FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: M8-1MR-BM005-X

SUBSYSTEM NAME: MECHANICAL - EDS
REVISION: 2 9/1/95

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	GUIDE RING ASSEMBLY NPO-ENERGIA	33U.6271.011-05 33U.6271.011-05
SRU	:	ASSEMBLY, CAPTURE LATCH NPO-ENERGIA	33U.6322.025 33U.6322.025

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CAPTURE LATCH ASSEMBLY

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
THREE (ONE PER GUIDE PEDAL)

FUNCTION:
THREE ACTIVE (CAPTURE) LATCHES, ONE ON EACH GUIDE PEDAL OF THE ORBITER DOCKING RING, PROVIDES POSITIVE CAPTURE TO THREE PASSIVE (BODY MOUNTED) LATCHES LOCATED ON THE MIR DOCKING MECHANISM. CAPTURE LATCH ROLLER MECHANISMS MOVE ASIDE DURING CLOSING CONTACT WITH THEIR OPPOSING BODY MOUNTED LATCHES AND ARE SPRING DRIVEN TO LOCK AFTER PASSING THE THREE PASSIVE BODY LATCHES (LUGS). TWO ROLLER MECHANISMS LOCATED ON EACH CAPTURE LATCH ASSEMBLY PROVIDE A REDUNDANT MEANS OF CAPTURE.

UPON RECEIPT OF A "CLOSE CAPTURE LATCH" COMMAND, POWER IS APPLIED THROUGH REDUNDANT "LATCH MOTOR OPEN" SENSOR CONTACT SETS TO A SINGLE ACTUATOR MOTOR TO EXTEND BOTH ROLLERS OF ONE CAPTURE LATCH ASSEMBLY. A "LATCH INDICATION CLOSED" SENSOR ON EACH ACTUATOR SENSES THE CLOSED POSITION OF THE LATCH AND SENDS REDUNDANT SIGNALS TO THE DOCKING CONTROL PANEL VIA THE DSCU TO ILLUMINATE THE "LATCHES CLOSED" LIGHT WHEN ALL THREE CAPTURE LATCHES ARE CLOSED.

UPON RECEIPT OF AN "OPEN CAPTURE LATCH" COMMAND (FOLLOWING COMPLETION OF THE DOCKING PROCESS), POWER IS APPLIED THROUGH REDUNDANT "LATCH MOTOR CLOSED" SENSOR CONTACT SETS TO A SINGLE ACTUATOR MOTOR TO RETRACT BOTH ROLLERS OF THE CAPTURE LATCH ASSEMBLY FOR UNDOCKING OF THE MIR AND ORBITER. A "LATCH INDICATION OPEN" SENSOR LOCATED ON EACH CAPTURE LATCH ACTUATOR SENSES THE OPEN POSITION OF THE LATCH AND SENDS REDUNDANT SIGNALS TO THE DSCU TO ILLUMINATE THE "LATCHES OPEN" INDICATOR LIGHT ON THE DOCKING CONTROL PANEL AND COMMAND RING TO RETRACT WHEN THE SENSOR ON ALL THREE CAPTURE LATCH ACTUATORS IS CLOSED.

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THE THIRD CONTACT SET OF EACH "LATCH INDICATION OPEN" AND "LATCH INDICATION CLOSED" SENSOR IS UTILIZED FOR GROUND MONITORING OF CAPTURE LATCH POSITION. CAPTURE LATCH "INITIAL POSITION" IS ALSO DOWNLINKED FOR GROUND MONITORING.

IN THE EVENT A CAPTURE LATCH FAILS TO OPEN, THE MANUAL LATCH/UNBLOCKING DEVICE CONTAINED BEHIND THE CAPTURE LATCH ASSEMBLY WILL PROVIDE MANUAL RELEASE OF THE LATCH. A BUTTON ON EACH SIDE OF THE DEVICE, WHEN DEPRESSED SIMULTANEOUSLY, WILL RELEASE LATCH CONTROL BY THE LATCH ACTUATOR, THUS ALLOWING BOTH CAPTURE LATCH ROLLERS TO RETRACT TO THEIR OPEN POSITION.

