Trajectory Reconstruction for Beagle 2

- Paul Withers, 5th year PhD student at the University of Arizona/LPL
  - Worked on MGS accelerometer data from its aerobraking in upper atmosphere
  - Advisor to MER (NASA 2004 Mars Landers) for trajectory (and atmospheric structure) reconstruction
- John Zarnecki, Martin Towner, Brijen Hathi of the Open University (Great Britain)
- Huygens DTWG#6, JPL, 2002.12.02

Background

- Beagle 2 = UK/ESA Mars Lander, delivered by ESA's Mars Express in Dec 2003.
- Accelerometer is a small part of John Zarnecki's Environmental Sensor package
- I spent summer 2001 at Open University writing trajectory (and atmospheric structure) reconstruction programs
- At DTWG to learn about Huygens's techniques for doing this and share plans from Beagle 2

Aims of Summer Work

- Develop general techniques for trajectory reconstruction, then specialize for Beagle 2's instruments and capabilities
- Current status: Simple, general techniques without error analysis
- Apply to entry phase accelerometer data using specified entry position and velocity only.
  - I will highlight two areas I found complicated

(1) Constraining Spacecraft Attitude

- Head-on: Attitude adjusts to keep main accelerometer axis parallel to relative velocity between spacecraft and atmosphere
- Drag-only: Direction of measured 3-component acceleration is parallel to relative velocity
- Acceleration Ratios: Ratio of axial and normal accelerations gives spacecraft attitude
- Gyroscopes: Nice if you have them
- Current status: Head-on or Drag-only

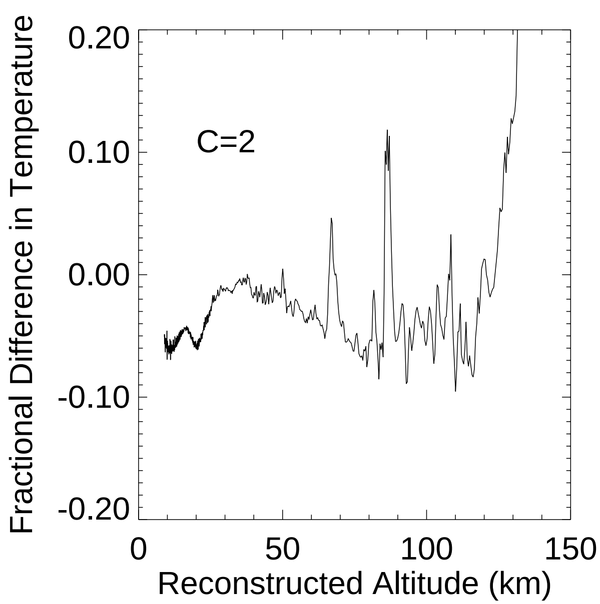
(2) Coordinate Frames

- Aerodynamic accelerations measured in spacecraft frame
- Equations of motion simplest in an inertial frame
- Final trajectory most useful in planet-fixed rotating frame
- My choice: Work in a different inertial frame at each timestep, which is coincident with planet-fixed rotating frame at that timestep. There are many other choices.

Testing on Mars Pathfinder

- Use poor aerodynamic database without additional constraints of near-landing radar altimeter and landed position
- Difference between our traj and PDS in latitude and longitude is 0.05^{o} or less, same scale as errors in entry position.
- Discovered inconsistency within PDS archive at high altitude
- (Atmospheric results are good)

Digression on Quick T(z)

- Trajectory + aerodynamic database gives density profile
- Density + gravity gives pressure profile
- Density + pressure gives temperature profile
- 

  Can get reasonable T(z) without any aerodynamic database at all since C_D changes slowly