



InterPlanetary Network and Information Systems Directorate
DSMS Engineering Office



JPL

Mission Services & Applications Office



Community Analyzer (SOA)

A Multi-Mission Approach to Science Planning

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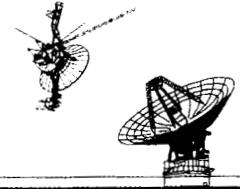
**California Institute of
Technology**

Pasadena CA

March 13, 2003

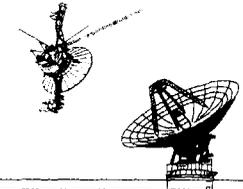
2003 IEEE

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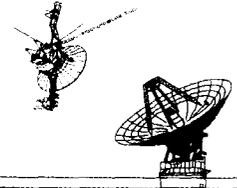
Background

- 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.



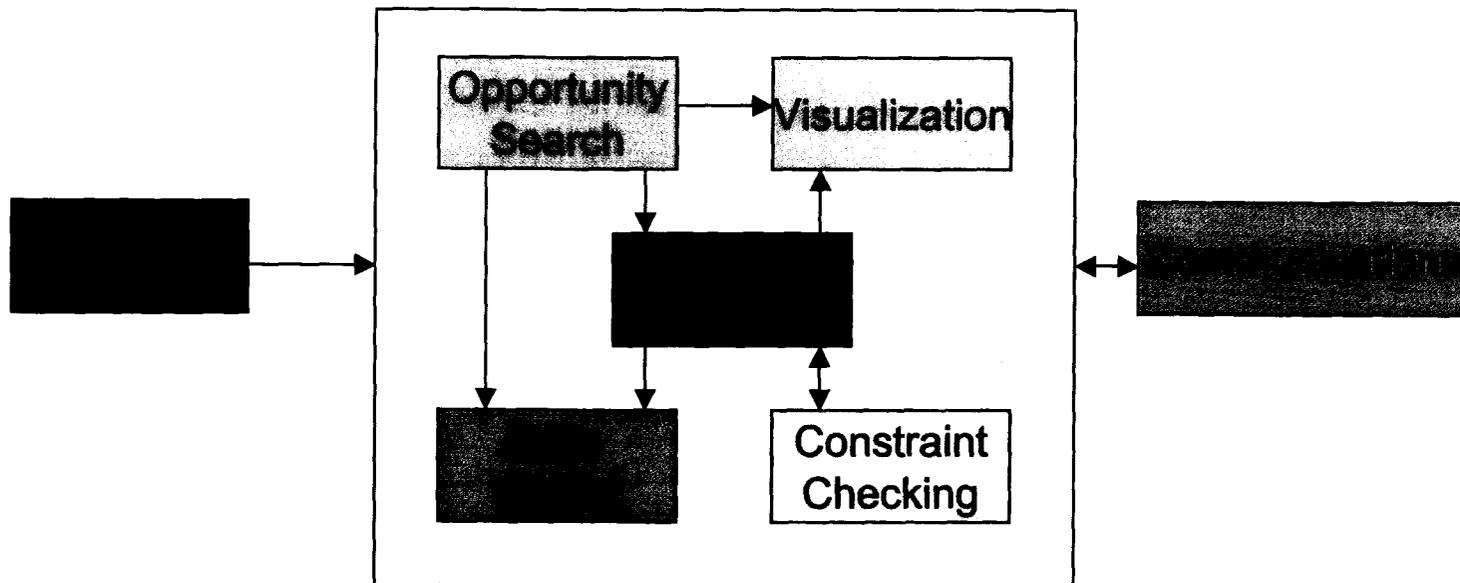
SOA is a Multi-Mission Tool

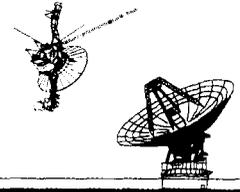
- SOA is configurable to a specific mission.
 - This process is called “adaptation”.
 - Adaptation adds the mission specific data for SOA to work with. This mission specific data include flight rules, observation types, physical phenomena models, celestial body data, instrument data, spacecraft-specific 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





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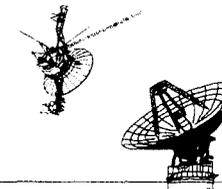
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Initialization

