

## FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 02-4H-R100-X

SUBSYSTEM NAME: KU-BAND DEPLOY MECHANISM

REVISION : 2 12/17/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU : ■	ACTUATOR, KU-BAND DEPLOY BALL AEROSPACE	MC287-0026-0003
■ LRU : ■	ACTUATOR, KU-BAND DEPLOY ROCKWELL	V740-544110-002

## PART DATA

## ■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

## ■ QUANTITY OF LIKE ITEMS: 1

## ■ FUNCTION:

REDUNDANT MOTORS IN THE ACTUATOR DRIVE THROUGH A DIFFERENTIAL AND GEARBOX TO DRIVE THE KU-BAND ANTENNA DEPLOYMENT MECHANISM. THERE ARE NO TORQUE LIMITERS IN THE KU-BAND DRIVE TRAIN. THE TWO MOTORS INCORPORATE INTEGRAL BRAKE MECHANISMS AND ARE CONTROLLED BY POSITION SWITCHES LOCATED WITHIN THE DEPLOYMENT MECHANISM. TWO OF THREE AC PHASES WILL RELEASE THE BRAKE AND DRIVE THE MOTOR. THE BRAKE PREVENTS BACKDRIVING IN THE EVENT OF ASSOCIATED MOTOR FAILURE.

NOTE: THE V740-544110-002 ACTUATOR MANUFACTURED AND QUALIFICATION TESTED BY ROCKWELL IS A SIMILAR DESIGN AND IS INTERCHANGEABLE WITH THE MC287-0026-0003 ACTUATOR MANUFACTURED AND QUALIFICATION TESTED BY BALL AEROSPACE.

PAGE: 6

PRINT DATE: 12/17/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
 NUMBER: 02-4H-R100-02

SUBSYSTEM: KU-BAND DEPLOY MECHANISM  
 LRU :ACTUATOR, KU-BAND DEPLOY  
 ITEM NAME: ACTUATOR, KU-BAND DEPLOY

REVISION# 2 12/17/91 R

CRITICALITY OF THIS  
 FAILURE MODE:1R2

- FAILURE MODE:  
GEARBOX FAILS FREE

MISSION PHASE:  
 00 ON-ORBIT

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

CAUSE:  
 EXCESSIVE LOAD, FAILURE/DEFLECTION OF INTERNAL PART, FATIGUE, VIBRATION

- CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS  
 B) PASS  
 C) PASS

PASS/FAIL RATIONALE:

- A)  
FUNCTIONAL OPERATION CAN BE VERIFIED DURING GROUND TURNAROUND.
- B)  
DEPLOY/STOW POSITIONS ARE VISUALLY DETECTABLE ON ORBIT.
- C)  
JETTISON IS UNLIKE REDUNDANCY FOR STOW FUNCTION.

- FAILURE EFFECTS -

(A) SUBSYSTEM:  
 FAILURE WILL RESULT IN A LOSS OF ABILITY TO DRIVE THE KU-BAND STOWED OR DEPLOYED.

(B) INTERFACING SUBSYSTEM(S):  
 FAILURE WILL CAUSE CONTINUOUS MOTOR RUN AND RESULT IN AN INABILITY TO EITHER USE KU-BAND SYSTEM OR CLOSE PAYLOAD BAY DOOR. PROCEDURALLY,

FAILURE MODES EFFECTS ANALYSIS (FMEA) — CRITICAL FAILURE MODE  
NUMBER: 02-4H-R100-02

DRIVE COMMAND WILL BE REMOVED BEFORE MOTOR BURNOUT CAN OCCUR.

(C) MISSION:

FAILURE WILL RESULT IN A POSSIBLE LOSS OF MISSION DUE TO INABILITY TO USE KU-BAND SYSTEM.

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

FAILURE WILL REQUIRE JETTISON OF KU-BAND TO ALLOW PAYLOAD BAY DOOR CLOSURE. LOSS OF ALL REDUNDANCY RESULTS IN POSSIBLE LOSS OF CREW/VEHICLE DUE TO AN INABILITY TO CLOSE PAYLOAD BAY DOORS.

