FMEA NO. 6.1.6.4 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT TCV/MLA DWG NO. 2294819-586-508/ 2294820-502 SHEET 1 OF 9

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Iris limit switch fails or shorted. MLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	see below

DESIGN FEATURES

The TVC/Lens Assembly is comprised of 16 electrical subassemblies; 13 subassemblies are RCA Astro designed and fabricated using standard printed-circuit board type of construction. The remaining three assemblies, high voltage power supply, oscillator, and stepper motors, are vendor supplied components which have been specified and purchased according to RCA Specification Control Drawings (SCDs) prepared by engineering and reliability assurance. Specifications per the SCD are prepared to establish the design, performance, test, qualification, and acceptance requirements for a procured piece of equipment.

Parts, materials, processes, and design guidelines for the Shuttle CCTV program are specified in accordance with RCA 2295503. This document defines the program requirements for selection and control of EEE parts. To the maximum extent, and consistent with availability, all parts have been selected from military specifications at the JAN level, as a minimum. In addition to the overall selection criteria, a subset of general purpose preferred parts has been defined by this document and the RCA Government Systems Division Standard Parts List. In the case of the CMOS and TTL family of microcircuits, devices are screened and tested to the MIL-STD-883C equivalent and procured under the designations of HI-REL/3WQ and SNC 54LS from RCA-SSD and Texas Instruments Corp, respectively. Parts not included in the above documents have been used in the design only after a nonstandard item approval form (NSIAF) has been prepared, submitted to Reliability Assurance Engineering (RAE) and approved for use in the specific application(s) defined in the NSIAF by NASA-JSC.

Worst-Case Circuit Analyses have been performed and documented for all circuit designs to demonstrate that sufficient operating margins exist for all operating conditions. The analysis was worst case-in that the value for each of the variable parameters was set to limits that will drive the output to a maximum (or minimum).

A component application review and analysis was conducted to verify that the applied stress on each piece part by the temperature extremes identified with environmental qualification testing does not exceed the stress derating values identified in RCA 2295503.

In addition, an objective examination of the design was performed through a PDR and CDR to verify that the TVC/Lens assembly met specification and contractual requirements.

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FAILURE MODE AND CAUSE	**FAILURE EFFECT ON END ITEM**	**RATIONALE FOR ACCEPTANCE**	
Iris limit switch fails or shorted. MLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	See below	

DESIGN FEATURES

The general arrangement of the lens assembly is to provide an integrated housing, motor, and circuit board package which can accommodate various commercially available lenses. Emphasis is placed on accessibility of the lens, its drive components, and limit stops. Components within the lens assembly have been modularized, serving both the MLA, CLA, and WLA assemblies.

The lens housing structure is a one-piece casting designed to minimize machining and provide a rugged dimensionally stable mounting for the optical components. The housing is in the form of a right angle. The vertical member interfaces with the front surface of the camera and the horizontal member supports the drive motors on the upper surface with the lens function circuit boards in a cavity on the underside.

Lens Function Drive Train

The iris, zoom, and focus drives are identical in concept; the only difference is the lower gear ratio in the iris train to provide the 2.8-second end-to-end travel capability necessary for the ALC operation.

The table (on next page) shows the drive train parameters with overall torque margins for the three lens functions.

The motor/gear heads are mounted on the lens housing rather than on the lens, to permit the desired lens interchangeability for the Shuttle mission with minimum impact on the actual lenses.

Various types of motors were considered for this application, trading off size, power, weight, control-circuit complexity, command capability, and qualification status. The brushless and stepper-motor types fit the package and power requirements, the latter being preferred because of its simplicity, reliability, and space-qualified status. The selected stepper motor (a size-8, Alnico-9 pole-piece, permanent-magnet stepper) is mated with a spur train gearhead. Both units are manufactured by Monaco Motor Co. A 48-diametral-pitch (48-DP) spur gear on the gearhead output shaft meshes directly with the gears which are a part of the zoom, focus, and iris ring functions on the lens gear.

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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM
Iris limit switch fails or shorted. **MLA** Switch failure	Inability to control focus, zoom, or iris. **Worst Case:** Loss of mission critical camera video.

