

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : INSTRUMENTATION

FMEA NO 05-4 -321200-2

REV: 9/7/88

ASSEMBLY : FWD AV BAY 3B

P/N RI : MC456-0051

P/N VENDOR:

QUANTITY : 1
: (ONE)

CRIT. FUNC: 1R

CRIT. HDW: 2

VEHICLE 102 103 104

EFFECTIVITY: X X X

PHASE(S): PL X LO X OO X DO X LS X

PREPARED BY:

DES P KEBEBEW

REL R GREGORIAN

QE E GUTIERREZ

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

APPROVED BY:

DES [Signature] SSM

REL [Signature] REL

QE [Signature] QE

APPROVED BY (NASA):

[Signature] (E. TM) 7/10

[Signature] 9/11/88

[Signature] 9/12/88

ITEM:

MASTER TIMING UNIT (MTU)

FUNCTION:

PROVIDES MASTER TIMING REFERENCE TO THE DISPLAY AND CONTROL (D&C), COMMUNICATION AND TRACKING (C&T), DATA PROCESSING SYSTEMS (DPS), MODULAR AUXILIARY DATA SYSTEM (MADS), ORBITER EXPERIMENT (OEX), PAYLOADS AND OI. GMT AND MET ARE GENERATED WITH PROVISIONS FOR SETTING AND UPDATING THROUGH THE ONBOARD COMPUTERS.

REFERENCE DESIGNATOR: 85V75A3.

FAILURE MODE:

ERRONEOUS OUTPUT.

CAUSE(S):

PIECE-PART STRUCTURAL FAILURE, VIBRATION, TEMPERATURE, MECHANICAL SHOCK, CONTAMINATION.

EFFECT(S) ON:

(A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE

(A) ERRONEOUS OUTPUT TO ORBITER TIMING BUFFER, PAYLOAD TIMING BUFFER, PULSE CODE MODULATION MASTER UNIT, AND PAYLOAD DATA INTERLEAVER.

(B) ERRONEOUS OUTPUT DELTAS GREATER THAN 800 MICRO SECONDS (MS) DETECTED BY ALL GENERAL PURPOSE COMPUTERS (GPC) WILL RESULT IN ALL GPC'S FAULTING DOWN TO A GPC AS TIME SOURCE. ON ORBIT: BACK-UP FLIGHT SYSTEM (BFS) IS "NO GO" FOR ENGAGEMENT DUE TO ITS INABILITY TO ESTABLISH BFS GPC TIME WHICH RESULTS IN LOSS OF GUIDANCE CAPABILITY.

(C) EARLY MISSION TERMINATION MAY BE REQUIRED IF GROUND PERSONNEL DETECT THAT TIME ERROR IS INCREASING.

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(D) FIRST FAILURE DETECTED BY ALL GPC'S OF ERRONEOUS OUTPUT GREATER THAN 800 MS CAUSES ALL GPC'S TO SELECT A GPC AS TIME SOURCE.

ON ORBIT: BFS IS "NO GO" FOR ENGAGEMENT UNTIL ACCEPTABLE MTU TIME IS RESTORED. SECOND FAILURE IS A GENERIC PASS FAILURE WHICH RESULTS IN LOSS OF CREW/VEHICLE.

DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

THE MTU IS A STABLE CRYSTAL CONTROLLED FREQUENCY SOURCE WHICH SHALL PROVIDE FREQUENCY OUTPUTS TO SELECTED SHUTTLE ORBITER SUBSYSTEMS AND PAYLOADS. 28 VDC WILL BE PROVIDED FROM REDUNDANT ORBITER ESSENTIAL BUSES. THE MTU INCLUDES REDUNDANT DOUBLE OVEN THERMALLY STABILIZED CRYSTAL CONTROLLED OSCILLATORS. THE 3 TIME ACCUMULATORS ARE DRIVEN BY 3 FREQUENCY DIVIDERS WHICH ARE OPERATING FROM THE AUTOMATICALLY SELECTED CRYSTAL OSCILLATOR. THE AUTOMATIC SELECTION CAN BE MANUALLY OVERRIDDEN. THE MTU CONTAINS THE NECESSARY BUILT-IN-TEST CAPABILITY TO DETECT AND REPORT FAILURES WHICH AFFECT OPERATION. EEE PARTS ARE SELECTED FROM OR IN ACCORDANCE WITH MF0004-400 OPPL REQUIREMENT. THE MTU IS DESIGNED WITH INPUT/OUTPUT ISOLATION SO THAT A FAILURE OF ONE I/O FUNCTION HAS NO ADVERSE EFFECT ON OPERATION OF ANY OTHER I/O FUNCTION. THE MTU SHALL HAVE A MINIMUM USEFUL LIFE OF 24,000 HOURS, WHICH IS EQUIVALENT TO 100 ORBITAL MISSIONS IN A 10 YEAR PERIOD FROM DATE OF DELIVERY.

(B) TEST

ACCEPTANCE REQUIREMENTS INCLUDE:

EXAMINATION OF PRODUCT, FUNCTIONAL PERFORMANCE TEST, ACCEPTANCE VIBRATION TEST (AVT), ACCEPTANCE THERMAL TEST (ATT).

QUALIFICATION TEST INCLUDE:

ACCEPTANCE TEST, POWER TEST, EMC, CABIN ATMOSPHERE, THERMAL CYCLE, VIBRATION, ACCELERATION, THERMAL VACUUM, LIFE, LIGHTNING, SHOCK.

GROUND TURNAROUND TEST

MTU BITE AND OUTPUT VERIFICATION PERFORMED EVERY FLIGHT.

(C) INSPECTION

RECEIVING INSPECTION

INCOMING PARTS AND MATERIALS ARE SUBJECTED TO A VISUAL AND DIMENSIONAL EXAMINATION WHERE APPLICABLE. CERTIFICATIONS ARE VERIFIED.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PLAN IS VERIFIED BY INSPECTION. THE PROCESS IS IMPLEMENTED AND CLEAN ROOM ENVIRONMENTS ARE MAINTAINED. (UP TO CLEANLINESS LEVEL 100,000)

ASSEMBLY/INSTALLATION

MANDATORY INSPECTIONS ARE SET UP IN THE ASSEMBLY PROCEDURE. MAGNIFICATION (10X) IS UTILIZED TO INSPECT PARTS IN DETAIL. ANTI-STATIC PROCESS IS HANDLED THROUGHOUT ASSEMBLY/INSTALLATION/SHIPPING FLOW. WIRE INSULATIONS ARE INSPECTED TO PRECLUDE ANY EXPOSED WIRE.

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CRITICAL PROCESSES

WIRE CRIMPING, STRIPPING AND SWAGING IS VERIFIED BY INSPECTION. PARTS PROTECTION, COATING AND PLATING REQUIREMENTS ARE VERIFIED BY INSPECTION. SOLDERING, BONDING, AND SHIELDED WIRES ARE SUBJECTED TO INSPECTION.

NONDESTRUCTIVE EVALUATION

X-RAY PENETRANT TEST IS CONDUCTED ON SAMPLING INSPECTION. ETCHING PROCESSES ARE CONDUCTED BY SUB-SUPPLIER (ROCKWELL COLLINS DIV.)

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED AND BOUGHT OFF BY ROCKWELL PQA.

(D) FAILURE HISTORY

"ERRONEOUS OUTPUT" FAILURES WILL BE ADDRESSED ON THIS CIL. THE FOLLOWING THREE FAILURES EXPLAINED BELOW INVOLVED THE FLASKS WHICH SURROUND THE MTU OSCILLATORS.

(1) CAR# A9023, OV101 EDW, MTU S/N 4, 4-9-77 - THE TEMPERATURE BITE BIT FOR OSCILLATOR #1 AND #2 EXHIBITED A "FAIL" CONDITION INDICATING IMPROPER OSCILLATOR TEMPERATURE. THE MTU EXHIBITED EXCESSIVE POWER DRAIN AND THE OUTER SURFACE WAS WARMER THAN NORMAL. A FAILURE OF DEWAR FLASK WHICH IS USED AS THE OVEN ENCLOSURE CAUSED THIS PROBLEM. THIS IS ATTRIBUTABLE TO A WORKMANSHIP DEFICIENCY IN THE DEWAR SEALING OPERATION. THE SUSPECT FLASKS SHOWED A SEVERE LOSS OF VACUUM WITH LEAKAGE EXHIBITED AT THE EXTREME TIP OF THE EVACUATION TUBE SEAL-OFF POINT. THE DEWAR FLASK WAS REPLACED ON THIS UNIT, AND ALL FLIGHT UNITS WILL RECEIVE 100% TESTING OF ALL DEWARS.

