

ASEN 6060

ADVANCED ASTRODYNAMICS

Creating Transfers in GMAT/STK

Objectives:

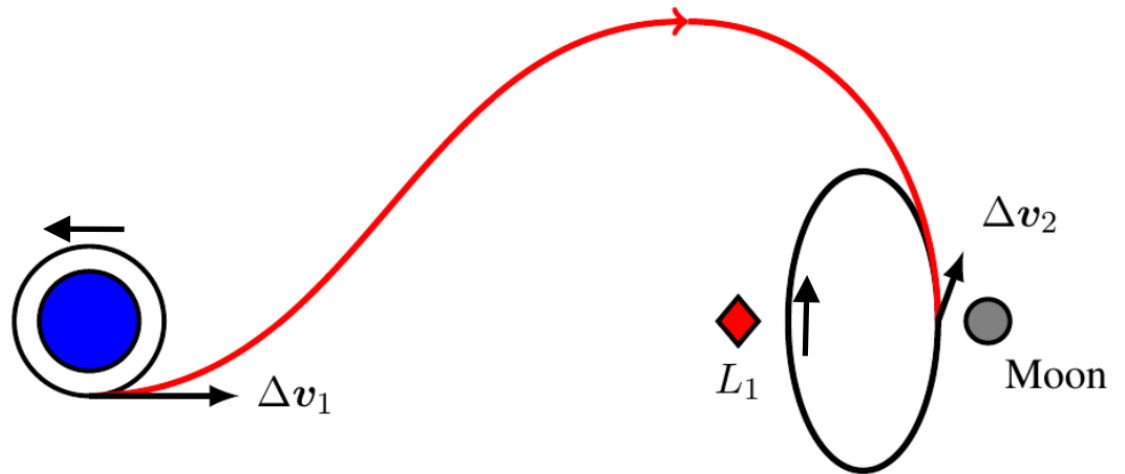
- Briefly summarize approach used to generate transfers in an ephemeris model from LEO to a motion resembling a periodic orbit

Follows the example in this document:

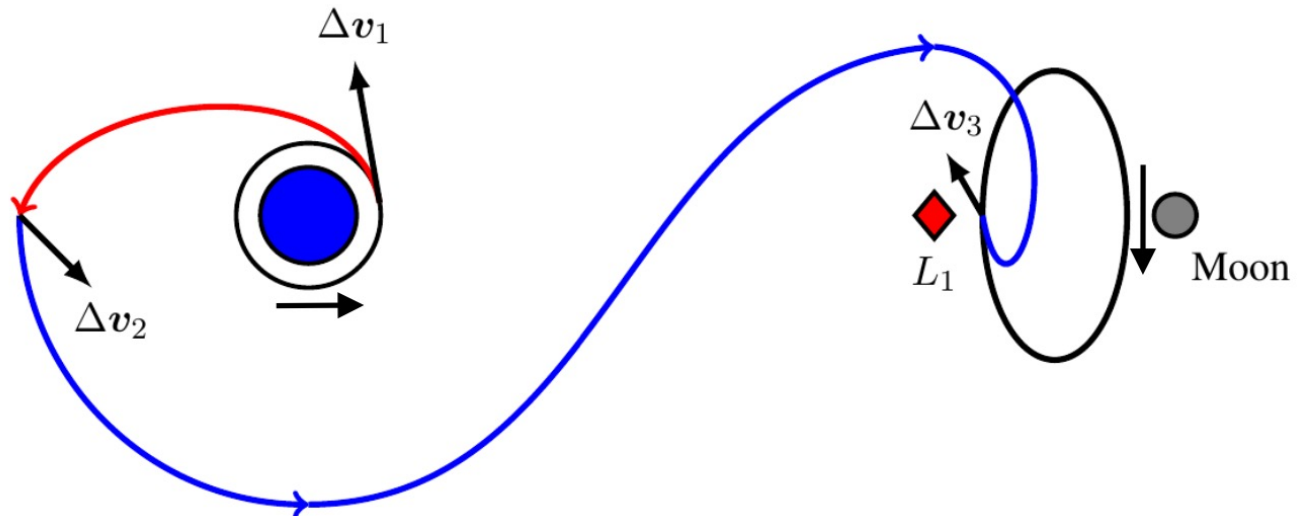
“Folta, D.; Bosanac, N.; Elliott, I.L.; Mann, L.; Mesarch, R.; Rosales, J., 2022, "Astrodynamics Convention and Modeling Reference for Lunar, Cislunar, and Libration Point Orbits (Version 1.1)", NASA/TP–20220014814”

