

National Aeronautics and Space Administration



Attitude and Pointing Concepts for ISS Payload Operations

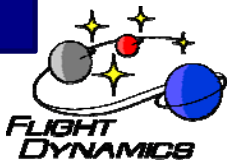
NASA/JSC
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Attitude & Pointing Office
July 2015



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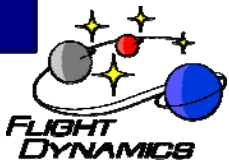
Topics

- 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)



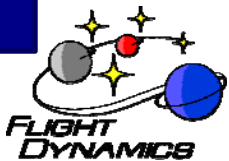
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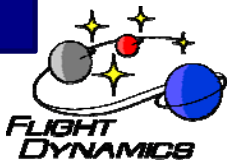
Trajectory

- 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



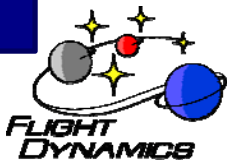
Blockage

- 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)



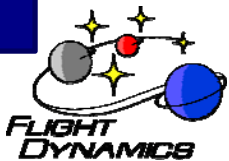
Pointing Considerations for Payloads

- 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?



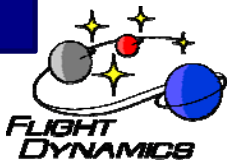
Pointing Officer

- 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



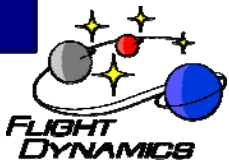
What Does Pointing Do For Payloads?

- 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



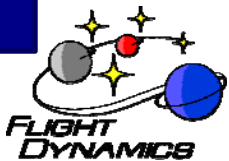
What Does Pointing Do For Payloads?

- 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



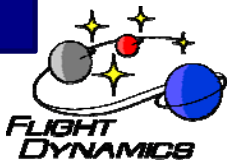
Examples: SCaN Testbed

- 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

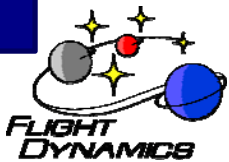


Examples: SOLAR

- 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?



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Further Information

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