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FAILURE MODES EFFECTS ANALYSIS (FMEA) — CRITICAL FAILURE MODE
NUMBER: 05-2C-22200-01

REVISION# 3 05/17/91 R

SUBSYSTEM: COMM & TRACK: TACAN
LRU :TACAN SET
ITEM NAME: TACAN

CRITICALITY OF THIS
FAILURE MODE:1R2

- FAILURE MODE:
LOSS OF OUTPUT

MISSION PHASE:

PL PRELAUNCH
LO LIFT-OFF
DO DE-ORBIT

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

- CAUSE:
VIBRATION, TEMPERATURE, MECHANICAL SHOCK, CONTAMINATION, MISHANDLING.

- 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:
LOSS OF REDUNDANT PATH
- (B) INTERFACING SUBSYSTEM(S):
FAILED TACAN OUTPUTS ARE IGNORED AND THE OUTPUTS FROM THE REMAINING

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TACAN'S ARE USED.

- (C) MISSION:
NO EFFECT
- (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT - FIRST FAILURE. OPERATION CONTINUES WITH THE TWO REMAINING UNITS. POSSIBLE LOSS OF CREW/VEHICLE AFTER TWO FAILURES (LOSS OF OUTPUT FAILURE, ERRONEOUS OUTPUT FAILURE) DUE TO THE INABILITY TO MAKE THE LANDING SITE.

■ (E) FUNCTIONAL CRITICALITY EFFECTS:

- DISPOSITION RATIONALE -

- (A) DESIGN:
THE TACAN (MC409-0014-0006, OLD TYPE) IS OFF THE SHELF PROCUREMENT WITH MORE THAN 25,000 UNITS FABRICATED WITHOUT MAJOR DESIGN OR SIGNIFICANT FAILURE HISTORIES. ORIGINALLY DESIGNED (1968) FOR MILITARY AIRCRAFT USE AND WAS BUILT PER MIL SPECS IN EFFECT AT THAT TIME. BECAUSE OF INHERENT SINGLE FAILURE POINTS, THE TACAN SYSTEM WAS IMPLEMENTED ON THE ORBITER AS THREE REDUNDANT END-TO-END STRINGS WITH GPC SOFTWARE CONTROL SELECTION AND EDITING DATA. MILITARY AND OPPL APPROVED PARTS, MATERIALS AND PROCESSES WERE USED. NASA SOLDERING REQUIREMENTS & EEE PARTS TRACEABILITY HAVE BEEN WAIVED FOR THE TACAN PER OVEI PARA. 3.5.17 (REGARDING EEE PARTS).

THE NEWLY DESIGNED TACAN (MC409-0184-0001) IS ALSO OFF THE SHELF AND IS AN ALL SOLID STATE DESIGN. THIS UNIT WAS DESIGNED IN 1988 FOR USE IN MILITARY AIRCRAFT AND BUILT TO MILITARY SPECIFICATIONS. THE TACAN, BEING BUILT TO MILITARY SPECIFICATIONS PROVIDED THE JUSTIFICATION FOR THE NASA SOLDERING REQUIREMENTS AND EEE PARTS TRACEABILITY TO BE WAIVED. THE NEW TACAN HAS AN MTBF IN EXCESS OF 3800 HOURS. THIS TACAN ASSEMBLY IS CONVECTION COOLED (DOES NOT REQUIRE SUCTION AIR) AND OPERATES FROM A 28 VOLT DC RATHER THAN 120 VAC, 400 HZ (OLD TACAN).

- (B) TEST:
A 96 HOUR BURN-IN IS PERFORMED ON EACH UNIT (OLD OR NEW TYPE) PRIOR TO ITS FIRST FORMAL ATP. THE BURN-IN REQUIRES TEMPERATURE CYCLING AND VIBRATION TO LOCATE INFANT MORTALITY FAILURES. THE ACCEPTANCE TESTING OF ALL UNITS INCLUDES EXAMINATION OF PRODUCT, THERMAL, VIBRATION AND PERFORMANCE TESTING. QUALIFICATION WAS PERFORMED BY SIMILARITY TO THE TESTED MILITARY DESIGN, EXCEPT THAT RANDOM VIBRATION WAS PERFORMED TO ORBITER REQUIREMENTS. DEVELOPMENTAL TESTING ALSO INCLUDED INTERFACING

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WITH THE AVIONICS DEVELOPMENTAL LABORATORY AND INTEGRATION TESTING BY THE SHUTTLE AVIONICS INTEGRATION LABORATORY. FURTHER TESTING WAS CONDUCTED AT PALMDALE TO VERIFY PROPER PERFORMANCE ON THE ORBITER AND THE OPERATION DURING APPROACH AND LANDING TEST DEMONSTRATED PERFORMANCE IN FLIGHT. PRIOR TO INITIAL SPACE FLIGHT OF EACH VEHICLE ALL PERTINENT PARAMETERS WERE VERIFIED.

GROUND TURNAROUND TEST
TACAN SELF TEST, TACAN RANGE, BEARING ACCURACY, POWER OUTPUT, FLAGS VERIFICATION AND TACAN GROUND STATION INTERFACE VERIFICATION - PERFORMED EVERY FLIGHT.