Transfers to Mission Orbit

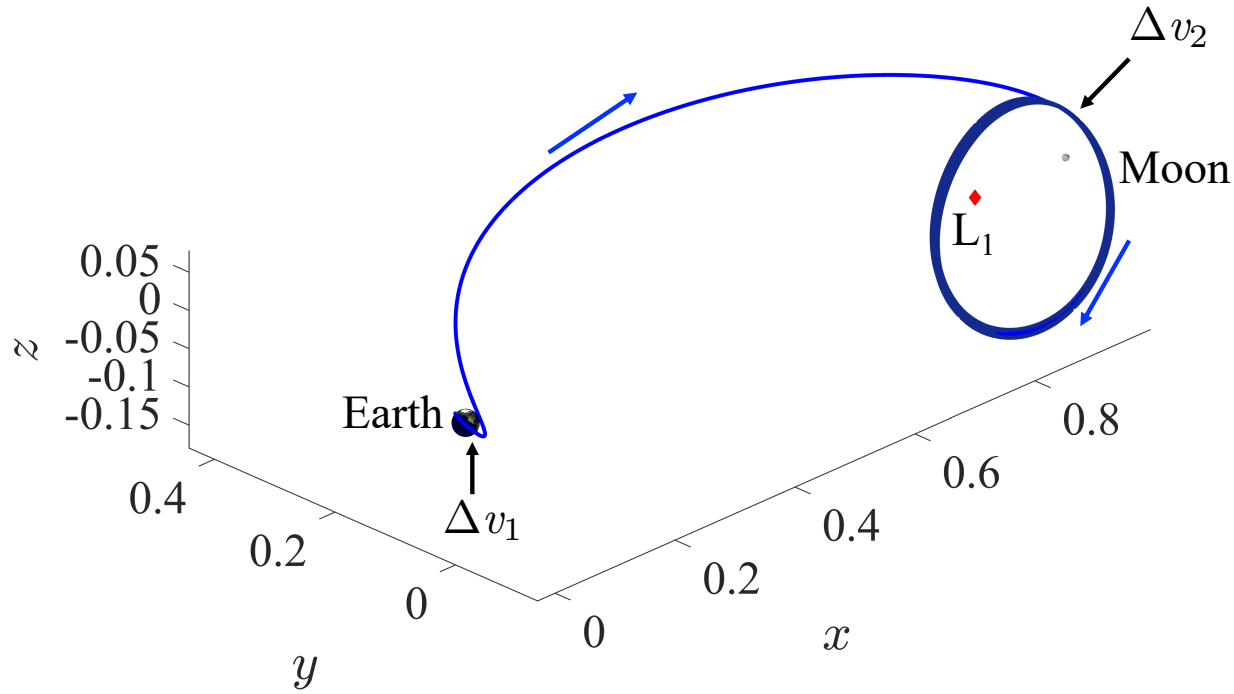
Direct Transfer



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

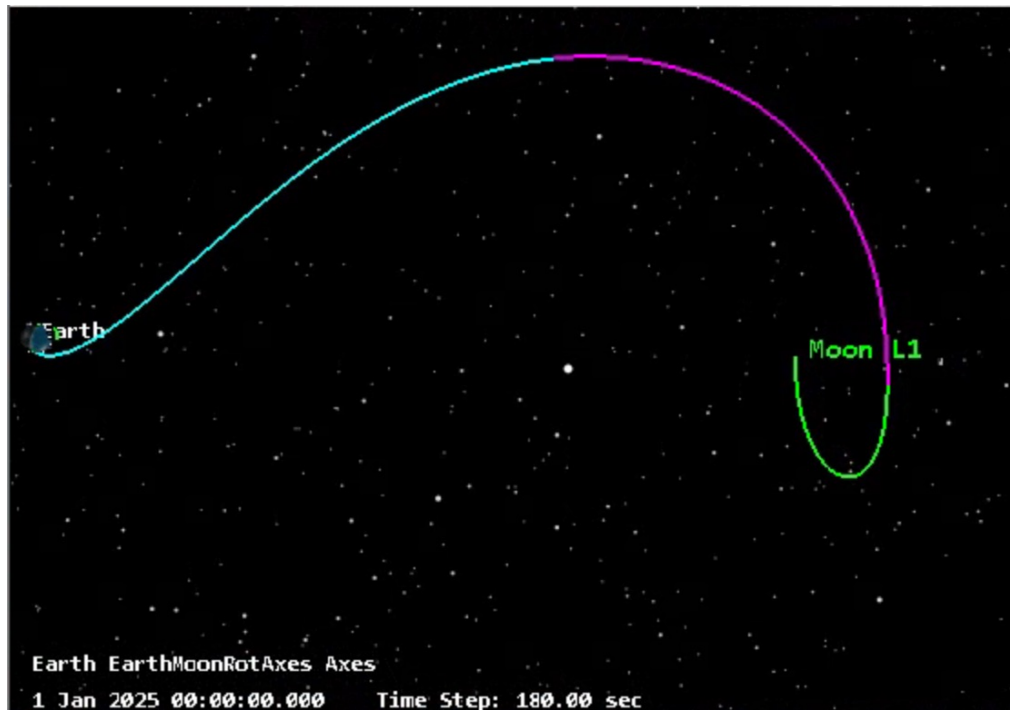
1. Define an initial state and epoch that produce a trajectory that resembles a periodic orbit until the next xz plane crossing
2. Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period
3. Apply impulsive maneuver $\Delta \bar{v}_2$ to depart the mission orbit in 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

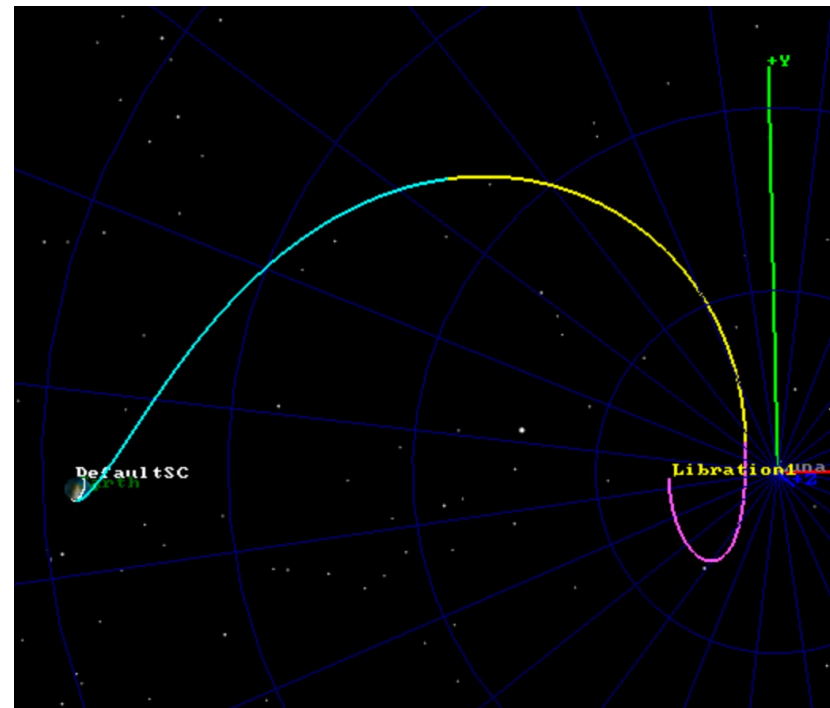
Construct a Transfer in Backward Time

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

STK:



