PrincetonSATELLITE SYSTEMS

Spacecraft Control Toolbox Version 7.0

Launch and Early Orbit Operations

When solid rockets are used for geosynchronous orbit insertion, a single burn is performed followed by a series of orbit corrections using the mission orbit propulsion system. Inaccuracies in the pointing direction and uncertainties in the thrust and burn duration of a solid motor will inevitably lead to errors. Liquid apogee engines (LAEs) allow for much more precise control of insertion burns leading to less of a need to use the mission orbit system. However, because LAEs have much lower thrusts than solid motors it is necessary to perform multiple burns.

LEOP Analysis Script

The toolbox can be used for Launch and Early Orbit Operations (LEOP) analysis. To demonstrate the capabilities a simple script, `LEOPAnalysis.m` is included in the toolbox. The script allows you to select a burn sequence for geosynchronous orbit transfer using a single array

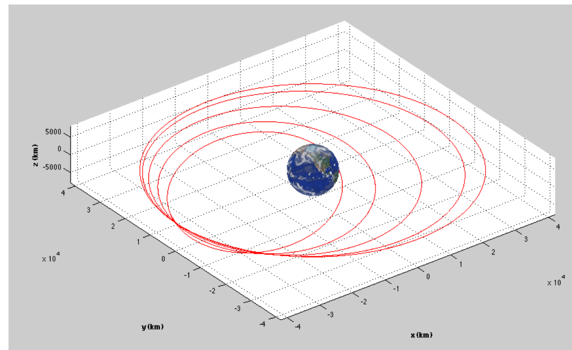
```
burn = [0 0.5 0 0.3 0 0.15 0 0.05 0]
```

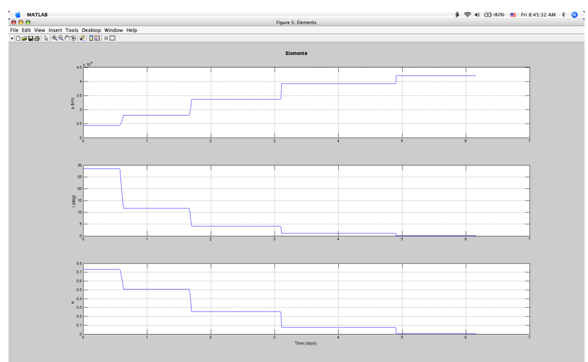
In this case nine revolutions (orbits) are in the plan and there are burns on rev 2, 4, 6 and 8. The number is the percentage of the total delta-v to be done on each burn. The script uses the rocket equation to compute the total amount of fuel needed for the spacecraft. All burns are done around apogee so the required delta-v vector is

$$\Delta v = v_{drift} - v_{transfer}$$

where drift refers to the orbit after the final burn because the insertion point is usually not the final station and the spacecraft "drifts" to station. Transfer orbit is the orbit upon separation from the launch vehicle.

The following figures shows the transfer orbit and the semi-major axis, inclination and eccentricity. The five distinct orbital paths correspond to the initial transfer orbit followed by the four burn sequence. The script uses MATLAB's ode113 for orbit propagation and uses ode113's "events" capability to find apogee on each burn rev. The entire script is only 172 lines long and can be easily customized to provide more sophisticated burn planning.





The dynamical model uses a point mass Earth model, although higher fidelity models can easily be used instead (the toolbox includes a 36th order gravity model). In this example the final burn leaves the spacecraft on station. In practice, it would be left with some drift velocity. In addition, the burn vector is held constant when small adjustments might need to be made due to orbit determination errors and orbit perturbations.

Upgrading to Version 7.0

If you have purchased or upgraded the Spacecraft Control Toolbox within the last year, you will receive this release for free. Prior customers should contact us for their upgrade price.

For More Information

Contact Princeton Satellite Systems by phone at (609) 275-9606 or by email to info@psatellite.com

6 Market Street, Suite 926 · Plainsboro, NJ 08536 · Phone: (609) 275-9606
Email: info@psatellite.com · Web: www.psatellite.com