FMEA NO. 2.4.2.1
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
oss of tilt up or down (electrical unction). TU 1 Tilt Stepper Drive. 2 Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and 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. BARE BOARD DESIGN (A2) The design of the associated A2 board is constructed from laminated copper-clad epoxy glass sheets (NEMA G-10) Grade FR-4), PER MIL-P-55617A. Circuit connections are made through printed traces which run from point to point on the board surfaces. Every trace terminates at an annular ring. The annular ring surrounds the hole in which a component lead or terminal is located. This ring provides a footing for the solder, ensuring good mechanical and electrical performance. Its size and shape are governed by MIL-P-55640 as are trace widths, spacing and routing. These requirements are reiterated specifically in drawing notes to further assure compliance. Variations between the artwork master and the final product (due to irregularities of the etching process) are also controlled by drawing notes. This prevents making defective boards from good artwork. Holes which house no lead or terminal, but serve only to electrically interconnect the different board layers, contain stitch bars for mechanical support and increased reliability. The thru holes are drilled from a drill tape thus eliminating the possibility of human error and allowing tight control over hole and annular ring concentricity, an important reliability criterion. After drilling and etching, All copper cladding is tin-lead plated per MIL-STD-1495. This provides for easy and reliable soldering at the time of board assembly, even after periods of prolonged storage.

FMEA NO. 2.4.2.1

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DWG NO. 2294822-502,503,504

SHEET 2 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
ss of tilt up or down (electrical nction). U Tilt Stepper Drive. Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and down direction. Worst Case: loss of mission critical video.	DESIGN FEATURES (Continued) BOARD ASSEMBLY DESIGN (A2) All components are installed in a manner which assures maximum reliability. Component leads are pre-tinned, allowing total wetting of solder joints. All leads are formed to provide stress relief and the bodies of large components are staked. Special mounting and handling instructions are included in each drawing required after final assembly. The board is coated with urethane which protects against humidity and contamination. BOARD PLACEMENT The A1 AND A2 boards are secured in the electronics assembly by gold-plated beryllium copper card guides. Connections are made to the mother board with blind-mated connectors. Disengagement during launch is prevented by a cover which spans the board's free edge. BARE BOARD CONSTRUCTION (A1) The boards are of "welded wire" construction. At the bare board level this does not distinguish it from a normal PC board except that holes which will take weld pins generally are not connected to PC traces. Only those pins which bring power and ground potentials to the ICs are on PCs. An annular ring surrounds the hole in the board where each power and ground pin is located. These pins are then soldered to the trace like any other component lead. Aside from this feature, all design & construction techniques used in PC board layout apply. BOARD ASSEMBLY (A1) The drilled and etched boards are populated with several hundred solderable or weldable pins. Power and ground pins, as well as connector pins, are soldered in place. Discreet components (resistors, diodes, capacitors) are attached to bifurcated terminals, where they are soldered. Flatpack ICs are welded, lead-by-lead,to the tops of the weld pins. After welding, extra lead material is trimmed away. Circuit connections are made using #30 AWG nickel weld wire. The wire is welded to the pin surfaces on the board backside. All wire welds are done using a machine which is tape driven, thus eliminating the possibility of miswiring due to operator error. All wiring & circuit performance is tested prior to box-level installation. After successful testing, components are staked as required by drawing notes and the assembly is coated with urethane. The board is inserted in the box on card-edge guides, in the same manner as the other PC boards.

FHEA NO. 2.4.2.1 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT PTU DWG NO. 2294822-502,503,504 SHEET 3 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Loss of tilt up or down (electrical function). PTU A1 Tilt Stepper Drive. A2 Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and down direction. Worst Case: Loss of mission critical video.	QUALIFICATION TEST For Qualification Test Flow, see Table 2 located a the front of this book.

REVISION 7-17-87

IEA NO. 2.4.2.1 ITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT PTU DWG NO. 2294822-502,503,504 SHEET 4 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
; of tilt up or down (electrical ction). Tilt Stepper Drive. Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and 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 Grms • 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 TEST 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, DER, 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.

REVISION 7-17-87

MEA NO. 2.4.2.1 RITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT PTU DWG NO. 2294822-502,503,504 SHEET 5 OF 8

AILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
s of tilt up or down (electrical ction). Tilt Stepper Drive. Power Supply Command/Clock Receivers.	loss of travel in the tilt up and 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 OCAS 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). OCAS 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 RTV-566 2280081, Process Standard - Bonding elcro Tape 2280889, Specification Soldering 2280749, Specification Name Plate Application 1960167, Specification - Crimping 2280800, Specification - Bonding and Staking 2280878, Specification - Urethane coating 2280877, Specification - locking compound 2026116, Specification Epoxy Adhesive 2010965, Specification - Marking 2280876, Specification-Workmanship 8030035, Specification Bonding and Staking 2280875.

REVISION F-17

FMEA NO. 2.4.2.1 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT PTU DWG NO. 2294822-502,503,504 SHEET 6 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
ıss of tilt up or down (electrical ınction). U Tilt Stepper Drive. Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and down direction. Worst Case: Loss of mission critical video.	QA/INSPECTION 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.

REVISION 7-17-87

FMEA NO. 2.4.2.1 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT PTU DWG NO. 2294822-502.503.509 SHEET 7 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
oss of tilt up or down (electrical unction). PTU 1 Tilt Stepper Drive. 2 Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and down direction. Worst Case: Loss of mission critical video.	FAILURE HISTORY NONE.

REVISION 2-17-87

FMEA NO. 2.4.2.1

CRITICALITY 2/2

SHUTTLE CCTV
CRITICAL ITEMS LIST

UNIT PTU
DWG NO. 2294822-502,503,504

SHEET 8 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
ss of tilt up or down (electrical nction). U Tilt Stepper Drive. Power Supply Command/Clock Receivers.	Loss of travel in the tilt up and 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 CONSTRAINTS Where possible, procedures should be designed so they can be accomplished without CCTV.