SciBox, a Proven Automated Planning and Commanding System

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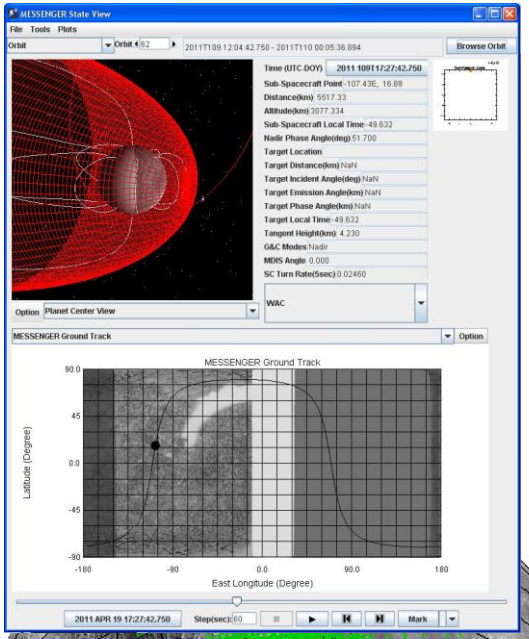
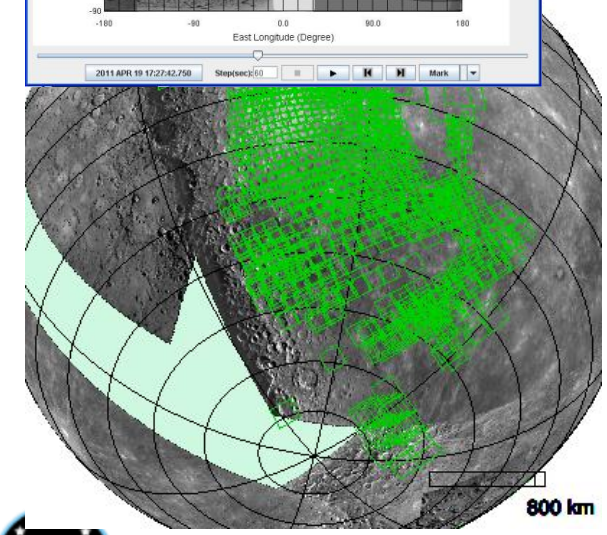
What is the SciBox Planning System?

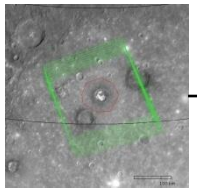




The SciBox Planning System is an end-to-end automated operational planning and commanding system

- **End-to-end**: from operation objectives to uploadable spacecraft commands
- **Planning**: plans and creates conflict-free and efficient operation schedules
- **Commanding**: creates commands to drive spacecraft and payloads
- **Automated**: no manual scheduling and no manual command scripting
- **New approach**: radically different from traditional planning system

Traditional Planning Process



Task Request from user

Payload teams

G&C Sequencers
Observation Opportunities

Payload Operators

Payload Sequencers
Command Scripts

Hardware Engineers
Constraint Validation

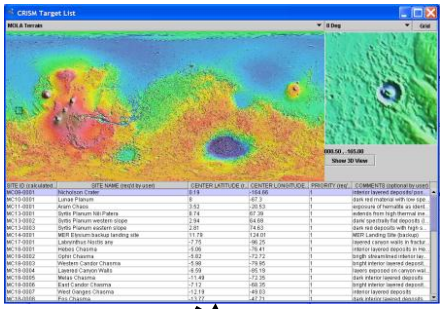
Mission Ops Team
Scheduling
Validation

- **Complicated, iterative approach**
- **Labor intensive process**
- **Poor system-response time**
- **Underutilized resources**
- **Hidden Risk**

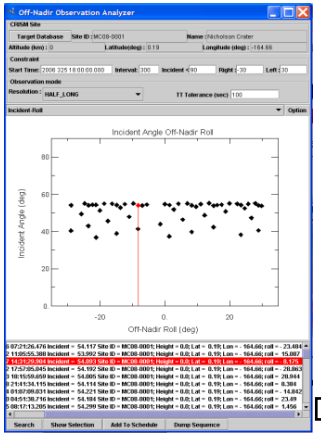
More Efficient SciBox Approach

- **Streamlined sequential steps**
- **Automated with an integrated software system**

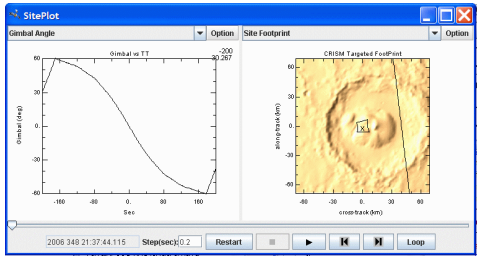
Objectives



Validated Opportunities



Opportunity Analyzers



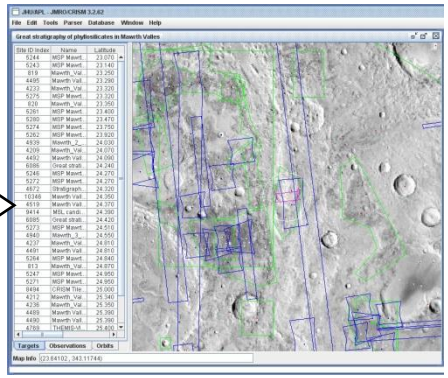
Hardware and Operational Constraints

1st Solar Day	2nd Solar Day
Eclipse	Eclipse
Orbit Correction Maneuver	Orbit Correction Maneuver
Mercury Orbit Insertion	Downlink - High Gain Antenna
Downlink - High Gain Antenna	Priority-1 Targeted Observation
Post MOI	UVVS Polar Exosphere Scan
Priority-1 Targeted Observation	MDIS Stereo Mapping
UVVS Polar Exosphere Scan	MLA North Polar Off-Nadir Coverage
MLA Northern Hemisphere Nadir Coverage	MLA Northern Hemisphere Nadir Coverage
Priority-2 Targeted Observation	Priority-2 Targeted Observation
MDIS-WAC South Pole Monitoring	MDIS NAC 3x2 South
UVVS Star Calibration	UVVS Star Calibration
XRS Star Calibration	XRS Star Calibration
UVVS Limb Scan	UVVS Limb Scan
Priority-3 Targeted Observation	Priority-3 Targeted Observation
XRS/VIRS Global Mapping	XRS/VIRS Mapping
MDIS Global Color Mapping	Priority-4 Targeted Observation
MDIS Global Monochrome Mapping	UVVS Exosphere Scan
Priority-4 Targeted Observation	MDIS North Polar Ride-Along
UVVS Exosphere Scan	MAG Observation
MAG Observation	GRS Northern Hemisphere Coverage
GRS Northern Hemisphere Coverage	NS Northern Hemisphere Coverage
NS Northern Hemisphere Coverage	EPS Observation
EPS Observation	FIPS Observation
FIPS Observation	RS - Low Gain Antenna
RS -Low Gain Antenna	Priority-5 Ride-Along Targeted Observations
Priority-5 Ride-Along Targeted Observations	Priority-6 Ride-Along Targeted Observations
Priority-6 Ride-Along Targeted Observations	Priority-7 Ride-Along Targeted Observations
Priority-7 Ride-Along Targeted Observations	

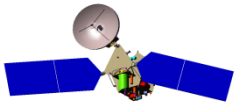
Priorities

Schedulers

Conflict-free and resource fully utilized schedule

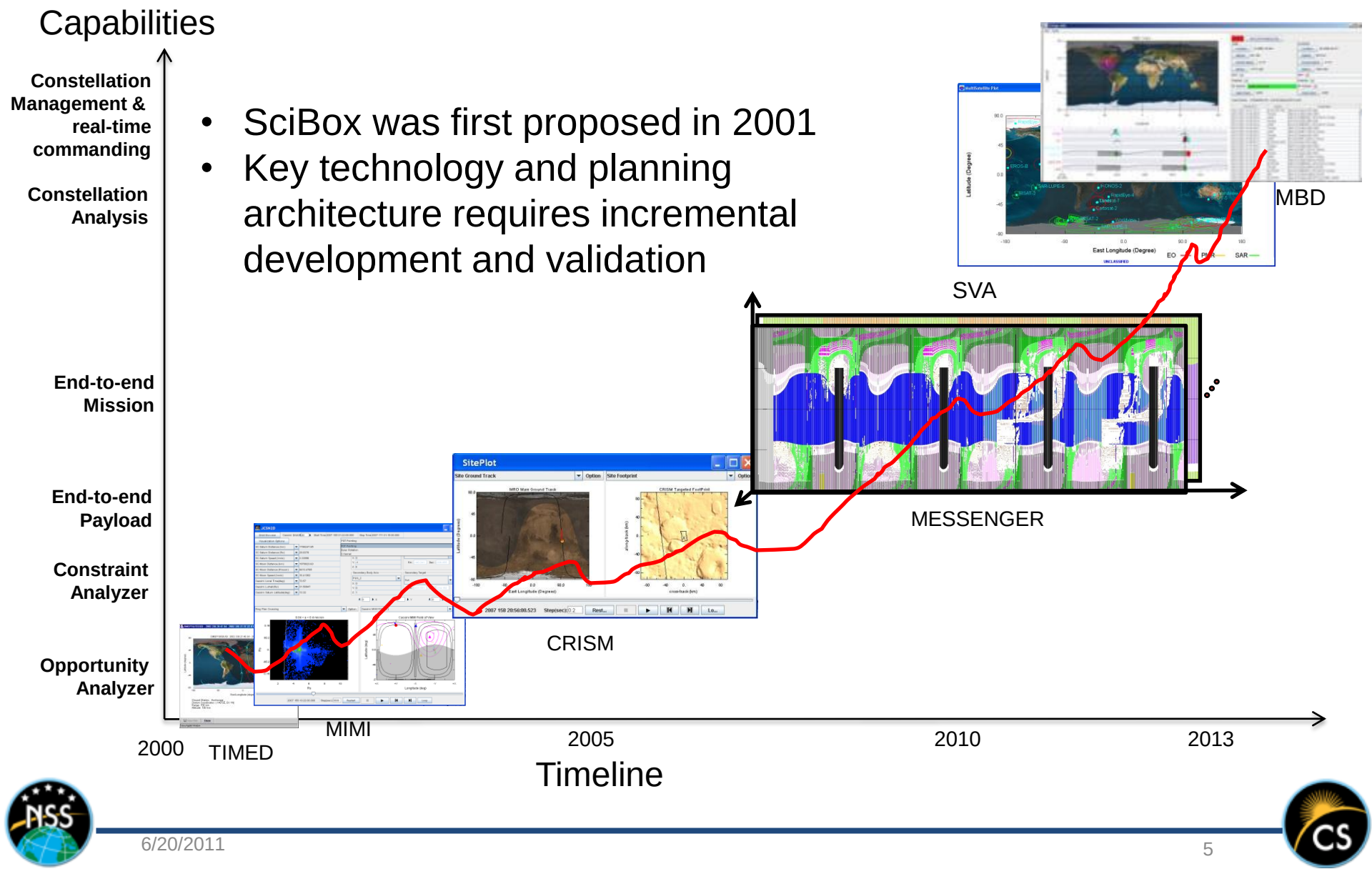


Command Generator

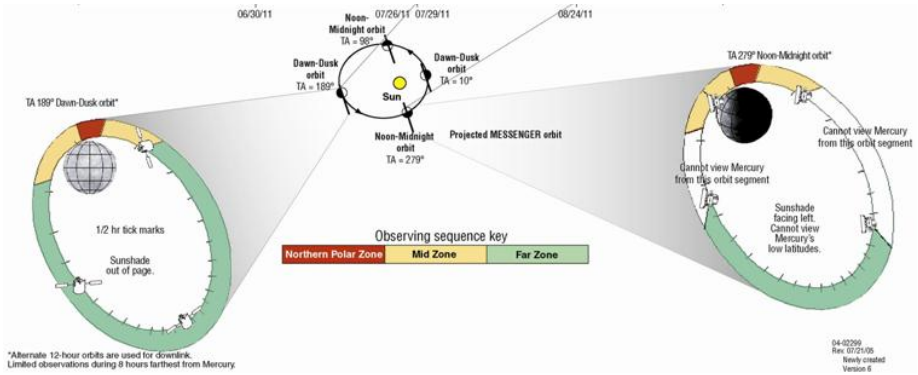


Commands

SciBox capabilities demonstration history

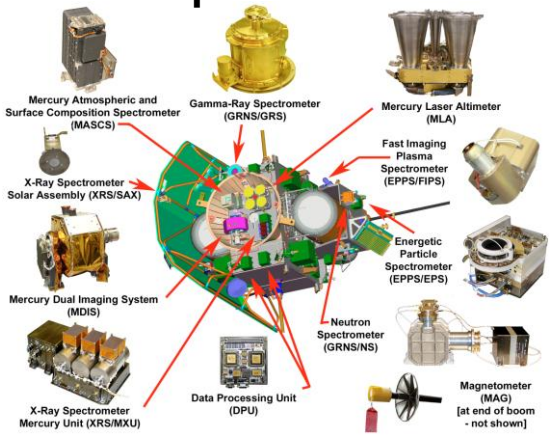


Challenging Mission



- **MESSENGER's mission is to study the Mercury environment**
- **Complex observing geometry**
  - Highly elliptical and non-Sun-synchronous orbit
  - Every observing position is unique
- **Many operational constraints imposed by the harsh environment**
  - Many thermal constraints
- **Limited resources to satisfy ambitious measurement requirements**
  - Competing pointing requirements
  - Limited downlink bandwidth
  - Limited data storage

7 Instruments(10 Sensors) + Radio Science Experiment



6 Measurement Activities
Global surface mapping
Northern hemisphere and polar region observations
In-situ observations
Exosphere survey
Region-of-interest targeting
Radio science measurements

MESSENGER SciBox Approach

- **SciBox tailors each operations sequence for each constraint-compliant observing geometry**
- **Different scheduling priorities for the two Mercury solar days**
  - 1 Mercury solar day = 176 Earth days
  - First Mercury solar day focuses on survey mapping
  - Second Mercury solar day focuses on stereo mapping, observation recovery, and high resolution targeting.

MESSENGER Scheduling Priorities

1st Solar Day	2nd Solar Day
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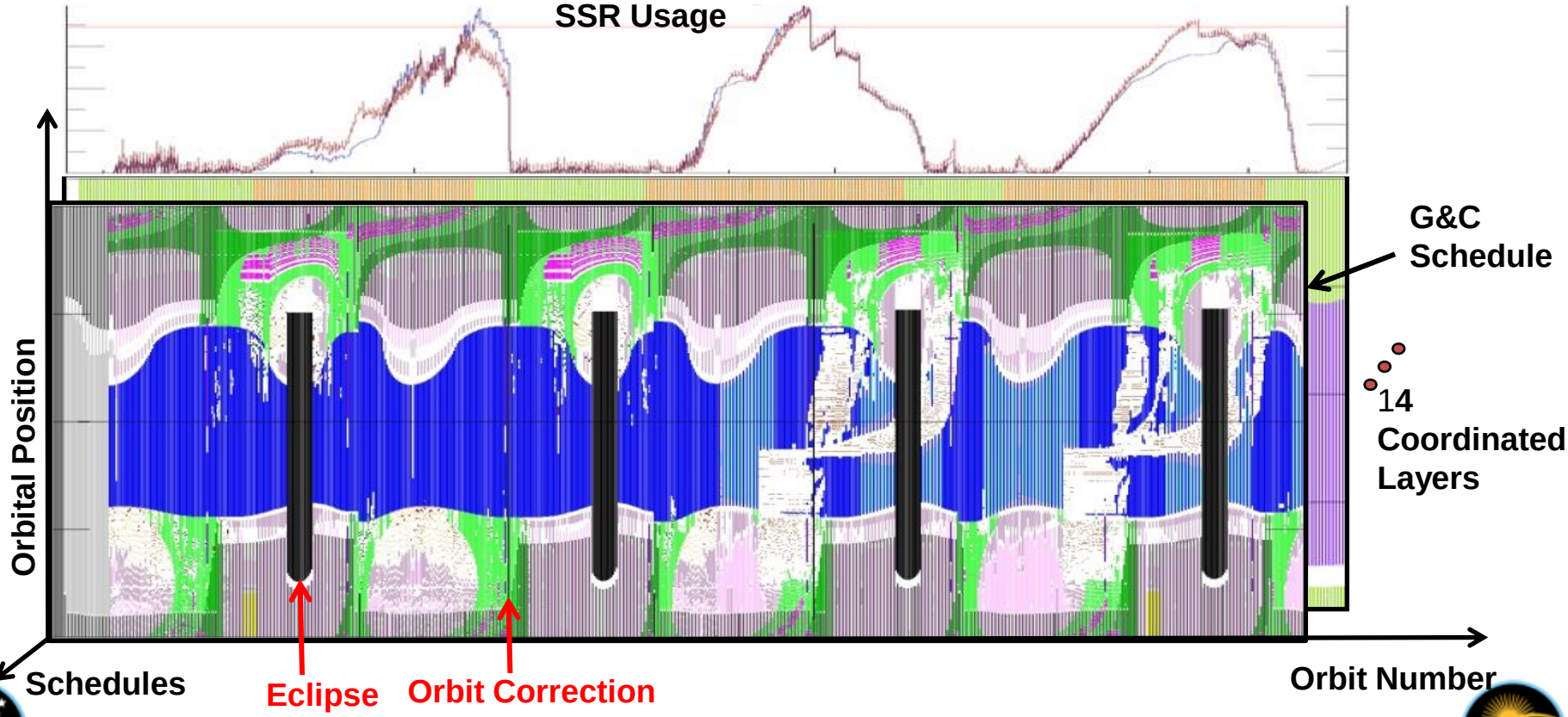
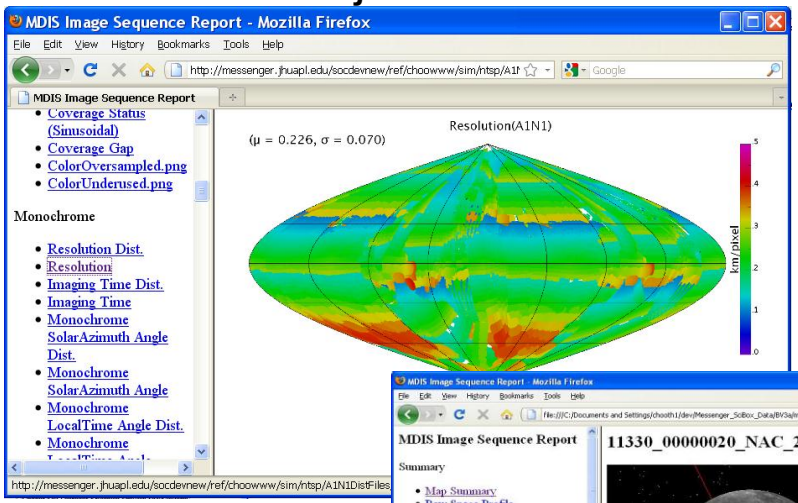
Fully Utilized Coordinated Schedules

- **750 orbits in a 1-year orbital phase**
- **14 coordinated schedules**
  - 10 sensors, G&C, SSR, Solar Panel, and RF
- **~80,000 images, > 4 millions spectra, > 360 DSN Tracks**
- **~ 3 hours to run**

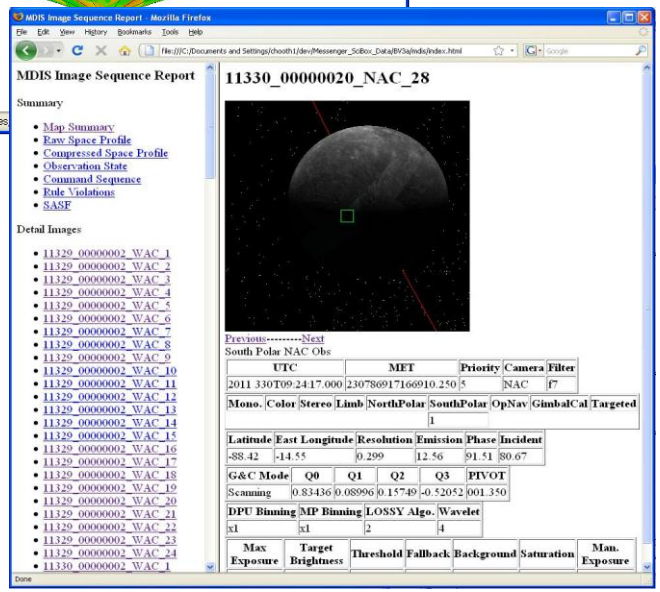


Comprehensive Reviewing System

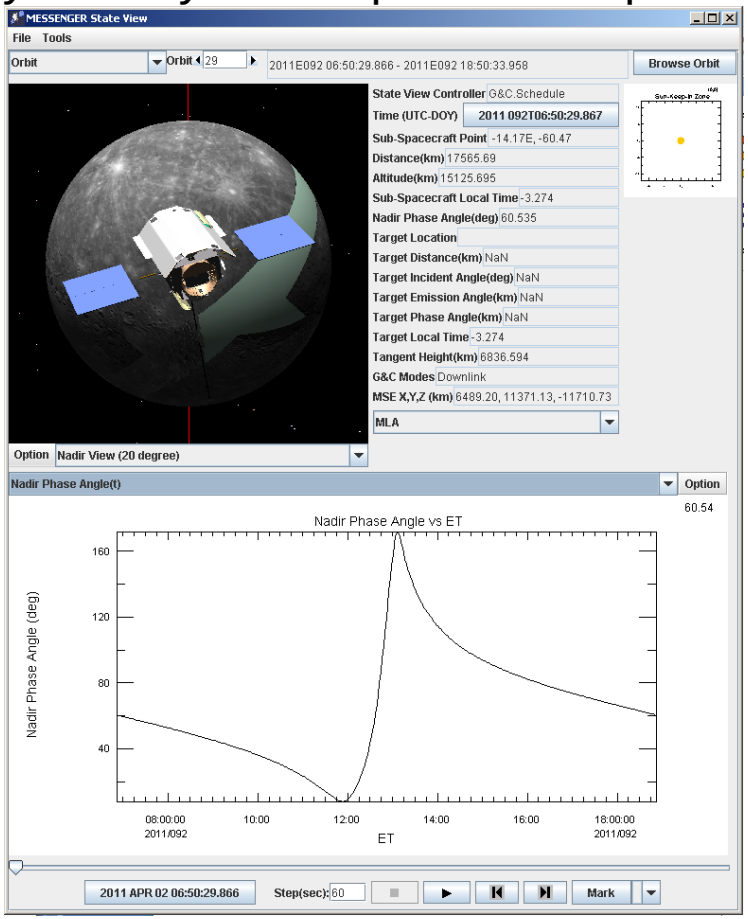
Qualitative global coverage for each measurement objective



Detailed quantitative statistics for individual measurement

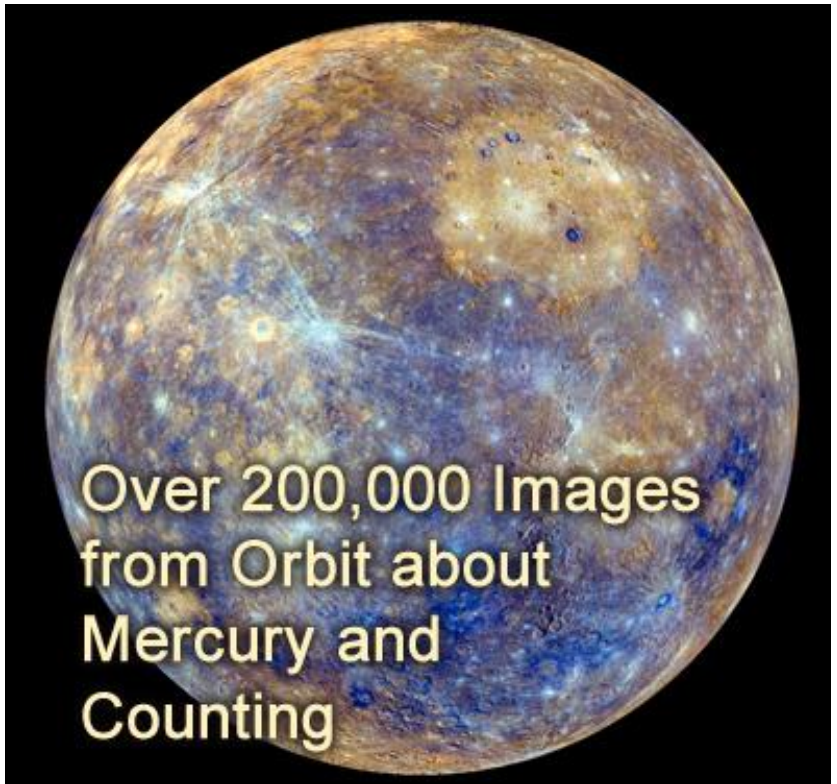


Interactive Graphical user interface for analysis of dynamic operation sequence



Actual Orbital Usage

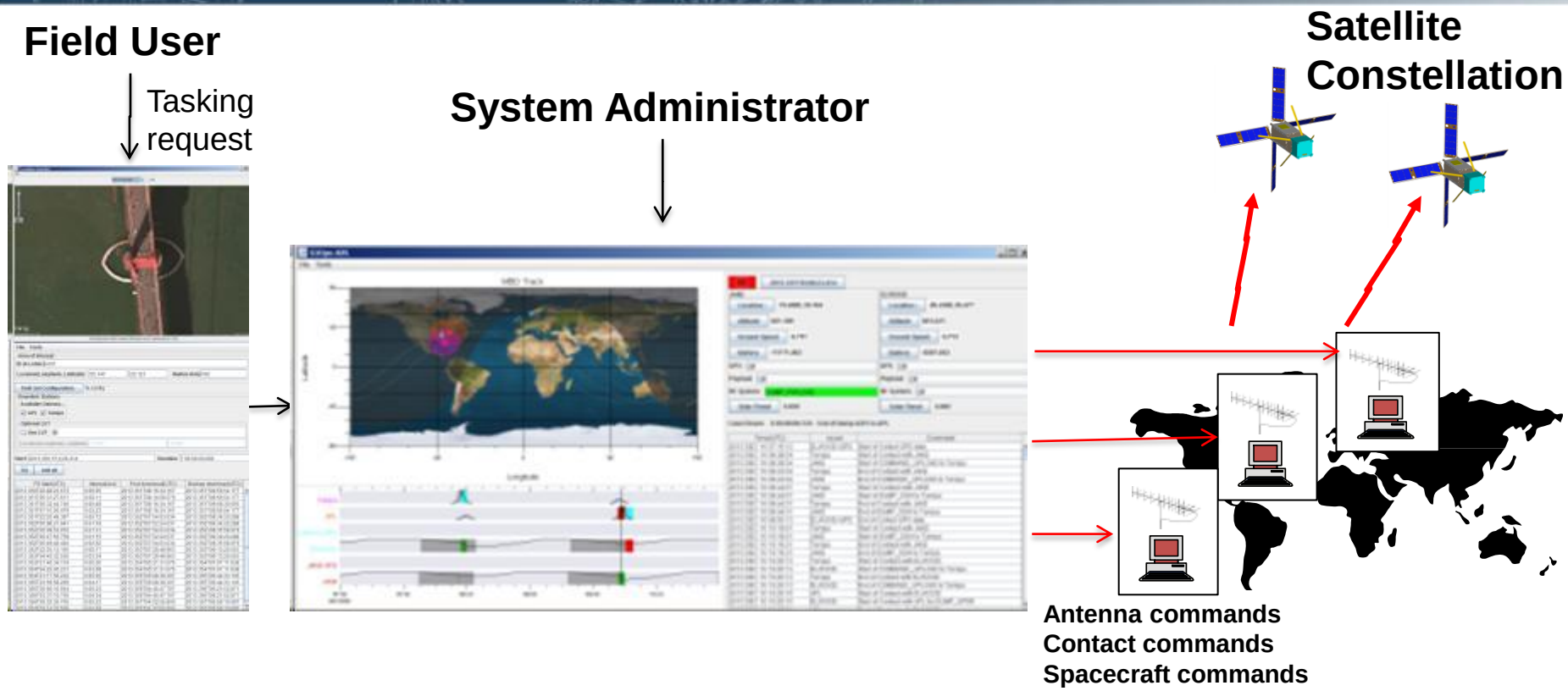
- **Schedule is re-planned every week**
  - Uses the latest orbit-prediction DSN schedule
  - Uses the latest feedback knowledge
  - Generates one week of commands
- **Science acquisition progress is monitored weekly**
- **>2.5 years of successful operation**
  - More observations
    - > 200,000 images
    - > 7 million spectra
  - Better observations
    - Better map resolution
    - Better spectra resolution
  - No safe mode and no commanding anomalies.



Mission News
February 6, 2014

MESSENGER Surpasses 200,000 Orbital Images of Mercury
MESSENGER has now returned more than 200,000 images acquired from orbit about Mercury. The 1996 proposal for the mission promised a return of at least 1,000 images says Robert Gold, MESSENGER's Science Payload Manager. "We expected then that we would have some data compression that would probably raise the image total to somewhere near 2,000 images," says Gold, of the Johns Hopkins University Applied Physics Laboratory (APL), but scientists did not imagine then the degree to which MESSENGER would surpass that goal. [more]

Recent National Security Space Application



- A JCTD program
- Direct user tasking
  - No manual intervention
  - Insulates user from operation of ground stations and satellites
- SciBox generates commands for ground and space segment

New Approach to Space Operations

SciBox is a proven new approach to space operations

- **Increase payload return**
  - Finds more observing opportunities than manually feasible
  - Better use of power, pointing, downlink, and recorder space
- **Improves system response**
  - Re-plans one-year orbital mission schedule in three hours
  - Enable direct user tasking
- **Reduces operations cost through reduced labor**
  - Enable > x5 cost saving on MESSENGER
- **Reduces operational risk**
  - Systematically validates every operational sequence
  - Long-term forecast provides lead-time for risk mitigation
- **New capabilities for Space Mission**
  - “What-if-scenarios” analysis
  - Free other orbital operational constraints