GMAT:



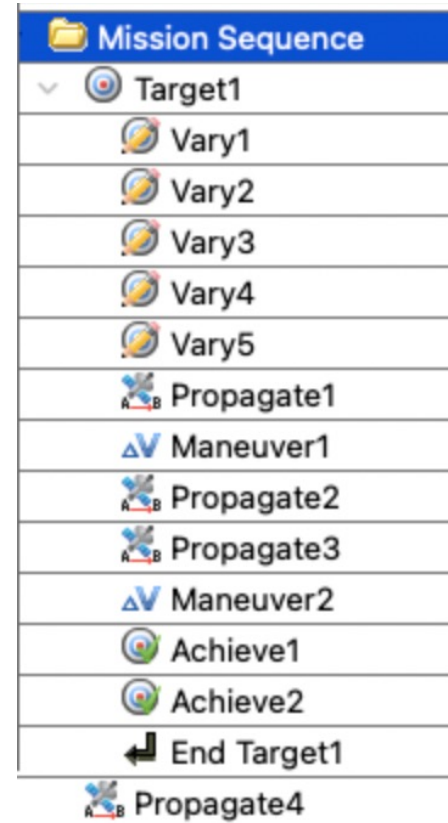
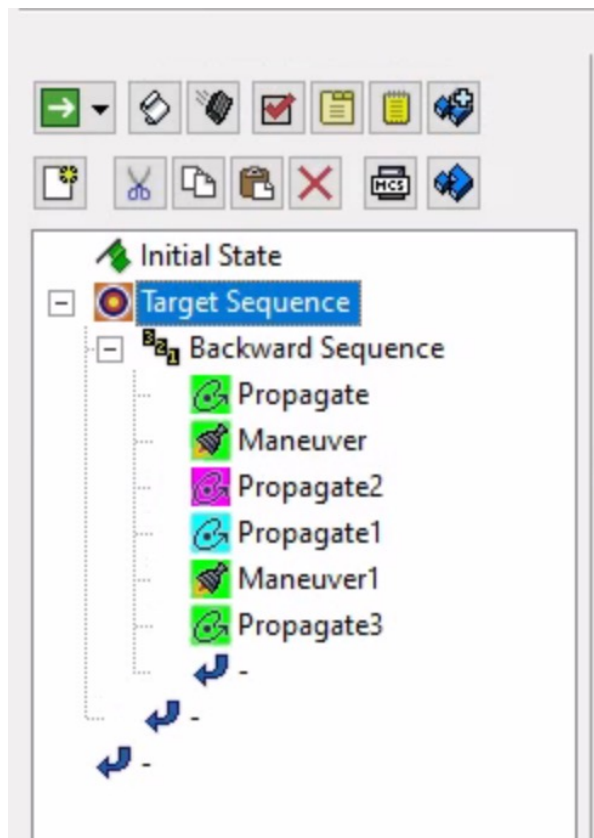
Start by copying your STK/GMAT scenarios from the previous lectures and giving them a new name. You will edit these scenarios!