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

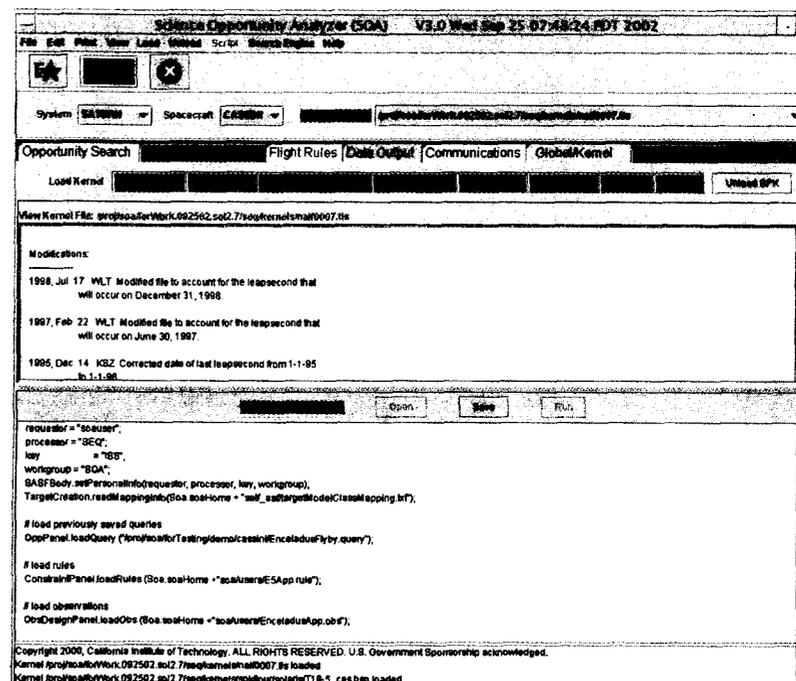
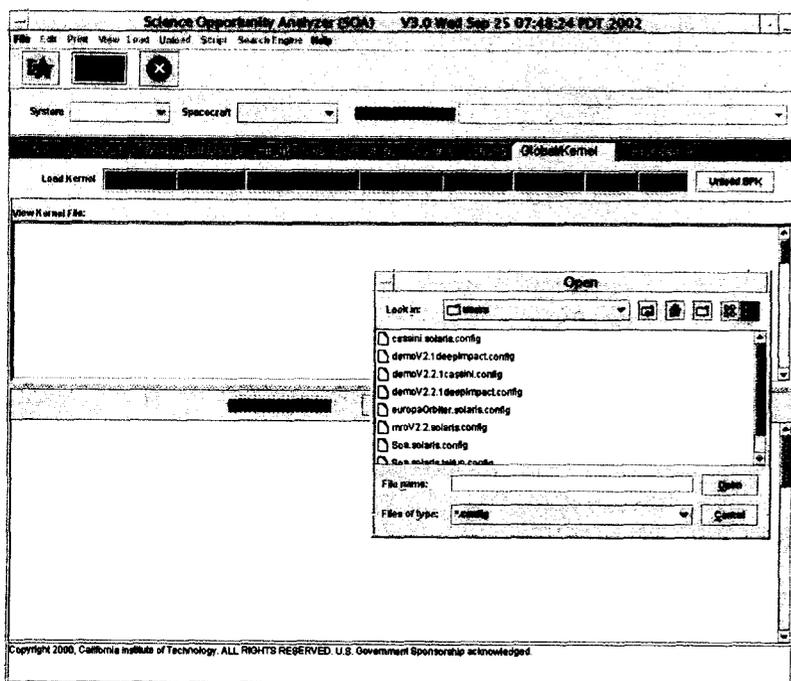
- Uses JPL Navigation and Ancillary Information Facility (NAIF) SPICE* software toolkit.
 - Planetary ephemeris and constants
 - Spacecraft trajectory
 - Spacecraft instrument field of view definitions
 - Spacecraft coordinate systems
 - Physical phenomena model parameters
- Additional Features:
 - Java-based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

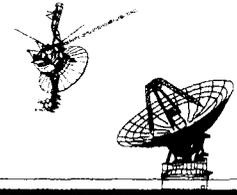
* SPICE = Spacecraft, Planetary, Instrument, Constant, Events



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

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





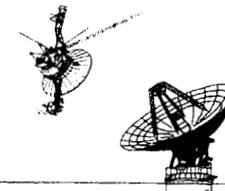
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Opportunity Search

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



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Opportunity Search Query Builder

File Edit Print

Query start: 2004 JAN 01 12:00:00.000 Query end: 2008 JUN 30 12:00:00.000

Central Meridian PERCY

Coor EVENTS

Descending Node EVENTS

Distance PERCY EVENTS

Eclipse PERCY

Elongation PERCY

EVENTS

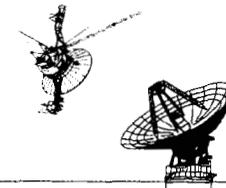
Occultation PERCY EVENTS

Fly By model properties Search engine for model:

Name	Value	Default	Range	Comment
beginTime	2004 JAN 01 12:00:00.000	0		Start time for the Query
endTime	2008 JUN 30 12:00:00.000	0		End time for the Query
systemBody	SATURN	SATURN		Central Body of the planetary system
spaceCraft	CASSINI	CASSINI		Space vehicle
flyByBody	ENCELADUS	TITAN		Celestial body to be within the specified dista...
distance		1000000 ...		Maximum distance -- used for comparison ag...

Click tree branch indicator to view events available in the category of interest.
Events can be selected and inserted into the query by clicking an event and dragging it to the Events Window

Opportunity Search Query Builder display with an Enceladus flyby query.



