FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: M8-1SS-BM024-X

SUBSYSTEM NAME: MECHANICAL - EDS
REVISION: 1 DEC, 1996

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	GUIDE RING ASSEMBLY RSC-ENERGIA	33U.6271.011-09 ("SOFT") 33U.6271.011-05 (PMA1) 33U.6201.008-08 (PMA2/3)
SRU	:	SENSOR RSC-ENERGIA	33U.5319.027 33U.5319.027

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CAPTURE SENSOR

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
THREE

FUNCTION:
THREE SENSORS, LOCATED ON THE GUIDE RING ASSEMBLY, ARE USED TO MONITOR THE RING MATCHING OF BOTH THE ORBITER/PMA1 AND ISS (PMA2/FGB) DOCKING RING ASSEMBLIES. EACH SENSOR CONTAINS TWO REDUNDANT SHORT CONTACTS AND TWO REDUNDANT LONG CONTACTS. THE SHORT CONTACTS OF THE THREE SENSORS ARE CONNECTED IN SERIES AND THE LONG CONTACTS OF THE THREE SENSORS ARE CONNECTED IN PARALLEL. TOGETHER THEY SENSE THE MATING OF THE TWO DOCKING RINGS AND SEND A SIGNAL TO THE DSCU TO ACTIVATE THE HIGH ENERGY (AND LOW ENERGY FOR THE "SOFT" MECHANISM) DAMPERS AND TO ILLUMINATE THE "CAPTURE" INDICATOR LIGHT ON THE DOCKING CONTROL PANEL WHEN ALL THREE SENSORS ACTUATE SIMULTANEOUSLY. THE LONG CAPTURE SIGNAL IS DOWNLINKED TO GROUND PERSONNEL. THESE SENSORS SENSE THE SECOND POINT IN THE AUTOMATIC DOCKING SEQUENCE - MATING OF THE TWO DOCKING RINGS. THE SIGNAL FROM THE PMA2/3 PASSIVE MECHANISM CAPTURE SENSORS IS TRANSFERED TO ISS (FGB) TO TURN OFF DYNAMIC REGIME (DOESN'T APPLY TO THE 2A MISSION).

SERVICE IN BETWEEN FLIGHT AND MAINTENANCE CONTROL:
VISUAL INSPECTION, SERVICEABILITY CONTOL, DOCKING WITH CALIBRATING DOCKING MECHANISM.

MAINTAINABILITY
REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.5319.027
33U.6271.011-09 ("SOFT")

33U.6271.011-05 (PMA1)
33U.6201.006-08 (PMA2/3)

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
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REVISION# 1 DEC, 1996

SUBSYSTEM NAME: MECHANICAL - EDS
LRU: GUIDE RING ASSEMBLY
ITEM NAME: SENSOR, CAPTURE

CRITICALITY OF THIS FAILURE MODE: 2R3

FAILURE MODE:
ONE CONTACT SET FAILS OPEN

MISSION PHASE:
OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:
PIECE PART FAILURE, VIBRATION, THERMAL/MECHANICAL SHOCK, MANUFACTURE/ MATERIAL DEFECT, CONTAMINATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

CRITICALITY 1R2 DURING INTACT ABORT ONLY (AVIONICS ONLY)? NO

REDUNDANCY SCREEN A) PASS
B) FAIL
C) FAIL

PASS/FAIL RATIONALE:
A)

B)
FAILS REDUNDANCY SCREEN "B" SINCE A FAILURE TO TRANSFER ON ONE CONTACT SET IS NOT DETECTABLE IN FLIGHT.

C)
FAILS REDUNDANCY SCREEN "C" SINCE NON-CONDUCTIVE CONTAMINATION CAN CAUSE A FAILS OPEN CONDITION ON BOTH CONTACT SETS AND AN OPEN/LOOSE CONNECTOR CAN RESULT IN LOSS OF SIGNAL FROM BOTH CONTACT SETS.

METHOD OF FAULT DETECTION:
UPON TERMINATING THE DOCKING PROCESS, GIVEN A LOSS OF CAPTURE INDICATION, CAPTURE OF BOTH MECHANISMS CAN BE DETERMINED DURING SEPARATION. IF BOTH MECHANISMS HAD PROPERLY LATCHED DURING CAPTURE IT WOULD BE DETECTED UPON SEPARATION, AT WHICH TIME A SECOND DOCKING ATTEMPT COULD BE MADE AT THE DISCRETION OF BOTH THE ORBITER/PMA1 AND ISS CREW. UNDER NORMAL DOCKING CONDITIONS THE "CAPTURE" INDICATION IS DISPLAYED WITHIN SECONDS FOLLOWING THE "INITIAL CONTACT" INDICATION.

