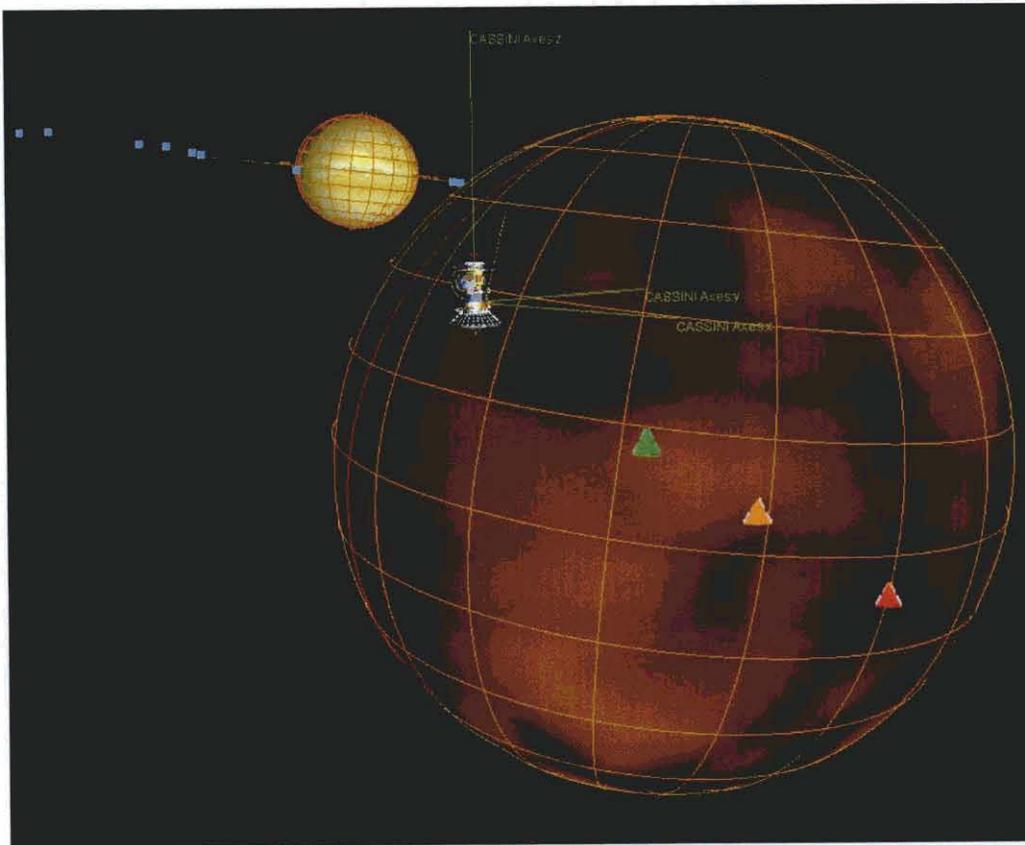




Science Opportunity Analyzer (SOA):

Science Planning Made Simple



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INTRODUCTION

- For the first time at JPL, the Cassini mission to Saturn is using distributed science operations for developing their experiments.
- 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 to other scientists
- Many existing tools provide one or more of these functions, but Science Opportunity Analyzer (SOA) has been built to unify these tasks into a single application.

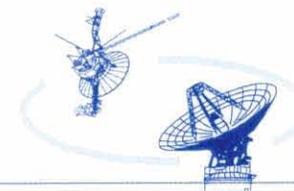


SOA's CHARACTERISTICS

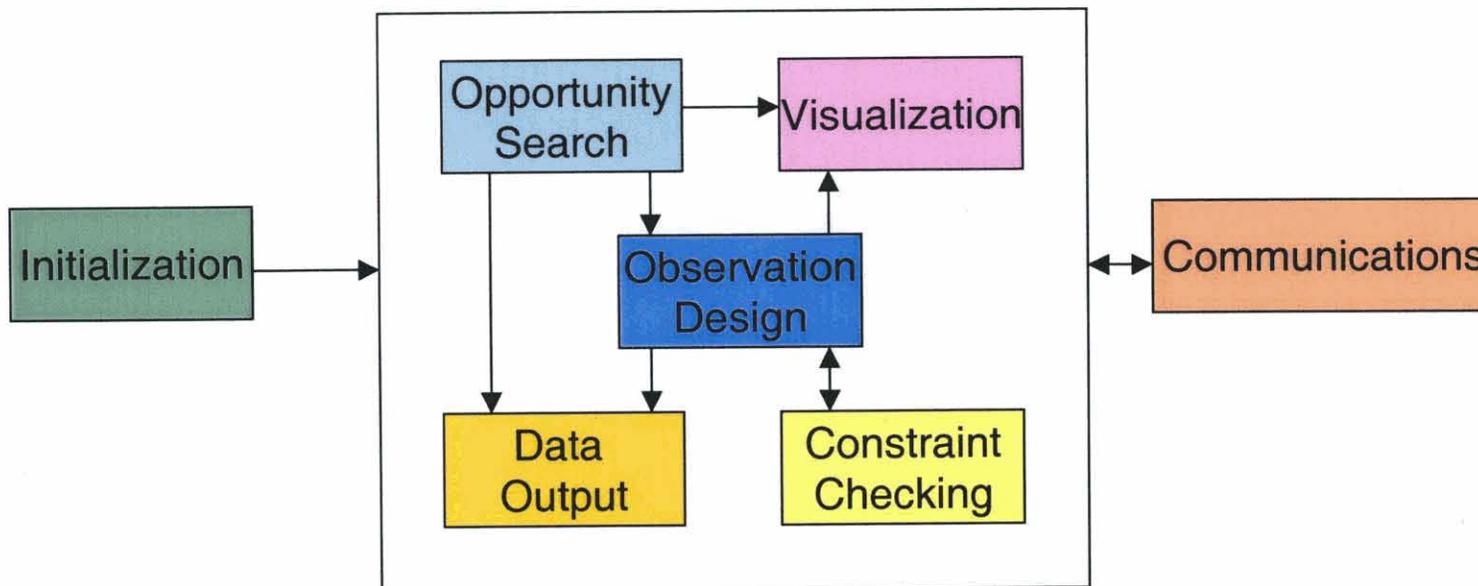
- Accurate: Utilizes JPL Navigation and Ancillary Information Facility (NAIF) SPICE* software toolkit
 - Provides high fidelity modeling
 - Facilitates rapid adaptation to other flight projects
- Portable: Available in Unix, Windows and Linux
- Adaptable: Designed to be a multi-mission tool so it can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

- Implemented in Java, Java 3D and other innovative technologies

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



SOA FUNCTIONS





6 Simple Steps

1. Start SOA and run the Configuration File. The Configuration File contains the spacecraft trajectory information as well as other data to run SOA.
2. Select the Opportunity Search tab. Select an opportunity search option from the 34 available. Fill in the search parameters. Save the search and then run it.
3. Select one of the returned search result windows and view it in either 2-D or 3-D displays by pressing the View button.
4. Select the Observation Design tab. Select to create a new observation. Create the observation using one of the five observation types (scoping, mosaic, continuous scan, track-a-target, or roll-about-an-axis). Fill in the parameters and save it.
5. Press the constraint-checking button. Correct any constraint violations and then view the observation. If the observation meets the users criteria, then save the observation for later retrieval or for sharing with others.
6. Finally, select the Data Output tab and select any of the data items that are desired and the type of data required (opportunity search, trajectory related or observation related). Select the type of output – graph or tabular data.