Construct a Transfer in Backward Time

Encode transfer design problem within a targeter

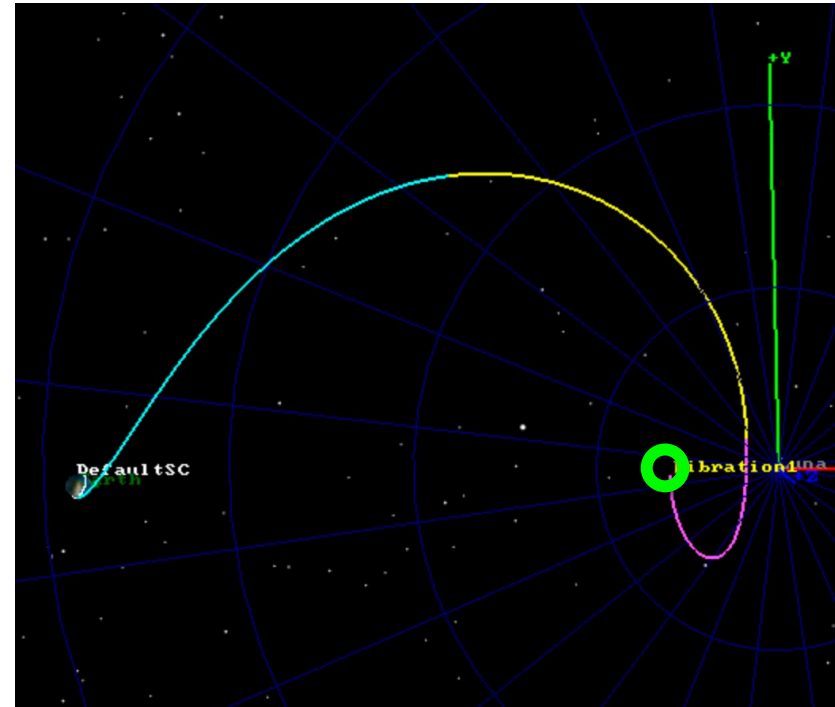
MCS in STK

Mission in GMAT



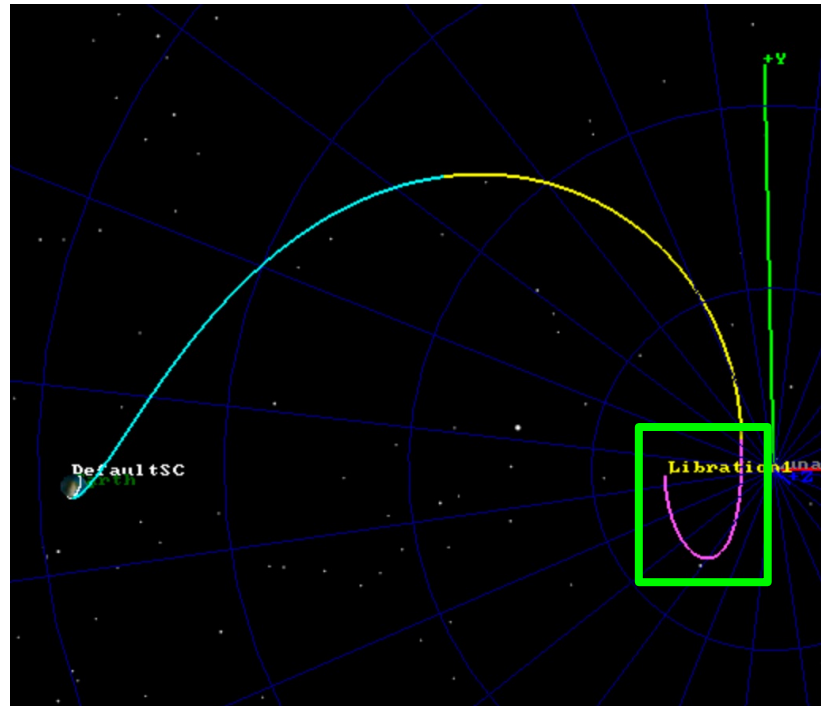
Step 1: Initial Condition Definition

- 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

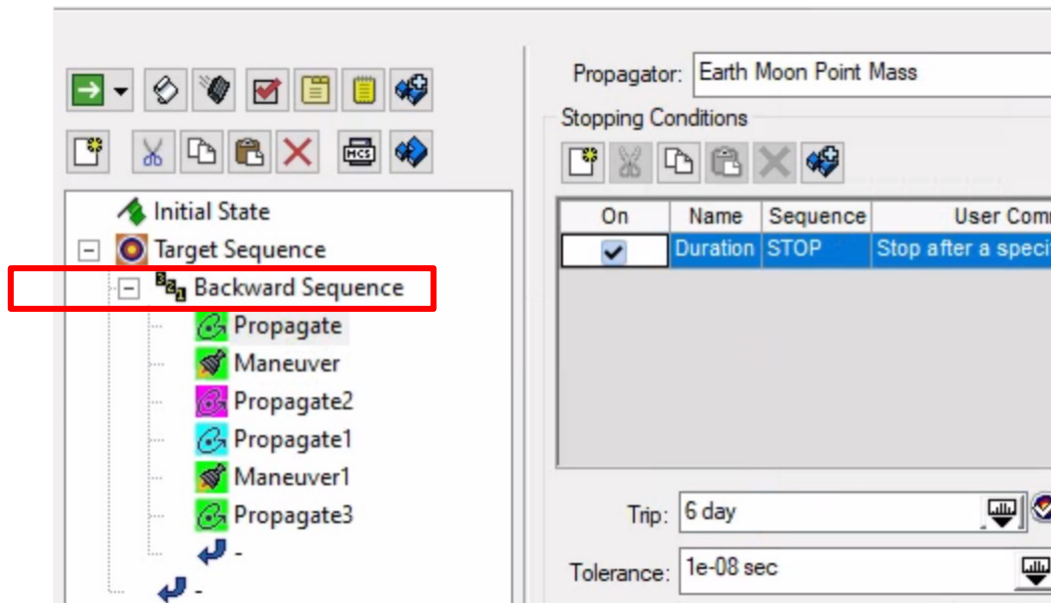
Integrate the spacecraft state backwards in time for Δt_{int} of approximately half a period



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

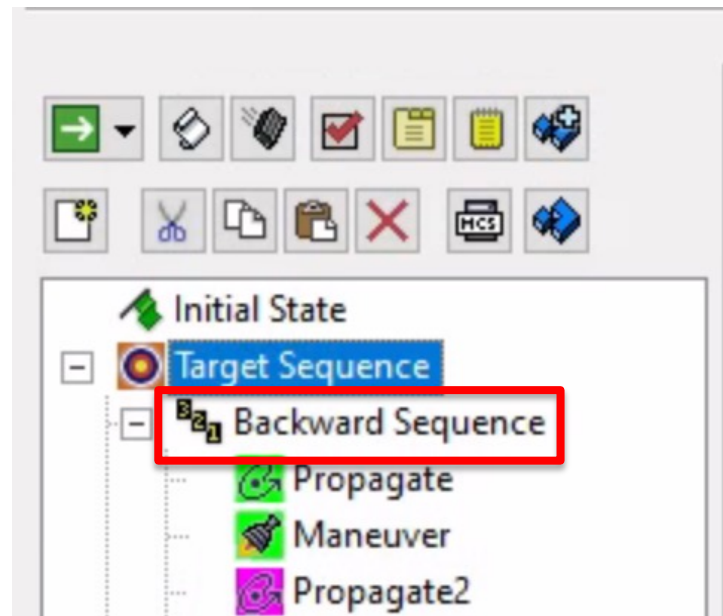
- a) Use as an initial guess $\Delta t_{int} \sim 6$ days
- b) STK: Set Δt_{int} as a variable in your targeter in a Backward Sequence
- c) GMAT: hold Δt_{int} fixed to reduce complexity



Step 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 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

- Use as an initial guess $\Delta t_{int} \sim 6$ days
- STK: Set Δt_{int} as a variable in your targeter in a Backward Sequence
- GMAT: hold Δt_{int} fixed to reduce complexity

Propagators and Spacecraft

Propagate Mode: None ☒ Backwards Propagation ☐ Propagate STM ☐ Compute A-Matrix

Propagator	Spacecraft List
... EMPointMass	... DefaultSC
...	...
...	...

