CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 511400470-1&-3
SHEET: 1

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 511400472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE ---------- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ---------- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	DESIGN FEATURES ---------- GEARS ARE LUBRICATED WITH DRY LUBRICANT WHICH HAS BEEN RATED AND WAS INITIALLY QUALIFIED TO HAVE A MISSION LIFE CAPABILITY OF GREATER THAN 424 MISSIONS. HOWEVER, RECENT FLIGHT DATA INDICATES LIFE MAY BE LOWER AND A TEST PROGRAMME HAS BEEN PLANNED TO EVALUATE THE GEAR LUBRICANT LIFE. 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 10**7 MESH CYCLES OR MORE AT THE APPLIED LOAD WILL NOT RESULT IN TOOTH FAILURE. 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 REMOTE. THE SOLID FILM LUBRICANT SYSTEM USED IS LUBECO 905. THIS COMPRISES A SPRAY AND CURE (400 DEGREES F) APPLICATION OF MOLYDENUM DISULPHIDE, IN AN IN ORGANIC BINDER APPLIED PER PPS:28:11 AND 28:13. BURNISHING AND RUN IN PER SPAR PPS 28:14. THE LUBRICATED BEARING IS TORQUE TRACED TO ENSURE ACCEPTABILITY PER SPAR PPS.28:14. THE LIFE OF THE BEARING LUBRICATION HAS BEEN ANALYZED USING ULTIMATE LOADS TO EVALUATE HERTZIAN STRESSES. ULTIMATE LOAD = 1.4 X WORKING LOAD. THE LUBRICANT ON ALL BEARINGS IS GOOD FOR OVER 400 MISSIONS USING THE ULTIMATE LOADS. THE RIGIDIZE GEAR TRAIN IS HOUSED WITHIN THE BACKPLATE ASSEMBLY ELIMINATING THE LIKELIHOOD OF GEARS JAMMING DUE TO FOREIGN MATERIAL INGRESS. MATERIALS SELECTION AND USAGE CONFORMS TO SPAR-SG.368 WHICH IS EQUIVALENT TO THE NASA MATERIALS USAGE REQUIREMENTS. THE BEARING ANALYSIS USES ULTIMATE LOADS TO DETERMINE THE MARGINS OF SAFETY OF THE LUBRICANT. THE FACTOR BETWEEN WORKING LOADS AND ULTIMATE IS 1.4. THE LUBRICANT FAILURE STRESSES ARE LOWER THAN THE BRINELLING STRESS. LIFE FOR ALL BEARINGS IS GREATER THAN 400 MISSIONS BASED UPON THE ABOVE CRITERIA. THE ALLOWABLE CONTACT STRESS FOR THE LUBRICANT IS ABOUT 1/5TH THE ALLOWABLE CONTACT STRESS FOR THE BEARING, THEREFORE THE LUBRICANT PROPERTIES DICTATE THE DESIGN, THE BEARINGS AS A RESULT ARE LIGHTLY LOADED AND SURFACE FATIGUE IN THE BEARING MATERIAL IS NOT A VIABLE FAILURE MODE. BALL SCREWS ARE PROCURED IN ACCORDANCE WITH SPAR-SG.464 AND ARE REQUIRED TO PASS AN ACCEPTANCE TEST AT THE SUPPLIER'S FACILITY PRIOR TO USAGE ON FLIGHT HARDWARE. THE END EFFECTOR CLUTCH IS A MAJOR BOUGHT-OUT-PART WHICH IS SUPPLIED BY HONEYWELL SPERRY CORPORATION AND MEETS OR EXCEEDS THE REQUIREMENTS OF SPECIFICATION SPAR-SG.450 FOR P/N 511400575-1 AND SPAR-SG.1092 FOR P/N511400575-3.

PREPARED BY: MFWG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY: _____
DATE: 24 JUL 91
CIL REV: 2

