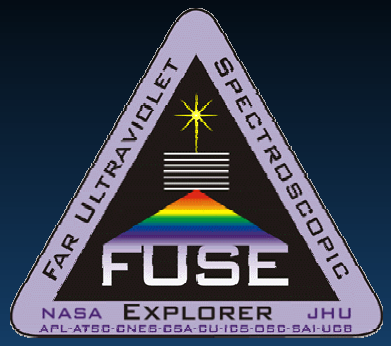
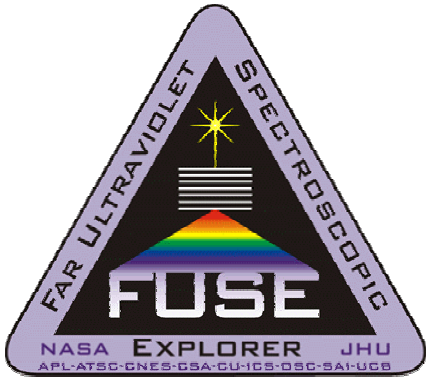


Challenges of FUSE Operations with the New Attitude Control System

Bryce Roberts & the FUSE Operations Team
Johns Hopkins University

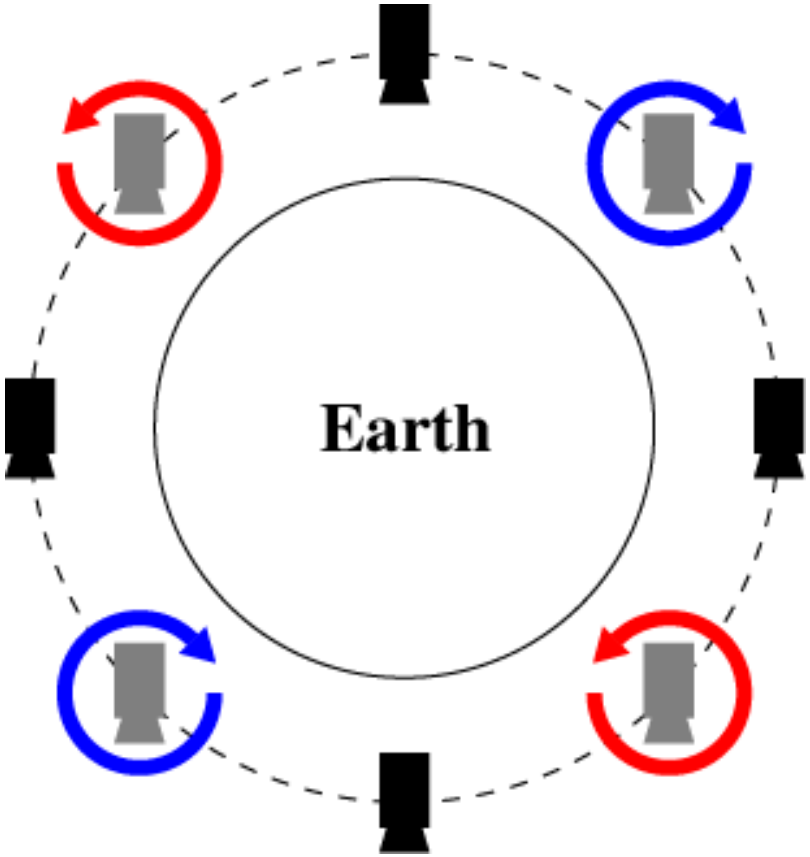
Overview of Challenges



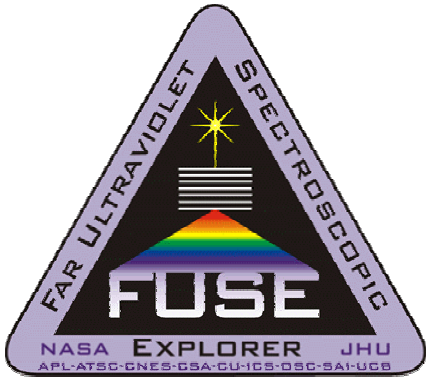
- Control on axes with RWAs – as good as before!
- A-axis control is now more complicated:
  - MTB torque must equal or exceed sum of disturbance torques for stable pointing
  - MTB torque must equal or exceed disturbance torques *AND* ramp up/ramp down torque for accurate slewing
- On-board control system simply responds to the environment, but…
- Ground-based planning software must model environment for accurate predictions

