INDEPENDENT ORBITER ASSESSMENT

ASSESSMENT OF THE PYROTECHNICS SUBSYSTEM

5 FEBRUARY 1988

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

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

APPROVED BY: K.R. Schmeckpeper
Power & Propulsion
Lead
Independent Orbiter
Assessment

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

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

APPROVED BY: J.I. McPherson
Project Manager
STSEOS

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1.0 EXECUTIVE SUMMARY

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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.

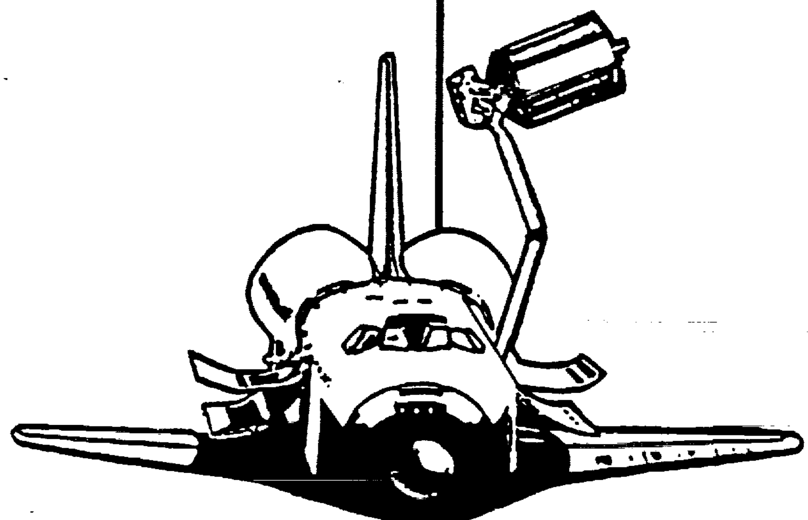
The IOA effort first completed an analysis of the Pyrotechnics (PYRO) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Pyrotechnics hardware.

The IOA product for the Pyrotechnics analysis consisted of forty-one (41) failure mode "worksheets" that resulted forty-one (41) Potential Critical Items (PCIs) being identified. Comparison was made to the NASA baseline (as of 19 November 1986) which consisted of thirty-seven (37) FMEAs and thirty-seven (37) CIL items. The comparison determined if there were any results which had been found by the IOA that were not in the NASA baseline. This comparison produced agreement on all but seven (7) FMEAs which caused differences in four (4) CIL items. Three (3) of the differences were caused by incorrect criticality assignments on the IOA FMEAs where the IOA analysis numerical values were not in agreement with the "Effects" verbiage. IOA acknowledges the error and agrees with the NASA criticality assignment to the failure and these items are not issues. The CIL was not in question as IOA had considered all to be CIL items. The IOA analysis includes four (4) failure modes (CIL items) which were not included in the NASA FMEAs or CIL. Figure 1 presents a comparison of the proposed Post 51-L NASA baseline, with the IOA recommended baseline, and any issues.

Some of the miscompares arose due to differences between the NASA and IOA FMEA/CIL preparation instructions. NASA had used an older ground rules document which has since been superseded by the NSTS 22206 used by the IOA. After comparison, there were no other discrepancies found that were not already identified by NASA, and the remaining issues may be attributed to differences in ground rules.

PYROTECHNICS ASSESSMENT SUMMARY

	IOA	NASA	ISSUES
FMEA	41	37	4
CIL	41	37	4



LANDING/DECELERATION

	IOA	NASA	ISSUES
FMEA	9	9	0
CIL	9	9	0

ORBITER/ET SEPARATION

	IOA	NASA	ISSUES
FMEA	12	12	0
CIL	12	12	0

CREW STATION & EQUIPMENT

	IOA	NASA	ISSUES
FMEA	6	6	0
CIL	6	6	0

P/L RETN/DEPLOY

	IOA	NASA	ISSUES
FMEA	6	6	0
CIL	6	6	0

RENDEZVOUS RADAR ANTENNA

	IOA	NASA	ISSUES
FMEA	8	4	4
CIL	8	4	4

Figure 1 - PYROTECHNICS FMEA/CIL ASSESSMENT

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 re-evaluating the FMEA/CIL for the Space Shuttle design. The MDAC is providing an independent assessment of the proposed Post 51-L Orbiter FMEA/CIL 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 proposed Post 51-L NASA and Prime Contractor FMEA/CIL. 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 FMEA/CIL which is documented in this report.

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 Ground Rules and Assumptions

The ground rules and assumptions used in the IOA are defined in Appendix B. The Pyrotechnic specific ground rules and assumptions are defined in paragraph B.3 of 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. 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 RR Antenna is necessary to permit payload bay door closure.

4. Payload Retention and Deploy Jettison Pyrotechnics are used to guillotine the cables and jettison the 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.

3.1 Design and Function (cont'd)

5. Crew Station and Equipment Ground Emergency Egress Pyrotechnics are employed to break the attach bolts to the sever the outer window and to open the inner window. Window severance 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 Jettison 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 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 mechanically 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.

