PRINT DATE: 05/07/97

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER:MB-1SS-M021 -X

SUBSYSTEM NAME: MECHANICAL - CREW EQUIPMENT
REVISION: D 06/28/96

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:TOOL STOWAGE ASSEMBLY	V849-000150-001
SRU	:SLIDE ASSEMBLY JONATHAN	V849-001200-001 1202371

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
TOOL STOWAGE ASSEMBLY (TSA) DRAWER SLIDE ASSEMBLY

QUANTITY OF LIKE ITEMS: 4
FOUR - TWO PER DRAWER, TWO DRAWERS PER TSA

FUNCTION:
THE TSA CONTAINS TWO DRAWERS. ATTACHED TO EACH SIDE OF A DRAWER IS A SLIDE ASSEMBLY THAT CONTAINS ROLLER BEARINGS TO ALLOW EASY OPENING/CLOSING OF THE DRAWER. THE SLIDE ASSEMBLIES ARE NOT REDUNDANT TO EACH OTHER. EACH SLIDE ASSEMBLY CONTAINS A MECHANICAL STOP THAT PREVENTS THE DRAWER FROM COMPLETELY SEPARATING FROM THE TSA WHEN OPENED.

REFERENCE DOCUMENTS: V849-000150
V849-001200

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: M8-1SS-M021-01

REVISION#: 2 05/06/97

SUBSYSTEM NAME: MECHANICAL - CREW EQUIPMENT
LRU: TOOL STOWAGE ASSEMBLY
ITEM NAME: DRAWER SLIDE ASSEMBLY

CRITICALITY OF THIS FAILURE MODE: 1R2

FAILURE MODE:
JAMMED, INCREASED RESISTANCE

MISSION PHASE: OO ON-ORBIT

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

CAUSE:
CONTAMINATION, STRUCTURAL FAILURE DUE TO THERMAL OR MECHANICAL SHOCK, MANUFACTURER/MATERIAL DEFECT, LACK OF LUBRICATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

METHOD OF FAULT DETECTION:
PHYSICAL OBSERVATION DURING DRAWER OPENING/CLOSING.

REMARKS/RECOMMENDATIONS:
EACH DRAWER OF THE TSA CONTAINS TWO SLIDE ASSEMBLIES, BOTH OF WHICH ARE REQUIRED FOR DRAWING OPENING/CLOSING. WITH A DRAWER FULLY OPEN, THE DOOR EXTENSION WILL NOT INTERFERE WITH PROPER CLOSING OF THE PAYLOAD BAY DOORS. IMPACT OF DE-ORBIT AND LANDING WITH A DRAWER FULLY EXTENDED CANNOT BE ASSESSED UNTIL A LOADS TEST OF THE TSA DRAWER SLIDE ASSEMBLY IS COMPLETED. IT IS RECOMMENDED THAT THE FOLLOWING STATIC LOAD TESTS BE

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PERFORMED: (1) DRAWER SLIDE ASSEMBLY LOAD TEST - WITH A DRAWER IN A FULL OPEN POSITION (SLIDE ASSEMBLY FULLY EXTENDED) THE MAXIMUM DE-ORBIT/LANDING LOADS (AS SEEN BY THE TSA) SHOULD BE APPLIED TO THE SLIDE ASSEMBLY TO ENSURE THAT THE SLIDE ASSEMBLY WILL NOT STRUCTURALLY FAIL. (2) DRAWER MECHANICAL STOP LOAD TEST - MAXIMUM LOADS SHOULD BE APPLIED TO THE DRAWER SLIDE ASSEMBLY MECHANICAL STOPS TO ENSURE THAT THESE STOPS WILL NOT STRUCTURALLY FAIL. LOADS ANALYSIS SHOULD BE ABLE TO DETERMINE THE MAGNITUDE OF THESE LOADS TO APPLY TO THE STOPS.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
PREVENTS MOVEMENT OF THE DRAWER IN EITHER THE EXTEND (OPENING) OR RETRACT (CLOSING) POSITION. AN INCREASE MOMENT OF RESISTANCE COULD BE OVERCOME BY THE FORCE OF OPENING/CLOSING.

(B) INTERFACING SUBSYSTEM(S):
WORST CASE (DURING OPENING) - INABILITY TO OPEN DRAWER #1 OR #2 WOULD PREVENT USE OF ISS GENERIC TOOLS CONTAINED IN THE AFFECTED DRAWER.

(C) MISSION:
IF FAILURE OCCURS:
DURING DRAWER OPENING (EXTENSION) - UNABLE TO OPEN DRAWER. INABILITY TO UTILIZE GENERIC TOOLS CONTAINED IN AFFECTED DRAWER MAY AFFECT MISSION COMPLETION - CRITICALITY 2/2 CONDITION.
DURING DRAWER CLOSING (RETRACTION) - INABILITY TO CLOSE DRAWER HAS NO EFFECT ON MISSION SUCCESS SINCE MISSION OBJECTIVES ARE MET WITH A DRAWER OPEN.

(D) CREW, VEHICLE, AND ELEMENT(S):
IF FAILURE OCCURS:
DURING DRAWER OPENING (EXTENSION) - UNABLE TO OPEN DRAWER. LOSS OF CAPABILITY TO UTILIZE TOOLS CONTAINED WITHIN AFFECTED DRAWER COULD RESULT IN LOSS OF CREW AND VEHICLE IF CONTINGENCY EVA IS REQUIRED.
DURING DRAWER CLOSING (RETRACTION) - UNABLE TO CLOSE DRAWER. NO EFFECT - TOOLS CONTAINED IN THE AFFECTED DRAWER WOULD HAVE TO BE REMOVED AND STOWED IN THE CREW CABIN AND THE DRAWER ITSELF WOULD EITHER HAVE TO BE REMOVED AND STOWED OR REMAIN OPEN DURING DE-ORBIT AND LANDING.

(E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST FAILURE (DRAWER SLIDE ASSEMBLY JAMMED IN CLOSED POSITION) - LOSS OF CAPABILITY TO UTILIZE TOOLS CONTAINED WITHIN AFFECTED DRAWER. INABILITY TO COMPLETE MISSION OBJECTIVES ASSOCIATED WITH THESE ISS TOOLS. - CRITICALITY 2/2 CONDITION
SECOND FAILURE (FAILURE NECESSITATES AN EVA TO CORRECT A CRIT 1 CONDITION) POSSIBLE LOSS OF CREW AND VEHICLE DUE TO THE INABILITY TO CONDUCT AN

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EMERGENCY EVA BECAUSE EVA TOOLS ARE NOT AVAILABLE FOR USE. • CRITICALITY 1R2 CONDITION

DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)): 1R2

(F) RATIONALE FOR CRITICALITY DOWNGRADE:
THERE IS NO CORRECTIVE ACTION TO CIRCUMVENT A DRAWER SLIDE ASSY THAT JAMS DURING DRAWER OPENING. CRITICALITY REMAINS AT 1R2.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: IMMEDIATE

TIME FROM DETECTION TO COMPLETED CORRECTING ACTION: N/A

IS TIME REQUIRED TO IMPLEMENT CORRECTING ACTION LESS THAN TIME TO EFFECT?
NO

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
THERE IS NO CORRECTIVE ACTION IF THE SLIDE ASSEMBLY COMPLETELY JAMS AND THE DRAWER CANNOT BE OPENED OR CLOSED.

HAZARD REPORT NUMBER(S): FF-09

HAZARD(S) DESCRIPTION:
INABILITY TO SAFELY PERFORM EVA.

-DISPOSITION RATIONALE-

(A) DESIGN:
EACH DRAWER OF THE TSA CONTAINS TWO SLIDE ASSEMBLIES, ONE ON EACH SIDE. EACH SLIDE ASSEMBLY CONSISTS OF THREE SECTIONS: THE NARROW SECTION IS ATTACHED TO THE DRAWER USING FOUR (4) #10-32 SCREWS; THE MIDDLE SECTION (WHICH THE NARROW SECTION ROLLS INTO) SLIDES INTO THE LARGE SECTION; AND THE LARGE SECTION WHICH CONTAINS EIGHT HOLES, IS ATTACHED TO THE CLOSEOUT PANELS AND THE SIDE WALL OF THE TSA BOX, DEPENDING ON THE SLIDE. THE SLIDE WILL BE ATTACHED TO THE CLOSEOUT PANELS USING EIGHT (8) #10-32 SCREWS AND SELF-LOCKING NUT PLATES (MD114-5015-0302) ATTACHED BEHIND THE PANELS. THE SLIDE CONTAINS BALL BEARINGS BETWEEN THE LARGE SECTION AND THE MIDDLE SECTION, AND ROLLERS BETWEEN THE MIDDLE SECTION AND THE NARROW SECTION. THESE BALL BEARINGS AND ROLLERS WILL BE LUBRICATED WITH AN ACCEPTABLE LUBRICANT, POSSIBLY BRAYCOTE 601. EACH SLIDE CONTAINS A MECHANICAL STOP THAT PREVENTS THE DRAWER FROM COMPLETELY SEPARATING FROM THE TSA. THIS STOP WILL NOT PREVENT THE DRAWER FROM RETRACTING. THESE STOPS ARE INSTALLED WITH EVA BOLTS WHICH CAN BE REMOVED DURING AN EVA TO ALLOW REMOVAL OF THE DRAWER. THE SLIDE CHANNELS ARE MADE OF

ALUMINUM 2014-T6 AND THE BALL BEARINGS ARE MADE OF STAINLESS STEEL TYPE 440.

