REVISED 5-7-87

FMEA NO. 2.4.2.2

CRITICALITY 2/2

SHUTTLE CCTV
CRITICAL ITEMS LIST

UNIT PTU
DWG NO. 2294822-502,503,504
SHEET 1 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	DESIGN FEATURES The heritage for the PTU mechanisms is the designs used successfully on the Lunar Rover equipment on the Apollo 15, 16, and 17 missions. All support bearings in the azimuth and elevation axes are conservatively designed when compared to the launch load environment. The design was prepared by a detailed finite element analysis of the structure, taking into account the derating for the fatigue cycles represented by 100 missions. A series of developmental tests were conducted to verify the analytical models for the structure and drive train analyses. Reviews were held at preliminary design and critical design review levels to evaluate the designs and test data. The PTU has been used on 24 missions at four bulkhead locations and at the RMS elbow location without a failure in the drive train, axis support mechanisms, or structure. The mounting provision from the PTU base to the orbiter structure and RMS arm was analyzed for worst-case landing loads and showed adequate margins.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	QUALIFICATION TEST For Qualification Test Flow, see Table 2 located at the front of this book.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
ass of elevation (tilt) drive due o a mechanical failure. · Motor failure · Gear head failure · Gear box failure · Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	ACCEPTANCE TEST The CCTV systems' PTU is subjected directly, without vibration isolators which might be used in their normal installation, to the following testing: • Vibration: 20-80Hz: 3 dB/Oct-rise from 0.01 G^2/Hz 80-350 Hz: 0.04 G^2/Hz 350-750 Hz: -3 dB/10 Oct-slope Test Duration: 1 Minute per Axis Test Level: 6.6 Gros • Thermal Vacuum: In a pressure of $1X10^{-5}$ Torr, the temperature shall be as follows: 125° F: Time to stablize equipment plus 1 hour 25° F: Time to stablize equipment plus 1 hour 125° F: Time to stablize equipment plus 1 hour The PTU may not have been subjected to the vacuum condition. For Acceptance Test Flow, see Table 1 located at the front of this book. OPERATIONAL TESTS In order to verify that CCTV components are operational, a test must verify the health of all the command related components from the PHS (A7A1) panel switch, through the RCU, through the sync lines to the Camera/PTU, to the Camera/PTU command decoder. The test must also verify the camera's ability to produce video, the VSU's ability to route video, and the monitor's ability to display video. A similar test would be performed to verify the MDM command path. Pre-Launch on Orbiter Test/In-Flight Test 1. Power CCTV System. 2. Via the PHS panel, select a monitor as destination and the camera under test as source. 3. Send "Camera Power On" command from PHS panel. 4. Select "External Sync" on monitor. 5. Observe video displayed on monitor. Note that if video on monitor is synchronized (i.e., stable raster) then this indicates that the camera is receiving composite sync from the RCU and that the camera is producing synchronized video. 6. Send Pan, Tilt, Focus, Zoom, ALC, and Gamma commands and visually (either via the monitor or direct observation) verify operation. 7. Select downlink as destination and camera under test as source. 8. Observe video routed to downlink. 9. Send "Camera Power Off" command via PHS panel. 10. Repeat Steps 3 through 9 except issue commands via the MDM command path. This proves that the CCTV equipment is operational.

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SHEET 4 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	QA/INSPECTION Procurement Control - The PTU EEE Parts and hardware items are procured from approved vendors and suppliers, which meet the requirements set forth in the CCTV contract and Quality Plan Work Statement (WS-2593176). Resident DCAS personnel review all procurement documents to establish the need for GSI on selected parts (PAI 517). Incoming Inspection and Storage - Incoming Quality inspections are made on all received materials and parts. Results are recorded by lot and retained in file by drawing and control numbers for future reference and traceability. All EEE parts are subjected to incoming acceptance tests as called for in PAI 315 - Incoming Inspection Test Instructions. Incoming Flight parts are further processed in accordance with RCA 1846684 - Preconditioning and Acceptance Requirements for Electronic Parts, with the exception that DPA and PIND testing is not performed. Mechanical items are inspected per PAI 316 - Incoming Inspection Instructions for mechanical items, PAI 305 - Incoming Quality Control Inspection Instruction, and PAI 612 - Procedure for Processing Incoming or Purchased Parts Designated for Flight Use. Accepted items are delivered to Material Controlled Stores and retained under specified conditions until fabrication is required. Non-conforming materials are held for Material Review Board (MRB) disposition. (PAI 307, PAI IQC-531). Board Assembly & Test - Prior to the start of PTU board assembly, all items are verified to be correct by stock room personnel, as the items are accumulated to form a kit. The items are verified again by the operator who assembles the kit by checking against the as-built-parts-list (ABPL). DCAS Mandatory Inspection Points are designated for all printed circuit, wire wrap and welded wire boards, plus harness connectors for soldering wiring, crimping, solder splices and quality workmanship prior to coating of the component side of boards and sleeving of harnesses. Specific PTU board assembly and test instructions are provided in drawing notes, and applicable documents are called out in the Fabrication Procedure and Record (FPR-2294822) and parts list PL 2294822. These include wire connection List 2295901, Process Standard NIV-565 228081, Process Standard - Bonding elcro Tape 2280889, Specification Soldering 2280749, Specification Name Plate Application 1968167, Specification - Crimping 2280800, Specification - Bonding and Staking 2280878, Specification - Urethane coating 2280877, Specification - locking compound 2026116, Specification Epoxy Adhesive 2010985, Specification - Marking 2280876, Specification-Workmanship 8030035, Specification Bonding and Staking 2280875.

