

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1214

SHEET: 1

FMEA REF.	REV.	NAME, QTY. & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RDMN / FUNC. 1/1 CRITICALITY RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINTON GEAR. QTY: 6 P/N 51140D1201	<p>MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT.</p> <p>CAUSE(S): (1) FATIGUE FAILURE.</p>	<p>LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES.</p> <p>WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNOUNCED. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATHS REMAINING N/A</p>	<p>DESIGN FEATURES</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 REMOTE.</p> <p>THE MINIMUM MARGIN OF SAFETY OF THIS SHAFT IS 11.35 WHICH INCLUDES ALL STRESS CONCENTRATION FACTORS AND THE LIMIT TO ULTIMATE FACTOR OF 1.40. A FATIGUE ANALYSIS SHOWS THAT THE ITEM HAS INFINITE LIFE WHEN SUBJECTED TO MAXIMUM LOAD CONDITIONS. (THE MARGIN OF SAFETY ON THE ENDURANCE LIMIT IS 9.7). THE FACTORS SHOWN ABOVE INDICATE THAT STRUCTURAL FAILURE OF THE SHAFT WILL NOT OCCUR. (REF/STR/314).</p>

PREPARED BY: MFLG

SUPERSEDING DATE: 13 OCT 89

APPROVED BY:

RMS/MECH - 256

IE: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1214

SHEET: 2

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINTON GEAR. QTY-6 P/N 51140D1281	MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT. CAUSE(S): (1) FATIGUE FAILURE.	LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES. WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNUNCIATED. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING N/A		ACCEPTANCE TESTS THE JOINTS MOTOR MODULE ASSEMBLY CONSIST OF THE BRAKE ASSEMBLY, MOTOR ASSEMBLY, TACHOMETER, COMM. SCANNER AND SCU ALL OF WHICH ARE EXPOSED TO AN ACCEPTANCE TEST BY THE VENDOR PRIOR TO ACCEPTANCE BY SPAR. THE MOTOR MODULE ASSEMBLY IS SUBJECTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENT: O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE B O THERMAL VACUUM: +85 DEGREE C TO -25 DEGREE C (1.5 CYCLES) 1 X 10**5 TORR THE MOTOR MODULE IS INSTALLED IN THE JOINTS ASSEMBLY AND AGAIN IS EXPOSED TO ANOTHER ACCEPTANCE TEST, WHICH INCLUDES VIBRATION AND THERMAL VACUUM OF THE SAME APPROXIMATE LEVEL AND DURATION. QUALIFICATION TESTS A TYPICAL MOTOR MODULE ASSEMBLY WAS TOTALLY QUALIFIED BY SPAR FOR THE LISTED BELOW ENVIRONMENTS. FURTHER, THE BRAKE / ASSEMBLY, MOTOR ASSEMBLY, TACHOMETER AND COMM. SCANNER, ARE SUBJECTED TO SOME DEGREE OF QUALIFICATION TESTING BY THE VENDOR. THE MOTOR MODULE TESTS: O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE B O THERMAL VACUUM: +96 DEGREE C TO -36 DEGREE C (8 CYCLES) 1 X 10**6 TORR O SHOCK: 20G/11 MS - 3 AXES (6 DIRECTIONS) O HUMIDITY: TESTED IN SHOULDER JOINT HUMIDITY TEST O EMC: MIL-STD-461 AS MODIFIED BY SL-E-0002 (TESTS CS01, CS02, CS06, CE01, RE02(N/B), RS03, RS04) FLIGHT CHECKOUT PORS OPS CHECKLIST (ALL VEHICLES) JSC 14987

PREPARED BY: HLWG

SUPERSEDING DATE: 13 OCT 89

APPROVED BY:

TE: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1214

SHEET: 3

ITEM REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOLD / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINION GEAR. QTY-6 P/N 51140D12B1	MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT. CAUSE(S): (1) FATIGUE FAILURE.	LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES. WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNOUNCED. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING N/A	QA/INSPECTIONS.	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. PARTS ARE INSPECTED THROUGHOUT MANUFACTURE AND ASSEMBLY AS APPROPRIATE TO THE MANUFACTURING STAGE COMPLETED. THESE INSPECTIONS INCLUDE, 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. SHAFTS ARE DIMENSIONAL INSPECTED TO DRAWING REQUIREMENTS THROUGHOUT THE MANUFACTURING STAGES. FOLLOWING HEAT TREATMENT THE SHAFTS ARE SUBJECTED TO MAGNETIC PARTICLE INSPECTION FOR CRACKS. 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. 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. INSPECTION VERIFIES THAT KITTED PARTS ARE CORRECT PRIOR TO ASSEMBLY AND TRACEABILITY INFORMATION RECORDED. 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