Stopping Conditions

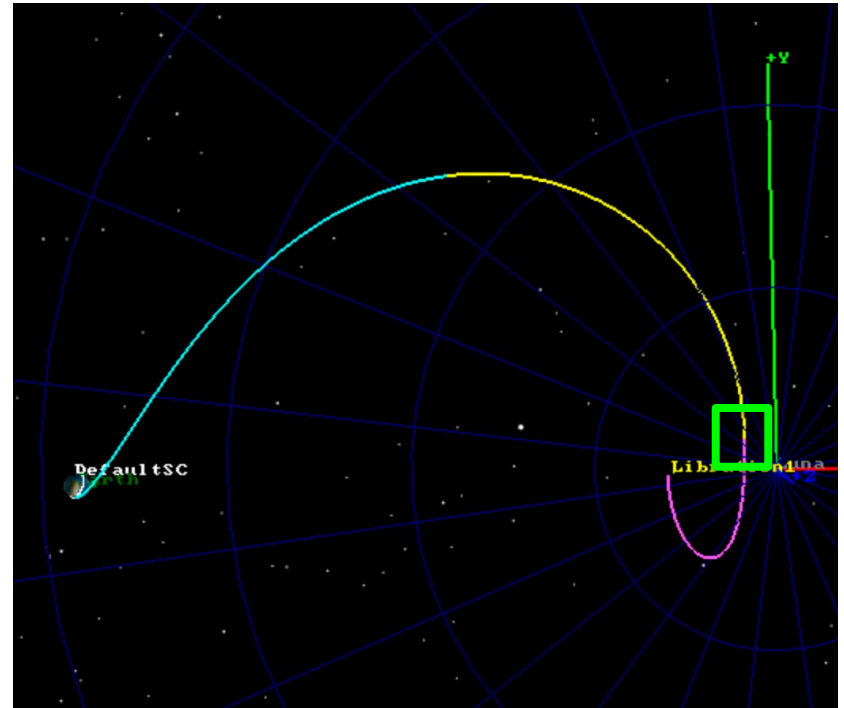
Stop Tolerance: 1e-07

Parameter	Condition
... DefaultSC.ElapsedDays	= ... -6
...	...
...	...

Step 3: Orbit Insertion Maneuver

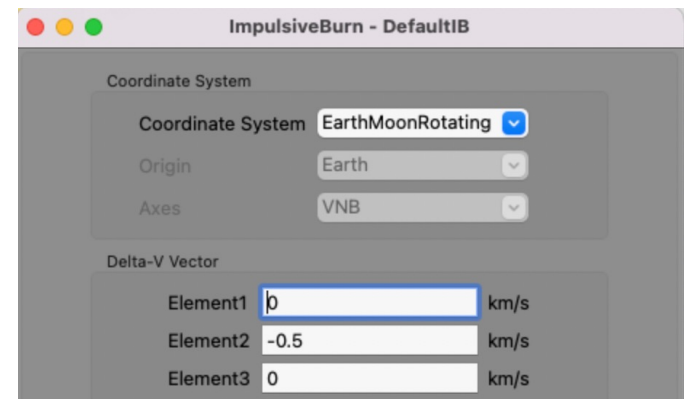
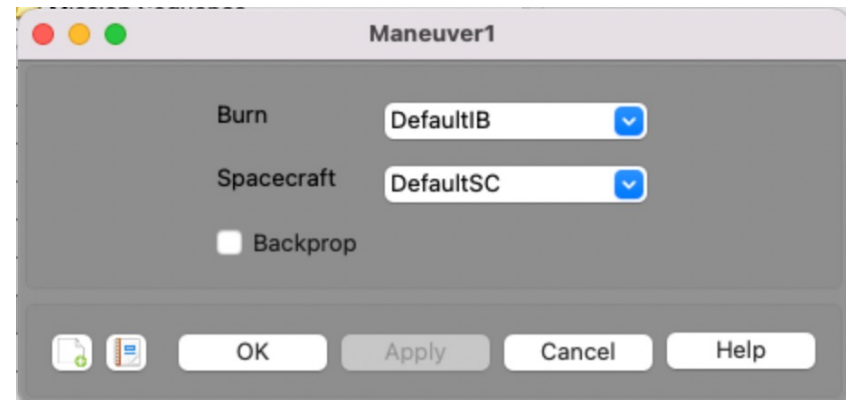
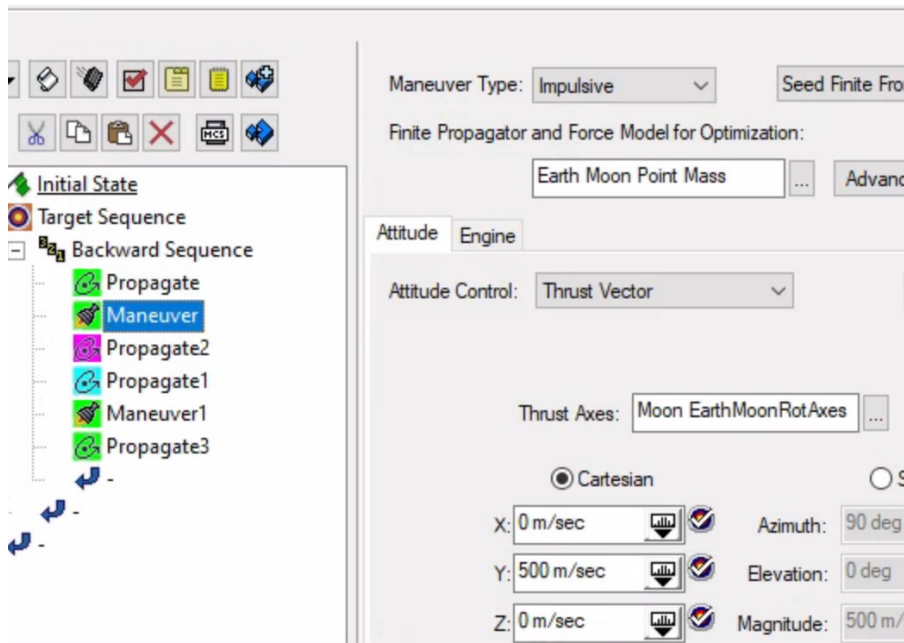
Apply impulsive maneuver $\Delta \bar{v}_2$ to depart the mission orbit in backwards time (or insert into it in forward time) near perilune