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

MAINTAINABILITY
REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.6322.025
33U.6271.011-05

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REVISION# 1 9/1/96

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

CRITICALITY OF THIS FAILURE MODE: 2/2

FAILURE MODE:
FAILS TO CLOSE

MISSION PHASE:
OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 104 ATLANTIS

CAUSE:
CAPTURE LATCH FAILURE - CONTAMINATION, MECHANICAL/THERMAL SHOCK, MANUFACTURE/MATERIAL DEFECT

ACTUATOR FAILS TO EXTEND - CONTAMINATION, MECHANICAL/THERMAL SHOCK, MANUFACTURE/MATERIAL DEFECT, MOTOR FAILURE

MANUAL LATCH/UNBLOCKING DEVICE FAILS TO RESET - SPRING FAILURE, MECHANICAL/THERMAL SHOCK, MANUFACTURE/MATERIAL DEFECT, CONTAMINATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

CRITICALITY 1R2 DURING INTACT ABORT ONLY (AVIONICS ONLY)? N/A

REDUNDANCY SCREEN
A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:
A)
N/A

B)
N/A

C)
N/A

METHOD OF FAULT DETECTION:
NO INDICATION IF ROLLER MECHANISM FAILS. HOWEVER AN ACTUATOR FAILING TO CLOSE (EXTEND) A LATCH WOULD BE DETECTED BY A LOSS OF "LATCH CLOSED" INDICATION ON THE DOCKING CONTROL PANEL. AN OPEN MANUAL LATCH/ UNBLOCKING DEVICE WOULD ONLY BE DETECTED THROUGH EVALUATION OF TELEMETRY DATA.

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• FAILURE EFFECTS •

(A) SUBSYSTEM:
NO EFFECT ON CURRENT DOCKING SINCE CAPTURE LATCHES ARE CLOSED ON THE GROUND AND REMAIN CLOSED DURING CAPTURE. HOWEVER, IF FAILURE OCCURRED PRIOR TO SUBSEQUENT DOCKINGS AFFECTED CAPTURE LATCH ASSEMBLY ON ORBITER DOCKING MECHANISM WILL NOT BE LATCHED TO OPPOSING BODY MOUNTED LATCH ON MIR DOCKING MECHANISM. ALTHOUGH IT MAY BE POSSIBLE TO CAPTURE AND RETRACT THE DOCKING RING WITH ONLY TWO CLOSED CAPTURE LATCHES, MATING OF THE TWO DOCKING MECHANISMS FOR CLOSING STRUCTURAL HOOKS WOULD BE IMPAIRED. WORST CASE WOULD BE THE INABILITY TO MATE AND STRUCTURALLY LATCH INTERFACE.

(B) INTERFACING SUBSYSTEM(S):
NO EFFECT ON INTERFACING ORBITER SUBSYSTEMS.

(C) MISSION:
NO EFFECT ON CURRENT DOCKING. A FAILURE TO CLOSE CAPTURE LATCHES WOULD ONLY RESULT IN LOSS OF SUBSEQUENT DOCKINGS. INABILITY TO DOCK, WHEN REQUIRED, WOULD RESULT IN LOSS OF MISSION OBJECTIVES.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT ON CREW OR VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
N/A

DESIGN CRITICALITY (PRIOR TO OPERATIONAL DOWNGRADE, DESCRIBED IN F): 2/2

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

-DISPOSITION RATIONALE-

(A) DESIGN:
CAPTURE LATCH ASSEMBLY IS EFFECTIVELY ENCASED TO PREVENT INTRODUCING CONTAMINATION THAT COULD CAUSE THE LATCH OR ACTUATOR TO JAM IN THE OPEN POSITION.

(B) TEST:
DOCKING MECHANISM ACCEPTANCE TESTS:

1. ELECTRICAL SCHEMATIC CHECKOUT - CONTACT RESISTANCE ON EACH PIN OF THE CONNECTOR WHICH IS ELECTRICALLY TIED TO EACH CAPTURE LATCH ACTUATOR MOTOR IS CHECKED. THIS TEST VERIFIES CONTINUITY THROUGH THE ACTUATOR MOTOR WINDINGS.