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

Science Opportunity Analyzer (SOA) V3.0 Wed Sep 25 07:48:24 PDT 2002

File Edit Print View Load Unload Script Search/Engine Help

System: SATURN Spaccraft: CASSINI

Opportunity Search Flight Rules Data Output Communications Global/Kernel

New/Edit Query Delete Query Search Cancel Search Load Query Save Query

Query Name	Query Expression	Query Start	Query End
EnceladusFlyby	Fly By	2004 JAN 01 12:00:00	2008 JUN 30 12:00:00

Query Name	Window	Begin Time	End Time	Additional Info.
EnceladusFlyby	1	2004 JUL 01 00:38:36.470	2004 JUL 01 00:38:36.470	
EnceladusFlyby	2	2004 NOV 29 10:39:47.980	2004 NOV 29 10:39:47.980	
EnceladusFlyby	3	2005 JAN 16 13:20:38.740	2005 JAN 16 13:20:38.740	
EnceladusFlyby	4	2005 FEB 17 04:33:07.320	2005 FEB 17 04:33:07.320	
EnceladusFlyby	5	2005 MAR 09 09:28:41.820	2005 MAR 09 09:28:41.820	
EnceladusFlyby	6	2005 MAR 29 19:56:14.270	2005 MAR 29 19:56:14.270	
EnceladusFlyby	7	2005 MAY 21 08:00:14.870	2005 MAY 21 08:00:14.870	
EnceladusFlyby	8	2005 JUL 14 19:59:51.440	2005 JUL 14 19:59:51.440	
EnceladusFlyby	9	2005 OCT 12 03:56:39.670	2005 OCT 12 03:56:39.670	
EnceladusFlyby	10	2005 OCT 30 00:17:55.560	2005 OCT 30 00:17:55.560	
EnceladusFlyby	11	2005 NOV 27 10:43:53.970	2005 NOV 27 10:43:53.970	
EnceladusFlyby	12	2005 DEC 24 20:54:19.360	2005 DEC 24 20:54:19.360	
EnceladusFlyby	13	2006 JAN 17 03:28:22.440	2006 JAN 17 03:28:22.440	
EnceladusFlyby	14	2006 JUN 30 08:25:33.310	2006 JUN 30 08:25:33.310	
EnceladusFlyby	15	2006 SEP 09 20:31:26.320	2006 SEP 09 20:31:26.320	
EnceladusFlyby	16	2006 NOV 09 01:58:29.010	2006 NOV 09 01:58:29.010	
EnceladusFlyby	17	2007 APR 24 13:48:31.600	2007 APR 24 13:48:31.600	
EnceladusFlyby	18	2007 MAY 10 21:28:22.730	2007 MAY 10 21:28:22.730	
EnceladusFlyby	19	2007 JUN 28 00:57:35.530	2007 JUN 28 00:57:35.530	
EnceladusFlyby	20	2007 SEP 30 11:10:12.480	2007 SEP 30 11:10:12.480	
EnceladusFlyby	21	2007 NOV 17 05:30:31.000	2007 NOV 17 05:30:31.000	

Delete Results Load Results Save Results Create Observation Create Epoch View New Viewer Data Output

Select "Load Query" button to input search criteria from file, or select "New/Edit Query" button to start the Query Builder and create a new query. You may edit an existing query by double-clicking the desired query in the Query Table



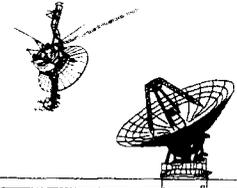
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Observation Design

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).

Science Opportunity Analyzer (SOA) V3.0 Thu Jan 16 14:29:28 PST 2003

File Edit Print View Load Unload Script Search Engine Help

System **SATURN** Spacecraft **CASSINI** **/home/cm/CMV26.3_baseline/soa/seq/kernels/hal0007.tls**

Opportunity Search | **Observation Design** | Flight Rules | Data Output | Communications | Global/Kernel

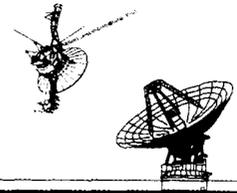
Delete Obs Load Obs Save Obs Load SASF Load CK Save CK Add to Plan Delete from Plan Save Plan

Observation Name	Activity	Start Time	In Plan	Type	Description
EnceladusApproach	Scoping	2005 MAR 09 07:29:46.000	false	Scoping	E5 - 2 hours (rounded to nearest minute)

New Obs Convert Obs Apply Write to list Module Parameters Nominal Target Check Constraint Cancel Constraint View New Viewer

EnceladusApproach:Scoping

Name	Value	Default	Range	Comment
Observation Start Time	E5App	2008 JUN 08 1...		Valid S/C orientation is acquired
Observation Duration	04:00:00.0	0:01:00.000		Calculated duration of valid S/C orientation
Step Interval	00:00:30.0	00:00:05		Frequency of calculations
Primary Target	ENCELADUS Center	SATURN Center		Tracking reference point
Secondary Target	Align to ENCELADUS pole	Align to SATUR...		Used to specify S/C orientation around Primary O...
Target Offsets	X:0 deg;Y:0 deg;Z:0 deg	X:0 deg;Y:0 de...		Target Offsets
Primary Observer	UVIS_HLV_OCC	S/C X Axis	S/C X Axis,S/C -X Axis...	Vector pointed at Primary Target + Offsets
Secondary Observer	S/C_Z_Axis	S/C Z Axis	S/C X Axis,S/C -X Axis...	Secondary Observer



