

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE
NUMBER: 05-2C-22200 - 04

REVISION# 01/17/95

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

CRITICALITY OF THIS
 FAILURE MODE: 1R2

FAILURE MODE:

BLANKING PULSE FAILS ON (REQUIRES TWO TACAN INTERNAL HARDWARE FAILURES
 THE BLANKING DRIVER TRANSISTOR AND THE DC BLOCKING CAPACITOR MUST BOTH
 FAIL SHORTED FOR THE BLANKING PULSE TO FAIL ON.)

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) FAIL
 B) FAIL
 C) PASS

PASS/FAIL RATIONALE:

A)
 FAILS SCREEN A BECAUSE A SHORTED DC BLOCKING CAPACITOR CANNOT BE
 DETECTED DURING TURNAROUND TESTING WITHOUT INVASIVE PROCEDURES
 B)
 FAILS SCREEN B BECAUSE A SHORTED DC BLOCKING CAPACITOR IS NOT DETECTABLE
 IN FLIGHT SINCE IT WILL NOT AFFECT THE OPERATION OF THE TACAN
 C)
 PASSES SCREEN C BECAUSE NO SINGLE, CREDIBLE EVENT HAS BEEN IDENTIFIED
 WHICH CAN RESULT IN SHORTING BOTH THE DC BLOCKING CAPACITOR AND THE
 BLANKING DRIVER TRANSISTOR.

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- FAILURE EFFECTS -

(A) SUBSYSTEM:

THE "BLANKING PULSE FAILS ON" IS A TWO-FAILURE EVENT. THERE IS NO EFFECT AFTER THE FIRST FAILURE, A SHORTED DC BLOCKING CAPACITOR. AFTER THE SECOND FAILURE (A SHORTED BLANKING DRIVER TRANSISTOR IN THE SAME TACAN) THE FAILED TACAN PRODUCES A DC VOLTAGE LEVEL IN LIEU OF BLANKING PULSES. IN THE WORST CASE (ALL THREE TACANS ARE GOULD TACANS) THIS DC VOLTAGE LEVEL WILL CONTINUOUSLY BLANK THE RECEIVERS OF ALL THREE TACANS, RESULTING IN LOSS OF ALL TACAN FUNCTION.

FOR LESS THAN THE WORST CASE (ONE OR BOTH OF THE REMAINING TACANS ARE COLLINS TACANS), THE REMAINING COLLINS TACAN(S) WILL CONTINUE TO FUNCTION WITH DEGRADED PERFORMANCE AS LONG AS THE FAILED TACAN IS OPERATING BECAUSE NO EXTERNAL BLANKING PULSES ARE BEING DETECTED FROM THE FAILED TACAN. ADDITIONAL FAILURES WOULD BE REQUIRED BEFORE LOSS OF ALL TACAN FUNCTION, BECAUSE THE COLLINS DESIGN IS PROTECTED BY A CAPACITOR IN THE INPUT CIRCUIT WHICH MUST ALSO SHORT BEFORE ITS RECEIVER IS CONTINUOUSLY BLANKED.

(B) INTERFACING SUBSYSTEM(S):

BLANKING PULSE "FAILS ON" IS A TWO FAILURE EVENT. NO EFFECT AFTER FIRST FAILURE (CAPACITOR). AFTER SECOND FAILURE (TRANSISTOR). IN THE WORST CASE SCENARIO (3 GOULD TACANS) TACAN DATA (RANGE AND BEARING) WILL NOT BE AVAILABLE FOR INCORPORATION BY GN&C PRIOR TO THE MINIMUM REQUIRED RANGE OF 160 N MI.

(C) MISSION:

NO EFFECT.

(D) CREW, VEHICLE, AND ELEMENT(S):

BLANKING PULSE "FAILS ON" IS A TWO FAILURE EVENT. NO EFFECT AFTER FIRST FAILURE (CAPACITOR). POSSIBLE LOSS OF CREW/VEHICLE AFTER SECOND FAILURE (TRANSISTOR) DUE TO LOSS OF TACAN DATA (RANGE AND BEARING) RESULTS IN THE INABILITY TO MAKE THE LANDING SITE.

(E) FUNCTIONAL CRITICALITY EFFECTS:

BLANKING PULSE "FAILS ON" IS A TWO FAILURE EVENT. NO EFFECT AFTER FIRST FAILURE (CAPACITOR). POSSIBLE LOSS OF CREW/VEHICLE AFTER SECOND FAILURE (TRANSISTOR) DUE TO LOSS OF TACAN DATA (RANGE AND BEARING) RESULTS IN THE INABILITY TO MAKE THE LANDING SITE.