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 2

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE ---------- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ---------- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	THE END EFFECTOR PRIME AND BACK-UP RELEASE CLUTCH DESIGNS UTILIZE THREE BEARINGS, TWO OF WHICH ARE IDENTICAL. THE BEARINGS ARE PERMANENTLY LUBRICATED WITH WET LUBRICANT. THE TWO IDENTICAL BEARINGS ARE SEALED WITH TEFLON SEALS AND THE OTHER IS SEALED WITH TEFLON COATED FIBREGLASS SEALS, BOTH SIDES, TO PREVENT THE INGRESS OF DEBRIS. THE GREASE LUBRICANT USED IS BRAYCOTE 601 (FORMERLY 3L-38RP) WHICH HAS A PERFLUORINATED POLYETHER OIL BASE WHICH IS VERY STABLE UNDER VACUUM ENVIRONMENT. THE GREASE IS APPLIED IN PRECISE QUANTITY TO EACH BEARING. INVOLUTE SPLINE ASSEMBLY QUALIFICATION TESTING INCLUDED THERMAL/VACUUM LIFE CYCLE TESTING PERFORMED IN ACCORDANCE WITH SPAR-RMS-QTP.1034 AND DEMONSTRATED COMPONENT MISSION LIFE IN EXCESS OF 848 MISSIONS (2 TIMES A MISSION LIFE OF 424 MISSIONS) WITHOUT DEGRADATION IN PERFORMANCE. UNIT QUALIFICATION VIBRATION TESTING (QVT AND QAVT) WAS PERFORMED AT LEVELS 1.69 TIMES GREATER THAN END EFFECTOR LRU VIBRATION LEVELS TO VERIFY THE STRUCTURAL INTEGRITY OF THE INVOLUTE SPLINE ASSEMBLY. A POST QUALIFICATION TEST EVALUATION CONCLUDED THAT THE UNIT WAS STILL SERVICEABLE AND WAS NOT CONSIDERED TO BE A LIFE LIMITED ITEM. ALL END EFFECTOR MODELS ARE PRESENTLY EQUIPPED WITH INVOLUTE SPLINE ASSEMBLIES. THE END EFFECTOR BRAKE IS A MAJOR BOUGHT-OUT-PART WHICH IS SUPPLIED BY HONEYWELL SPERRY CORPORATION AND MEETS OR EXCEEDS THE REQUIREMENTS OF SPECIFICATION SPAR-SG.451 FOR P/N 511400574-1&-3 AND SPAR-SG.1093 FOR P/N 5114002219-1. THE BRAKE DESIGN FEATURES THAT LIMIT THE POSSIBILITY OF AN OPEN OR SHORT CIRCUIT IN THE WINDINGS ARE THE SAME AS THE FEATURES FOR THE CLUTCH DISCUSSED PREVIOUSLY IN THIS CIL ITEM. THE CALIPER BRAKE INCORPORATES MANY DESIGN FEATURES TO IMPROVE THE BRAKES CAPABILITY AND GIVE HIGHER RELIABILITY AS FOLLOWS: - SLIP TORQUE CAPABILITY UP TO 85 OZ-IN. - TOTAL INTERNAL CONTAINMENT OF FRICTION DEBRIS WITH THE USE OF LABYRINTH PATHS AND THE PLACEMENT OF THE FRICTION DISKS ON THE OPPOSITE END OF THE BRAKE SHAFT FROM THE PINION GEAR. - MECHANICALLY REDUNDANT SLIDING SPLINES FOR THE CALIPER DISK. - MECHANICALLY REDUNDANT LOCATING PINS WITH VESPEL SLEEVES FOR DISK LOCATION. - BEARING LOADS ARE REDUCED BY A 5 TO 1 FACTOR OVER THE ORIGINAL E/E SHARE BRAKE P/N 511400574-3. - SLIDING SURFACES ARE LUBRICATED WITH MOLYBDENUM DISULFIDE. - BEARINGS ARE WET LUBRICATED WITH BRAYCOTE 3L-38RP. - AIR GAP CAN BE ADJUSTED WITHOUT BRAKE DISASSEMBLY. THE FOLLOWING IS A LIST OF DESIGN CHARACTERISTICS THAT LIMIT THE POSSIBILITY OF AN OPEN OR SHORT CIRCUIT IN THE UNIT WINDINGS: THE INSULATION SYSTEM IS CLASS 185 (185 DEGREES C) OR BETTER AND IS PROVEN THROUGH YEARS OF USE.