(2) CAR# AB7861 OV102 KSC, MTU S/N 4, 10-11-80 - SUBSYSTEM TEST INDICATED BITE BIT #4 (FREQUENCY DIFFERENCE) TO BE INTERMITTENT AND BIT#6 (OVEN #2 TEMPERATURE) TO BE STEADY FAIL. ALSO, THE OSCILLATOR ASSEMBLY INNER OVEN TEMPERATURE CONTROLLER WAS FOUND TO BE "ON" CONSTANTLY. DEWAR #2 WAS REMOVED FOR TEST AND VERIFIED DEFECTIVE BY LN2 TEST. THE FAILURE RESULTED FROM A VACUUM LEAK PATH THROUGH THE SEAL-OFF TIP BECAUSE OF SILVER CONTAMINATION IN THE CAPILLARY VACUUM TIP AND INSUFFICIENT THICKNESS IN THE GLASS BEAD COVERING THE SEAL-OFF TIP. TO DATE, 5 OUT OF 10 DELIVERED FLASKS HAVE FAILED BECAUSE OF VACUUM LOSS, ALL FROM THE SAME LOT. THIS CAR WAS "EXPLAINED": (1) EXISTING MTU'S WILL BE USED "AS IS" UNTIL FAILURE OCCURS FOR DDT&E PHASE. (2) FOR INCREMENT III UNITS AND ANY DDT&E UNITS RETURNED FOR REPAIR, ALL FLASKS WILL BE INSPECTED AND THE SEAL TIP WILL BE VERIFIED.

(3) CAR# AD0338, SUPPLIER, MTU S/N 5, 9-3-85 - OSCILLATOR B FREQUENCY JUMPED 20 PARTS PER 10⁹ HZ DURING ATT. THE CAUSE WAS A CRACKED DEWAR FLASK ON THE "A" SIDE. THERE WAS NO DAMAGE TO THE OSCILLATOR ASSEMBLY CASE OR IN ANY INTERIOR AREA. BOTH DEWAR FLASKS WERE REPLACED IN OSCILLATOR ASSEMBLY SN 4277 WAS THEN RETURNED TO WESTINGHOUSE FOR UNRESTRICTED USAGE. CAUSE OF FAILURE WAS NOT ESTABLISHED AND THE EVENT WAS AN ISOLATED INCIDENT. 05-4-12

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THE FOLLOWING 2 FAILURES INVOLVE CRACKED SOLDER JOINTS ON THE MTU PRINTED CIRCUIT BOARDS. SUBSEQUENT SOLDER CRACKS WERE EXPERIENCED AND ARE BEING COMPILED UNDER CAR# AD1346 WITH FORMAL CLOSEOUT IN PROCESS. SOLDER CRACKS WERE FOUND TO BE ATTRIBUTABLE TO SOLDER CREEP FAILURES RESULTING FROM RESIDUAL STRESS INHERENT IN THE LEADS OF I.C. DEVICES. THE STRESS RESULTED FROM SOLDERING TECHNIQUES WHICH RESTRAINED THE LEAD DURING THE SOLDERING PROCESS. FLIGHT UNITS HAVE BEEN REWORKED USING REVISED SOLDER PROCESSES TO ELIMINATE BUILT IN LEAD STRESS AND INSPECTED. THE UNITS WERE SUCCESSFULLY RE-TESTED TO ATP REQUIREMENTS.