Gravity Gradient Disturbances

- Gravity gradient is only significant external disturbance torque
- Equivalent to 'tidal forces'
- Equation: $\tau = \frac{3GM_{\oplus}}{r^2} R_S \times IR_S$
- Magnitude and per-axis components depend on:
  - Spacecraft orientation
  - Instantaneous orbital parameters
- Easy to model gravity gradient torques accurately with a good orbit propagator

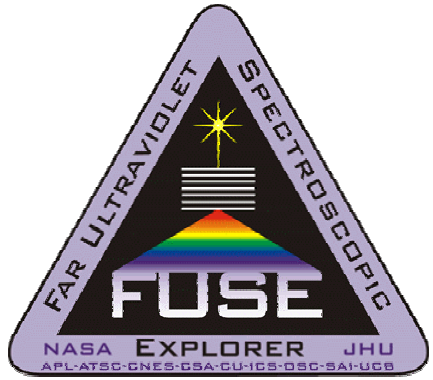


Magnetic Torque Authority



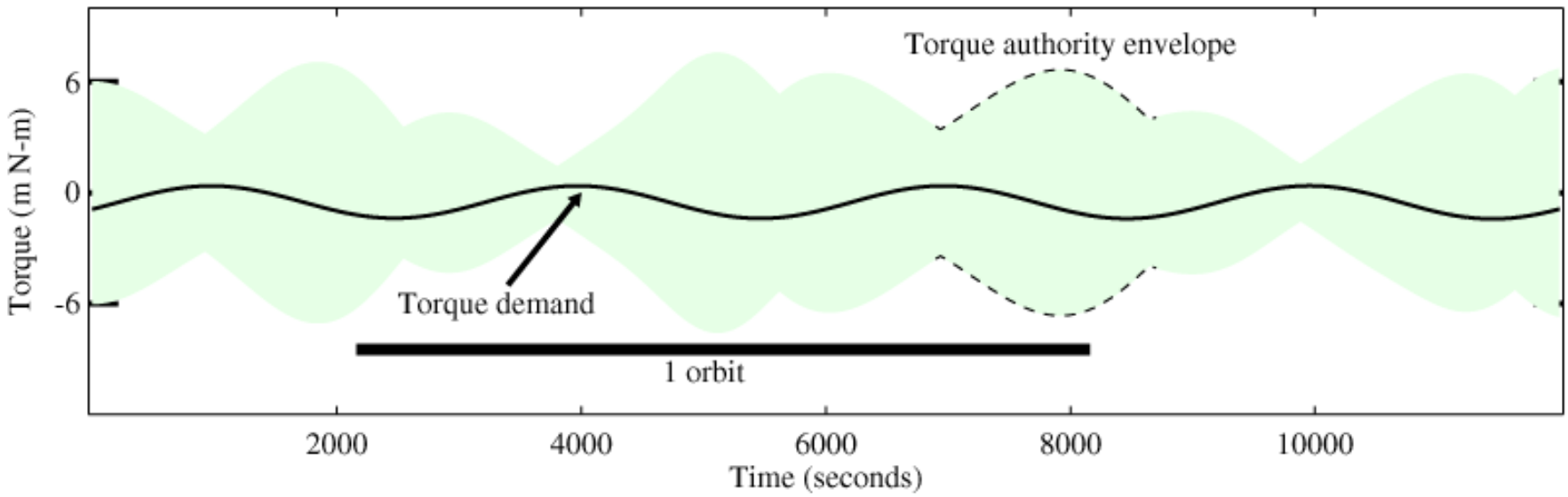
- Torques developed as control system commands MTBs to work against geomagnetic field
- Formula: $\tau = \mu \times B$
- Magnetic field direction and strength varies significantly with time
- Variations are *predictable* with a good model
- MTB dipole moments were determined pre-launch exclusively for wheel unloading
  - Have to predict MTB command saturation

