nity Analyzer (SOA)

A Multi-Mission Approach to Science Planning

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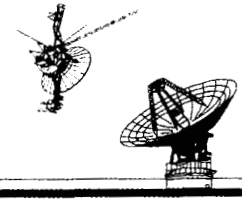
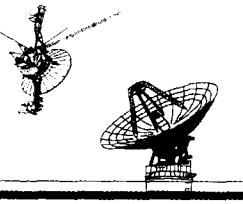


Background

- Scientists on spacecraft instrument teams need the ability to identify and design observations for their instruments.
- They generally do not have access to detailed spacecraft commanding software and don't always understand how to use it..
- SOA has been developed as a multi-mission science planning tool that allows scientists to design, check, and modify observations and feed those designs into the detailed uplink software system without having to use the entire uplink software system.
- Initial SOA design used a survey of the user community to incorporate their needs and desires into the software requirements.



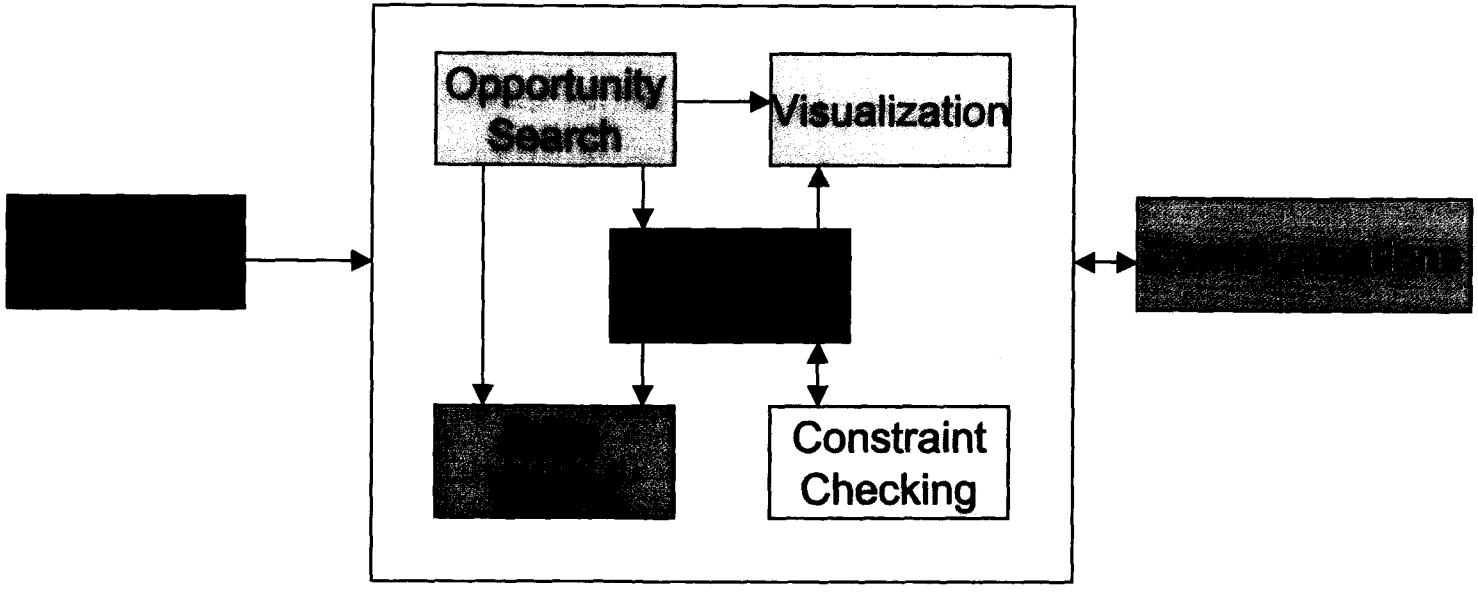
SOA is a Multi-Mission Tool

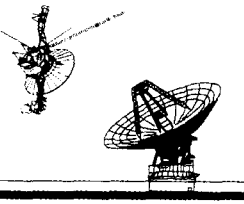
- SOA is configurable to a specific mission.
  - This process is called "adaptation".
  - Adaptation adds the mission specific data for SOA to work with. This mission specific data include flight rules, observation types, physical phenomena models, celestial body data, instrument data, spacecraft-specific data and a spacecraft trajectory.
  - Much of this data can be provided through the use of JPL navigation files.

- SOA's first customer is the Cassini/Huygens mission to Saturn.
  - Examples in this presentation are for the Cassini mission. Cassini arrives at Saturn July 1, 2004, to begin a four year orbital "tour" of the Saturn system, including planet, rings, satellites, and magnetosphere. SOA is designed to handle observations of these diverse targets.

Science Observation Planning with SOA

- A sample SOA use case is presented in the following slides
  - Steps presented can be done in any order
  - Not all steps of the process are required





Initialization

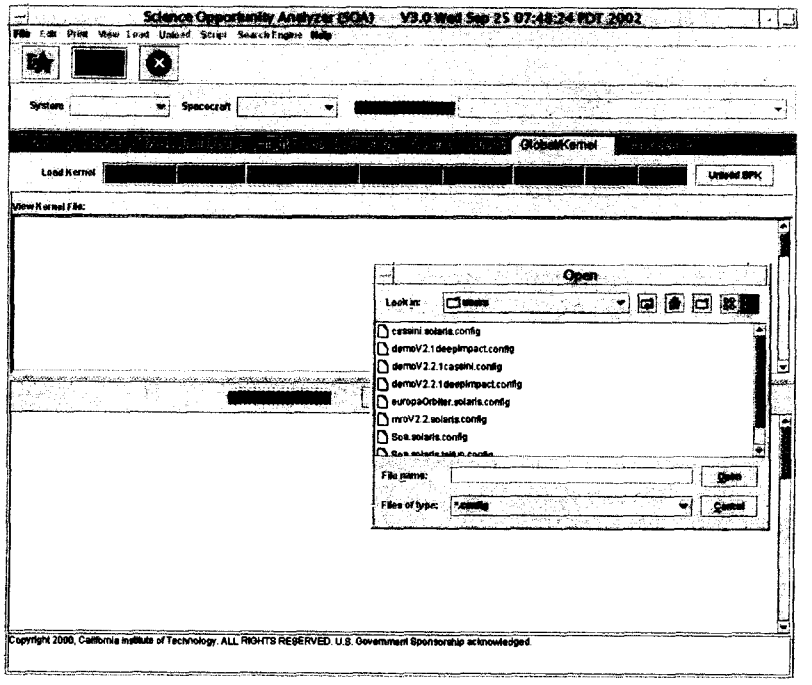
Step 1: The user runs an SOA Configuration File to determine the flight project adaptation.