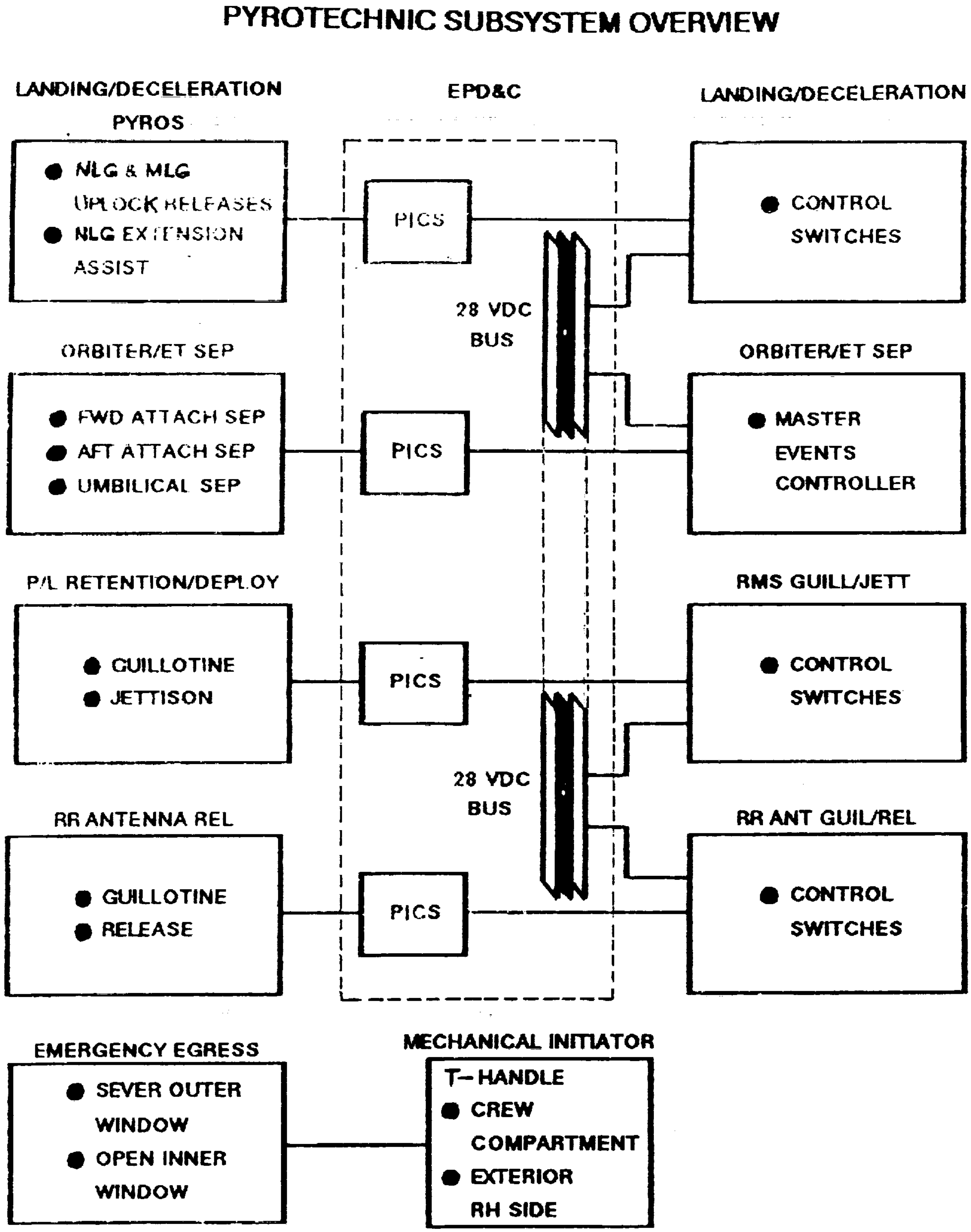


Figure 2 - PYROTECHNIC SUBSYSTEM OVERVIEW

NASA Standard Detonator (NSD)

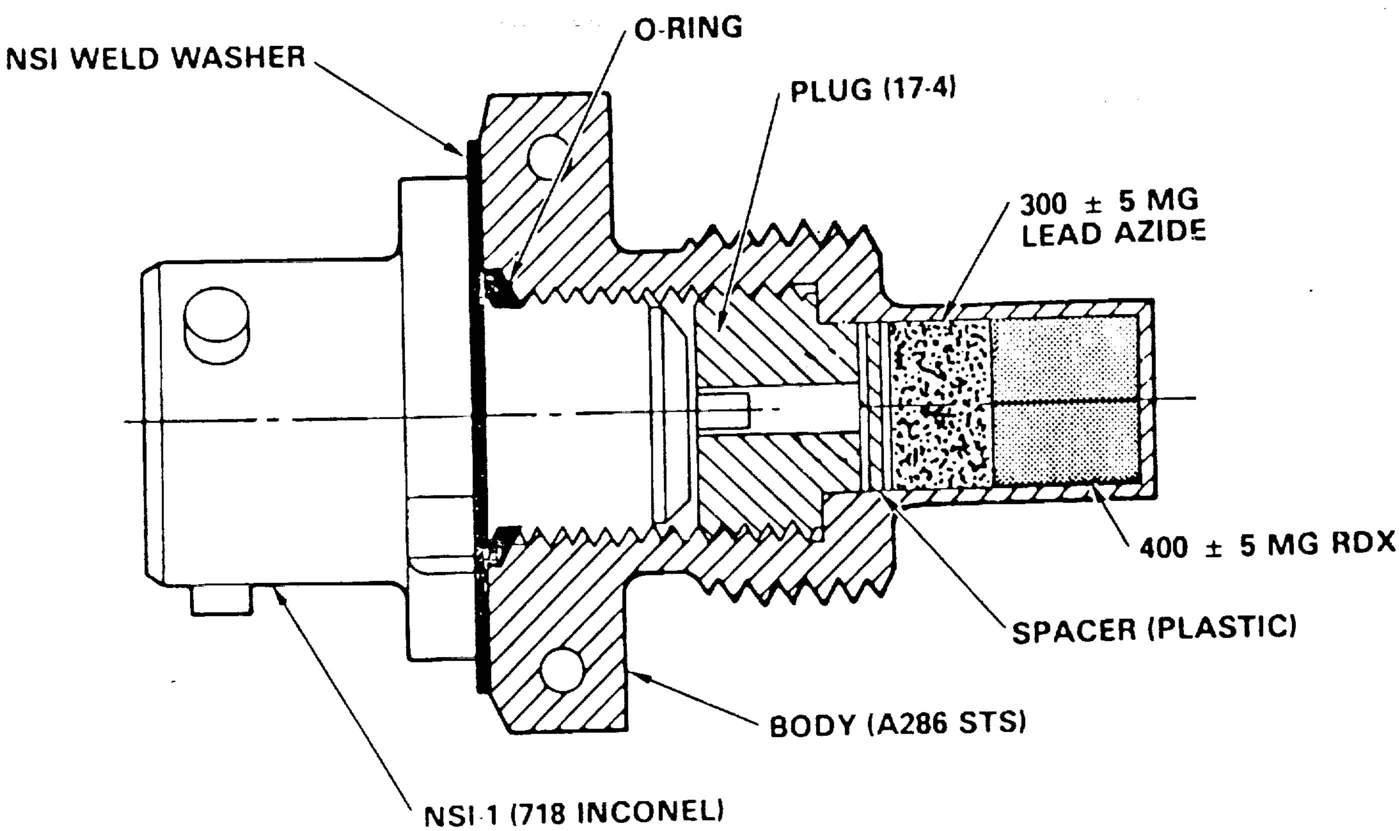


Figure 3 - NASA STANDARD DETONATOR (NSD)

NASA Standard Initiator (NSI)