- Define the impulsive maneuver in the axes of the Earth-Moon rotating frame
- Use as an initial guess $[0, 500, 0]$ m/s (you can change if needed!)
- Set the three components of the maneuver as variables in your targeter



Step 3: Orbit Insertion Maneuver

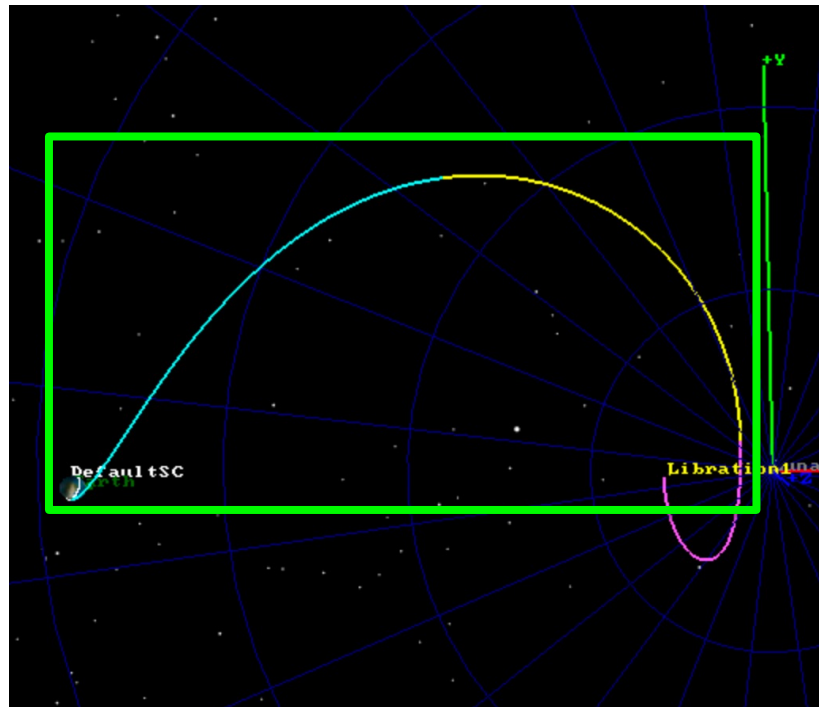
Apply impulsive maneuver $\Delta \vec{v}_2$ to depart the mission orbit in backwards time (or insert into it in forward time) near perilune



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



Step 4: Propagate to Perigee

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

- Propagate for 3 days
- Then propagate further, set stopping condition as perigee

The screenshot displays the GMAT/STK software interface for configuring spacecraft propagation. On the left, a tree view shows the sequence of events: Initial State, Target Sequence, Backward Sequence, Propagate, Maneuver, Propagate2, Propagate1, Maneuver1, and Propagate3. Annotations with arrows point to 'Propagate1' (labeled '← 3 days') and 'Propagate3' (labeled '← To perigee'). The main panel shows the 'Propagator' set to 'Earth Moon Point Mass' and 'Stopping Conditions' with a table:

On	Name	Sequence	User Comment
<input type="checkbox"/>	Duration	STOP	Stop after a specified duration
<input checked="" type="checkbox"/>	Periapsis	STOP	Stop at the point closest to Earth

Below the table, 'Trip' is set to '1e-07' and 'Tolerance' is '1e-07'. On the right, a 'Propagators and Spacecraft' panel shows 'Propagate Mode' set to 'None' and 'Backwards Propagation' checked. A table lists the propagator and spacecraft:

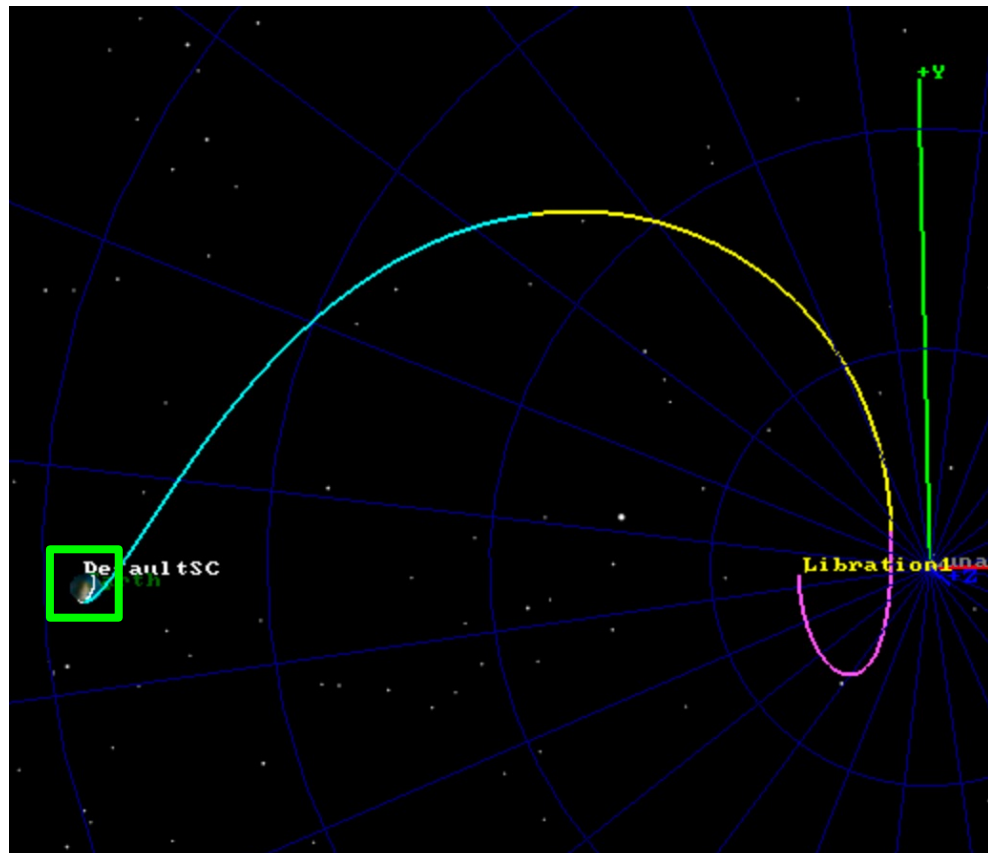
Propagator	Spacecraft
DefaultProp	DefaultSC