- Uses JPL Navigation and Ancillary Information Facility (NAIF) SPICE* software toolkit.
  - Planetary ephemeris and constants
  - Spacecraft trajectory
  - Spacecraft instrument field of view definitions
  - Spacecraft coordinate systems
  - Physical phenomena model parameters

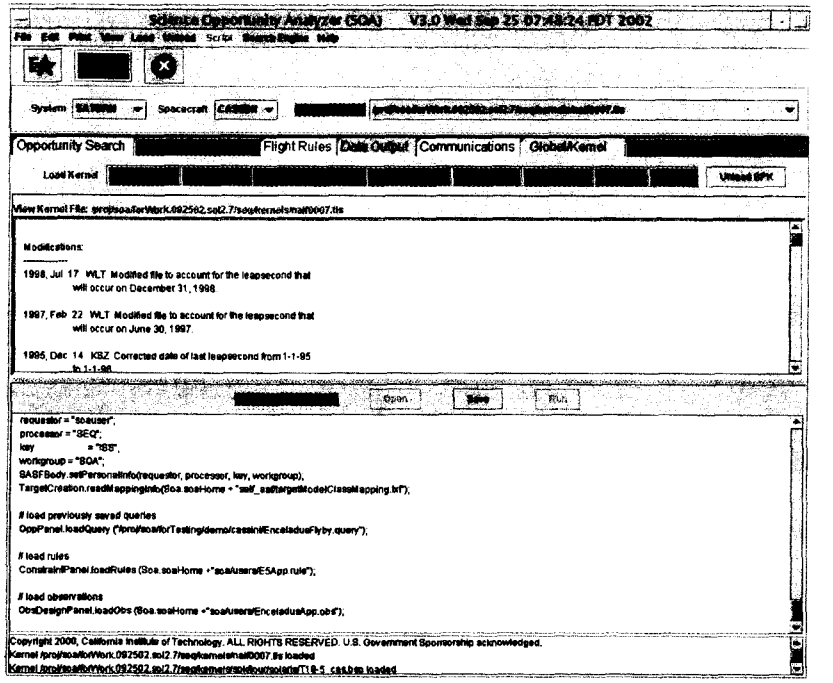
- Additional Features:
  - Java-based for portability to multiple platforms
  - A different configuration file and project specific SPICE kernels are all that is needed to change to a different flight project – no recompilation

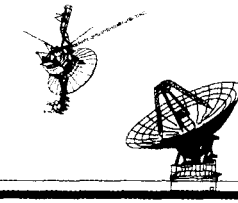
* SPICE = Spacecraft, Planetary, Instrument, Constant, Events

Initial Global/Kernels Tab display with Configuration File Selection Box open.



Global/Kernels Tab display after Configuration File has been run.



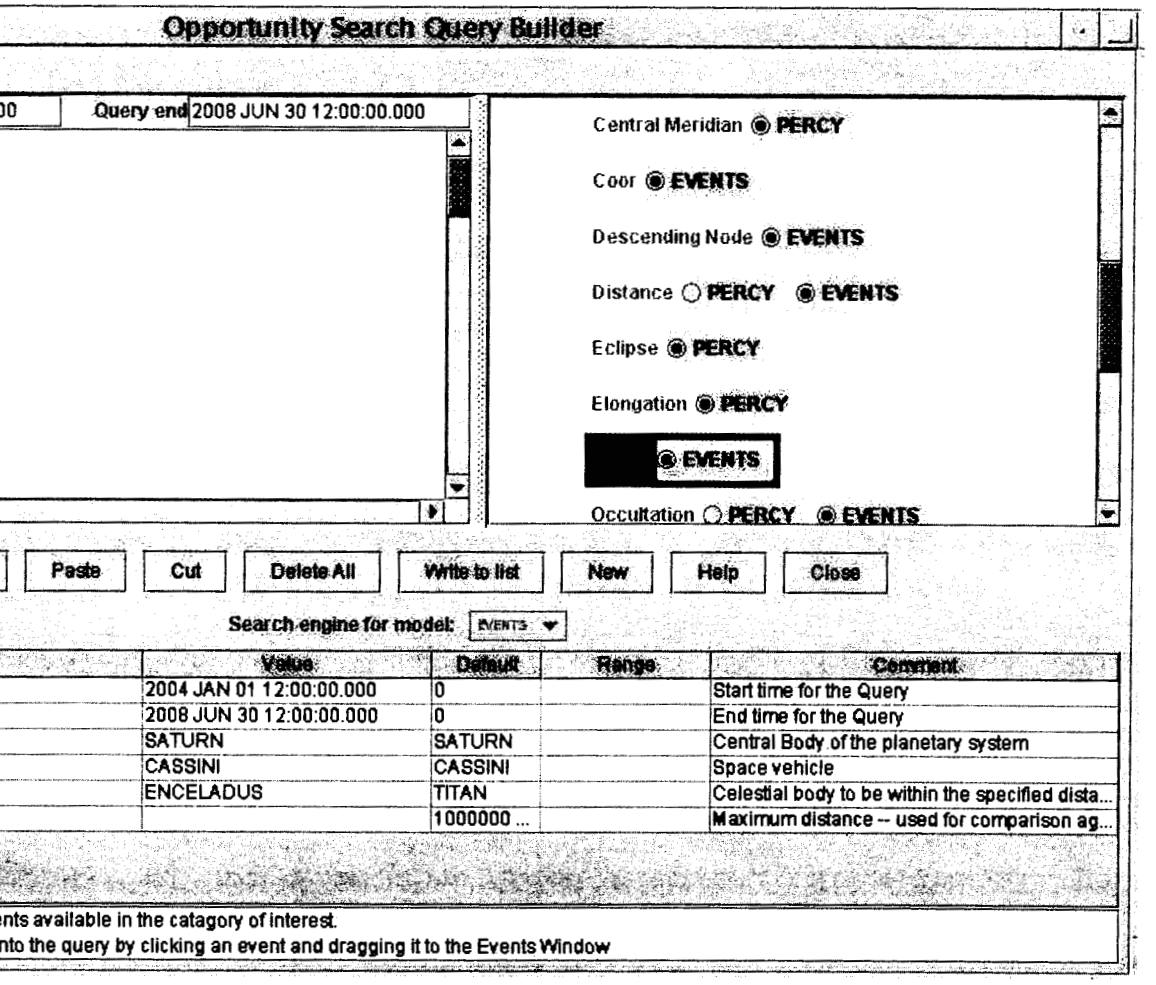


Opportunity Search

Step 2: The user finds one or more windows of opportunity for an observation based on specific geometric criteria.