STRUCTURAL LOADS ANALYSIS IS PERFORMED ON THE TSA WHICH INCLUDES THE DRAWER SLIDE ASSEMBLIES - ANALYSIS HAS SHOWN THAT ALL COMPONENTS HAVE OF FACTOR OF SAFETY OF AT LEAST 1.4. REFER TO TSA STRESS ANALYSIS REPORT #SSD96D0456, DATED SEPT 1996, FOR DETAILS.

(B) TEST:
DRAWER SLIDE CERTIFICATION - CERTIFICATION OF THE DRAWER SLIDE ASSEMBLIES WILL BE PERFORMED BY TEST AND ANALYSIS. ANALYSIS DATA WAS PREVIOUSLY ADDRESSED IN THE "DESIGN" SECTION AND TEST DATA IS SHOWN BELOW:

A. TESTING AT NASA (TSA) - THERMAL, LIFE CYCLE, AND DYNAMIC TESTING OF THE TSA AND ITS COMPONENTS IS PERFORMED BY NASA AS FOLLOWS.
1. THERMAL CERTIFICATION TESTING - TSA'S WERE SUBJECTED TO THE FOLLOWING THERMAL PROFILE. FIRST, A PRETEST OBJECTIVE FUNCTIONAL TEST (OPENING/CLOSING DRAWERS AND DOORS USING A FORCE GAUGE) WAS PERFORMED AT AMBIENT CONDITIONS. THE CHAMBER TEMPERATURE WAS RAMPED TO -70°F +/-5°F AT A RATE OF 4°F/MIN AND THE TEMPERATURE REMAINED CONSTANT AT -70°F FOR ABOUT 5 MINUTES AND A SUBJECTIVE FUNCTIONAL TEST (OPENING/CLOSING DRAWERS AND DOORS USING THE HAND INSTEAD OF A FORCE GAUGE) WAS PERFORMED. THE CHAMBER TEMPERATURE WAS THEN RAMPED DOWN TO -125°F +/-5°F AT A RATE OF 4°F/MIN. THE TSA'S WERE SOAKED FOR 30 MINUTES AND THE COLD CASE OBJECTIVE FUNCTIONAL TEST WAS PERFORMED. THEN, THE CHAMBER TEMPERATURE WAS RAMPED UP TO 205°F +/-5°F. THE TSA'S WERE SOAKED AT THIS TEMPERATURE FOR 30 MINUTES AND THE HOT CASE OPERATIVE FUNCTIONAL TEST WAS PERFORMED. LAST, THE CHAMBER TEMPERATURE WAS RETURNED TO AMBIENT CONDITIONS AND A FULL POST OBJECTIVE FUNCTIONAL TEST WAS PERFORMED.
2. LIFE CYCLE TESTING - PRIOR TO PERFORMING THE LIFE CYCLE TEST OF THE DRAWER SLIDES THE FOLLOWING FUNCTIONAL TEST IS PERFORMED: (A) WITH DRAWERS IN THE HORIZONTAL ORIENTATION, SMOOTH OPERATION OF EACH DRAWER IS VERIFIED BY PULLING OUT THE DRAWER UNTIL IT STOPS, AND PUSHING IT BACK INTO THE FULLY RETRACTED POSITION. (B) ALL LATCHES ARE VERIFIED TO BE FULLY UNLOCKED BEFORE OPENING THE DRAWERS; (C) THE FORCE REQUIRED TO OPEN EACH DRAWER IS VERIFIED TO BE WITHIN A 1 TO 10 LB RANGE, NOT INCLUDING THE WEIGHT OF ANY STOWED TOOLS OR THE DRAWER ITSELF; AND (D) THE FORCE REQUIRED TO CLOSE EACH DRAWER IS VERIFIED TO BE WITHIN A 4 TO 12 LB RANGE, NOT INCLUDING THE WEIGHT OF ANY STOWED TOOLS OR THE DRAWER ITSELF. WITH THE TSA BOX ASSEMBLY AND TWO DRAWER SLIDE ASSEMBLIES IN THE PROPER CONFIGURATION, THE DRAWER IS CYCLED FROM ITS FULLY RETRACTED POSITION TO ITS FULLY EXTENDED POSITION, AND THEN BACK TO ITS FULLY RETRACTED POSITION. THIS CYCLE IS REPEATED A TOTAL OF 400 TIMES. FOLLOWING THIS LIFE CYCLE TEST, VERIFICATION STEPS A, B, C, AND D, AS PREVIOUSLY ADDRESSED, ARE PERFORMED AGAIN.
3. DYNAMIC TESTING - A RANDOM VIBRATION TEST IS PERFORMED ON FOUR (4) TSA FLIGHT ARTICLES FOR TWO ENVIRONMENTS; FLIGHT VIBRATION AND ACCEPTANCE VIBRATION AS FOLLOWS. FLIGHT VIBRATION LEVELS ARE SHOWN IN THE TABLE BELOW:

20 TO 50 HZ:	+ 5 DB/OCTAVE
50 TO 400 HZ:	0.01 G^2/HZ
400 TO 2000 HZ:	- 4 DB/OCTAVE
GRMS:	3.0
DURATION:	AS DEFINED IN THE NEXT SECTIONS
TEST TOLERANCES:	GRMS = +15%, - 5%
	G^2/HZ = + 4 DB, - 1 DB

ACCEPTANCE VIBRATION LEVELS ARE SHOWN IN THE TABLE BELOW:

20 TO 80 HZ:	+ 3 DB/OCTAVE
80 TO 350 HZ:	0.04 G^2/HZ
350 TO 2000 HZ:	- 3 DB/OCTAVE
GRMS:	6.1
DURATION:	1.0 MINUTE IN EACH OF X, Y, AND Z AXES
TEST TOLERANCES:	GRMS = +15%, - 5%
	G^2/HZ = + 4 DB, - 1 DB

TSA NO. 1 RANDOM VIBRATION TEST - WITH TSA FILLED WITH LIMIT DESIGN WEIGHT, RANDOM VIBRATION TEST PERFORMED AT 6 DB BELOW FLIGHT LEVEL ENVIRONMENT FOR A DURATION OF 1.0 MINUTE, IN ALL 3 AXES (X,Y,Z). THEN TSA CONTENTS REMOVED AND TSA EXPOSED TO ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.
TSA NO. 2 RANDOM VIBRATION TEST - WITH TSA FILLED WITH LIMIT DESIGN WEIGHT, RANDOM VIBRATION TEST PERFORMED AT FLIGHT LEVEL ENVIRONMENT FOR A DURATION OF 16.7 MINUTES, IN ALL 3 AXES.
TSA NO. 3 RANDOM VIBRATION TEST - WITH TSA EMPTY, RANDOM VIBRATION TEST PERFORMED AT ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.
TSA NO. 4 RANDOM VIBRATION TEST - WITH TSA EMPTY, RANDOM VIBRATION TEST PERFORMED AT ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.

5. ATP AT BOEING (DRAWER SLIDE ASSEMBLY/LATCHES) - ACCEPTANCE TESTING AT BOEING WILL VERIFY PROPER FUNCTIONING OF THE DRAWERS AND THEIR COMPONENTS (SLIDE ASSEMBLIES/LATCHES) AS FOLLOWS:
1. LATCH TESTING - PRIOR TO THE FUNCTIONAL TEST, ALL LATCHES ARE VERIFIED TO BE IN THEIR LATCHED POSITION. THEN EACH LATCH IS TESTED, IN ANY SEQUENCE, AS FOLLOWS: (A) THE LATCH PAWL IS ROTATED AND THE FOLLOWING IS VERIFIED: THE HANDLE TURNS SMOOTHLY AND THERE IS NO INTERFERENCE BETWEEN THE LATCH AND LATCH HOUSING OR THE LATCH RECEIVER; (B) THE LATCH HANDLE IS POSITIONED AGAINST THE HOUSING AND THE FOLLOWING IS VERIFIED: THE HANDLE IS FIRMLY IN PLACE BY THE SPRING AND THE LATCH/HANDLE IS UNABLE TO MOVE; (C) THE FORCE REQUIRED TO PULL UP THE LATCH HANDLE TO THE VERTICAL POSITION, TAKEN FROM THE CENTER OF GRAVITY OF THE HANDLE, IS VERIFIED TO BE IN THE RANGE OF 5 TO 10 LB; (D) THE FORCE REQUIRED TO PUSH THE LATCH HANDLE IN THE LOCKED POSITION FROM THE CENTER OF GRAVITY IS VERIFIED TO BE IN THE RANGE OF 5 TO 10 LB; (E) AFTER THE LATCH HANDLE IS LIFTED TO ITS VERTICAL POSITION, THE TORQUE REQUIRED TO TURN THE LATCH TO THE UNLOCKED POSITION AND THEN BACK TO THE LOCKED POSITION IS LESS THAN OR EQUAL TO 30IN-LB.
2. DRAWER TESTING - DURING OPERATION OF THE DRAWINGS (OPENING AND CLOSING) THE FOLLOWING IS VERIFIED: (A) ALL LATCHES ARE FULLY DISENGAGED