•Configuration

–Flight project adaptation is created by loading a project-specific configuration file, SPICE kernels and models.

Science Opportunity Analyzer (SOA) V5.0 Mon Sep 20 13:37:36 PDT 2004

File Edit Print View Load Script Search Engine Help

System SATURN Spacecraft CASSINI Kernels Loaded proj/soaforDistributionV5.0/seq/kernels/spk/tour/T18-5_cas.bsp

Opportunity Search Observation Design Flight Rules Data Output Communications Configuration Preference

Load Kernel Ephemeris Trajectory Planetary Constants Leap Second SIC Clock Instrument Frame Other Unload

Body Name	Center	Begin Time	End Time
CASSINI	JUPITER BARYCENTER	1999 SEP 28 11:58:55.818	2002 SEP 28 11:58:55.818
CASSINI	SATURN BARYCENTER	2002 SEP 28 11:58:55.818	2008 JUN 30 23:58:55.816

View Kernel File: proj/soaforDistributionV5.0/seq/kernels/spk/tour/T18-5_cas.bsp

CONFIGURATION FILE

```
// soa version 5.0
//*****

// set spacecraft name
spacecraftName = "CASSINI";
ConfigPanel.setSpacecraft (spacecraftName);

// set system name
systemName = "SATURN";
ConfigPanel.setDefaultSystem (systemName);

// set begin and end time
beginTime = "2004 JAN 01 12:00:00.000";
endTime = "2008 JUN 30 12:00:00.000";
plotTime = "2008 JUN 08 12:00:00.000";

// set in/out file paths
// The user can specify default input and output directories by supplying
// the appropriate paths to directories which exist on their system.
// If not specified, the program will default to the .soa directory which
// it creates on the users system.
//fileOutPath = "proj/soaforTesting/testScripts";
//Soa.setFileOutputPath (fileOutPath);
fileInPath = Soa.soaHome + "/soa/users/cassinr";
```

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Kernel proj/soaforDistributionV5.0/seq/kernels/sha1/0007.tls loaded
Kernel proj/soaforDistributionV5.0/seq/kernels/spk/tour/T18-5_cas.bsp loaded



Multi Mission Operations Office



•Opportunity Search

–Find windows of opportunity for an observation based on 34 specific geometric criteria.

The screenshot displays the Science Opportunity Analyzer (SOA) V5.0 interface. The main window shows the 'Opportunity Search' tab with a table of query results. A secondary window, 'Opportunity Search Query Builder', is open, showing a query expression and a table of fly-by parameters.

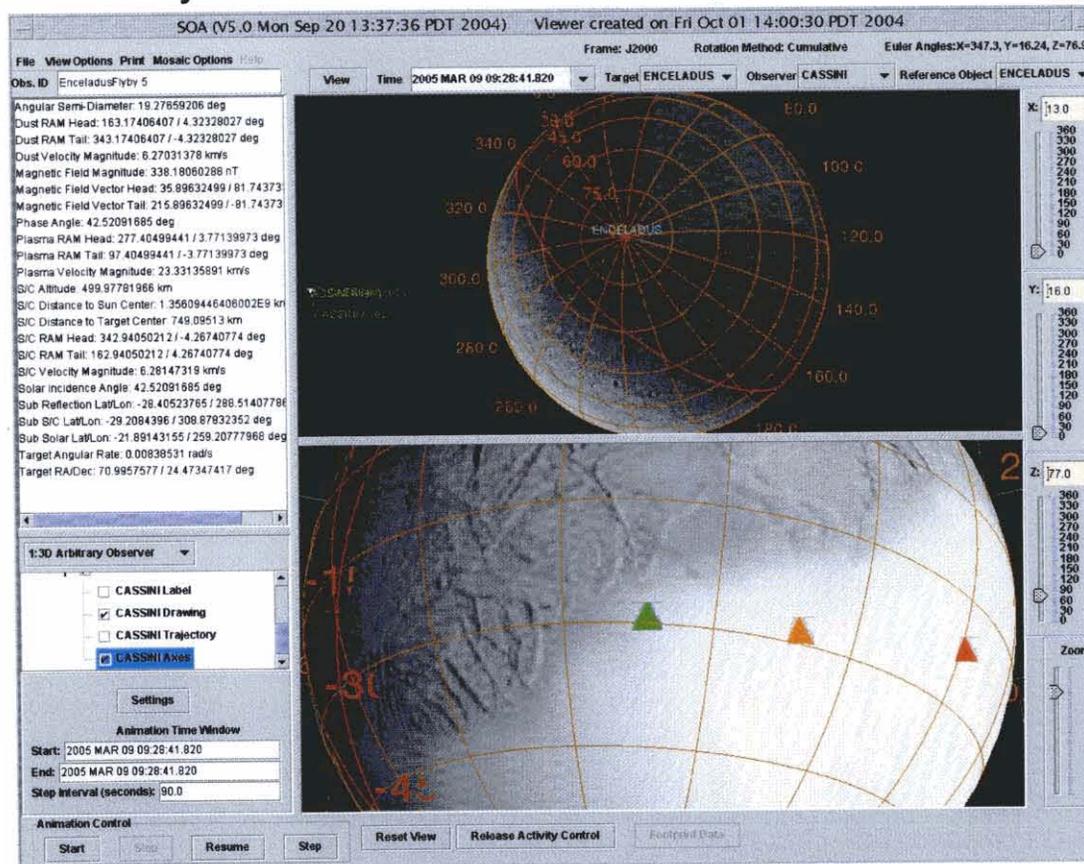
Query Name	Window	Begin Time	End Time
EnceladusFlyby	1	2004 JUL 01 00 38 36.470	2004 JUL 01 00 38 36.470
EnceladusFlyby	2	2004 NOV 29 10 39 47 980	2004 NOV 29 10 39 47 980
EnceladusFlyby	3	2005 JAN 16 13 20 39 740	2005 JAN 16 13 20 39 740
EnceladusFlyby	4	2005 FEB 17 04 33 07 320	2005 FEB 17 04 33 07 320
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 06 00 14 870	2005 MAY 21 06 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 31 800	2007 APR 24 13 48 31 800
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 39 21 000	2007 NOV 17 05 39 21 000
EnceladusFlyby	22	2007 DEC 19 08 58 04 650	2007 DEC 19 08 58 04 650
EnceladusFlyby	23	2008 JAN 27 17 03 19 890	2008 JAN 27 17 03 19 890
EnceladusFlyby	24	2008 FEB 08 17 25 24 230	2008 FEB 08 17 25 24 230

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	TITAN			Central body to be within the specified dist.
distance	ENCCELADUS	100000		Maximum distance - used for comparison ap.



