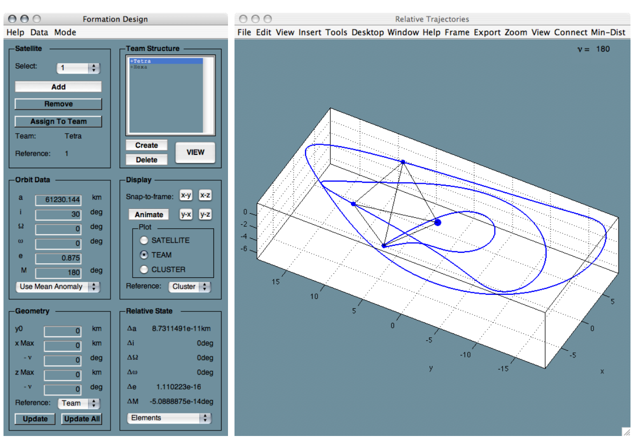
Spacecraft Control Toolbox Version 7.0

now with *Formation Flying*

An exciting new addition in v7.0 of the Spacecraft Control Toolbox is the Formation Flying Module. This software package provides a variety of simulations, control algorithms, and visualization tools specifically for spacecraft formation flying missions. In addition, a complete chapter on formation flying dynamics and control is provided in the new textbook that is comes with v7.0 of the toolbox.

Intuitive Formation Design

The Formation Design GUI enables you to rapidly design individual repeating trajectories and combine them to meet the geometric objectives of your mission. The example below shows a set of relative trajectories in a highly elliptic orbit that form a tetrahedron at apogee – this is the type of formation geometry to be executed by NASA's Magnetospheric Multi-Scale (MMS) mission.

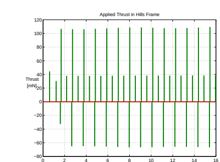


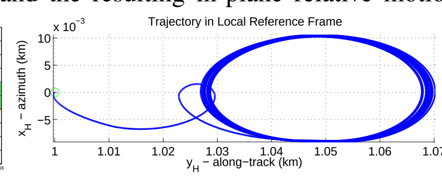
Disturbance Analysis

A critical performance metric for formation flying missions is the projected annual delta-v required to maintain the formation. The `FFMaintenanceSim` function allows us to simulate 2 spacecraft in any type of naturally repeating relative trajectory in any orbit. The effects of navigation uncertainty and differential disturbances from atmospheric drag, solar pressure and Earth oblateness can be evaluated in concert or separately. Consider the effects of differential drag on a formation in LEO, where the 2 spacecraft are identical except for a 50 kg difference in mass. We attempt to maintain a constant 1 km along-track separation distance. The simulation is run as follows:

```
s = FFMaintenanceTests( 'diff drag demo' );
d = FFMaintenanceSim(s);
FFMaintenancePlotter(d)
```

`FFMaintenanceTests` stores the initial conditions and control parameters for multiple test cases, so that they can revised and re-run at any time. `FFMaintenancePlotter` plots time histories of the disturbances, applied thrust, and the resulting relative motion. Because the 2 spacecraft have different ballistic coefficients, one is decelerated by drag slightly more than the other, causing them to drift apart. The plots below show the regular pattern of small corrective thrusts (about 60-100 mN each) and the resulting in-plane relative motion.





In this example, maneuvers are planned using an LP algorithm that is based on a discrete model of relative orbit dynamics. Using a maneuver duration of one full orbit (about 90 minutes), gives a maximum along-track error of 70 meters and an annual delta-v of 73 m/s. When the maneuver duration is cut in half, the maximum error reduces to 17 meters but the annual delta-v jumps to 198 m/s. These same kinds of trade studies can be applied to different types of orbits and relative motion, and can be extended to include the impacts of other disturbances, navigation uncertainty, and custom designed algorithms.

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