PREPARED BY: MFWG
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CIL REV: 2

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 3

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	THE WIRE USED IN THE UNITS IS HEAVY ML MAGNET WIRE WHICH HAS AN EXTRA COAT OF INSULATION ON THE MAGNET WIRE. THE WINDINGS ARE PREBAKED AFTER THE WINDINGS ARE FORMED BUT PRIOR TO IMPREGNATION. THIS IS A STRESS RELIEVING OPERATION OF BOTH THE COPPER WIRE AND THE INSULATION, PERFORMED TO MINIMIZE ANY DEGRADATION DURING PROCESSING. KAPTON TAPE IS APPLIED OVER THE BOBBIN AND WINDINGS O.D. TO PROTECT THE MAGNET WIRE DURING PROCESSING AND INSTALLATION. THE UNIT IS IMPREGNATED WITH 100% SOLID EPOXY THAT IMPROVES THE COIL MECHANICAL PROPERTIES ESPECIALLY DURING VIBRATION AND HELPS THE UNIT RUN COOLER BY INCREASING THE EFFECTIVE THERMAL CONDUCTION WITHIN THE WINDING MASS. IT SHOULD BE NOTED THAT THE MAGNET WIRE USED IN THE WINDINGS OF THESE UNITS IS SINGLE STRAND. TO LIMIT THE POSSIBILITY OF A LOSS OF INPUT VOLTAGE DUE TO AN OPEN LEAD WIRE ALL SOLDERING IS ACCOMPLISHED BY OPERATORS WHO ARE TRAINED AND CERTIFIED TO NASA NHB 5300.4 (3A) STANDARD, AS MODIFIED BY JSC 08800A. THE BRAKE USES FOUR PINS PRESS FITTED INTO THE CORE TO HOLD THE ARMATURE FROM ROTATING AND TO ALLOW AXIAL SLIDING FOR ENGAGEMENT AND DISENGAGEMENT. THE FOLLOWING IS A LIST OF CHARACTERISTICS TO LIMIT THE POSSIBILITY OF THE BRAKE HANGING-UP DUE TO MECHANICAL BINDING BETWEEN THE PINS AND THE HOLES. THE HOLES IN THE ARMATURE AND BRAKE CORE ARE MATCH-BORED (JIG BORED) TO ASSURE GOOD ALIGNMENT. THE ARMATURE HOLES ARE 0.004 TO 0.005 INCH LARGER THAN THE CORE PINS TO ASSURE ADEQUATE CLEARANCE. MEASUREMENTS ARE PERFORMED TO CONFIRM A MINIMUM OF 0.002 INCH RADIAL PLAY BETWEEN THE TWO ASSEMBLED PARTS. THE UNIT IS TESTED A MINIMUM OF SEVEN TIMES DURING ACCEPTANCE TESTING FOR POTENTIAL BINDING. THE TEST CONSISTS OF APPLYING FULL RATED LOAD TORQUE WITH THE UNIT ENGAGED. A VOLTAGE IS THEN APPLIED TO DISENGAGE THE UNIT. THE TIME FROM APPLICATION OF VOLTAGE UNTIL FULL DISENGAGEMENT IS MEASURED. ANY BINDING OF THE ARMATURE WOULD EITHER PREVENT DISENGAGEMENT OR CAUSE AN EXCESSIVE TIME DELAY. THE PINS ARE LUBRICATED WITH MOLYBDENUM DISULFIDE. THE HEAVIEST AMOUNT OF FRICTION MATERIAL DEBRIS IS GENERATED DURING THE CALIBRATION RUN-IN OF THE UNIT. THE RUN-IN CONSISTS OF ROTATING THE UNIT IN ONE DIRECTION AT 50 RPM FOR A TOTAL OF 16 HOURS MINIMUM USING A DUTY CYCLE OF 10 SECONDS ENGAGED AND THEN 10 SECONDS DISENGAGED. THE UNITS RECEIVE A VERY LIMITED AMOUNT OF SLIPPING DURING ON MISSION USAGE. DEBRIS IS PREVENTED FROM ESCAPING FROM THE -3 CLUTCH USED IN THE 51140E1470-3 END EFFECTOR WITH A LABYRINTH NETWORK.

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CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 4