(E) FUNCTIONAL CRITICALITY EFFECTS:

-----  
- DISPOSITION RATIONALE -  
-----

(A) DESIGN:

THE GEARBOX IS DESIGNED FOR MAXIMUM STIFFNESS AND INCORPORATES HIGH STRENGTH ALLOYS SUCH AS CUSTOM 455, MP35N, AND A-286 CRES. ULTIMATE FACTOR OF SAFETY 1.4 MINIMUM.

● (B) TEST:

ACCEPTANCE TESTS: THE FOLLOWING TESTS ARE PERFORMED FOR ALL FLIGHT ARTICLES AND ARE PERFORMED FOR EACH QUALIFICATION TEST ARTICLE.  
VIBRATION - RANGE 20 TO 2,000 HZ MAXIMUM LEVEL OF 0.04 g<sup>2</sup>/HZ FROM 80 TO 350 HZ ALL AXES. THERMAL - STABILIZED RANGE FROM -100 DEG F TO +300 DEG F. FUNCTIONAL TESTS CONDUCTED AT -100 DEG F, +70 DEG F AND +160 DEG F.  
LOADS/TORQUE - VERIFY ROTATIONAL POSITION IS MAINTAINED AT 10,000 INCH-LB MINIMUM, IN EITHER DIRECTION. ELECTRICAL-VERIFY (WITHIN DESIGN LIMITS) CONTINUITY, DIELECTRIC STRENGTH, INSULATION RESISTANCE, AND POWER CONSUMPTION.

QUALIFICATION TESTS: THE FOLLOWING IS A SUMMARY OF TESTS CONDUCTED ON THE MC287-0026-0003 ACTUATOR PER CR 44-287-0026-0002 TO INCLUDE BOTH NATURAL AND INDUCED ENVIRONMENTAL EFFECTS TO THE GEARBOX ASSEMBLY. FUNCTIONAL TESTS WERE CONDUCTED DURING AND FOLLOWING EACH PHASE OF TESTING TO DETERMINE EFFECTS. ENVIRONMENTS AND REQUIREMENTS ACCEPTED BY ANALYSIS INCLUDE FUNGUS, OZONE, SALT SPRAY, ACCELERATION, SOLAR RADIATION (THERMAL AND NUCLEAR), METEORIDS, SAND AND DUST, STORAGE, FACTOR OF SAFETY, RELIABILITY, MAINTAINABILITY, MATERIALS AND PROCESSES, ELECTRICAL DESIGN AND SAFETY. VIBRATION - QUALIFICATION ACCEPTANCE VIBRATION TEST (QAVT) RANGE OF 20 TO 2,000 HZ WITH MAXIMUM LEVEL OF 0.067 g<sup>2</sup>/HZ AT 80 TO 350 HZ ALL AXES. FLIGHT VIBRATION LEVEL-20 TO 2,000 HZ WITH MAXIMUM LEVEL OF 0.017 g<sup>2</sup>/HZ AT 100 TO 250 HZ ALL AXES. SHOCK - BENCH HANDLING PER MIL-STD-810C, METHOD 516.2, PROCEDURE V. THERMAL - STABILIZED RANGE FROM -100 DEG F TO +300 DEG F. FUNCTIONAL TESTS CONDUCTED AT -100 DEG F, +70 DEG F, AND +160 DEG F.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
NUMBER: 02-4H-R100-02**

THERMAL VACUUM AT 10 -6 TORR, HUMIDITY, EXPLOSIVE ATMOSPHERE PER MIL-STD-810C, METHOD 511.1, PROCEDURE I. LOAD TESTS COMBINED AXIS LOADING TO 100% LIMIT LOAD. LIFE CYCLE TESTS 1,750 CYCLES IN ADDITION TO CYCLES CONDUCTED DURING VARIOUS QUALIFICATION TESTING AT VARIOUS LOAD AND MOTOR CONDITIONS. STALL/MAXIMUM TORQUE-25,000 INCH-LB OR LESS AT -100 DEG F AND +160 DEG F.

NOTE: QUALIFICATION TESTS TO BE CONDUCTED ON THE V740-544110-002 ACTUATOR PER CR44-544110-002 INCLUDE ALL OF THE PRECEDING TESTS EXCEPT THAT THE FOLLOWING ENVIRONMENTS WILL BE CERTIFIED BY ANALYSIS OR SIMILARITY: HUMIDITY, EXPLOSIVE ATMOSPHERE, THERMAL VACUUM, LOAD TEST - COMBINED AXIS LOADING TO 100% LIMIT LOAD. A TOTAL OF 1461 OPERATIONAL CYCLES WILL BE PERFORMED.

OMRSD: DEPLOY MOTORS' PERFORMANCE IS VERIFIED DURING NORMAL IN-FLIGHT OPERATIONS. GROUND TESTING WOULD BE ACCOMPLISHED WHEN A VALID VERIFICATION IS UNOBTAINABLE DURING FLIGHT, OR FOLLOWING LRU REPLACEMENT. ALSO, SINGLE MOTOR OPERATION IS VERIFIED EVERY FLOW: DEPLOY MOTOR 1/STOW MOTOR 2 IS VERIFIED ON ODD FLOWS; AND DEPLOY MOTOR 2/STOW MOTOR 1 IS VERIFIED ON EVEN FLOWS.

**■ (C) INSPECTION:****RECEIVING INSPECTION**

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. HEAT LOT STRENGTH OF TEST COUPONS IS VERIFIED BY INSPECTION.

**CONTAMINATION CONTROL**

INSPECTION VERIFIES ASSEMBLY IN CLASS 100 FLOW BENCH OR CLASS 10,000 (OR BETTER) CLEAN AREA. INSPECTION VERIFIES CLEANLINESS PER DRAWING AND SPECIFICATION REQUIREMENTS.

**ASSEMBLY/INSTALLATION**

CRITICAL DIMENSIONS ARE VERIFIED BY INSPECTION. SURFACE ROUGHNESS OF GEAR TEETH IS VERIFIED BY INSPECTION. LUBRICATION PER REQUIREMENTS IS VERIFIED BY INSPECTION. TOTAL COMPOSITE TOLERANCE (TCT) AND TOOTH-TO-TOOTH COMPOSITE TOLERANCE (TTCT) ARE VERIFIED BY INSPECTION.

**CRITICAL PROCESSES**

HEAT TREATING IS VERIFIED BY INSPECTION. HARDNESS TESTING OF GEARS IS VERIFIED BY INSPECTION. PASSIVATION IS VERIFIED BY INSPECTION.

**NONDESTRUCTIVE EVALUATION**

MAGNETIC PARTICLE INSPECTION OF GEARS AND GEARBOX HOUSING IS VERIFIED.

**TESTING**

ATP IS VERIFIED PER PROCEDURE.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
NUMBER: 02-4H-R100-02

HANDLING/PACKAGING

HANDLING AND PACKAGING PER DRAWING AND SPECIFICATION REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

■ (E) OPERATIONAL USE:

FAILURE WILL REQUIRE JETTISON OF KU-BAND ANTENNA TO ALLOW PAYLOAD BAY DOOR CLOSURE AND PREVENT LOSS OF CREW/VEHICLE DURING ENTRY.

- APPROVALS -

RELIABILITY ENGINEERING: O. M. MAYNE  
DESIGN ENGINEERING : S. L. SHARP  
QUALITY MANAGER : O. J. BUTTNER  
NASA RELIABILITY :  
NASA SUBSYSTEM MANAGER :  
NASA QUALITY ASSURANCE :

: *[Signature]*  
: *[Signature]*  
: *[Signature]*  
: *[Signature]* 2/19/92  
: *[Signature]* 2/19/92  
: *[Signature]* 1/27/92