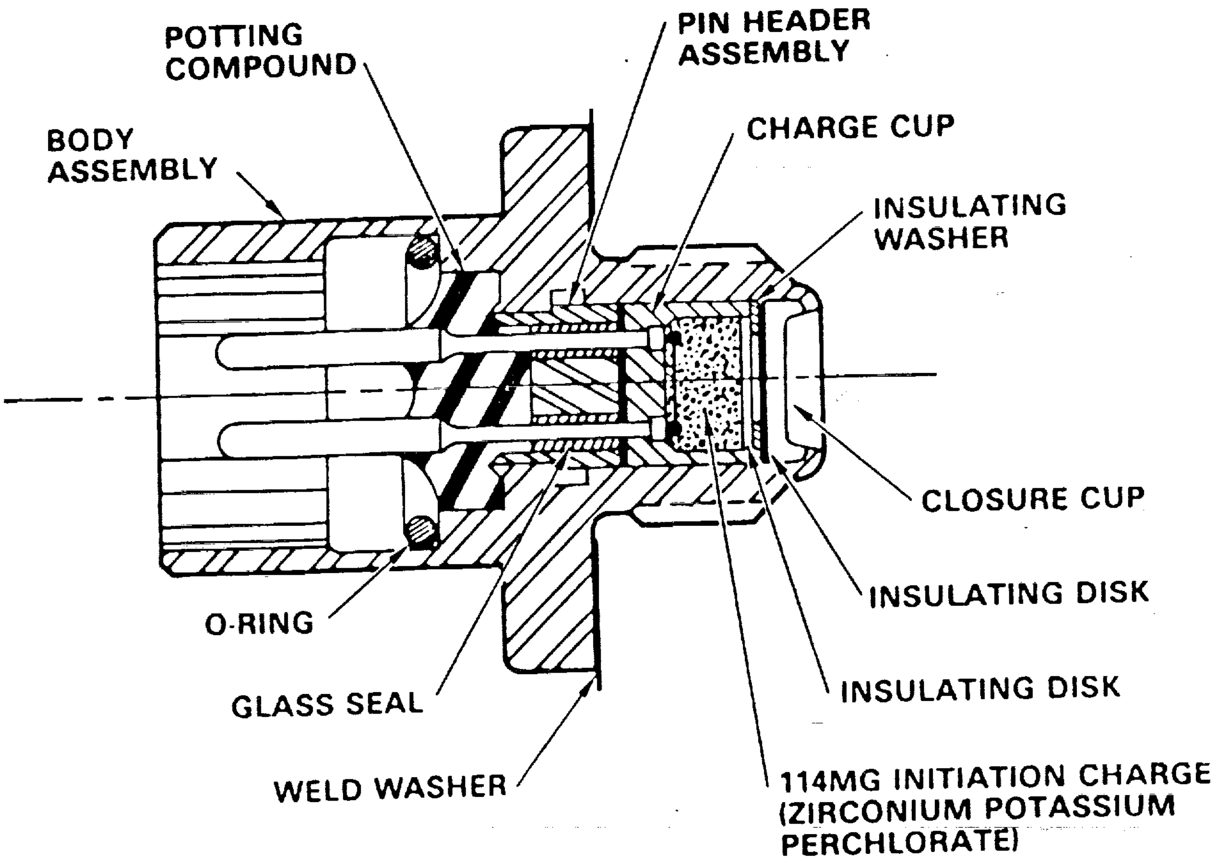


Figure 4 - NASA STANDARD INITIATOR (NSI)

