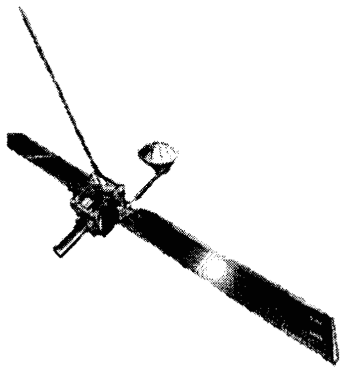
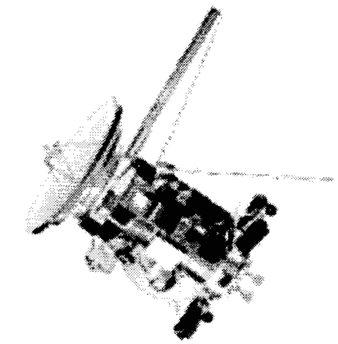


Section 314



Mission Systems Engineering

Agenda

- Overview of Mission Systems Engineering Section.
- Possible areas we may be able to provide expertise.
- Possible areas for collaboration.

JPL

Section Charter

Section 314 provides people, processes, tools, and infrastructure that transform scientific and engineering goals into spacecraft executable events.

Section Role

The Mission Systems Engineering Section is a center of excellence for the engineering and operation of project systems for space missions. It provides a resource of expertise for the design, development, integration, test and management of innovative mission operation systems. It leads the system analysis for cost-efficient migration of ground functions to the spacecraft. It manages the operations of project systems in the areas of science planning and sequencing.

Major Responsibilities

- Lead the Mission Operations Systems Engineering and Project Data System Engineering design activities for flight projects.
- Coordinate mission systems implementation and ensure compliance with requirements.
- Lead the Mission Sequence process development, generation, and operations.
- Capture science system requirements and coordinate science sequence development, integration, and operations.
- Lead the development and maintenance of project software systems for science and spacecraft planning and sequencing, incorporating state of the art hardware and software technologies.
- Lead the development of technological innovation for advanced mission concepts and systems.
- Coordinate Project Data System Engineering Integration and Test.

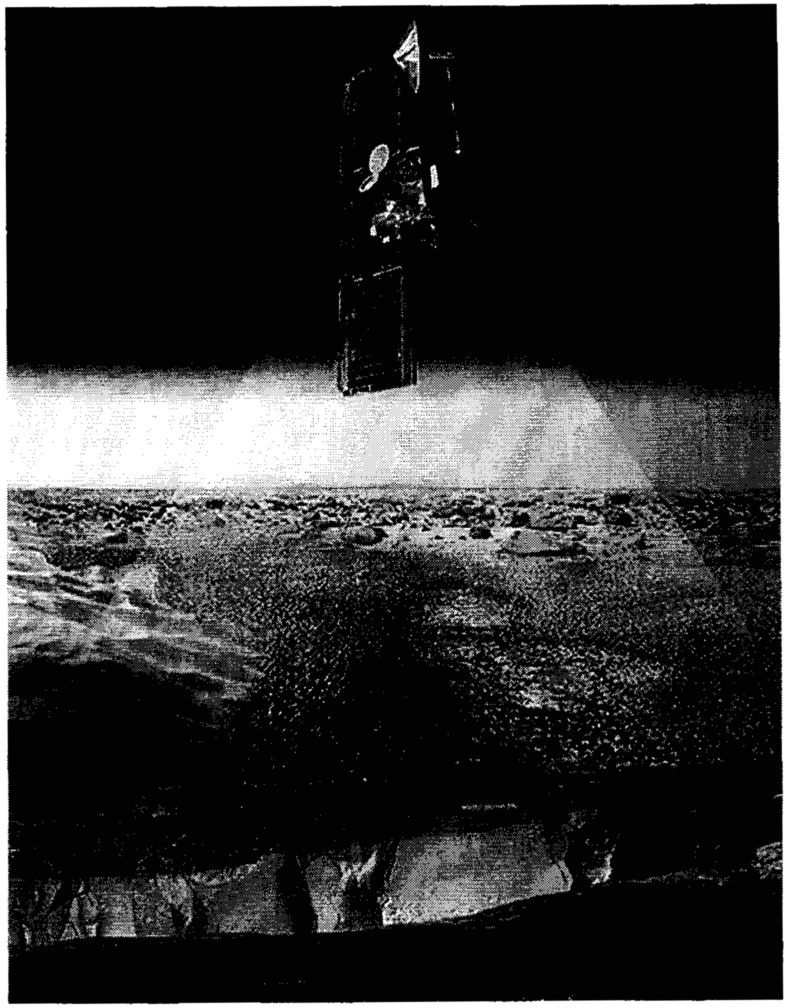
Major Products Supplied by Section 314 Include:

Mission Operations System

The Mission Operations System (MOS) is the set of resources (people, processes, procedures, interfaces, hardware, software, and networks) and activities required to remotely control, analyze, and monitor a space flight system and to deliver the engineering data and scientific products to the users (engineers and scientific community).

Mission Ground Data System

GDS: The Ground Data System is the set of hardware and software tools utilized by Mission Operations System operations teams to carry out uplink and downlink procedures required for mission data system processing.



Level 3 Groups Include:

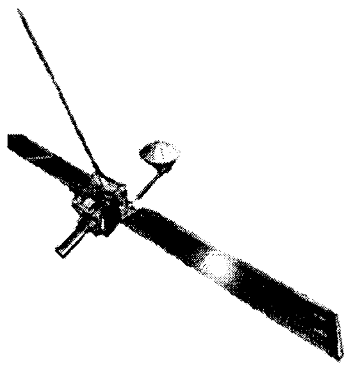
Mission Operations Systems Engineering
Mission Data Systems Engineering
Advanced Mission Systems Engineering

Level 4 Groups Include:

Science System Engineering
Cassini Science and Sequence Systems
Integrated Flight Engineering
Integrated Mission Capability Engineering

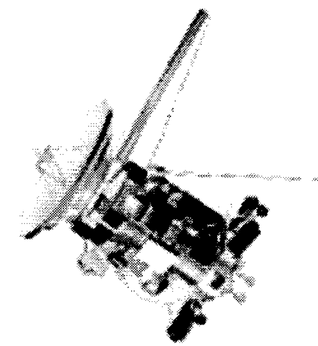
Level 5 Groups Include:

Mission Modeling and Adaptation
Mission Applications Software Engineering



Areas We

May Be Able to Help



•Sequencing Architecture - the software architecture being used enables a rapid initial development and less time spent in test & verification.

•Multi-Mission Operations - smaller teams can support more missions, developed over a many year period.

•Event Driven Sequencing - events occur at absolute and relative times. non-deterministic sequencing permits more efficient operations.

•Constellation Operations - modeling of multiple spacecraft with limited interaction of "other" spacecraft states is needed for Deep Impact.

Sequencing Architecture

•Until the early 1990s, each spacecraft developed its own individual sequencing system/programs. Sequencing systems are quite expensive to develop

•In an effort to reduce cost and development time, a "Multi-Mission" Sequencing architecture was developed which promoted reuse of sequencing system components.

•The Sequencing software is broken into two components

- •"Core" software contains the ability to perform a specific function
- •"Adaptation" is the process of adding project specific components that rely on Core functionality.

Current Sequence Architecture

SEQ

- CORE (MULTI-MISSION & GENERAL PURPOSE)
- Adaptation
  - PROJECT ADAPTATION
  - CUSTOM

CORE (MULTI-MISSION & GENERAL PURPOSE)

TOOLS FOR:

- SCIENCE OPPORTUNITY ANALYSIS
- SEQUENCE AND ACTIVITY PLANNING
- SEQUENCE DESIGN
- SEQUENCE INTEGRATION & VERIFICATION
- COMMAND GENERATION

PROJECT ADAPTATION

DATABASES AND SCRIPTS

FOR PROJECT-SPECIFIC:

- COMMANDS
- FLIGHT RULES
- MODELS
- OPERATIONS PROCESSES
- PROCESS AUTOMATION (ASP)

CUSTOM

TOOLS AND SCRIPTS FOR PROJECT-UNIQUE:

- FILE CONVERSIONS
- DATA INTERFACES
- OTHER PROCESSES

Pro & Con of the Multi-Mission Architecture

- Pro
  - Time savings
    - Since the basis for the sequencing system already exists, simple commands (NOOP) can be passed through the "real" sequencing system in less than a week.
  - Cost savings
    - The "functionality" correctness is checked once. Projects need to verify only the adaptation.
    - Pool of adapters who are familiar with the sequencing software. Adapters can easily transition from one project to another.
- Con
  - Having to balance the needs across multiple customers
    - Conflicting desires in software functionality
    - The continued support of legacy needs
    - Balancing delivery schedules to meet needs of new customers or during critical mission events.

Multi-Mission Operations (MMO)

- Operations procedures are common to all more recent spacecraft (Mars Global Surveyor, Stardust, Mars Odyssey, Genesis, Space InfraRed Telescope Facility, Deep Impact, Mars Reconnaissance Orbiter), except Mars Exploration Rover.
- The MMO team is comprised of individuals that concentrate on a single project, but are able to backfill on several other (if not all) projects.

Pro & Con of Multi-Mission Operations

- Pro
  - Smaller teams
    - Common procedures mean fewer single point failures.
  - Cost savings
    - Working operations procedures already exist; operations development procedures are much more rapid.
    - Pool of personnel who can easily transition from one project to another and provide assistance during critical event periods.
- Con
  - Many projects think they are special, and their needs cannot be met by a multi-mission team.

Event Driven Sequencing

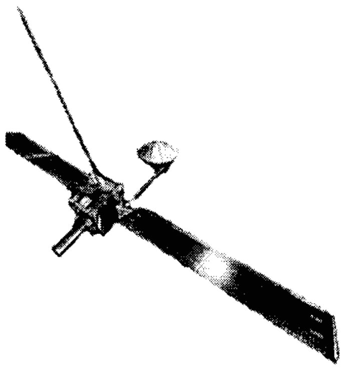
- Until the last few years, all of our spacecraft used absolute time tagged sequencing. Events occurred at an absolute time, and padding in the time was added to account for non-deterministic events (e.g. setting time for a slew, aerobraking)
- This "padding" negatively impacted SIRTF's ability to meet efficiency requirements and science goals.
- The use of event driven sequencing was began and is in use on Mars Odyssey and SIRTF.
  - WAIT until a Step A is completed, then start Step B.
  - A combination of absolute and relative time sequencing is used.
    - Absolute times are used for critical events, such as DSN communications.
    - Relative times are used for difficult to predict time events.

Pro & Con of Event Driven Sequencing

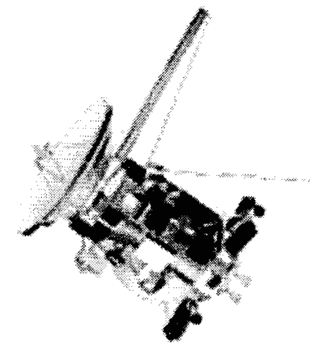
- Pro
  - More efficient operations.
  - Enables completion of more difficult operations strategies.
- Con
  - You no longer totally control your spacecraft! You no longer know when certain events will occur.

Constellation Operations

- Deep Impact consists of two spacecraft. The Flyby and the Impactor.
- The Impactor will have, in a limited set of circumstances, the need to make decisions based upon the states of Flyby.
- At SpaceOps 2002 (October 2002, Houston Tx), none of the constellation spacecraft relied on any information on another spacecraft in the constellation.
- We are only beginning this work.



Areas We May Collaborate



- Non-Deterministic Sequence Validation
- Formation Flying

Non-Deterministic Sequence Validation

- Fuzzy Sequence Validation
  - Sequence validation when the time of an event is unknown (current state).
  - Sequence validation as the spacecraft get smarter (perhaps including artificial intelligence) (eg. Mars Reconnaissance Orbiter will decide whether it has sufficient time to observe a target).
  - Sequence validation when the order of events is unknown (eg. if I finish my other tasks quickly, study Rock A next, otherwise, study Rock B.)

Formation Flying Operations

- Constellations - when multiple spacecraft are flown in loose proximity.
- Formation Flying - when the operation of a spacecraft is dependent on states of other spacecraft.

- Eg. if an interesting target is observed by multiple spacecraft. Decisions about next activity based on
  - Which spacecraft is better "prepared" (resources, critical events, geometric position, etc.) to perform the next series of activities