•Visualization

- Provides accurate representation of the solar system in multiple ways:
3-D Arbitrary Observer and 3-D Perspective Projection



November 8, 2004

2004 Core Technologies for
Space Systems

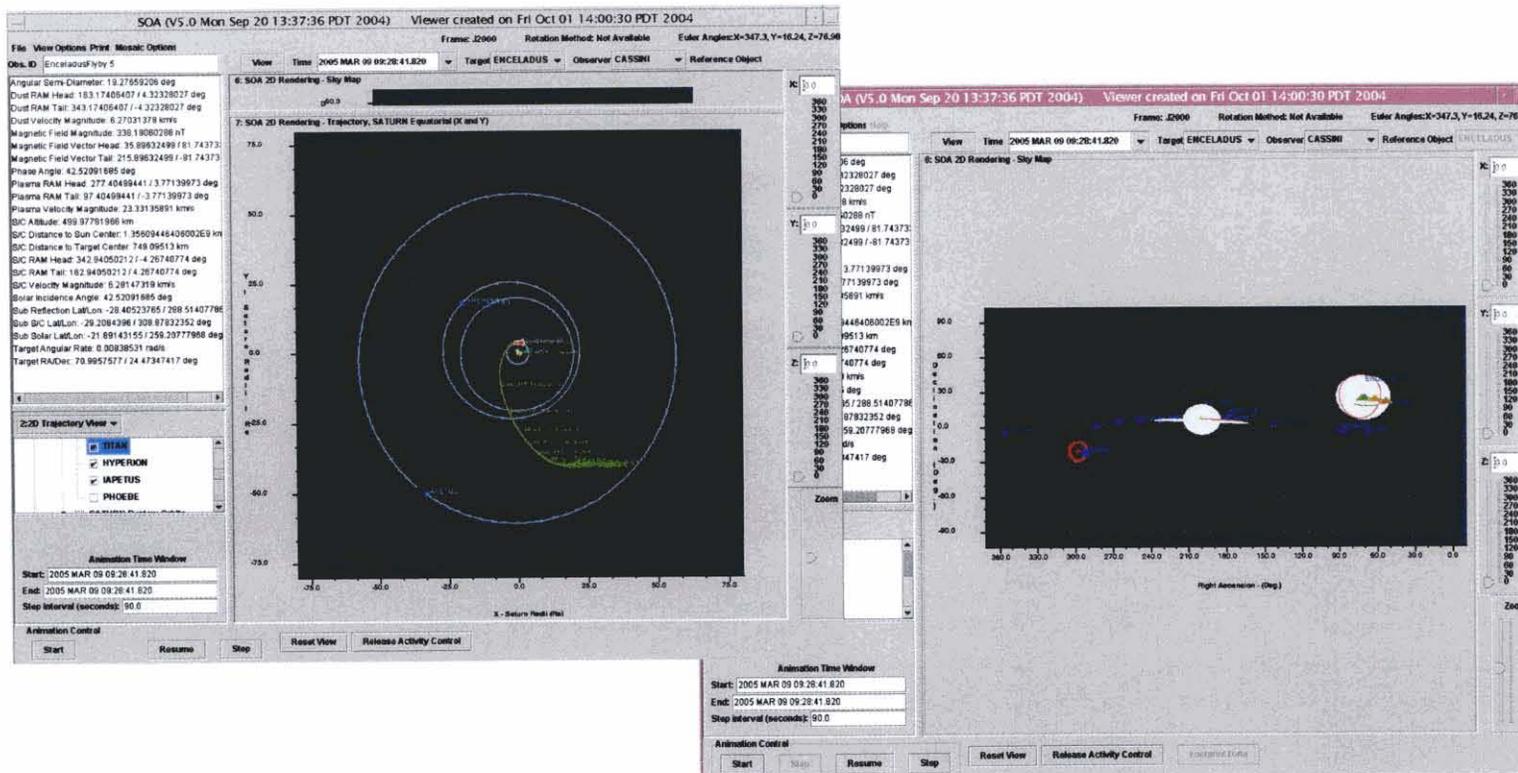


Multi Mission Operations Office



•Visualization

- Provides accurate representation of the solar system in multiple ways:
2-D Equidistant Projection Skymap and 2-D Trajectory Plot





Multi Mission Operations Office



• Observation Design

- High level "Scoping" design tool for "what if" studies
- Create nxm mosaic, scan mosaic, roll-about-an-axis, or track-a-target

Observation Design Request Builder

File Print

Request Scoping

Activities

- Absolute Pointing
 - Initial Attitude
 - Track
 - Turn and Track
- Continuous Scan
 - Continuous Scan
- Roll Scan
 - Roll Scan
- Scoping
 - Scoping
 - Start Stop Mosaic
 - Start Stop Mosaic
- Unmodeled
 - Note
 - Unmodeled

Copy Paste Cut Convert Obs Delete All Apply Write to list New Module Parameters Done

EnceladusApproach:Scoping parameters

Name	Value	Default	Range	Comment
Request Index	1	-1		Number of the activity (step) within the request
Scheduled Time Option	FROM_REQUEST_START	FROM_R...	FROM_REQUES	Timing relationship of the current activity with...
Scheduled Time Offset	00:00:00	00:00:00		Duration relative to time specified by Schedul...
Scheduled Time	2005 MAR 09 07:29:00.000	2008 JUN...		Absolute time calculated using Schedule Tim...
Activity Start Time	2005 MAR 09 07:29:00.000	2008 JUN...		Time spacecraft starts to acquire target
Activity End Time	2005 MAR 09 11:29:00.000	2008 JUN...		Time of final valid orientation
Activity Duration	04:00:00.0	00:00:00		Total time calculated from parameters
Primary Observer	ENC WFL	S/C X Axis	S/C X Axis,S/C -X	Vector pointed at Primary Target + Offsets
Primary Target	ENCLADUS Center	SATURN...		Tracking Reference Point
Secondary Observer	S/C Z AXIS	S/C Z Axis	S/C X Axis,S/C -X	Used to specify spacecraft orientation around
Secondary Target	Align to ENCLADUS pole	Align to S...		Used to specify spacecraft orientation around
Target Offsets	X:0 deg;Y:0 deg;Z:0 deg	X:0 deg;Y...		Angular offset from Primary Target in spacerc...
Step Interval	00:00:30.0	00:00:05		Frequency of calculations

Click tree branch indicator to view activity available in the category of interest.
Activity can be selected and inserted into the request by clicking an event and dragging it to the Request Window



Multi Mission Operations Office



- Constraint Checking
 - Check observations against specific geometric constraints

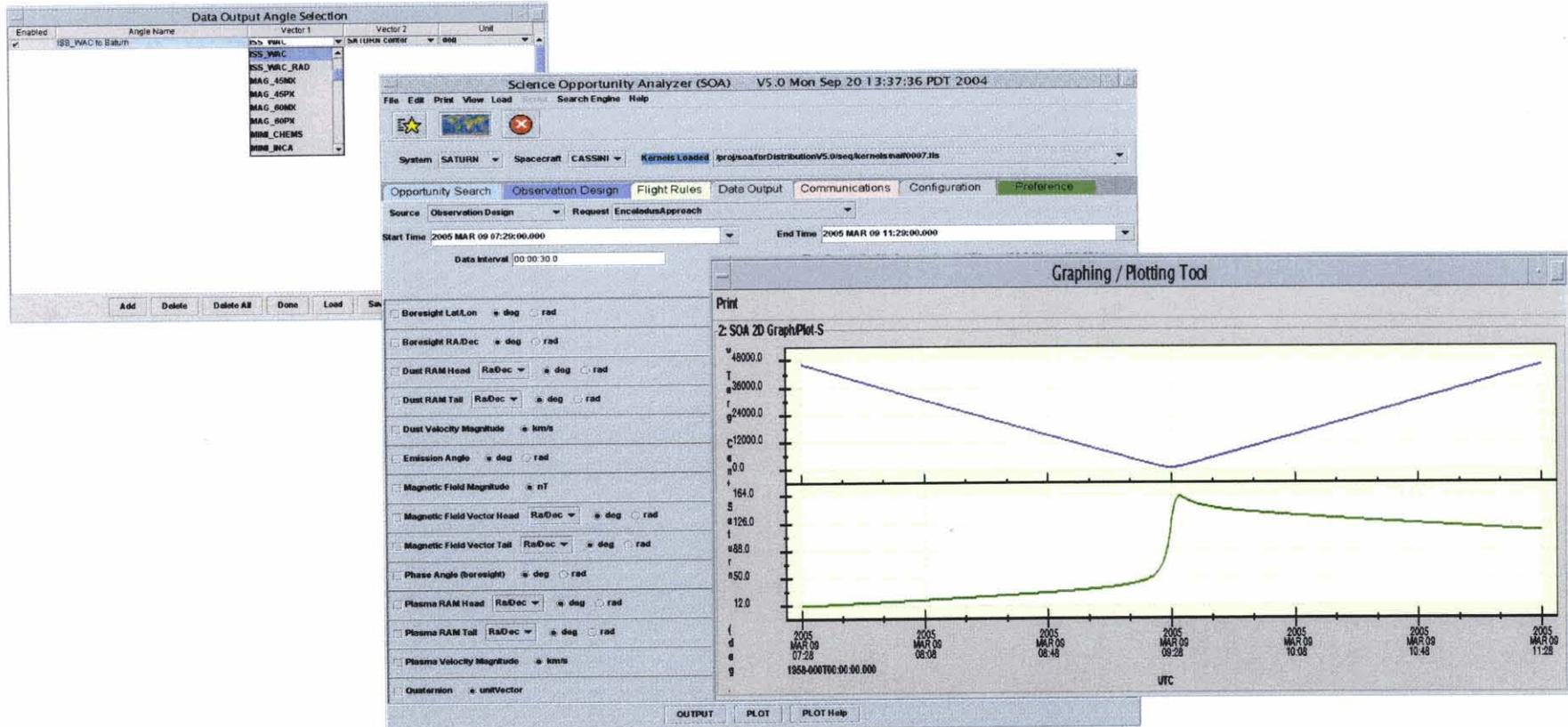
The screenshot displays the Science Opportunity Analyzer (SOA) software interface, version 0.0, running on Monday, September 20, 2004, at 13:37:36 PDT. The interface is divided into several panels:

- System:** SATURN, Spacecraft: CASSINI, Keywords Loaded: Enceladus for Data Station VS.0/ep/kernels/mar0007.0
- Opportunity Search:** Includes tabs for Observation Design, Flight Rules, Data Output, Communications, and Configuration. A table lists observation opportunities with columns for Name, Start Time, In Plan, Title, and Description.
- Enceladus Approach Summary:** A table showing scheduled times, activity start/end times, and offsets for various observation indices.
- 3D Perspective Projection:** Two 3D visualizations of the Saturn system. The left view shows the planet Saturn and its rings, with a red line representing the Cassini spacecraft's trajectory. The right view shows a similar perspective but with a different spacecraft position and orientation.
- Parameter Lists:** Detailed lists of spacecraft parameters such as Velocity Magnitude, WAC Emission Angle, Magnetic Field Magnitude, and Plasma RAM Head, among others.
- Animation Time Window:** Controls for starting, ending, and stepping through the simulation.
- Animation Control:** Buttons for Start, Resume, Stop, Reset View, Release Activity Control, and Footprint Data.



•Data Output

–Obtain ancillary data related to an opportunity search, a trajectory or an observation as either a text file or plots





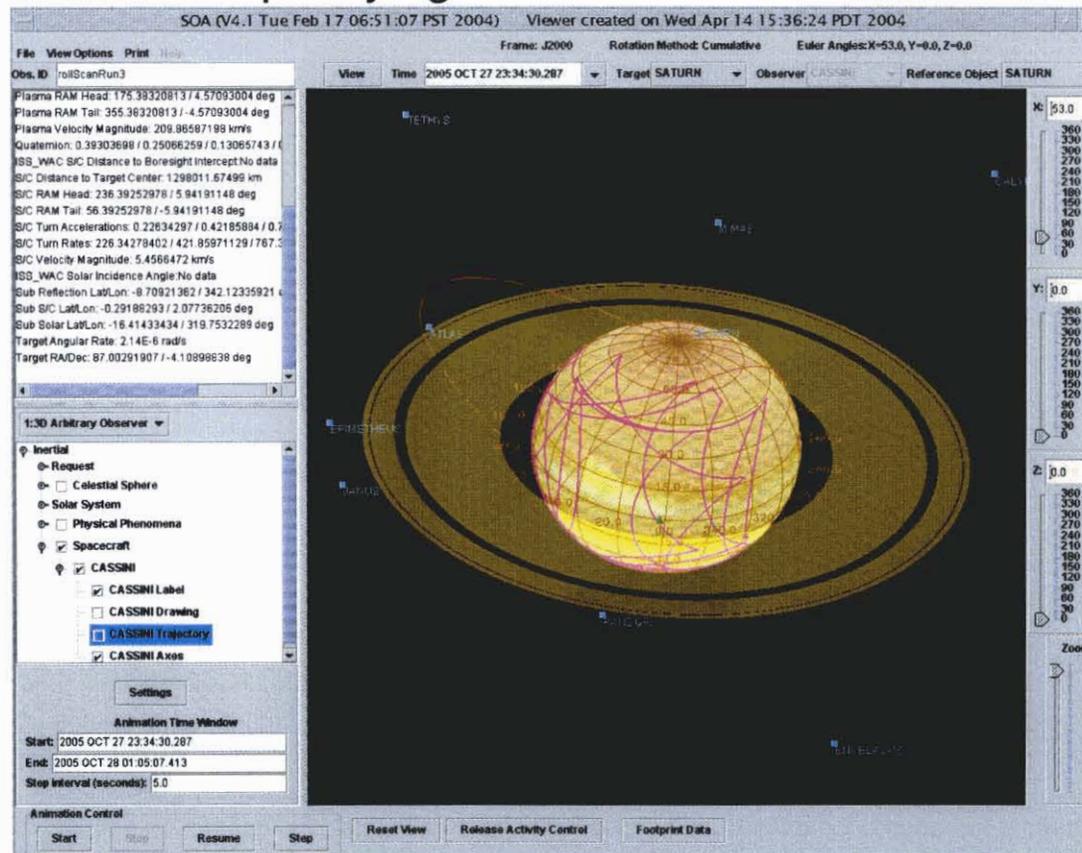
Multi Mission Operations Office



JPL

- Communications

- Reads/writes spacecraft attitude files (SPICE* C-kernels), a universally accepted method for specifying attitude information



*SPICE = Spacecraft, Planet, Instrument, Constants, Events

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13

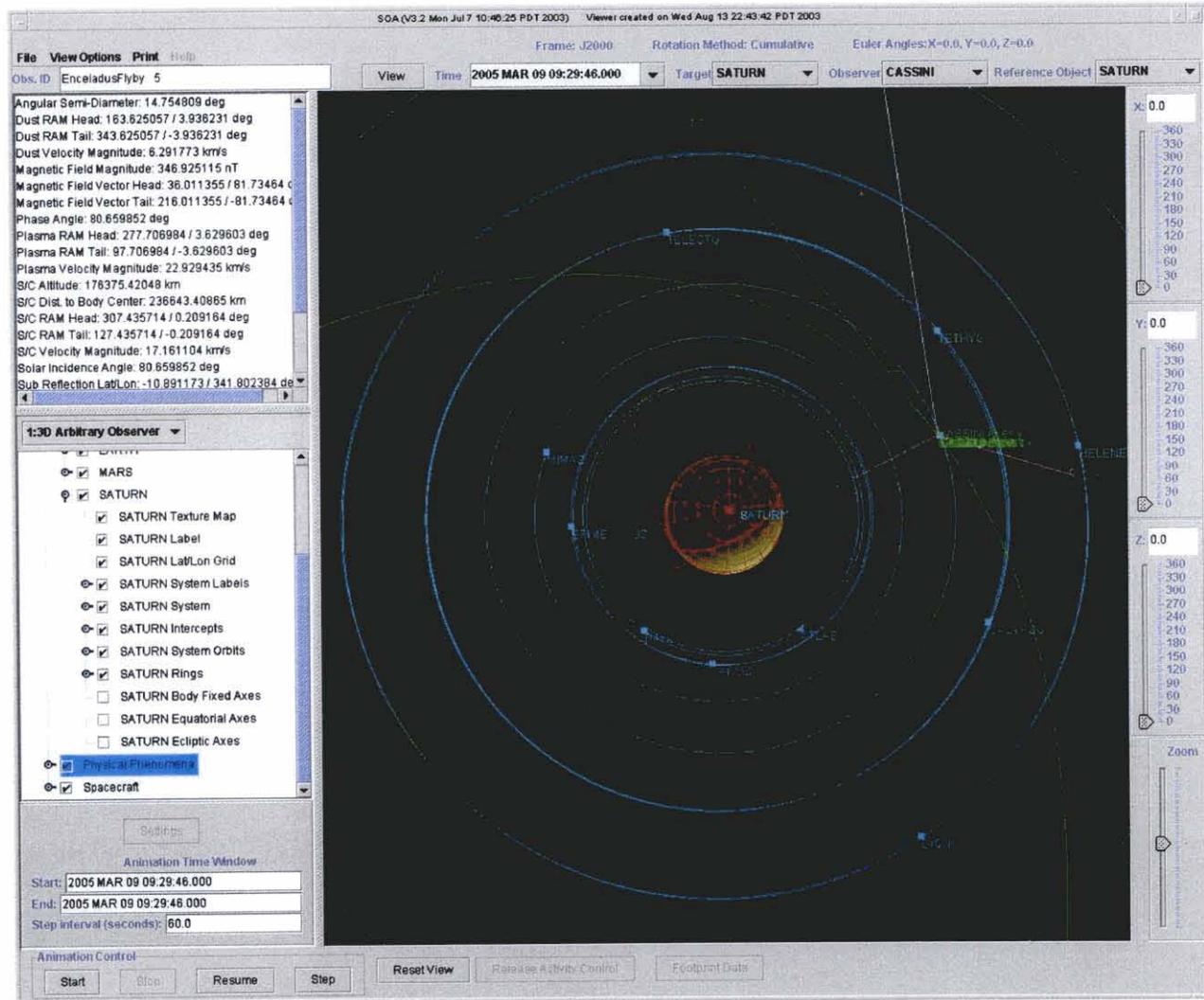


Additional Displays



CASSINI

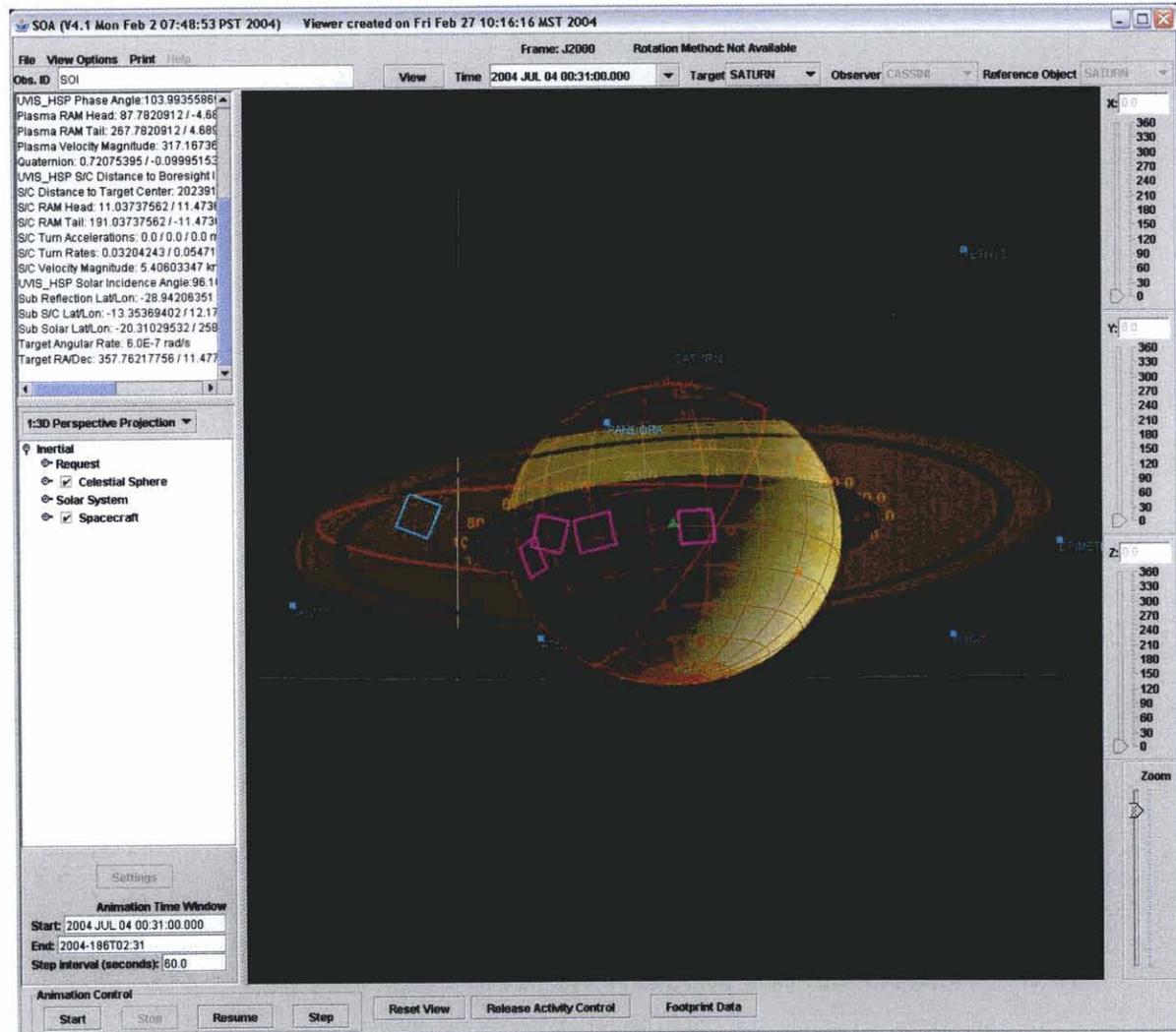
3-D Arbitrary Observer view of the Saturn system showing the Cassini trajectory in green and the satellite orbits in blue.





CASSINI

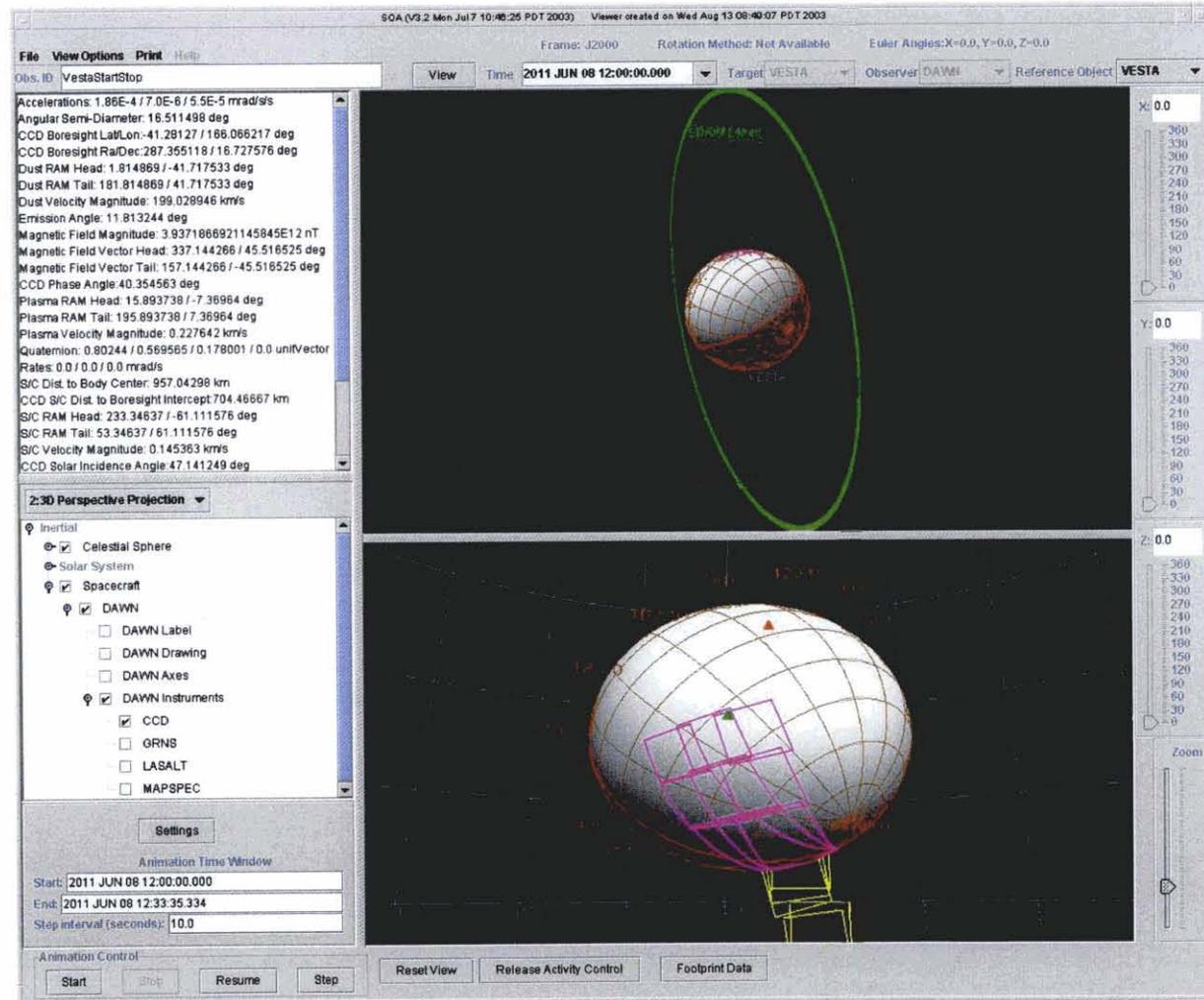
3-D Perspective
Projection view of an
Ultra-Violet Imaging
Spectrometer (UVIS)
observation of
Saturn's rings in the
shadow cast by
Saturn. The blue
UVIS field of view is
close to the edge of
the shadow.





DAWN

3-D Arbitrary
Observer view and
3-D Perspective
Projection of Vesta
as viewed from the
Dawn spacecraft.
The start stop
mosaic observation
shows the camera
field of view

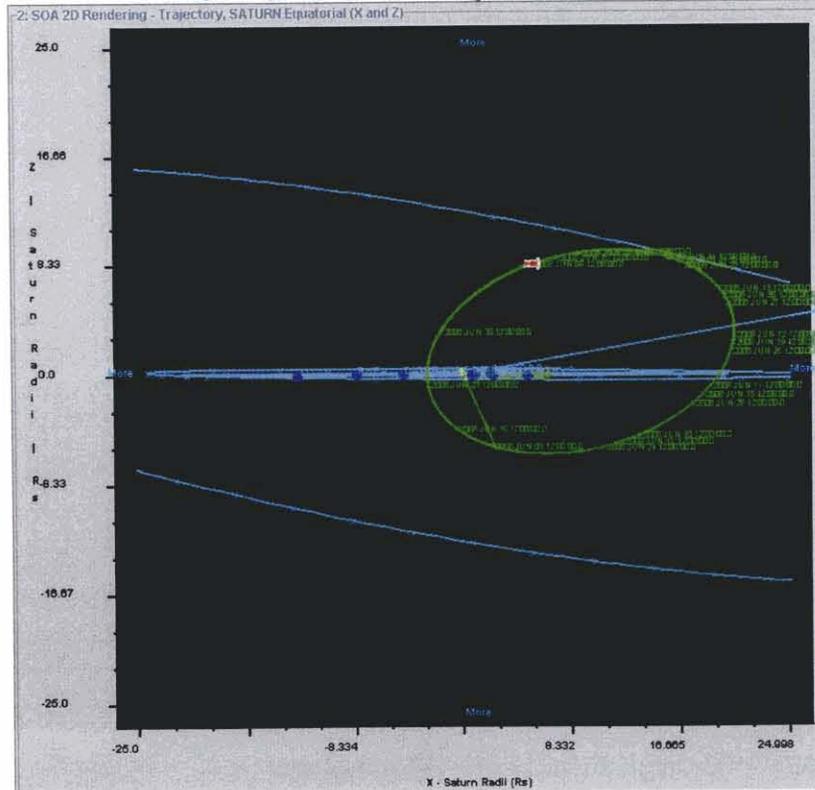
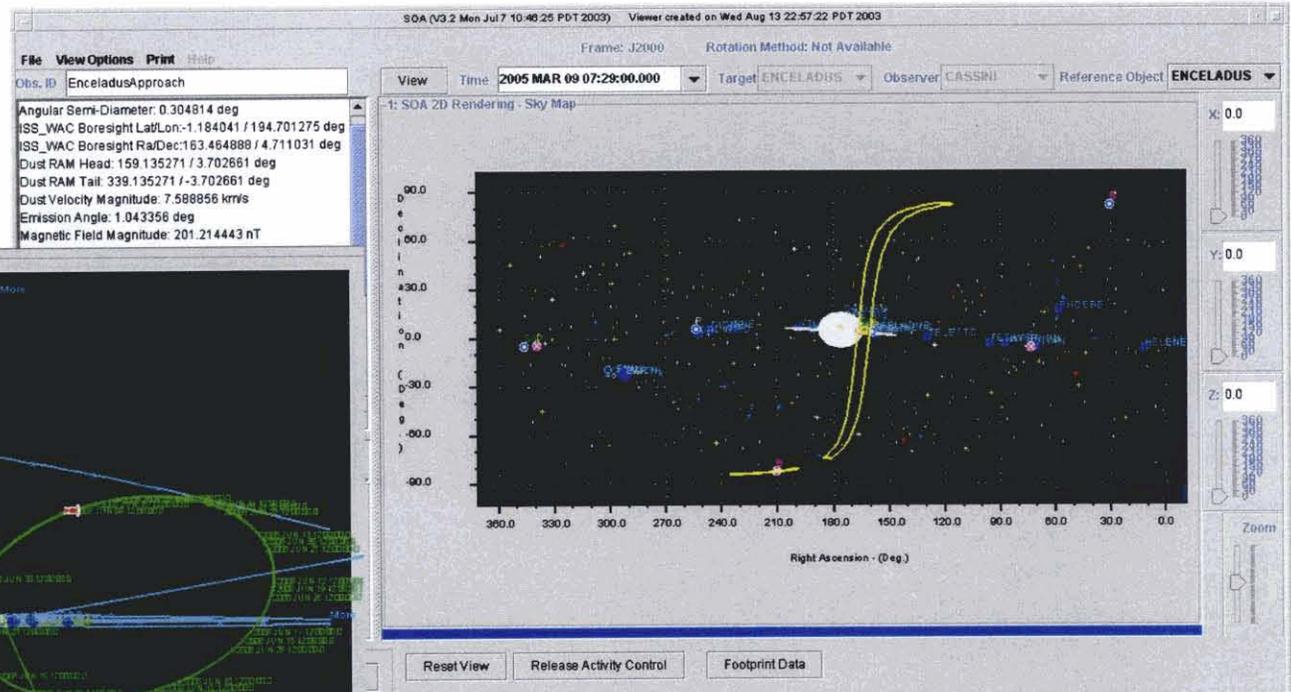




JPL

CASSINI

2-D Sky Map view with the CAPS ELS FOV displayed



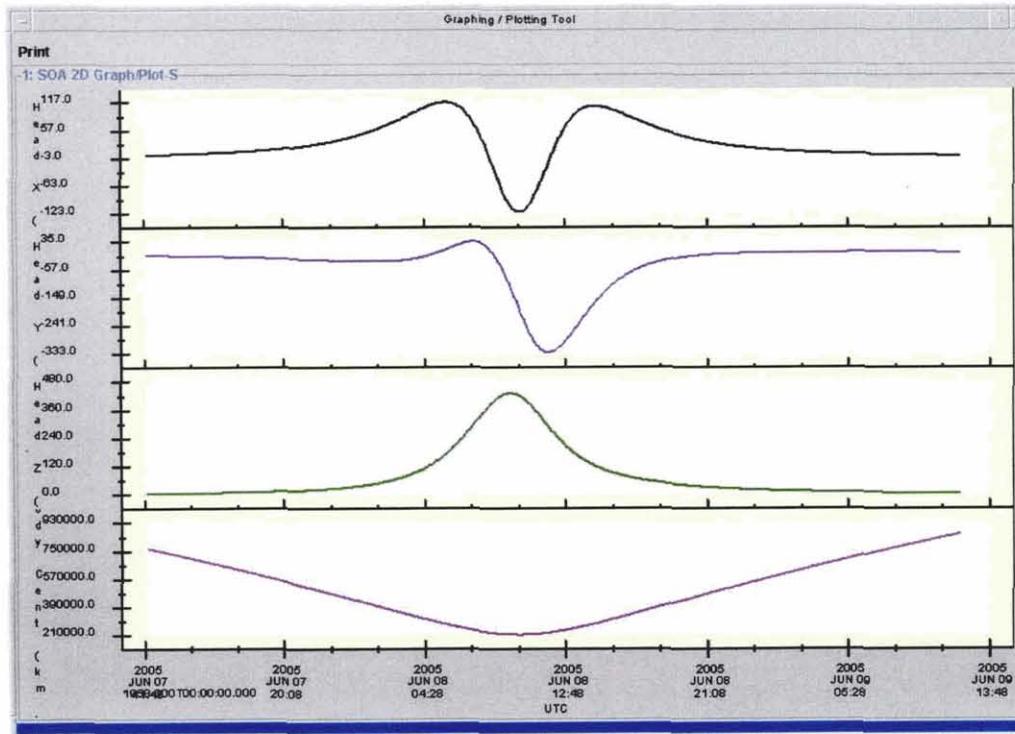
2-D Trajectory view of the X-Z plane, with Cassini spacecraft trajectory (green) and satellite trajectories (blue) shown. Time tick marks help the user identify times of interest for an observation.



Data Output

CASSINI

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.

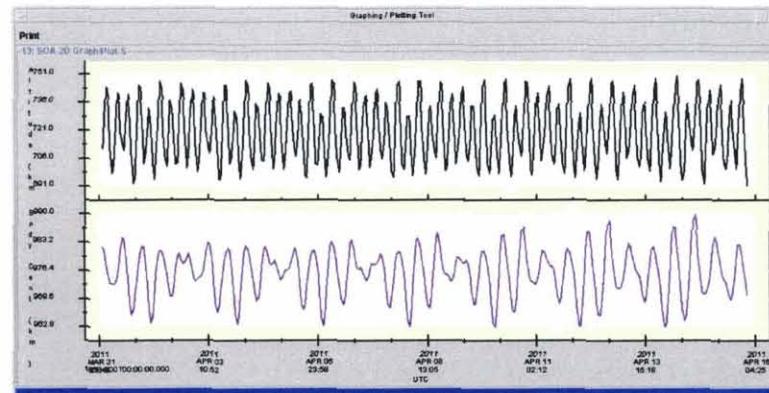
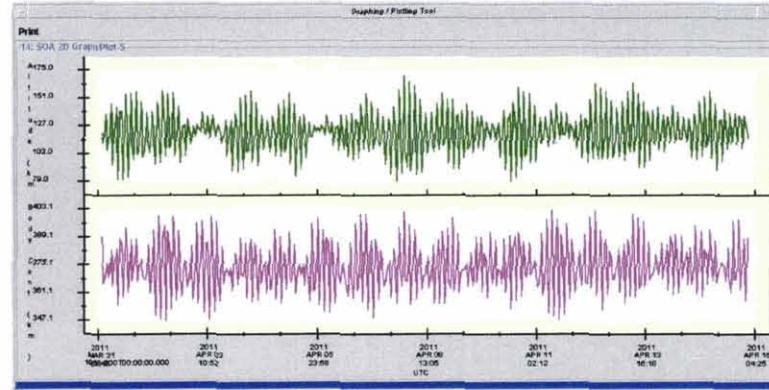




Multi Mission Operations Office



JPL

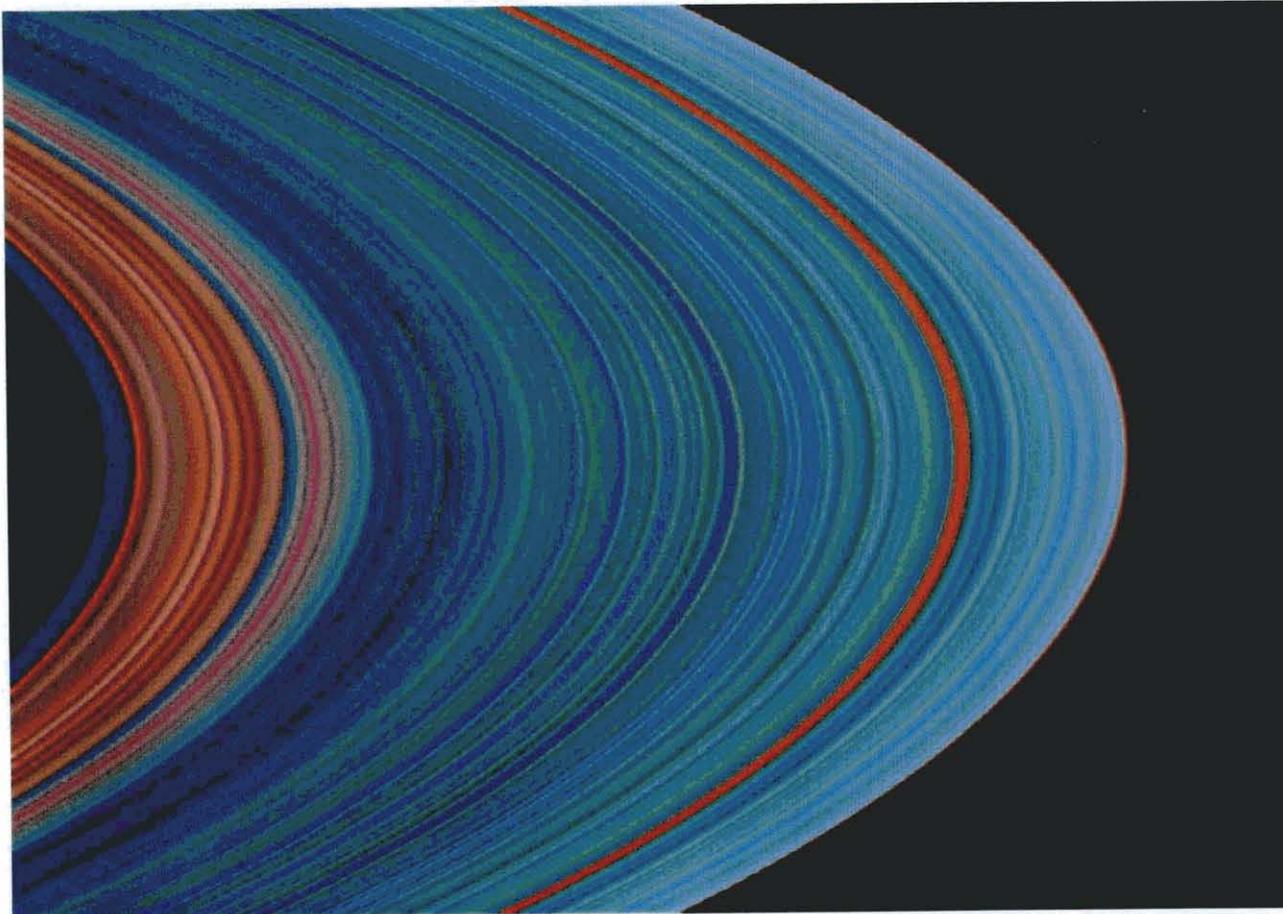


DAWN

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.



Actual Cassini Observation of Saturn's Rings



Courtesy of NASA/JPL/University of Colorado



CONCLUSION

- SOA is easy to use. It only requires 6 simple steps.
- 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.

