nity Analyzer (SOA)

CREATE YOUR OWN SCIENCE PLANNING TOOL IN 3 DAYS WITH SOA

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1. INTRODUCTION

- 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.
- SOA can be made available to new space missions at low cost
- SOA is written in Java and is available on the Sun, PC Windows and PC Linux.

2. THE 3 DAY SCIENCE PLANNER

- SOA is configurable to a specific mission by a process 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.
- SOA.
  - SOA has been fully adapted for the Cassini/Huygens mission to Saturn by adding project specific activities, flight rules, output, etc.
  - 3 Day adaptations have been made for the Europa Orbiter, Mars Reconnaissance Orbiter, Deep Impact, and Dawn missions
  - This presentation describes a 3 Day adaptation for the Dawn mission to the asteroids Vesta and Ceres. Dawn is planned to launch in 2006 and arrive at Vesta in 2010.

2. THE 3 DAY SCIENCE PLANNER

- The SOA Development Team created the Dawn 3 Day Adaptation using the following information:
  - UCLA Website (http://www-ssc.igpp.ucla.edu/dawn/)
    - Mission objectives
    - Mission timeline
  - Proposal
    - Instrument names
    - Instrument definition
  - SPICE kernels
    - Dawn spacecraft trajectory
    - Ephemeris for Ceres and Vesta
- At this point the Dawn project is evaluating its use of SOA

3. NAVIGATION/CELESTIAL BODY DATA

STEP 1: Obtain or create the mission specific SPICE kernels

•SOA is a SPICE based tool and requires the SPICE library and SPICE kernels to perform modeling and celestial coordinate transformations.

•This step is the most challenging of the three steps of adaptation

–Often new missions don't have an official spacecraft identification number (S/C ID)

•A special Name kernel had to be created for Dawn

•Different Dawn trajectories had different S/C IDs

–New target bodies may not have supporting coordinate frame kernels

•Coordinate frame kernels were created for Vesta and Ceres

3. NAVIGATION/CELESTIAL BODY DATA

List of required SPICE kernels indicating those normally provided by the Navigation and Ancillary Information Facility (NAIF) at JPL and those created by the SOA Development Team

Provided by NAIF	Created by SOA Team
•Planetary ephemeris data (Sp kernels) •S/C Trajectory (Sp kernels) •Planetary constants (Pc kernels) •Leap second kernel	•S/C coordinate frames definition (Frame kernels) •S/C clock kernel •S/C rates and acceleration definitions (Mission kernel) •Instrument field of view geometry specification (I kernels) •Vesta & Ceres coordinate frames

4. SOA CONFIGURATION FILE

STEP 2: Create SOA Configuration File

- SOA configuration file loads project-specific information into SOA
  - SPICE kernels
  - Significant event times defined as "epochs"
  - List of generated "Favorite times"
  - User Preferences
- Configuration file uses Java Beans
  - Advantage: Java does the interpretation of the file
  - Disadvantage: It looks like code
- SOA does not need to be recompiled to switch from mission to mission nor does it need to be restarted to switch from one S/C trajectory to another.

