Attitude and Pointing Concepts for ISS Payload Operations

NASA/JSC
Maggie Michalczyk
Attitude & Pointing Office
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Topics

• What Can Pointing Do for Payloads
• Typical Questions for Payload Customers
• Variables that Affect Target Viewing
  – Time
  – Blockage
• Examples of Pointing Support for Payloads
  – SCaN
  – OPALS
  – SOLAR
The Pointing Officer is responsible for flight control support of communications predictions, unique target lines-of-sight (LOS) computations, and optimization of ISS attitude to support payload, onboard systems, or user pointing requirements, as requested.

Pointing can integrate multiple planning 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 Can Pointing Do For Payloads?

- **Line-of-Sight Capabilities**
  - Determine instrument (e.g., sensor, aperture, etc.) operation times based on orbital constraints
    - Compute acquisition times for targets
    - Integrate operational constraints (like sun avoidance) into analysis
  - Compute ISS (and any other orbiting object) overflight information for given ground sites
  - Incorporate any sensor Field of View (FOV) limits/constraints
  - Compute look angles to target, within any reference frame (ISS, payload, etc.)
  - Filter target computations based on S and Ku comm. availability (if required)
What Can 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
  – Verify operational constraints are not violated during robotic motion for installation

• Blockage Capabilities
  – Create blockage diagrams for antennas/instrument FOVs, from a specific point on ISS or payload structure
  – Model movement of ISS appendages (SSRMS, radiators, etc.)

• Integration Capabilities
  – Incorporate payload-specific information into analysis
  – Provide information to payload in their language
Typical Questions for Payload Customers

• 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?
Variables that Affect Target Viewing

- **Trajectory**
  - Weekly trajectory updates realize an average of 10 – 30 seconds of acquisition error

- **Attitude**
  - The ISS attitude fluctuates during the course of an orbit

- **Time**

- **Structural Blockage**
Variables that Affect Target Viewing: 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
Variables that Affect Target Viewing:
Structural Blockage

• ISS structure is big and frequently 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 usually repositioned for high beta periods and visiting vehicles
  – Positioning plan for the future received from SPARTAN console
• Robotics
  – Robotic elements – MBS, SSRMS and SPDM – can cause significant blockage
  – Positioning plan for future received from Robotics Officer (ROBO)
Examples of Pointing Support for Payloads

- SCaN Testbed
- OPALS
- SOLAR
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
SCaN Testbed FOV
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 and Sun are not concurrently within OPALS FOV
SOLAR

• LOS Operations
  – Observing Sun
  – Pointed out ISS -Z axis

• Analysis Provided by ISS Pointing
  – ROBO notifies Pointing and SOLAR if planned robotic operations will cause any robotic elements to enter SOLAR FOV
  – Pointing analyzes if Sun’s track will pass behind robotic elements and notifies SOLAR of any violations
  – SOLAR uses this information to note potential interruptions to their data
SOLAR FOV

- Sun traces through the FOV
- SSRMS in FOV
- SOLAR FOV
Questions?
Further Information

• If you have any questions, please contact:
  – Maggie Michalczyk (Pointing Payloads Lead)
    • Email: magdalen.i.michalczyk@nasa.gov
    • Phone: 281-483-9237
  – Sadie Holbert (Pointing Payloads Backup)
    • Email: sadie.m.holbert@nasa.gov
    • Phone: 281-244-8263