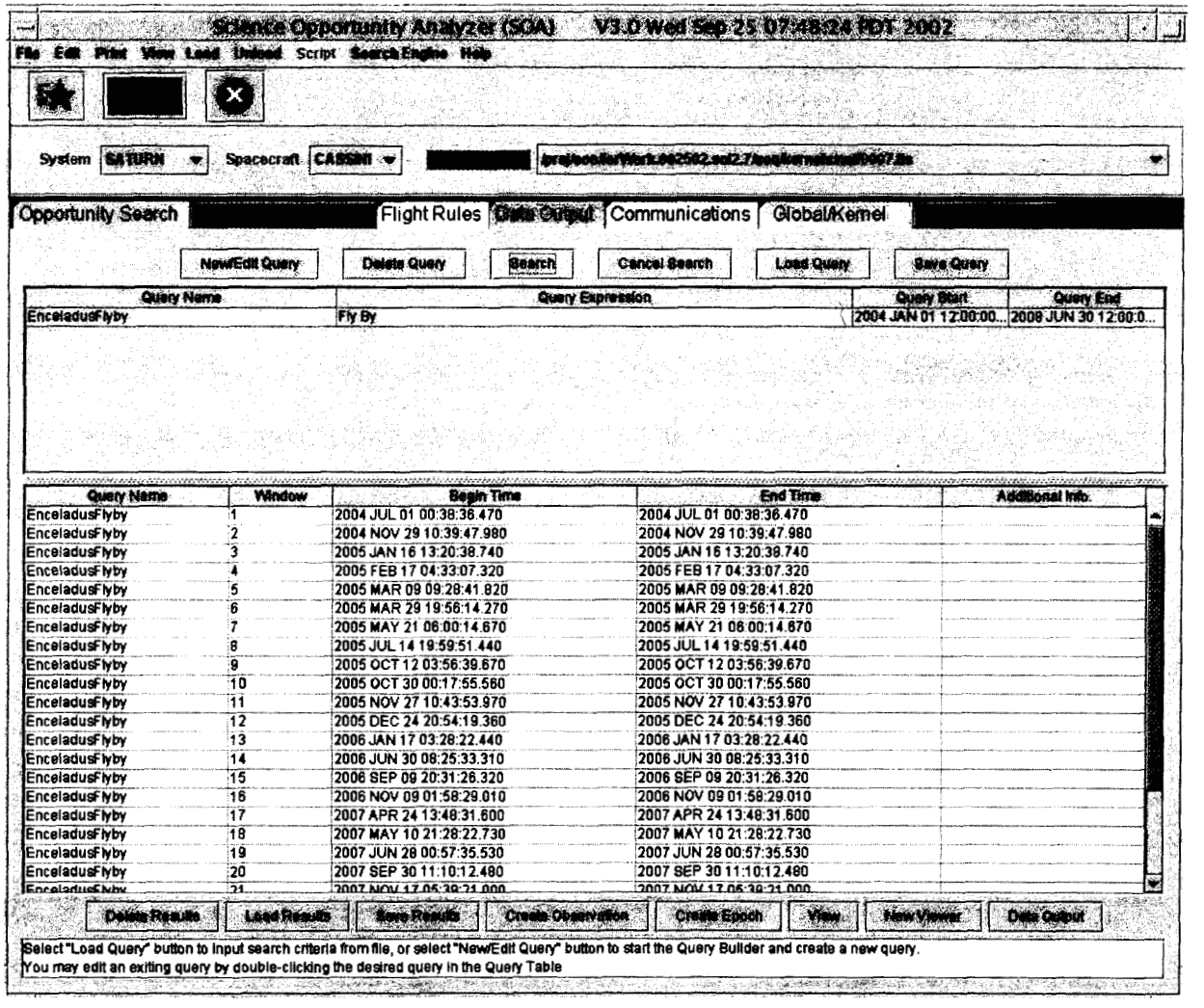
- Uses Percy and EVENTS search engines created at JPL
- Over 30 different events are supplied with SOA core software
  - Examples are eclipse, periapsis, occultation, fly by,...
- Complex search criteria can be constructed using AND, OR and NOT operators
- Additional search engines or events can be added through adaptation

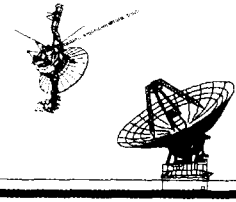
- Additional Features:
  - Use visualization to validate observation geometry results
  - Requires no knowledge of specific spacecraft characteristics
  - Available early in the mission to help evaluate candidate trajectories
  - Requires little or no adaptation



Opportunity Search Query Builder display with an Enceladus flyby query.

Opportunity Search Tab display with the Enceladus Flyby query selected and the resultant search windows displayed.