RATIONALE FOR ACCEPTANCE

DESIGN FEATURES

LENS DRIVE TRAIN PARAMETERS

Drive	Component	Travel (degrees)	Time End-to-End (seconds)	Input Torque (oz-in)	Ratio No. or Teeth	Efficiency (%)	Loss Torque (oz-in)	Net Torque (oz-in)
Zoom	Motor	150	6.6	-	-	-	-	0.27
	Gearhead			0.27	78:1	80	3.7	18.4
	Gearhead Output Gear			18.4	50	96	2.2	52.0
	Lens Gear				156		10.0 Torque Margin 5.2:1:	
Focus	Motor	282	7.5	-	-	-	-	0.27
	Gearhead			0.27	48:1	80	2.6	10.3
	Gearhead Output Gear			10.3	50	96	1.3	30.0
	Lens Gear				156		10.0 Torque Margin 3:1	
Iris	Motor	105	2.8	-	-	-	-	0.27
	Gearhead			0.27	48:1	80	2.6	10.3
	Gearhead Output Gear			10.3	50	96	1.3	30.0
	Lens Gear				156		5.0 Torque Margin 6:1	

FMEA NO. 6.1.6.4 CRITICALITY 2/2		SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT TCV/MLA DWG NO. 2294819-506,508 2294820-502 SHEET 4 OF 9
FAILURE MODE AND CAUSE	**FAILURE EFFECT ON END ITEM**	**RATIONALE FOR ACCEPTANCE**	
Iris limit switch fails or shorted MLA Switch failure	Unable to control the opening of the lens iris. Worst case: Loss of mission critical camera video.	QUALIFICATION TEST For Qualification Test Flow, see Table 2 located at the front of this book.	

FMEA NO. 5.1.6.4 CRITICALITY 2/2		SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT TCV/HLA DWG NO. 2294819-506-508/ 2294820-502 SHEET 5 OF 9
FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE	
Iris limit switch fails or shorted. HLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	See below	

ACCEPTANCE TEST

The CCTV systems' TVC/HLA 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: 6.1 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 TVC/HLA 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, 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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FMEA NO. 6.1.8.4 CRITICALITY 2/2		SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT ICV/HLA DWG NO. 2294819-506-508/ 2294820-502 SHEET 6 OF 9

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Iris limit switch fails or shorted. HLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	QA/INSPECTION Procurement Control - The IVC/HLA EEE Parts and hardware items are procured from approved vendors and suppliers who 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 1QC-531.) Board Assembly & Test - Prior to the start of HLA 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. HLA Boards Specific Instructions are given in assembly drawing notes and applicable documents called out in the fabrication procedure and record (FPR-2307088) and Parts List PL 2307088. These include wire connection list 2295902, Notes - wide angle zoom lens assy 2303191, Process Standard - bonding staking, potting, encapsulating 2280878, Specification - Urethane protective coating 2280877 and Workmanship Spec 8030035.

FMEA NO. 6.1.6.4 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT TCV/MLA DWG NO. 2294819-506-508/ 2294820-502 SHEET 7 OF 9

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Iris limit switch fails or shorted. MLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	QA/INSPECTION (Continued) MLA Assembly and Test - An open box test is performed per TP-IT-2307088, Acceptance Test per TP-AT-2307088. Torques are specified and witnessed, traceability numbers are recorde 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-217 and PAI-402. DCAS personnel witness WLA button-up and critical torquing. TVC/MLA - After a TVC/MLA have been tested individually, they are mated and a final acceptance test is performed per TP-AT-2294819, including vibration and thermal vacuum environments. RCA and DCAS personnel monitor these tests and review the acceptance test data/results. These personnel also inspect after all repair, rework and retest. Preparation for Shipment - The TVC and MLA are separated prior to shipment after fabrication and testing is complete. Each 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 assembly in accordance with the requirements of WS-2593176. RCA QC and DCAS personnal witness crating, packaging, packing, and marking, and review the EIDP for completeness and accuracy.

FMEA NO. 5.1.0.4 CRITICALITY 2/2		SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT ICY/MLA DWG NO. 2294819-506-508/ 2294820-502 SHEET 8 OF 9

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Iris limit switch fails or shorted. MLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	FAILURE HISTORY NONE.

FMEA NO. 5.1.6.4 CRITICALITY 2/2	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT ICV/HLA DWG NO. 2294819-506-508/ 2294820-502 SHEET 9 OF 9

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
Iris limit switch fails or shorted. HLA Switch failure	Unable to control the opening of the lens iris. Worst Case: Loss of mission critical camera video.	OPERATIONAL EFFECTS Loss of video. Possible loss of major mission objectives due to loss of RMS cameras or other required cameras. CREW ACTIONS If possible, continue RMS operations using alternative visual cues. CREW TRAINING Crew should be trained to use possible alternatives to CCTV. MISSION CONSTRAINT Where possible, procedures should be designed so they can be accomplished without CCTV.

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