

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER:05-2P-300RCV -X

SUBSYSTEM NAME: GPS THREE STRING REVISION: 0 04/09/97

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:RECEIVER/PROCESSOR, MAGR-S ROCKWELL COLLINS AVIONICS & COMMUNICATIONS	MC478-0153 822-1017

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
GPS RECEIVER/PROCESSOR, MAGR-S (MINIATURE AIRBORNE GPS RECEIVER - SHUTTLE), UTILIZES 28 VDC ORBITER POWER, 33 WATTS NOMINAL.

REFERENCE DESIGNATORS: 81V74A181
 83V74A182
 85V74A158

QUANTITY OF LIKE ITEMS: 3
THREE

FUNCTION:
TO RECEIVE, TRACK, AND PROCESS THE GPS SIGNALS FROM THE ANTENNA ASSEMBLIES; ACCEPTS CONTROL, CONFIGURATION AND AIDING DATA FROM THE GPC; AND PROVIDES POSITION, VELOCITY, TIME, HEALTH, AND STATUS DATA TO THE GPC.

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REVISION#: A 10/14/99

SUBSYSTEM NAME: GPS THREE STRING
LRU: RECEIVER, MAGR-S
ITEM NAME: RECEIVER, MAGR-S

CRITICALITY OF THIS
FAILURE MODE: 1R2

FAILURE MODE:
ERRONEOUS OUTPUT

MISSION PHASE: DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

CAUSE:
PIECE PART FAILURE (VIBRATION, MECHANICAL STRESS), CONTAMINATION, ELECTRICAL STRESS, THERMAL STRESS, PROCESSING ANOMALY

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN	A) PASS
	B) PASS
	C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
ERRONEOUS DATA SENT FROM THE GPS RECEIVER RESULTING IN LOSS OF ONE OF THREE GPS RECEIVER PATHS.

(B) INTERFACING SUBSYSTEM(S):

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ERRONEOUS GPS OUTPUTS ARE IGNORED AND THE OUTPUTS OF THE REMAINING GPS' ARE USED.

(C) MISSION:
NO EFFECT-FIRST FAILURE.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT - FIRST FAILURE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NO EFFECT - FIRST FAILURE. OPERATIONS CONTINUE WITH TWO REMAINING UNITS. SECOND FAILURE MAY CAUSE A DILEMA IF THE TWO UNITS DISAGREE AND THE CREW CANNOT RESOLVE THE DIFFERENCES. A GPS DILEMMA PREVENTS THE USE OF GPS DATA FROM EITHER SYSTEM UNTIL IT IS RESOLVED. PROLONGED LOSS OF DATA DUE TO GPS DILEMMA MAY CAUSE LOSS OF CREW/VEHICLE DUE TO INABILITY TO MAKE LANDING SITE.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: MINUTES

TIME FROM FAILURE OCCURRENCE TO DETECTION: MINUTES

TIME FROM DETECTION TO COMPLETED CORRECTING ACTION: MINUTES

IS TIME REQUIRED TO IMPLEMENT CORRECTING ACTION LESS THAN TIME TO EFFECT?
YES

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
N/A

-DISPOSITION RATIONALE-

(A) DESIGN:
THE GPS IS AN OFF-THE-SHELF PROCUREMENT ITEM THAT HAS BEEN MODIFIED FOR SHUTTLE USE. MAGR WAS ORIGINALLY DESIGNED IN (1993) FOR MILITARY AIRCRAFT USE AND WAS BUILT PER MIL SPECS IN EFFECT AT THAT TIME. MORE THAN 20,000 UNITS FABRICATED WITHOUT MAJOR DESIGN CHANGE OR SIGNIFICANT FAILURE HISTORIES. HOWEVER, SHUTTLE UNITS HAVE BEEN MODIFIED (ESPECIALLY THE FIRMWARE) SO THAT SOME OF THIS HISTORY IS NOT APPLICABLE.

BECAUSE OF THE INHERENT SINGLE FAILURE POINTS, THE GPS SYSTEM WAS IMPLEMENTED ON THE ORBITER AS THREE REDUNDANT END-TO-END STRINGS WITH SOFTWARE CONTROL, SELECTION, AND EDITING OF DATA. MILITARY PARTS,

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MATERIALS, AND PROCESSES WERE USED. NASA SOLDERING REQUIREMENTS AND EEE PARTS TRACEABILITY HAVE BEEN WAIVED FOR THE GPS SINCE IT IS A MILITARY-OFF-THE-SHELF (MOTS) PROCUREMENT.

BOARD-BY-BOARD PROTON BOMBARDMENT, WAS PERFORMED, AT THE 200 MEV ENERGY LEVEL, $1E10$ PROTONS/CM² DENSITY, AND 622 RAD TOTAL IONIZING DOSE TO CHECK THE EFFECTS DUE TO RADIATION INDUCED SINGLE EVENT UPSETS OR RADIATION INDUCED LATCHUP.

THERE ARE VARIOUS BUILT-IN-TEST CAPABILITIES TO DETECT AND ISOLATE FAULTS AT THE LRU LEVEL DURING FLIGHT AND GROUND OPERATIONS. PERFORMANCE MONITORING, IN THE GPS, IS PERFORMED CONTINUOUSLY WHILE THE UNIT IS OPERATING IN THE NAV MODE. A COMMANDED OR POWER-ON SELF TEST IS USED TO VERIFY, AT A MINIMUM, THE POWER SUPPLY, RF/SIGNAL PROCESSOR, NAV BOARD, AND S/I/O BOARD ARE OPERATING PROPERLY.

