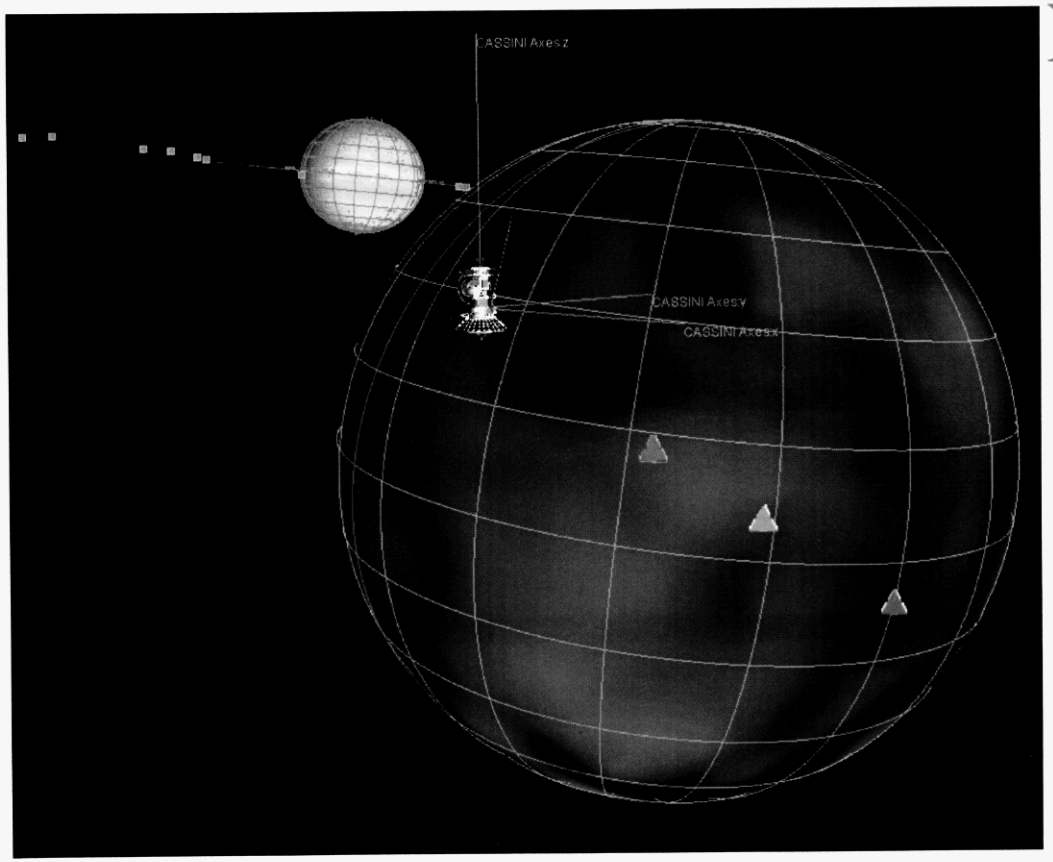
Science Opportunity Analyzer (SOA): Not Just Another Pretty Face



Carol A. Polanskey

Barbara Streiffert

Taifun O'Reilly

Jet Propulsion Laboratory,

California Institute of Technology

Pasadena, CA

INTRODUCTION

- For the first time at JPL, the Cassini mission to Saturn is using distributed science operations for sequence generation.
  - Scientists at their home institutions have become more responsible for building spacecraft sequences than before.
  - Tools have been needed at their institutions to support science sequence development.
  - Existing JPL uplink tools had required a complete configuration of the sequence development environment on a workstation behind a firewall
  - Existing user community tools did not interface easily with the JPL tools
- Science Opportunity Analyzer (SOA) has been created to bridge the gap between the remote scientists and the JPL operations teams.

SCIENCE TEAM TASKS

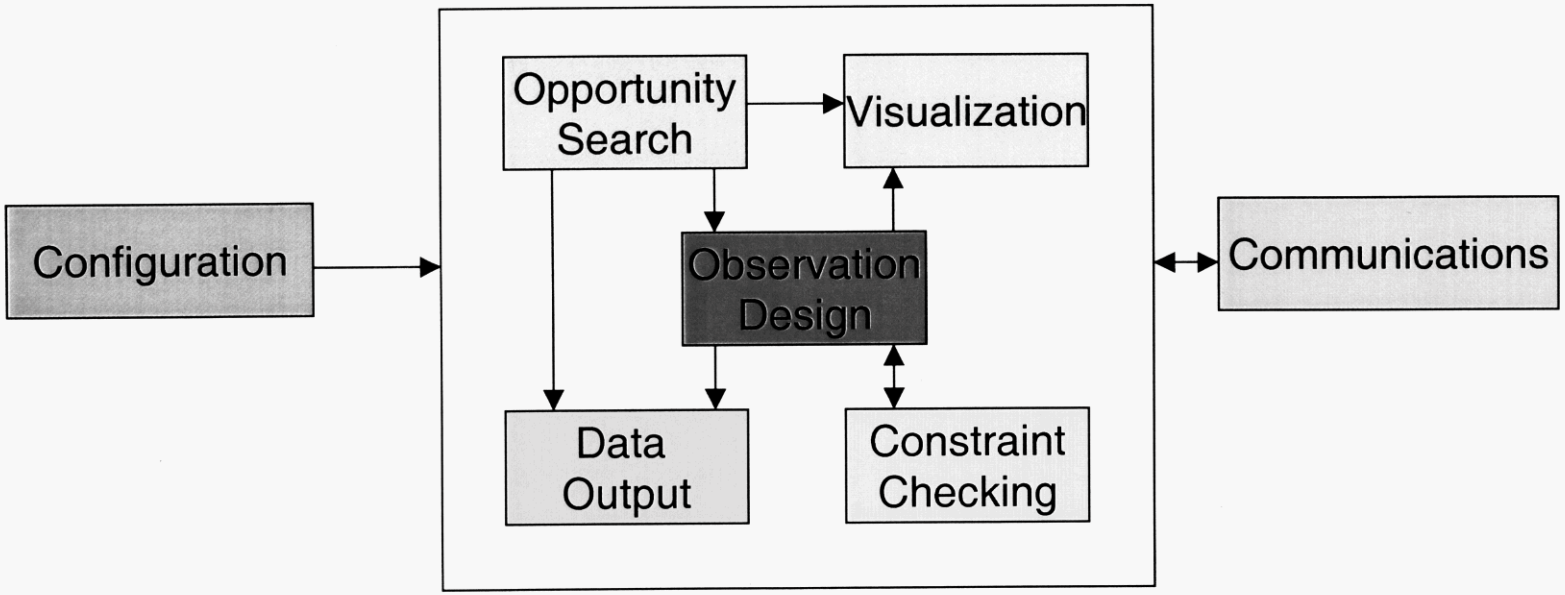
- A survey was conducted of the science user community to determine the requirements for a tool that would meet their needs.
- Remote scientists needed the ability to:
  - Identify observation opportunities
  - Create accurate, detailed designs for their observations
  - Verify that their designs meet their objectives
  - Check their observations against project flight rules and constraints
  - Communicate their observations back to JPL for integration into the science plan.
- Many existing tools provide one or more of these functions, but SOA's mandate was to unify these tasks into a single application

