2.5 POINTING CONTROL SUBSYSTEM

Table 2-4 shows the verification activities that must be accomplished during SMOV to verify the performance of the Pointing Control System to support normal science operations.

Table 2-4
Pointing Control Subsystem SMOV Activities

<table>
<thead>
<tr>
<th>Activity Summary #</th>
<th>Observatory Verification Activity</th>
<th>Method of Execution</th>
<th>Duration Hr:min</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCS-01</td>
<td>FHST FOV Check</td>
<td>Real-Time</td>
<td>03:00</td>
</tr>
<tr>
<td>PCS-02</td>
<td>Fine Attitude Determination</td>
<td>Real-Time</td>
<td>01:00</td>
</tr>
<tr>
<td>PCS-03</td>
<td>Initial Gyro Rate Bias Correction</td>
<td>Real-Time</td>
<td>05:00</td>
</tr>
<tr>
<td>PCS-04</td>
<td>FHST/FHST Alignment</td>
<td>Real-Time</td>
<td>31:00</td>
</tr>
<tr>
<td>PCS-06</td>
<td>Gyro/FHST Alignment</td>
<td>SMS</td>
<td>56:00</td>
</tr>
<tr>
<td>PCS-07</td>
<td>FHST/FGS Alignment</td>
<td>SMS</td>
<td>75:00</td>
</tr>
<tr>
<td>PCS-08</td>
<td>Vehicle Disturbance Test (VDT)</td>
<td>SMS</td>
<td>24:00</td>
</tr>
</tbody>
</table>

2.5.1 FHST Field of View Check

ID: PCS-01

APPLICABLE REQUIREMENT: Preliminary to L.10.4.8.1 and L.10.4.8.2.

DESCRIPTION: The proper mapping of all three FHSTs must be verified to ensure the success of all subsequent PCS verification activities. The FHSTs will be commanded to perform maps of their full FOV and the observations will be examined for adequacy to support subsequent activities.

HOW THE ACTIVITY IS BEST IMPLEMENTED: R/T COMMAND

DEPENDENCIES: FHSTs powered on.
DURATION: Three hours.

RESULTS: Verification that the FHSTs are mapping successfully and that a sufficient number of observations have been obtained from each FHST to support subsequent attitude determinations and calibrations.

ANALYSIS: Data will be processed through the SAC Fine Attitude Determination application. Observations will be plotted on FOV grid and the stars will be identified. The attitude results and statistics will be evaluated. At least two FHSTs must be successfully mapping in order to continue to initialize gyro drift rate bias determination.

COMMENTS: None

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DATE: January 3, 2001

2.5.2 Fine Attitude Determination

ID: PCS-02

APPLICABLE REQUIREMENT: L.10.4.8.1.

DESCRIPTION: Compute a Fine Attitude using FHST map data and use the result to update the on-board quaternion, QCI. This is needed in preparation for transition to normal operations.

HOW THE ACTIVITY IS BEST IMPLEMENTED: R/T COMMAND

DEPENDENCIES: FHSTs powered on, Coarse attitude has been determined.
DURATION: One hour.

RESULTS: Attitude Reference Update to vehicle. Planned real-time slew to desired attitude. The vehicle will be within 0.2 degrees of the desired attitude to allow communication via the HGAs upon H&S SMS intercept, and return to normal operations.

ANALYSIS: Any planned real time slew is constraint checked by the Interactive Pointing Control System program. Coarse attitude results will be used to initialize the Fine Attitude processing.

COMMENTS: Forward link needed to send ARU/PRT to vehicle.

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DATE: September 27, 2007

2.5.3 Initial Gyro Rate Bias Correction

ID: PCS-03

APPLICABLE REQUIREMENT: L.10.4.8.1.

DESCRIPTION: The purpose of this activity is to compute the initial low mode gyro drift rate biases. During this activity the S/C is in normal mode maintaining a constant attitude. The FHST maps are used to measure the vehicle attitude drift due to the uncompensated gyro drift rate bias. There will be two FHST map periods. Observations from the period will be used to measure the low mode bias. The new gyro drift biases will be uplinked to the spacecraft.

HOW THE ACTIVITY IS BEST IMPLEMENTED: R/T COMMAND
DEPENDENCIES: Fine attitude is determined. FHSTs are turned on. FHST FOV check is successful.