PREPARED BY: MFMG

SUPERCEDING DATE: 13 OCT 89

APPROVED BY:

TE:

RMS/MECH - 258

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140ET214

SHEET: 4

P/N & REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOW / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINION GEAR. QTY-6 P/N 51140D1281	<p>MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT.</p> <p>CAUSE(S): (1) FATIGUE FAILURE.</p>	<p>LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES.</p> <p>WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNOUNCIATED. CREW ACTION REQUIRED</p> <p>REDUNDANT PATHS REMAINING N/A</p>		<p>AND THERMAL-VAC TESTING, (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p> <p>INTEGRATION OF UNIT TO JOINT SRU - INSPECTIONS INCLUDE GROUNDING CHECKS, CONNECTORS FOR BENT OR PUSHBACK CONTACTS, VISUAL, CLEANLINESS, INTERCONNECT WIRING AND POWER UP TEST TO THE APPROPRIATE JOINT INSPECTION TEST PROCEDURE (ITP) ETC.</p> <p>JOINT LEVEL PRE-ACCEPTANCE TEST INSPECTION, INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC.</p> <p>JOINT LEVEL 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>

PREPARED BY: MFMG

SUPERSEDING DATE: 13 OCT 89

APPROVED BY:

RMS/MECH - 259

AIE:

2116

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1214

SHEET: 5

ITEM REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOW / FUNC. 1/1 CRITICALITY RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINION GEAR. QTY-6 P/N 51140D12B1	MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT. CAUSE(S): (1) FATIGUE FAILURE.	LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES. WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNUNCIATED. 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: MFMG

SUPERCEDING DATE: 13 OCT 89

APPROVED BY

DATE:

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: MOTOR MODULE

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1214

SHEET: 6

P/N REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOUR / YR. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4090	1	MOTOR MODULE DRIVE SHIFT AND PINION GEAR. QTY-6 P/N 51140D1201	MODE: BROKEN DRIVE GEAR OR DRIVE SHAFT. CAUSE(S): (1) FATIGUE FAILURE.	LOSS OF ABILITY TO DRIVE OR STOP A JOINT. JOINT WILL ONLY BE RESTRAINED BY REMAINING FRICTION OF GEARBOXES. ARM MAY TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES. HOWEVER, FAILED JOINT WILL NOT STOP. LOSS OF ALL MODES. WORST CASE UNEXPECTED MOTION. FREE JOINT. UNANNUNCIATED. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING N/A		<p>OPERATIONAL EFFECTS ONE JOINT FAILS FREE. THE FAILED JOINT IS ONLY RESTRAINED BY GEARBOX FRICTION. ARM MAY BACKDRIVE IF BRAKES ARE OFF AND ANY OF THE OTHER JOINTS ARE DRIVEN. ARM DOES NOT RESPOND TO COMMANDS. FOR HAND CONTROLLER COMMANDS CREW INHERENTLY COMPENSATES FOR ANY UNDESIRED ARM TRAJECTORY. NO DRIVE MODES AVAILABLE FOR FAILED JOINT.</p> <p>CREW ACTION USE SINGLE MODE TO POSITION OTHER JOINTS FOR STOP OR JETTISON.</p> <p>CREW TRAINING THE CREW WILL BE TRAINED TO ALWAYS OBSERVE WHETHER THE ARM IS RESPONDING PROPERLY TO COMMANDS. IF IT ISN'T APPLY BRAKES.</p> <p>MISSION CONSTRAINT CREW SHOULD BE TRAINED TO OPERATE UNDER VERNIER RATES WITHIN 10 FT OF STRUCTURE. AUTO TRAJECTORIES MUST BE DESIGNED TO COME NO CLOSER THAN 5 FT FROM STRUCTURE. THE OPERATOR MUST BE ABLE TO DETECT THAT THE ARM IS RESPONDING PROPERLY TO COMMANDS VIA WINDOW AND/OR CCTV VIEWS DURING ALL ARM OPERATIONS. ARM SHOULD NOT BE MANEUVERED TO POSITION WHERE JETTISON CANNOT BE SAFETY PERFORMED.</p> <p>SCREEN FAILURES N/A</p> <p>OMSD OFFLINE IN DIRECT DRIVE WITH ELBOW DEMATED VERIFY JOINT MOTION</p> <p>OMSD ONLINE INSTALLATION NONE</p> <p>OMSD ONLINE TURNAROUND IN SINGLE MODE DRIVE ALL JOINTS VERIFY TACHOMETER SIGNATURE</p>

PREPARED BY: MFVG

SUPERSEDING DATE: 13 OCT 89

APPROVED BY:

DATE: _____