Jet Propulsion Laboratory
California Institute of Technology

JPL Software Plan

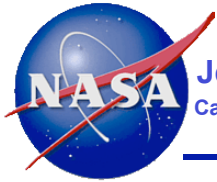# For BepiColombo MORE

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# JPL Software Tools for Radio Science

- ODP
  - Currently in use for Cassini (including U. Rome)
  - No longer being maintained or upgraded
- MIRAGE
  - Modified version of ODP
    - Not used for mission-critical navigation
    - Uses parallel processors for large gravity field estimation
      - Mars, GRACE, GRAIL
    - Can be modified for research purposes
- MONTE
  - Used for Phoenix navigation and all future JPL missions
    - Not suitable for estimation of large gravity fields
    - Can't be modified for research purposes
- SSDPS (solar system data processing program)
  - Used to integrate and fit planetary ephemeris
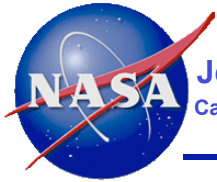
How to Support MORE

- MIRAGE currently includes
  - Spacecraft forces, data reduction
  - Accepts file from SSDPS for planetary orbital elements

- For MORE
  - Modify MIRAGE to include asteroid GM partials from SSDPS
  - Modify light-time computation as needed
  - Fit MORE data simultaneously with MGS, Odyssey, etc to estimate
    - Mercury gravity field
    - PPN parameters
    - Effect of asteroids
  - Add new measurement type to tie to ICRF
    - VLBI 'normal point' observations of MGS etc.

- Will properly handle correlations of all dynamic parameters
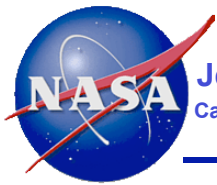
Mars OD Accuracy

- Orbit overlap differences for MGS, radial component
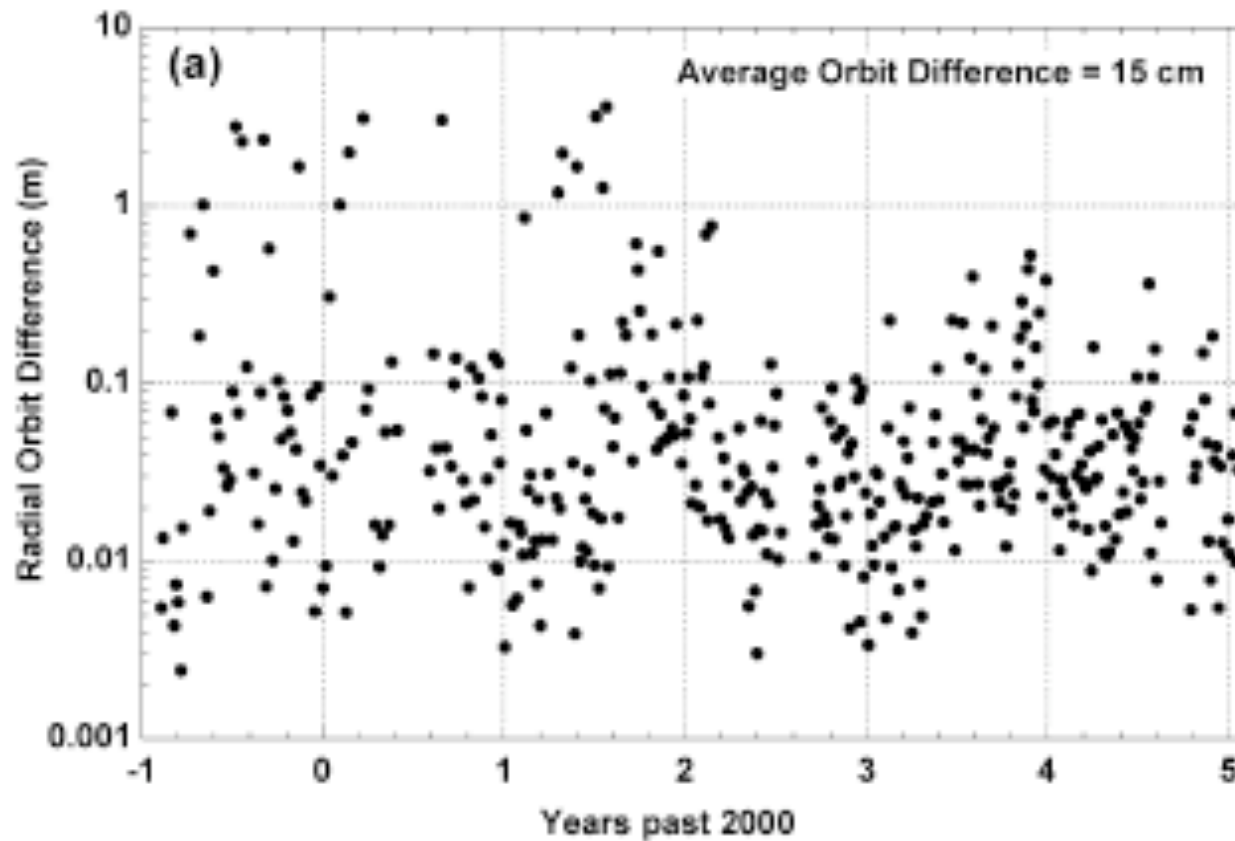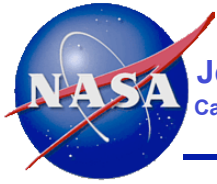
Simulation With Asteroids

- ## Using SSDPS

  - ### Data set: all planetary data used for DE421

    - Simulated MRO range measurements through 2016 (1 m accuracy)
    - Simulate MORE range for 1.5 years
      - 1 point per pass, to Mercury c.g., 10 cm accuracy, SEP>2°

  - ### Estimated parameters

    - All planetary orbital elements
    - Up to 67 asteroid GM
    - PPN parameters, (dG/dt)/G, and J2_sun

# ast GM	67	36	11
gamma	5.10E-06	4.50E-06	4.20E-06
beta	5.40E-05	2.90E-05	7.10E-06
J2sun	6.60E-09	3.50E-09	1.20E-09
dG/dt/G	2.00E-14	1.30E-14	4.60E-15
4b-g-3	6.90E-04	2.70E-04	1.00E-04

DISCREET
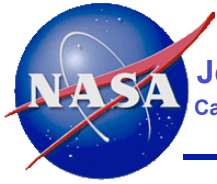
Other Relevant Work

- ## Ranging Calibration Task

  - ### Currently in progress

  - ### Improve current ranging system uncertainty

- ## Advanced Ranging Instrument Prototype proposal

  - ### The next generation instrument conceived for BepiColombo that brings resolution down to ~cm

- ## GRAIL modeling and simulations

  - ### Proved very helpful for BepiColombo preparations