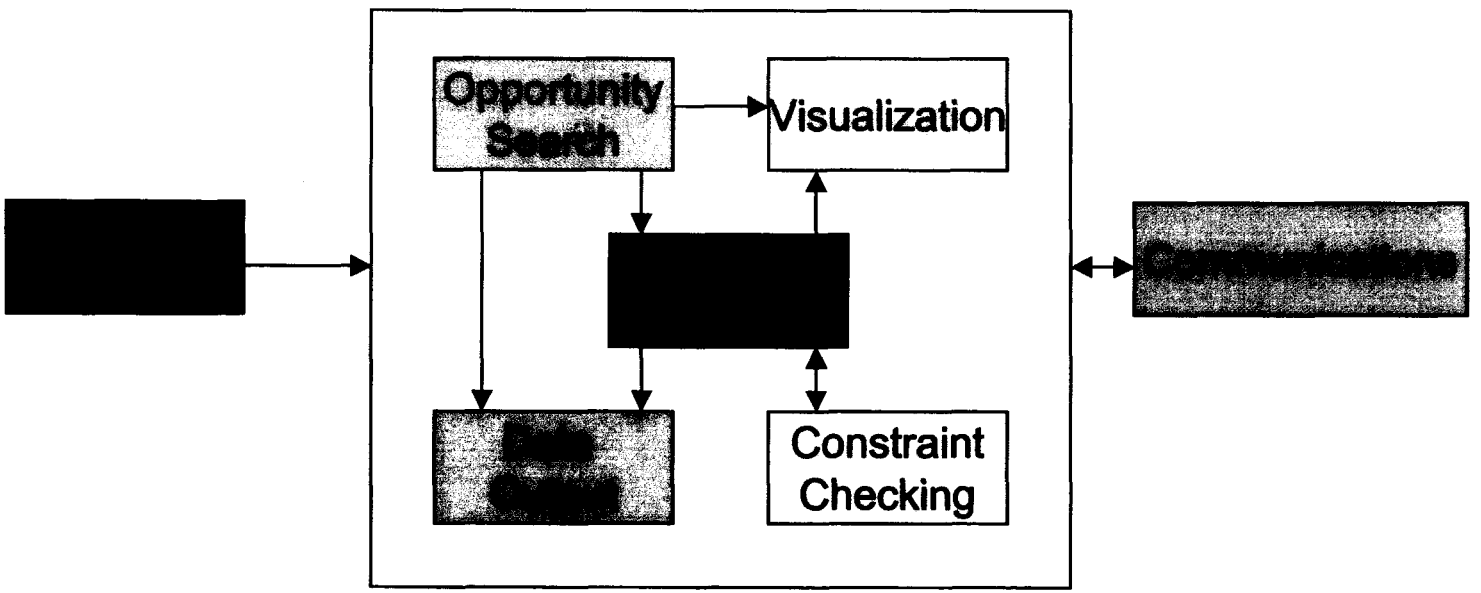
5. CHECKING CONSTRAINTS

STEP 3: Create mission specific flight rules (Optional)

- Although it is not required to create flight rules in SOA, most science instruments do have operating constraints to insure their health and data quality
  - Example: Sun avoidance or other exclusion zones
- SOA provides rule building blocks and an easy-to-use, drag and drop interface to create project specific flight rules
- For the DAWN 3 Day Adaptation a rule has been constructed to detect when the framing camera is within 20 degrees of the Sun.

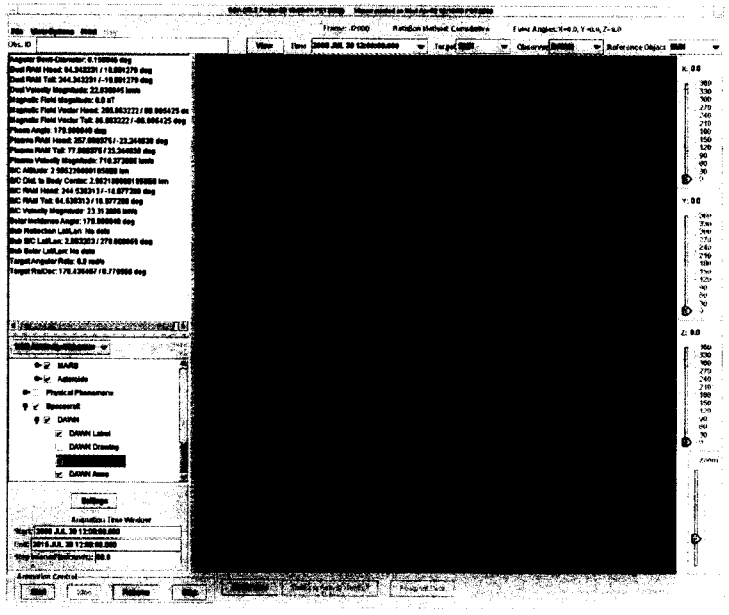
6. SOA FUNCTIONS

- Now the Dawn 3 Day Adaptation is complete and SOA is ready to be used
  - 5 of the 6 major functions are available



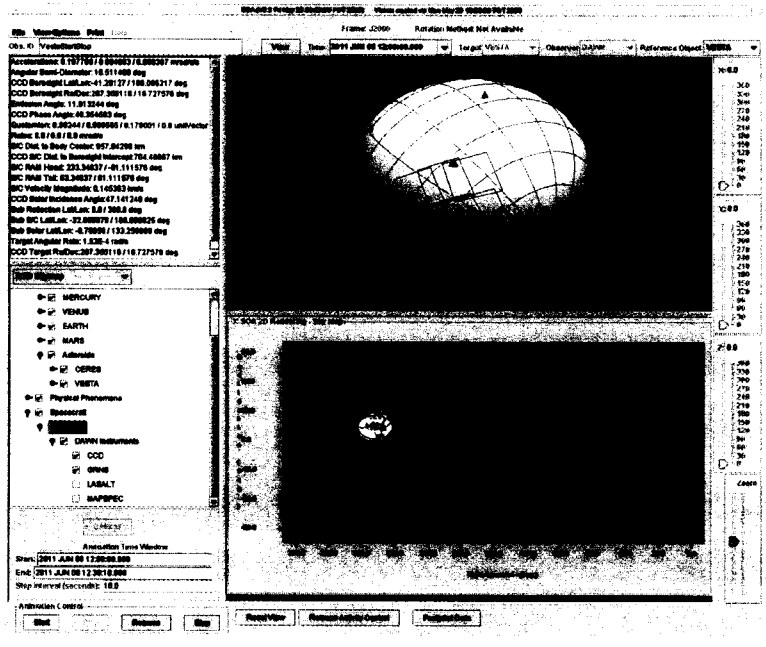
6. SOA FUNCTIONS

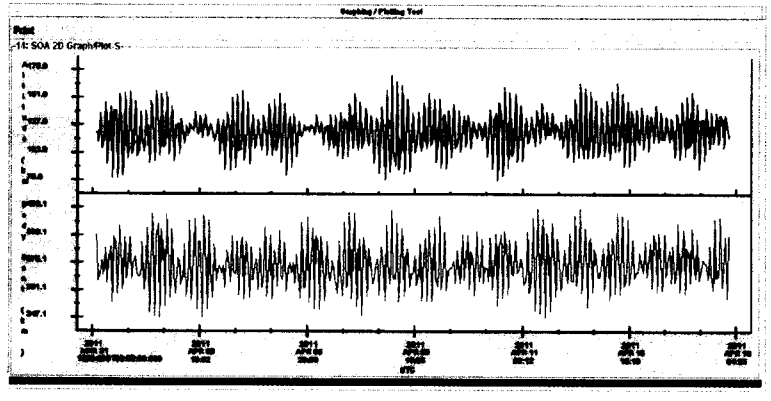
- Opportunity Search
  - Find one or more windows of opportunity for an observation based on specific geometric criteria using the PERCY search engine
- Observation Design
  - Create nxm mosaic, scan mosaic, roll about an axis, or track a target
- Constraint Checking
  - Check observations against specific geometric constraints
- Data Output
  - Obtain ancillary data as either a tab delimited text file or plots
- Visualization
  - Visualize the system or an observation 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

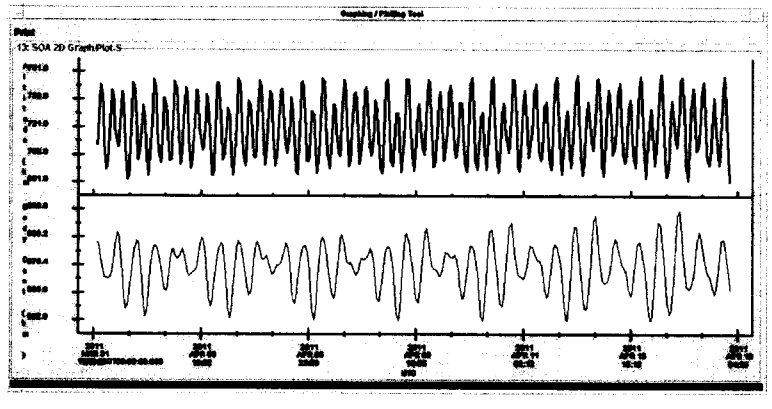


View of the Dawn trajectory and all of the inner planets around the Sun.

Two views (a 3-D perspective projection and a 2-D sky map) of Vesta from the Dawn spacecraft. The start stop mosaic observation shows both the camera and the gamma ray/neutron spectrometer fields of view







Two Data Output plots show the 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.

7. MISSION PHASES

SOA can be used in any mission phase

- Formulation: Pre-Phase A through Phase B
  - 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
- Implementation: Phases C & D
  - Mission and Science operations planning
- Operations: Phase E
  - Create observations and promote to the uplink system
  - Investigate the impacts of changes to the nominal trajectory

8. COST SAVINGS

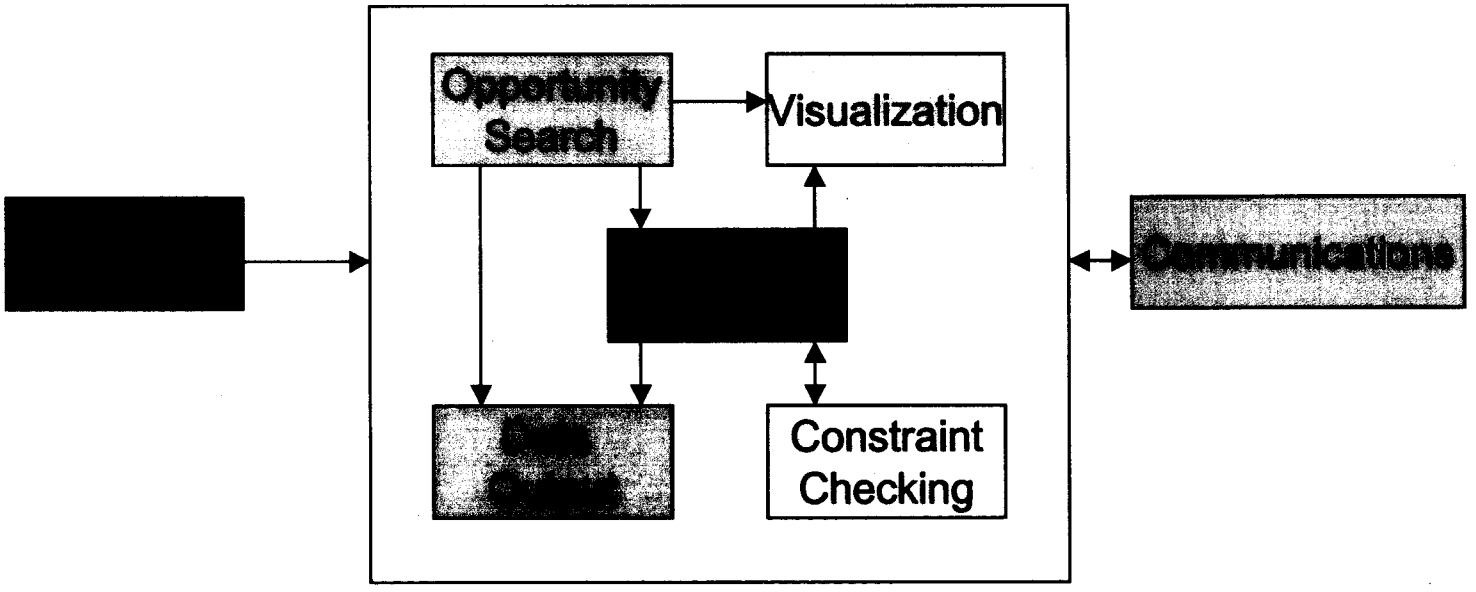
- No Initial Cost
  - 3 Day Adaptation is FREE
- Little or No Training Costs
  - SOA is EASY TO USE
- No Documentation Costs
  - SOA comes with both a User's Guide and an Adapter's Guide
- Increased Productivity
  - No knowledge of navigation or orbital mechanics required
  - Feasibility of observation design promoted
  - Reduced feedback loop with planners

REQUIREMENTS FOR DISTRIBUTION

- SOA software is International Traffic in Arms Regulations (ITAR) controlled
  - International investigators can be cleared through their JPL projects to obtain SOA.
  - USA investigators can obtain SOA through a contract with JPL.
- SOA is licensed through California Institute of Technology.
  - All investigators must sign a license agreement.

9. CONCLUSIONS

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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