FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: 05-5-B11-1 -X

SUBSYSTEM NAME: DATA PROCESSING SYSTEM (DPS)
REVISION: 8 04/26/96

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: GENRL PURPOSE CMPTR, AP101S LOCKHEED	MC615-0025-0202, 0203 6966000-22

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

REFERENCE DESIGNATORS:
81V72A16
82V72A17
83V72A18
81V72A19
82V72A20

QUANTITY OF LIKE ITEMS: 5
FIVE

FUNCTION:
THE GENERAL PURPOSE COMPUTERS (GPC'S) SUPERVISE, COMMAND, CONTROL AND COORDINATE ALL FLIGHT GUIDANCE FUNCTIONS, VEHICLE ATTITUDES AND FLIGHT GEOMETRY. THE GPC ALSO PROCESSES MATHEMATICAL AND LOGICAL FUNCTIONS. THE GPC READS IN COMPUTER DATA FROM THE ORBITER SUBSYSTEMS. THE DATA IS PROCESSED AND MADE AVAILABLE FOR DISPLAY, TRANSMISSION, OR COMMAND EXECUTION BY ORBITER SUBSYSTEMS. THE GPC CONTROLS TWO-WAY TRANSFER OF INFORMATION TO AND FROM THE OTHER UNITS OF THE SPACE SHUTTLE. INTERNAL BUILT IN TEST EQUIPMENT (BITE) AND COOPERATIVE SYNC BETWEEN THE REDUNDANT SET GIVE FAULT DETECTION AND ISOLATION (FDI) OF COMPUTERS DURING CRITICAL MISSION PHASES. FOUR GPC'S ARE NOMINALLY ASSIGNED TO THE PRIMARY AVIONICS SOFTWARE SYSTEMS (PASS). THE 5TH GPC IS ASSIGNED TO THE BACKUP FLIGHT SYSTEM (BFS).

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NUMBER: 05-5-B11-1-02

REVISION#: 9 02/02/98

SUBSYSTEM NAME: DATA PROCESSING SYSTEM (DPS)
LRU: GENRL PURPOSE CMPTR, AP101S **CRITICALITY OF THIS**
ITEM NAME: GENRL PURPOSE CMPTR, AP101S **FAILURE MODE:** 1/1

FAILURE MODE:
ERRONEOUS OUTPUT

MISSION PHASE:
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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

CAUSE:
TEMPERATURE, CONTAMINATION, PIECE-PART FAILURE, CHEMICAL REACTION, RADIATION, VIBRATION. MANY ELECTRONIC PARTS IN THE REGISTERS, ARITHMETIC LOGIC UNIT, MICRO PROGRAM UNIT, MAIN MEMORY, GPC CLOCKS, AND OPEN/SHORTED SELECT LINE ARE SINGLE FAILURE POINTS FOR EACH LINE REPLACEABLE UNIT (LRU).

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
POSSIBLE LOSS OF GPC. POSSIBLE LOSS OF REDUNDANT SET DUE TO NON- UNIVERSAL I/O ERRORS. IF GPC IS ASSIGNED AS BFS, POSSIBLE LOSS OF BFS FUNCTION.

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(B) INTERFACING SUBSYSTEM(S):
POSSIBLE LOSS OF JETS ASSIGNED TO FAILED GPC.

(C) MISSION:
PASS: PER FLIGHT RULES LOSS OF ONE GPC NO EFFECT. LOSS OF TWO GPC'S RESULTS IN MINIMUM DURATION FLIGHT. LOSS OF THREE GPC'S RESULTS IN ENTRY TO NEXT PRIMARY LANDING SITE (PLS).

(D) CREW, VEHICLE, AND ELEMENT(S):
PASS OR BFS: POSSIBLE LOSS OF VEHICLE/CREW.

(E) FUNCTIONAL CRITICALITY EFFECTS:
CRITICALITY 1/1 BECAUSE OF THE FOLLOWING REASONS:

FOR ON-ORBIT:
GPC ERRONEOUS OUTPUT COMMANDS TO ENABLED MAIN REACTION CONTROL SYSTEM (RCS) DURING PROXIMITY OPERATIONS CAN RESULT IN LOSS OF CREW/VEHICLE.

FOR ASCENT/ENTRY: (PRE-MEDS)
A BFS FAILURE, CAUSING LOSS OF PASS (E.G., DUAL BUS COMMANDERS), FOLLOWED BY INABILITY OF BFS TO ASSUME CONTROL OF VEHICLE CAN RESULT IN LOSS OF CREW/VEHICLE. ONE POSSIBLE SCENARIO IS INTERFERENCE ON DK BUSES PREVENTS PASS-DEU (DISPLAY ELECTRONICS UNIT) COMMUNICATIONS.

FOR ASCENT/ENTRY: (MEDS CONFIGURATION)
A BFS FAILURE, CAUSING LOSS OF PASS (E.G., DUAL BUS COMMANDERS), FOLLOWED BY INABILITY OF BFS TO ASSUME CONTROL OF VEHICLE CAN RESULT IN LOSS OF CREW/VEHICLE. ONE POSSIBLE SCENARIO IS INTERFERENCE ON DK BUSES PREVENTS PASS-IDP (INTEGRATED DISPLAY PROCESSOR) COMMUNICATIONS.

CRITICALITY 1R2 BECAUSE OF THE FOLLOWING REASONS:

FOR ASCENT/ENTRY:
THIS FAILURE COUPLED WITH AN UNDETECTED FLIGHT CONTROL SYSTEM (FCS) FAILURE (E.G., IN THE AEROSURFACE AMPLIFIER (ASA) OR ASCENT THRUST VECTOR CONTROLLER (ATVC)), COULD RESULT IN THE TWO HEALTHY PATHS BEING VOTED OUT. THIS COULD RESULT IN A VOTING DILEMMA IN THE FCS (E.G., "FORCE FIGHT" IN THE SERVO ACTUATORS. REFERENCE FMEA 05-1-FC6042-1 AND 05-1-FC6542-1).

FOR ASCENT:
(1) IDENTICAL ERRONEOUS OUTPUT FROM TWO GPC'S (GPC1, 3 OR 4) CAN RESULT IN OPENING BOTH SERIES CONNECTED RTLS LH2 DUMP VALVES.

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DUMPING LH2 OVER ORBITER WING. IF LESS THAN 100,000 FEET, COULD RESULT IN EXPLOSION. SIMILAR ERRONEOUS OUTPUTS CAN OPEN TWO SERIES LH2 MANIFOLD REPRESSURIZATION VALVES WHICH CAN INJECT GASEOUS HE AND H2 INTO THE LH2 MANIFOLD RESULTING IN POSSIBLE SPACE SHUTTLE MAIN ENGINE (SSME) COMBUSTION INSTABILITY.

(2) MASTER EVENT CONTROLLER (MEC) VOTER DILEMMAS (2 VERSUS 2) MAY OCCUR THAT CAN RESULT IN INABILITY TO PERFORM MEC SEPARATION FUNCTIONS (E.G., EXTERNAL TANK (ET) AND SOLID ROCKET BOOSTER (SRB) SEPARATION).

(3) MULTIPLEXER DEMULTIPLEXER (MDM) (FLIGHT AFT) FA1, 2, 3 OR GPC1, 2, OR 3 ERRONEOUS OUTPUT WHICH RESULTS IN BODY FLAP ENABLE AND UP COMMANDS ON THE SAME CHANNEL, COUPLED WITH LOSS OF OUTPUT ON ANOTHER CHANNEL (GPC, MDM, ACTUATOR, MOTOR OR AUXILIARY POWER UNIT (APU)), WILL CAUSE THE BODY FLAP TO DRIVE IN THE UP DIRECTION, CONTACTING AN ENGINE BELL. THIS CAN RESULT IN LOSS OF VEHICLE/CREW.

(4) TWO GPC FAILURES THAT CAUSE IMPROPER COMMANDS TO A SUFFICIENT NUMBER OF JETS CAN RESULT IN ORBITER EXTERNAL TANK (ET) CONTACT OR AN ORBITER OUT-OF-CONTROL CONDITION AT SEPARATION.