(B) TEST:

ACCEPTANCE REQUIREMENTS INCLUDE:

EXAMINATION OF PRODUCT
FUNCTION AND PERFORMANCE TEST
ACCEPTANCE THERMAL TEST
ACCEPTANCE VIBRATION TEST
FUNCTIONAL AND PERFORMANCE RECHECK

AVT

20 TO 80 HZ	PLUS 3 DB/OCTAVE
80 TO 350 HZ	0.04 G ² /HZ
350 TO 2000 HZ	MINUS 3 DB/OCTAVE

ATT

THE GPS SHALL BE THERMAL CYCLED 10-CYCLES OF 21C TO 70C TO -50C TO 21C WITH PERFORMANCE AND BIT MONITORING THROUGHOUT. DWELL AT EACH TEMPERATURE LIMIT SHALL BE A MINIMUM OF 60-MINUTES AFTER THERMAL STABILIZATION OF THE TEST ARTICLE.

QUALIFICATION REQUIREMENTS INCLUDE:

ACCEPTANCE TEST
PERFORMANCE TEST
POWER TEST
EMC TEST
LIGHTNING
CABIN ATMOSPHERE
HUMIDITY
SALT FOG
SAND AND DUST BY ANALYSIS
ACCELERATION/OPERATING LIFE TEST

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QUALIFICATION ACCEPTANCE VIBRATION TEST
THERMAL VACUUM TEST
THERMAL CYCLE TEST
SHOCK TEST
POST PERFORMANCE TESTS
PACKAGE QUALIFICATION TEST BY SIMILARITY TO MIL-STD-1367A

QAVT

20 TO 80 HZ	PLUS 3 DB/OCTAVE TO 0.067 G ² /HZ
80 TO 350 HZ	CONSTANT 0.067 G ² /HZ
350 TO 2000 HZ	MINUS 3 DB/OCTAVE FROM 0.067 G ² /HZ
DURATION	5 TIMES AVT

ACCELERATION

ACCELERATION TEST REQUIREMENT SHALL BE MET BY ANALYSIS.

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

CERTIFICATION AND SOURCE INSPECTION TEST REPORTS ARE ON FILE. CASES AND FLATPACKS ARE SCREENED FOR LOOSE PARTICLES DETECTION IN RECEIVING INSPECTION. ALL HYBRID COMPONENTS ARE LOT SAMPLED IN RECEIVING INSPECTIONS.

CONTAMINATION CONTROL

LRU'S SHALL BE CLEANED TO LEVELS SPECIFIED IN MIL-STD-454M

ASSEMBLY/INSTALLATION

VISUAL INSPECTION IS PERFORMED AT KIT RELEASE. QUALITY CONTROL VERIFIES SOLDERED CONNECTIONS AND ASSEMBLY OF PARTS. TOOL CERTIFICATIONS ARE MAINTAINED. QUALITY CONTROL PERFORMS PRE-CAP VISUAL INSPECTION FOR CLEANLINESS. QUALITY CONTROL VERIFIES CONVEYOR FURNACE PROFILE/TEMPERATURE EVERY 90-DAYS. POPULATED PWB'S WILL BE PURGED OF IONIC CONTAMINATION PRIOR TO CONFORMAL COAT.

CRITICAL PROCESSES

INSPECTION VERIFIES CRIMPING OPERATIONS AND CERTIFICATION. SOLDERING REQUIREMENTS PER MIL-STD-2000 ARE VERIFIED BY INSPECTION.

TESTING

ATP IS OBSERVED AND VERIFIED BY QUALITY CONTROL, INCLUDING AVT AND ATT.

HANDLING/PACKAGING

PROPER GROUNDING IS UTILIZED FOR THE HANDLING OF ELECTRO-STATIC SENSITIVE DEVICES. PACKAGING AND PROTECTION ARE VERIFIED BY INSPECTION.

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(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITIES CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

LANDING AT NOMINAL END-OF-MISSION SITES (EDWARDS, KSC, NORTHROP) MAY BE SUPPORTED BY (HIGHLY DESIRABLE, BUT NOT MANDATORY). IF RADAR TRACKING DATA (NOT AVAILABLE AT TAL SITES) AND COMMUNICATIONS WITH THE GROUND ARE AVAILABLE, A CAPABILITY EXISTS WITH MCC THAT CAN BE USED AS ANOTHER LEVEL OF REDUNDANCY OR AS A BACKUP TO GPS.

IN ORDER TO AVOID THE AUTOMATIC INCORPORATION OF BAD GPS DATA INTO ONBOARD NAVIGATION, THE FLIGHT SOFTWARE PERFORMS UP TO FOUR GPS QUALITY ASSESSMENT (QA) CHECKS WHICH DETECT CERTAIN TYPES OF PROBLEMS AND SELECT GPS SOLUTIONS ACCORDINGLY. HOWEVER, IT SHOULD BE RECOGNIZED THAT THESE QA SCHEMES, LIKE ALL RM SCHEMES, DO NOT PROVIDE 100% PROTECTION.

CREW PROCEDURES CALL FOR MANUALLY ATTEMPTING TO RESOLVE DILEMMA SITUATIONS USING AVAILABLE CUES (E.G., QUALITY ASSESSMENT INDICATIONS OR COMPARATIVE PERFORMANCE DATA, IF AVAILABLE). IF RADAR TRACKING DATA AND GROUND COMMUNICATIONS ARE AVAILABLE, THE MCC MAY BE ABLE TO HELP THE CREW RESOLVE A GPS DILEMMA OR PREVENT THE USE OF BAD DATA IF THE LAST UNIT FAILS.

CREWS ARE TRAINED TO ISOLATE A FAILED GPS BY COMPARING GPS DATA WITH BASELINE NAVIGATION DATA. MCC PERSONNEL ARE TRAINED TO ISOLATE A FAILED GPS BY COMPARING GPS DATA WITH THE RADAR TRACKING DATA (WHEN AVAILABLE).

- APPROVALS -

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