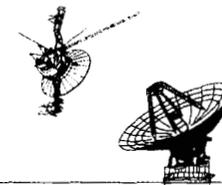
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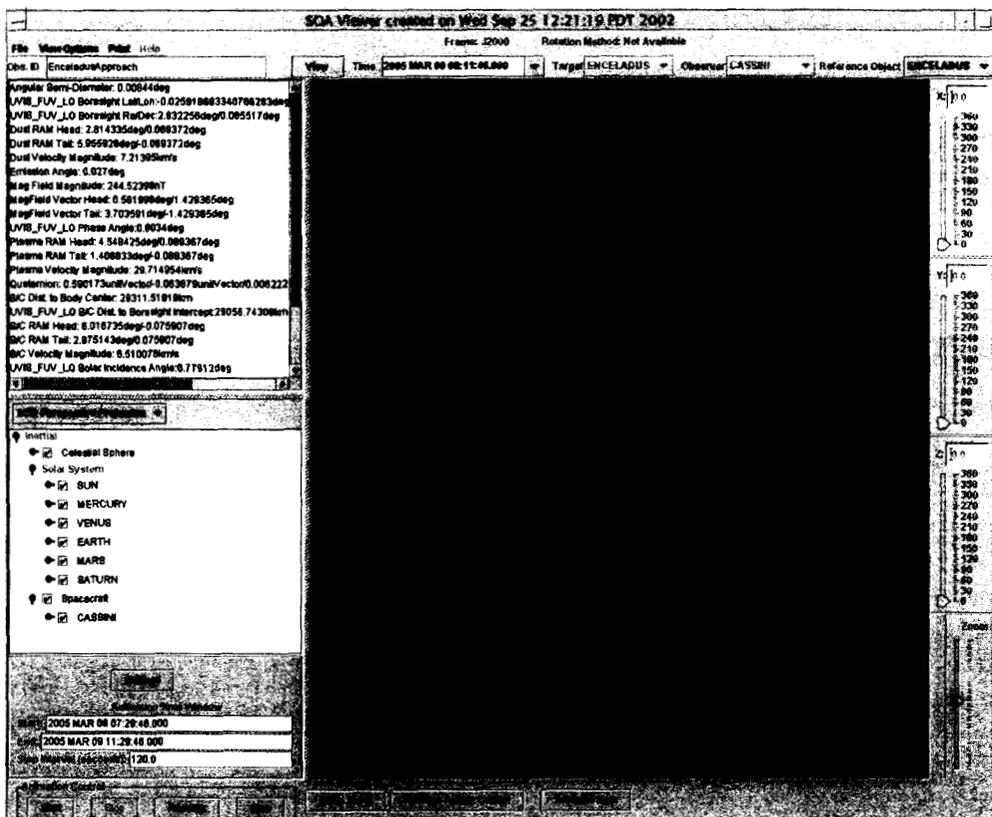
Visualization

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

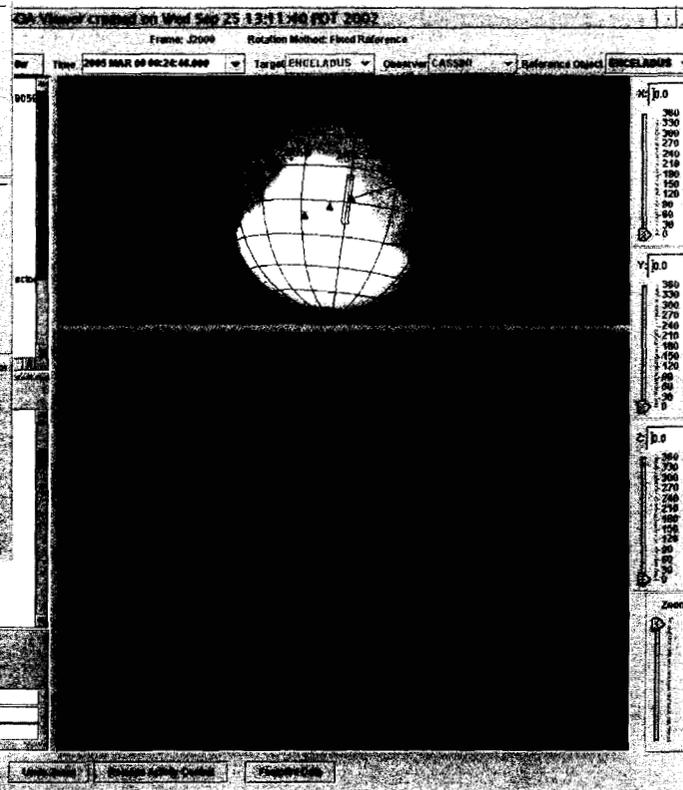
- Visualize the system in 3D and 2D from the point of view of any object in the system, including the s/c, or from an arbitrary point of view
 - 3-D Perspective Projection view
 - 3-D Arbitrary Observer view
 - 2-D SkyMap view
 - 2-D Trajectory view
- Visualize observations with instrument fields of 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



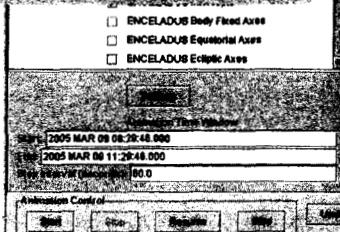
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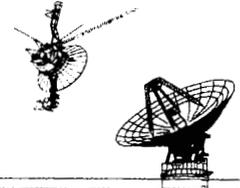


A 3-D perspective view and a 3-D arbitrary observer view of closest approach to Enceladus in the same viewer window.