Below this, 'Stopping Conditions' shows 'Stop Tolerance' set to '1e-07'. A table lists the parameter for the stopping condition:

Parameter
DefaultSC.Earth.Periapsis

Step 5: LEO Departure Maneuver

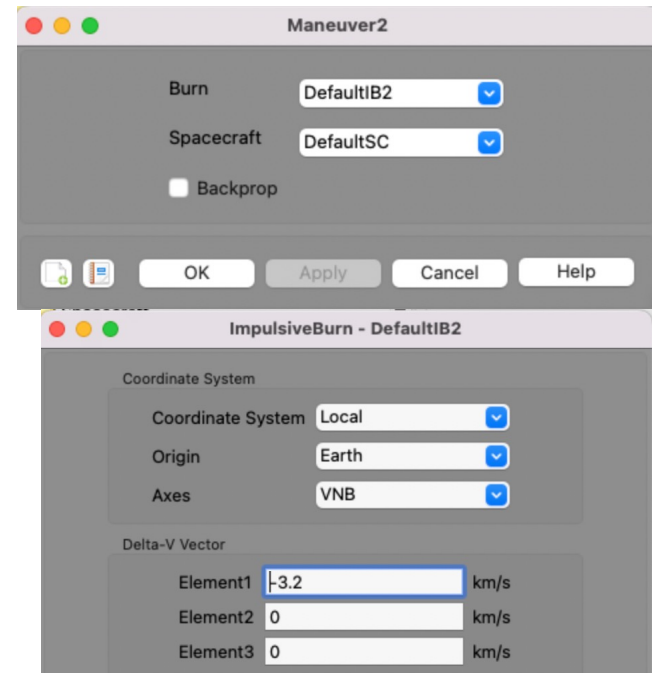
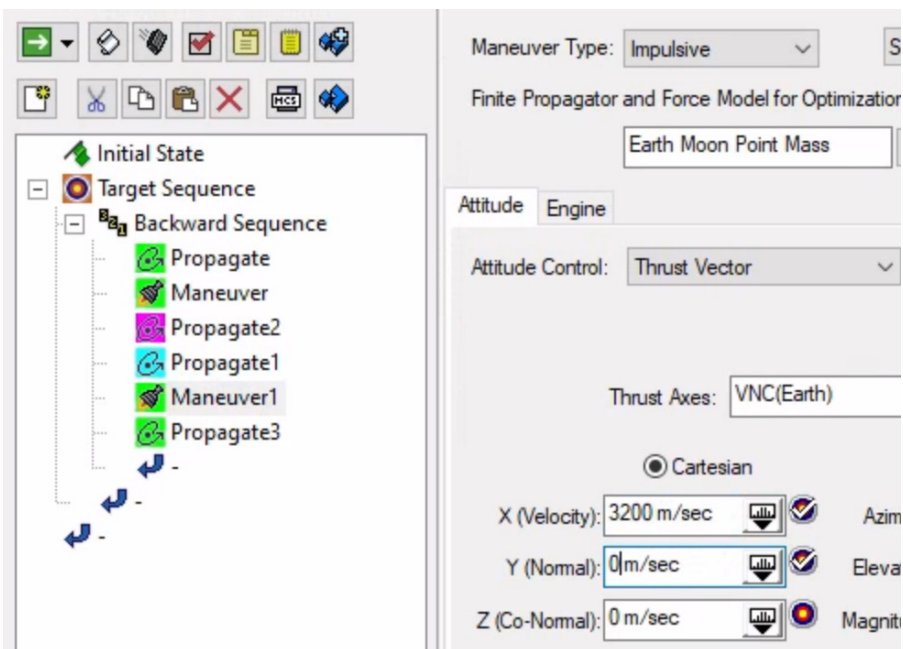
Apply impulsive maneuver $\Delta \bar{v}_1$ to insert into a LEO in backward time (or depart it in forward time)



Step 5: LEO Departure Maneuver

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

- Define maneuver in VNC axes relative to Earth
- 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)
- Only allow the targeter to vary maneuver in V, N directions