DURATION: Five hours. Two hours for the mapping, and three hours for the data processing, data validation, and Table load generation.

RESULTS: High and low mode gyro drift rate bias Table Loads will be generated and uplinked to the vehicle. The uncompensated gyro drift rate bias should be reduced to less than 0.014 arcseconds per second.

ANALYSIS: The RGA Calibration application with the Long Baseline Bias (LBBIAS) option will be used to compute the initial low mode gyro drift rate biases. The high mode gyro drift rate biases will be determined by adding the ATP high mode offsets to the low mode gyro drift rate biases. The fine attitude results and statistics will be quality assured. The gyro bias change results will be compared to the expected changes. The ground system will be updated with the new gyro drift rate biases in order to return to normal operations.

COMMENTS: None

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2.5.4 FHST/FHST Alignment

ID: PCS-04

APPLICABLE REQUIREMENT: Preliminary to L.10.4.8.2.
DESCRIPTION: Verify that the FHST/FHST alignment has not changed following the Servicing Mission. The vehicle will be at a constant attitude, and each pair of FHSTs will be commanded to perform a map of the full field of view. An FHST/FHST alignment will be computed and compared to the pre-Servicing Mission alignment. The FHST maps will be repeated as a backup to the first set.

HOW THE ACTIVITY IS BEST IMPLEMENTED: R/T COMMAND

DEPENDENCIES: Vehicle under normal operations. Accurate gyro biases uplinked to vehicle.

DURATION: Seven hours of data collection and 24 hours of data processing and analysis.

RESULTS: FHST/FHST alignment table loads may be uplinked to the vehicle if the boresight separation between any pair of FHSTs has changed by more than 20 arcseconds.

ANALYSIS: The data will be prepared by running the SAC Fine Attitude program to compute attitudes from the FHST map data. The prepared data will be processed by the SAC FALIGN program to compute an FHST/FHST alignment with FHST 1 as the reference tracker. The application reports the change to the boresight separation for each pair of trackers. If necessary an alignment will be written to a calibration file, and the ground system will be updated with the new alignment.

COMMENTS: None

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DATE: April 19, 1999
2.5.6 Gyro/FHST Alignment

ID: PCS-06

APPLICABLE REQUIREMENT: Contingent on the replacement of one or more of the RSUs.  L.10.4.8.2

DESCRIPTION: This activity is performed to compute the alignment of the gyro to the FHSTs. The scale factors and high mode bias are also determined. The purpose is to reduce the attitude errors after large maneuvers to less than one arcsecond per degree of slew. Six maneuvers are executed that allow measurements to be obtained along each of the gyro input axes. Before and after each maneuver traditional FHST maps are commanded. Attitude changes computed from the FHST data are compared to attitude changes derived from the gyro data in order to solve for the RGA/FHST scale factor/alignment matrix and the gyro biases. A follow-up set of six maneuvers is executed to verify the alignment results after they have been uplinked to the vehicle.

HOW THE ACTIVITY IS BEST IMPLEMENTED: SMS Proposal.

DEPENDENCIES: FHST/FHST alignment must be verified, or updated if it has changed. The high mode gyro bias should be updated as close as possible to the start of this activity by applying the ATP high mode offsets to the most recent low mode drift rate bias. No significant data gaps can exist.

DURATION: About 56 hours. The maneuvers require about 8 hours to execute. Approximately 24 hours are required to process the data and generate table loads. Another 8 hours are required for the verification slews and about 16 hours to process the data.

RESULTS: RGA/FHST scale factor/alignment and gyro bias table loads for uplink to the vehicle. Following this calibration attitude errors after a large maneuver are reduced to less than 1 arc-second per degree of slew.
ANALYSIS: The data is prepared in the SAC Fine Attitude Determination application. Attitudes are computed before and after each maneuver using FHST observations. An attitude change is computed by integrating gyro data for the maneuver period. The prepared data is processed by the SAC RGA Calibration program. The ground system is updated with the new alignments.

COMMENTS: None

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DATE: September 27, 2007

2.5.7 FHST/FGS Alignment

ID: PCS-07

APPLICABLE REQUIREMENT: L.10.4.8.3. This is a Contingency Activity.