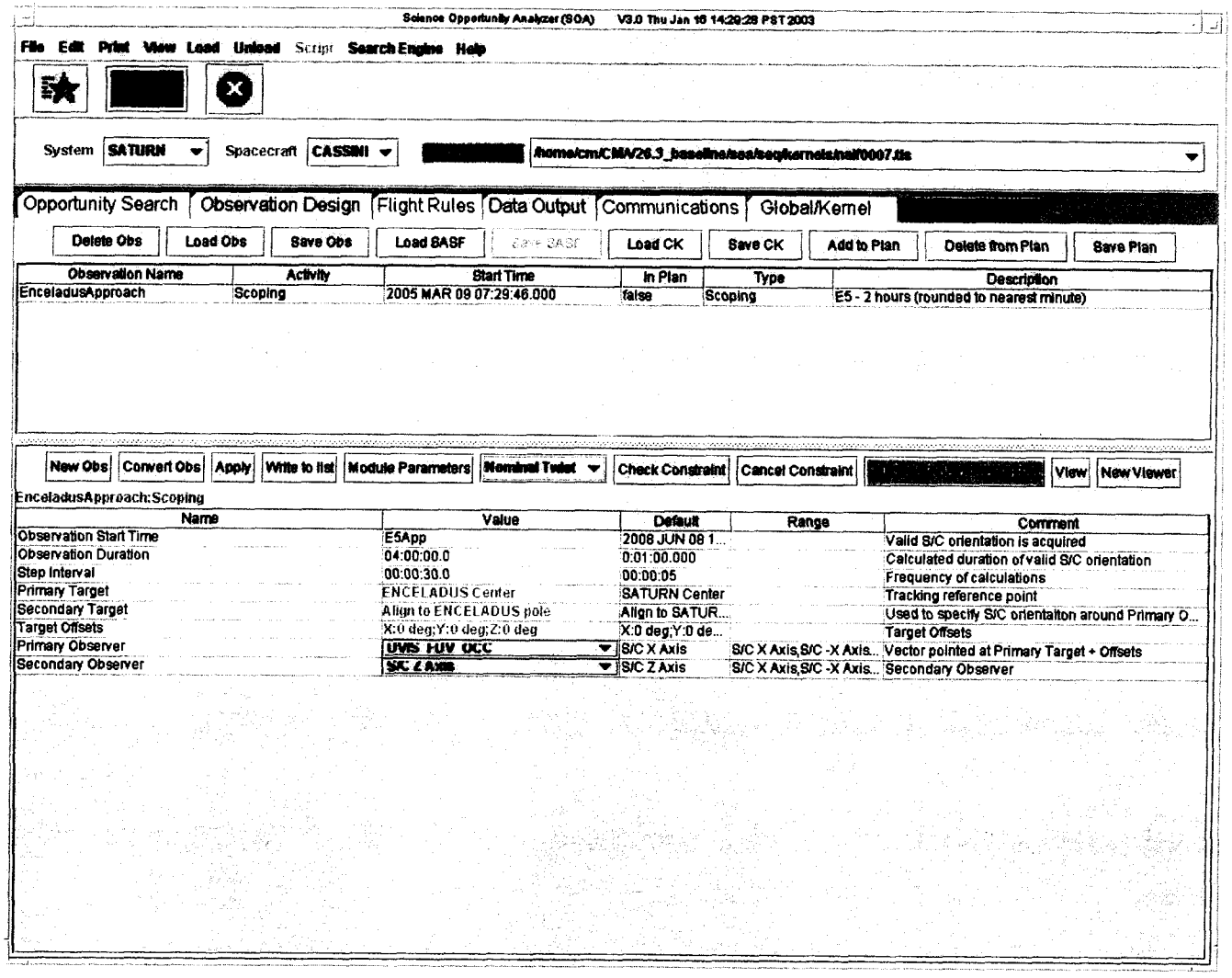
Observation Design

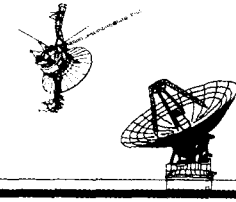
Step 3: The user selects a time window and begins to design an observation.

- Scientists control and verify observation parameters to ensure that desired observation objectives will be met (exposure times, target coverage, observing geometry)
- High level "Scoping" design tool for "what if" studies
- User provides simple input parameters and software models spacecraft movement

- Additional features:
  - Presentation of information in a user friendly and understandable fashion
  - Provides feedback to the user of spacecraft rate and acceleration violations

The Observation Design Tab display showing a scoping level observation of Enceladus with constraint violations (the orange button with the date in the center of the display).



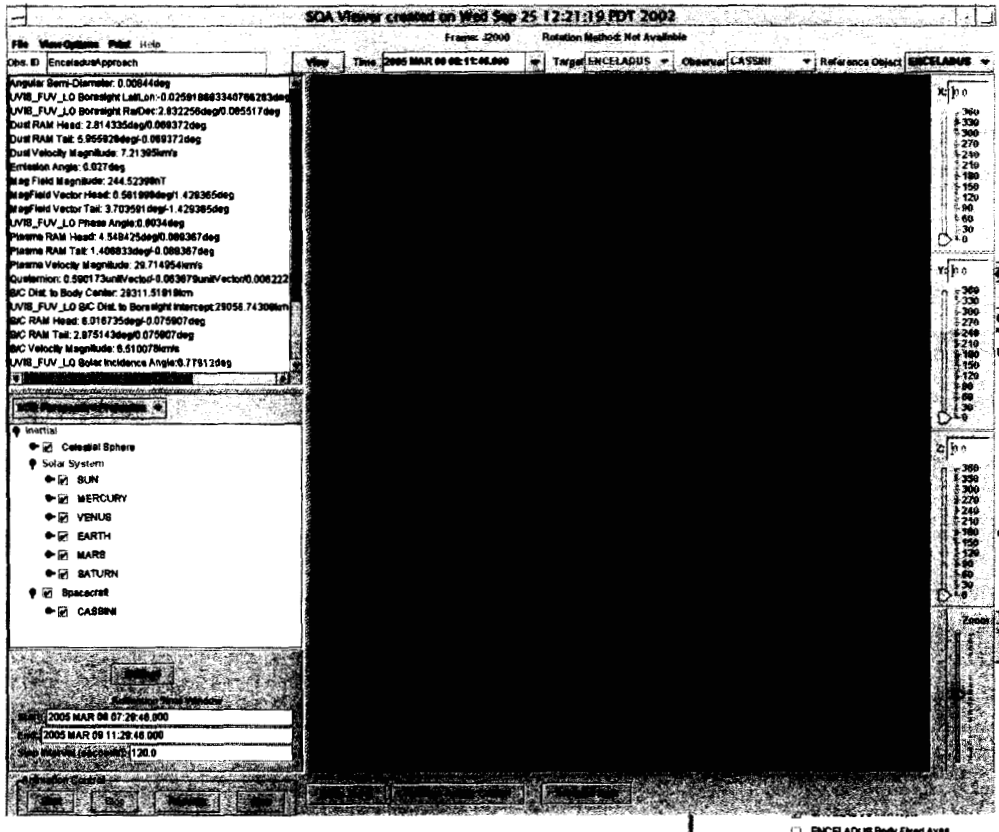


Visualization

Step 4: The user views the design in a visualization window.

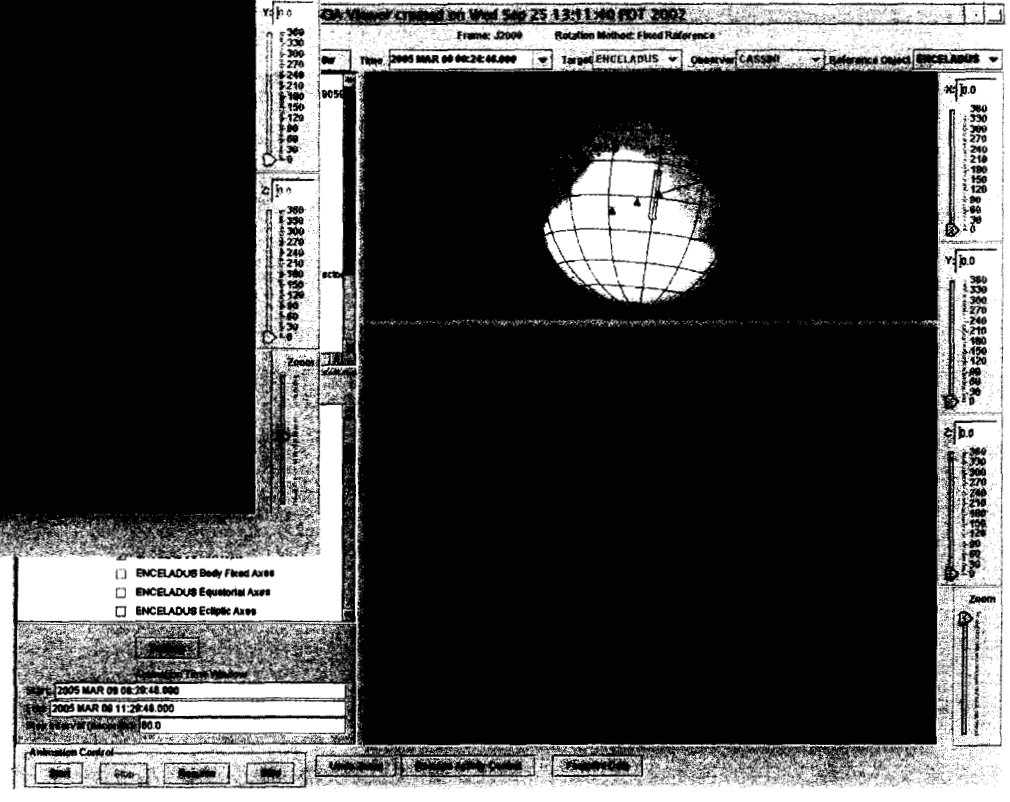
- Visualize the system in 3D and 2D from the point of view of any object in the system, including the s/c, or from an arbitrary point of view
  - 3-D Perspective Projection view
  - 3-D Arbitrary Observer view
  - 2-D SkyMap view
  - 2-D Trajectory view
- Visualize observations with instrument fields of view projected onto any object in the system, including observations designed in other software and "as-flown" observations
- Animate the view for arbitrary times or for the period of an observation