■ (C) INSPECTION:

RECEIVING INSPECTION (OLD AND NEW TYPES)
INCOMING MATERIAL IS VERIFIED BY RECEIVING INSPECTION. CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL (OLD AND NEW TYPES)
QC INSPECTS IN-PROCESS ASSEMBLIES 100% TO ASSURE LACK OF CONTAMINANTS. ALL PRINTED WIRING BOARDS ARE CLEANED, USING AN AUTOMATIC IN-LINE WASHER, TO ASSURE DECONTAMINATION IMMEDIATELY FOLLOWING THE SOLDERING PROCESS.

ASSEMBLY/INSTALLATION (OLD AND NEW TYPES)
DETAILED INSPECTION PERFORMED ON ALL ASSEMBLIES AND DETAIL PARTS PRIOR TO NEXT ASSEMBLY. KITTING, SOLDERING, M&P, AND SHOP TRAVELERS ARE VERIFIED BY INSPECTION. MAINTENANCE OF ESD PREVENTION CONTROLS MONITORED AND VERIFIED BY QC. TORQUING OPERATIONS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES (OLD AND NEW TYPES)
SPECIAL PROCESSES (SOLDERING AND CONFORMAL COATING) ARE CONTROLLED AND MONITORED BY QUALITY ENGINEERING, AND THE PERFORMANCE OF SPECIAL PROCESSES IS WITNESSED BY INSPECTION.

TESTING (OLD AND NEW TYPE)
BURN-IN, ACCEPTANCE TEST PROCEDURES, INCLUDING ACCEPTANCE VIBRATION AND ACCEPTANCE THERMAL TESTING, ARE VERIFIED BY QUALITY ENGINEERING.

HANDLING/PACKAGING (OLD AND NEW TYPE)
HANDLING OF ELECTROSTATIC-SENSITIVE DEVICES IS MONITORED AND VERIFIED BY QC; GROUNDING WRIST STRAPS ARE UTILIZED.

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■ (D) FAILURE HISTORY:

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD, OR FLIGHT "LOSS OF OUTPUT" FAILURES.

■ (E) OPERATIONAL USE:

THE TACAN'S ARE NORMALLY TURNED ON 2 HOURS BEFORE THE DEORBIT BURN. AFTER TRANSITION TO MM304 (APPROXIMATELY 15 MIN. AFTER DEORBIT BURN) TACAN AGC DATA IS DOWN-LISTED AND OBSERVED BY GROUND CONTROLLERS. WITH PROPER BLANKING OPERATION, THE AGC WILL READ GREATER THAN OR EQUAL TO 4.9 VOLTS. IF THE AGC VOLTAGE IS NOT GREATER THAN OR EQUAL TO 4.9 VOLTS, THE GROUND CONTROLLERS WILL CALL THE CREW AND ASK THEM TO SWITCH ONE TACAN AT A TIME TO "RCV" UNTIL THE PROPER AGC VOLTAGE IS OBSERVED, THUS ISOLATING THE FAILED LRU. ONCE THE FAILED LRU IS SWITCHED TO "RCV", THE PROPER AGC VOLTAGE WILL BE OBSERVED AND NORMAL TACAN OPERATION WILL CONTINUE WITH THE 2 REMAINING LRU'S. WHEN A FAILED TACAN IS SWITCHED TO "RCV" MODE, BEARING DATA WOULD STILL BE AVAILABLE (NO RANGE DATA).

LANDING AT NOMINAL END OF MISSION SITES (EDWARDS, KSC, NORTHROP) PROVIDES RADAR TRACKING DATA AND UPLINK CAPABILITY (NOT AVAILABLE AT TAL SITES) WHICH CAN BE USED FOR A STATE VECTOR UPLINK AS A BACKUP TO TACAN. TACAN REDUNDANCY MANAGEMENT SOFTWARE AUTOMATICALLY SAFES AND/OR RE-CONFIGURES THE SYSTEM AFTER TACAN FAILURES. NAVIGATION SOFTWARE KALMAN FILTER PROVIDES SOME PROTECTION AGAINST INCORPORATION OF BAD TACAN DATA INTO THE STATE VECTOR. CREW PROCEDURES CALL FOR MANUALLY ATTEMPTING TO RESOLVE A DILEMMA IF THE AUTOMATIC TACAN SELF-TEST CANNOT ISOLATE THE FAILED UNIT. IF RADAR TRACKING DATA AND COMMUNICATIONS WITH THE GROUND ARE AVAILABLE, THE MISSION CONTROL CENTER (MCC) CAN RESOLVE A TACAN DILEMMA AND PROTEST AGAINST USE OF BAD DATA IF THE LAST UNIT FAILS. CREW PROCEDURES CALL FOR DE-SELECTING A FAILED TACAN IN THE BACKUP FLIGHT SOFTWARE TO PROTECT AGAINST SUBSEQUENT LOSS OF PRIMARY AVIONICS SOFTWARE SYSTEM (PASS). CREW IS TRAINED TO ISOLATE A FAILED TACAN BY COMPARING TACAN DATA WITH NAVIGATION DATA. MCC PERSONNEL ARE TRAINED TO ISOLATE A FAILED TACAN BY COMPARING TACAN DATA WITH RADAR TRACKING DATA.

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