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SHEET 5 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	QA/INSPECTION (Continued) PTU Assembly and Test - An open box test is performed per TP-IT-2294822, and an Acceptance Test per TP-AT-2294822, including vibration and thermal vacuum. Torques are specified and witnessed, traceability numbers are recorded and calibrated tools are checked prior to use. RCA Quality and DCAS inspections are performed at the completion of specified FPR operations in accordance with PAI-204, PAI-205, PAI 206 and PAI 217. DCAS personnel witness PTU button-up and critical torquing. RCA and DCAS personnel monitor acceptance tests and review the test data/results. These personnel also inspect for conformance after all repair, rework and retest. Preparation for Shipment - The PTU is packaged according to CCTV Letter 8011 and 2280746, Process standard for Packaging and Handling guidelines. All related documentation including assembly drawings, Parts List, ABPL, Test Data, etc. is gathered and held in a documentation folder assigned specifically to each assembly. This folder is retained for reference. An EIDP is prepared for each PTU in accordance with the requirements of WS-2593176. RCA QC and DCAS personnel witness crating, packaging, packing and marking, and review the EIDP for completeness and accuracy.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	FAILURE HISTORY TDR-C0642 Log #2101-PTU-S/N030-503 TDR-C0643 Log #2102-PTU-S/N030-503 Description: Evaluation Test Failure, Box Level Ambient Environment. Pan-Tilt unit will not tilt. Cause: Stepper motor gear train retaining clip was not fully seated. This caused interference with internal arc ring, causing loss of torque. Corrective Action: Retaining clip groove was widened by 0.002-in. allowing outer ring clip to seat properly. TDR-W2599 Log #0418 PTU-S/N003-502 Description: Acceptance Test Failure, Box Level Ambient Environment. During X-axis vibration checking, tilt up and down was observed to hang up. Cause: Tolerance build-up in yoke and bearing assembly together with excessive protrusion of screw heads. Corrective Action: Add shims to assembly per ECN 01155 to assure free play is eliminated. Assure screw heads do not protrude above surface. All other units measured to insure adequate clearance.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	FAILURE HISTORY TDR C4594 - Log #2088 - PTU S/N030-503 TDR C4647 - Log #2091 - PTU S/N031-503 TDR B3483 - Log #1155 - PTU S/N037-503 Description: Prelaunch Test Failure, Box Level Ambient Environment. Tilt function is intermittent. It does not travel at the same speed through entire cycle. Cause: Large snap ring on outer shaft interfering with small snap ring. Corrective Action: The gear head retaining clip groove was widened by 0.002-in. allowing the outer retaining ring clip to seat deeper and not interfere with the inner clip. TDR C0641 - Log #2100 - PTU S/N031-503 Description: Evaluation Test Failure, Part Level, Ambient Environment Tilt Stepper Motor Intermittent. (Vendor Evaluation) Cause: Gear Train Retaing Ring not full seated. Corrective Action: The gear head retaining clip groove was widened by 0.002-in. allowing the outer retaining ring clip to seat deeper and not interfere with the inner clip.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of elevation (tilt) drive due to a mechanical failure. - Motor failure - Gear head failure - Gear box failure - Elevation bearing failure	Loss of travel in the tilt up or down direction. Worst Case: Loss of mission critical video.	OPERATIONAL EFFECTS Possible loss of major mission objectives due to inability to position camera for desired FOV. CREW ACTION If possible, continue mission using alternate visual cues. CREW TRAINING Crew should be trained to use possible alternates to CCTV. MISSION CONSTRAINT Where possible procedures should be designed so they can be accomplished without CCTV.