2. INSULATION ELECTRICAL RESISTANCE TEST - THE INSULATION RESISTANCE AND ELECTRICAL STRENGTH OF INSULATION CHECKOUT OF EACH PIN OF EACH CAPTURE LATCH ACTUATOR CONNECTOR TO THE APDA HOUSING WILL VERIFY THAT THE CAPTURE LATCH ACTUATOR MOTOR WINDINGS ARE NOT ELECTRICALLY SHORTED TO GROUND.

3. INSPECTION SERVICEABILITY TEST - PROPER CLOSING OF CAPTURE LATCHES VERIFIED DURING CAPTURE LATCH FUNCTIONING PERFORMANCE TEST. INDIVIDUAL REDUNDANT ROLLERS ARE RETRACTED AND ALL THREE CAPTURE LATCHES ARE CLOSED.

4. VIBRORESISTENT TEST - APDS SUBJECTED TO THE FOLLOWING VIBRATION LEVELS FOR 2 MINUTES PER AXIS:

FREQUENCY (HZ)	SPECTORAL DENSITY ACCELERATION
FROM 20 TO 80	INCREASING, 3DB OCTAVE TO $0.04G^2/HZ$
FROM 80 TO 350	PERMANENT $0.04G^2/HZ$
FROM 350 TO 2000	DECREASING 3DB OCTAVE WITH $0.04G^2/HZ$

SUBSEQUENT TO THIS TEST AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT TEST, AN INSULATION RESISTANCE TEST, AND INSPECTION SERVICEABILITY TEST ARE PERFORMED AS DEFINED IN ATP TESTS #1, #2, AND #3 ABOVE.

5. DOCKING MECHANISM CHECKOUT (STATIC) TEST - CLOSING OF CAPTURE LATCHES IS VERIFIED. CAPTURE LATCHES ARE CLOSED PER STEP 11 OF INSTRUCTION 33U.6201.008-05 PM-3.

6. THERMO VACUUM TEST - DOCKING OF THE MECHANISM IS THERMALLY CYCLED, UNDER LOAD CONDITIONS, FROM +20°C TO -50/-55°C TO +50/+55°C TO +20°C IN A VACUUM AT 10^{-4} TO 10^{-5} TORR. DWELL AT EACH TEMPERATURE AND BETWEEN OPERATIONS AT EACH TEMPERATURE IS A MINIMUM OF 60 MINUTES AFTER STABILIZATION. OPERATIONS INCLUDES PERFORMING DOCKING/CAPTURE WHICH IS ACCOMPLISHED AT A SPEED OF 0.15M/SEC BETWEEN THE SIMULATOR AND MOVEABLE PLATFORM (CONTAINING THE DOCKING MECHANISM). PROPER CLOSING OF CAPTURE LATCHES IS VERIFIED FOR A TEMPERATURE RANGE OF -50°C/-55°C TO 50°C/55°C.

7. CONTROLLED DOCKING TEST - CONTROLLED DOCKING IS PERFORMED UNDER LOAD CONDITIONS. CAPTURE LATCHES ARE VERIFIED CLOSED PRIOR TO CAPTURE.

DOCKING MECHANISM QUALIFICATION TESTS:

1. ELECTRICAL CIRCUIT TEST - CONTACT RESISTANCE ON EACH PIN OF THE CONNECTOR WHICH IS ELECTRICALLY TIED TO EACH CAPTURE LATCH ACTUATOR MOTOR IS CHECKED. THIS TEST VERIFIES CONTINUITY THROUGH THE ACTUATOR MOTOR WINDINGS.

2. INSULATION ELECTRICAL RESISTANCE TEST - THE INSULATION RESISTANCE AND ELECTRICAL STRENGTH OF INSULATION CHECKOUT OF EACH PIN OF EACH CAPTURE LATCH ACTUATOR CONNECTOR TO THE APDA HOUSING WILL VERIFY THAT THE CAPTURE LATCH ACTUATOR MOTOR WINDINGS ARE NOT ELECTRICALLY SHORTED TO GROUND.

