Kepler Mission Operations Scheduling — Resource Optimization

Charlie Sobeck
Kepler Deputy Project Manager
Kepler Mission Overview

**Mission Objectives** - Explore the diversity of extrasolar planetary systems and determine:
- The frequency of terrestrial and larger planets in or near the habitable zone of a wide variety of stellar spectral types
- The distribution of sizes and semi-major axes of these planets
- If there are additional members of each planetary system using other techniques
- Determine the distributions of semi-major axis, albedo, size, and density of short-period giant planets
- The percentage and orbital distribution of planets orbiting multiple star systems
- The characteristics of those stars that harbor planetary systems

**Mission Design**
- 3.5-year flight (>6 years consumables)
- Earth-trailing heliocentric orbit
- Single instrument
- Single field-of-view
- 170,000 targets
- Monthly data downlinks
- Quarterly rotations about the line-of-sight

Launched March 6, 2009
Transit Detection Method

• Kepler will discover planets around other stars by observing transits
• A transit occurs when a planet passes in front of its star and blocks part of the star’s light.
  – Jupiter would block 1% of the sun’s disk
  – Earth (or Venus) would block 0.01% of sun’s disk
  – Mercury blocks 0.001% of sun’s disk

Sequence of images of the Nov 8, 2006 transit of Mercury taken by the SOHO spacecraft.
Distributed Team

Key
- JPL
- ARC
- BATC
- LASP
- STScI
- Sci Team

Functional Interface
- Primary Command Flow
- Primary Telemetry Flow
Key Requirement – Data Completeness

- Transits are 5 – 20 hours in duration
- Don’t know where or when a transit will occur
- Telescope requirement is to gather data 92% of the time
- Data breaks occur due to:
  - Monthly/Quarterly downlinks
  - Reaction wheel desaturation
  - Cosmic rays
  - Anomalies
  - Others…
Data Completeness

- April Monthly Contact was 16.7 hrs
Operational Cadences

Monthly Contact:
- RWA Desat
- Turn to Earth
- P/B data stored in SSR
- File Management
- Turn Back to Science Attitude
- Thermal Stabilization
- Resume Science

≤ 24 hours

Semi-weekly Contact:
- RWA Desat
- P/B data stored in NVM
- File Management

≤ 8 hours

Quarterly Roll Contact:
- RWA Desat
- Turn to Earth
- P/B data stored in SSR
- File Management
- 90 deg roll to new Science Attitude
- Thermal Characterization/Settling
- Resume Science

Year 1:
- ~ 40 hours

Years 2-4:
- Thermal Settling
- Resume Science

25-31 hours
Cadence Data Flow

[Diagram showing various data flow processes and timelines for different tasks such as Bi-weekly DSN Contact, Monthly DSN Contact, Quarterly Roll DSN Contact, Ka-band Data Processing, Routine Contact, Generate Retransmission Req, Process Science Data, Process SSR Engineering Data, Process Science Data, Archive Science Data, PDQ Processing, Post-Roll Attitude Determination, Monthly Processing, Quarterly Processing, Science Target Update, Ops Planning and Status Mtg.]
Other Scheduling Challenges

Follow-up Observing
- Kepler has identified thousands of interesting signals that require follow-up by other ground and space-based telescopes
  - Medium and high resolution spectra
  - High resolution imaging
  - Differing band passes
- Involves many different observers, instruments and telescopes

Data Processing, Release & Publication
- Updated analysis software requires reprocessing of the data set
  - When should data be released internally to the team? To the public?
- At what point should we slow the analysis in order to publish results?

Target Management?