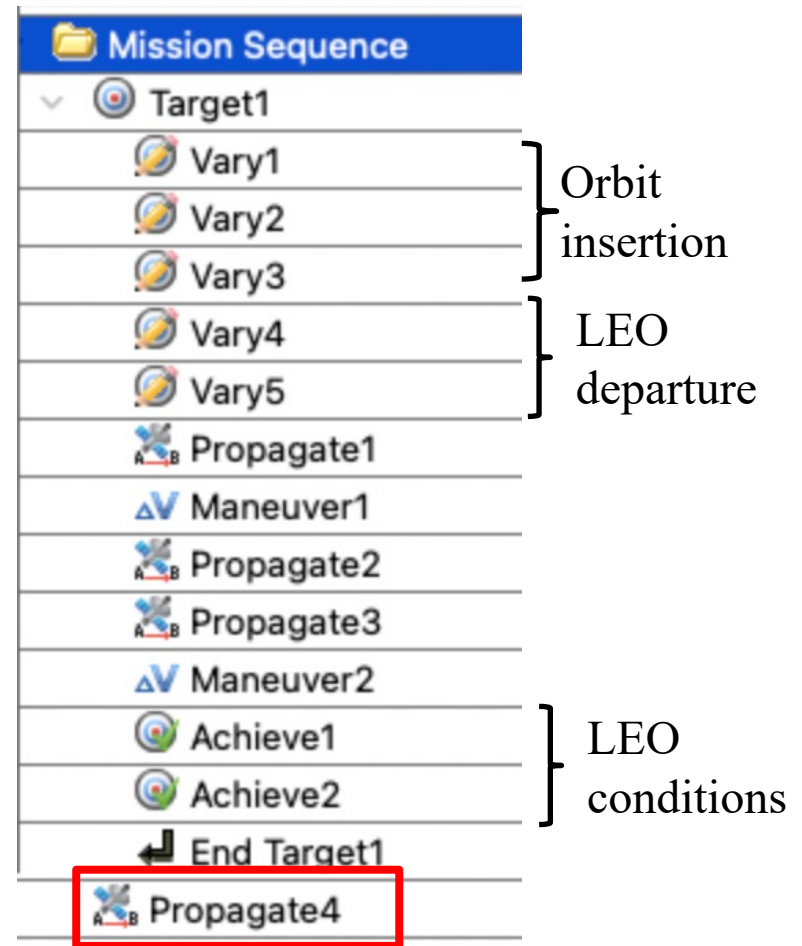
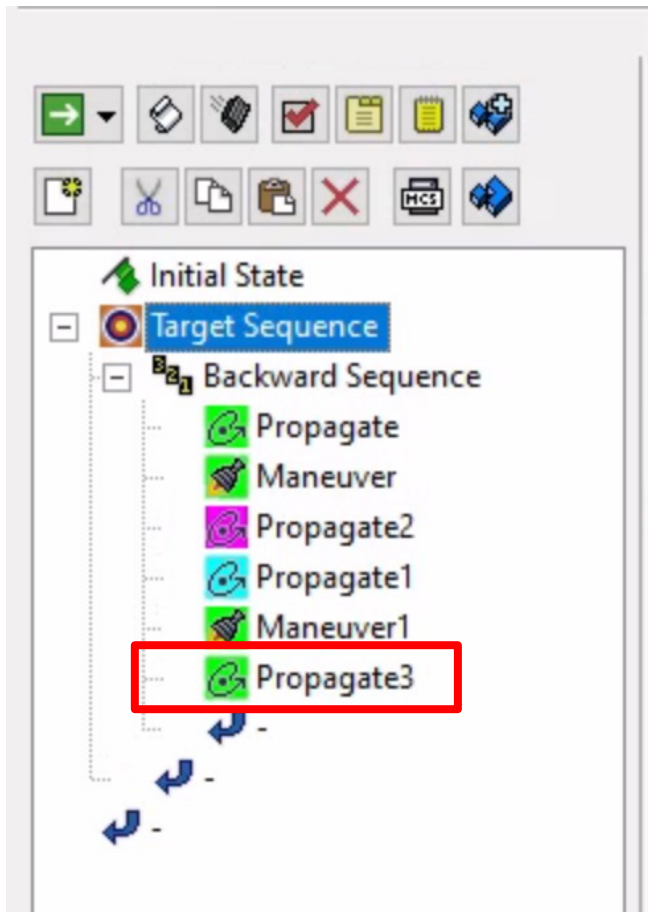


Step 6: Propagate for 1 Rev in LEO

Propagate for approximately one revolution in LEO

MCS in STK

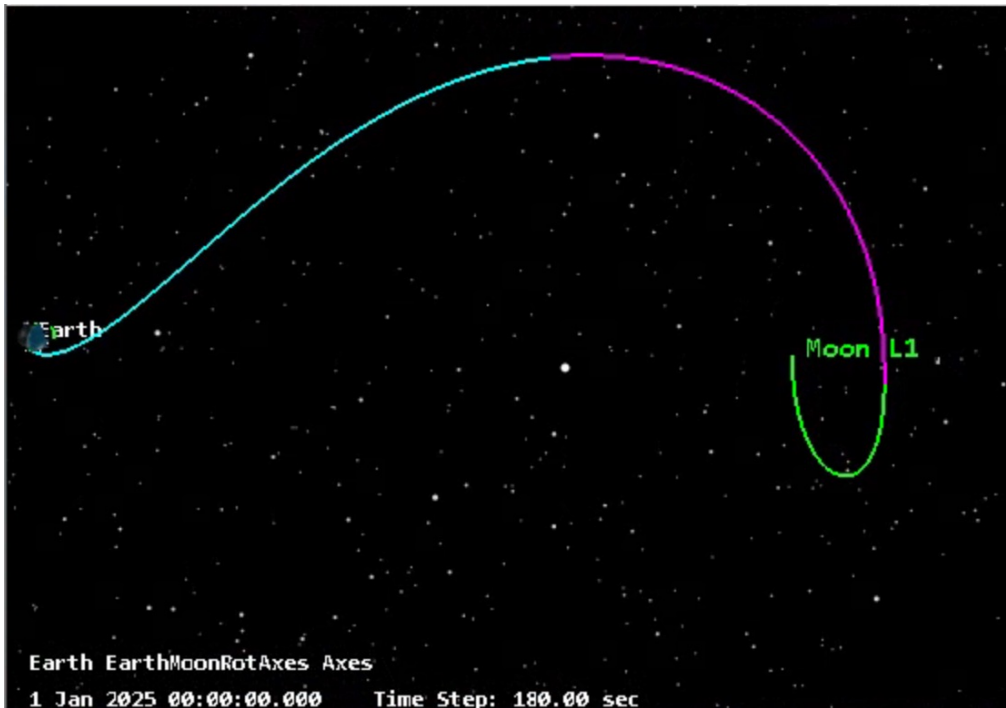
Mission in GMAT



Construct a Transfer in Backward Time

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

STK:



GMAT:

