INDEPENDENT ORBITER ASSESSMENT

ANALYSIS
OF THE
PYROTECHNICS
SUBSYSTEM

19 JANUARY 1988

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

WORKING PAPER NO. 1.0-WP-VA88005-01

INDEPENDENT ORBITER ASSESSMENT ANALYSIS OF THE PYROTECHNICS SUBSYSTEM

01 JANUARY 1988

This Working Paper is Submitted to NASA under
Task Order No. VA88005, Contract NAS 9-17650

PREPARED BY: W.W. Robinson
Lead Analyst
Independent Orbiter
Assessment

APPROVED BY: A.J. Marino
Section Manager-FMEA/CIL
Independent Orbiter
Assessment

APPROVED BY: G.W. Knori
G.W. Knori
Technical Manager
Independent Orbiter
Assessment

APPROVED BY: J.I. McPherson
J.I. McPherson
Project Manager
STSEOS

CONTENTS

List of Figures

List of Tables

Independent Orbiter Assessment
Analysis of the Pyrotechnics Subsystems

1.0 EXECUTIVE SUMMARY

The McDonnell Douglas Astronautics Company (MDAC) was selected in June 1986 to perform an Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL). Direction was given by the STS Orbiter and GFE Projects Office to perform the hardware analysis using the instructions and ground rules defined in NSTS 22206, Instructions for Preparation of FMEA and CIL, 10 October 1986. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents (Appendix C) the independent analysis results corresponding to the Orbiter Pyrotechnics hardware.

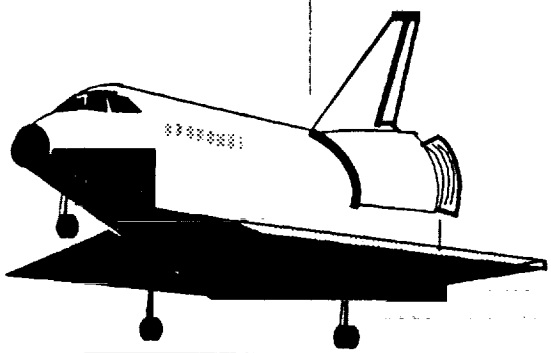
The IOA analysis process utilized available Pyrotechnics hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

Figure 1 presents a summary of the failure criticalities for each of the 5 major subdivisions of Pyrotechnics. A summary of the number of failure modes, by criticality, is also presented below with Hardware (HW) criticality first and Functional (F) criticality second.

Summary of IOA Failure Modes By Criticality (HW/F)

Criticality :	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Number :	27	11	3	0	0	0	41

PYROTECHNICS ANALYSIS SUMMARY		
CRIT	#FM	#PCI
1/1	27	27
2/1R	11	11
2/2	3	3
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	41	41



LANDING/DECELERATION		
CRIT	#FM	#PCI
1/1	7	7
2/1R	2	2
2/2	0	0
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	9	9

ORBITER/ET SEPARATION		
CRIT	#FM	#PCI
1/1	9	9
2/1R	3	3
2/2	0	0
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	12	12

RENDEZVOUS/RADAR		
CRIT	#FM	#PCI
1/1	4	4
2/1R	2	2
2/2	2	2
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	8	8

CREW STATION & EQUIPMENT		
CRIT	#FM	#PCI
1/1	2	2
2/1R	4	4
2/2	0	0
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	6	6

P/L RETENTION/DEPLOY		
CRIT	#FM	#PCI
1/1	5	5
2/1R	0	0
2/2	1	1
3/1R	0	0
3/2R	0	0
3/3	0	0
TOTAL	6	6

Figure 1 - PYROTECHNICS OVERVIEW ANALYSIS SUMMARY

For each failure mode identified, the criticality and redundancy screens were examined to identify critical items. A summary of Potential Critical Items (PCIs) is presented as follows:

Summary of IOA Potential Critical Items (HW/F)						
Criticality :	1/1	2/1R	2/2	3/1R	3/2R	TOTAL
Number :	27	11	3	0	0	41

2.0 INTRODUCTION

2.1 Purpose

The 51-L Challenger accident prompted the NASA to readdress safety policies, concepts, and rationale being used in the National Space Transportation System (NSTS). The NSTS Office has undertaken the task of reevaluating the FMEA/CIL for the Space Shuttle design. The MDAC is providing an independent assessment of the Orbiter FMEA/CIL reevaluation results for completeness and technical accuracy.

2.2 Scope

The scope of the independent FMEA/CIL assessment activity encompasses those Shuttle Orbiter subsystems and GFE hardware identified in the Space Shuttle Independent FMEA/CIL Assessment Contractor Statement of Work. Each subsystem analysis addresses hardware, functions, internal and external interfaces, and operational requirements for all mission phases.

2.3 Analysis Approach

The independent analysis approach is a top-down analysis utilizing as-built drawings to breakdown the respective subsystem into components and low-level hardware items. Each hardware item is evaluated for failure mode, effects, and criticality. These data are documented in the respective subsystem analysis report, and are used to assess the NASA and Prime Contractor FMEA/CIL reevaluation results. The IOA analysis approach is summarized in the following Steps 1.0 through 3.0. Step 4.0 summarizes the assessment of the NASA and Prime Contractor FMEAs/CILs that is performed and documented at a later date.

Step 1.0 Subsystem Familiarization
- 1.1 Define subsystem functions
- 1.2 Define subsystem components
- 1.3 Define subsystem specific ground rules and assumptions

Step 2.0 Define subsystem analysis diagram
- 2.1 Define subsystem
- 2.2 Define major assemblies
- 2.3 Develop detailed subsystem representations

Step 3.0 Failure events definition
- 3.1 Construct matrix of failure modes
- 3.2 Document IOA analysis results

Step 4.0 Compare IOA analysis data to NASA FMEA/CIL
- 4.1 Resolve differences
- 4.2 Review in-house
- 4.3 Document assessment issues
- 4.4 Forward findings to Project Manager

2.4 Pyrotechnics Ground Rules and Assumptions

The Pyrotechnics ground rules and assumptions used in the IOA are defined in Appendix B.

3.0 SUBSYSTEM DESCRIPTION

3.1 Design and Function

Space Shuttle Orbiter Pyrotechnics are defined as the devices and assemblies operated by solid propellants or explosive devices. The Pyrotechnics addressed in this study are those that are used in the following applications. The Pyrotechnics used as the primary method for separation of the External Tank from the Orbiter. The Pyrotechnics used for assist and backup devices for Landing Gear deployment. The Pyrotechnics employed as emergency devices to guillotine and jettison the Remote Manipulator Arm, guillotine and release the Rendezvous Radar (RR) Antenna, and separate the outer window and open the inner window for ground emergency egress.

1. Landing/Deceleration Systems Pyrotechnics are employed in the Nose Landing Gear (NLG) Uplock Release, Main Landing Gear (MLG) Uplock Release, and the NLG Extension Thruster. Pyrotechnic uplock thrusters serve as backup to the Hydraulic Deployment System for the NLG and the MLG prior to landing and are used only if the primary hydraulic system fails. The pyrotechnic NLG Extension thruster is used to provide mechanical assist to initiate nose gear and nose gear door movement against opposing air loads and are fired every flight whether needed or not.

2. Orbiter/External Tank (ET) Separation Mechanisms employ pyrotechnic devices as the primary method to separate the ET from the Orbiter at one forward (fwd) and two aft attach points and to disconnect the Liquid Hydrogen (LH2) and the Liquid Oxygen (LO2) umbilical plates. The fwd structural attach point is separated by fracture of a single Fwd Attach Shear Bolt. The aft structural attach points are separated by fracture of their respective Aft Attach Frangible Nut. The umbilical plates are separated by fracturing six frangible nuts.

3. Payload Retention and Deploy Jettison Pyrotechnics are used to guillotine the cables and jettison the remote manipulator arm and arm support bracket in the event the normal retraction stowage mechanism fails and the arm interferes with payload bay door closure for safe deorbit.

4. Rendezvous Radar (RR) Antenna Emergency Release Pyrotechnics are provided to release the structural attachment and sever the cable in the event the normal RR Antenna stowage mechanism fails and emergency release RR Antenna is necessary to permit payload bay door closure.

3.1 Design and Function (cont'd)

5. Crew Station and Equipment Ground Emergency Egress Pyrotechnics are employed to break the attach bolts to sever the outer window and to open the inner window. Window severence can be initiated from either the interior of the crew compartment or the exterior right hand side for ground crew use. The system would only be utilized if a failure occurs that requires crew egress and the entry door is jammed.

3.2 Interfaces and Locations

1. The Landing/Deceleration Pyrotechnics interface with the Electrical Power Distribution and Control (EPD&C) Subsystem at the Nasa Standard Initiators (NSIs) via the Pyro Initiator Controllers (PICs) to initiate operation of the pyrotechnic devices. The pyrotechnics interface mechanically with the NLG and MLG Uplock Release Mechanisms to provide backup to the Hydraulic Deployment System and to provide assist to the NLG to initiate Nose Gear/Door movement against opposing air loads.

2. The Orbiter/ET Separation Pyrotechnics interface with the Electrical Power Distribution and Control (EPD&C) Subsystem at the Nasa Standard Initiators (NSIs) via the Pyro Initiator Controllers (PICs) to initiate operation of the pyrotechnic devices to effect Orbiter/ET separation upon command. The pyrotechnics interface at one fwd and two aft attach points that structurally attach the elements and also at the LO2 and LH2 umbilical plates.

3. The RMS Guillotine and Jettision Pyrotechnics interface with the Electrical Power Distribution and Control (EPD&C) Subsystem at the Nasa Standard Initiators (NSIs) via the Pyro Initiator Controllers (PICs) to initiate operation of the pyrotechnic devices to sever the electrical cable and release the manipulator arm and arm support bracket if required. The pyrotechnics interface physically with the RMS at the base and at the three Manipulator Positioning Mechanisms (MPMs).

4. The RR Antenna Guillotine and Release Pyrotechnics interface with the Electrical Power Distribution and Control (EPD&C) Subsystem at the Nasa Standard Initiators (NSIs) via the Pyro Initiator Controllers (PICs) to initiate operation of the pyrotechnic devices to sever the electrical cable and effect non-propulsive emergency release of the RR Antenna. The pyrotechnics interface mechanicallly with the RR Antenna at the antenna structural attach point.

3.2 Interfaces and Locations (cont'd)

5. The Crew Station and Equipment Pyrotechnics interface with a T-handle in the crew compartment and another on the exterior right hand side, either of which can be used to fire a mechanical initiator to blow away the outer panel and open the inner window panel for emergency crew egress. A stowed prybar is provided to force open the inner window if required.

3.3 Hierarchy

Figure 2 illustrates the hierarchy of the Pyrotechnics hardware and the corresponding subcomponents. Figures 3 through 9 comprise the detailed system representation.

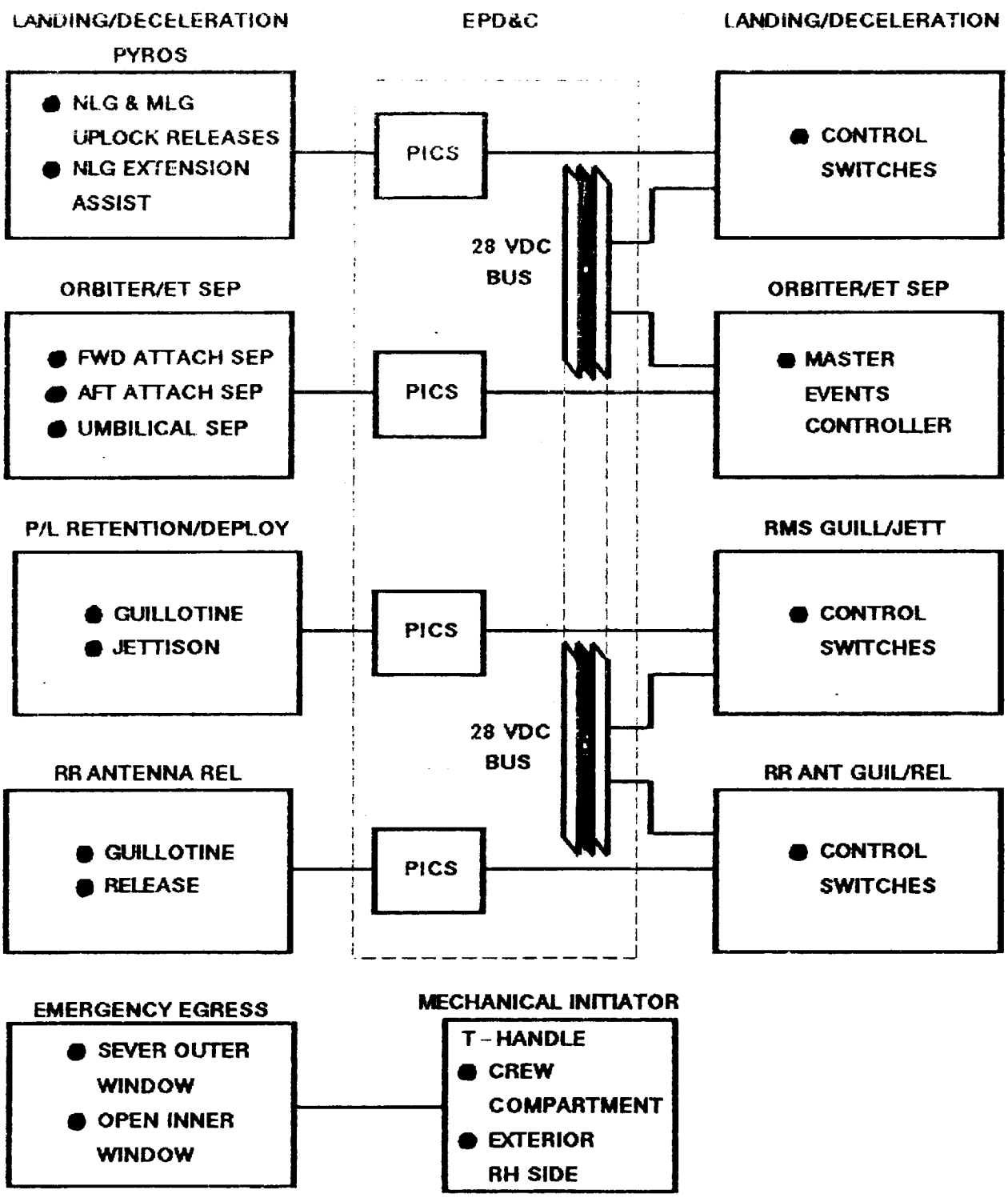


Figure 2 - PYROTECHNIC SUBSYSTEM OVERVIEW

NASA Standard Detonator (NSD)

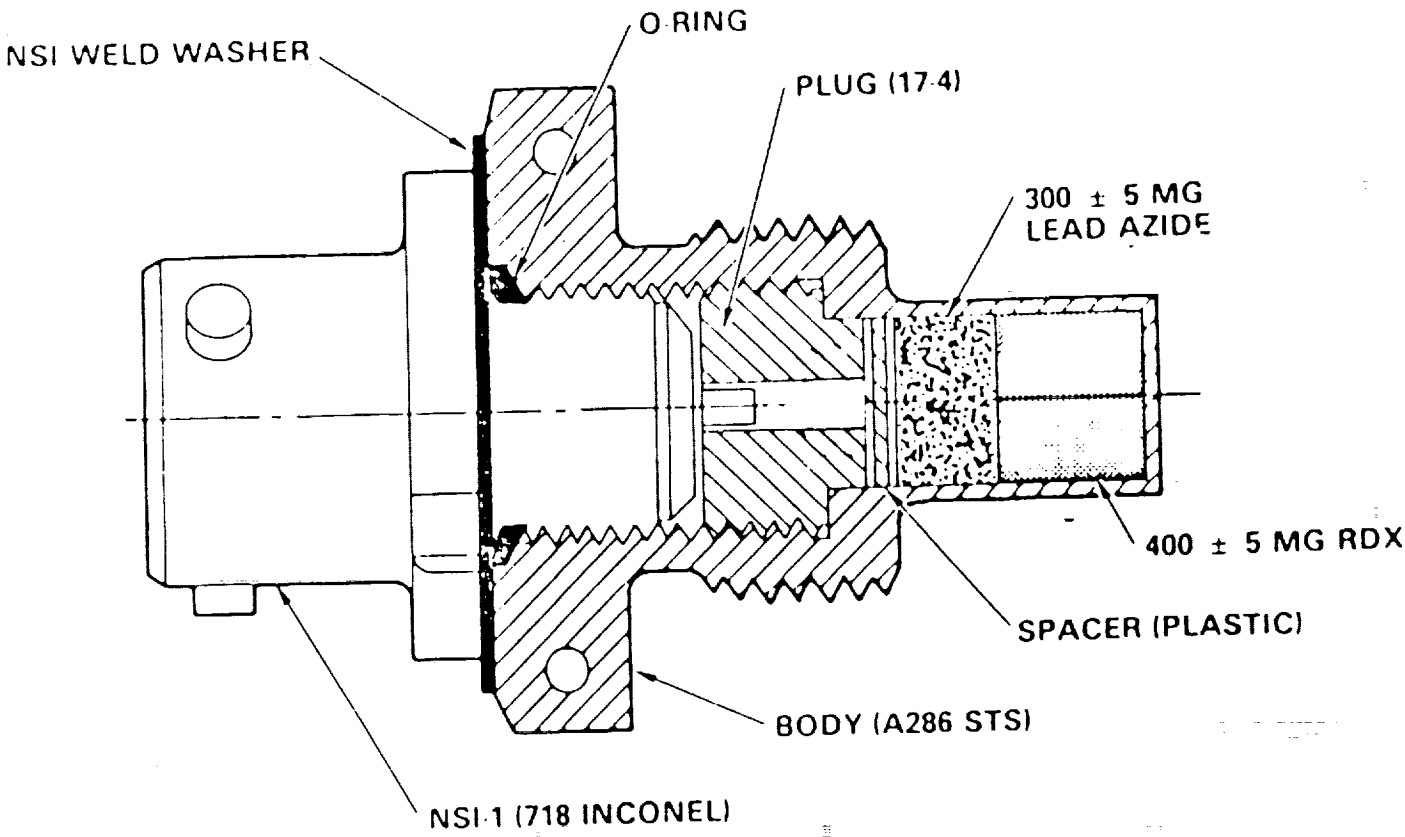


Figure 3 - NASA STANDARD DETONATOR (NSD)

NASA Standard Initiator (NSI)

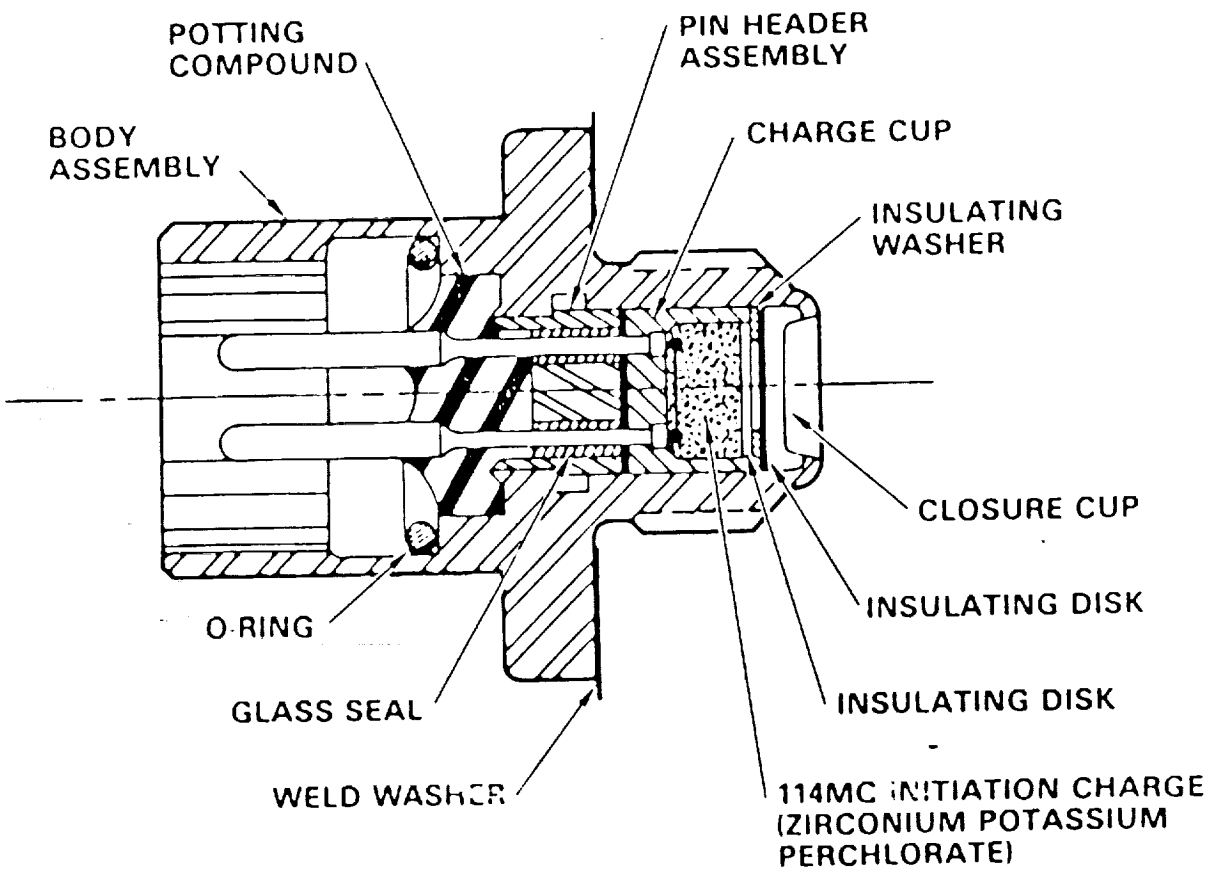


Figure 4 - NASA STANDARD INITIATOR (NSI)

Orbiter/ET Separation

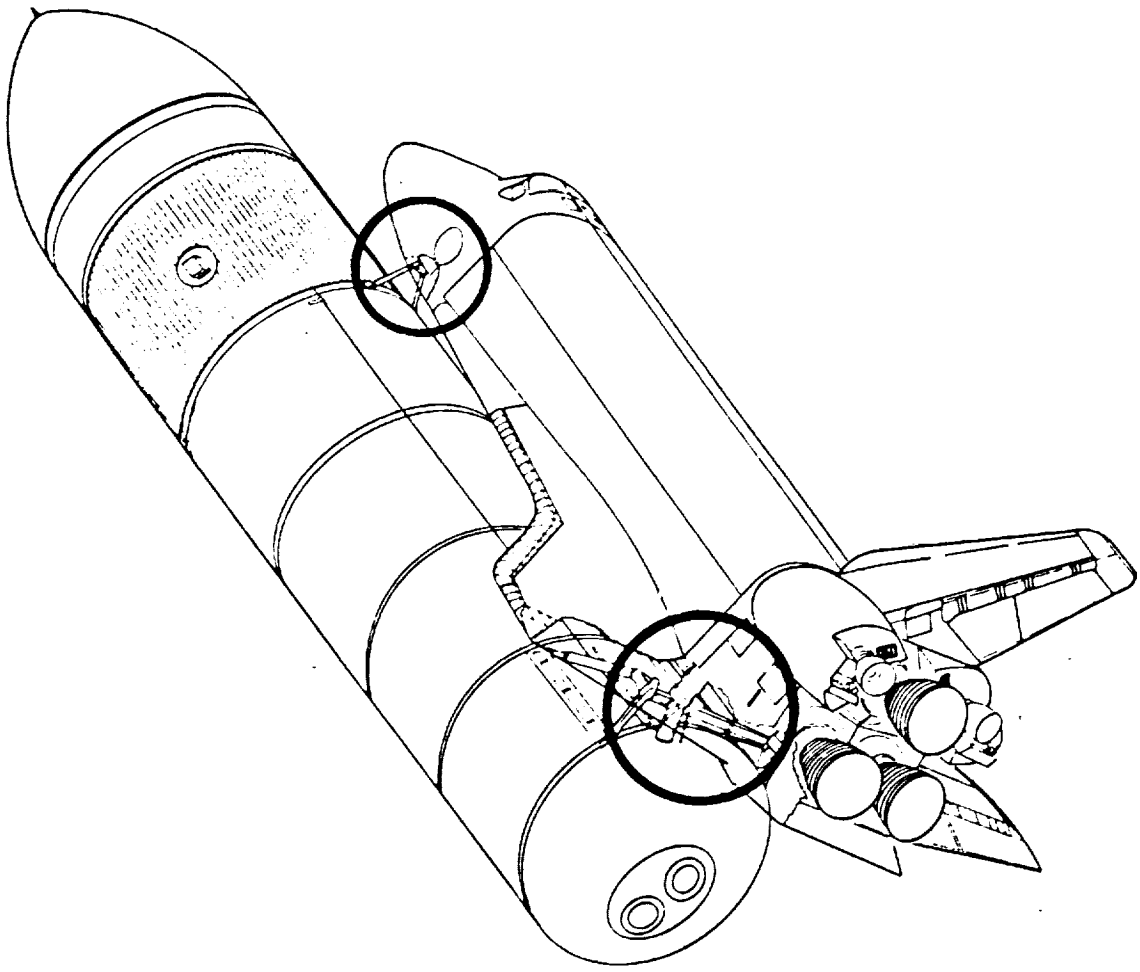


Figure 5 - ORBITER ET SEPARATION

LANDING GEAR CONTROL SYSTEM OVERVIEW

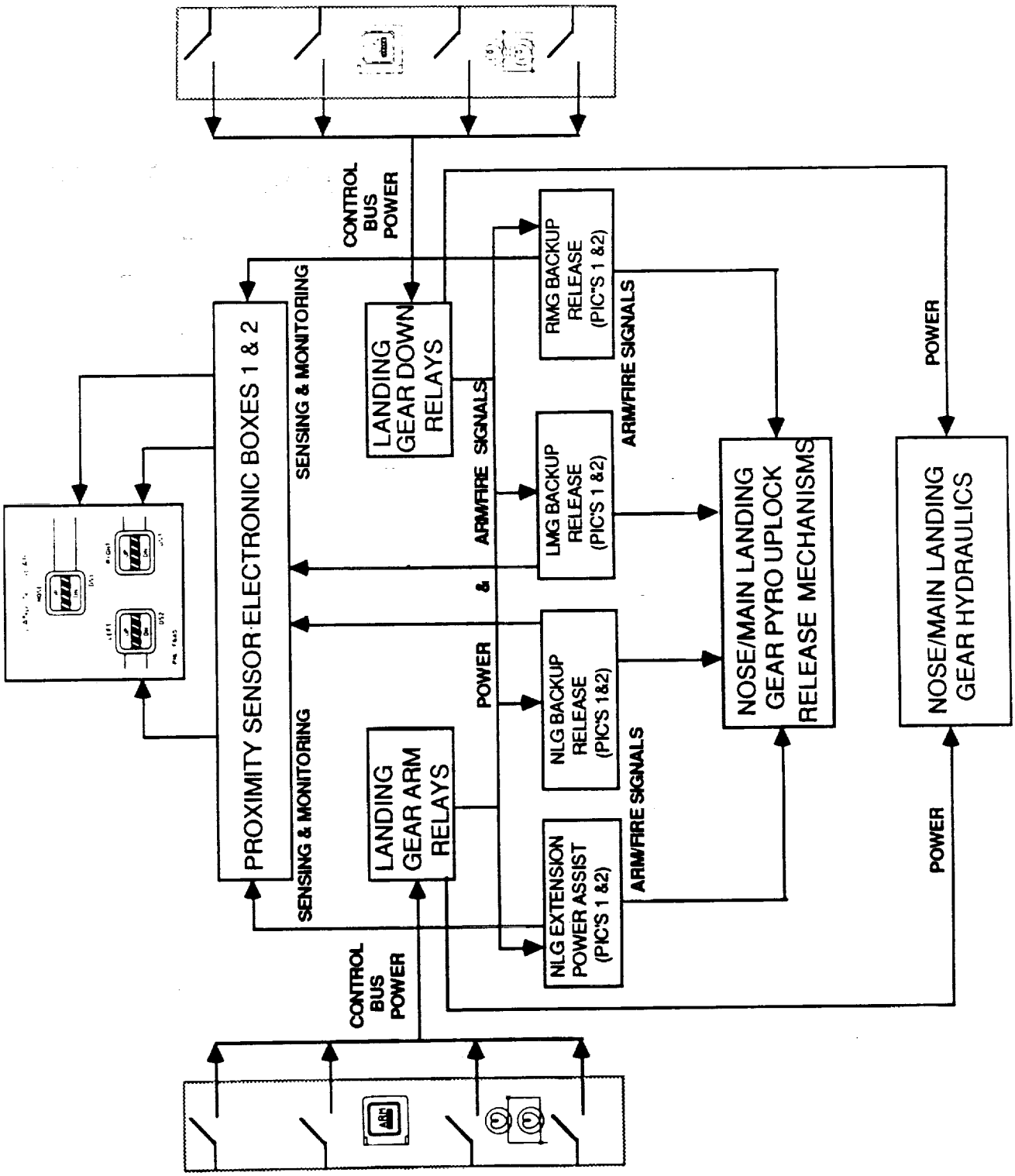


Figure 6 - LANDING GEAR CONTROL SYSTEM OVERVIEW

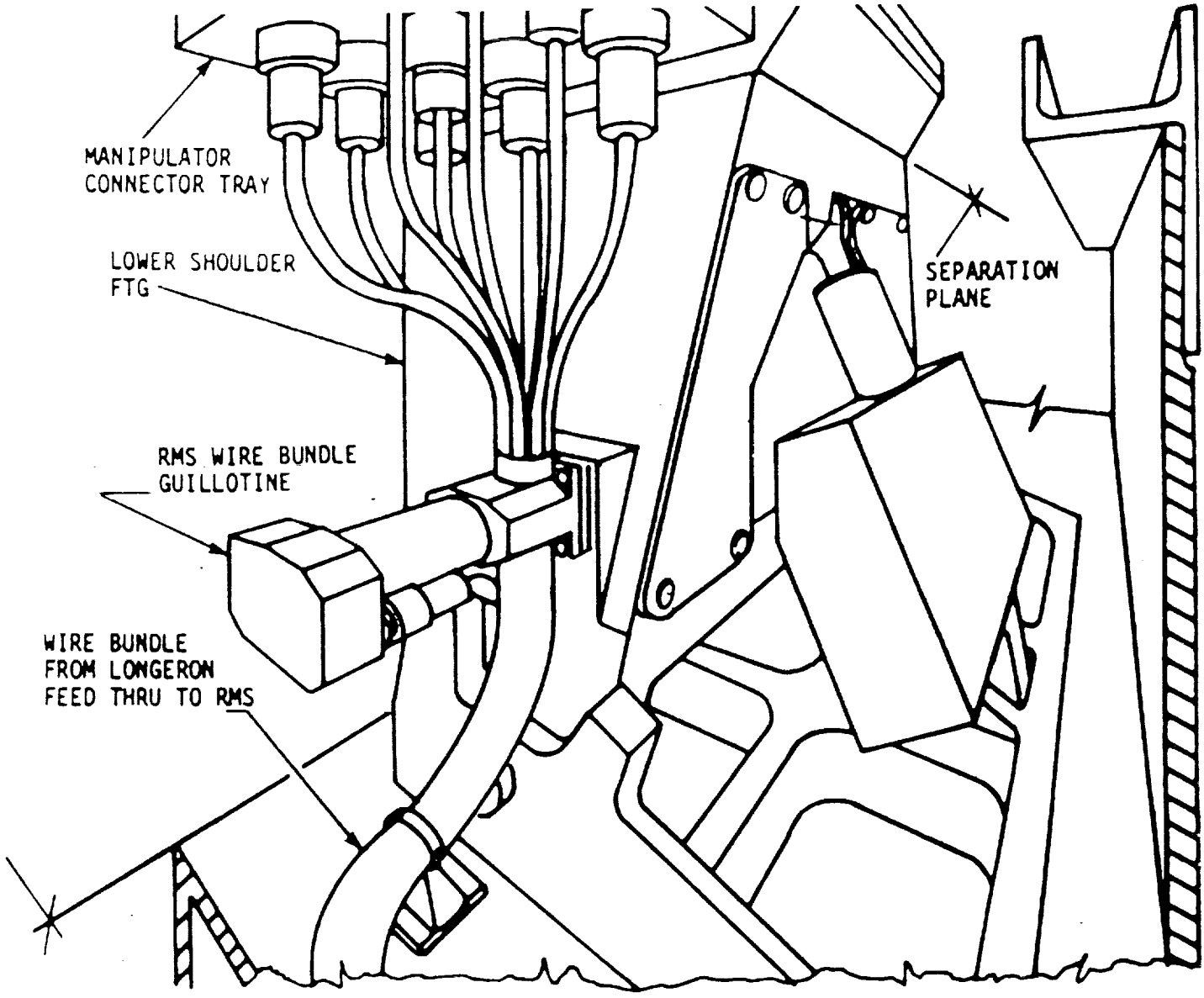


Figure 7 - REMOTE MANIPULATOR SYSTEM (RMS) WIRE BUNDLE GUILLOTINE

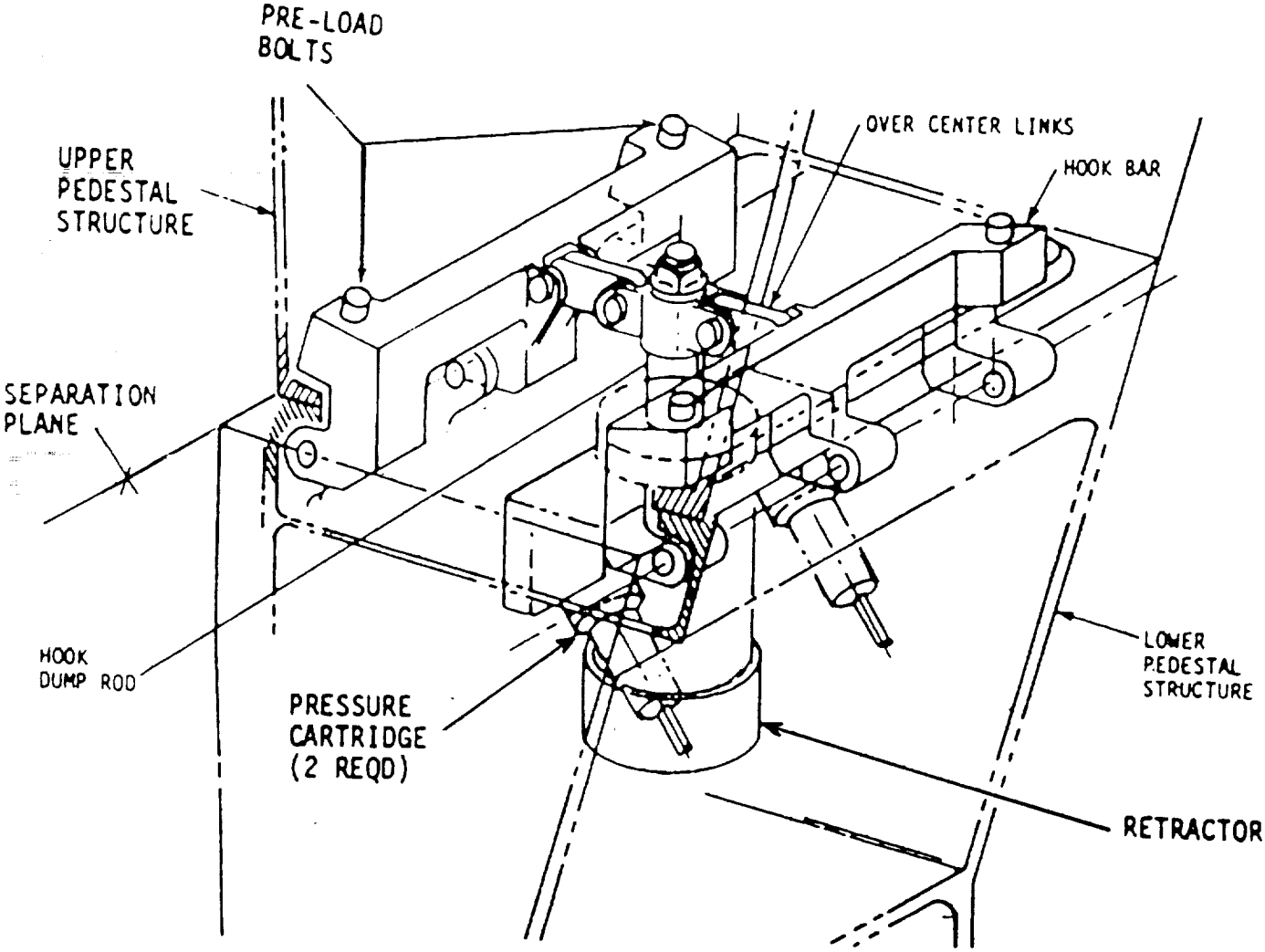


Figure 8 - RMS RETRACTOR

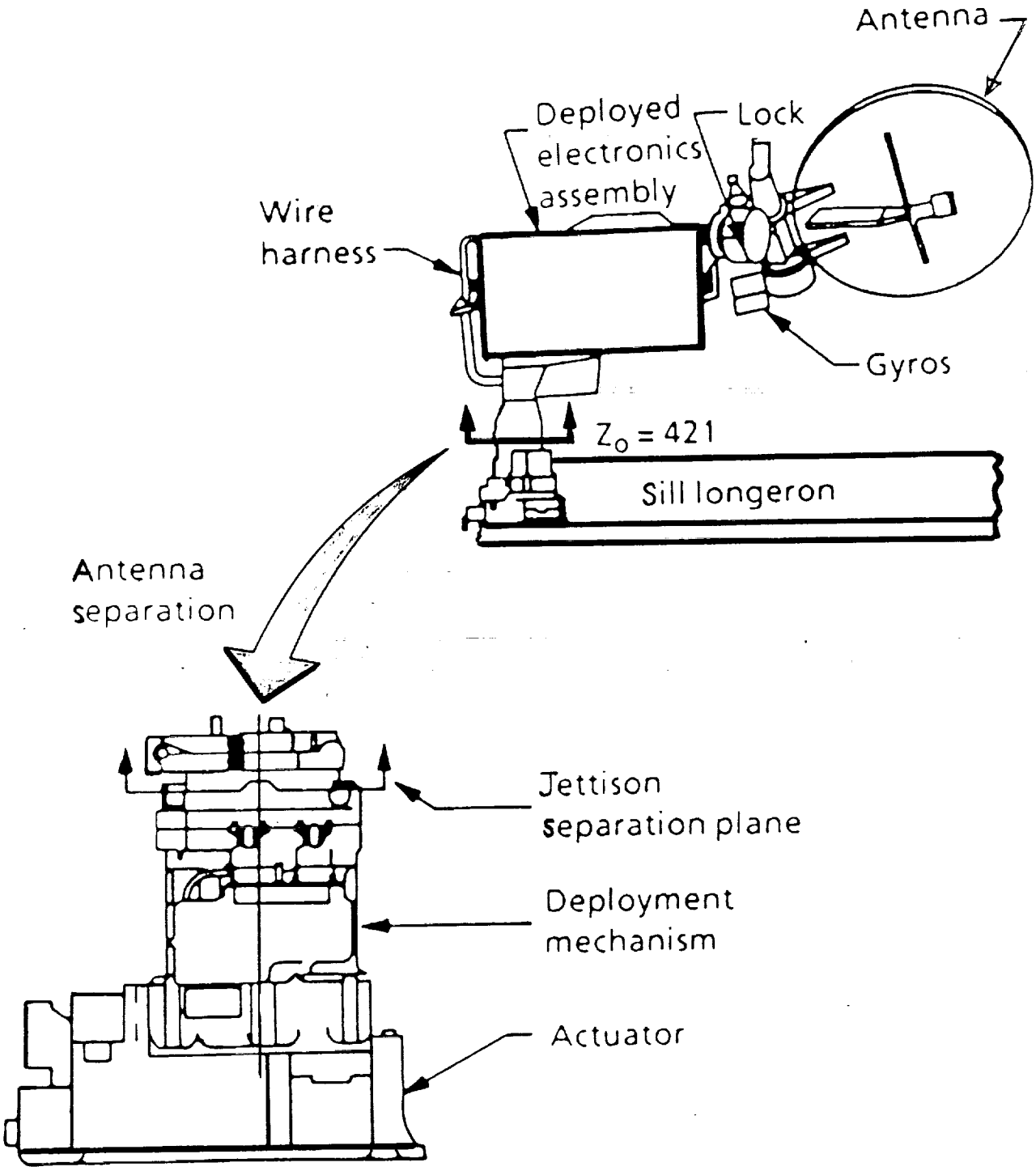


Figure 9 - RENDEZVOUS RADAR ANTENNA SEPARATION

4.0 ANALYSIS RESULTS

Detailed analysis results for each of the identified failure modes are presented in Appendix C. Table I presents a summary of the failure criticalities for each of the five major subdivisions of the Orbiter Pyrotechnics. Further discussion of each of these subdivisions and the applicable failure modes is provided in subsequent paragraphs.

TABLE I Summary of IOA Failure Modes and Criticalities

Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Landing Sys	7	2	0	0	0	0	9
Orb/ET Sep	9	3	0	0	0	0	12
RR Ant Rel	4	2	2	0	0	0	8
P/L Retn/Depl	5	0	1	0	0	0	6
Crew Sta Eq	2	4	0	0	0	0	6
TOTAL	27	11	3	0	0	0	41

Of the 41 failure modes analyzed, 38 failures were determined to result in loss of crew or vehicle, and 3 were determined to result in loss of mission. A summary of the potential critical items is presented in Table II. Appendix D presents a cross reference between each potential critical item (PCI) and a specific worksheet in Appendix C.

TABLE II Summary of IOA Potential Critical Items

Criticality:	1/1	2/1R	2/2	3/1R	3/2R	TOTAL
TOTAL:	27	11	3	0	0	41

4.1 Analysis Results - Landing/Deceleration System Pyrotechnics

The Orbiter Landing/Deceleration System uses pyrotechnics in the Nose Landing Gear for uplock release as backup to the hydraulic system and as assist (every mission whether needed or not) for nose gear extension. Pyrotechnics are used in the Main Landing Gear for uplock release as backup to the hydraulic system. The backup functions are initiated one second after the down Push Button Indicator (PBI) is activated if the hydraulic system has failed to lower the landing gear. There are nine (9) pyrotechnic failure modes identified for this system. Of these, seven (7) are Criticality 1/1 and two (2) are Criticality 2/1R.

4.2 Analysis Results - Orbiter/ET Separation Mechanisms Pyrotechnics

The Orbiter/ET Separation Mechanisms employs Pyrotechnics as the prime method of separation of the two elements. The Orbiter is separated at the fwd attach point by a pyrotechnic separation bolt that includes a single piston and dual pressure cartridges that are fired to shear the attach bolt. The two aft attach points are separated by fracture of its respective single frangible nut. Each frangible nut has two booster cartridges and two detonator cartridges either of which is adequate to fracture the nut. The two umbilical plates are each disconnected by means of three frangible nuts with each nut having two detonator cartridges. There are twelve (12) pyrotechnic failure modes identified for this system. Of these, nine (9) are Criticality 1/1 and three (3) are Criticality 2/1R.

4.3 Analysis Results - Rendezvous Radar (RR) Antenna Release Pyrotechnics

The Rendezvous Radar Antenna can be jettisoned to permit payload bay door closure if the normal stowage mechanism fails. The pyrotechnic sustem releases the structural attachment and severs the umbilical. The guillotine and release nut each have dual pressure cartridges such that successful firing of one of the cartridges is adequate to cause the device to function. There are eight (8) pyrotechnic failure modes identified for this system. Of these, four (4) are Criticality 1/1; two (2) are Criticality 2/1R; and two (2) are Criticality 2/2.

4.4 Analysis Results - Payload Retention and Deploy Jettison Pyrotechnics

The Remote Manipulator System (RMS) Pyrotechnics are emergency separation devices that consist of four separate subsystems that release the Remote Manipulator Arm and the three Manipulator Positioning/Retention Mechanisms (MPMs). The guillotine with the dual pressure cartridges and one of the retractors is located on the sill longeron, at the base of the RMS. Their purpose is to sever the RMS electrical wire bundle and release the RMS mechanically. The remaining three guillotine devices and retractors are mounted on the three MPMs. Their purpose is to sever the control cable to the Manipulator Retention Latch (MRL) and to mechanically release the MPM at the designated separation plane to allow closure of the Payload Bay Doors (PLBDs). There are six (6) pyrotechnic FMEAs indentified for this system. Of these, five are criticality 1/1 and one (1) is criticality 2/2.

4.5 Analysis Results - Crew Station Emergency Egress System Pyrotechnics

Crew Station and Equipment Emergency Egress System Pyrotechnics are employed to break the attach bolts to sever the outer window and to open the inner window. Window severence can be initiated from either the interior of the crew compartment or the exterior right hand side for ground crew use. The system would only be utilized if a failure occurs that requires crew egress and the entry door is jammed. There are six pyrotechnic FMEAs identified for this system. Of these, two (2) are criticality 1/1 and four (4) are criticality 2/1R.

5.0 REFERENCES

Reference documentation available from NASA and Rockwell International Space Division was used in the analysis. The documentation used in the analysis includes the following:

1. NSTS 22206, Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL), Oct 10, 1986

2. JSC-08934, Shuttle Operational Data Book, Systems Performance and Constraints Data, Rev D, Oct 1984

3. JSC-11174, Space Shuttle Systems Handbook, Rev C, DCN-5, Sep 13, 1985

4. MC114-0018, Rockwell Procurement Specification, Nut, Frangible, Rev C-05, Mar 20, 1980

5. MC325-0004, Rockwell Procurement Specification, Energy Transfer System, Pyrotechnic, Crew Escape, Rev D-13, Jun 13, 1982

6. MC325-0005, Rockwell Procurement Specification, Initiator Assembly, Pyrotechnic, Panel Jettison, Energy Transfer System, Rev B-07, Mar 12, 1982

7. MC325-0006, Rockwell Procurement Specification, Thruster Assembly, Pyrotechnic, Emergency Nose Gear Uplock Release, Rev B-01, Jan 2, 1977

8. MC325-0007, Rockwell Procurement Specification, Pressure Cartridge, Electrically Initiated, Oct 30, 1974

9. MC325-0014, Rockwell Procurement Specification, Separation Bolt, Pyrotechnic, Mechanically Redundant, Rev D-02, Jul 29, 1983

10. MC325-0017, Rockwell Procurement Specification, Booster Cartridge Assembly, Frangible Device, Rev A-04, Oct 31, 1978

11. MC325-0018, Rockwell Procurement Specification, Nut, Frangible, Rev C-05, Mar 20, 1980

12. MC325-0019, Rockwell Procurement Specification, Thruster Assembly, Main Landing Gear Uplock Release, Aug 3, 1976

13. MC325-0021, Rockwell Procurement Specification, Manipulator Arm Release, Rev A-04, Jan 3, 1979

5.0 REFERENCES cont'd

14. MC325-0022, Rockwell Procurement Specification, Guillotine Assembly, Pyrotechnic, Remote Manipulator System Umbilical Separation, Rev A-04, Jan 18, 1982

15. MC325-0024, Rockwell Procurement Specification, Guillotine Assembly, Pyrotechnic, Ku-Band Radar/ Communications Umbilical Separation, Rev A-03, Feb 22, 1979

16. MC325-0025, Rockwell Procurement Specification, Release Nut, Segmented, Rendezvous Radar/Ku-Band Communication Antenna Retention and Separation, Rev A-03, Feb 22, 1980

17. MC353-0021, Rockwell Procurement Specification, Cartridge Assembly, Detonator, Hotwire, Electrically Initiated, Rev S-02, Sep 9, 1977

18. VO70-510550, Rockwell Drawing, Uplock Assembly - Nose Landing Gear, Rev B-10, Nov 7, 1985

19. VO70-552001, Rockwell Drawing, Cartridge Installation - Nose Landing Gear Thruster, Rev B-06, Nov 8, 1982

20. VO70-552002, Rockwell Drawing, Thruster, Nose Landing Gear Emergency Uplock Release, Rev A-05, Nov 17, 1980

21. VO70-553301, Rockwell Drawing, Energy Transfer System Installation - Emergency Egress Window, Rev D-03, Dec 2, 1985

22. VO70-553302, Rockwell Drawing, Window Installation - Outer Emergency Egress, Rev A-05, Mar 12, 1983

23. VO70-553303, Rockwell Drawing, Window Installation, CM, Emergency Egress, Rev C-07, Oct 12, 1984

24. VO70-562001, Rockwell Drawing, External Tank / Orbiter, Forward Attach Installation, Rev C-18, Aug 20, 1985

25. VO70-562003, Rockwell Drawing, Attach Assembly - Forward, Orbiter ET Separation System, Rev D-02, Oct 25, 1985

26. VO70-562033, Rockwell Drawing, Ball - Multipiece Bearing, ET / Orbiter Forward Attach, Rev A-05, Aug 27, 1985

27. VO70-562038, Rockwell Drawing, Bolt - Instrumented, Orbiter / ETT Forward Attach, Assembly of, Rev A-02, May 27, 1986

5.0 REFERENCES cont'd

28. VO70-565000, Rockwell Drawing, Installation - ET Umbilical Door Mechanism, Rev F-08, Jun 28, 1984

29. VO70-565212, Rockwell Drawing, Spring, Helical Compression, Orbiter / ET Aft Attach Separation System, Rev A-09, Oct 30, 1981

30. VO70-565217, Rockwell Drawing, Bolt, Frangible Nut, Orbiter / ET Aft Attach Seperation System, Rev A-09, Jun 19, 1975

31. VO70-565330, Rockwell Drawing, Bracket Assembly - Orbiter LO2 Electrical, Umbilical, ET / Orbiter Separation System, Rev D-07, Oct 28, 1982

32. VO70-565371, Rockwell Drawing, Curtain Closeout, ET Umbilical Plate, LH2, Assembly of, Rev C-02, Jun 15, 1986

33. VO70-565381, Rockwell Drawing, Side Strut - Orbiter / External Tank Umbilical Separation System, Assembly of, Rev A-01, May 13, 1976

34. VO70-565382, Rockwell Drawing, Side Strut Installation - Umbilical Separation System, External Tank, Rev A-03, Jan 12, 1983

35. VO70-565396, Rockwell Drawing, Curtain Closeout, ET Umbilical Plate, LO2, Assembly of, Rev C-03, Jun 13, 1986

36. VO70-585227, Rockwell Drawing, Clamp Set - Support, Two Lines, Rev 7, Nov 7, 1975

37. VO72-555215, Rockwell Drawing, Pyrotechnic and Cover Installation - Orbiter / External Tank, Aft Attach / Separation System Rev D-03, Mar 3, 1987

38. VO72-555369, Rockwell Drawing, Wire Harness Installation - ET / Orbiter, Umbilical Hold Down / Release, Rev E-01, Jan 23, 1983

39. VO72-565201, Rockwell Drawing, Fastener Installation - Orbiter / External Tank, Aft Attach / Separation System, Rev D-05, Feb 27, 1987

40. VO72-565249, Rockwell Drawing, Stopper - Orbiter / External Tank, Aft Attach - Separation System, Rev A-03, May 19, 1982

41. VO72-565370, Rockwell Drawing, Mechanical / Pyrotechnic Installation - ET / Orbiter Umbilical Hold Down / Release, Rev D-10, Aug 7, 1986

5.0 REFERENCES cont'd

42. VO72-565450, Rockwell Drawing, Stud - Orbiter / ET Umbilical Hold Down / Release, Assembly of, Rev A-05, Aug 31, 1981

43. VS27-415267, Rockwell Drawing, Disconnect Assembly - LH2, ET Half, Rev D-03, Mar 18, 1986

44. VS27-415273, Rockwell Drawing, Disconnect Assembly - LO2, ET Half, Rev D-02, Mar 20, 1986

APPENDIX A

ACRONYNS and ABBREVIATIONS

AC - Alternating Current
AOA - Abort Once Around
Ant - Antenna
ATO - Abort To Orbit

BFS - Backup Flight Software

CIL - Critical Items List
Ckt - Circuit
Cont'd - Continued
Cur - Current

Depl - Deploy
DC - Direct Current

EPD&C - Electrical Power Distribution and Control
Eq - Equipment
ET - External Tank

F - Functional
FMC - Forward Motor Controller
FMEA - Failure Mode Effects Analysis
FPC - Forward Power Controller
Func - Functional
Fwd - Forward

Guill - Guillotine

Herm - Hermetically
HW - Hardware
Hz - Hertz (cycles per second)

IOA - Independent Orbiter Analysis

Jett - Jettison

LH2 - Liquid Hydrogen
Lim - Limiting
LO2 - Liquid Oxygen

MDAC - McDonnell Douglas Astronautics Company
MDM - Multiplexer/Demultiplexer
MLG - Main Landing Gear
MPM - Manipulator Positioning Mechanixm
MRL - Manipulator Retention Mechanism

NA - Not applicable
NASA - National Aeronautics and Space Administration
NLG - Nose Landing Gear
NSI - NASA Standard Initiator
NSP - NASA Standard Detonator
NSTS - National Space Transportation System

OAO - Once-Around-Abort
Orb - Orbiter

P - Pass
PASS - Primary Avionics Systems Software
PBM - Payload Bay Mechanical
PCI - Potential Critical Item
PIC - Pyro Initiator Controller
P/L - Payload
PLBD - Payload Bay Door
Pos - Position
Pyro - Pyrotechnic

Rel - Release
Retn - Retention
RMS - Remote Manipulator System
RR - Rendezvous Radar
RTLS - Return-To-Launch-Site

Sep - Separation
Sta - Station
STS - Space Transportation System
Sys - System

TAL - Trans-Atlantic-Landing (Abort Landing)

APPENDIX B

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

APPENDIX B
DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.1 Definitions

Definitions contained in NSTS 22206, Instructions For Preparation of FMEA/CIL, 10 October 1986, were used with the following amplifications and additions.

INTACT ABORT DEFINITIONS:

RTLS - begins at transition to OPS 6 and ends at transition to OPS 9, post-flight

TAL - begins at declaration of the abort and ends at transition to OPS 9, post-flight

AOA - begins at declaration of the abort and ends at transition to OPS 9, post-flight

ATO - begins at declaration of the abort and ends at transition to OPS 9, post-flight

CREDIBLE (CAUSE) - an event that can be predicted or expected in anticipated operational environmental conditions. Excludes an event where multiple failures must first occur to result in environmental extremes

CONTINGENCY CREW PROCEDURES - procedures that are utilized beyond the standard malfunction procedures, pocket checklists, and cue cards

EARLY MISSION TERMINATION - termination of onorbit phase prior to planned end of mission

EFFECTS/RATIONALE - description of the case which generated the highest criticality

HIGHEST CRITICALITY - the highest functional criticality determined in the phase-by-phase analysis

MAJOR MODE (MM) - major sub-mode of software operational sequence (OPS)

MC - Memory Configuration of Primary Avionics Software System (PASS)

MISSION - assigned performance of a specific Orbiter flight with payload/objective accomplishments including orbit phasing and altitude (excludes secondary payloads such as GAS cans, middeck P/L, etc.)

MULTIPLE ORDER FAILURE - describes the failure due to a single cause or event of all units which perform a necessary (critical) function

OFF-NOMINAL CREW PROCEDURES - procedures that are utilized beyond the standard malfunction procedures, pocket checklists, and cue cards

OPS - software operational sequence

PRIMARY MISSION OBJECTIVES - worst case primary mission objectives are equal to mission objectives

PHASE DEFINITIONS:

PRELAUNCH PHASE - begins at launch count-down Orbiter power-up and ends at moding to OPS Major Mode 102 (liftoff)

LIFTOFF MISSION PHASE - begins at SRB ignition (MM 102) and ends at transition out of OPS 1 (Synonymous with ASCENT)

ONORBIT PHASE - begins at transition to OPS 2 or OPS 8 and ends at transition out of OPS 2 or OPS 8

DEORBIT PHASE - begins at transition to OPS Major Mode 301 and ends at first main landing gear touchdown

LANDING/SAFING PHASE - begins at first main gear touchdown and ends with the completion of post-landing safing operations

APPENDIX B
DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.2 IOA Project Level Ground Rules and Assumptions

The philosophy embodied in NSTS 22206, Instructions for Preparation of FMEA/CIL, 10 October 1986, was employed with the following amplifications and additions.

1. The operational flight software is an accurate implementation of the Flight System Software Requirements (FSSRs).

   RATIONALE: Software verification is out-of-scope of this task.

2. After liftoff, any parameter which is monitored by system management (SM) or which drives any part of the Caution and Warning System (C&W) will support passage of Redundancy Screen B for its corresponding hardware item.

   RATIONALE: Analysis of on-board parameter availability and/or the actual monitoring by the crew is beyond the scope of this task.

3. Any data employed with flight software is assumed to be functional for the specific vehicle and specific mission being flown.

   RATIONALE: Mission data verification is out-of-scope of this task.

4. All hardware (including firmware) is manufactured and assembled to the design specifications/drawings.

   RATIONALE: Acceptance and verification testing is designed to detect and identify problems before the item is approved for use.

5. All Flight Data File crew procedures will be assumed performed as written, and will not include human error in their performance.

   RATIONALE: Failures caused by human operational error are out-of-scope of this task.

6. All hardware analyses will, as a minimum, be performed at the level of analysis existent within NASA/Prime Contractor Orbiter FMEA/CILs, and will be permitted to go to greater hardware detail levels but not lesser.

   RATIONALE: Comparison of IOA analysis results with other analyses requires that both analyses be performed to a comparable level of detail.

7. Verification that a telemetry parameter is actually monitored during AOS by ground-based personnel is not required.

   RATIONALE: Analysis of mission-dependent telemetry availability and/or the actual monitoring of applicable data by ground-based personnel is beyond the scope of this task.

8. The determination of criticalities per phase is based on the worst case effect of a failure for the phase being analyzed. The failure can occur in the phase being analyzed or in any previous phase, whichever produces the worst case effects for the phase of interest.

   RATIONALE: Assigning phase criticalities ensures a thorough and complete analysis.

9. Analysis of wire harnesses, cables, and electrical connectors to determine if FMEAs are warranted will not be performed nor FMEAs assessed.

   RATIONALE: Analysis was substantially complete prior to NSTS 22206 ground rule redirection.

10. Analysis of welds or brazed joints that cannot be inspected will not be performed nor FMEAs assessed.

    RATIONALE: Analysis was substantially complete prior to NSTS 22206 ground rule redirection.

11. Emergency system or hardware will include burst discs and will exclude the EMU Secondary Oxygen Pack (SOP), pressure relief valves and the landing gear pyrotechnics.

    RATIONALE: Clarify definition of emergency systems to ensure consistency throughout IOA project.

B.3 Pyrotechnics-Specific Ground Rules and Assumptions

The IOA analysis was performed to the component or assembly level of the Pyrotechnic devices in the Orbiter Landing Systems, Orbiter/ET Separation System, RMS Guillotine and Jettison System, Rendezvous Radar Release System, and the Ground Emergency Egress System. The analysis considered the worst case effects of the hardware or functional failure on the subsystem, mission, and crew and vehicle safety.

1. Component age life was not considered in the analysis.

   RATIONALE: Component age analysis is beyond the scope of this task.

2. Criticality of emergency system failure modes were established on the basis of the effect of the first failure of the emergency system on the crew or vehicle.

   RATIONALE: Regardless of the number of failures that would have to occur before the emergency system would be required, its purpose is to accomplish its intended task without fail under emergency conditions. Emergency systems are not employed unless there is an emergency condition in existence.

3. Criticality of backup system pyrotechnic failures were established with the same approach as emergency systems.

   RATIONALE: The backup pyrotechnics involved in this analysis are employed only (albeit automatically) after failure of the primary system, as in the Landing Gear deployment, therefore all previous failures are discounted in the Criticality assignments.

4. Premature or inadvertent operation of pyrotechnic devices is considered to be the highest criticality.

   RATIONALE: Uncommanded operation by a pyrotechnic device would be catastrophic particularly when involved in separation of Shuttle elements and premature deployment of landing gear. Premature operation of emergency or backup pyrotechnics could likewise cause unpredictable results.

5. Failure modes were limited to failure of the component or assembly to function as intended and inadvertent or premature uncommanded operation.

RATIONALE: Whether the cause of the failure of a pyrotechnic device to function as intended to accomplish an action be a failure to fire, fire with insufficient force, or low pressure output, the result would be essentially the same. Failures of other systems that cause inadvertent operation of the pyrotechnic devices covered in this analysis are not considered a failure of the pyrotechnic device itself. If a switch fails and causes a command to be issued to fire a pyrotechnic device, the failure lies with the switch.

APPENDIX C
DETAILED ANALYSIS

This section contains the IOA analysis worksheets employed during the analysis of the Pyrotechnics subsystem. The information on these worksheets is intentionally similar to the FMEA's written by Rockwell and the NASA. Each of these sheets identifies the item being analyzed, and parent assembly, as well as the function. For each failure mode, the possible causes are outlined, and the assessed hardware and functional criticality for each mission phase is listed, as described in the Rockwell Desk Instructions 100-2G. Finally, effects are entered at the bottom of each sheet, and the worst case criticality is entered at the top.

LEGEND FOR IOA ANALYSIS WORKSHEETS

Hardware Criticalities :

- 1 = Loss of life or vehicle
- 2 = Loss of mission
- 3 = Non loss of life or vehicle or mission

Functional Criticalities :

- 1R = Redundant identical hardware components or redundant functional paths all of which, if failed, could cause loss of life or vehicle.
- 2R = Redundant identical hardware components or redundant functional paths all of which, if failed, could cause loss of mission.

Redundancy Screen A :

- 1 = Is Checked Out PreFlight
- 2 = Is Capable of Check Out PreFlight
- 3 = Not Capable of Check Out PreFlight
- 4 = Do Not Know

Redundancy Screens B and C :

- P = Passed Screen
- F = Failed Screen
- NA = Not Applicable

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87
SUBSYSTEM: PYROTECHNICS
MDAC ID: 4601

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 1/1
ABORT: 1/1

ITEM: THRUSTER ASSY
FAILURE MODE: FAILS TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) MAIN LANDING GEAR
3) PYRO UPLOCK RELEASE THRUSTER
4) THRUSTER ASSY
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	/NA	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0019-0001, SKD26100102-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND ONE MAIN LANDING GEAR DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER SHOULD EFFECT NORMAL OPERATION OF THE RELEASE ASSEMBLY TO EXTEND THE MAIN LANDING GEAR.
REFER ALSO TO IOA FMEA 21102.

REFERENCES: MC325-0019

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4602 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FAILS TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) MAIN LANDING GEAR
3) PYRO UPLOCK RELEASE THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE - DUAL INITIATORS)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	/NA	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0019-0002, SKD26100102-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND ONE MAIN LANDING GEAR DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER SHOULD EFFECT NORMAL OPERATION OF THE RELEASE ASSEMBLY TO EXTEND THE MAIN LANDING GEAR.
REFER ALSO TO IOA FMEA 21102.

REFERENCES: MC325-0019

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4603 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) MAIN LANDING GEAR
3) PYRO UPLOCK RELEASE THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE - DUAL INITIATORS)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	1/1	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0019-0002, SKD26100102-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE EXTENTION OF MAIN LANDING GEAR COULD POSSIBLY CAUSE LOSS OF VEHICLE/CREW DURING ASCENT, ABORT AND DEORBIT. COULD CAUSE LOSS OF VEHICLE AND POSSIBLY LOSS OF CREW ON-ORBIT IF RESCUE WERE NOT POSSIBLE.
INADVERTENT FIRING OF EITHER OF THE DUAL INITIATORS WOULD SUFFICE TO OPERATE THE PYRO UPLOCK RELEASE ASSY THEREFORE CRIT 1 IS APPLICABLE.
REFER ALSO TO IOA FMEA 21101.

REFERENCES: MC325-0019

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4604 ABORT: 2/1R

ITEM: THRUSTER ASSY
FAILURE MODE: FAILS TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO UPLOCK RELEASE THRUSTER ASSY
4) THRUSTER ASSY
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	2/1R
LIFTOFF:	/NA	TAL:	2/1R
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	2/1R	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100101-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND THE NOSE WHEEL GEAR DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER SHOULD EFFECT NORMAL OPERATION OF THE RELEASE ASSEMBLY TO EXTEND THE NOSE WHEEL GEAR.
REFER ALSO TO IOA FMEA 11102.

REFERENCES: MC325-0006, VO70-51550

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4605 ABORT: 2/1R

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FAILS TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO UPLOCK RELEASE THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	2/1R
LIFTOFF:	/NA	TAL:	2/1R
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	2/1R	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100101-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND THE NOSE WHEEL GEAR DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER SHOULD EFFECT NORMAL OPERATION OF THE RELEASE ASSEMBLY TO EXTEND THE NOSE WHEEL GEAR.
REFER ALSO TO IOA FMEA 11102.

REFERENCES: MC325-0006, VO70-51550

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4606 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FIRES INADVERTENTLY

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO UPLOCK RELEASE THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100101-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE EXTENTION OF NOSE WHEEL GEAR COULD POSSIBLY CAUSE LOSS OF VEHICLE/CREW DURING ASCENT, ABORT AND DEORBIT. COULD CAUSE LOSS OF VEHICLE AND POSSIBLY LOSS OF CREW ON-ORBIT IF RESCUE WERE NOT POSSIBLE.
INADVERTENT FIRING OF EITHER OF THE DUAL INITIATORS WOULD SUFFICE TO OPERATE THE THRUSTER ASSY OF THE NOSE WHEEL GEAR PYRO UPLOCK RELEASE ASSY THEREFORE CRIT 1 IS APPLICABLE.
REFER ALSO TO IOA FMEA 11101.

REFERENCES: MC325-0006, VO70-510550, VO70-552002

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4607 ABORT: 1/1

ITEM: THRUSTER ASSY
FAILURE MODE: FAIL TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO GEAR EXTENSION ASSIST THRUSTER ASSY
4) THRUSTER ASSY
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	/NA	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100100-205

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND THE NOSE WHEEL GEAR IN TIME DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER INITIATOR SHOULD EFFECT NORMAL OPERATION OF THE GEAR EXTENSION ASSIST TO EXTEND THE NOSE WHEEL GEAR.
REFER ALSO TO IOA FMEA 11202.

REFERENCES: MC325-0006

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4608 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FAIL TO OPERATE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO GEAR EXTENSION ASSIST THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	/NA	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100101-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE TO EXTEND THE NOSE WHEEL GEAR IN TIME DURING LANDING (INCLUDING ABORT LANDING SITUATIONS) WOULD CAUSE LOSS OF VEHICLE/CREW.
THE INITIATORS ARE REDUNDANT THEREFORE NORMAL OPERATION OF EITHER INITIATOR SHOULD EFFECT NORMAL OPERATION OF THE GEAR EXTENSION ASSIST TO EXTEND THE NOSE WHEEL GEAR.
REFER ALSO TO IOA FMEA 11202.

REFERENCES: MC325-0006

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4609 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FIRES INADVERTENTLY

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) LANDING/DECELERATION SYSTEMS
2) NOSE WHEEL GEAR
3) PYRO GEAR EXTENSION ASSIST THRUSTER ASSY
4) PRESSURE CARTRIDGE
5) (SINGLE CARTRIDGE)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	1/1	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0006-0001, SKD26100101-201

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE EXTENTION OF MAIN LANDING GEAR COULD POSSIBLY CAUSE LOSS OF VEHICLE/CREW DURING ASCENT, ABORT AND DEORBIT. COULD CAUSE LOSS OF VEHICLE AND POSSIBLY LOSS OF CREW ON-ORBIT IF RESCUE WERE NOT POSSIBLE.
INADVERTENT FIRING OF EITHER OF THE DUAL INITIATORS WOULD SUFFICE TO OPERATE THE THRUSTER ASSY OF THE PYRO-GEAR EXTENSION ASSIST THEREFORE CRIT 1 IS APPLICABLE.
REFER ALSO TO IOA FMEA 11201.

REFERENCES: MC325-0006

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	11/23/87	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	PYROTECHNICS	FLIGHT:	1/1
MDAC ID:	4651	ABORT:	1/1

ITEM: SHEAR BOLT
FAILURE MODE: PREMATURE BOLT FRACTURE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) FORWARD SEPARATION
3) SHEAR BOLT
4) (1 PER SHUTTLE)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	1/1	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0014-0007, SKD26100098-245

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE FRACTURE OF THE FWD SEPARATION BOLT OR THE MONOBALL WOULD SEPARATE THE ORBITER STRUCTURALLY FROM THE ET AT THE FWD ATTACH POINT.
PREMATURE STRUCTURAL SEPARATION OF THE ORBITER AND ET WOULD PRODUCE CATASTROPHIC RESULTS FROM UNCONTROLLED FORCES BEING APPLIED IN UNCONTROLLED DIRECTIONS WHICH COULD TEAR APART THE ORBITER.

REFERENCES: MC325-0014

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4652 ABORT: 1/1

ITEM: SHEAR BOLT
FAILURE MODE: FAIL TO FRACTURE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) FORWARD SEPARATION
3) SHEAR BOLT
4) (1 PER SHUTTLE)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0014-0007, SKD26100098-245

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF THE FWD ATTACH BOLT TO FRACTURE UPON SEPARATION COMMAND WOULD RESULT IN INABILITY TO SEPARATE THE ORBITER FROM THE ET.
FAILURE OF ABILITY TO SEPARATE THE ORBITER FROM THE ET WOULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0014

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4653 ABORT: 2/1R

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: FAIL TO FUNCTION OR LOW PRESSURE OR REDUCED OUTPUT.

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) FORWARD SEPARATION
3) SHEAR BOLT
4) PRESSURE CARTRIDGE
5) (2 PER BOLT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	2/1R
LIFTOFF:	2/1R	TAL:	2/1R
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0014-0008, SKD26100098-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF ONE PRESSURE CARTRIDGE WOULD NOT BE DETECTABLE IF THE OTHER FUNCTIONED PROPERLY SINCE THEY ARE DUAL REDUNDANT.
FAILURE OF BOTH REDUNDANT PRESSURE CARTRIDGES WOULD RESULT IN INABILITY TO SEPARATE THE ORBITER FROM THE ET.
LOSS OF ABILITY TO SEPARATE THE ORBITER FROM THE ET WOULD RESULT IN LOSS OF CREW/VEHICLE. WHETHER THE FAILURE TO EFFECT PROPER SEPARATION IS CAUSED BY THE DETONATOR, PRESSURE CARTRIDGE, OR THE BOLT, THE RESULT WOULD BE THE SAME.

REFERENCES: MC325-0014

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4654 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) FORWARD SEPARATION
3) SHEAR BOLT
4) PRESSURE CARTRIDGE
5) (2 PER BOLT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	1/1	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0014-0008, SKD26100098-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE OPERATION OF EITHER PRESSURE CARTRIDGE WOULD CAUSE FRACTURE OF THE FWD SEPARATION BOLT WHICH WOULD SEPARATE THE ORBITER STRUCTURALLY FROM THE ET AT THE FWD ATTACH POINT. PREMATURE STRUCTURAL SEPARATION OF THE ORBITER AND ET WOULD PRODUCE CATASTROPHIC RESULTS FROM UNCONTROLLED FORCES APPLIED IN UNCONTROLLED DIRECTIONS WHICH COULD TEAR APART THE ORBITER.

REFERENCES: MC325-0014

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4655 ABORT: 1/1

ITEM: FRANGIBLE NUT
FAILURE MODE: PREMATURE FRACTURE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) AFT SEPARATION (1 LEFT/1 RIGHT)
3) FRANGIBLE NUT
4) (1 LEFT/1 RIGHT)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	1/1	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC114-0018-0007, SKD26100099-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE FRACTURE OF THE FRANGIBLE NUT WOULD THEREBY SEPARATE THE ORBITER STRUCTURALLY FROM THE ET AT THAT ATTACH POINT. PREMATURE STRUCTURAL SEPARATION OF THE ORBITER AND ET AT AN AFT ATTACH POINT WOULD PRODUCE CATASTROPHIC RESULTS FROM UNCONTROLLED FORCES BEING APPLIED IN UNCONTROLLED DIRECTIONS WHICH COULD TEAR APART THE ORBITER.
REFER TO IOA FMEA 4652. WHETHER THE FAILURE WERE CAUSED BY PREMATURE DETONATION OF A DETONATOR OR STRUCTURAL FAILURE OF THE FRANGIBLE NUT, THE RESULTS ARE IDENTICAL.

REFERENCES: MC114-0018

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4656 ABORT: 1/1

ITEM: FRANGIBLE NUT
FAILURE MODE: FAIL TO FRACTURE UPON RECEIVING SHOCK OUTPUT FROM DETONATOR(S).

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) AFT SEPARATION (1 LEFT/1 RIGHT)
3) FRANGIBLE NUT
4) (1 LEFT/1 RIGHT)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC114-0018-0007, SKD26100099-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF THE FRANGIBLE NUT TO FRACTURE UPON COMMAND WOULD DISALLOW SEPARATION OF THE ET/ORBITER AT THAT AFT ATTACH POINT. FAILURE OF AN ATTACH POINT TO DETACH WHEN REQUIRED WOULD PROBABLY CAUSE A CATASTROPHIC COLLISION OF THE ET AND ORBITER. ABORT LANDING OF THE ORBITER WOULD BE IMPOSSIBLE IF THE ORBITER COULD NOT BE SEPARATED FROM THE ET.

REFERENCES: MC114-0018

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4657 ABORT: 2/1R

ITEM: DETONATOR BOOSTER (2)
FAILURE MODE: FAILS TO FIRE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) AFT SEPARATION (1 LEFT/1 RIGHT)
3) FRANGIBLE NUT
4) DETONATOR/BOOSTER CARTRIDGE
5) (2 PER NUT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	2/1R
LIFTOFF:	2/1R	TAL:	2/1R
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME453-0021-0009, SKD26100099-401

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF ONE DETONATOR TO FIRE WOULD NOT BE DETECTABLE. ADEQUATE PERFORMANCE BY EITHER DUAL REDUNDANT DETONATOR WOULD SATISFACTORILY PERFORM THE INTENDED FUNCTION TO FRACTURE THE FRANGIBLE NUT TO EFFECT ET/ORBITER SEPARATION AT THE AFT ATTACH POINTS.
ANY DUAL FAILURE OF A PAIR OF MATED AFT ATTACH FRANGIBLE NUT DETONATORS WOULD CAUSE INABILITY TO SEPARATE THE ORBITER FROM THE ET.
INABILITY TO SEPARATE THE ORBITER FROM THE ET WOULD CAUSE LOSS OF VEHICLE/CREW.

REFERENCES: MC453-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4658 ABORT: 1/1

ITEM: DETONATOR BOOSTER (2)
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) AFT SEPARATION (1 LEFT/1 RIGHT)
3) FRANGIBLE NUT
4) DETONATOR/BOOSTER CARTRIDGE
5) (2 PER NUT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME453-0021-0009, SKD26100099-401

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE FIRING OF EITHER OF THE DUAL REDUNDANT DETONATORS WOULD SUFFICE TO INITIATE THE BOOSTER CHARGE TO FRACTURE THE FRANGIBLE NUT AND THEREBY SEPARATE THE ORBITER STRUCTURALLY FROM THE ET AT THAT ATTACH POINT.
PREMATURE STRUCTURAL SEPARATION OF THE ORBITER AND ET WOULD PRODUCE CATASTROPHIC RESULTS FROM UNCONTROLLED FORCES BEING APPLIED IN UNCONTROLLED DIRECTIONS WHICH COULD TEAR APART THE ORBITER.
REFER TO IOA FMEA 4653. WHETHER THE FAILURE WERE CAUSED BY PREMATURE DETONATION OF A DETONATOR OR SIMPLY STRUCTURAL FAILURE OF THE FRANGIBLE NUT THE RESULTS ARE IDENTICAL.

REFERENCES: MC453-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	11/23/87	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	PYROTECHNICS	FLIGHT:	1/1
MDAC ID:	4661	ABORT:	1/1

ITEM: FRANGIBLE NUT
FAILURE MODE: FAIL TO FRACTURE UPON RECEIVING SHOCK INPUT FROM DETONATOR(S).

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) UMBILICAL PLATE SEPARATION
3) FRANGIBLE NUT
4) (3 PER PLATE)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC114-0018-0003, SKD26100099-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF ANY OF THE THREE FRANGIBLE NUTS ON EITHER THE LEFT OR RIGHT SIDE TO FRACTURE UPON COMMAND WOULD PREVENT SEPARATION OF THAT ORBITER/ET UMBILICAL PLATE.
FAILURE TO SUCCESSFULLY EFFECT ORBITER/ET UMBILICAL PLATE SEPARATION WOULD PREVENT SAFE ORBITER/ET SEPARATION.
INABILITY TO SEPARATE THE ORBITER AND ET WOULD CAUSE LOSS OF VEHICLE CREW.

REFERENCES: MC114-0018

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4662 ABORT: 1/1

ITEM: FRANGIBLE NUT
FAILURE MODE: PREMATURE FRACTURE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) UMBILICAL PLATE SEPARATION
3) FRANGIBLE NUT
4) (3 PER PLATE)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	1/1	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC114-0018-0003, SKD26100099-201

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE FRACTURE OF ANY ONE OF THE THREE FRANGIBLE NUTS COULD VIOLATE STRUCTURAL INTEGRITY OF THE ORBITER AND ET UMBILICAL PLATES AT O2 AND H2 VALVE SEPARATION PLANE.
LOSS OF STRUCTURAL INTEGRITY AT THE ORBITER/ET UMBILICAL PLATE SEPARATION PLANE COULD RESULT IN PREMATURE SEPARATION WHICH WOULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC114-0018

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4663 ABORT: 2/1R

ITEM: DETONATOR
FAILURE MODE: FAIL TO FIRE OR REDUCED OUTPUT

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) UMBILICAL PLATE SEPARATION
3) FRANGIBLE NUT
4) DETONATOR
5) (2 PER NUT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	2/1R
LIFTOFF:	2/1R	TAL:	2/1R
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC453-0021-0009, SKD26100094

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF ONE DETONATOR OF A GIVEN PAIR WOULD NOT BE DETECTABLE. EITHER DUAL REDUNDANT DETONATOR IS CAPABLE OF PERFORM THE INTENDED FUNCTION TO FRACTURE ITS FRANGIBLE NUT TO EFFECT PLATE SEPARATION.
ANY DUAL FAILURE OF A MATED PAIR OF DETONATORS COULD CAUSE INABILITY TO EFFECT UMBILICAL PLATE SEPARATION.
INABILITY TO EFFECT SEPARATION OF EITHER UMBILICAL PLATE WOULD CAUSE LOSS OF VEHICLE/CREW.

REFERENCES: MC453-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4664 ABORT: 1/1

ITEM: DETONATOR
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) ORBITER/EXTERNAL TANK (ET) SEPARATION MECHANISMS PYROS
2) UMBILICAL PLATE SEPARATION
3) FRANGIBLE NUT
4) DETONATOR
5) (2 PER NUT)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	1/1	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC453-0021-0009, SKD26100094

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
PREMATURE OPERATION OF ANY DETONATOR WOULD CAUSE FRACTURE OF THE RESPECTIVE FRANGIBLE NUT. THERE ARE THREE NUTS STRUCTURALLY TYING EACH (1 LEFT/1 RIGHT) UMBILICAL PLATE.
FAILURE OF ANY ONE OF THE SIX NUTS WOULD REDUCE STRUCTURAL INTEGRITY AND POSSIBLY BE SUFFICIENT TO ALLOW LOSS OF O2 OR H2 WHICH COULD CAUSE FIRE.
ULTIMATELY THE PREMATURE FRACTURE OF ONE OF THE SIX FRANGIBLE NUTS COULD LEAD TO OTHER FAILURES THAT COULD POSSIBLY CAUSE LOSS OF VEHICLE/CREW.

REFERENCES: MC453-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4701 ABORT: /NA

ITEM: GUILLOTINE ASSY, PYROTECHNIC
FAILURE MODE: FAIL TO FUNCTION UPON RECEIVING NOMINAL PRESSURE

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) GUILLOTINE ASSY, PYROTECHNIC
3) (DUAL PRESSURE CARTRIDGES)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0024-0001, SKD26100105-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
SEVERING THE ELECTRICAL UMBILICAL IS REQUIRED TO EFFECT JETTISON OF THE RR ANTENNA IF REQUIRED.
INABILITY TO STOW OR JETTISON THE ANTENNA COULD PREVENT PAYLOAD BAY DOOR CLOSING.
INABILITY TO CLOSE THE PAYLOAD BAY DOORS COULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0024

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/2
MDAC ID: 4702 ABORT: /NA

ITEM: GUILLOTINE ASSY, PYROTECHNIC
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) GUILLOTINE ASSY, PYROTECHNIC
3) (DUAL PRESSURE CARTRIDGES)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	2/2	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0024-0001, SKD26100105-201

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
UNTIMELY OPERATION OF THE RENDEZVOUS RADAR GUILLOTINE ASSY PYRO WOULD SEVER THE ELECTRICAL UMBILICAL.
UNTIMELY SEVERING OF THE ELECTRICAL UMBILICAL WOULD DISABLE ANY USE OF THE ANTENNA.
LOSS OF RENDEZVOUS RADAR WOULD CAUSE LOSS OF MISSION.

REFERENCES: MC325-0024

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4703 ABORT: /NA

ITEM: PRESSURE CARTRIDGE (2)
FAILURE MODE: FAIL TO FUNCTION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) GUILLOTINE ASSY, PYROTECHNIC
3) PRESSURE CARTRIDGE (2)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	2/1R	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0024-0002, SKD26100105-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
ONE CARTRIDGE FAILING WOULD NOT PREVENT OPERATION OF THE GUILLOTINE ASSY. SEVERING THE ELECTRICAL UMBILICAL IS REQUIRED TO EFFECT JETTISON OF THE RR ANTENNA IF REQUIRED.
INABILITY TO STOW OR JETTISON THE ANTENNA COULD PREVENT PAYLOAD BAY DOOR CLOSING.
INABILITY TO CLOSE THE PAYLOAD BAY DOORS COULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0024

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/2
MDAC ID: 4704 ABORT: /NA

ITEM: PRESSURE CARTRIDGE (2)
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) GUILLOTINE ASSY, PYROTECHNIC
3) PRESSURE CARTRIDGE (2)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	2/2	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0024-0002, SKD26100105-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
UNTIMELY OPERATION OF THE RENDEZVOUS RADAR GUILLOTINE ASSY PYRO WOULD SEVER THE ELECTRICAL UMBILICAL.
UNTIMELY SEVERING OF THE ELECTRICAL UMBILICAL WOULD DISABLE ANY USE OF THE ANTENNA.
LOSS OF RENDEZVOUS RADAR WOULD CAUSE LOSS OF MISSION.

REFERENCES: MC325-0024

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4705 ABORT: /NA

ITEM: RELEASE NUT
FAILURE MODE: FAIL TO FUNCTION UPON RECEIVING NOMINAL PRESSURE OUTPUT

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) RELEASE NUT
3) (DUAL PRESSURE CARTRIDGES)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME325-0025-0001, SKD26100105-501

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
INABILITY TO SEPARATE THE RENDEZVOUS RADAR ANTENNA WHEN IT CANNOT BE SAFELY AND PROPERLY STOWED WOULD PREVENT CLOSURE OF THE PAYLOAD BAY DOORS.
IF THE PAYLOAD BAY DOORS CANNOT BE CLOSED THEN DEORBIT CANNOT BE ACCOMPLISHED.
IF SAFE DEORBIT CANNOT BE ACCOMPLISHED LOSS OF THE VEHICLE/CREW COULD RESULT.

REFERENCES: MC325-0025

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4706 ABORT: 1/1

ITEM: RELEASE NUT
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) RELEASE NUT
3) (DUAL PRESSURE CARTRIDGES)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	2/2	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME325-0025-0001, SKD26100105-501

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
INADVERTENT SEPARATION OF THE RENDEZVOUS RADAR ANTENNA DURING ASCENT COULD PHYSICALLY DAMAGE THE ORBITER AND PAYLOADS. DEPENDING ON THE LEVEL OF THE PHYSICAL/STRUCTURAL DAMAGE TO THE ORBITER AND PAYLOADS, POSSIBLE CAUSE LOSS OF THE PAYLOADS/ORBITER/CREW COULD RESULT.

REFERENCES: MC325-0025

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4707 ABORT: /NA

ITEM: PRESSURE CARTRIDGE (2)
FAILURE MODE: FAIL TO FUNCTION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) RELEASE NUT
3) PRESSURE CARTRIDGES (2)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	2/1R	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME325-0025-0003, SKD26100105-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF BOTH WOULD BE REQUIRED BEFORE FAILURE OF RELEASE NUT WOULD NOMINALLY OCCUR. INABILITY TO RELEASE THE RENDEZVOUS RADAR ANTENNA WHEN IT CANNOT BE SAFELY AND PROPERLY STOWED WOULD PREVENT CLOSURE OF THE PAYLOAD BAY DOORS.
INABILITY TO PROPERLY CLOSE THE PAYLOAD BAY DOORS WOULD ENDANGER SAFE DEORBIT.
IF SAFE DEORBIT CANNOTT BE ACCOMPLISHED, LOSS OF CREW/VEHICLE COULD RESULT.

REFERENCES: MC325-0025

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 12/18/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4708 ABORT: 1/1

ITEM: PRESSURE CARTRIDGE (2)
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE
2) RELEASE NUT
3) PRESSURE CARTRIDGES (2)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	2/2	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: ME325-0025-0003, SKD26100105-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
INADVERTENT SEPARATION OF THE RENDEZVOUS RADAR ANTENNA DURING ASCENT COULD PHYSICALLY DAMAGE THE ORBITER AND PAYLOADS. DEPENDING ON THE LEVEL OF THE PHYSICAL/STRUCTURAL DAMAGE TO THE ORBITER AND PAYLOADS, POSSIBLE CAUSE LOSS OF THE PAYLOADS/ORBITER/CREW COULD RESULT.

REFERENCES: MC325-0025

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4751 ABORT: /NA

ITEM: RETRACTOR - MANIPULATOR ARM RELEASE
FAILURE MODE: FAILS TO FUNCTION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) RETRACTOR - MANIPULATOR ARM RELEASE
4) (4 PER ARM)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0021-0001, SKD26100104-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF THE MANIPULATOR ARM RELEASE RETRACTOR TO RELEASE WHEN COMMANDED TO DO SO WOULD RESULT IN INABILITY TO JETTISON AN ARM WHEN REQUIRED.
INABILITY TO JETTISON AN ARM WHEN REQUIRED COULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4752 ABORT: 1/1

ITEM: RETRACTOR - MANIPULATOR ARM RELEASE
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) RETRACTOR - MANIPULATOR ARM RELEASE
4) (4 PER ARM)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	1/1
LIFTOFF:	1/1	TAL:	1/1
ONORBIT:	1/1	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0021-0001, SKD26100104-201

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
UNTIMELY OPERATION OF THE RMS ARM COULD CAUSE PHYSICAL/STRUCTURAL DAMAGE TO THE ORBITER/PAYLOADS.
DEPENDING ON THE NATURE OF THE DAMAGE TO THE ORBITER POSSIBLE LOSS OF VEHICLE/CREW COULD RESULT.

REFERENCES: MC325-0021

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4753 ABORT: /NA

ITEM: GUILLOTINE ASSY PYRO
FAILURE MODE: FAILS TO FUNCTION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) GUILLOTINE ASSY PYRO
4) RMS SHOULDER UMBILICAL SEPARATION
5) (1 PER ARM) TYPE I
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0022-0001, SKD26100103-201

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF THE RMS SHOULDER UMBILICAL SEPARATION GUILLOTINE ASSY TO RELEASE WHEN COMMANDED TO DO SO WOULD RESULT IN INABILITY TO JETTISON AN ARM WHEN REQUIRED.
INABILITY TO JETTISON AN ARM WHEN REQUIRED COULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0022

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4754 ABORT: /NA

ITEM: GUILLOTINE ASSY PYRO
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) GUILLOTINE ASSY PYRO
4) RMS SHOULDER UMBILICAL SEPARATION
5) (1 PER ARM) TYPE I
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	/NA
LIFTOFF:	2/2	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0022-0001, SKD26100103-201

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
UNTIMELY OPERATION OF THE RMS SHOULDER UMBILICAL SEPARATION GUILLOTINE ASSY WHILE THE ARM IS IN USE WOULD CAUSE LOSS OF CONTROL OF THE ARM WITH POSSIBLE PHYSICAL/STRUCTURAL DAMAGE TO THE ORBITER/PAYLOADS
DEPENDING ON THE EXTENT AND TYPE OF DAMAGE TO THE ORBITER, LOSS OF VEHICLE/CREW COULD RESULT.

REFERENCES: MC325-0022

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4755 ABORT: /NA

ITEM: GUILLOTINE ASSY
FAILURE MODE: FAILS TO FUNCTION WHEN BOTH INITIATORS ARE FIRED.

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) RMS PEDESTAL UMBILICAL SEPARATION
4) GUILLOTINE ASSY
5) (3 PER ARM) TYPE II
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	1/1	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0022-0002, SKD261100103-301

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
FAILURE OF THE RMS PEDESTAL UMBILICAL SEPARATION GUILLOTINE ASSY TO FUNCTION TO SEVER THE ELECTRICAL WIRE BUNDLE WOULD PREVENT JETTISON OF THE ARM WHEN REQUIRED.
INABILITY TO JETTISON AN ARM WHEN REQUIRED COULD RESULT IN LOSS OF VEHICLE/CREW.

REFERENCES: MC325-0022

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/2
MDAC ID: 4756 ABORT: /NA

ITEM: GUILLOTINE ASSY
FAILURE MODE: INADVERTENT OPERATION

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) PAYLOAD RETENTION & DEPLOY
2) MANIPULATOR POSITIONING/RETENTION MECHANISM
3) GUILLOTINE ASSY
4) RMS PEDESTAL UMBILICAL SEPARATION
5) (3 PER ARM) TYPE II
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	2/2	RTLS:	/NA
LIFTOFF:	2/2	TAL:	/NA
ONORBIT:	2/2	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	/NA		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0022-0002, SKD261100103-301

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
UNTIMELY OPERATION OF THE RMS PEDESTAL UMBILICAL SEPARATION GUILLOTINE ASSY WOULD ABILITY TO STOW/DEPLOY THE ARM.
INABILITY TO DELOY THE ARM COULD CAUSE LOSS OF MISSION.
INABILITY TO STOW THE ARM WOULD REQUIRE THE ARM BE JETISSONED.

REFERENCES: MC325-0022

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4801 ABORT: /NA

ITEM: OUTER WINDOW ASSY
FAILURE MODE: FAILS TO OPEN

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) OUTER WINDOW ASSY
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	1/1		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: VO70-553302

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
EMERGENCY CREW EGRESS CAPABILITY WILL NOT BE PROVIDED IN SITUATIONS WHERE IT IS NEEDED.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE WHEN REQUIRED.

REFERENCES: VO70-553302

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 1/1
MDAC ID: 4802 ABORT: /NA

ITEM: INNER WINDOW ASSY
FAILURE MODE: FAILS TO OPEN

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) INNER WINDOW ASSY
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	1/1		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: VO70-553303

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
EMERGENCY CREW EGRESS CAPABILITY WILL NOT BE PROVIDED IN SITUATIONS WHERE IT IS NEEDED.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE WHEN REQUIRED.

REFERENCES: VO70-553302

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4803 ABORT: /NA

ITEM: ENERGY TRANSFER SYSTEM
FAILURE MODE: REDUCED OR NO OUTPUT

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) ENERGY TRANSFER SYSTEM
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	2/1R		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0004

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
REDUNDANT FAILURE OF ENERGY TRANSFER SYSTEM COULD RESULT IN LOSS OF EMERGENCY CREW EGRESS CAPABILITY IN SITUATIONS WHERE IT IS NEEDED.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE WHEN REQUIRED.

REFERENCES: MC325-0004

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4804 ABORT: /NA

ITEM: INITIATOR ASSY PYRO
FAILURE MODE: NO OUTPUT

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) INITIATOR ASSY PYRO
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	2/1R		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0005-0003,-0005

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
REDUNDANT FAILURE OF WINDOW SEVERENCE FUNCTION COULD RESULT IN LOSS OF EMERGENCY CREW EGRESS CAPABILITY IN SITUATIONS WHERE IT IS NEEDED.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE WHEN REQUIRED.

REFERENCES: MC325-0005

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4805 ABORT: /NA

ITEM: 0.3-SEC TIME DELAY CARTRIDGE ASSY
FAILURE MODE: NO OUTPUT, EXCESSIVE DELAY OF CARTRIDGE FIRING.

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) 0.3 SEC TIME DELAY CARTRIDGE ASSY
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	2/1R		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0004-0003

CAUSES: MECHANICAL/STRUCTURAL MALFUNCTION, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
COULD RESULT IN EXCESSIVE TIME BEFORE MAKING CREW EMERGENCY EGRESS POSSIBLE.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE IN TIME WHEN REQUIRED.

REFERENCES: MC325-0004

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 11/23/87 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: PYROTECHNICS FLIGHT: 2/1R
MDAC ID: 4806 ABORT: /NA

ITEM: THRU BULKHEAD INITIATOR
FAILURE MODE: NO OUTPUT

LEAD ANALYST: W. W. ROBINSON SUBSYS LEAD: ROBINSON

BREAKDOWN HIERARCHY:
1) CREW STATION & EQUIPMENT
2) EMERGENCY EGRESS
3) THRU BULKHEAD INITIATOR
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	/NA	RTLS:	/NA
LIFTOFF:	/NA	TAL:	/NA
ONORBIT:	/NA	AOA:	/NA
DEORBIT:	/NA	ATO:	/NA
LANDING/SAFING:	2/1R		

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION:
PART NUMBER: MC325-0004-0003, -0023, SKD26100108-301, -401

CAUSES: HIGH TEMPERATURE ENVIRONMENT, MECHANICAL/STRUCTURAL MALFUNCTION, SHOCK, CORROSION, CONTAMINATION, CHEMICAL DETERIORATION.

EFFECTS/RATIONALE:
DUAL FAILURE COULD RESULT IN LOSS OF EMERGENCY CREW EGRESS CAPABILITY.
LOSS OF CREW COULD RESULT IF EMERGENCY CREW EGRESS NOT AVAILABLE WHEN REQUIRED.

REFERENCES: MC325-0004

APPENDIX D

POTENTIAL CRITICAL ITEMS

MDAC-ID	FLIGHT	ITEM	FAILURE MODE
4601	1/1	THRUSTER ASSY	FAILS TO OPERATE
4602	2/1R	PRESSURE CARTRIDGE	FAILS TO OPERATE
4603	1/1	PRESSURE CARTRIDGE	INADVERTENT OPERATION
4604	2/1R	THRUSTER ASSY	FAILS TO OPERATE
4605	2/1R	PRESSURE CARTRIDGE	FAILS TO OPERATE
4606	1/1	PRESSURE CARTRIDGE	FIRES INADVERTENTLY
4607	1/1	THRUSTER ASSY	FAILS TO OPERATE
4608	1/1	PRESSURE CARTRIDGE	FAILS TO OPERATE
4609	1/1	PRESSURE CARTRIDGE	FIRES INADVERTENTLY
4651	1/1	SHEAR BOLT	PREMATURE BOLT FRACTURE
4652	1/1	SHEAR BOLT	FAILS TO FRACTURE
4653	2/1R	PRESSURE CARTRIDGE	FAILS TO FUNCTION
4654	1/1	PRESSURE CARTRIDGE	INADVERTENT OPERATION
4655	1/1	FRANGIBLE NUT	PREMATURE FRACTURE
4656	1/1	FRANGIBLE NUT	FAILS TO FRACTURE
4657	2/1R	DETONATOR BOOSTER (2)	FAILS TO FIRE
4658	1/1	DETONATOR BOOSTER (2)	INADVERTENT OPERATION
4661	1/1	FRANGIBLE NUT	FAILS TO FRACTURE
4662	1/1	FRANGIBLE NUT	PREMATURE FRACTURE
4663	2/1R	DETONATOR	FAILS TO FIRE
4664	1/1	DETONATOR	INADVERTENT OPERATION

APPENDIX D (CONT'D)

POTENTIAL CRITICAL ITEMS

MDAC-ID	FLIGHT	ITEM	FAILURE MODE
4701	1/1	GUILLOTINE ASSY, PYROTECHNIC	FAILS TO FUNCTION
4702	2/2	GUILLOTINE ASSY, PYROTECHNIC	INADVERTENT OPERATION
4703	1/1	PRESSURE CARTRIDGE (2)	FAILS TO FUNCTION
4704	2/2	PRESSURE CARTRIDGE (2)	INADVERTENT OPERATION
4705	1/1	RELEASE NUT	FAILS TO FUNCTION
4706	1/1	RELEASE NUT	INADVERTENT OPERATION
4707	2/1R	PRESSURE CARTRIDGE (2)	FAILS TO FUNCTION
4708	1/1	PRESSURE CARTRIDGE (2)	INADVERTENT OPERATION
4751	1/1	RETRACTOR - MANIPULATOR ARM RELEASE	FAILS TO FUNCTION
4752	1/1	RETRACTOR - MANIPULATOR ARM RELEASE	INADVERTENT OPERATION
4753	1/1	GUILLOTINE ASSY PYRO	FAILS TO FUNCTION
4754	1/1	GUILLOTINE ASSY PYRO	INADVERTENT OPERATION
4755	1/1	GUILLOTINE ASSY	FAILS TO FUNCTION
4756	2/2	GUILLOTING ASSY	INADVERTENT OPERATION
4801	1/1	OUTER WINDOW ASSY	FAILS TO OPEN
4802	1/1	OUTER WINDOW ASSY	FAILS TO OPEN
4803	2/1R	ENERGY TRANSFER SYSTEM	REDUCED OR NO OUTPUT
4804	2/1R	INITIATOR ASSY PYRO	NO OUTPUT
4805	2/1R	0.3-SEC TIME DELAY CARTRIDGE ASSY	NO OUTPUT, EXCESSIVE DELAY OF CART FIRING
4806	2/1R	THRU BULKHEAD INITIATOR	NO OUTPUT