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

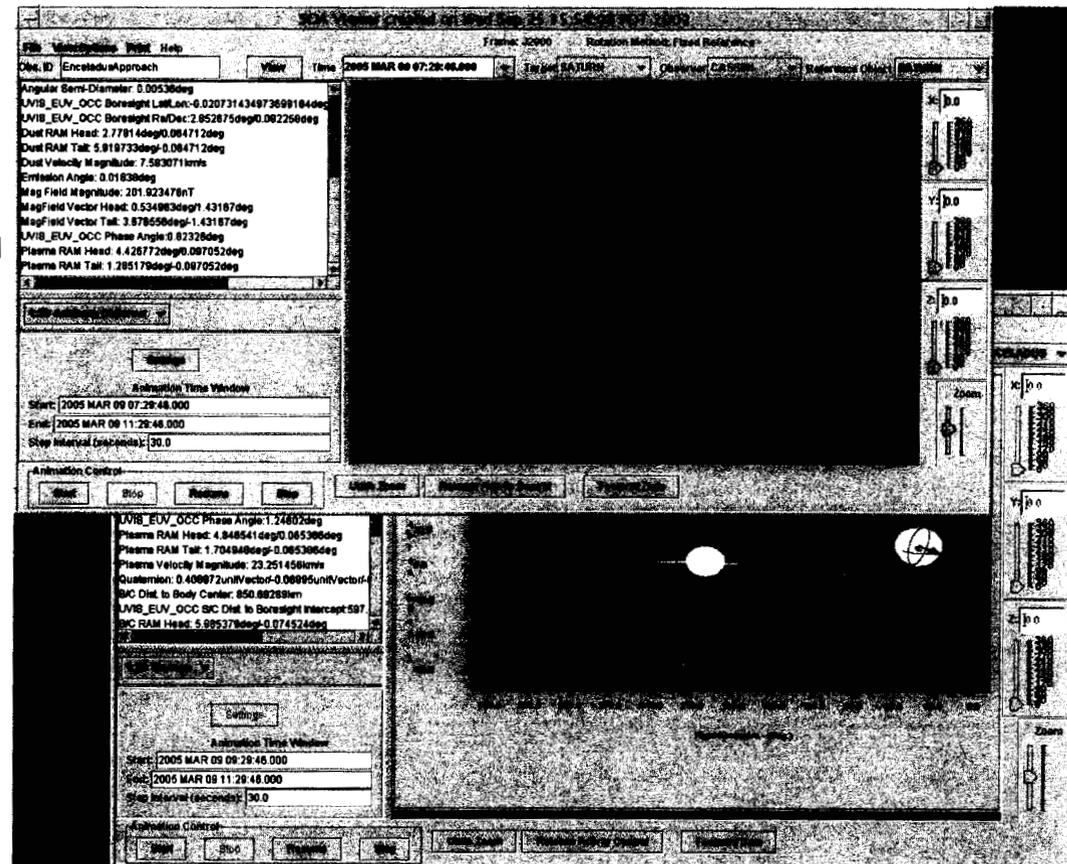




Two viewers are displayed.

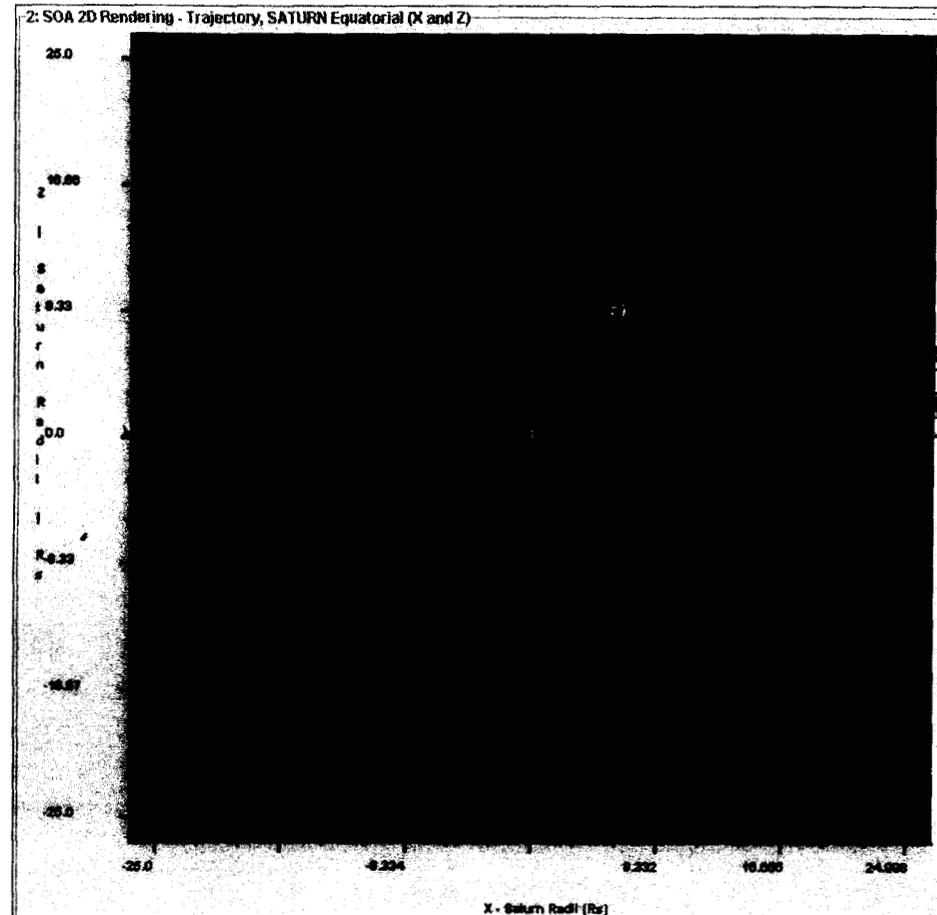
The top one shows a 3-D Arbitrary Observer view with Saturn as the target. The green arc by Enceladus is the spacecraft trajectory.