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-DISPOSITION RATIONALE-

(A) DESIGN:

THE TACAN (MC409-0014-0006, GOULD) IS OFF THE SHELF PROCUREMENT WITH MORE THAN 25,000 UNITS FABRICATED WITHOUT MAJOR DESIGN CHANGE 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 OF 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 SOLDERING) AND PER IPAR RIBC-015, AMENDMENT A (REGARDING EEE PARTS). THE GOULD TACAN OPERATES FROM 120 VAC, 400HZ.

THE NEWLY DESIGNED TACAN (MC409-0184-0001, RI-COLLINS) IS ALSO OFF THE SHELF AND IS A SOLID STATE DESIGN. THIS UNIT WAS DESIGNED IN 1988 FOR USE IN MILITARY AIRCRAFT AND BUILT TO MILITARY SPECIFICATIONS. THE NASA SOLDERING REQUIREMENTS AND EEE PARTS TRACEABILITY WERE WAIVED ON THIS TACAN ASSEMBLY. THE NEW TACAN MTBF WAS CALCULATED TO BE IN EXCESS OF 3800 HOURS. THE NEW TACAN IS CONVECTION COOLED (DOES NOT REQUIRE SUCTION AIR) AND OPERATES FROM 28 VOLTS DC.

(B) TEST:

A 96 HOUR BURN-IN IS PERFORMED ON EACH UNIT (GOULD OR RI-COLLINS) PRIOR TO FIRST FORMAL ATP. THE BURN-IN REQUIRES TEMPERATURE CYCLING AND VIBRATION TO LOCATE INFANT MORTALITY FAILURES. 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. FOR RI-COLLINS TACAN. DEVELOPMENTAL TESTING ALSO INCLUDED INTERFACING WITH THE AVIONICS DEVELOPMENTAL LABORATORY (FOR GOULD ONLY) AND INTEGRATION TESTING BY THE SHUTTLE AVIONICS INTEGRATION LABORATORY. FURTHER TESTING WAS CONDUCTED AT PALMDALE TO VERIFY PROPER PERFORMANCE ON THE ORBITER. 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, AND FLAGS VERIFICATION AND TACAN GROUND STATION INTERFACE VERIFICATION. VERIFICATION OF NO LOSS OF RECEIVER LOCK WITH ALL TACAN'S TRANSMITTING-PERFORMED EVERY TURNAROUND.

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NUMBER: 05-2C-22200 - 04****(C) INSPECTION:****RECEIVING INSPECTION (GOULD AND RI-COLLINS)**

INCOMING MATERIAL IS VERIFIED BY RECEIVING INSPECTION. CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL (GOULD AND RI-COLLINS)

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 WAVE SOLDERING PROCESS. GOULD TACAN WAS WAVE SOLDERED TO MIL-STD 454C. RI-COLLINS TACAN WAS HAND SOLDERED TO MIL-STD 454F.

ASSEMBLY/INSTALLATION (GOULD AND RI-COLLINS)

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 (GOULD AND RI-COLLINS)

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

TESTING (GOULD AND RI-COLLINS)

ATP, INCLUDING ACCEPTANCE VIBRATION AND ACCEPTANCE THERMAL TESTING, ARE VERIFIED BY QUALITY ENGINEERING.

HANDLING/PACKAGING (GOULD AND RI-COLLINS)

HANDLING OF ELECTROSTATIC-SENSITIVE DEVICES IS MONITORED AND VERIFIED BY QC; GROUNDING WRIST STRAPS ARE UTILIZED.

(D) FAILURE HISTORY:

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD, OR FLIGHT "BLANKING PULSE FAILS ON" FAILURES TO DATE.

(E) OPERATIONAL USE:

TWENTY FOUR (24) HOURS PRIOR TO DEORBIT, A SELF TEST IS PERFORMED TO VERIFY THE STATUS OF EACH TACAN. THE TACANS ARE THEN SWITCHED OFF. THE TACANS 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 NO RF SIGNAL PRESENT AND WITH PROPER BLANKING OPERATION, THE AGC WILL READ GREATER THAN OR EQUAL TO 4.9 VOLTS. A DECREASE IN AGC VOLTAGE IS EXPECTED TO OCCUR WHEN THE DISTANCE BETWEEN THE ORBITER AND THE SELECTED GROUND STATION IS LESS THAN 325 NAUTICAL MILES. IF THE BLANKING PULSE FAILS "ON", FOR THE WORST CASE SCENARIO (3 GOULD TACANS) THE AGC VOLTAGE WILL REMAIN GREATER THAN OR EQUAL TO 4.9 VOLTS AND NO TACAN DATA WILL BE PRESENT AT THE EXPECTED RANGE FROM THE GROUND STATION.

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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 PROTECT 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.

- APPROVALS -

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Stell 2/25/95
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