Table 2-5 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>
<thead>
<tr>
<th>Activity Summary #</th>
<th>Observatory Verification Activity</th>
<th>Execution Phase</th>
<th>Duration Hr:min</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCS-01</td>
<td>FHST Field of View Check</td>
<td>Real-Time</td>
<td>03:00</td>
</tr>
<tr>
<td>PCS-02</td>
<td>First Attitude Determination (Initial Gyro Drift Rate Bi-Determination)</td>
<td>Real-Time</td>
<td>06:00</td>
</tr>
<tr>
<td>PCS-03</td>
<td>Attitude Initialization</td>
<td>Real-Time</td>
<td>01:00</td>
</tr>
<tr>
<td>PCS-04</td>
<td>FHST/FHST Alignment</td>
<td>Real-Time</td>
<td>31:00</td>
</tr>
<tr>
<td>PCS-05</td>
<td>RGA Polarity Check</td>
<td>SMS</td>
<td>03:00</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>27:00</td>
</tr>
<tr>
<td>PCS-09</td>
<td>Transfer Function Test (TFT)</td>
<td>SMS</td>
<td>29:00</td>
</tr>
</tbody>
</table>
2.7.1 **FHST Field of View Check**

**ID:** PCS-01

**APPLICABLE REQUIREMENT:** Preliminary to J.10.4.8.1 and J.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
2.7.2 First Attitude Determination and Initial Gyro Drift Rate Bias Determination

ID: PCS-02

APPLICABLE REQUIREMENT: J.10.4.8.2.

DESCRIPTION: The purpose of this activity is to compute the initial high and 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 three FHST map periods, with the gyro mode switched from high to low in the middle of the second map period. Observations from the first and second periods will be used to measure the high mode gyro bias, and observations from the second and third periods 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: Coarse attitude are determined.
FHSTs are turned on.
FHST FOV check is successful.

DURATION: Six hours. Three 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 .05 arcseconds per second.

ANALYSIS: The RGA Calibration application with the Long Baseline Bias (LBBIAS) option will be used to compute the initial high and 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 proceed to the attitude initialization and return to normal operations.

COMMENTS: None

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DATE: January 3, 2001
2.7.3 Attitude Initialization

ID: PCS-03

APPLICABLE REQUIREMENT: J.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: FHST FOV check completed successfully. High and low mode gyro biases have been uplinked to the vehicle.

DURATION: One hour.

RESULTS: Attitude Reference Update to vehicle. Planned real-time slew to desired attitude. The vehicle will be within .2 degrees of the desired attitude to allow communication via the HGAs, 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: April 19, 1999
2.7.4 FHST/FHST Alignment

ID: PCS-04

APPLICABLE REQUIREMENT: J.10.4.8.3.

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
2.7.5  RGA Polarity Check

ID: PCS-05

APPLICABLE REQUIREMENT: Contingent on the replacement of one or more of the RSUs. Preparation work for J.10.4.8.4.

DESCRIPTION: In order to confirm the RGA polarity a positive and negative 1 degree slew will be executed about each vehicle axis. The FHST’s will be mapping throughout this period and will be used as a reference.

HOW THE ACTIVITY IS BEST IMPLEMENTED: R/T COMMAND

DEPENDENCIES: FHSTs able to perform mapping.

DURATION: 3 hours.

RESULTS: Verification that the RGAs are sensing vehicle motion with the correct polarity.

ANALYSIS: Data will be processed through the PASS Fine Attitude Determination application. The attitude before and after each slew will be computed and the attitude change will be compared to the commanded slew.

COMMENTS: None

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DATE: May 3, 1999
2.7.6  Gyro/FHST Alignment

ID: PCS-06

APPLICABLE REQUIREMENT: J.10.4.8.4.  Contingent on the replacement of one or more of the RSUs.

DESCRIPTION: This activity is performed to compute the alignment of the gyros 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 the FHSTs are commanded to execute a map of the full field of view. 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. No significant data gaps can exist. Preferably implement this activity with gyros in high mode.

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 sufficiently small to allow FHST updates to remove them.

ANALYSIS The data is prepared in the SAC Fine Attitude 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 allowing for successful FHST updates.

COMMENTS: None

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DATE: April 19, 1999
2.7.7 FHST/FGS Alignment

ID: PCS-07

APPLICABLE REQUIREMENT: J.10.4.8.5. This 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 updates 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 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 SACOPS 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 a contingency activity that will be implemented if guide star acquisitions are not successful and FHST to FGS alignment miscalibration is the cause.

ANALYSIS: None

COMMENTS: None

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DATE: April 19, 1999
2.7.8: Vehicle Disturbance Test (VDT)

ID: PCS-08

APPLICABLE REQUIREMENT: J.10.4.8.7

DESCRIPTION: The purpose of the VDT is to 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. SA-3) and internally induced (e.g. NCC) disturbances for comparison with past VDT results. 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 occurs after the BEA period is complete. The VDT shall consist of five separate tests that need not occur consecutively. The overall duration of the VDT tests is at least 17 orbits of spacecraft time including (1) at least 1 full orbit at +V3 sunpoint prior to NCC operation while performing ACS Filter Wheel moves simulating routine flight operations, (2) at least 5 full orbits at +V3 sunpoint prior to NCC operation, (3) at least 1 full orbit at +V3 sunpoint during NCC startup, (4) at least 5 full orbits at +V3 sunpoint while NCC is operating at steady-state, and (5) at least 5 full orbits at –V1 sunpoint with the NCC operating at steady-state. 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: PN Format, vehicle in gyro hold, gyros in low mode, SAGA filter off, 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 full maneuver attitude updates shall be performed to re-enable VAP processing and to correct attitude errors prior to subsequent science operations. FHST maps shall be scheduled in the SMS during the VDT for monitoring vehicle attitude. Continuous SSR data recording shall occur during test intervals.

DURATION: Seventeen orbits: 12 orbits at +V3 sunpoint with 90-degree solar array angle, and 5 orbits at –V1 sunpoint with 0-degree 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 four months of the servicing mission.

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 (OBSINT
method) 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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DATE: 8 January 2001
2.7.9: Transfer Function Test (TFT)

ID: PCS-09

APPLICABLE REQUIREMENT: J.10.4.8.8.

DESCRIPTION: Contingent upon analysis of PCS performance post-SM3B, perform a Transfer Function Test (TFT). The TFT is a forced response test that measures HST system modal parameters (modal gains, modal damping ratios and frequencies) by applying a RWA forcing function and measuring RGA gyro response. This test will be performed if PCS analysis of post-SM3B HST flight data (such as the VDT) suggests that HST system modal parameters significantly differ from pre-SM3B analytical models. On-orbit modal parameters that differ from pre-SM3B models can cause degraded performance of the HST attitude control system because of reductions in stability margins and/or increased vehicle jitter.

The test occurs after release and after the Vehicle Disturbance Test is complete. The overall duration of the TFT is approximately 18 orbits (contiguous) of spacecraft time that includes nine orbits in the +V3 sunpoint orientation and nine orbits at –V1 sunpoint. While in each orientation, three orbits will be allocated for applying forcing functions about each of the three vehicle axes. Forced response of the HST is required at two different vehicle attitudes because HST modal parameters are a function of solar array angle. At the beginning of the test, Stored Program Commands are activated to establish “modified PN Format” telemetry, to switch the attitude control law to the maneuver gain set, and to command the gyros to low mode. The nominal telemetry format and attitude control law configuration will be restored at the end of the test.

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

DEPENDENCIES: If performed, the TFT shall occur at least 24-hours after completion of the Vehicle Disturbance Test. The NCC shall either be off or operating at steady state temperature (out of surge). Modified PN Format, vehicle in gyro hold, gyros in low mode, SAGA filter off, attitude control law maneuver gains (low bandwidth controller), and two different solar array angles are used. VAP processing shall remain off during the TFT, and no vehicle slews shall be scheduled during the TFT that may turn-on VAP processing. Forward link opportunities shall be provided after planned vehicle slews to disable VAP processing prior to resuming TFT tests. At the end of the test, SMS scheduled null slews and full maneuver attitude updates shall be performed to enable VAP processing and to correct attitude errors prior to subsequent science operations. FHST maps shall be scheduled in the SMS during the TFT for monitoring vehicle attitude. Continuous SSR data recording shall occur during test intervals.

DURATION: Eighteen orbits: 9 orbits at +V3 sunpoint with 90-degree solar array angle, and 9 orbits at –V1 sunpoint with 0-degree solar array angle.

RESULTS: Verify that the HST is in the prescribed configuration during the test, and confirm that the commanded torque forcing functions are being applied to the vehicle by monitoring telemetry. Verify that the gyro measured vehicle response is consistent with pre-test simulation results. If possible, provide near-real time processing of telemetry for quick-look transfer function results.

ANALYSIS: Data will be processed by the Pointing Control System and Safing groups. On-orbit modal parameters will be extracted using standard modal processing methods. Results and observations will be documented in a final report within four months of the servicing mission.
COMMENTS: It is preferable to have a 2-guide star FGS acquisition (with no moving target maneuvers) prior to the TFT to ensure that a fresh gyro bias is available (OBSINT method) 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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DATE: 8 January 2001