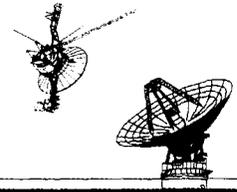
The bottom one shows the 2-D SkyMap view at this time.





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.





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





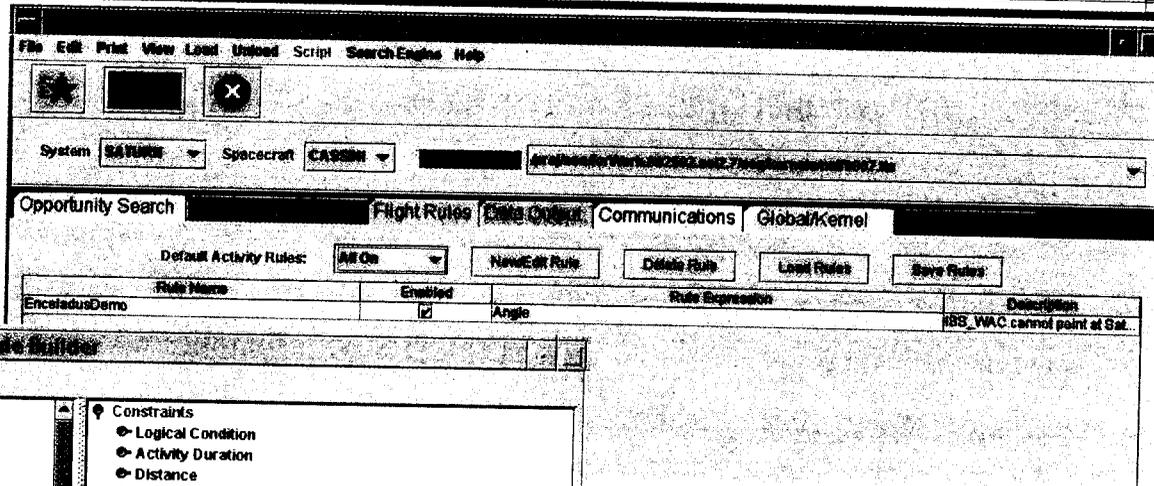
Constraint Checking

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

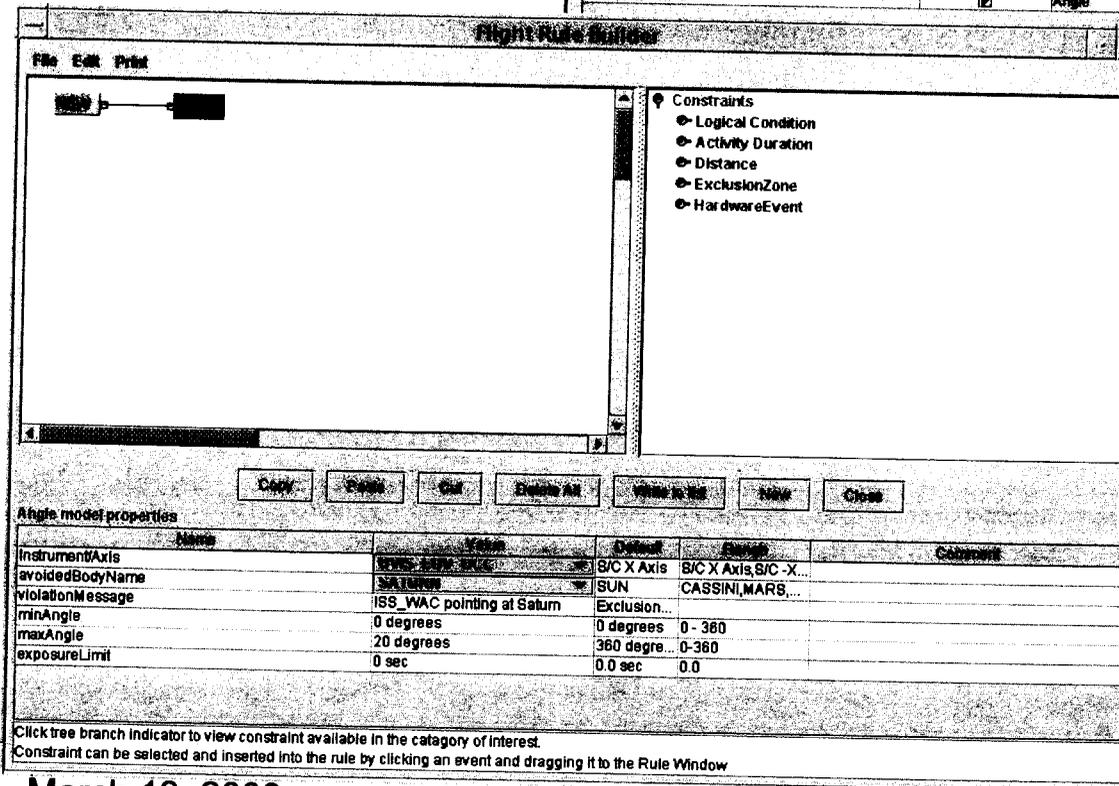
- Checks high level observation design constraints early in the sequence development process
 - Provides feedback and a log on all violations
 - Permits user-level and project-level rule checking
 - Allows selection of rules to be checked
-
- Additional Features:
 - Provides easy to use flight rule builder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





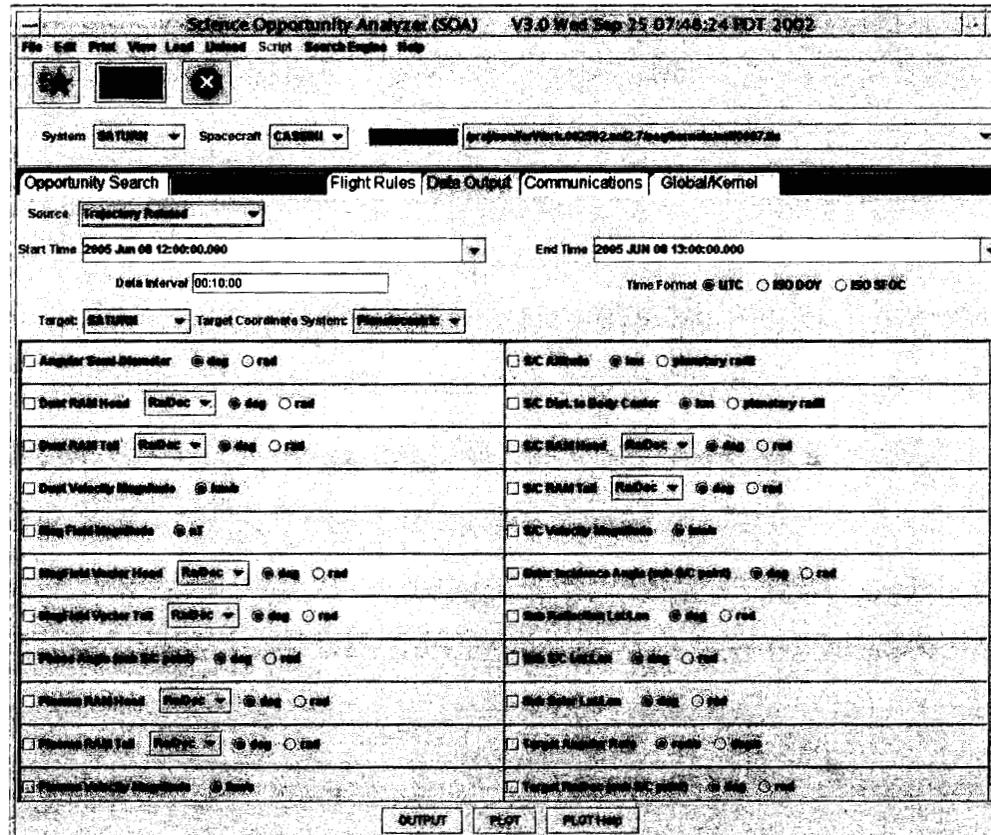
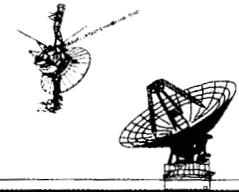
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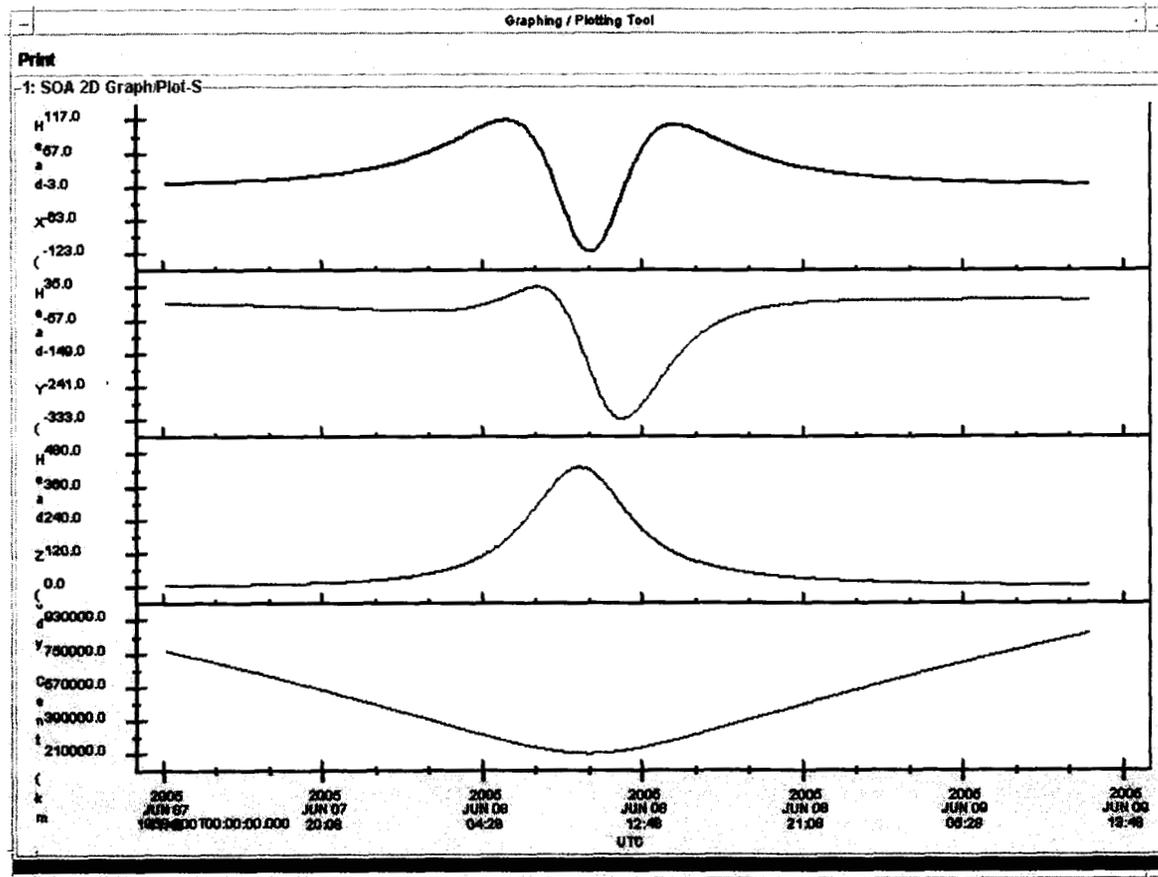
Data Output

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.



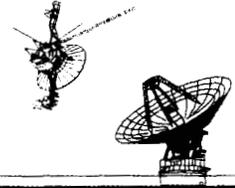
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Communications

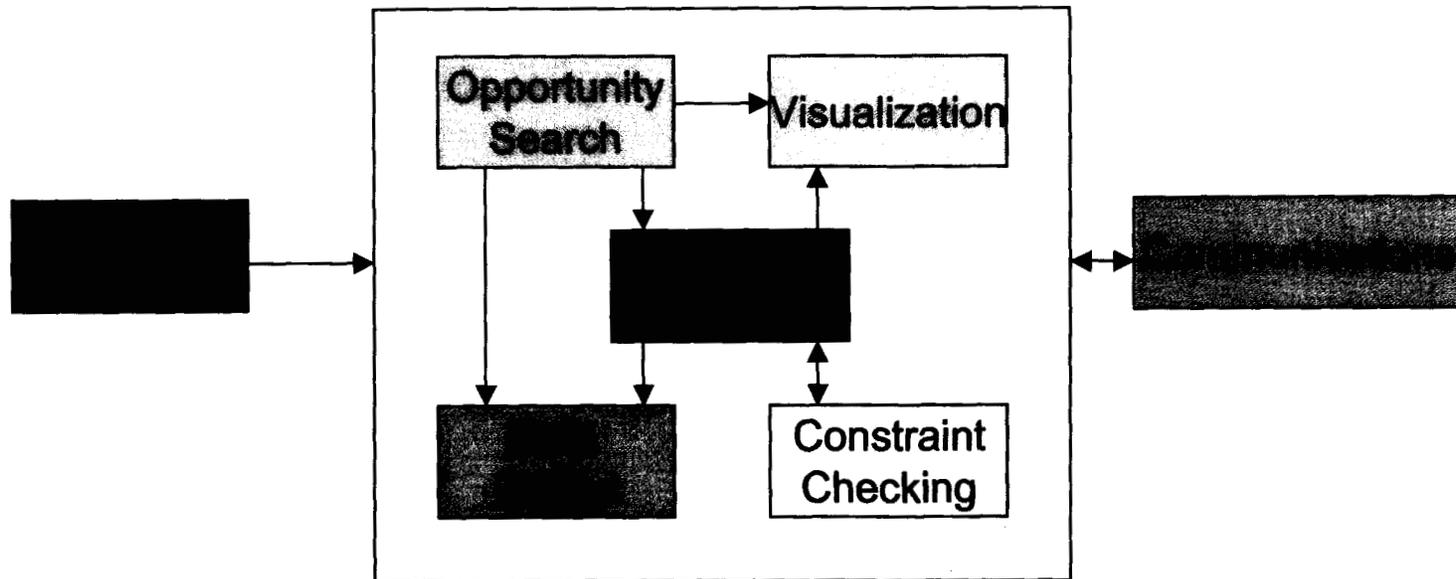
Step 7: The user saves the observation for future recall and/or sends it to downstream software to be added to the plan of spacecraft activities. SOA observations can be saved in 3 formats.

- 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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