SCIENCE REQUIRED CHARACTERISTICS

- Accurate: Utilizes JPL Navigation and Ancillary Information Facility (NAIF) SPICE* software toolkit
  - Provides high fidelity modeling
  - Facilitates rapid adaptation to other flight projects
- Portable: Available in Unix, Windows and Linux
- Adaptable: Designed to be a multi-mission tool so it can be readily adapted to other flight projects
- Implemented in Java, Java 3D and other innovative technologies

- SPICE = Spacecraft, Planetary, Instrument, Constant, Events

SOA FUNCTIONS



SOA FUNCTIONS

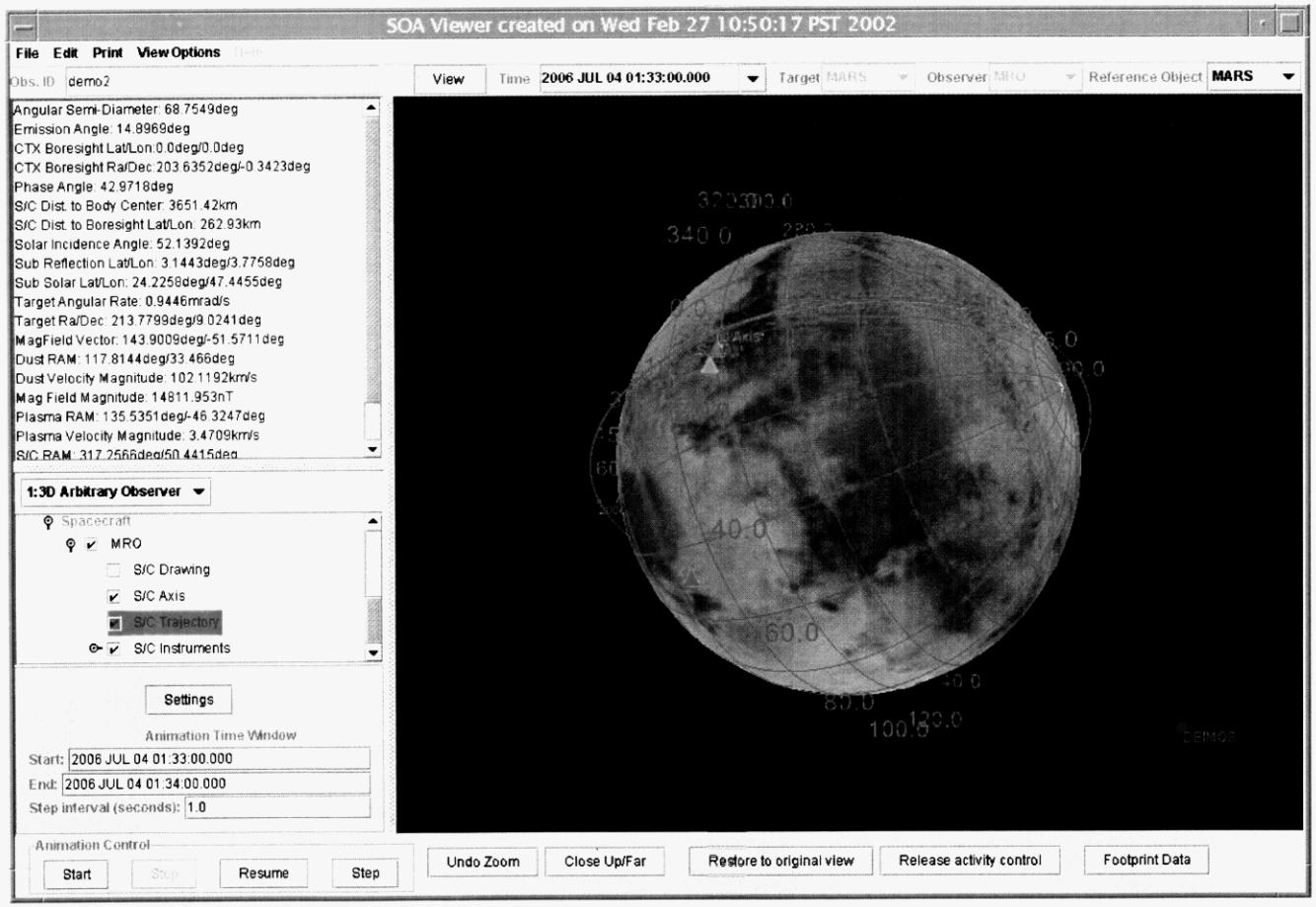
- Configuration
  - Flight project adaptation is created by loading a project-specific configuration file, SPICE kernels and models
  - Examples are shown from several differenct SOA adaptations
- Opportunity Search
  - Find windows of opportunity for an observation based on specific geometric criteria
  - 13 different searches available with SOA core software using the Percy search engine supplied by the Navigation section
    - Examples are eclipse, periapsis, occultation, …
  - Construct complex search criteria using AND, OR and NOT operators
  - Requires little or no adaptation; however, new search engines or events can be added
  - Requires no knowledge of spacecraft characteristics

