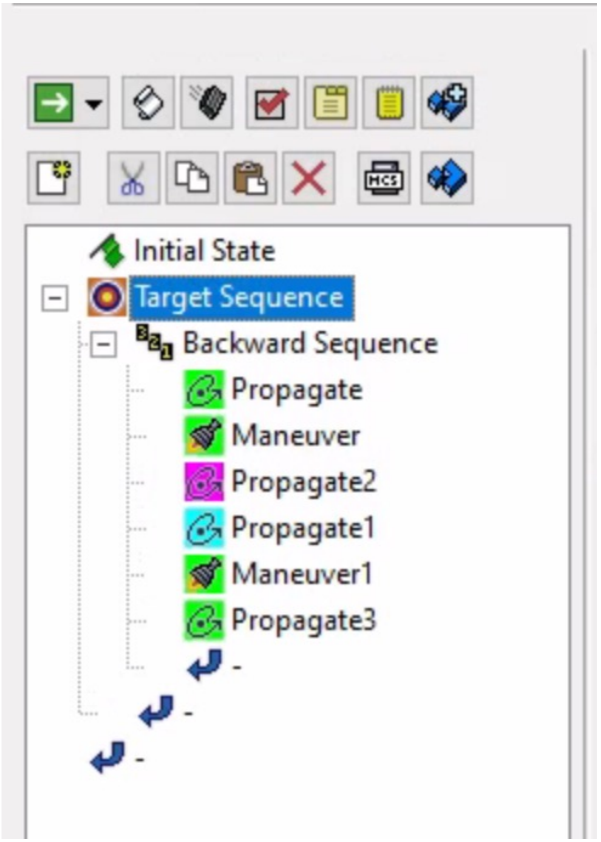


Start by copying your STK/GMAT scenarios from the previous lectures and giving them a new name. You will edit these scenarios!