- Additional Features:
  - Allows multiple views on one display each with its own display controls
  - Allows views to be added and deleted at user's discretion



3D Perspective view of the Enceladus observation. The yellow rectangle round Enceladus is the spectrograph field of view.

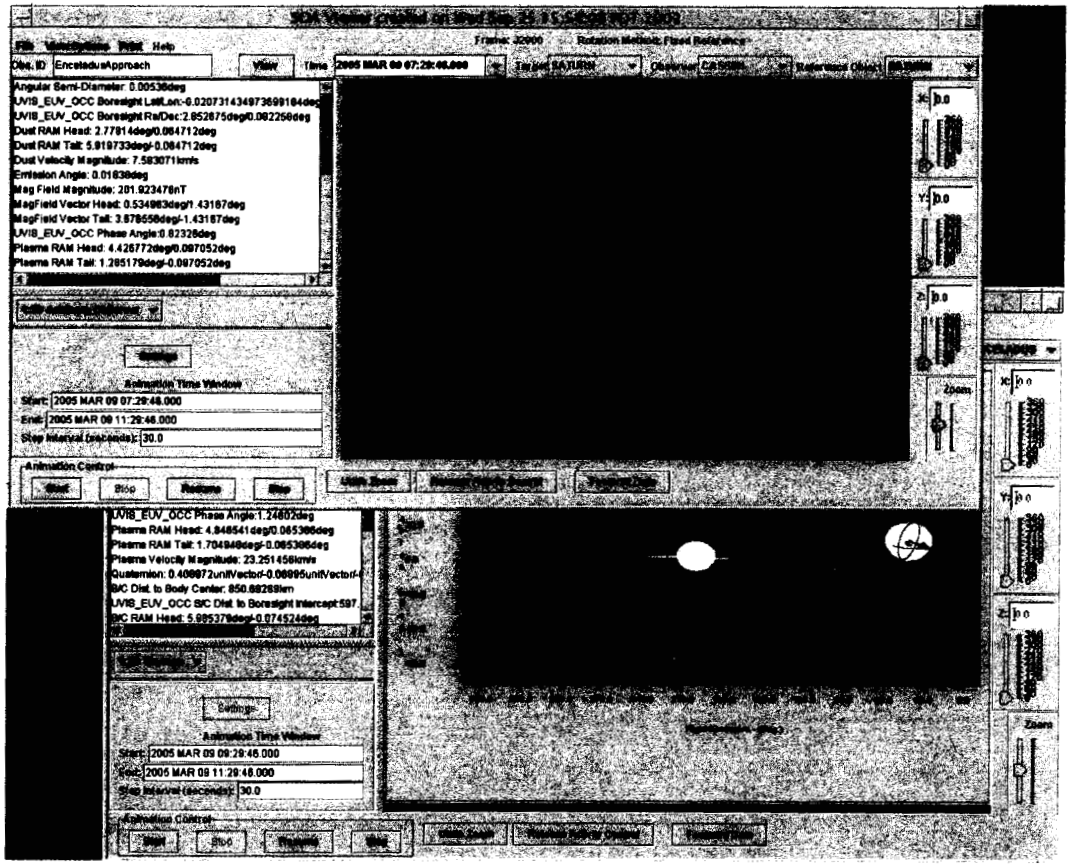
A 3-D perspective view and a 3-D arbitrary observer view of closest approach to Enceladus in the same viewer window.



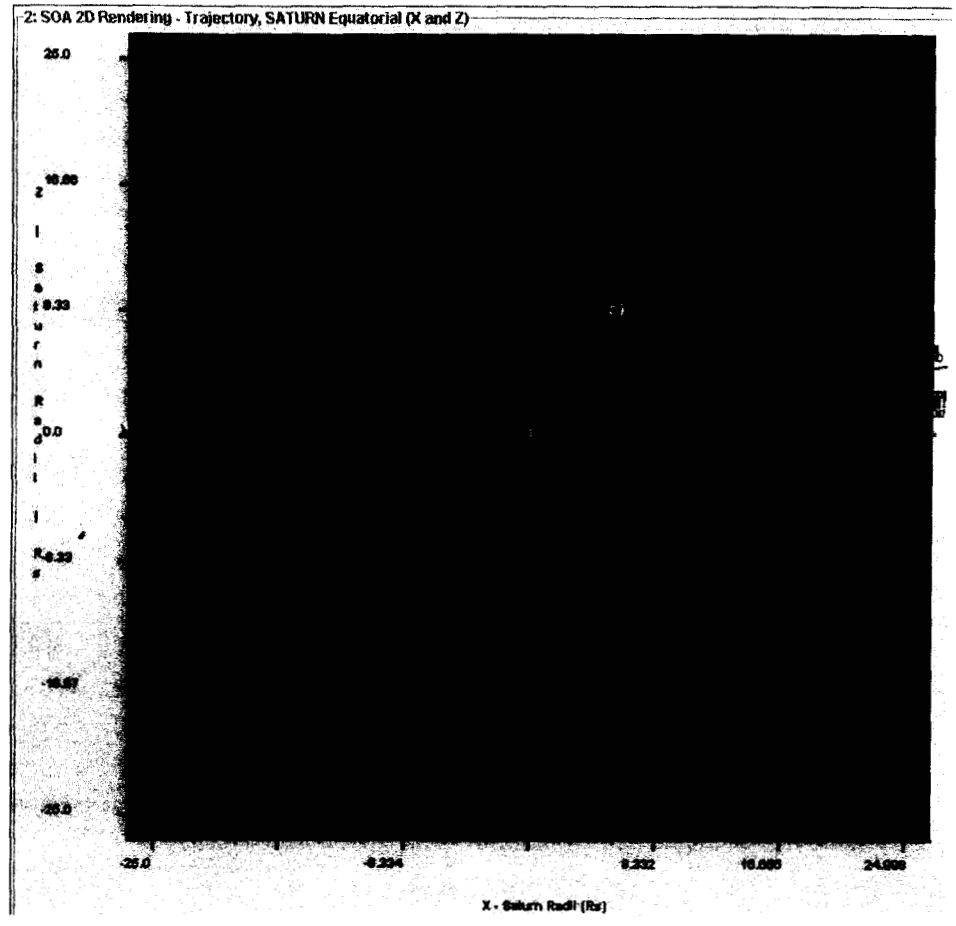
Two viewers are displayed.

The top one shows a 3-D Arbitrary Observer view with Saturn as the target. The green arc by Enceladus is the spacecraft trajectory.

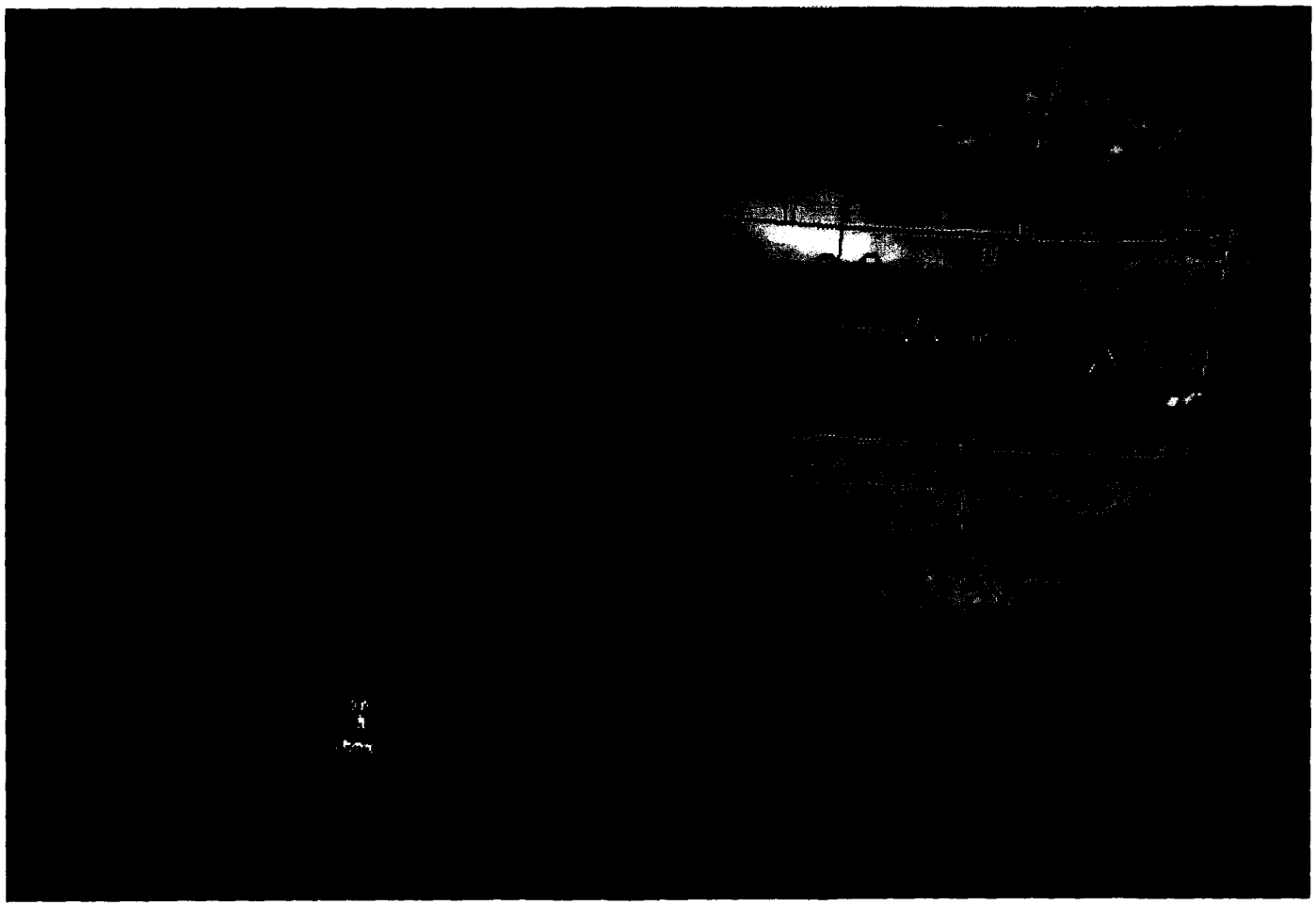
The bottom one shows the 2-D SkyMap view at this time.

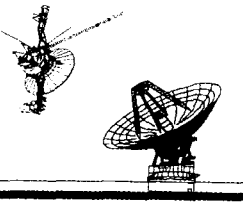


2-D Trajectory view of the X-Z plane, with spacecraft (green) and satellite (blue) trajectories shown. Time tick marks help the user identify times of interest for an observation.