SOA FUNCTIONS

- Visualization
  - Provides accurate representation of the solar system in multiple ways
    - 3-D Arbitrary Observer: from an arbitrary point of view
      - Allows users to select specific view points or "fly" through the system
    - 3-D Perspective Projection: from the viewpoint of the spacecraft
      - Allows uses to view constraint violations and their possible solutions
    - 2-D Equidistant Projection Skymap: Right Ascension/Declination map of the solar system
      - Allows instruments with large fields of view (aperatures) to be displayed
      - Assists users in resolving sun exposure violations
    - 2-D Trajectory Plot: spacecraft trajectory plotted on either the x/y, x/z or y/z planes
      - Allows users to see position of the spacecraft with respect to the orbits and positions of satellites
  - Allows multiple views on one display or multiple viewer windows
  - Animate the view over time

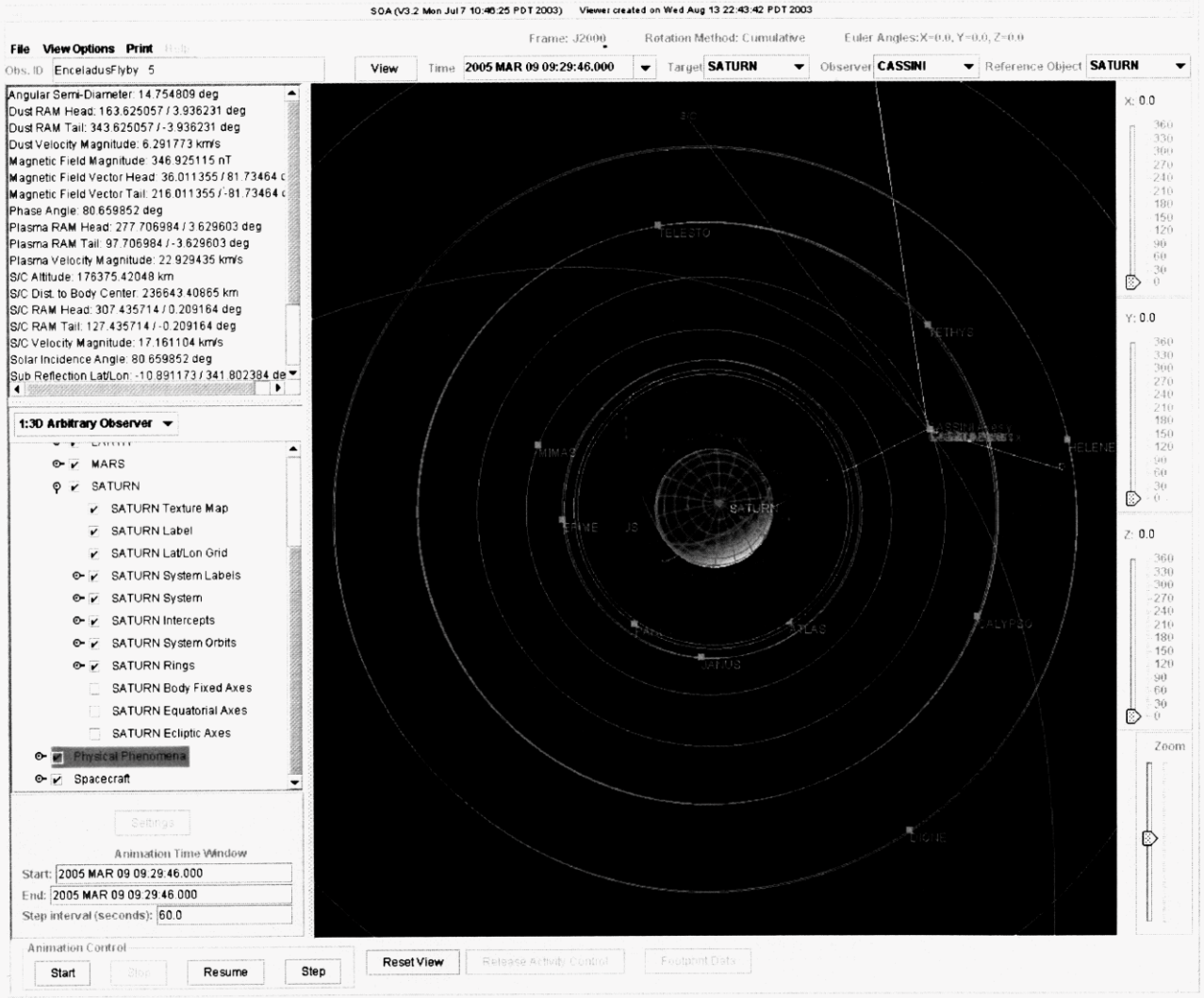
MARS RECONNAISSANCE ORBITER

3D perspective scene from the 3 Day Adaptation for MRO



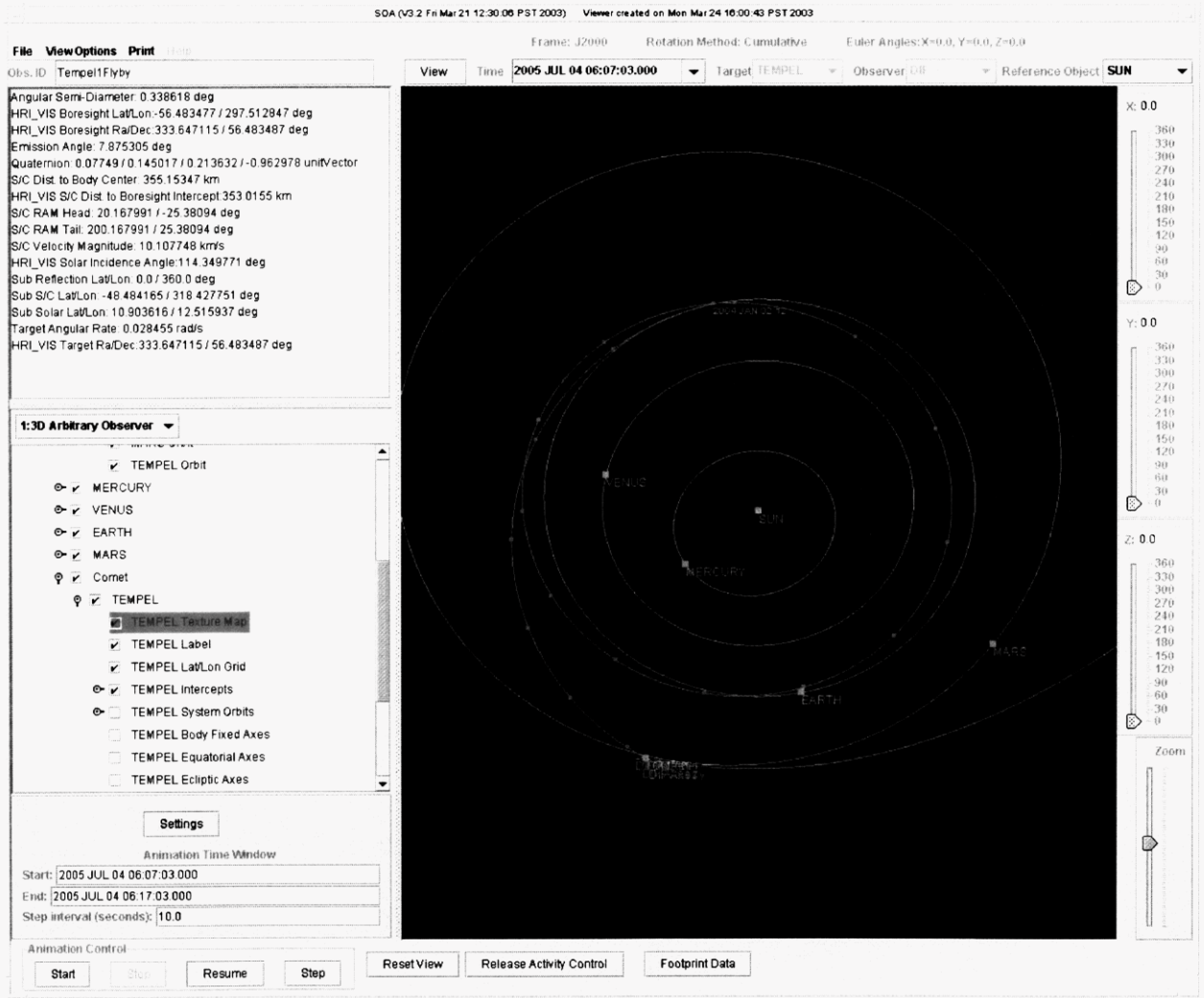
CASSINI

3-D arbitrary observer view of the Saturn system showing the Cassini trajectory in green and the satellite orbits in blue.