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --------- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --------- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	THE AIR GAP OF THE UNIT IS VERIFIED TO MEET A MINIMUM VALUE BY THE END PLAY TEST (LARGEST APPLIED LOAD) DURING ACCEPTANCE TESTING. THE STRIPDOWN AND INSPECTION OF FLIGHT HARDWARE RETURNED FOR REFURBISHMENT HAS REVEALED THAT A SIGNIFICANT AMOUNT OF FRICTION MATERIAL DEBRIS MAY HAVE ACCUMULATED AT THE UNIT END-OF-LIFE. IT IS VERY UNLIKELY; HOWEVER, THAT SUFFICIENT FRICTION DEBRIS COULD ACCUMULATE BEHIND THE ARMATURE OR BETWEEN THE FRICTION SURFACES, SO AS TO AFFECT THE UNITS PERFORMANCE CONNECTOR USED ARE TO GSFC SPECIFICATION S.311.P.4/9. CONTACTS USED ARE TO GSF SPEC.S.311.P.4/9. CRIMPING IS CONTROLLED TO SPAR PPS 9:17 WHICH EMBODIES NSC-SPEC-Q-1A. THE STRUCTURAL ANALYSIS CONDUCTED ON THE END EFFECTOR, PER SPAR-TM.1531, CONFIRMED A POSITIVE MARGIN OF SAFETY FOR ALL END EFFECTOR PARTS AND GEARS. THE MARGIN OF SAFETY FOR ULTIMATE STRENGTH M(UTS) INCORPORATES A FACTOR OF SAFETY OF 1.4 AGAINST LIMIT LOAD, AS SPECIFIED IN SPAR-SG. 392. 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. 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. A FATIGUE ANALYSIS WHICH SHOWS INDIFINITE 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.

PREPARED BY: MFWG
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CIL REV: 2

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 5

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	ACCEPTANCE TESTS --- THE EE ASSEMBLY IS TESTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENTS: 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 THE EE ASSEMBLY IS FURTHER TESTED IN THE IN THE RMS SYSTEM TEST (TP518 RMS STRONGBACK AND TP552 FLAT FLOOR TESTS) WHICH VERIFIES THE ABSENCE OF THE FAILURE MODE. QUALIFICATION TESTS --- THE EE ASSEMBLY QUALIFICATION TESTING CONSISTED OF THE FOLLOWING ENVIRONMENTS: 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-E-0002 (TEST CE01, CE03, CS01, CS02, CS06, RE02 (N/B)) o STRUCTURAL STIFFNESS AND LOAD TEST FLIGHT CHECKOUT --- PDRS OPS CHECKLIST (ALL VEHICLES) JSC 16987

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CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 6

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE ---------- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ---------- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	QA/INSPECTIONS ---------- 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. 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. INSPECTION VERIFIES THAT KITTED PARTS ARE CORRECT PRIOR TO ASSEMBLY AND TRACEABILITY INFORMATION RECORDED. INSPECTION TO DRAWING IS CONDUCTED THROUGHOUT THE ASSEMBLY PROCESS, INCLUDING INSPECTION OF LOCKING, WITNESSING OF TORQUING AND APPLICATION OF TORQUE STRIPING. BEARINGS RECEIVE DIMENSIONAL INSPECTION AT THE SUPPLIER AND VERIFICATION BY SPAR RECEIVING INSPECTION. PRE-ASSEMBLY INSPECTION VERIFIES CIRCULARITY OF BALL TRACKS AND INNER/OUTER RACE DIAMETERS. AFTER ASSEMBLY PRIOR TO LUBRICATION, RADIAL CLEARANCE MEASUREMENTS ARE TAKEN. FOLLOWING LUBRICATION, RUN-IN/BURNISHING AND CLEANING OF DRY LUBE BEARINGS, SPECIALIZED BEARING INSPECTION EQUIPMENT AT SPAR IS USED TO VERIFY QUALITY AND STICTION LEVELS THROUGH STRIP CHART RECORDING OF TORQUE TRACES. BEARINGS ARE THEN RETURNED TO THE SUPPLIER FOR FINAL RADIAL CLEARANCE MEASUREMENTS. GOVERNMENT SOURCE INSPECTION IS ENVOKED ON ALL BEARING PROCUREMENTS. 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. CARPENTER 455 STEEL USED FOR THE MANUFACTURE OF (E.G. GEARS) RECEIVES ADDITIONAL LABORATORY INSPECTIONS WHICH INCLUDE CHEMICAL ANALYSIS, INCLUSION RATING, HARDNESS AND TENSILE TESTING TO VERIFY THE PROPERTIES OF THE MATERIAL SUPPLIED. 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

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CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 7

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	POSSIBLE (TENSILE AND BENDING) AS WELL AS METALLAGRAPHIC ANALYSIS TO ENSURE DEFECT FREE WELDS. PRE-ACCEPTANCE TEST INSPECTION, WHICH INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC., (MANDATORY INSPECTION POINT). 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). ACCEPTANCE TESTING (ATP) INCLUDES, AMBIENT, VIBRATION AND THERMAL-VAC TESTING, (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT) 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. SRMS SYSTEMS TESTING - STRONGBACK AND FLAT FLOOR AMBIENT PERFORMANCE TEST. (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)

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CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1&-3
SHEET: 8

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY	RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --------- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --------- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	FAILURE HISTORY --------- THERE HAVE BEEN NO FAILURES ASSOCIATED WITH THIS FAILURE MODE ON THE SRMS PROGRAM.

PREPARED BY: MFWG
SUPERCEDING DATE: 06 OCT 87
DATE: 24 JUL 91
CIL REV: 2

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-16-3
SHEET: 9

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE & CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 2/1R CRITICALITY — RATIONALE FOR ACCEPTANCE SCREENS: A-PASS, B-PASS, C-PASS
3790	2	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -16-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --- 1) MANUAL EE MODE RELEASE. 2) BACKUP EE RELEASE.	OPERATIONAL EFFECTS --- UNABLE TO RIGIDIZE/DERIGIDIZE. IF FAILURE OCCURS DURING RIGIDIZE SEQUENCE, THE CARRIAGE WILL NOT COMPLETELY RIGIDIZE AND ARM WILL REMAIN LIMP IF IN AUTO MODE. OPERATOR WILL DETECT OFF NOMINAL OPERATION OF THE EE. CREW ACTION --- THE EE MODE SWITCH SHOULD BE TURNED OFF. CREW SHOULD OBSERVE THE CAPTURE SEQUENCE AND DETERMINE THAT THE GRAPPLE FIXTURE HAS BEEN DRAWN FAR ENOUGH INTO THE EE TO PROHIBIT PAYLOAD ROTATIONS. IF THE INTERFACE DOES NOT APPEAR RIGID, ATTEMPT TO RIGIDIZE IN THE ALTERNATE MODE. IF RIGIDIZE IS UNSUCCESSFUL, ATTEMPT RELEASE USING A PRIMARY EE MODE. IF SNARES OPEN, MANEUVER THE ARM AWAY FROM THE PAYLOAD. IF SNARES DON'T OPEN, ATTEMPT TO RELEASE IN BACKUP MODE. IF SNARES OPEN, MANEUVER ARM AWAY FROM THE PAYLOAD. MANEUVER ORBITER AWAY FROM PAYLOAD. IF SNARES CANNOT BE OPENED IN ANY MODE, THEN THE ARM/PAYLOAD COMBINATION CAN BE JETTISONNED. CREW TRAINING --- CREW TO BE TRAINED TO RECOGNIZE OFF NOMINAL OPERATION OF THE EE AND TO TURN MODE SWITCH TO OFF AFTER SPEC TIME AND MANEUVER THE ORBITER AWAY FROM A FREE FLYING PAYLOAD AT ANY TIME DURING ARM OPERATIONS. MISSION CONSTRAINT --- WHEN CAPTURING A FREE FLYING PAYLOAD, THE EE MUST BE FAR ENOUGH AWAY FROM STRUCTURE TO PROHIBIT CONTACT REGARDLESS OF PAYLOAD ROTATIONS. OMRSD OFFLINE --- PERFORM MANUAL CAPTURE RIGIDIZE. VERIFY CORRECT FLAG TIMING-EXTEND TO RIGIDIZE. OMRSD ONLINE INSTALLATION --- NONE OMRSD ONLINE TURNAROUND --- PERFORM MANUAL CAPTURE/RIGIDIZE. VERIFY CORRECT FLAG TIMING-EXTEND TO RIGIDIZE.

PREPARED BY: MFWG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY: _____
DATE: 24 JUL 91
CIL REV: 2

CRITICAL ITEMS LIST

PROJECT: SRMS
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y NOMENCLATURE: END EFFECTOR
ASS'Y P/N: 51140E1470-18-3
SHEET: 10

FMEA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
3790	1 -	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -18-3	MODE: RIGIDIZE DRIVE TRAIN WILL NOT DRIVE. CAUSE(S): (1) JAMMED GEAR TRAIN. (2) BINDING BALL SCREWS. (3) RIGIDIZE CLUTCH SEIZED. (4) BINDING OF INVOLUTE SPLINE (5) RIGIDIZATION BRAKE ENGAGED. (6) STRUCTURAL FAILURE.	PAYLOAD CANNOT BE RIGIDIZED OR DERIGIDIZED. ARM WILL STAY LIMP. WORST CASE --- UNEXPECTED MOTION. INCOMPLETE RIGIDIZE SEQUENCE. UNANNUNCIATED. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING --- N/A		VERIFY CORRECT FLAG TIMING-EXTEND TO RIGIDIZE.

PREPARED BY: MWG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY: ___