(4) CAR# AC7630, SAIL, MTU S/N 2, 2-17-84 - THE MTU NON-VOTED OUTPUT CH-2 HAD A IMPROPER SYNCHRONIZING CODE OUTPUT. THE CRACKED SOLDER JOINTS WERE FOUND IN LEADS OF FLATPACKS. NO CAUSE FOR THE CRACKED SOLDER JOINTS WAS DETERMINED BUT THE FAILURE MECHANISM WAS BELIEVED TO BE RELATED TO TEMPERATURE CYCLING. THE REPAIR ACTION OF THESE SOLDER JOINTS WAS TO REMOVE THE CONFORMAL COATING, CLEAN THOROUGHLY AND REFLOW THE SOLDER CONNECTIONS. THE MTU WAS SUBJECTED TO AN ABBREVIATED ATP INCLUDING THERMAL AND VIBRATION, WITH NO ANOMALIES DETECTED. THE MTU WAS THEN SUCCESSFULLY SUBJECTED TO THE TOTAL ATP TEST PROCEDURE INCLUDING THERMAL CYCLING AND 3 AXIS VIBRATION. THIS HAS BEEN ACCOMPLISHED IN ITS ENTIRETY WITH NO FAULT OCCURRING.

(5) CAR# AC7813, SAIL, MTU S/N 3, 3-21-84 - MTU BITE BIT #4 INDICATED AN UNACCEPTABLE FREQUENCY DIFFERENCE BETWEEN OSCILLATORS 142 . THE CAUSE WAS TRACED TO A FRACTURED SOLDER JOINT AT U80 PIN 9 IN THE A13 BOARD S/N 5. THE DEFECTIVE SOLDER JOINT WAS REFLOWED AND RECOATED. SINCE THE CAUSE OF THE SOLDER JOINT FRACTURES HAD NOT BEEN DETERMINED, NO CORRECTIVE ACTION WAS PLANNED, EXCEPT TO USE IMPROVED PROCEDURES IN MOUNTING AND SOLDERING FLATPACK I.C.'S IN NEW PRINTED WIRING BOARDS.

(6) CAR# A4475, SUPPLIER, MTU S/N 3, 6-3-76 - AFTER 28 MINUTES OF RANDOM QVT IN THE X-AXIS, A WIRE LEAD ON CHOKE L3 BROKE. L3 WAS MOUNTED ON THE OSCILLATOR PWB (P/N 21203-5151). SCANNING ELECTRON MICROSCOPE (SEM) ANALYSIS INDICATED A WORK-HARDENED CONDITION AT THE LEAD BREAK. TWO SIMILAR CHOKES WERE TAKEN FROM STOCK FOR LEAD ASSESSMENT, BUT NO ANOMALIES WERE FOUND. REVIEW OF THE TEST RECORDS SHOWED A CUMULATIVE EXPOSURE OF 48 MINUTES PER AXIS. CAUSE OF FAILURE WAS ATTRIBUTED TO LEAD FATIGUE AGGRAVATED BY EXCESSIVE LEAD FLEXURE DURING THE BUILD CYCLE. IT WAS ALSO NOTED THAT THE MTU CONTAINS 51 SIMILARLY MOUNTED CHOKES, ALL OF WHICH PASSED QVT. THIS IS A FIRST OCCURRENCE. NO TREND OR GENERIC PROBLEM IS INDICATED. NO ACTION WAS TAKEN EXCEPT TO CAUTION AND INSTRUCT ALL ASSEMBLERS AGAINST EXCESSIVE LEAD FLEXURE.

(7) CAR# A4959, SUPPLIER, MTU S/N 3, 9-8-76 - THE MTU OSCILLATOR OUTPUT SIGNAL (SINWAVE) OF CONNECTOR J6 WAS BELOW THE SPECIFICATION OF 0.8 TO 1.4 VRMS AFTER 30 MINUTES OF Z-AXIS VIBRATION. A FRACTURE OF A CHOKE LEAD WAS FOUND ON THE PRINTED CIRCUIT BOARD. THE CAUSE OF FRACTURE WAS DETERMINED TO BE REPEATED COLLISION OF THE COMPONENT LEAD WITH THE SIDE OF THE OSCILLATOR CHASSIS DURING QUAL VIBRATION. TO PREVENT FURTHER FRACTURES OF BOARDS, SPACERS WERE ADDED AT EACH CORNER OF THE TOP EDGE OF THE PRINTED CIRCUIT BOARDS A3 AND A4 TO PREVENT VIBRATION. THIS CHANGE WAS IMPLEMENTED ON ALL FLIGHT UNITS. THE MTU SUCCESSFULLY COMPLETED THE FLIGHT VIBRATION RETEST.

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(8) CAR# AD3031, SAIL, MTU S/N 3, 5-29-87 - MTU ACCUMULATOR NO. 2 INTERMITTENTLY READ ZERO IN THE GMT TENS OF MINUTES COLUMN. THIS FAILURE WAS INDICATED BY BOTH THE GPC (MDM FF2) AND OI (MDM OF2) DATA WORDS. AN OSCILLOSCOPE CHECK FOR WAVEFORM AND VOLTAGE IRREGULARITIES ON THE A06 ACCUMULATOR #2 BOARD (P/N 641R237G01, S/N 8) WAS PERFORMED WITH NO ANOMALIES DETECTED. AMONG THE PARTS PROBED, WERE I.C.'S U59, U60, AND U62, ALL OF WHICH RELATE TO THE TEN MINUTE GMT PARAMETER. THE CAUSE OF THIS ANOMALY COULD NOT BE DETERMINED. IT COULD ONLY BE CONCLUDED THAT INTERMITTENT GLITCHES WITHIN THE TENS OF MINUTES GMT CIRCUITRY OF THE A06 ACCUMULATOR BOARD WERE RESPONSIBLE FOR THE PROBLEM. THE PROBLEM COULD NOT BE DUPLICATED AT THE SUPPLIER. SINCE THIS LRU IS A QUAL UNIT, THIS UNIT WILL NEVER POSE A PROBLEM DURING FLIGHT. NO PROBLEMS CONCERNING OTHER UNITS ARE FORSEEN BECAUSE NO TREND OF GENERIC PROBLEM IS INDICATED. THIS WAS THE FIRST INSTANCE OF AN UNEXPLAINED ANOMALY ACCUMULATOR FAILURE.

(9) CAR# A4509, SUPPLIER, MTU S/N 4, 6-9-76 - THE MTU FAILED ATP NOISE TEST (ERRONEOUS OUTPUT), IT SHOULD HAVE BEEN 65 DB MIN. BUT IT WAS 59DB. IT WAS CAUSED BY A GROUND LOOP CAUSED BY COUPLING BACK TO THE OSCILLATOR. THE OSCILLATOR COUPLING WAS REMOVED AND THE SHIELDS WERE FLOATED. EDCP #3291-392-310-4 THAT REMOVES THE GROUND COUPLING AND LETTING THE SHIELD FLOAT HAS BEEN APPROVED. THIS CHANGE IS EFFECTIVE ON ALL FLIGHT UNITS.

(10) CAR# AC9705, OV103 RSC, MTU S/N 6, 5-17-85 - IT WAS SUSPECTED THAT OSC #2 EXHIBITED A RAPID NEGATIVE FREQUENCY CHANGE WHICH RESULTED IN THE GPC'S FAULTING DOWN TO INTERNAL TIMING. OSC #1 WAS AUTOMATICALLY SELECTED AND NORMAL OPERATION WAS RESTORED IN ABOUT 3 SECONDS. OSC #2 WAS LATER SELECTED, BUT THE PROBLEM DID NOT REPEAT. THIS FAILURE OCCURED WHEN MTU S/N 6 WAS STILL IN A STATE OF "WARM-UP". OSCILLATOR S/N 622 WAS REMOVED FROM THE MTU, AND AFTER EXTENSIVE TESTING THE SUPPLIER COULD NOT DUPLICATE THE ANOMALY. THE OSCILLATOR WAS REINSTALLED IN MTU S/N 6. THE MTU WAS THEN FULLY RE-ATP'D AND INSTALLED IN SAIL FOR TWO MONTHS OF CONTINUOUS OBSERVATION. AFTER COMPLETING THE ABOVE WITH NO PROBLEMS, MTU S/N 6 WAS RETURNED TO THE FIELD FOR UNRESTRICTED USAGE.

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(11) CAR# AC8313, SAIL, MTU S/N 3, 6-21-84 - THE MTU GMT TIME OUTPUT B HAD A 40 MILLISECOND(MS) ERROR AT THE 40 MINUTE ROLLOVER TIME DURING JSC/SAIL TESTING. THE MET REMAINED OK. IT WAS FOUND WHEN TESTING REQUIRED THE USE OF ACCUMULATOR B, THE SYSTEM(SOFTWARE) AUTOMATICALLY SWITCHED TO THE THIRD ACCUMULATOR, C. IT WAS THEN DETERMINED THAT AT THE HOUR AND AT THE 40 MINUTE INDICATION, THE GMT OUTPUT JUMPED AHEAD 40 MS, THEN AUTOMATICALLY CORRECTED TO THE ACCURATE TIME. THIS CONDITION WAS NOT FOUND ON EITHER ACCUMULATOR A OR C. THE FAILURE WAS ISOLATED TO U63 ON BOARD AD6(SHIFT REGISTER TYPE 4021A) BY WESTINGHOUSE-BALTIMORE. THE MICROCIRCUIT WAS X-RAYED, OPENED AND INTERNALLY VISUALLY EXAMINED AND NO DEFECT WAS FOUND. EXCESSIVE LEAKAGE CURRENT WAS MEASURED ON THE SERIAL INPUT, HOWEVER, THIS COULD HAVE BEEN CAUSED BY THE DELIDDING PROCESS. THIS PREMATURE DESTRUCTIVE TEST MAY HAVE DESTROYED EVIDENCE IN DETERMINING THE MINUTE COMPONENT MALFUNCTION. THE ACCUMULATOR BOARD RETEST CLEARLY INDICATES THAT U63 WAS THE ONLY PROBABLE CAUSE FOR FAILURE. U63 IS NOT AVAILABLE FOR ANY ADDITIONAL TESTING. FAILURE RATE OF DEVICE IS BELOW FAILURE RATE PREDICTION. NO GENERIC TREND IS INDICATED. NO FURTHER ACTION IS CONTEMPLATED AT THIS TIME. SUPPLIER DID NOT UNDERSTAND RA10 REQUIREMENTS FOR DEVICE RETENTION AND DETAILED FAILURE ANALYSIS. NEW DESIGN WOULD USE A 4021B(M38510)/05754) WHERE THE DEVICE IS TESTED FOR LEAKAGES AT A HIGHER VOLTAGE. THE MOST LIKELY CAUSE OF FAILURE IS AN EXTERNALLY APPLIED ELECTRICAL OVERSTRESS ON INPUT PIN 1.

(12) CAR# AC9356, SUPPLIER, MTU S/N 5, 9-25-84 - DURING ATP, THE DEMAND CHANNEL BECAME INTERMITTENT. PROBLEM WAS ISOLATED TO U96 ON CARD A10 (ACCUMULATOR, P/N 641R237). CURVE TRACER TEST OF U96 INDICATED HIGH LEAKAGE CURRENT BETWEEN PINS 1 & 15. ONE FAILURE OF THE SAME TYPE AND PART WAS PREVIOUSLY NOTED ON CAR# AC8313 (U63 ON CARD A06). SEM ANALYSIS OF U63 FAILED TO REVEAL THE CAUSE OF FAILURE. U96 WAS NOT EXPOSED TO SEM ANALYSIS BECAUSE THE SUPPLIER INADVERTENTLY DISCARDED IT AFTER THE CURVE TRACER TEST. PACO RECORDS INDICATED TWO OTHER FAILURES OF THE I.C., BUT NEITHER HAD A SIMILAR/ OR SAME FAILURE MODE. NO TREND OR GENERIC PROBLEM IS INDICATED AND NO FURTHER ACTION WAS TAKEN. THE MOST PROBABLE CAUSE WAS ATTRIBUTED TO AN EXTERNALLY APPLIED ELECTRICAL OVERSTRESS AT PIN 1. U96 IDENTIFICATION IS: M358510/05704BFA.

(E) OPERATIONAL USE

FOR GROUND DETECTED ERRONEOUS OUTPUT ON ORBIT THERE IS A PRE FLIGHT APPROVED AND VERIFIED G-MEM PROCEDURE TO RECOVER PROPER BPS TIME.