

FMEA NO. <u>1.1.1</u> CRITICALITY <u>2/1R</u>	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT <u>Remote Control Unit (RCU)</u> DWG NO. <u>2294824-506, 507</u> SHEET <u>1</u> OF <u>8</u>
FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
composite sync/ command to all cameras and monitors. uses:) Sync Amplifier A1, 2294860-502 or A2, 2294861-502) Pattern Generator A3, 2294862-502) Pattern Decode A4, 2294863-506) Clock/Multiburst A5, 2592384-507 or 2294864-502	(1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost. (4) Same as above plus loss of all RCU/VSU functions (can not route video). Worst Case: Loss of PTU control prevents RMS stowing.	<p style="text-align: center;"><u>DESIGN FEATURES</u></p> <p>The RCU is a microprocessor-based command and control unit using an RCA 1802 CMOS microprocessor, CMOS RAM, and TTI PROM. Computer I/O circuitry is implemented in CMOS CD4000 series logic to minimize power dissipation. The design incorporates a dual master oscillator (one active, one cold backup). The master oscillator is a Temperature Compensated Crystal Oscillator (TCXO) purchased from Vectron to an RCA specification control drawing (SCD). Decode logic consists of Low Power Schottky TTL, and the sync amplifier design uses monolithic NE5539 wideband op amps.</p> <p>Parts were required to be JAN reliability level parts or their equivalent. Part selection falls into three categories: (1) JAN or better parts from the Military QPL, (2) Parts demonstrated to NASA to be equivalent to JAN level via test data (e.g., CD4000/3W series parts), or (3) Parts procured to an RCA spec control drawing which calls out tests and screening to effect JAN equivalency.</p> <p><u>BARE BOARD DESIGN (A1, A2, A3, A5)</u></p> <p>The design for the associated boards A1, A2, A3, A5 are 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.</p> <p>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-S10-1495. This provides for easy and reliable soldering at the time of board assembly, even after periods of prolonged storage.</p>

INRA NO. L1.1

CRITICALITY 2/1R

SHUTTLE CCTV
CRITICAL ITEMS LIST

UNIT Remote Control Unit (RCU)
DWG NO. 2294824-506, 507

SHEET 2 OF 8

FAILURE MODE AND CAUSE

FAILURE EFFECT ON END ITEM

Composite sync/ command to all cameras and monitors.

(1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion).
Loss of synchronization of video.
Monitor picture out of lock on external sync.
Split screen lost.
(4) Same as above plus loss of all RCU/VSU functions (can not route video).

Worst Case:
Loss of PTU control prevents RMS stowing.

uses:

- 1) Sync Amplifier
A1, 2294860-502 or
A2, 2294861-502
- 2) Pattern Generator
A3, 2294862-502
- 1) Pattern Decode
A4, 2294863-506
- 1) Clock/Multiburst
A5, 2292304-501
or 2294864-502

RATIONALE FOR ACCEPTANCE

DESIGN FEATURES

BOARD ASSEMBLY DESIGN (A1, A2, A3, A5)

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.

BARE BOARD CONSTRUCTION (A4)

The board is 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 (A4)

The drilled and etched board is 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.

BOARD PLACEMENT (A1, A2, A3, A4, A5)

The 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.

FAILURE MODE AND CAUSE		FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
FNFA NO. <u>1.1.1</u> CRITICALITY <u>2/1R</u>		SHUTTLE CCTV CRITICAL ITEMS LIST	
composite sync/ command to all meras and monitors.		UNIT <u>Remote Control Unit (RCU)</u> DWG NO. <u>2294824-500, 507</u> SHEET <u>3</u> OF <u>8</u>	
uses: } Sync Amplifier A1, 2294860-502 or A2, 2294861-502 } Pattern Generator A3, 2294862-502 } Pattern Decode A4, 2294863-506 } Clock/Multiburst A5, 2592384-501 or 2294864-502		<u>QUALIFICATION TEST</u> For Qualification Test Flow, see Table 2 located at the front of this book.	
		(1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost. (4) Same as above plus loss of all RCU/VSU functions (can not route video). <u>Worst Case:</u> Loss of PTU control prevents RMS stowing.	

(MEA NO. 1.1.1) CRITICALITY 2/TR	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT Remote Control Unit (RCU) DWG NO. 2294824-506, 507 SHEET 4 OF 8																
FAILURE MODE AND CAUSE composite sync/ command to all cameras and monitors. Issues: 1) Sync Amplifier A1, 2294860-502 or A2, 2294861-502 2) Pattern Generator A3, 2294862-502 3) Pattern Decoder A4, 2294863-506 4) Clock/Multiburst A5, 2592384-501 or 2294864-502	FAILURE EFFECT ON END ITEM (1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost. (4) Same as above plus loss of all RCU/VSU functions (can not route video). Worst Case: Loss of PTU control prevents RMS stowing.	RATIONALE FOR ACCEPTANCE ACCEPTANCE TEST The CCTV systems' RCU is subjected to the following testing: <ul style="list-style-type: none"> • Vibration: <table border="0" style="margin-left: 20px;"> <tr> <td>20-80Hz:</td> <td>3 dB/Oct-rise from 0.01 G²/Hz to 0.04 G²/Hz</td> </tr> <tr> <td>80-350 Hz:</td> <td>0.04 G²/Hz</td> </tr> <tr> <td>350-750 Hz:</td> <td>3 dB/Oct-Fall to 0.018 G²/Hz</td> </tr> <tr> <td>750-1000:</td> <td>0.018 G²/Hz</td> </tr> <tr> <td>1000-2000:</td> <td>3 dB/Oct-Fall to 0.009 G²/Hz</td> </tr> </table> • Thermal: <table border="0" style="margin-left: 20px;"> <tr> <td>100° F:</td> <td>Time to stabilize equipment plus 1 hour</td> </tr> <tr> <td>0° F:</td> <td>Time to stabilize equipment plus 1 hour</td> </tr> <tr> <td>100° F:</td> <td>Time to stabilize equipment plus 1 hour</td> </tr> </table> 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 or Orbiter Test/In-Flight Test <ol style="list-style-type: none"> 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). 	20-80Hz:	3 dB/Oct-rise from 0.01 G ² /Hz to 0.04 G ² /Hz	80-350 Hz:	0.04 G ² /Hz	350-750 Hz:	3 dB/Oct-Fall to 0.018 G ² /Hz	750-1000:	0.018 G ² /Hz	1000-2000:	3 dB/Oct-Fall to 0.009 G ² /Hz	100° F:	Time to stabilize equipment plus 1 hour	0° F:	Time to stabilize equipment plus 1 hour	100° F:	Time to stabilize equipment plus 1 hour
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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
<p>composite sync/ command to all cameras and monitors.</p> <p>uses:</p> <ul style="list-style-type: none"> 1) Sync Amplifier <ul style="list-style-type: none"> A1, 2294860-502 or A2, 2294861-502 2) Pattern Generator <ul style="list-style-type: none"> A3, 2294862-502 3) Pattern Decode <ul style="list-style-type: none"> A4, 2294863-506 4) Clock/Multiburst <ul style="list-style-type: none"> A5, 2592384-501 or 2294864-502 	<p>(1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost.</p> <p>(4) Same as above plus loss of all RCU/VSD functions (can not route video).</p> <p><u>Worst Case:</u> Loss of PTU control prevents RMS stowing.</p>	<p><u>QA/INSPECTION</u></p> <p><u>Procurement Control</u> - The RCU 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).</p> <p><u>Incoming Inspection and Storage</u> - 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. Nonconforming materials are held for Material Review Board (MRB) disposition. (PAI-307, PAI IQC-531.)</p> <p><u>Board Assembly & Test</u> - Prior to the start of RCU 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 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 RCU board assembly and test instructions are provided in drawing notes, and applicable documents are called out in the Fabrication Procedure and Record (FPR-2294824) and parts list PL-2294824. These include wire connection List 2295901, Process Standard RTV-566 2280881, Process Standard - Bonding Velcro 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 2010985, Specification - Marking 2280876, Specification - Workmanship 8030035, Specification Bonding and Staking 2280875.</p> <p><u>RCU Assembly and Test</u> - An open box test is performed per IP-II-2294824, and an Acceptance Test per IP-AT-2294824, 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 RCU button-up and critical torquing. RCA and</p>

IHLA NO. <u>1.1.1</u> CRITICALITY <u>2/IR</u>	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT <u>Remote Control Unit (RCU)</u> DWG NO. <u>2294824-506, 507</u> SHEET <u>6</u> OF <u>8</u>
FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
<p>to composite sync/ command to all cameras and monitors.</p> <p>Causes:</p> <ol style="list-style-type: none"> 1) Sync Amplifier A1, 2294860-502 or A2, 2294861-502 2) Pattern Generator A3, 2294862-502 3) Pattern Decode A4, 2294863-506 4) Clock/Multiburst A5, 2592384-501 or 2294864-502 	<p>{1}{2}{3} Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost. {4} Same as above plus loss of all RCU/VSU functions (can not route video).</p> <p><u>Worst Case:</u> loss of PTU control prevents RMS stowing.</p>	<p><u>QA/INSPECTION</u> (Continued)</p> <p>DCAS personnel monitor acceptance tests and review the test data/results. These personnel also inspect for conformance after all repair, rework and retest.</p> <p><u>Preparation for Shipment</u> - The RCU is packaged according to 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 RCU 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.</p>

FMEA NO. <u>L.L.L</u> CRITICALITY <u>2/R</u>	SHUTTLE CCTV CRITICAL ITEMS LIST	UNIT <u>Remote Control Unit (RCU)</u> DWG NO. <u>2294824-506.502</u> SHEET <u>7</u> OF <u>8</u>
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FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
<p>a composite sync/ command to all cameras and monitors.</p> <p>causes:</p> <ol style="list-style-type: none"> 1) Sync Amplifier A1, 2294860-502 or A2, 2294861-502 2) Pattern Generator A3, 2294862-502 3) Pattern Decode A4, 2294863-506 4) Clock/Multiburst A5, 2592384-501 or 2294864-502 	<p>{1}{2}{3} loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost. {4} Same as above plus loss of all RCU/VSU functions (can not route video).</p> <p>Worst Case: loss of PTU control prevents RMS stowing.</p>	<p><u>FAILURE HISTORY</u></p> <p>TDR - W0506, Log #0288, -501 S/N 002</p> <p><u>Description:</u> Acceptance Test failure. Box Level, Ambient Environment. No sync output.</p> <p><u>Cause:</u> A3B0 - R113 had loose end cap.</p> <p><u>Corrective Action:</u> R113 removed and replaced with one of the ten samples x-rayed by RCA Q.A. lab. All tested resistors were normal. This is a random failure.</p>

FMEA NO. 1.1.1

CRITICALLY 2/1R

SHUTTLE CCTV
CRITICAL ITEMS LIST

UNIT Remote Control Unit (RCU)
DWG NO. 2294824-506, 507

SHEET 8 OF 8

FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RATIONALE FOR ACCEPTANCE
<p>to composite sync/ command to all cameras and monitors.</p> <p>Causes:</p> <p>(1) Sync Amplifier A1, 2294860-502 or A2, 2294061-502</p> <p>(2) Pattern Generator A3, 2294862-502</p> <p>(3) Pattern Decode A4, 2294863-506</p> <p>(4) Clock/Multiburst A5, 2592384-501 or 2294864-502</p>	<p>(1)(2)(3) Loss of remote control of cameras and PTU (No PTU motion). Loss of synchronization of video. Monitor picture out of lock on external sync. Split screen lost.</p> <p>(4) Same as above plus loss of all RCU/VSU functions (can not route video).</p> <p>Worst Case: Loss of PTU control prevents RMS stowing.</p>	<p><u>OPERATIONAL EFFECTS</u></p> <p>Loss of ability to position the elbow camera. Possible inability to stow the RMS if the elbow camera physically interferes with a payload. If RMS cannot be stowed the port payload bay door cannot be closed. Loss of crew and vehicle.</p> <p><u>CREW ACTIONS</u></p> <p>Perform EVA to reposition the elbow camera, use RMS motion to reposition the camera, or jettison the RMS.</p> <p><u>CREW TRAINING</u></p> <p>Crew should be trained in contingency EVA and RMS operations procedures.</p> <p><u>MISSION CONSTRAINT</u></p> <p>Do not manifest elbow camera for any flight where the payload and the elbow camera can interfere with each other (for any pan or tilt angle). If the camera must be flown do not change the camera position until the interfering payload is deployed.</p>