3. OPERATIONAL CAPABILITY TEST - OPERATION OF CAPTURE LATCHES IS VERIFIED DURING THE OPERATIONAL CAPABILITY CHECK.

4. VIBRATION STRENGTH TEST - APDS SUBJECTED TO THE FOLLOWING VIBRATION LEVELS IN EACH AXIS FOR A 400 SECOND DURATION.

FREQUENCY (HZ)	SPECTORAL DENSITY ACCELERATION
FROM 20 TO 80	INCREASING, 3DB OCTAVE TO 0.067G^2/HZ
FROM 80 TO 350	CONSTANT 0.067G^2/HZ
FROM 350 TO 2000	DECREASING 3DB OCTAVE WITH 0.067G^2/HZ

SUBSEQUENT TO THIS TEST AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND OPERATIONAL CAPABILITY TEST ARE PERFORMED, AS DEFINED IN QTP TESTS #1, #2, AND #3 ABOVE, TO VERIFY PROPER CLOSING OF CAPTURE LATCHES.

5. TRANSPORTABILITY STRENGTH TEST - SHIPPING LOADS ARE SIMULATED ON A VIBRATING TABLE TO VERIFY THAT THE DOCKING MECHANISM WILL NOT BE DAMAGED DURING SHIPMENT. THIS TEST IS CONDUCTED UNDER THE CONDITIONS CONTAINED IN THE FOLLOWING TABLE.

VIBRATION ACCELER DIRECTION	VIBRATION ACCELER AMPLITUDE	FREQUENCY SUBBAND, HZ					TOTAL TEST DURATION	
		5-7	7-16	16-30	30-40	40-60		
		TEST DURATION, MIN					HR	MIN
ALONG X-AXIS	1.4	–	4	–	–	–	–	4
	1.2	76	93	32	61	39	5	7
ALONG Y-AXIS	1.1	–	4	–	–	–	–	4
	1.0	13	16	7	10	7	–	53
ALONG Z-AXIS	1.1	–	4	–	–	–	–	4
	1.0	32	40	16	26	16	2	10

SUBSEQUENT TO THIS TEST AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND OPERATIONAL CAPABILITY TEST ARE PERFORMED, AS DEFINED IN QTP TESTS #1, #2, AND #3 ABOVE, TO VERIFY PROPER CLOSING OF CAPTURE LATCHES.

6. SHOCK AND SAWTOOTH LOADING STRENGTH TEST - DOCKING MECHANISM IS SUBJECTED TO 20G TERMINAL SAWTOOTH SHOCK PULSES IN EACH AXIS, 3 PULSES IN EACH DIRECTION FOR A TOTAL OF 6 PULSES/AXIS. AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND AN OPERATIONAL CAPABILITY TEST ARE CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TESTS #1, #2, & #3, TO VERIFY PROPER CAPTURE LATCH CLOSING PERFORMANCE.

7. APDS SERVICEABILITY TEST IN A SIX-DEGREE-OF-FREEDOM DYNAMIC TEST - THE SIX-DEGREE-OF-FREEDOM DYNAMIC TEST VERIFIES APDS DOCKING AND UNDOCKING OPERATIONS UNDER CLOSE-TO-FULL-SCALE CONDITIONS. STATIC MOTION OF ENTITIES IS SIMULATED UNDER SPECIFIC INERTIAL AND GEOMETRICAL PARAMETERS FOR VARIOUS INITIAL CONDITIONS FOR MIR/SHUTTLE DOCKING. A TOTAL OF 20 DOCKINGS IS PERFORMED. CLOSING OF CAPTURE LATCHES IS VERIFIED PRIOR TO EACH DOCKING. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND AN OPERATIONAL CAPABILITY TEST ARE CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TESTS #1, #2, & #3, TO VERIFY PROPER CAPTURE LATCH PERFORMANCE.

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8. COLD AND HEAT RESISTANCE TEST - DOCKING OF THE MECHANISM IS THERMALLY CYCLED FROM +20°C TO -50/-55°C TO +50/+55°C TO +20°C IN A VACUUM AT 10^{-4} TO 10^{-5} TORR. DWELL AT EACH TEMPERATURE AND BETWEEN OPERATIONS AT EACH TEMPERATURE IS A MINIMUM OF 60 MINUTES AFTER STABILIZATION. PRIOR TO EACH DOCKING, AS SHOWN IN THE FOLLOWING TABLE, CAPTURE LATCH CLOSING IS VERIFIED.

SEQ NO.	DOCKING RATE, M/S	SIMULATOR ROTATIONAL ANGLE		TEMP °C	VOLTAGE VOLTS	PRESS INTEGRITY CHECKOUT
		PITCH	ROLL			
1	0.10	0°	0°	25 +/-10	23	YES
2	0.10	0°	4°	25 +/-10	34	NO
3	0.12	4°	4°	25 +/-10	27	NO
4*	---	---	---	+60+/-5	---	YES
4	0.10	4°	0°	+50+/-5	27	YES
5*	---	---	---	-(60+/-5)	---	YES
5	0.10	4°	0°	-(30+/-5)	27	YES
6*	---	---	---	+60+/-5	---	YES
6	0.12	0°	4°	+50+/-5	23	YES
7*	---	---	---	-(60+/-5)	---	YES
7	0.10	0°	4°	-(30 +/-5)	23	YES
8*	---	---	---	+60+/-5	---	YES
8	0.12	4°	4°	50 +/-5	34	YES
9*	---	---	---	-(60+/-5)	---	YES
9	0.12	4°	4°	-(30 +/-5)	34	YES
10*	---	---	---	+60+/-5	---	YES
10	0.10	4°	0°	+50+/-5	27	YES
11*	---	---	---	-(60+/-5)	---	YES
11	0.10	0°	4°	-(30 +/-5)	27	YES
12*	---	---	---	+60+/-5	---	YES
12	0.10	0°	4°	+50+/-5	27	YES
13*	---	---	---	-(60+/-5)	---	YES
13	0.12	4°	4°	-(30 +/-5)	27	YES
14*	---	---	---	+60+/-5	---	YES
14	0.12	4°	4°	+50+/-5	27	YES
15*	0.12	4°	4°	+25+/-10	23	YES

*MC621-0087-2001, -4001, & -5001 ONLY

AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND AN OPERATIONAL CAPABILITY TEST ARE CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TESTS #1, #2, & #3, TO VERIFY PROPER CAPTURE LATCH PERFORMANCE.

9. TARGET SERVICE LIFE TEST - TESTS ARE PERFORMED TO VERIFY PROPER DOCKING AND UNDOCKING OPERATIONS OVER ITS LIFE OF 100 DOCKINGS. PROPER CLOSING OF THE CAPTURE LATCHES IS VERIFIED PRIOR TO 100 DOCKING AND UNMATING CYCLES (FOR MC621-0087-1001/-3001 UNITS ONLY). FOR MC621-0087-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED

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DURING 388 CYCLES (44 VACUUM/LOAD CYCLES, 16 LOAD CYCLES, & 324 NO-LOAD CYCLES). AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN ELECTRICAL CIRCUIT CHECK TEST, INSULATION RESISTANCE TEST, AND AN OPERATIONAL CAPABILITY TEST ARE CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TESTS #1, #2, & #3, TO VERIFY PROPER CAPTURE LATCH PERFORMANCE.

10. CONTROL DISASSEMBLY - UPON COMPLETION OF ALL QUAL TESTING THE DOCKING MECHANISM IS DISMANTLED AND CAPTURE LATCH ASSEMBLIES ARE CHECKED FOR EVIDENCE OF WEAR OR FAILURE.

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

(C) **INSPECTION:**
RECEIVING INSPECTION
COMPONENTS ARE SUBJECTED TO A 100% RECEIVING INSPECTION PRIOR TO INSTALLATION.

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

ASSEMBLY/INSTALLATION
TORQUE, ADJUSTMENTS AND TOLERANCES ACCORDING TO TECHNICAL REQUIREMENTS OF THE DRAWINGS ARE VERIFIED BY INSPECTION.

TESTING
ATP/QTP/OMRSD TESTING VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING/PACKAGING PROCEDURES AND REQUIREMENT FOR SHIPMENT 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.

(E) **OPERATIONAL USE:**
NONE

PRINT DATE: 29.06.95

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- APPROVALS -

DESIGN ENGINEER	:	M. NIKOLAYEVA	:
DESIGN MANAGER	:	A. SOUBCHEV	:
NASA SS/MA	:		:
NASA SUBSYSTEM MANAGER	:		: