

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1A-1

SHEET: 1

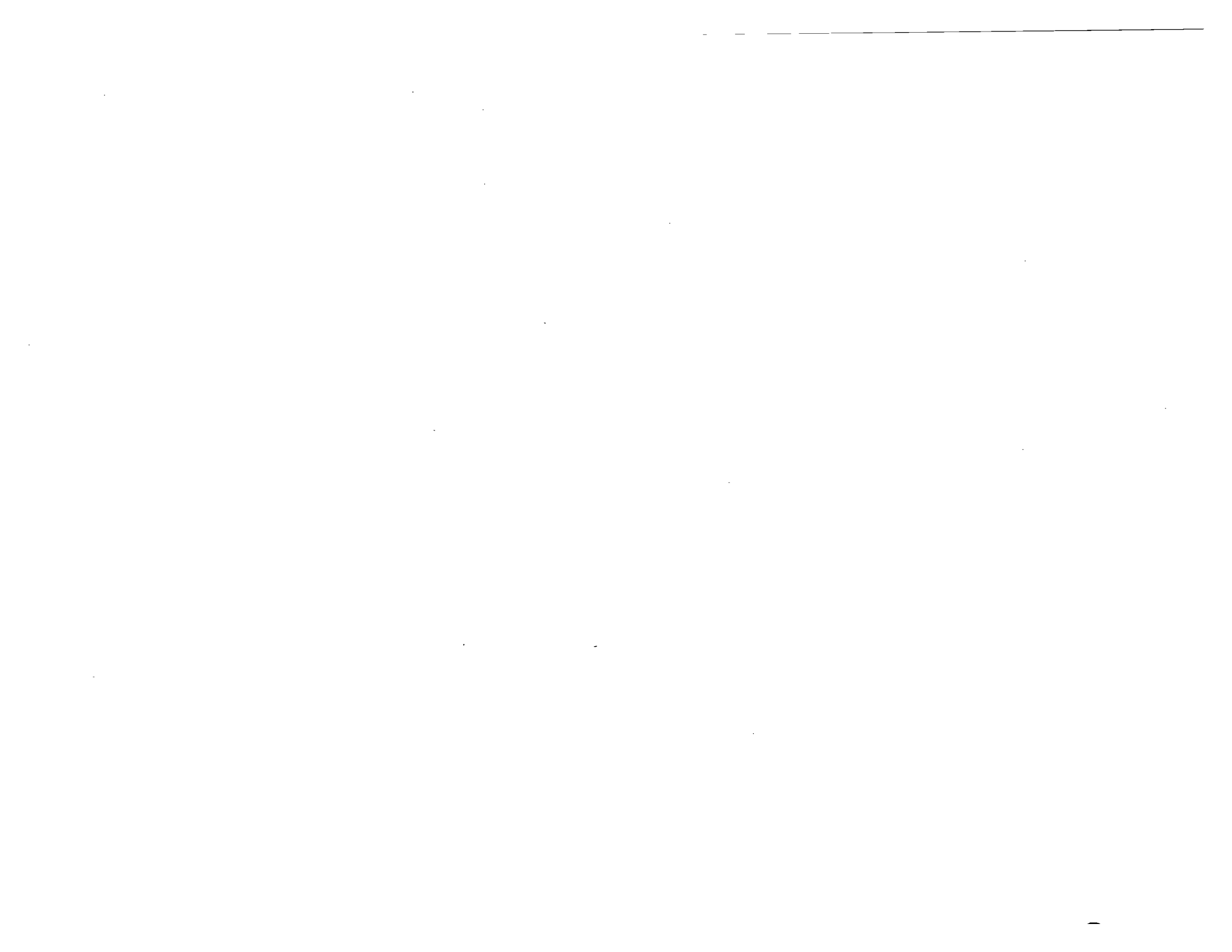
FMEA REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3800	1	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1B-3	MODE: RIGIDIZE DRIVE TRAIN FAILS FREE. CAUSE(S): (1) FRACTURED GEAR.	PAYLOAD CANNOT BE RIGIDIZED. IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED. REDUANT PATHS REMAINING N/A		<p>DESIGN FEATURES</p> <p>MATERIALS SELECTION AND USAGE CONFORMS TO SPAR-SG.360 WHICH IS EQUIVALENT TO THE NASA MATERIALS USAGE REQUIREMENTS.</p> <p>THE STRUCTURAL ANALYSIS CONDUCTED ON THE END EFFECTOR, PER SPAR-1N.1531, CONFIRMED A POSITIVE MARGIN OF SAFETY FOR ALL END EFFECTOR PARTS AND GEARS. THE MARGIN OF SAFETY FOR ULTIMATE STRENGTH (RUTS) INCORPORATES A FACTOR OF SAFETY OF 1.4 AGAINST LIMIT LOAD, AS SPECIFIED IN SPAR-SG. 392.</p> <p>A NEGATIVE MARGIN DOES NOT NECESSARILY IMPLY BREAKAGE OF THE PART, RATHER IT INDICATES THAT A LIMITING STRESS LEVEL ESTABLISHED BY THE FACTOR OF SAFETY, HAS BEEN EXCEEDED.</p> <p>THE MARGIN OF SAFETY FOR YIELD STRENGTH S(YIELD) EMPLOYS A FACTOR OF SAFETY OF 1.0 AGAINST LIMIT LOAD, AS SPECIFIED IN SPAR-SG.392. TABLE 14 LISTS MARGINS OF SAFETY FOR SRMS STRUCTURAL COMPONENTS.</p> <p>A FATIGUE ANALYSIS WHICH SHOWS INDEFINITE LIFE HAS BEEN PERFORMED ON THE GEARS AND MECHANICAL FASTENERS AND A FRACTURE ANALYSIS WHICH SHOWS LIVES GREATER THAN 424 MISSIONS HAS BEEN DEMONSTRATED ON STRUCTURAL COMPONENTS WITHIN THE END EFFECTOR.</p> <p>ALL SRMS GEARS ARE DESIGNATED IN ACCORDANCE WITH AGMA STANDARDS TO GIVE A MINIMUM OF INFINITE LIFE. THE DEFINITION OF INFINITE LIFE IS THE CONDITION WHERE 10⁶ MESH CYCLES OR MORE AT THE APPLIED LOAD WILL NOT RESULT IN TOOTH FAILURE.</p> <p>FOR THIS (THESE) GEAR (S) THE CALCULATED LIFE WAS NOT BASED OR CONTROLLED BY CONSIDERATIONS OF STRESS, BUT INSTEAD WERE SIZED TO SATISFY SPECIAL CONSTRAINTS. CONSEQUENTLY, THE MESH IS WELL WITHIN THE DEFINITION OF INFINITE LIFE AND THE FAILURE MODE STATED IN THE FMEA IS REMOVE.</p> <p>THE APPLIED LOADS DERIVED FOR THIS (THESE) GEAR (S) WERE CATERED TO IN THE SIZING OF THE GEAR MESH. THE MATERIAL ALLOWABLES WERE DERATED BY SPAR AS CONSISTENT FOR FINE PITCH GEARING APPLIED TO POWER TRANSMISSIONS. THE RESULTING MESH DESIGN WAS CHECKED AGAINST THE INFINITE LIFE CRITERIA.</p> <p>UNIT LOADS WERE CALCULATED TO DETERMINE THE STRENGTH OF THE GEARS IN SHARE AND RIGIDIZE GEAR TRAINS. THE UNIT LOAD IN THIS CONTEXT, IS A STRESS INDICATOR AND IS GIVEN BY THE FOLLOWING FORMULA:</p> $\text{UNIT LOAD} = \frac{\text{(TANGENTIAL GEAR LOAD)} \text{ (DIAMETRAL PITCH)}}{\text{(FACE WIDTH)}}$ <p>A VALUE OF 15,000 POUNDS PER IN., PER INCH (FOR STATIC CONDITIONS) HAS A DESIGN GOAL FOR GEARS IN THE END EFFECTOR. IT IS NOT A STRESS AND MUST NOT BE CONSTRUED AS A LIMITING OR ULTIMATE VALUE.</p>

PREPARED BY: NHC

SUPERCEDING DATE: 06 OCT 87

APPROVED BY: _____

DATE: _____



CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1B-J SHEET: 2

YREA REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOUR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
1800	1	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1B-3	MODE: RIGIDIZE DRIVE TRAIN FAILS FREE. CAUSE(S): (1) FRACTURED GEAR.	PAYLOAD CANNOT BE RIGIDIZED. IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED. REUNDANT PATHS REMAINING ----- N/A		<p>ACCEPTANCE TESTS</p> <p>-----</p> <p>THE EE ASSEMBLY IS TESTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENTS:</p> <ul style="list-style-type: none"> O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 O THERMAL VACUUM: +70 DEGREES C TO -25 DEGREES C (1 1/2 CYCLES) 1 X 10**6 TORR <p>THE EE ASSEMBLY IS FURTHER TESTED IN THE IN THE RMS SYSTEM TEST (TP51B RMS STRONGBACK AND TP552 FLAT FLOOR TESTS) WHICH VERIFIES THE ABSENCE OF THE FAILURE MODE.</p> <p>QUALIFICATION TESTS</p> <p>-----</p> <p>THE EE ASSEMBLY QUALIFICATION TESTING CONSISTED OF THE FOLLOWING ENVIRONMENTS:</p> <ul style="list-style-type: none"> O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 O SHOCK: 20G/11 MS - 3 AXES (6 DIRECTIONS) O THERMAL VACUUM: +81 DEGREES C TO -36 DEGREES C (6 CYCLES) 1 X 10**6 TORR O HUMIDITY: 95% RH (65 DEGREES C MAINTAINED FOR 6 HRS) (65 DEGREES C TO 30 DEGREES C IN 16 HRS) 10 CYCLES 240 HRS. O EMC: MIL-STD-461A AS MODIFIED BY SL-C-0002 (TEST CE01, CE07, CS01, CS02, CS06, RE02 (N/B)) O STRUCTURAL STIFFNESS AND LOAD TEST <p>FLIGHT CHECKOUT</p> <p>-----</p> <p>PDRS OPS CHECKLIST (ALL VEHICLES) JSC 16987</p>

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-18-3 SHEET: 3

P/N & REV.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3800	1.	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -18-3	<p>MODE: RIGIDIZE DRIVE TRAIN FAILS FREE.</p> <p>CAUSE(S): (1) FRACTURED GEAR.</p>	<p>PAYLOAD CANNOT BE RIGIDIZED. IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ.</p> <p>WORST CASE</p> <p>UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATHS REMAINING</p> <p>N/A</p>	<p>QA/INSPECTIONS</p>	<p>UNITS ARE MANUFACTURED UNDER DOCUMENTED QUALITY CONTROLS. THESE CONTROLS ARE EXERCISED THROUGHOUT DESIGN, PROCUREMENT, PLANNING, RECEIVING, PROCESSING, FABRICATION, ASSEMBLY, TESTING AND SHIPPING OF THE UNITS. MANDATORY INSPECTION POINTS ARE EMPLOYED AT VARIOUS STAGES OF FABRICATION ASSEMBLY AND TEST. GOVERNMENT SOURCE INSPECTION IS INVOKED AT VARIOUS CONTROL LEVELS.</p> <p>RECEIVING INSPECTION VERIFIES THAT THE HARDWARE RECEIVED IS AS IDENTIFIED IN THE PROCUREMENT DOCUMENTS, THAT NO DAMAGE HAS OCCURRED DURING SHIPMENT, AND THAT APPROPRIATE DATA HAS BEEN RECEIVED WHICH PROVIDES ADEQUATE TRACEABILITY INFORMATION AND IDENTIFIES ACCEPTABLE PARTS.</p> <p>PARTS ARE INSPECTED THROUGHOUT MANUFACTURE AND ASSEMBLY AS APPROPRIATE TO THE MANUFACTURING STAGE COMPLETED. THESE INSPECTIONS INCLUDE:</p> <p>GEAR INSPECTION, BEFORE GEAR LUBRICATION AND RUN-IN A COMPOSITE ERROR GEAR CHECKER IS USED TO VERIFY THAT INVOLUTE FORM, PITCH CIRCLE CONCENTRICITY AND PITCH DIAMETER ARE TO DRAWING REQUIREMENTS. THIS INSPECTION ALSO INCLUDES TEXTURE EVALUATION. AFTER LUBRICATION, GEARS ARE VISUALLY INSPECTED TO CONFIRM APPROPRIATE LUBRICANT APPLICATION AND GEARS ARE THEN RUN-IN, CLEANED AND VISUALLY INSPECTED.</p> <p>FOLLOWING HEAT TREATMENT, STEEL PARTS (E.G. GEARS) ARE SUBJECTED TO A MAGNETIC PARTICLE INSPECTION FOR CRACKS OR IN THE CASE OF ALUMINUM PARTS (E.G. HOUSINGS) ARE DYE PENETRANT INSPECTED USING GROUP V PENETRANTS. WELDING OF GEARS OR HOUSINGS IS SUBJECTED TO DYE PENETRANT (GROUP V) AND RADIOGRAPHIC INSPECTION ON COMPLETION OF STRESS RELIEF TO CHECK FOR CRACKS. QUALIFICATION WELDING TEST SAMPLES FOR STRUCTURAL WELDS ARE SUBJECTED TO DESTRUCTIVE TESTING WHERE POSSIBLE (TENSILE AND BENDING) AS WELL AS METALLAGRAPHIC ANALYSIS TO ENSURE DEFECT FREE WELDS.</p> <p>INSPECTION VERIFIES THAT KITTED PARTS ARE CORRECT PRIOR TO ASSEMBLY AND TRACEABILITY INFORMATION RECORDED.</p> <p>INSPECTION TO DRAWING IS CONDUCTED THROUGHOUT THE ASSEMBLY PROCESS, INCLUDING INSPECTION OF LOCKING, WITNESSING OF TORQUING AND APPLICATION OF TORQUE STRIPING.</p> <p>PRE-ACCEPTANCE TEST INSPECTION, WHICH INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC., (MANDATORY INSPECTION POINT).</p> <p>A TEST READINESS REVIEW (TRR) WHICH INCLUDES VERIFICATION OF TEST PERSONNEL, TEST DOCUMENTS, TEST EQUIPMENT CALIBRATION/ VALIDATION STATUS AND HARDWARE CONFIGURATION IS CONVENED BY QUALITY ASSURANCE IN CONJUNCTION WITH ENGINEERING, RELIABILITY, CONFIGURATION CONTROL, SUPPLIER AS APPLICABLE, AND THE GOVERNMENT REPRESENTATIVE, PRIOR TO THE START OF ANY FORMAL TESTING (ACCEPTANCE OR QUALIFICATION).</p>

PREPARED BY: MMG

SUPERCEDING DATE: 06 OCT 87

APPROVED BY: _____

DATE: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1E SHEET: 4

P/N REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT OR END ITEM	HOWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3800	1	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1B-3	<p>MODE: RIGIDIZE DRIVE TRAIN FAILS FREE.</p> <p>CAUSE(S): (1) FRACTURED GEAR.</p>	<p>PAYLOAD CANNOT BE RIGIDIZED. IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ.</p> <p>WORST CASE</p> <p>UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATHS REMAINING</p> <p>N/A</p>		<p>ACCEPTANCE TESTING (ATP) INCLUDES AMBIENT, VIBRATION AND THERMAL-VAC TESTING. (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p> <p>SRMS SYSTEMS INTEGRATION. THE INTEGRATION OF MECHANICAL ARM SUBASSEMBLIES AND THE FLIGHT CABIN EQUIPMENT TO FORM THE SRMS. INSPECTIONS ARE PERFORMED AT EACH PHASE OF INTEGRATION WHICH INCLUDES GROUNDING CHECKS, THRU WIRING CHECKS, WIRING ROUTING, INTERFACE CONNECTORS FOR BENT OR PUSH BACK CONTACTS ETC.</p> <p>SRMS SYSTEMS TESTING - STRONGBACK AND FLAT FLOOR AMBIENT PERFORMANCE TEST. (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p>

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1470-1B-1 SHEET: 5

P/N REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDMR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3000	1	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1B-3	MODE: RIGIDIZE DRIVE TRAIN FAILS FREE. CAUSE(S): (1) FRACTURED GEAR.	PAYLOAD CANNOT BE RIGIDIZED. IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ----- N/A	FAILURE HISTORY ----- THERE HAVE BEEN NO FAILURES ASSOCIATED WITH THIS FAILURE MODE ON THE SRMS PROGRAM.	

PREPARED BY: HWG SUPERSEDING DATE: 06 OCT 87 APPROVED BY: _____

E: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140C1470-1B-3

SHEET: 6

AREA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT OR END ITEM	HOWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3000	1	RIGIDIZE MECHANISM QTY-1 PART OF 51140C1472 -1B-3	MODE: RIGIDIZE DRIVE TRAIN FAILS FREE. CAUSE(S): (1) FRACTURED GEAR.	PAYLOAD CANNOT BE RIGIDIZED IF A PAYLOAD IS RIGIDIZED IT WILL DERIGIDIZE AND THE CARRIAGE WILL EXTEND UNDER LOW APPLIED LOADS. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE UNCOMMANDED DERIGIDIZE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING N/A		<p>OPERATIONAL EFFECTS</p> <p>PAYLOAD WILL BE DERIGIDIZED WITH NO OPERATOR COMMAND. IF THIS OCCURS WHILE THE ARM IS BEING DRIVEN, THE PAYLOAD WILL TAKE AN UNEXPECTED TRAJECTORY. ARM WILL REMAIN LIMP UNTIL EE MODE SW TURNED TO OFF DURING AUTO CAPTURE SEQUENCE.</p> <p>CREW ACTION</p> <p>RELEASE PAYLOAD AND MANEUVER ARM AND ORBITER AWAY FROM PAYLOAD.</p> <p>CREW TRAINING</p> <p>CREW WILL BE TRAINED TO DETECT OFF NOMINAL EE OPERATIONS AND TO MANEUVER THE ORBITER AWAY FROM A FREE FLYING PAYLOAD AT ANY TIME DURING ARM OPERATIONS.</p> <p>MISSION CONSTRAINT</p> <p>SPEC OPERATE UNDER VERNIER RATES WITHIN 10 FT OF STRUCTURE. THE OPERATOR MUST BE ABLE TO DETECT THAT THE ARM/PAYLOAD IS RESPONDING PROPERLY TO COMMANDS VIA WINDOW AND/OR CCTV VIEWS DURING ALL ARM OPERATIONS. EE MODE SWITCH SET TO OFF IMMEDIATELY AFTER SPEC DRIVE TIME HAS ELAPSED.</p> <p>SCREEN FAILURES</p> <p>N/A</p> <p>OMRSD OFFLINE</p> <p>PERFORM MANUAL CAPTURE/RIGIDIZE. VERIFY CORRECT FLAG TIRING-EXTEND TO RIGIDIZE.</p> <p>OMRSD ONLINE INSTALLATION</p> <p>NONE</p> <p>OMRSD ONLINE TURNAROUND</p> <p>PERFORM MANUAL CAPTURE/RIGIDIZE. VERIFY CORRECT FLAG TIRING-EXTEND TO RIGIDIZE.</p>