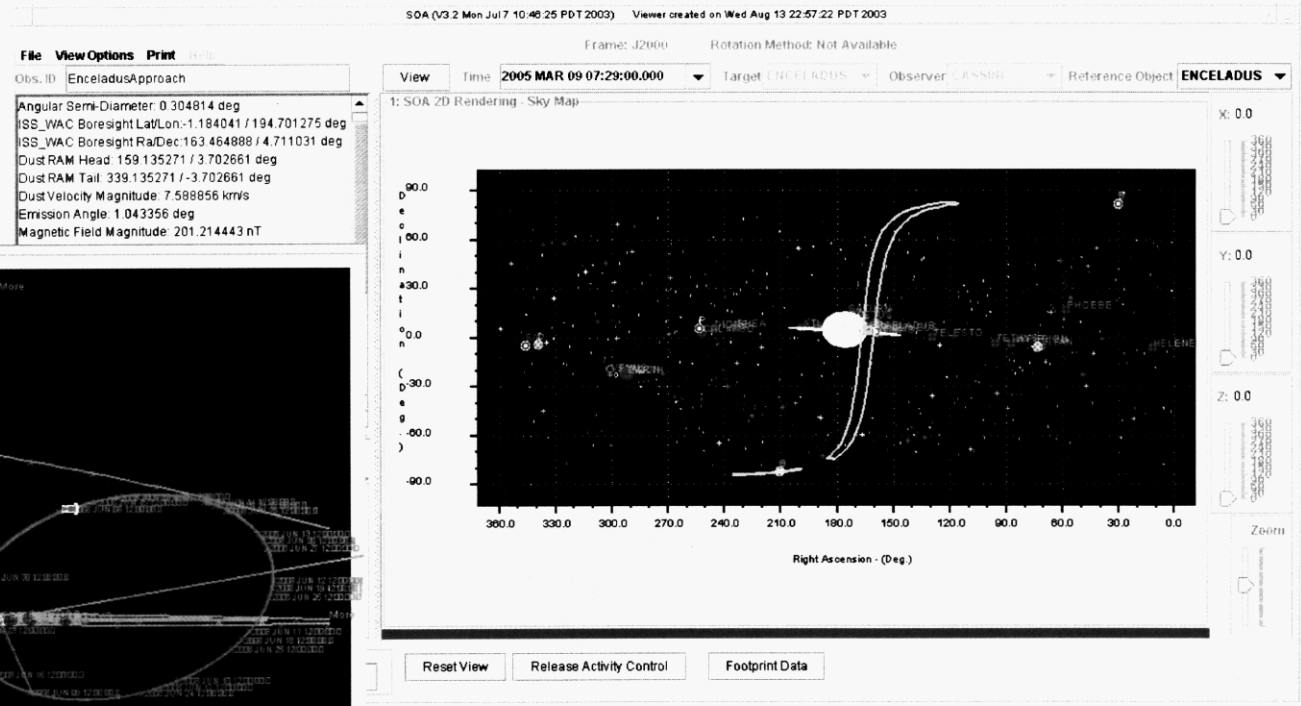
DEEP IMPACT

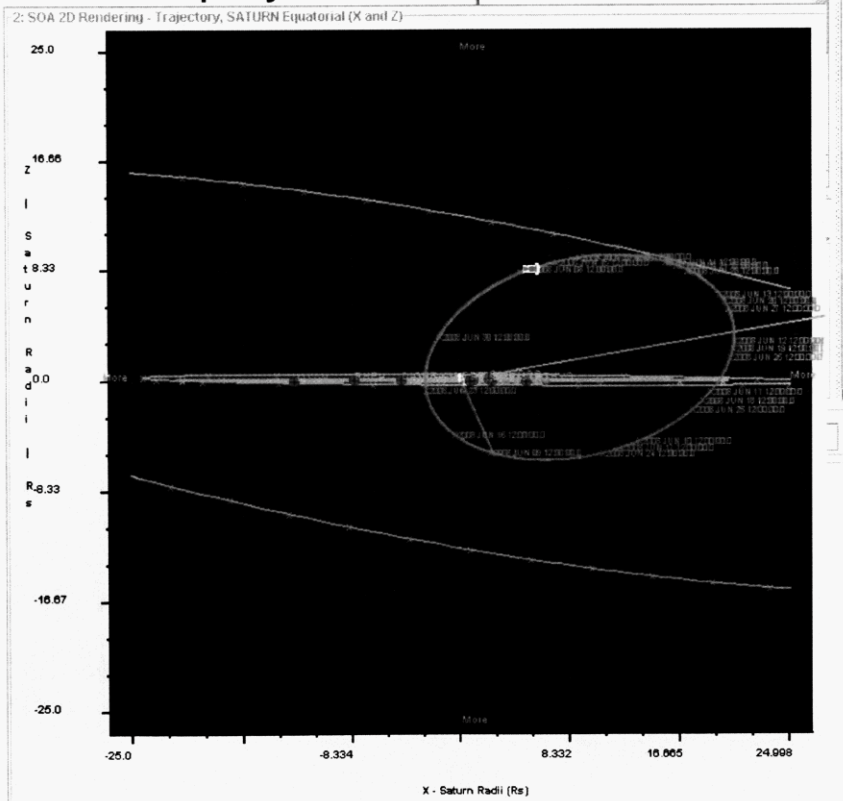
3D Arbitrary Observer view of the Deep Impact trajectory from launch to Tempel 1 flyby. The s/c trajectory is green and the comet orbit is orange. Other planetary orbits are blue.



CASSINI

2-D sky map view with the CAP ELS FOV displayed

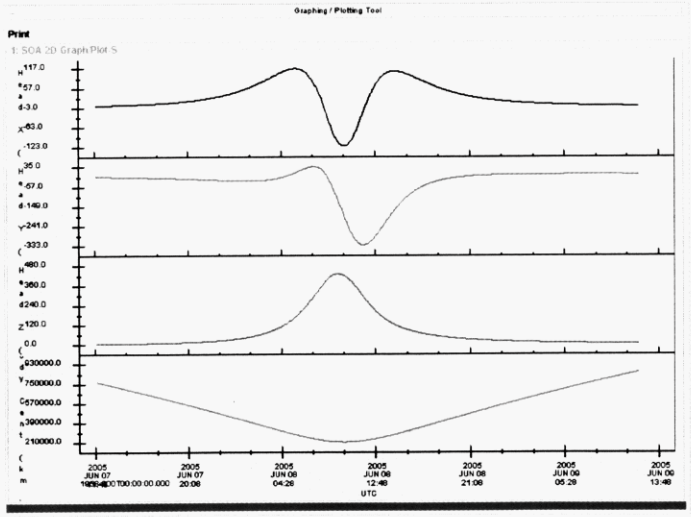




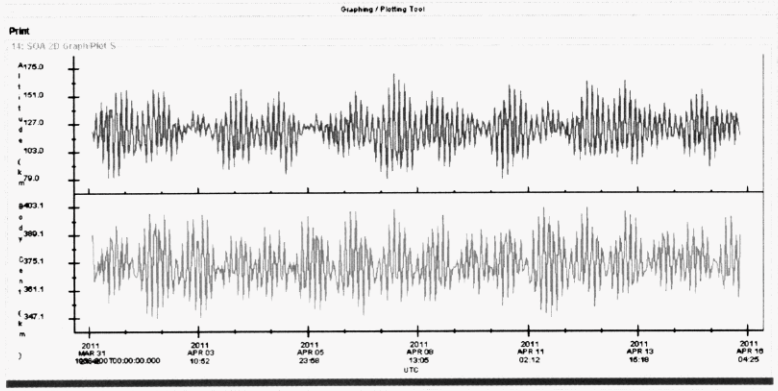
2-D trajectory view of the X-Z plane, with Cassini spacecraft trajectory (green) and satellite trajectories (blue) shown. Time tick marks help the user identify times of interest for an observation.

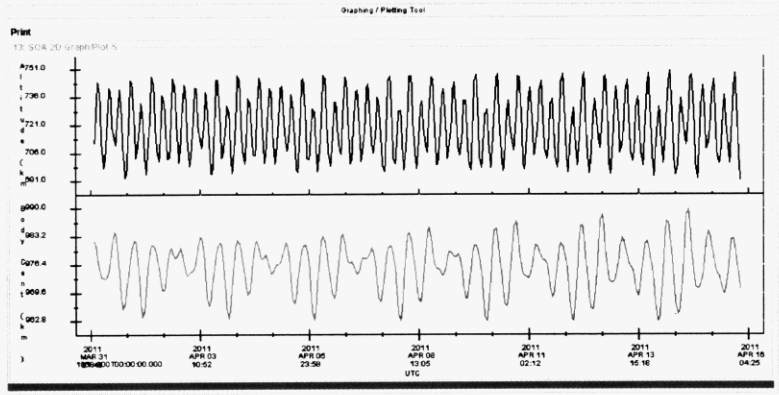
SOA FUNCTIONS

- Data Output
  - Obtain ancillary data as either a text file or plots
  - Both trajectory related data (any orientation) or observation data (specific orientation) available
  - Creates files that can be read into spreadsheet software
  - Permits customization of output parameter list



The Graphing/ Plotting Tool shows x/y data in a stacked graph. This figure is an example of Saturn's magnetic field x,y,z components and the Cassini spacecraft distance to Saturn.



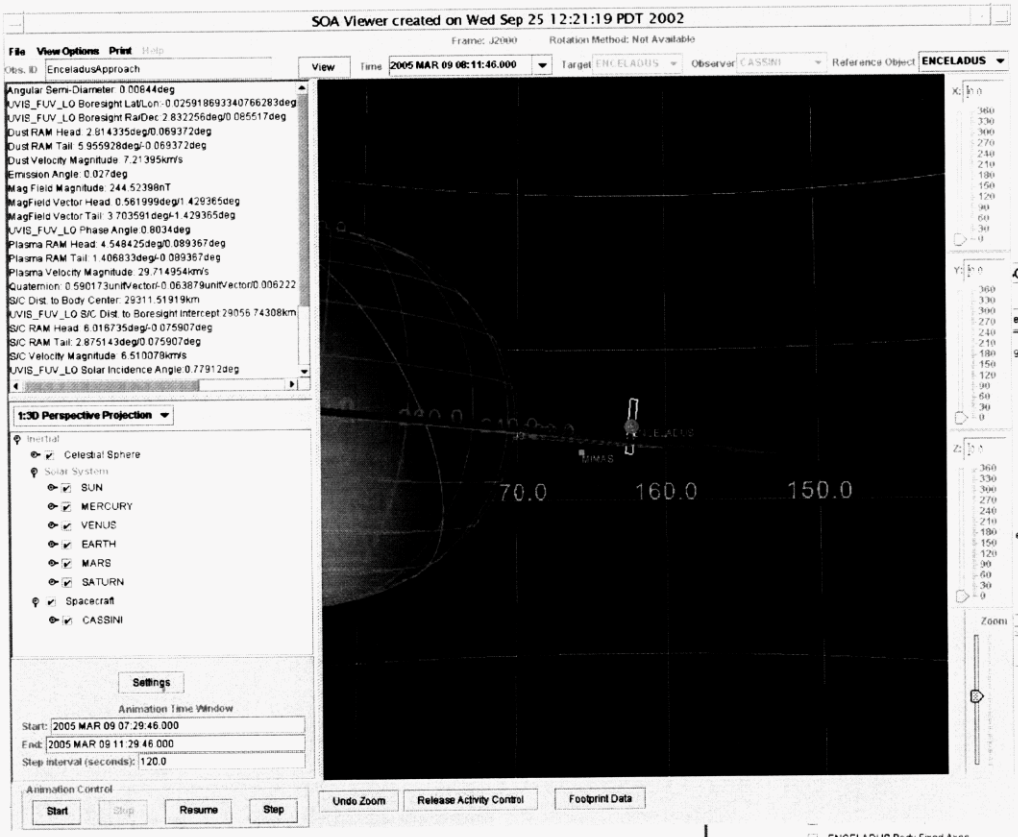


DAWN

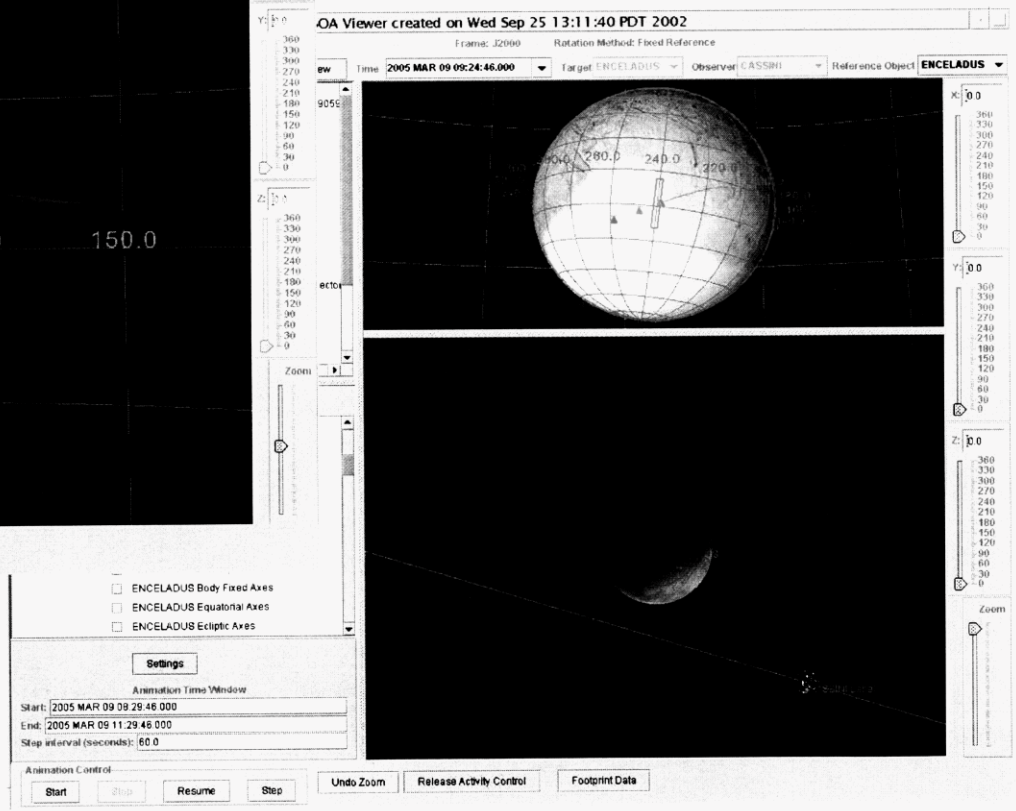
Two Data Output plots show the Dawn spacecraft altitude and the spacecraft distance to the center of Vesta for two different trajectories. Mission planners can use these types of comparisons to evaluate candidate trajectories.

SOA FUNCTIONS

- Observation Design
  - High level "Scoping" design tool for "what if" studies
  - Create nxm mosaic, scan mosaic, roll about an axis, or track a target
  - User provides simple input parameters and the software models spacecraft movement
- Constraint Checking
  - Check observations against specific geometric constraints
  - Allows user defined rules - project flight rules not required
  - Provides easy to use flight rule builder
  - Allows selection of rules to be checked



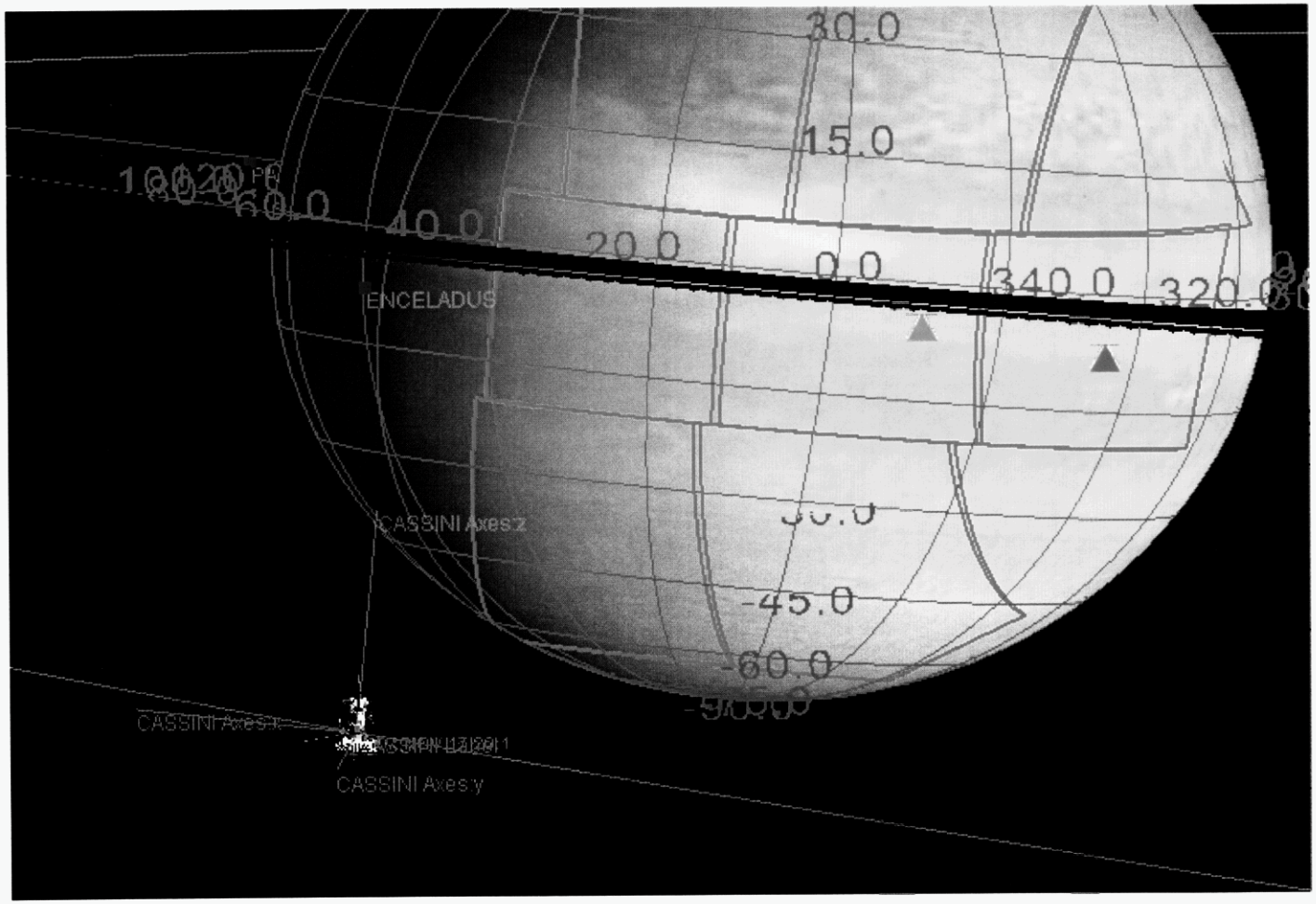
3-D perspective view and 3-D arbitrary observer view of closest approach of Cassini to Enceladus in the same viewer window.



CASSINI: 3-D perspective view of an Enceladus observation. The yellow rectangle around Enceladus is the spectrograph field of view.

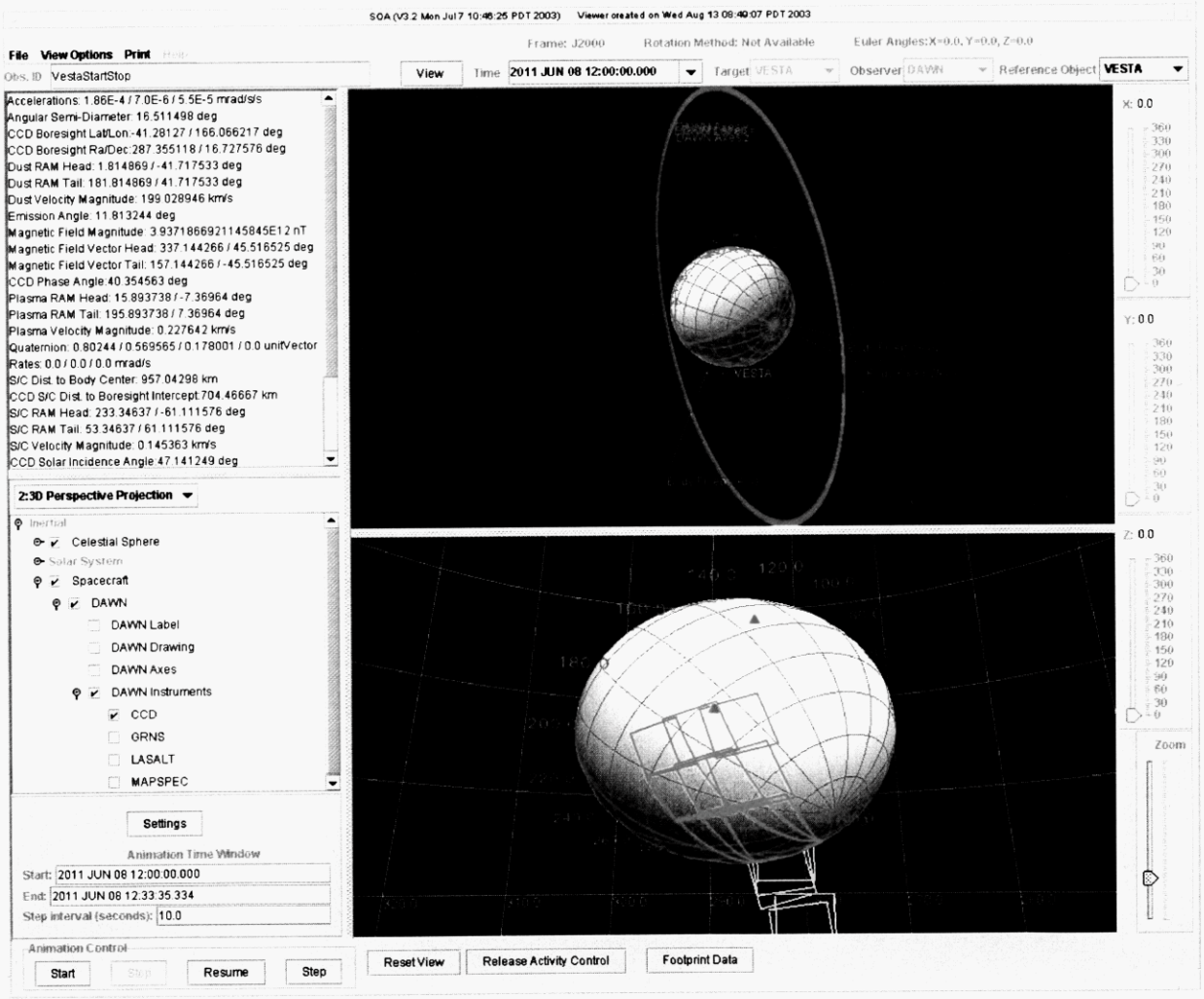
CASSINI

A mosaic on Saturn as viewed from the spacecraft. Scientists can see the spacecraft and its orientation (lower left of screen).



DAWN

3D arbitrary observer view and 3D perspective projection of Vesta as viewed from the Dawn spacecraft. The start stop mosaic observation shows the camera field of view



SOA FUNCTIONS

- Communications
  - Interfaces to other components of the JPL legacy uplink system
  - Reads/writes spacecraft attitude files (SPICE C-kernels), a universally accepted method for specifying attitude information
  - One of the first JPL sequencing tools to be created with communications in mind
  - Promotes electronic transfer of data to increase productivity

FUTURE OF SOA

- Any flight project can benefit from adapting SOA.
  - SOA is provided free to NASA projects with a minimal adaptation
  - Unadapted SOA provides generic capabilities
- SOA can grow with the mission over time to allow scientists to design, check, and modify observations and feed those designs downstream to the uplink software system.
- SOA can be used in any mission phase.
  - Evaluate impact of trades on potential science return
  - Evaluate trajectories or tours for critical science objectives
  - Create operations scenarios
  - Present graphics of science objectives & mission design characteristics

CONCLUSION

- SOA is not just another pretty face; it has the brains too. SOA's ability to show the same accurate information in multiple ways (multiple visualization formats, data plots, listings and file output) is essential to meet the needs of a diverse, distributed science operations environment.