DESCRIPTION: The purpose of this activity is to align the FHSTs to the FGS system. This will allow computation of accurate attitudes for FHST corrections following maneuvers, and for vehicle Attitude Reference Updates. FGS 3 will map out its field of view using coarse track astrometry observations. Comparing observed star positions to a catalog, SAC personnel will compute the vehicle attitude and the FHST/FGS alignments. (This is an abbreviated pattern match).

HOW THE ACTIVITY IS BEST IMPLEMENTED: SMS Proposal.

DEPENDENCIES: Gyro/FHST alignment.
DURATION: The data take requires approximately 3 hours and the subsequent data processing requires about 48 hours. An additional 24 hours is needed by SAC personnel to update calibration files to be used for future SMS processing.

RESULTS: FHST/FGS and modified RGA table loads for uplink to the vehicle. This will allow for successful guide star acquisitions to be achieved. This is a contingency activity that will be implemented if guide star acquisitions are not successful and FHST to FGS alignment miss-calibration is the cause.

ANALYSIS: None

COMMENTS: None

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DATE: September 27, 2007

2.5.8 Vehicle Disturbance Test (VDT)

ID: PCS-08

PCS Activity Description: Vehicle Disturbance Test (VDT)

APPLICABLE REQUIREMENT: L.10.4.8.6.

DESCRIPTION: The purpose of the VDT is to measure and characterize uncompensated environmental disturbances acting upon the HST during normal operation. The VDT is a passive test (not a forced-response test) used to obtain signatures for both externally induced (e.g. SCM, SA-3, SSM thermal gradients) and internally induced (e.g. HGA, RWA, COS and WFC3 mechanisms) disturbances affecting HST LOS pointing. The disturbances observed will be used as the
nominal on-orbit disturbances in pointing control simulations until the next VDT is run.

The test occurs after release, and most of the VDT can be run during the BEA period. The -V1 sunpoint portion of the VDT usually occurs after the BEA period is complete. The VDT shall consist of three separate tests that need not occur consecutively. The overall duration of the VDT is at least 15 orbits of spacecraft time including (1) at least 2 orbits at +V3 sunpoint while performing COS and WFC3 mechanism articulation simulating routine flight operations, (2) at least 8 orbits at +V3 sunpoint after achieving thermal equilibrium (at least 36-hours at +V3 sunpoint) and three out of 8-orbits have RWA Friction Compensation turned Off, and (3) at least 5 orbits at -V1 sunpoint (all or part of this segment have RWA Friction Compensation turned Off). At the beginning of each test, the attitude control law gains are switched to maneuver gains, and the gyros are commanded to low mode. The nominal attitude control law configuration will be restored at the end of each test.

HOW THE ACTIVITY IS BEST IMPLEMENTED: Stored Program Command and SMS

DEPENDENCIES: HN Format, vehicle in gyro hold, gyros in low mode, attitude control law maneuver gains (low bandwidth controller), and two different solar array angles are used. VAP processing shall remain off during VDT intervals, and no vehicle slews shall be scheduled during VDT test intervals that may turn-on VAP processing. Forward link opportunities shall be provided after planned vehicle slews to disable VAP processing prior to VDT tests. At the end of each test, SMS scheduled null slews and OBADs with maneuvers shall be performed to re-enable VAP processing and to correct attitude errors prior to subsequent science operations. OBADs without maneuvers shall be scheduled in the SMS during the VDT for monitoring vehicle attitude. Continuous SSR data recording shall occur during test intervals.

DURATION: Fifteen orbits: 10 orbits at +V3 sunpoint with a 90-degree (approximate) solar array angle, and 5 orbits
at -V1 sunpoint with a 0-degree (approximate) solar array angle.

RESULTS: Verify that the HST is in the prescribed configuration during the test, and confirm that external disturbances are being measured by monitoring gyro count mnemonics and control law position path mnemonics.

ANALYSIS: Data will be processed by the Pointing Control System group. Disturbances occurring during this test will be classified by source item and characterized for comparison to previously measured disturbances. Results and observations will be documented in a final report within six months of test completion.

COMMENTS: It is preferable to have a 2-guide star FGS acquisition (with no moving target maneuvers) prior to each VDT interval to ensure that a fresh gyro bias is available before the test begins. This ensures that minimal attitude drift occurs during the extended gyro hold intervals required by the test.

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