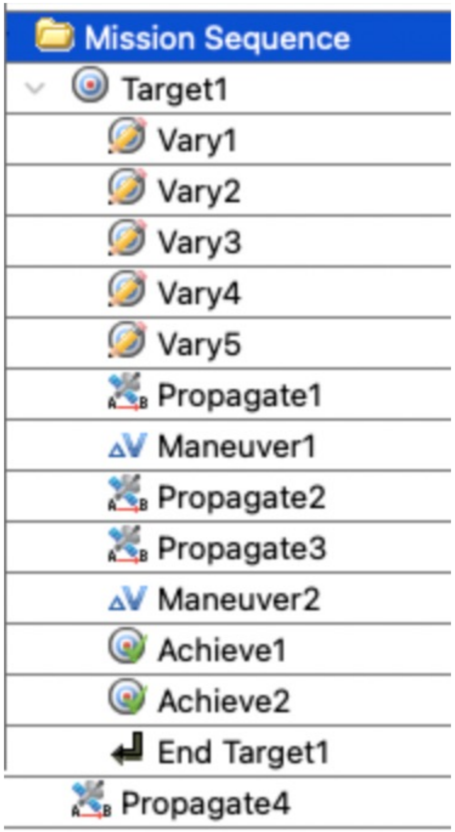
Construct a Transfer in Backward Time

Encode transfer design problem within a targeter

MCS in STK

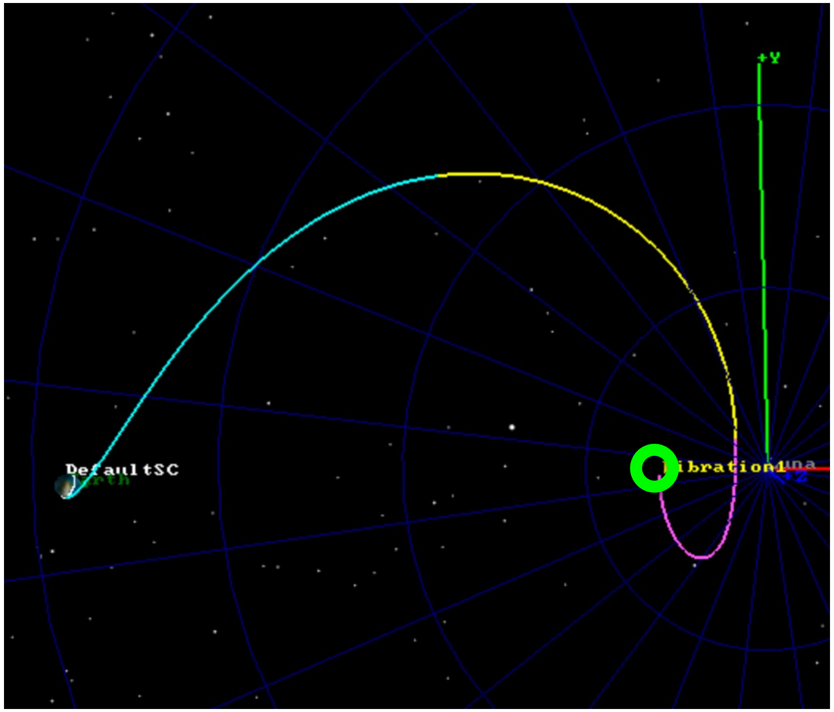


Mission in GMAT



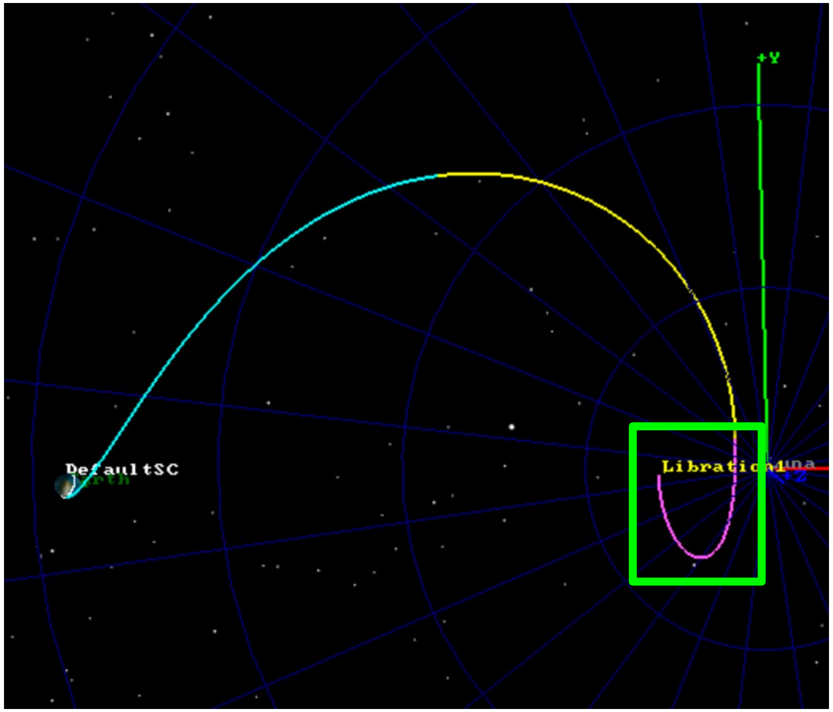
Step 1: Initial Condition Definition

- Define as the initial state and epoch the quantities you computed after the first corrections step in the "Recreating Periodic Orbits" document to produce a trajectory that resembles a periodic orbit
- Report and input state in **Earth-Moon rotating frame** (remember this state occurs on 12 January, 2025 00:00:00.000 UTC)
- In STK: outside the targeter
- In GMAT: in the spacecraft definition



Step 2: Generate Half a Rev on PO

Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period



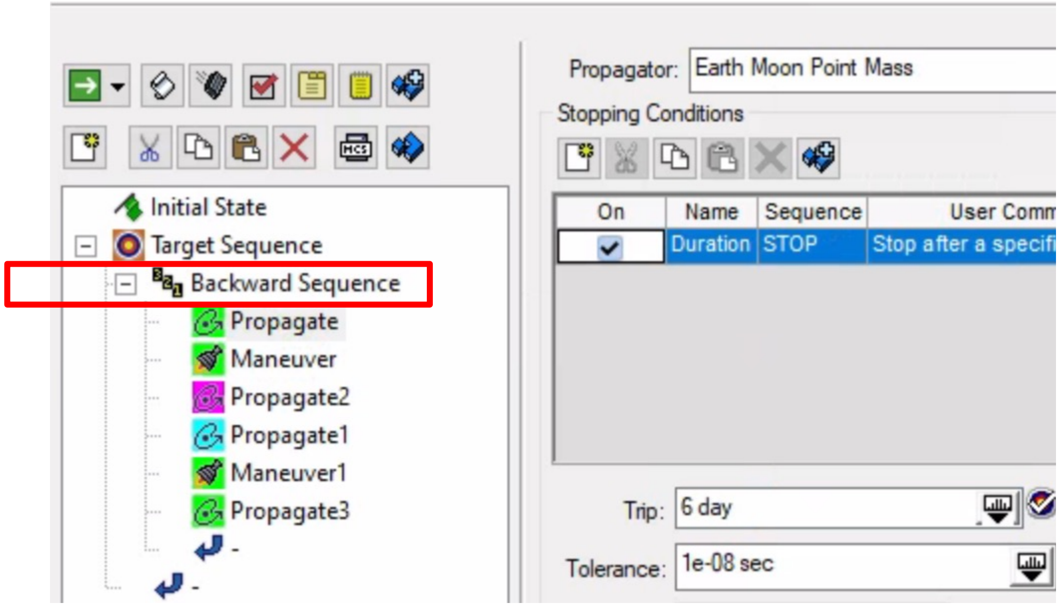
Step 2: Generate Half a Rev on PO

Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period within a "Propagate" segment

a) Use as an initial guess Δt_{int} ~ 6 days

b) STK: Set Δt_{int} as a variable in your targeter in a Backward Sequence

c) GMAT: hold Δt_{int} fixed to reduce complexity



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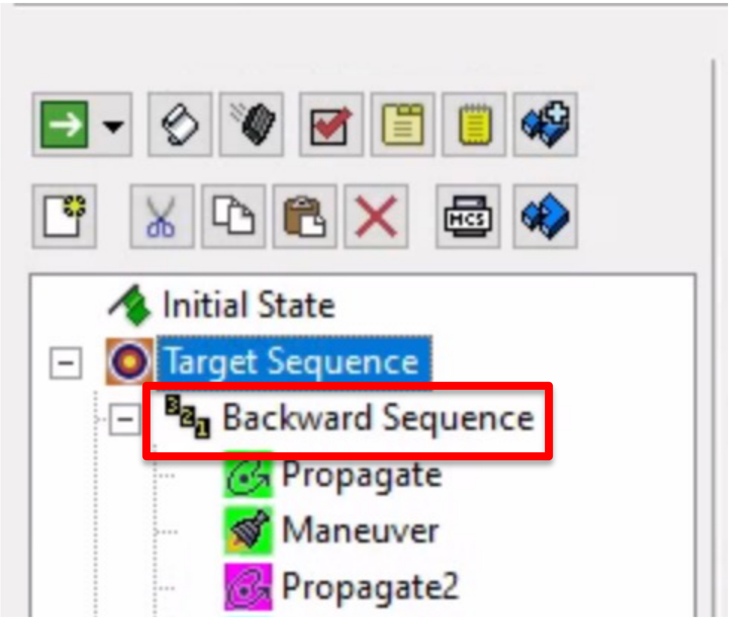


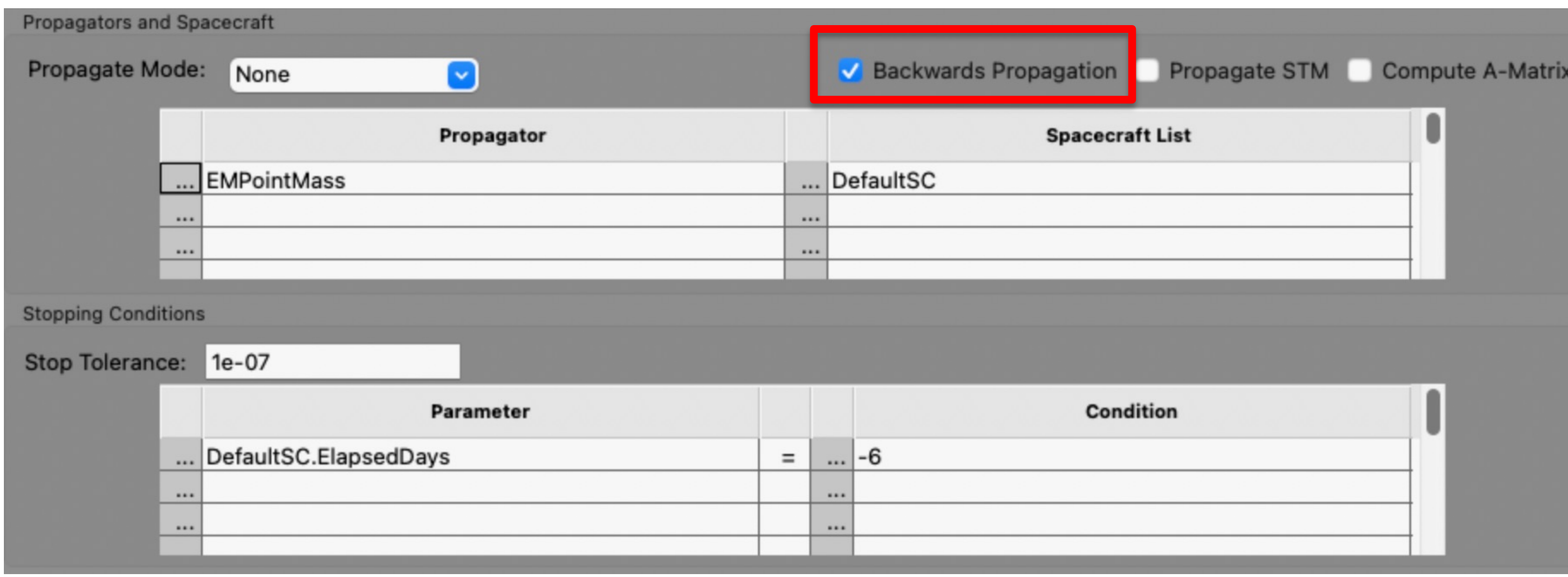
Step 2: Generate Half a Rev on PO

Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period within a "Propagate" segment

a) Use as an initial guess $\Delta t_{int} \sim 6$ days

b) STK: Set Δt_{int} as a variable in your targeter in a Backward Sequence

c) GMAT: hold Δt_{int} fixed to reduce complexity



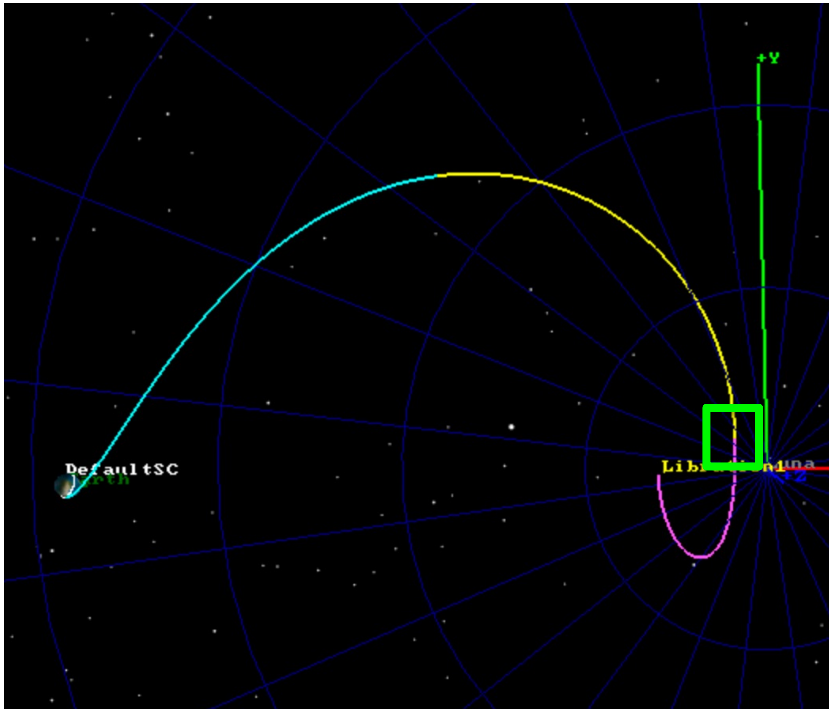
Step 3: Orbit Insertion Maneuver

Apply impulsive maneuver $\Delta\bar{v}_2$ to depart the mission orbit in backwards time (or insert into it in forward time) near perilune

a) Define the impulsive maneuver in the axes of the Earth-Moon rotating frame

b) Use as an initial guess [0, 500, 0] m/s (you can change if needed!)

c) Set the three components of the maneuver as variables in your targeter



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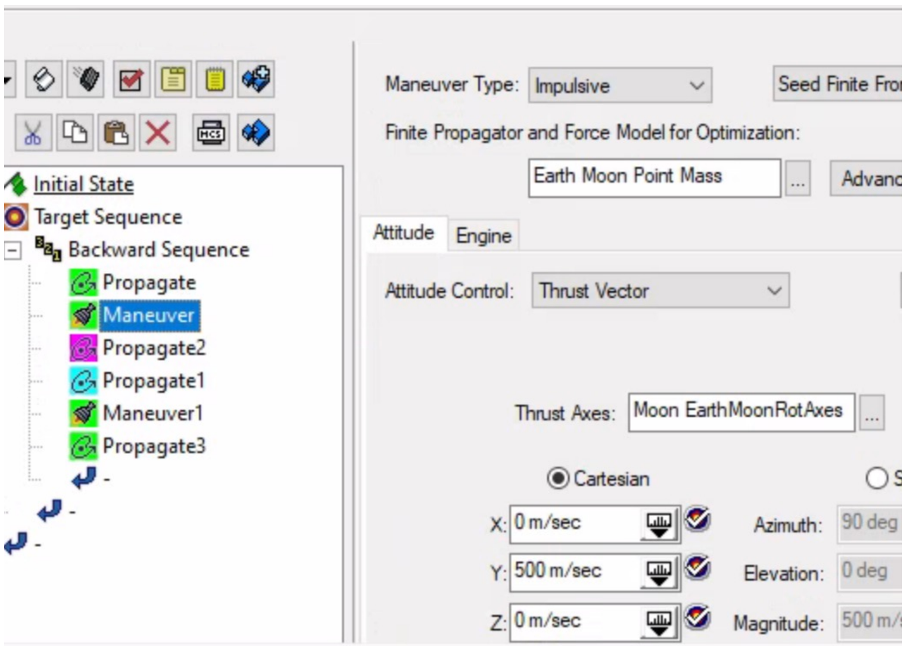
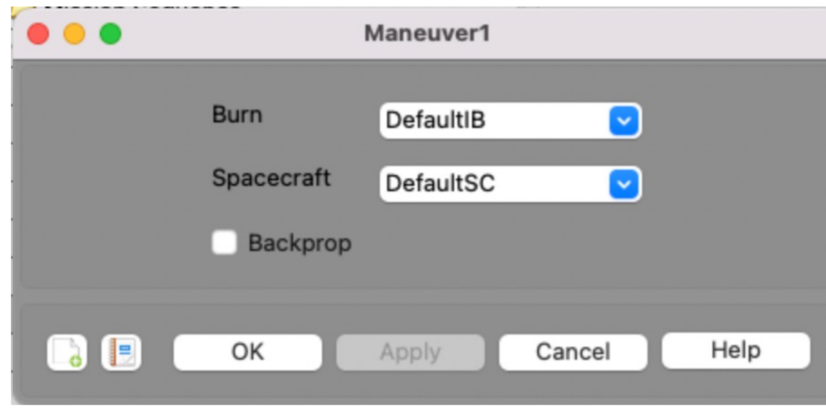
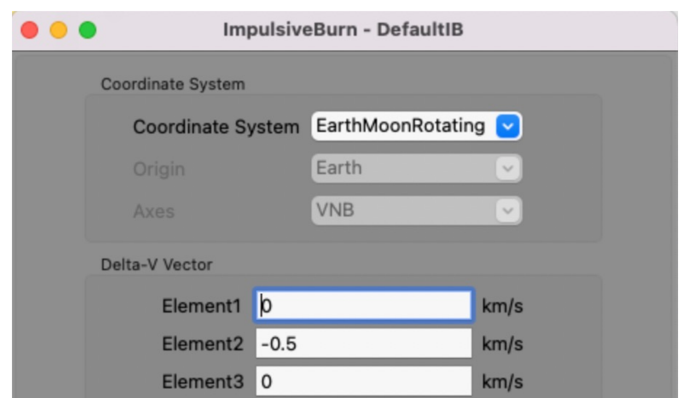




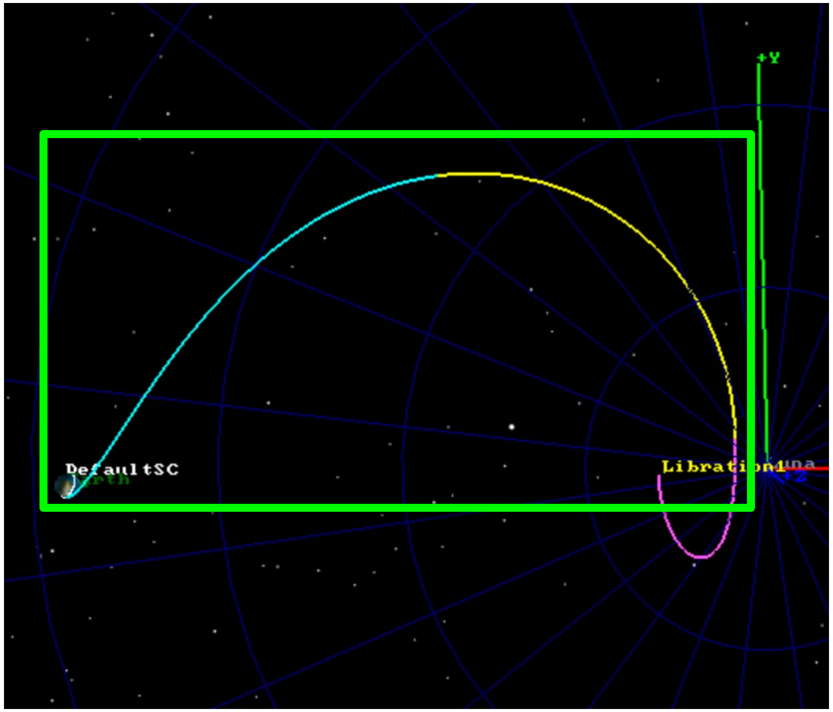


Step 4: Propagate to Perigee

Integrate the spacecraft state backwards in time until perigee (I suggest 2 propagate segments)

a) Propagate for 3 days

b) Then propagate further, set stopping condition as perigee



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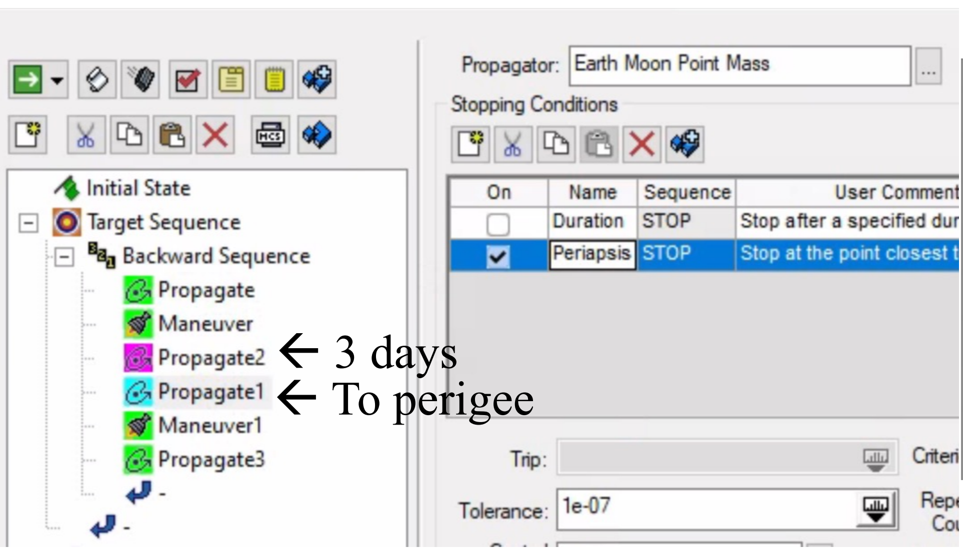
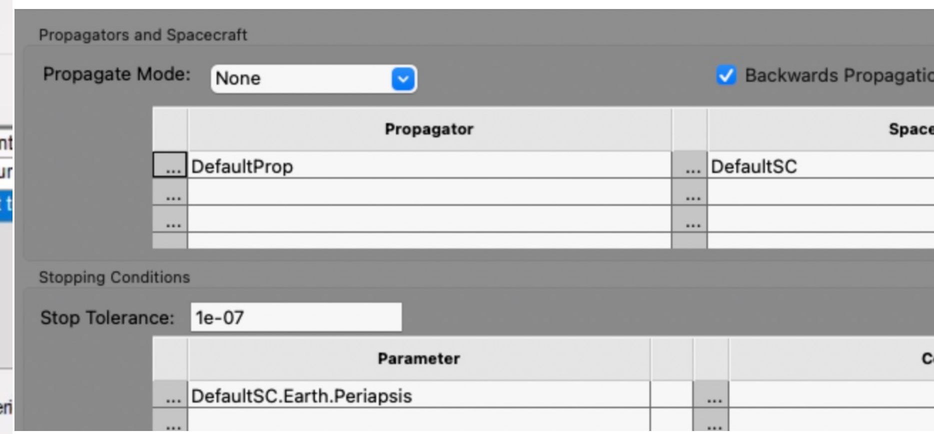
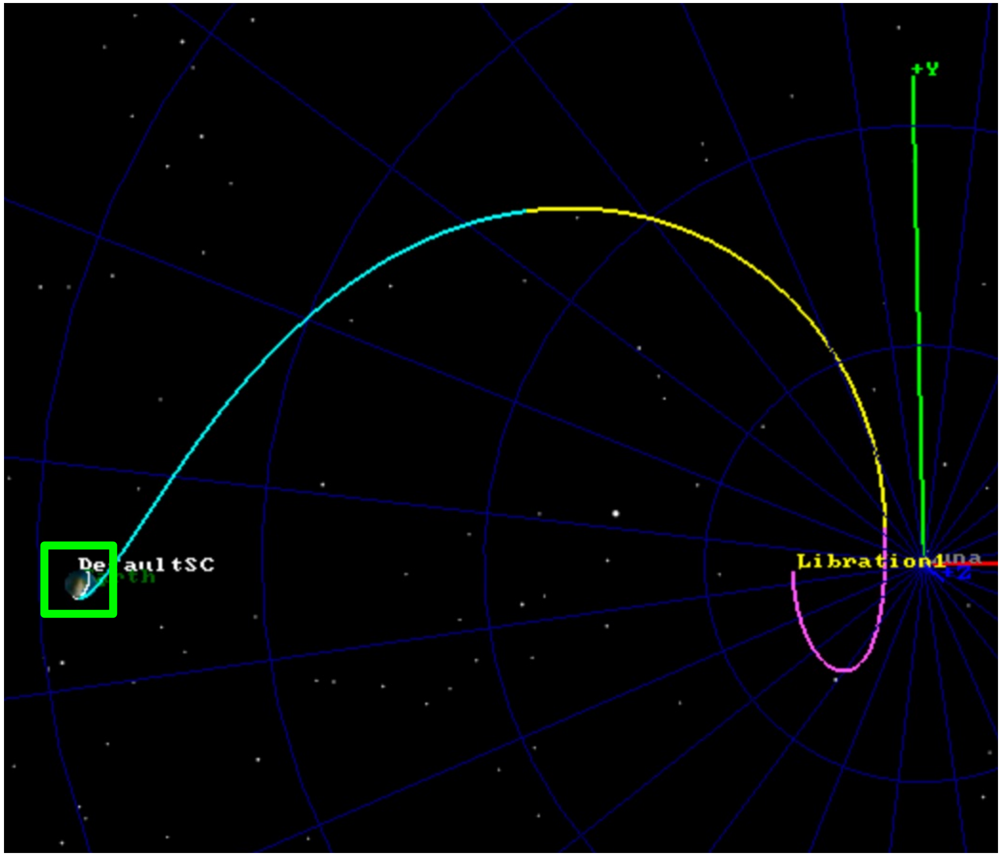




Step 5: LEO Departure Maneuver

Apply impulsive maneuver $\Delta\bar{v}_1$ to insert into a LEO in backward time (or depart it in forward time)



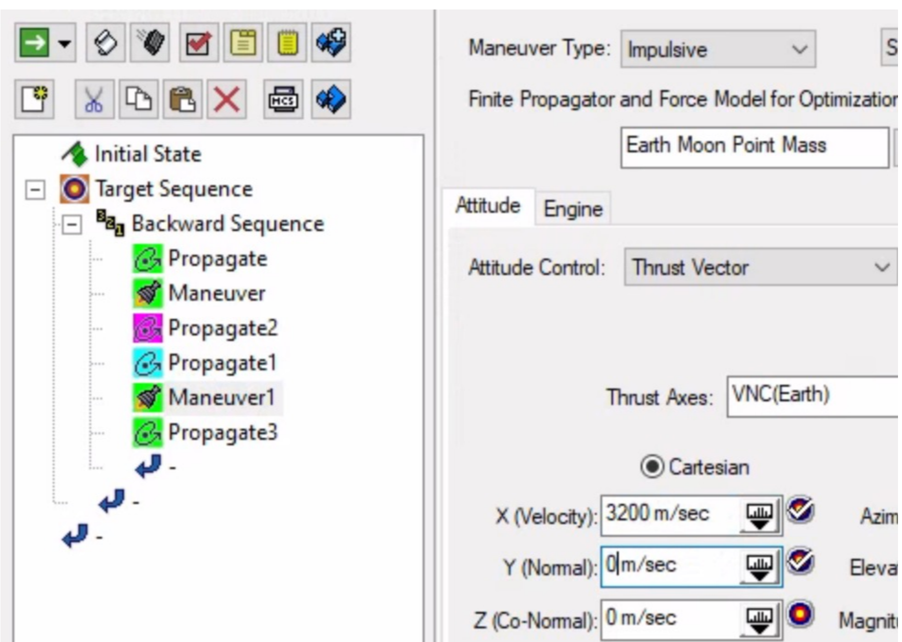
Step 5: LEO Departure Maneuver

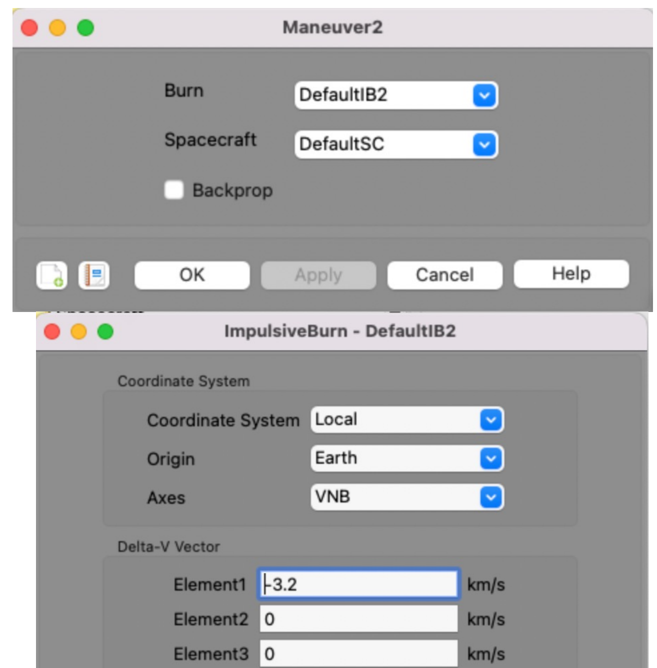
Apply impulsive maneuver $\Delta\bar{v}_1$ to insert into a LEO in backward time (or depart it in forward time)

a) Define maneuver in VNC axes relative to Earth

b) Define the target conditions as $r_p = r_a = 6578.14$ km to within 0.1 km relative to the Earth (allow any orientation for LEO)

c) Only allow the targeter to vary maneuver in V, N directions

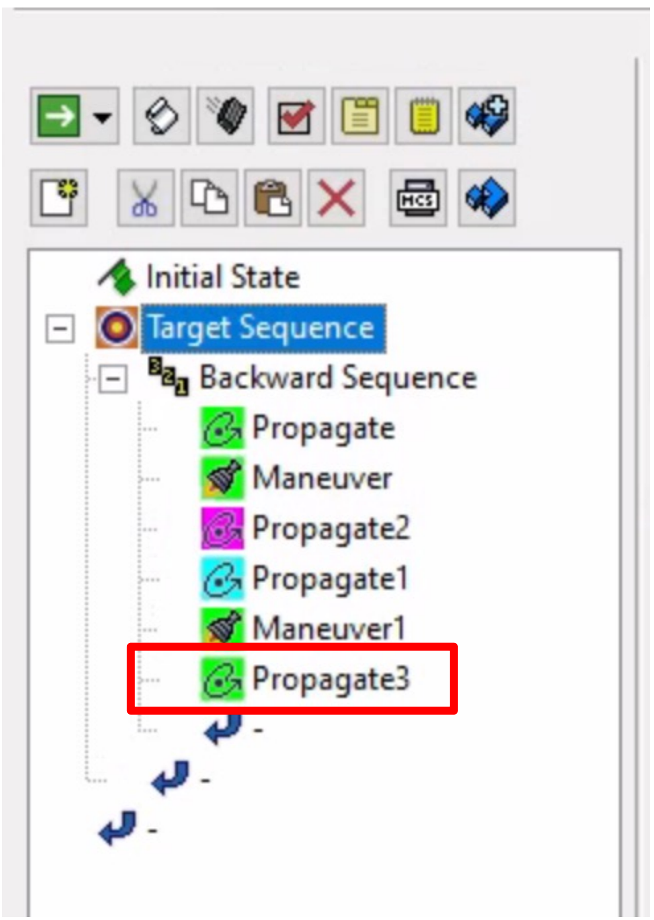




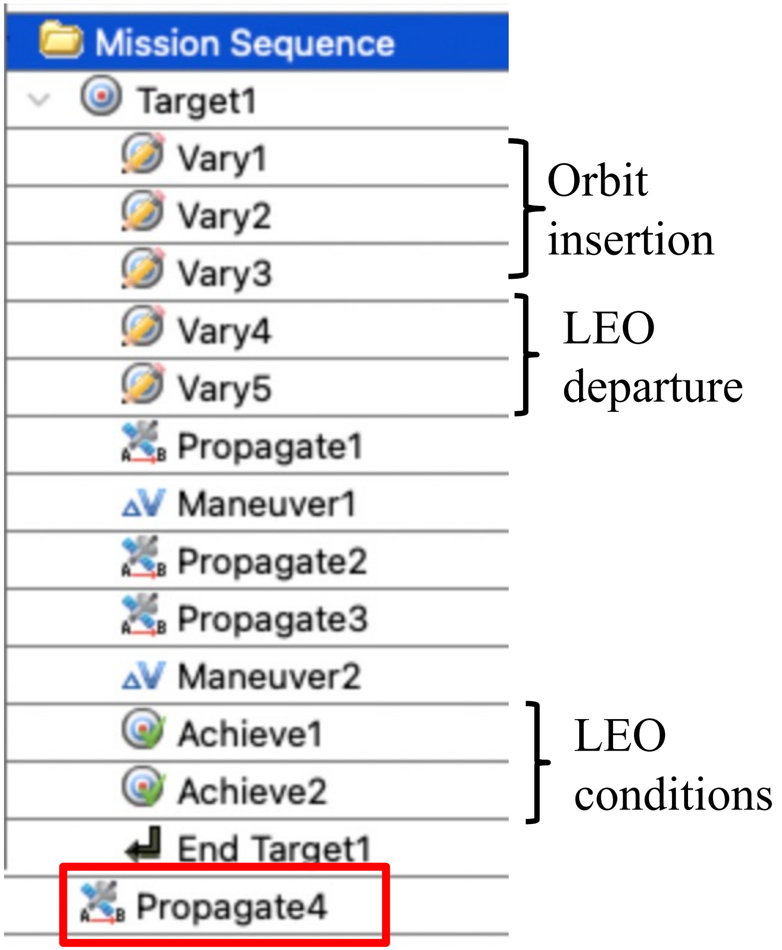
Step 6: Propagate for 1 Rev in LEO

Propagate for approximately one revolution in LEO

MCS in STK



Mission in GMAT



Construct a Transfer in Backward Time

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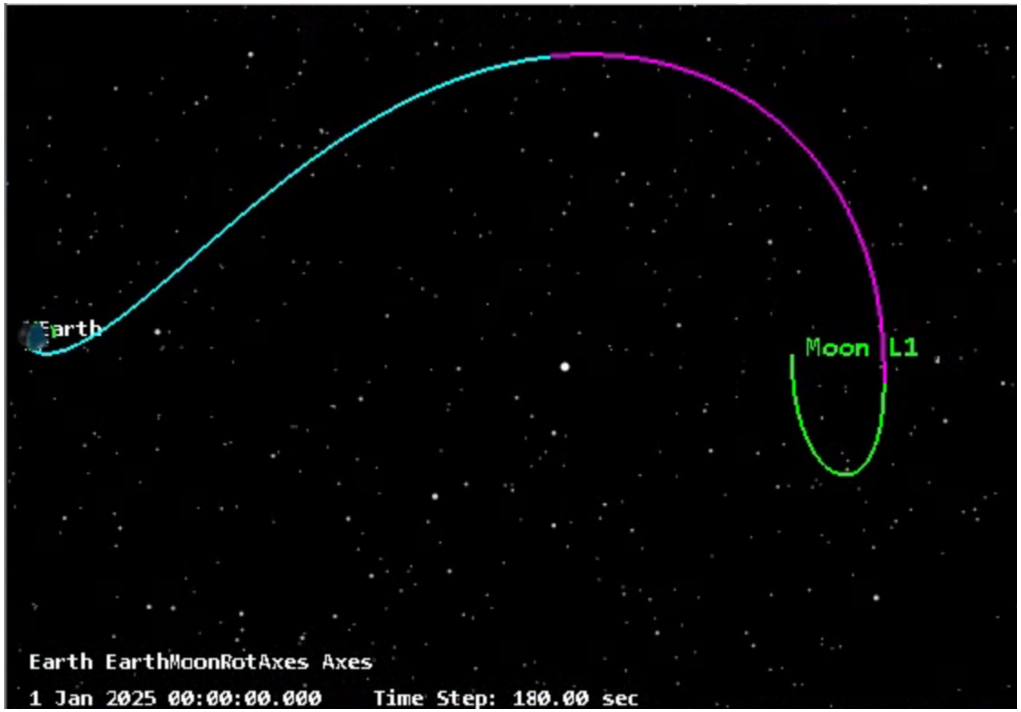

GMAT: