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Attitude and Pointing Concepts for ISS Payload Operations

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Topics

- What can be seen from ISS
- Variables that affect target viewing
  - Trajectory
  - Attitude
  - Time
  - Blockage
- Pointing considerations for payloads
- What does Pointing do for payloads
- Example payloads
  - SCaN
  - OPALS
  - SOLAR

What Can Be Seen From the ISS?

- Ground Targets
  - Cities
  - Mountains/Volcanoes
  - Rivers/Lakes
  - Natural Disasters (e.g. Hurricanes, Wildfires)
  - Ground Stations
- Celestial Targets
  - Sun/Moon/Planets
  - Stars/Asteroids/Comets
  - Extragalactic Objects (e.g. Pulsars)
- Orbiting Vehicles
  - Tracking and Data Relay Satellites (TDRS)
  - Visiting Vehicles
- Area Targets (e.g. South Atlantic Anomaly)

Trajectory

- Current ISS orbit determination can be performed by processing Global Positioning System (GPS) telemetry
- Prediction trajectory provided by the Trajectory Operations Officer (TOPO)
  - Long-term data updated weekly (8 week duration)
  - Near-term data updated every Mon, Wed, Fri (15 day duration)
- Weekly trajectory updates realize an average of 10 – 30 seconds of acquisition error
  - Re-planning trajectory events
  - ISS Debris Avoidance Maneuvers

Attitude

- ISS holds attitude by using Control Moment Gyros (CMGs)
- There are different controllers, each designed to have different steady-state performance features
  - Attitude precision vs propellant trade off
  - The ISS attitude fluctuates during the course of an orbit
- Prediction attitude data provided by the Attitude Determination and Control Officer (ADCO)
  - Attitude Timeline
  - Future maneuvers for next month

Time

- The ISS is moving at ~7 kilometers per second
- A significant factor in line-of-sight predictions for high resolution instruments is knowledge of exact time
- Depending on sensor resolution, being off by half a second may mean completely missing a small target
- GPS time is official time source for ISS
  - Currently GMT and GPS differ by 17 seconds

Blockage

- ISS structure is big and in the way
- Solar arrays
  - When in autotrack, arrays are moving at 4 deg/min
  - Predictive data received from Power Resource Officer (PRO)
- Radiators
  - Can cause significant amount of blockage
  - Positioning is typically static, but generally repositioned for high beta periods and visiting vehicles
  - Positioning plan for the future received from SPARTAN console
- Robotics
  - MBS/SSRMS/SPDM
  - Positioning plan for future received from Robotics Officer (ROBO)

Pointing Considerations for Payloads

- Does your payload have certain sensor requirements?
  - Can the Sun/Moon get in its field-of-view?
  - Do constraints matter if the sensor is on or off?
  - Time limit for how long it can look at the Sun?
  - Is there an additional buffer that needs to be protected?
- Does your payload need concurrent ISS communication with the ground?
  - S-band for telemetry?
  - Ku-band for video?
- Can ISS elements block your sensor field-of-view?
  - Solar arrays?
  - Thermal radiators?
  - Robotic elements?

Pointing Officer

- The Pointing Officer is responsible for flight control support of communications predictions, unique target lines-of-sight (LOS) computations, and attitude optimization of payload, onboard systems, or user pointing requirements as requested
- Integrate input products into a single output
  - TOPO's trajectory predictions
  - ADCO's attitude timeline
  - PRO's solar array plan
  - SPARTAN's radiator plan
  - ROBO's robotic plan

What Does Pointing Do For Payloads?

- Line-of-Sight Capabilities
  - Determine instrument (e.g., sensor, aperture, etc.) operation times based on orbital constraints
    - Compute AOS/LOS times for targets
  - Compute ISS overflight information for given ground sites
  - Incorporate any sensor Field of View (FOV) limits/constraints
  - Compute look angles to target, within any defined sensor grid system
  - Given if S and Ku comm is required, filter results

What Does Pointing Do For Payloads?

- Attitude Capabilities
  - Compute ISS / Robotics / payload attitude combinations to satisfy requirements for payload release, to acquire science, and to accomplish payload objectives
  - Given robotic motion for installation, verify constraints are not violated
- Blockage Capabilities
  - Create blockage diagrams for antennas/instrument FOVs, from a specific point on ISS or payload structure
  - Model movement of ISS appendages and compute LOS during movements

Examples: SCaN Testbed

- LOS Operations
  - Line of sight calculations to TDRS
  - Requires scheduled events during times ISS has S-band and Ku-band services available
  - It is also common for SCaN to request LOS analysis of non-TDRS targets such as the Sun and ground sites
- Analysis Provided by ISS Pointing
  - SCaN provides a TDRS Communication Request weekly to Pointing
  - Pointing determines available times SCaN will have events with TDRS satellites three weeks ahead
  - The week prior to SCaN activities, Pointing updates line-of-sight calculations with latest inputs and relays significant changes to scheduled passes

Examples: OPALS

- LOS Operations
  - Communication with ground sites via a laser
  - Need considerable accuracy
  - Acquire ground beacon
  - Closed loop
- Analysis Provided by ISS Pointing
  - Provide ISS flyover times of ground sites for next three weeks
  - Determine viable passes when ground site is within OPALS FOV and Sun is not

Examples: SOLAR

- LOS Operations
  - Observing Sun
  - Pointed out ISS -Z axis
- Analysis Provided by ISS Pointing
  - Notified by ROBO of robotics motion planned within SOLAR FOV
  - Pointing analyzes if Sun's track will pass behind robotic elements
  - SOLAR uses this information to note potential interruptions to their data

Questions?

Further Information

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