(5) UNVOTED EFFECTORS, NO EFFECT ON 1ST FAILURE. 2ND RELATED FAILURE COULD CAUSE EXTERNAL TANK (ET) SEPARATION DOORS TO CLOSE PREMATURELY RESULTING IN BENT LINKAGE WHICH PREVENTS SUBSEQUENT DOOR CLOSING.

FOR ON-ORBIT
GPC FAILURE COUPLED WITH REMOTE MANIPULATOR SYSTEMS (RMS) OPERATIONS AT THE EXTREMES OF THE ENVELOPE CAN CAUSE SERIOUS VEHICLE DAMAGE AND POTENTIAL LOSS OF VEHICLE/CREW.

FOR BFS:
AFTER LOSS OF PASS DUE TO GENERIC FAILURE(S), BFS ENGAGE IS REQUIRED. ANY SUBSEQUENT FAILURE IN THE BFS LEADS TO INABILITY TO CONTROL THE VEHICLE AND RESULTS IN LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
PARTS ARE DERATED 25 PERCENT TO ORBITER PROJECT PARTS LIST (OPPL) REQUIREMENTS. BASIC DESIGN IS PROVEN BY UTILIZING CIRCUITS FROM PREVIOUS GENERATIONS COMPUTERS. SUSCEPTIBILITY TO PROBLEMS OF GPC POLLUTION ANOMALIES HAVE BEEN MINIMIZED BY INCORPORATION OF SOFTWARE SAFEGUARDS TO THE MAXIMUM EXTENT POSSIBLE. THE AP101S GPC MICROCODE REDUCES EXPOSURE

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TO NON UNIVERSAL INPUT OUTPUT (I/O) ERRORS DUE TO ERRONEOUS BUS ACTIVITY. FOR EXPOSURE TO RADIATION, ERROR CORRECTING CODE WILL CORRECT 1 BIT CHANGE PER CMOS MEMORY WORD, BUT 2 BIT CHANGES PER ONE CMOS MEMORY WORD CANNOT BE CORRECTED. DESIGN ALSO INCORPORATES RELIABILITY, MAINTAINABILITY, ENVIRONMENTAL, TRANSPORTABILITY AND THERMAL REQUIREMENTS AND OTHER DESIGN AND CONSTRUCTION CONTROLS PER SPECIFICATION MC615-0025.

(B) TEST:
ACCEPTANCE TESTING, WHICH INCLUDES AP101S (GPC) FACTORY ACCEPTANCE TEST (FAT) AND CUSTOMER ACCEPTANCE TEST (CAT) PERFORMANCE TEST PROCEDURE (TP85-387-700), AP101S CAT-THERMAL TEST PROCEDURE (TP85-387-600), AP101S CAT-VIBRATION TEST PROCEDURE (TP85-387-500), PERFORMANCE, POWER VARIATION TEST AND EXAMINATION OF PRODUCT ARE PERFORMED ON EACH UNIT.

QUALIFICATION TESTING, INCLUDING POWER, ELECTROMAGNETIC COMPATIBILITY (EMC), THERMAL CYCLE, VIBRATION, THERMAL VACUUM, LIFE, CABIN ATMOS- PHERE, RADIATION, SHIPPING CONTAINER, LIGHTNING AND SHOCK HAS BEEN PERFORMED.

INTEGRATED AND SUBSYSTEM VERIFICATION PERFORMED AT JSC AND KSC. ALL COMPUTERS ARE BURNED-IN FOR 18 CYCLES MINIMUM (8 HOUR/CYCLE) OF +120 TO -65F, THEN 22 CYCLES OF +105 TO -5 DEGREES F, PLUS 3 AXES ACCEPTANCE VIBRATION TEST (AVT) TO .04G2/HZ LEVEL. PRIOR TO THE BURN-IN TEST, A 55 NONOPERATIONAL TEMPERATURE CYCLE (-55 DEGREES C TO +80 DEGREES C) SCREEN IS PERFORMED ON MOST PAGE ASSEMBLIES. FUNCTIONAL TESTS ARE MONITORED TO VERIFY SOFTWARE CONTROL IS WITHIN SPECIFIED LIMITS. INTEGRATED AND SUBSYSTEM VERIFICATION IS PERFORMED AT JSC AND KSC. NASA PERFORMS A MINIMUM OF 1,000 HOURS OF SYSTEM OPERATION ON EACH GPC PRIOR TO COMMITMENT TO FLIGHT.

GROUND TURNAROUND TEST: ALL TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
CERTIFICATES OF COMPLIANCE ARE IN RECEIVING INSPECTION FILES. RECEIVING INSPECTION PERFORMS PHYSICAL AND CHEMICAL ANALYSIS OF MATERIALS

CONTAMINATION CONTROL
AIR PLENUMS ARE VISUALLY INSPECTED AND VACUUM CLEANED DURING FINAL INSPECTION AND FILTERS ARE INSTALLED TO KEEP OUT DEBRIS. KSC TURNAROUND CHECKS INCLUDE INSPECTION/CLEANING OF FILTERS AND AIR PLENUMS.

ASSEMBLY/INSTALLATION
TORQUE VERIFICATION TOOLS ARE USED BY INSPECTION. MULTILAYER BOARDS ARE CHECKED FOR PROPER SOLDER PENETRATION, SHORTS AND OPENS, AND MICRO-SECTION ANALYSIS. 13X MAGNIFICATION AND FLUORESCENT RING ILLUMINATORS ARE USED FOR INSPECTION OF SOLDER JOINTS. 30X MAGNIFICATION IS USED FOR SUSPECTED CRACKS AND FRACTURES. CONFORMAL COATING IS CHECKED FOR CONTAMINATION, MINIMUM COVERAGE AND UNIFORMITY USING BLACKLIGHT.

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INSPECTION OF WIRE HARNESS IS PERFORMED DURING IN-PROCESS AND FINAL INSPECTION.

NONDESTRUCTIVE EVALUATION
ALL BRAZED HOUSINGS ARE VISUALLY INSPECTED INCLUDING RADIOGRAPHIC AND SILVER NITRATE TESTING. X-RAYS ARE TAKEN OF THE BACK PANEL TO ASSURE PROPER SOLDER PENETRATION.

CRITICAL PROCESSES
INSPECTION VERIFIES CRIMPING OPERATIONS AND CERTIFICATION. SOLDERING REQUIREMENTS PER NHB5300.4(3A) ARE VERIFIED BY INSPECTION.

TESTING
ACCEPTANCE TESTING IS OBSERVED AND VERIFIED BY BOEING, DCAS, AND LOCKHEED QUALITY CONTROL INCLUDING ACCEPTANCE VIBRATION TEST AND ACCEPTANCE THERMAL TEST.

HANDLING/PACKAGING
INSPECTION VERIFIES SPECIAL HANDLING OF ASSEMBLIES CONTAINING ELECTRICALLY STATIC SENSITIVE DEVICES. PACKAGING AND PROTECTION 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 DATABASE

(E) OPERATIONAL USE:
PRIOR TO THE START OF AN ERRONEOUS OUTPUT ON THE GPC, FLIGHT CRITICAL STRINGS (PAIRS OF DATA BUSES) ARE DISTRIBUTED AMONG THE OPERATING GUIDANCE NAVIGATION AND CONTROL (GN&C) REDUNDANT SET IN ACCORDANCE WITH FLIGHT RULE GUIDELINES IN AN ATTEMPT TO LIMIT EXPOSURE TO A NEXT FAILURE. FOLLOWING THE START OF ERRONEOUS GPC OUTPUT, THE FLIGHT CRITICAL STRINGS ARE REDISTRIBUTED ACCORDING TO FLIGHT RULE GUIDELINES IN AN ATTEMPT TO LIMIT EXPOSURE TO THE NEXT FAILURE. NO SPECIAL CREW TRAINING IS REQUIRED.

- APPROVALS -

SS&PAE MANAGER	: P. STENGER-NGUYEN	6/2/98
SS&PAE	: T. Al	
DESIGN ENGINEERING	: G. F. MCMULLEN	6-2-98
MEDS SYSTEM	: M. B. WARNER	6/2/98
MEDS HARDWARE	: R. SITAPARA	6/2/98
JSC MOD	: K. Bain	6-12-98