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





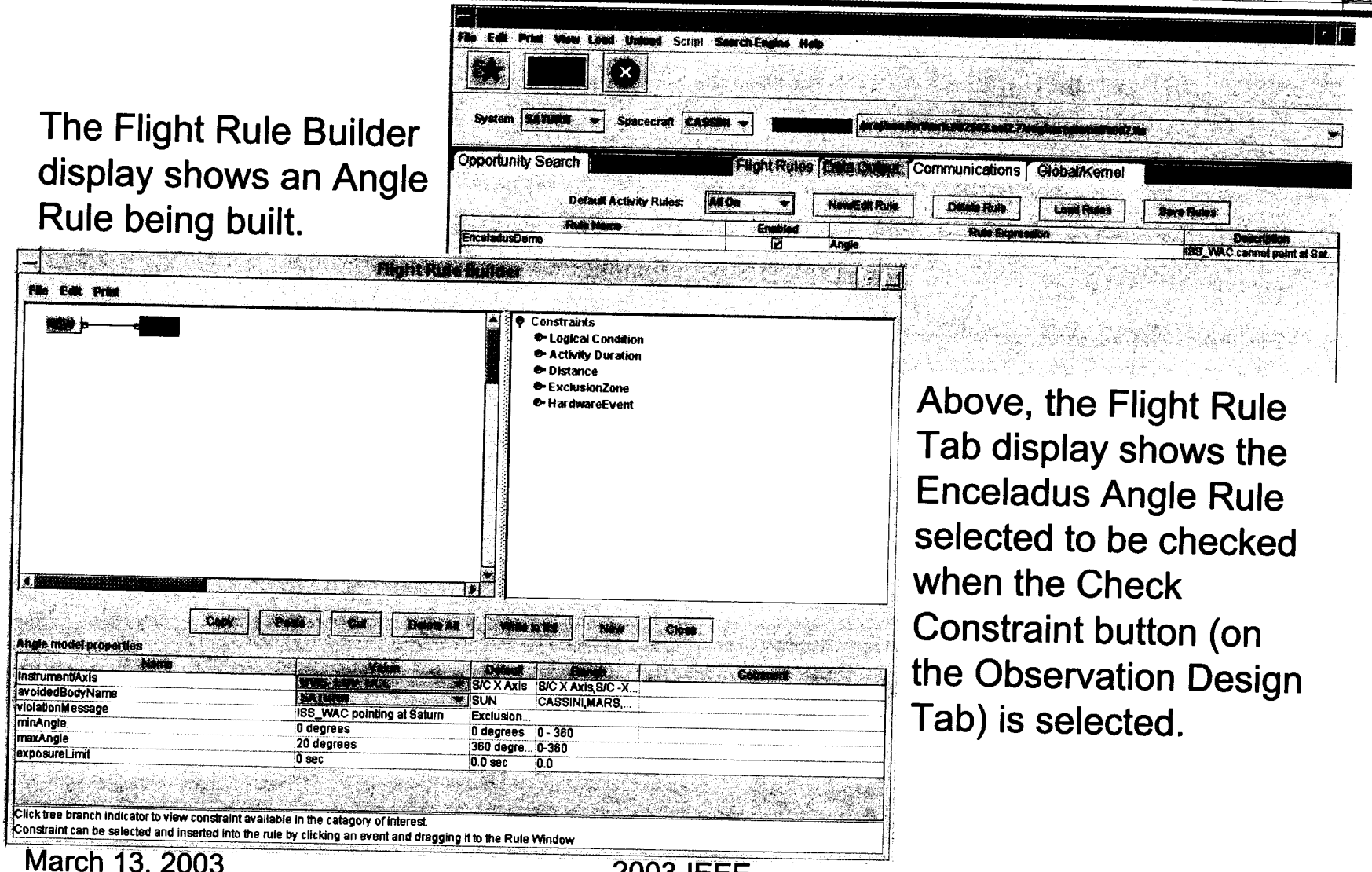
Constraint Checking

Step 5: The user checks to see if any constraints have been violated.

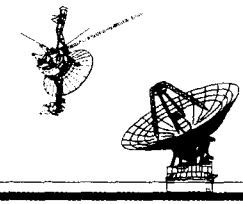
- Checks high level observation design constraints early in the sequence development process
- Provides feedback and a log on all violations
- Permits user-level and project-level rule checking
- Allows selection of rules to be checked

- Additional Features:
  - Provides easy to use flight rule builder similar to opportunity search query builder
  - Provides building blocks for creation of project rule adaptation

The Flight Rule Builder display shows an Angle Rule being built.



Above, the Flight Rule Tab display shows the Enceladus Angle Rule selected to be checked when the Check Constraint button (on the Observation Design Tab) is selected.

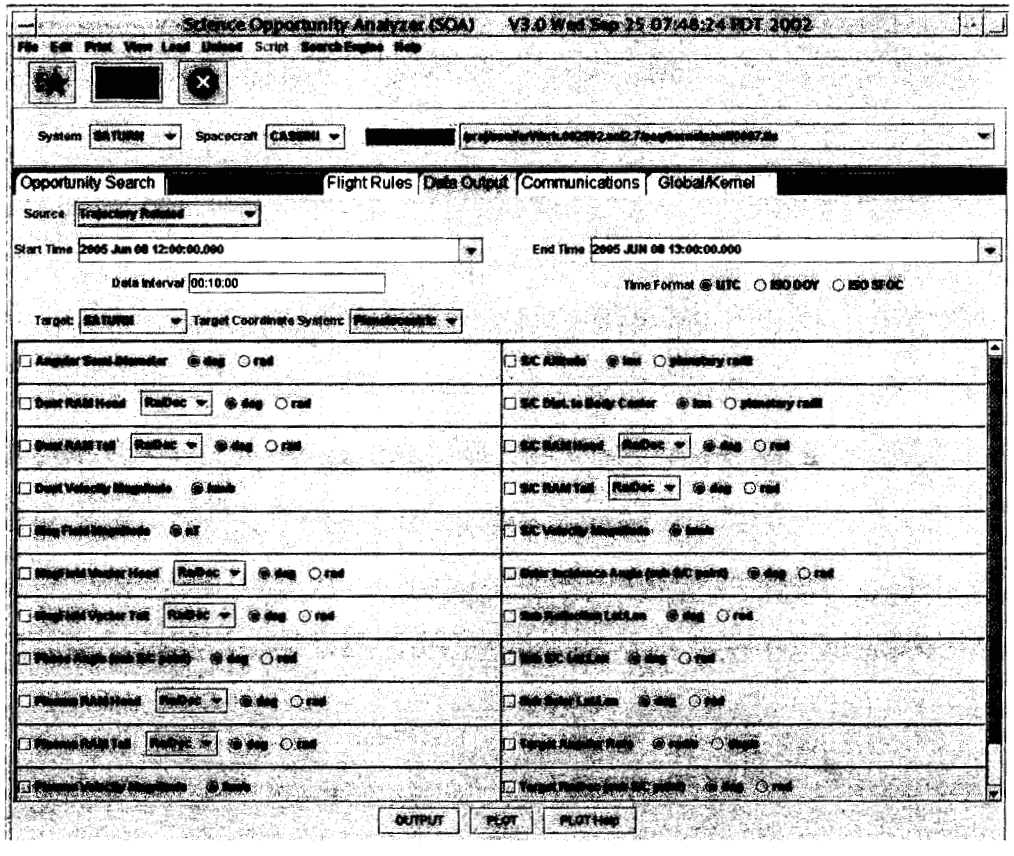


Data Output

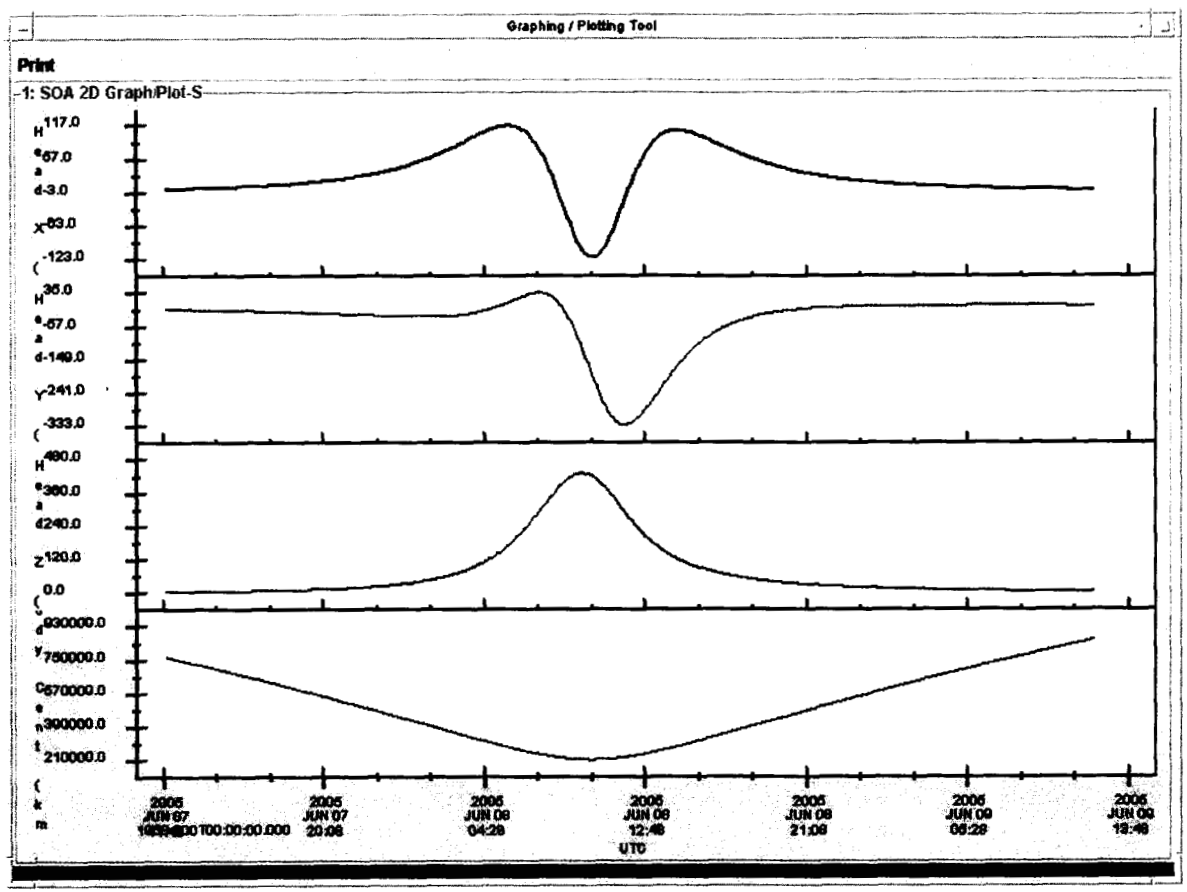
Step 6: User selects and views output data to ensure observation viability.

- Permits generation of data files with geometric information as a function of time
- Permits customization of output parameter list
- Plots ancillary geometric data for any period of time
- Provides complementary method for identifying observation opportunities and for validating geometry for designed observations

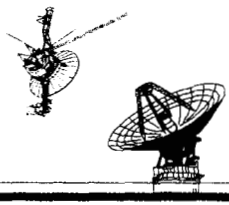
- Additional Features:
  - Permits 5 different types of plots
  - Creates files that can be read into spread sheet software



The Data Output Tab display shows the data items available for selection in the area on Spacecraft Trajectory Related Data.



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 spacecraft distance to Saturn.



Communications

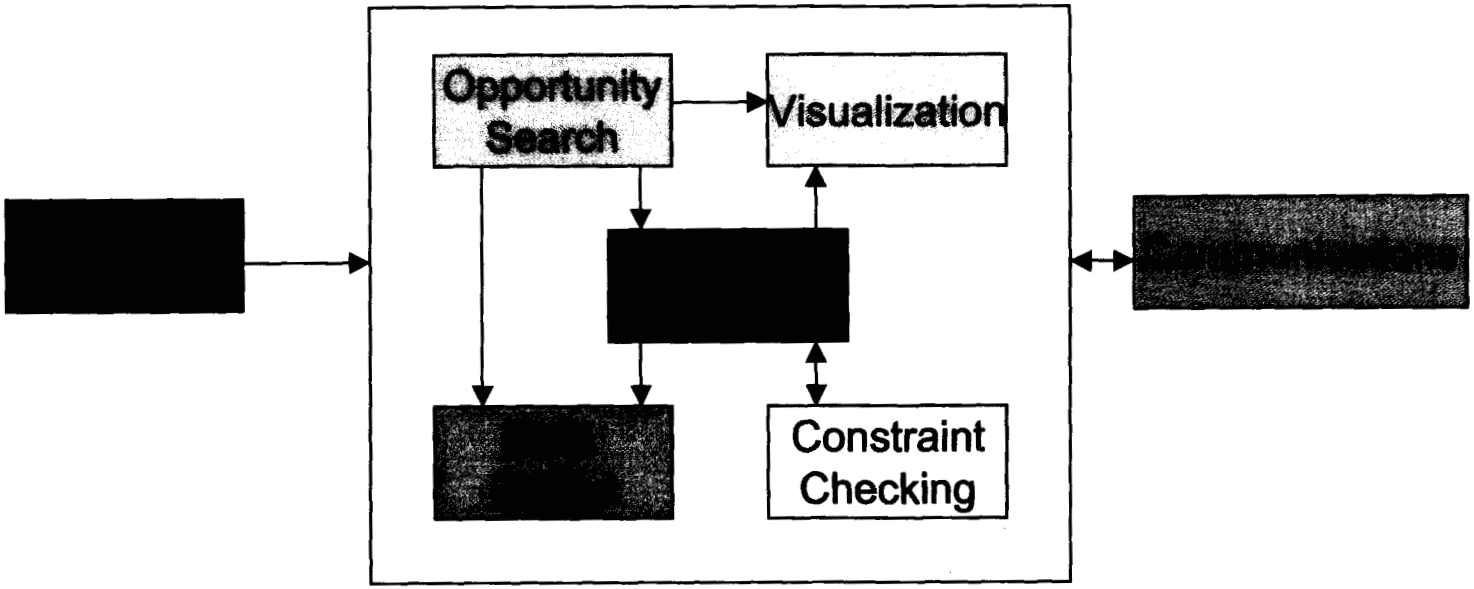
Step 7: The user saves the observation for future recall and/or sends it to downstream software to be added to the plan of spacecraft activities. SOA observations can be saved in 3 formats.

- SOA specific file format
- Downstream software format that is specified in a JPL interface control document
  - Used by JPL legacy planning and sequencing software
  - Requires the most project specific adaptation
- Binary file containing spacecraft attitude data (SPICE C-kernels)

- Additional Features:
  - One of the first software tools to be created with communication to downstream software as part of its design
  - Promotes electronic transfer of data to increase productivity

Conclusion

SOA's ability to show the same information in multiple ways (multiple visualization formats, data plots, listings, and file output) is essential to meet the needs of a broad and diverse science user community.



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