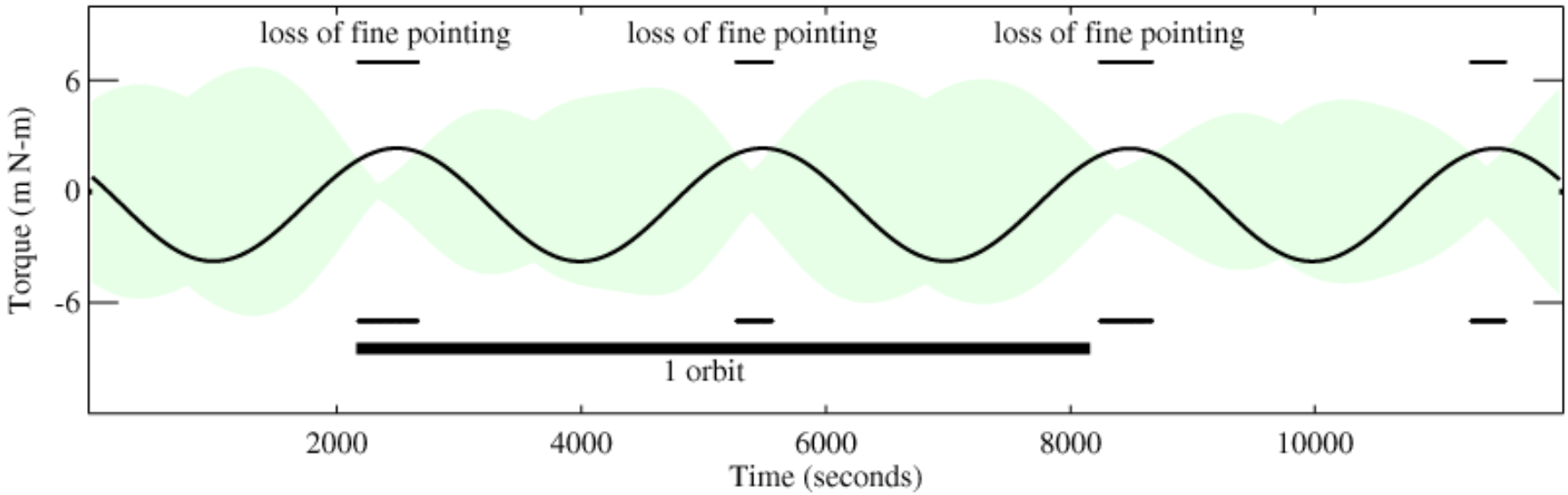
Putting it all together: predicting stability



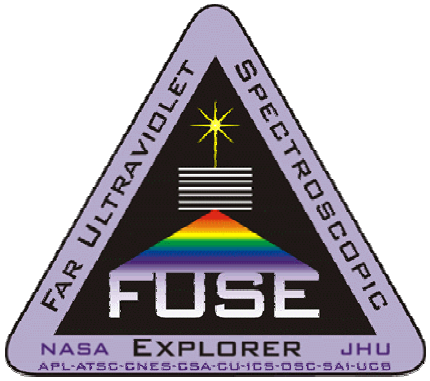
- Can generate an all-sky map by repeating calculation over many different sightlines (attitudes)
- Can generate torque authority time windows by repeating calculation over a long time span
- Regions of stability are highly variable over short timescales

Torque Balance Examples





A further complication: slewing



- Same principles as for predicting stable pointing, but:
  - A-axis ramp up/ramp down torque demand added to gravity gradient
  - Cross coupling of ‘gyroscopic torques’ into A-axis
  - Attitude continuously changing during slew