MASTER MEAS. LIST NUMBERS: V53X0757E

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REMARKS/RECOMMENDATIONS:
REDUNDANT SHORT CONTACT SETS ARE PROVIDED ON EACH CAPTURE SENSOR.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
TO THE "SOFT" MECHANISM, PMA1 MECHANISM:
LOSS OF "RING SHORT CAPTURE" OR "RING LONG CAPTURE" SIGNAL TO DSCU. NO EFFECT FIRST FAILURE. CAPTURE INDICATION IS ACHIEVED WHEN ONE SHORT CONTACT SET IN EACH OF THE THREE CAPTURE SENSORS AND ANY ONE LONG CONTACT SET ARE CLOSED. SHORT CONTACT SETS ON EACH CAPTURE SENSOR ARE CONNECTED IN SERIES, I.E. THE FIRST SHORT CONTACT SET IN EACH SENSOR ARE TIED TOGETHER AND THE SECOND SHORT CONTACT SET IN EACH SENSOR ARE TIED TOGETHER. A FAILED OPEN CONDITION ON ANY TWO CAPTURE SENSOR SHORT CONTACT SETS (ONE IN EACH SERIES CONTACT SET PATH) WILL PREVENT THE HIGH ENERGY (AND LOW ENERGY FOR THE "SOFT" MECHANISM) DAMPERS FROM ACTIVATING. FAILURE TO TURN ON DAMPERS JUST AFTER CAPTURE COULD RESULT IN EXCESSIVE DOCKING LOADS. SIMILAR FAILURE OF ALL SIX LONG CONTACT SETS WILL PRODUCE THE SAME EFFECTS.
TO THE PMA2/3 MECHANISM:
LOSS OF THE SIGNAL "CAPTURE PASSIVE" TO ISS. LOSS OF POSSIBILITY TO TURN OFF DYNAMIC REGIME OF THE STATION COULD RESULT IN EXCESSIVE DOCKING LOADS. INFORMATION ABOUT THE AVAILABLE CAPTURE COULD BE TRANSFERED TO ISS THROUGH THE GROUND MCC TO TURN OFF STATION DYNAMIC REGIME.

(B) INTERFACING SUBSYSTEM(S):
EXCESSIVE LOADS INCURRED DURING DOCKING, AS THE RESULT OF TWO SHORT CONTACT SETS FAILING OPEN AND CAUSING THE HIGH ENERGY (AND LOW ENERGY FOR THE "SOFT" MECHANISM) DAMPERS NOT TO ACTIVATE, COULD PROPAGATE TO EXTERNAL AIRLOCK AND ORBITER/PMA1 STRUCTURE.

(C) MISSION:
NO EFFECT FIRST FAILURE. POSSIBLE LOSS OF MISSION FOLLOWING FAILURE OF SECOND CONTACT SET.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT ON CREW OR VEHICLE. POTENTIAL DAMAGE TO ORBITER(PMA1)/ISS DOCKING MECHANISMS DUE TO HIGH LOADS INCURRED DURING CAPTURE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST SHORT CONTACT SET FAILS OPEN - NO EFFECT. SECOND SHORT CONTACT SET FAILS OPEN - LOSS OF "CAPTURE" INDICATION. WITH LOSS OF THIS INDICATION CREW WOULD NOT BE 100% CERTAIN THAT CAPTURE HAS OCCURRED. CREW IS GIVEN TEN SECONDS TO DECIDE TO TERMINATE THE DOCKING PROCESS FOLLOWING INDICATION OF INITIAL CONTACT IF NO "CAPTURE" INDICATION IS PRESENT. WITHOUT CERTAINTY THAT CAPTURE HAS OCCURRED, CONTACT BETWEEN VEHICLES WOULD OCCUR WITHIN 10 SECONDS FOLLOWING INITIAL CONTACT INDICATION. WORST CASE SCENARIO IS THAT DOCKING AT THIS POINT WOULD BE TERMINATED. SECOND CONTACT SET FAILURE WILL ALSO PREVENT ENERGIZING OF HIGH ENERGY (AND LOW ENERGY FOR THE "SOFT" MECHANISM) DAMPERS RESULTING IN POTENTIAL DAMAGE TO ORBITER(PMA1)/ISS DOCKING MECHANISMS DURING CAPTURE. DAMAGE COULD PRECLUDE DOCKING CAPABILITIES. ORBITER(PMA1)/ISS MISSION OBJECTIVES WOULD BE LOST WITH A FAILURE TO PERFORM DOCKING.

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DESIGN CRITICALITY (PRIOR TO OPERATIONAL DOWNGRADE, DESCRIBED IN F): N/A

(F) RATIONALE FOR CRITICALITY CATEGORY DOWNGRADE:
N/A (THERE ARE NO WORKAROUNDS TO CIRCUMVENT THIS FAILURE.)

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: HOURS TO DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: MINUTES TO HOURS

TIME FROM DETECTION TO COMPLETED CORRECTIVE ACTION: N/A

IS TIME REQUIRED TO IMPLEMENT CORRECTIVE ACTION LESS THAN TIME TO EFFECT?
N/A

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
THERE IS NO CORRECTIVE ACTION TO THIS FAILURE SINCE LOSS OF ALL HIGH ENERGY (AND LOW ENERGY FOR THE "SOFT" MECHANISM) DAMPERS IS NOT DETECTABLE UNTIL AFTER CAPTURE, AT WHICH TIME THE RESULTING HIGH LOADS COULD DAMAGE BOTH ORBITER/PMA1 AND ISS DOCKING MECHANISMS TO THE POINT OF PRECLUDING DOCKING.

HAZARDS REPORT NUMBER(S): ORBI 402B

HAZARD(S) DESCRIPTION:
DAMAGE TO BOTH ORBITER/PMA1 AND ISS DOCKING MECHANISMS.

-DISPOSITION RATIONALE-

(A) DESIGN:
DESIGN OF THE SENSOR, SELECTION OF MATERIALS, AND SMALL ELECTRICAL LOADS REDUCE THE FAILURE PROBABILITY OF BOTH CONTACTS. DESIGN OF THE CONTACT PAIR (DUAL CHANNEL) HAS PASSED MAGNITUDES OF GROUND FUNCTIONAL TESTING AND MULTIPLE USES DURING PILOTED VEHICLE OPERATIONS IN SPACE. WIRE REDUNDANCY FOR EACH CONTACT, CHOICE OF MATERIALS AND COATINGS FOR THE CONTACT PAIR, AND MAXIMUM SPACING BETWEEN LEADS OF EACH CONTACT PAIR ASSURES A HIGH LEVEL OF RELIABILITY. SPRING WHICH RETURNS THE INTERNAL ROD TO THE INITIAL POSITION IS DESIGNED TO OPERATE BEYOND LIMITS OF FATIGUE AND THUS, POSSIBILITY OF SPRING FAILURE IS VERY LOW. MISALIGNMENT OF THE ROD IS NOT POSSIBLE BY DESIGN.

ANALYSIS HAS SHOWN THAT THE MAXIMUM MOMENT IN THE Y DIRECTION IS EXCEEDED GIVEN A FAILURE TO ENGAGE THE HIGH ENERGY DAMPERS FOLLOWING CAPTURE. HOWEVER THIS MOMENT WOULD NOT EXCEED THE LIMITS ON THE EXTERNAL AIRLOCK OR ORBITER STRUCTURE.

(B) TEST:
REFER TO "APPENDIX B" FOR DETAILS OF THE FOLLOWING ACCEPTANCE AND QUALIFICATION TESTS OF THE DOCKING MECHANISMS RELATIVE TO THIS FAILURE MODE.

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DOCKING MECHANISM ACCEPTANCE TESTS:

1. ELECTRICAL CIRCUIT VERIFICATION TEST
2. INSULATION ELECTRICAL RESISTANCE TEST
3. INTERFACE SENSOR FUNCTIONAL PERFORMANCE TEST
4. CAPTURE LATCH FORCE LOAD TEST
5. VIBRATION TEST
6. THERMAL VACUUM TEST

DOCKING MECHANISM QUALIFICATION TESTS:

1. ELECTRICAL CIRCUIT VERIFICATION TEST
2. INSULATION ELECTRICAL RESISTANCE TEST
3. TRANSPORTABILITY STRENGTH TEST
4. VIBRATION TEST
5. SHOCK-BASIC DESIGN TEST
6. THERMAL VACUUM TEST
7. SIX-DEGREE-OF-FREEDOM TEST
8. SERVICE LIFE TEST
9. DISASSEMBLY INSPECTION

OMRSD - TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
ALL INCOMING PARTS ARE SUBJECTED TO EXTERIOR INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROVISIONS AND CONTAMINATION CONTROL VERIFIED BY INSPECTION. CHECK OF ROOM CLEANLINESS; PARTS WASHING AND OTHER OPERATIONS OF THE TECHNOLOGICAL PROCESS WHICH PROVIDES CLEANLINESS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
HEAT TREATING, SOLDERING, CHEMICAL PLATING, AND CURING VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ASSEMBLY/INSTALLATION VERIFIED BY INSPECTION.

TESTING
ATP/OTP/OMRSD TESTING VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PROPER PACKAGING, STORAGE, AND TRANSPORTATION VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
DATA ON TEST FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING OF ODS DOCKING MECHANISMS CAN BE FOUND IN PRACA DATA BASE.

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(E) OPERATIONAL USE:
CREW COULD OPEN CAPTURE LATCHES AND FIRE APPROPRIATE ORBITER RCS JETS TO INITIATE SEPARATION. IF CONDITIONS ARE ACCEPTABLE, CREW COULD REMAINED CAPTURED AND ALLOW PASSIVE DAMPERS AND SPRING MECHANISMS TO DAMPEN RELATIVE MOTION SUFFICIENTLY TO CONTINUE DOCKING.

- APPROVALS -

PRODUCT ASSURANCE ENGR.	:	M. NIKOLAYEVA	:
DESIGN ENGINEER	:	E. BOBROV	:
NASA SS/MA	:		:
NASA SUBSYSTEM MANAGER	:		:
JSC MOD	:		: