Basic backwards Propagation

1. Building an ephemeris

Open new scenario and create an Astrogator satellite. Delete the default sequences in the MCS.

Insert a backward sequence.

Note that you can configure the sequence to pass either the final or initial state to the next segment. Recall that in a backward sequence, the initial state is actually –after-, in time, the final state, since we start at an initial state and propagate backwards. Leave the default at 'Final State'.

In the backward sequence, insert an initial state segment. Change the element type to keplerian (so we can see the elements). Leave the defaults.

Insert a propagate segment after the Initial state, rename '**prop back 1/2 days**'. Leave it with the default stopping condition (duration, ½ day). Change the color to Red.

Set the 3D graphics/pass orbit track lead type to be 'all'.

Propagate the MCS and look at the orbit in the 3D window.

Use the 'Update Animation Time' drop down selection from the initial and final state of the 'prop back 1/2 days' field to see where the initial and final states are. Note that when you animate, you'll need to start at the final state to see the orbit when you animate forward.

Add a propagate segment after the backward sequence (outside of it, so that it will propagate forwards). Rename it '**prop forward ½ day**'.

Change the segment color to green and propagate the MCS.

Note that this has now erased the ephemeris of the backwards propagation segment, and simply used the final state of the backward segment as an initial state for the forwards segment.

Insert a maneuver segment before the **prop forward ½ day** segment, that burns 1 km/sec in the Y(normal) direction in the VNC coordinate frame.

Propagate the MCS. (You'll see the inclination change).

Now set the 'State to pass to next segment' field in the backwards propagation segment to 'Initial'. This will cause the backwards segment now be included in the MCS, before the **prop forward ½ day** segment. Thus, we'll calculate this segment's backwards, but still include the entire ephemeris of this segment normally in the final ephemeris.

Rerun the segment.

To make things more clear, change the 3D graphics/pass orbit track trail type to be 'all', and the lead type to be 'None' before you animate. Now you can see the red segment is included as part of the total ephemeris.

2. Targeting backwards

We'll now build a scenario that targets back to the Earth from the Moon and using backwards propagation.

Imagine that the user has a particular time that they'd like their spacecraft to be at Lunar Orbit Insertion, along with a given transfer duration and orbit they'd like to achieve, and we'd like to establish the orbit plane (i.e. the RAAN) that's appropriate for this transfer from a given inclination.

Open an new scenario

Create a second 3D window, centered at the Moon. Make sure the window is showing the Moon Centered Inertial trajectory (check the view/from to button).

Remove the default segments, and insert a targeting sequence.

Insert a backwards segment inside the target sequence.

Inside the backwards segment, place:

A**n initial state segment.**
Moon centered TOD coord. System
Keplerian:
SMA = 1838 km
E = 0.01
Inc = 90 deg
All else at zero
Select the RAAN and Arg of perigee as controls.
Default date

A maneuver segment
Named: **LOI** (Lunar Orbit insertion)

-800 m/sec along the **Moon VNC** X(vel) axis.
Select the X(vel) component as a control.

A Propagate segment
Named: **prop to SOI**
Lunar Propagator
Altitude (WRT Moon) stopping condition of 50,000 km.

Another Propagate segment
Named: **prop to peri**
Cislunar Propagator
Periapsis (WRT Earth) stopping condition.
Change the color.

Add the results of 'Altitude of Periapsis' and 'Inclination' (both WRT the Earth) to the '**prop to peri**' segment.

Add a result of 'Duration' to the backward segment.

Set up the default targeting profile in the target sequence as follows:

Controls

RAAN of initial state (1 deg perturbation, 10 deg max step)
Arg of Peri of initial state (1 deg perturbation, 10 deg max step)
Cartesian X of LOI (0.001 km/sec perturbation, 0.01 km/sec max step)

Constraints

Alt of Peri (Desired = 200 km, default tolerance)
Inclination (Desired = 28.5 deg, default tolerance)
Duration (Desired = -5 days, default tolerance) Note the negative duration here.

Turn on 'draw while calculating in 3D', and deactivate the 2D DWC.

Set the action of the Targeter to 'Run Active profiles'

Propagate the MCS.

This should converge in 22 iterations.

This demonstrates an alternate way to solve the Earth-Moon trajectory problem. With our targeted inclination of 28.5, if we wanted to achieve our lunar insertion parameters on this date, we’d have to launch into the orbit plane defined by 28.5 and the ending RAAN of that final segment. (**6.3 deg in this case)**