BEFORE OPENING THE DRAWERS; (B) THE FORCE REQUIRED TO OPEN EACH DRAWER IS IN THE 0.5 LB TO 10 LB RANGE, NOT INCLUDING THE WEIGHT OF THE TOOLS AND DRAWERS; (C) SMOOTH OPERATION OF THE DRAWERS WHEN THEY ARE PULLED OUT TO THEIR STOPS AND PUSHED BACK INTO THE EMPTY TSA BOX; AND (D) THE FORCE REQUIRED TO CLOSE EACH DRAWER IS IN THE 8 LB TO 16 LB RANGE, NOT INCLUDING THE WEIGHT OF THE TOOLS AND DRAWERS.

MISSION MANIFEST VERIFICATION - PRIOR TO EACH FLIGHT, THE ORBITER IS CONFIGURED TO SUPPORT A MISSION AS DEFINED IN THE MISSION MANIFEST. AT THIS TIME, IF THE MISSION IS TO SUPPORT ISS, THE TSA WILL BE INSTALLED ON THE EXTERNAL AIRLOCK TRUSS ASSEMBLY AND THE FOLLOWING WILL BE VERIFIED: THE DRAWERS CAN BE OPENED/CLOSED AND DRAWER LATCHES ARE IN THEIR CLOSED AND LOCKED POSITION.

(C) INSPECTION:
RECEIVING INSPECTION
ALL RECEIVING SLIDE ASSEMBLIES ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION. CLEANLINESS LEVEL GC PER MA0110-301.

ASSEMBLY/INSTALLATION
MODIFICATION OF SLIDE ASSEMBLY TO REMOVE LOCK/QUICK DISCONNECT MECHANISM INSPECTED PER DRAWING V649-001200. INSTALLATION OF SLIDE ASSEMBLY PER TSA ASSEMBLY TOP LEVEL DRAWING V649-000100. ACCEPTABLE LUBRICANT ON BALL BEARINGS AND ROLLERS VERIFIED BY INSPECTION.

CRITICAL PROCESSES
ANODIZING OF ALUMINUM SIDE CHANNELS INSPECTED PER MIL-A-5625-1A, TYPE 2, CLASS 1. PASSIVATION OF STAINLESS STEEL BALL BEARINGS VERIFIED PER MIL-S-5002.

TESTING
CERTIFICATION TEST/MISSION MANIFEST CHECKLIST VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE, AND SHIPPING PROCEDURES VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

(E) OPERATIONAL USE:
DURING DRAWER OPENING - THERE IS NO CORRECTIVE ACTION IF ONE OR BOTH SLIDE ASSEMBLIES ON ONE DRAWER COMPLETELY JAM. HOWEVER, AN INCREASE IN RESISTANCE CAN BE OVERCOME BY THE FORCE OF OPENING THE AFFECTED DRAWER.

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DURING DRAWER CLOSING - AN INCREASE IN RESISTANCE CAN BE OVERCOME BY THE FORCE OF CLOSING THE AFFECTED DRAWER. IN THE CASE WHERE THE SLIDE ASSEMBLY COMPLETELY JAMS, CREW COULD REMOVE THE TOOLS FROM THE AFFECTED DRAWER AND THE DRAWER ITSELF, AND STOW THEM WITHIN CREW CABIN AREA.

- APPROVALS -

SS & PAE ENGINEER	:	M. W. GUENTHER	:
SS & PAE MANAGER	:	C. A. ALLISON	:
DESIGN ENGINEER	:	R. C. GROO	:
NASA SS/MA	:		: 6/30/97
NASA SUBSYSTEM MANAGER	:		: 6-30-97
JSC MOD	:		: 6-30-97