Orbiter/ET Separation

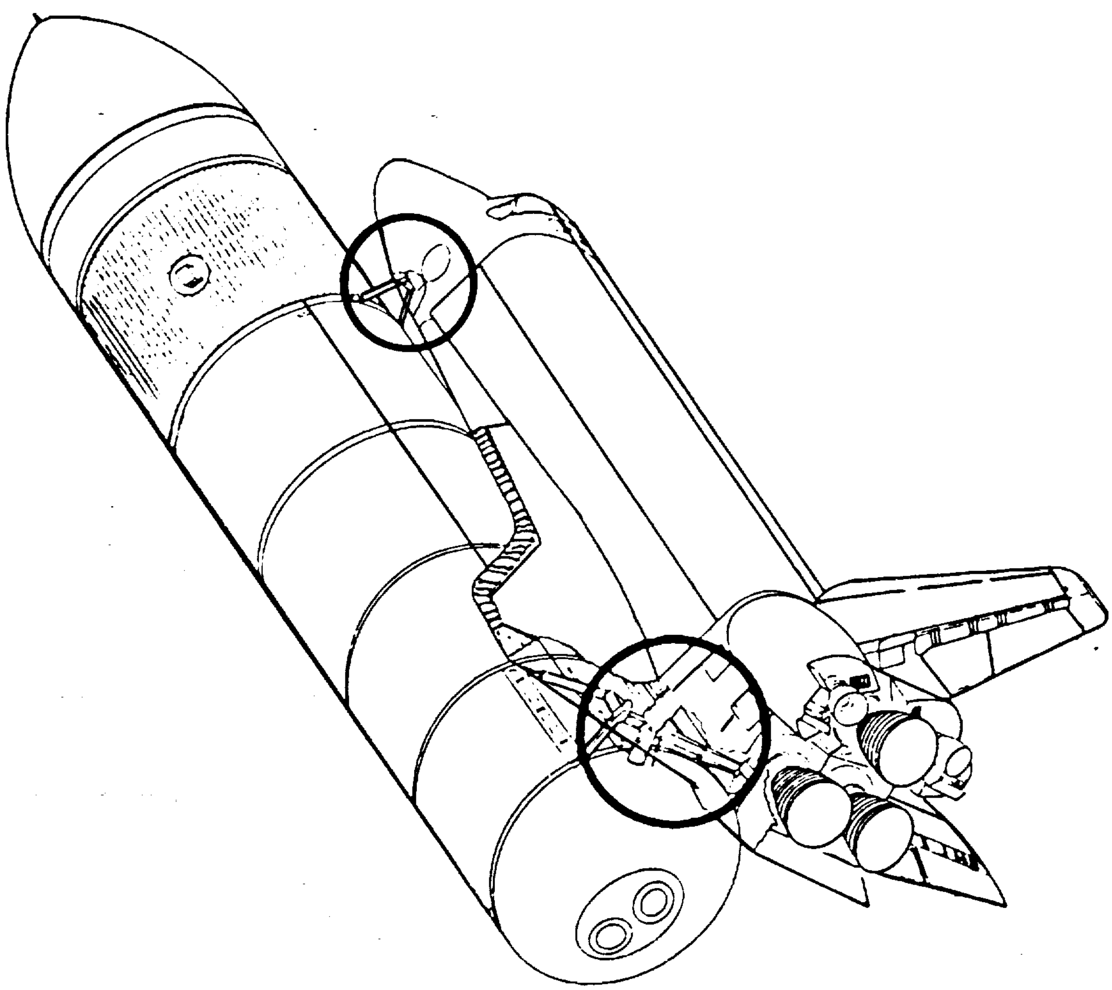


Figure 5 - ORBITER ET SEPARATION

LANDING GEAR CONTROL SYSTEM OVERVIEW

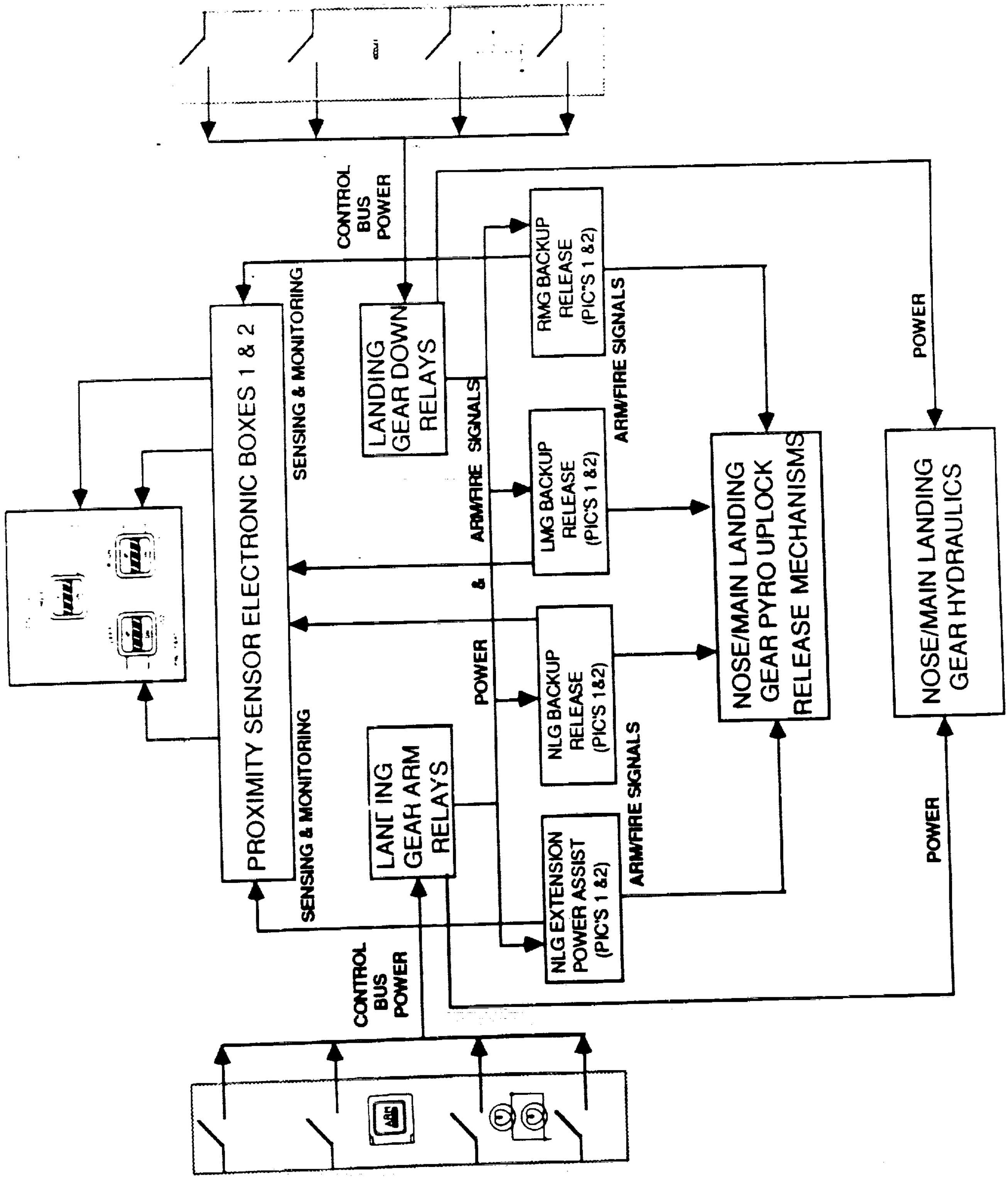


Figure 6 - LANDING GEAR CONTROL SYSTEM OVERVIEW

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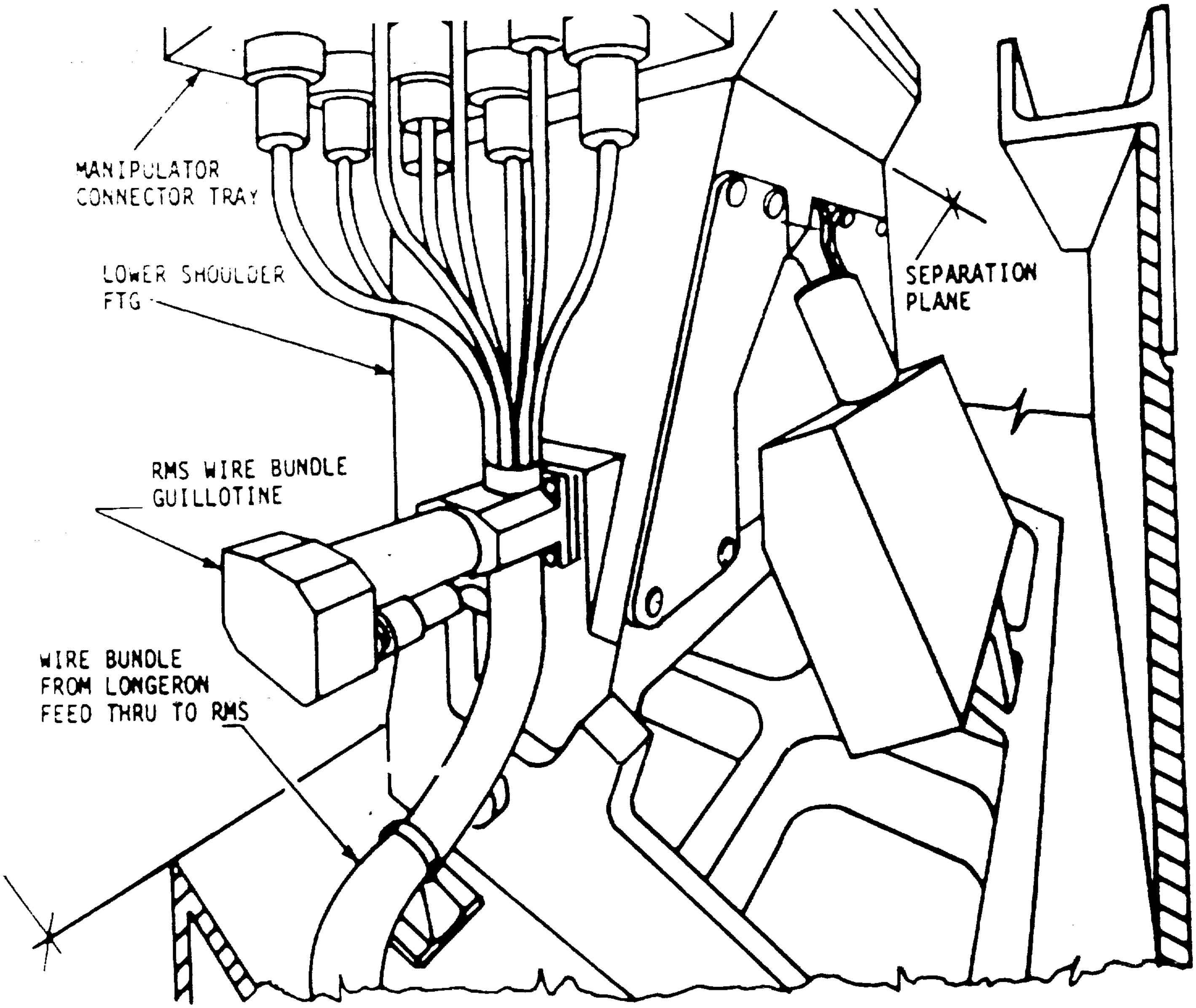

Figure 7 - REMOTE MANIPULATOR SYSTEM (RMS) WIRE BUNDLE GUILLOTINE

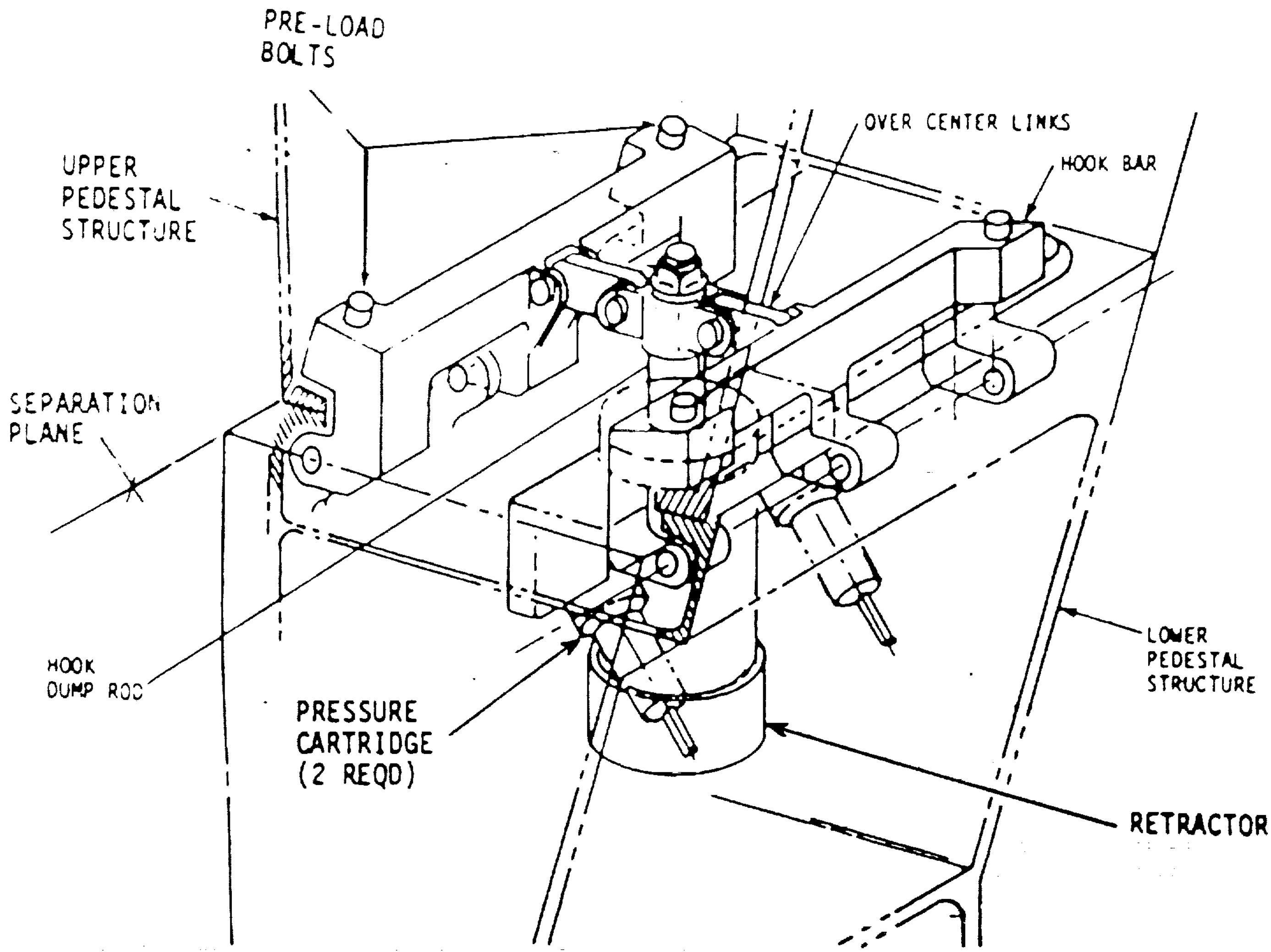

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Figure 8 - RMS RETRACTOR

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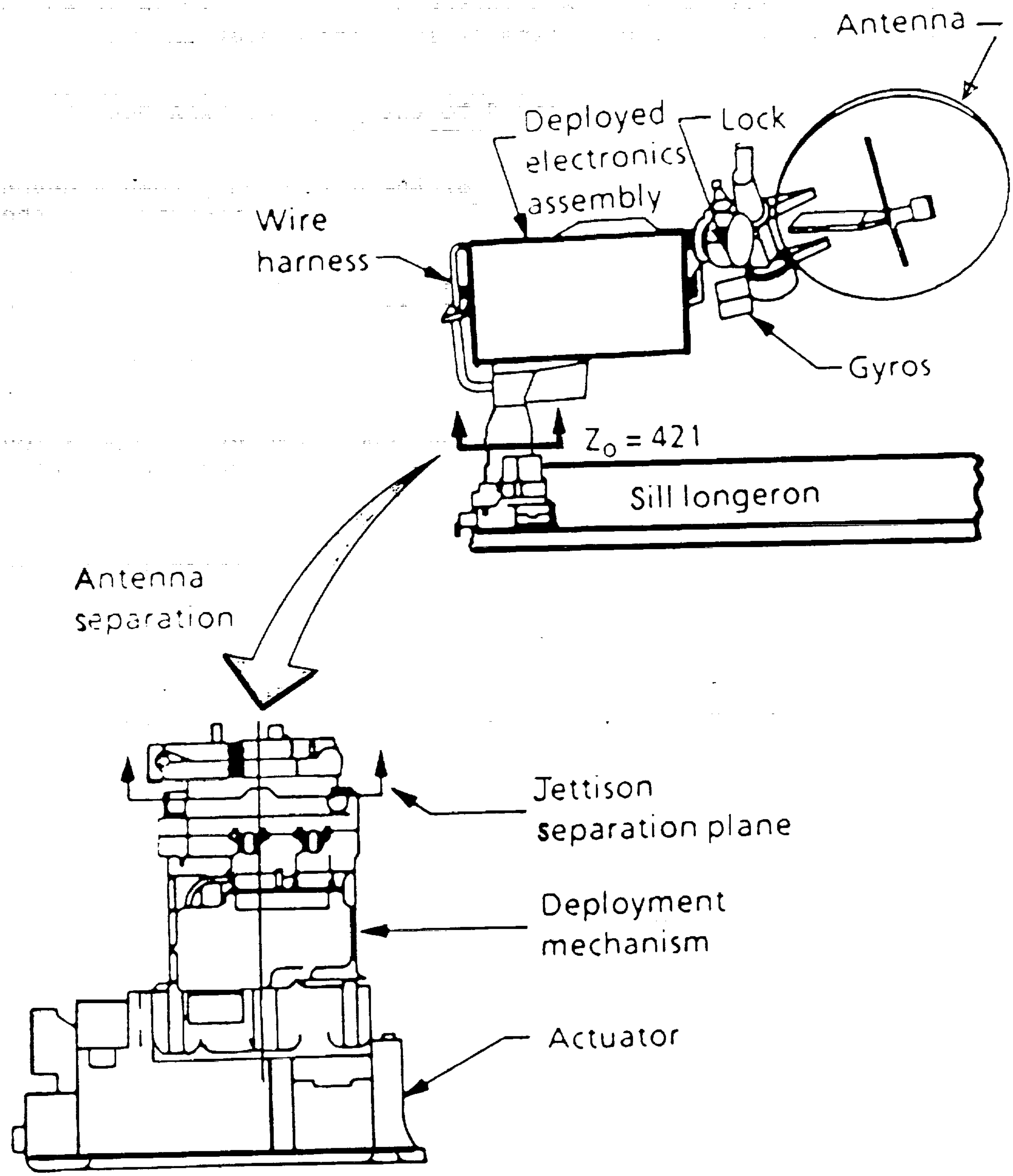

Figure 9 - RENDEZVOUS RADAR ANTENNA SEPARATION

4.0 ASSESSMENT RESULTS

The IOA analysis of the Pyrotechnics hardware initially generated forty-one (41) failure mode worksheets and identified forty-one (41) Potential Critical Items (PCIs) before starting the assessment process. No additional failure mode analysis worksheets were generated to facilitate comparison. These analysis results were compared to the proposed NASA Post 51-L baseline of thirty-seven (37) FMEAs and thirty-seven (37) CIL items, which were generated using the NSTS-22206 FMEA/CIL instructions. Upon completion of the assessment, twenty-seven (27) of the thirty-seven (37) FMEAs were in agreement. Of the thirteen (13) that remained, seven (7) had minor discrepancies that did not affect criticality. Of the remaining six (6), three (3) were the result of data entry errors and involve the numerical criticality assignment. IOA recommends upgrading the criticalities of two (2) IOA FMEAs from 2/1R to 1/1 and downgrading the criticality of one IOA FMEA from 1/1 to 2/1R. There are four (4) IOA FMEAs for two (2) components not analyzed by the NASA FMEAs. In summary, IOA recommends that the credible failure modes of "Fail to Function" and "Inadvertent Operation" be included for the respective pressure cartridges in the RMS Guillotine Assembly and the Rendezvous Radar Release Mechanism.

A summary of the quantity of NASA FMEAs assessed, versus the recommended IOA baseline, and any issues identified is presented in Table I.

Table I Summary of IOA FMEA Assessment

Component	NASA	IOA	Issues
Landing/Decel	9	9	0
Orbiter/ET Sep	12	12	0
Rend Radar Rel	4	8	4
P/L Retn/Depl	6	6	0
Crew Sta & Eqp	6	6	0
TOTAL	37	41	4

A summary of the quantity of NASA CIL items assessed, versus the recommended IOA baseline, and any issues identified is presented in Table II.

Table II Summary of IOA CIL Assessment			
Component	NASA	IOA	Issues
Landing/Decel	9	9	0
Orbiter/ET Sep	12	12	0
Rend Radar Rel	4	8	4
P/L Retn/Depl	6	6	0
Crew Sta & Eqp	6	6	0
TOTAL	37	41	4

Appendix C presents the detailed assessment worksheets for each failure mode identified and assessed. Appendix D highlights the NASA Critical Items and corresponding IOA worksheet ID. Appendix E contains IOA analysis worksheets supplementing previous analysis results reported in Space Transportation System Engineering and Operations Support (STSEOS) Working Paper No. 1.0-WP-VA86005-01, Analysis of the Pyrotechnics Subsystem, 19 January, 1988. Appendix F provides a cross reference between the NASA FMEA and corresponding IOA worksheet(s). IOA recommendations are also summarized.

Table III presents a summary of the IOA recommended failure criticalities for the Post 51-L FMEA baseline. Further discussion of each of these subdivisions and the applicable failure modes is provided in subsequent paragraphs.

TABLE III Summary of IOA Recommended Failure Criticalities							
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Landing/Decel	8	1	0	0	0	0	9
Orbiter/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	28	10	3	0	0	0	41

Of the failure modes analyzed, forty-one (41) were determined to be critical items. A summary of the IOA recommended critical items is presented in Table IV.

TABLE IV Summary of IOA Recommended Critical Items							
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Landing/Decel	8	1	0	0	0	0	9
Orbiter/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	28	10	3	0	0	0	41

The scheme for assigning IOA assessment (Appendix C) and analysis (Appendix E) worksheet numbers is shown in Table V.

Table V IOA Worksheet Numbers

Pyrotechnic Systems and Components	ID Number
LANDING/DECELERATION SYSTEMS	
MLG Uplock Release Thruster Assy	4601
MLG Uplock Release Thruster Pressure Cartridge	4602
MLG Uplock Release Thruster Pressure Cartridge	4603
NWG Uplock Release Thruster Assy	4604
NWG Uplock Release Thruster Pressure Cartridge	4605
NWG Uplock Release Thruster Pressure Cartridge	4606
NWG Extension Assist Thruster Assy	4607
NWG Exten Assist Thrust Assy Pressure Cartridge	4608
NWG Exten Assist Thrust Assy Pressure Cartridge	4609
ORBITER/ET SEPARATION MECHANISMS	
Forward Separation Shear Bolt	4651
Forward Separation Shear Bolt	4652
Fwd Sep Shear Bolt Pressure Cartridge	4653
Fwd Sep Shear Bolt Pressure Cartridge	4654
Aft Separation Frangible Nut (1 Left/1 Right)	4655
Aft Separation Frangible Nut (1 Left/1 Right)	4656
Aft Sep Frangible Nut Detonator Booster (2/Nut)	4657
Aft Sep Frangible Nut Detonator Booster (2/Nut)	4658
Umbilical Plate Sep Frangible Nut (3/Plate)	4661
Umbilical Plate Sep Frangible Nut (3/Plate)	4662
Umbil Plate Sep Frangible Nut Detonator (2/Nut)	4663
Umbil Plate Sep Frangible Nut Detonator (2/Nut)	4664
RENDEZVOUS RADAR ANTENNA EMERGENCY RELEASE	
Guillotine Assy	4701
Guillotine Assy	4702
Guillotine Assy Pressure Cartridge	4703
Guillotine Assy Pressure Cartridge	4704
Release Nut	4705
Release Nut	4706
Release Nut Pressure Cartridge	4707
Release Nut Pressure Cartridge	4708

Table V IOA Worksheet Numbers (Cont'd)	
Pyrotechnic Systems and Components	ID Number
PAYLOAD RETENTION AND DEPLOY RMS RELEASE	
Manipulator Positioning Mechanism Retractor	4751
Manipulator Positioning Mechanism Retractor	4752
Shoulder Umbilical Guillotine Assy Type I	4753
Shoulder Umbilical Guillotine Assy Type I	4754
Pedestal Umbilical Guillotine Assy Type II	4755
Pedestal Umbilical Guillotine Assy Type II	4756
CREW STATION AND EQUIPMENT	
Outer Window Assy	4801
Inner Window Assy	4802
Energy Transfer System	4803
Initiator Assy Pyro	4804
0.3-Sec Time Delay Cartridge Assy	4805
Thru Bulkhead Initiator	4806

4.1 Assessment Results - Landing/Deceleration System Pyrotechnics

The IOA analysis of the Landing/Deceleration System Pyrotechnics generated nine (9) failure mode worksheets and identified nine (9) Potential Critical Items before starting the assessment process. Of the nine (9) IOA FMEAs, seven (7) were Criticality 1/1 and two were Criticality 2/1R. The NASA analysis consisted of nine (9) FMEAs and nine (9) CIL items. Of the nine (9), eight (8) were Criticality 1/1 and one (1) was Criticality 2/1R. After re-evaluating the component involved and the function it performs in comparison to the NASA Post 51L FMEA/CILs, IOA recommends the IOA FMEAs be changed to agree with the NASA FMEAs and CIL items. There are no issues to be resolved for the Landing/Deceleration System Pyrotechnics.

4.2 Assessment Results - Orbiter/ET Separation Mechanisms Pyrotechnics

The IOA analysis of the Orbiter/ET Separation Mechanisms Pyrotechnics generated twelve (12) failure mode worksheets and identified twelve (12) Potential Critical Items before starting the assessment process. Of the twelve (12) IOA FMEAs, nine (9) were Criticality 1/1 and three (3) were Criticality 2/1R and all are considered PCIs. The NASA analysis consisted of twelve (12) FMEAs and twelve (12) CIL items. Of the twelve (12), nine (9) were Criticality 1/1 and three (3) were Criticality 2/1R. There are no issues to be resolved for the Orbiter/ET Separation Mechanisms Pyrotechnics.

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

The IOA analysis of the RR Antenna Release Pyrotechnics generated eight (8) failure mode worksheets and identified eight (8) Potential Critical Items before starting the assessment process. Of the eight (8) IOA FMEAs, four (4) were Criticality 1/1, two (2) were Criticality 2/1R and two (2) were Criticality 2/2. The NASA baseline consists of four (4) FMEAs and four (4) CIL items. The four (4) NASA FMEAs and four (4) of the IOA FMEAs are in agreement. However, there are four (4) IOA FMEAs which were generated for two (2) RR Antenna Release Pyrotechnics components that were not included in the NASA baseline. The two (2) components involved are the dual Pressure Cartridges for the Guillotine Assembly and also the dual Pressure Cartridges for the Release Nut. The failure modes identified by IOA are "Fail to Function" and "Inadvertent Operation" which results in four FMEAs, all of which are considered to be Potential Critical Items. IOA recommends that the NASA consider these failure modes for inclusion in the CIL for the RR Antenna Release Pyrotechnics. These issues have not been resolved.

4.4 Assessment Results - Payload Retention/Deploy Guillotine and Jettison Pyrotechnics

The IOA analysis of the Payload Retention/Deploy Guillotine and Jettison Pyrotechnics generated six (6) failure mode worksheets and identified six (6) Potential Critical Items before starting the assessment process. Of the six (6) IOA FMEAs, five (5) were Criticality 1/1 and one (1) was Criticality 2/2. The are considered PCIs. The NASA analysis consisted of six (6) FMEAs and six (6) CIL items. Of the six (6), five (5) were Criticality 1/1 and one (1) was Criticality 2/2. There are no issues to be resolved for the Payload Retention/Deploy Guillotine and Jettison Pyrotechnics.

4.5 Assessment Results - Crew Station and Equipment Ground Emergency Egress Pyrotechnics

The IOA analysis of the Crew Station and Equipment Ground Emergency Egress Pyrotechnics generated six (6) failure mode worksheets and identified six (6) Potential Critical Items before starting the assessment process. Of the six (6) IOA FMEAs, two (2) were Criticality 1/1 and four (4) were Criticality 2/1R. There are no issues to be resolved for the Crew Station and Equipment Emergency Egress Pyrotechnics.

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 / ET Forward Attach, Assembly of, Rev A-02, May 27, 1986

5.0 REFERENCES cont'd

28. V070-565000, Rockwell Drawing, Installation - ET Umbilical Door Mechanism, Rev F-08, Jun 28, 1984

29. V070-565212, Rockwell Drawing, Spring, Helical Compression, Orbiter / ET Aft Attach Separation System, Rev A-09, Oct 30, 1981

30. V070-565217, Rockwell Drawing, Bolt, Frangible Nut, Orbiter / ET Aft Attach Separation System, Rev A-09, Jun 19, 1975

31. V070-565330, Rockwell Drawing, Bracket Assembly - Orbiter LO2 Electrical, Umbilical, ET / Orbiter Separation System, Rev D-07, Oct 28, 1982

32. V070-565371, Rockwell Drawing, Curtain Closeout, ET Umbilical Plate, LH2, Assembly of, Rev C-02, Jun 15, 1986

33. V070-565381, Rockwell Drawing, Side Strut - Orbiter / External Tank Umbilical Separation System, Assembly of, Rev A-01, May 13, 1976

34. V070-565382, Rockwell Drawing, Side Strut Installation - Umbilical Separation System, External Tank, Rev A-03, Jan 12, 1983

35. V070-565396, Rockwell Drawing, Curtain Closeout, ET Umbilical Plate, LO2, Assembly of, Rev C-03, Jun 13, 1986

36. V070-585227, Rockwell Drawing, Clamp Set - Support, Two Lines, Rev 7, Nov 7, 1975

37. V072-555215, Rockwell Drawing, Pyrotechnic and Cover Installation - Orbiter / External Tank, Aft Attach / Separation System Rev D-03, Mar 3, 1987

38. V072-555369, Rockwell Drawing, Wire Harness Installation - ET / Orbiter, Umbilical Hold Down / Release, Rev E-01, Jan 23, 1983

39. V072-565201, Rockwell Drawing, Fastener Installation - Orbiter / External Tank, Aft Attach / Separation System, Rev D-05, Feb 27, 1987

40. V072-565249, Rockwell Drawing, Stopper - Orbiter / External Tank, Aft Attach - Separation System, Rev A-03, May 19, 1982

41. V072-565370, 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
Amp - Ampere
Ant - Antenna
ATO - Abort To Orbit

BFS - Backup Flight Software

CB - Circuit Breaker
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

Hdw - Hardware
Herm - Hermetically

HW - Hardware
Hz - Hertz (cycles per second)

IOA - Independent Orbiter Analysis

Jett - Jettison

LH2 - Liquid Hydrogen
Lim - Limiting
LO2 - Liquid Oxygen

ACRONYMS and ABBREVIATIONS (Cont'd)

MDAC	- McDonnell Douglas Astronautics Company
MDM	- Multiplexer/Demultiplexer
MLG	- Main Landing Gear
MPM	- Manipulator Positioning Mechanixm
MRL	- Manipulatot Retention Mechanism
NA	- Not applicable
NASA	- National Aeronautics and Space Administration
NLG	- Nose Landing Gear
NSI	- NASA Standard Initiator
NSTS	- National Space Transportation System
OA	- Operational Aft
OAO	- Once-Around-Abort
ATO	- Abort-to-Orbit
OF	- Operational Forward
Orb	- Orbiter
P	- Pass
PASS	- Primary Avionics Systems Software
PBM	- Payload Bay Mechanical
PCA	- Power Controller Assembly
PCI	- Potential Critical Item
Ph	- Phase
PIC	- Pyro Initiator Controller
P/L	- Payload
PLBD	- Paylaod Bay Door
Pos	- Position
Pyro	- Pyrotechnic
Rel	- Release
Retn	- Retention
RMS	- Remote Manipulator System
RPC	- Remote Power Controller
RR	- Rendezvous Radar
RTLS	- Return-To-Launch-Site
Sep	- Separation
Sta	- Station
STS	- Space Transportation System
Sys	- System
TAL	- Trans-Atlantic-Landing (Abort Landing)
VAC	- Volts Alternating Current
VDC	- Volts Direct Current
1-Ph	- Single Phase
3-Ph	- Three Phase

APPENDIX B

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.1 Definitions
B.2 Project Level Ground Rules and Assumptions
B.3 Subsystem-Specific 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 of 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 ASSESSMENT

This section contains the IOA assessment worksheets generated during the Assessment of the Pyrotechnics Subsystem. The information on these worksheets facilitates the comparison of the NASA FMEA/CIL (Pre and Post 51-L) to the IOA detailed analysis worksheets included in Appendix E. Each of these worksheets identifies the NASA FMEA being assessed, corresponding MDAC Analysis Worksheet ID (Appendix E), hardware item, criticality, redundancy screens, and recommendations. For each failure mode, the highest assessed hardware and functional criticality is compared and discrepancies noted as "N" in the compare row under the column where the discrepancy occurred.

LEGEND FOR IOA ASSESSMENT WORKSHEETS

Hardware Criticalities:
- 1 = Loss of life or vehicle
- 2 = Loss of mission or next failure of any redundant item (like or unlike) could cause loss of life/vehicle
- 3 = All others

Functional Criticalities:
- 1R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of life or vehicle
- 2R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of mission

Redundancy Screens A, B and C:
- P = Passed Screen
- F = Failed Screen
- NA = Not Applicable

NASA Data :
- Baseline = NASA FMEA/CIL
- New = Baseline with Proposed Post 51-L Changes

CIL Item :
- X = Included in CIL

Compare Row :
- N = Non compare for that column (deviation)

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4601
NASA FMEA #: P2-1A-015-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4601
ITEM: THRUSTER ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4602
NASA FMEA #: P2-1A-035-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4602
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4603
NASA FMEA #: P2-1A-035-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4603
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4604
NASA FMEA #: P2-1A-097-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4604
ITEM: THRUSTER ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE, IOA CONCURS WITH NASA POST 51L FMEA. UPGRADE IOA CRIT TO 1/1.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4605
NASA FMEA #: P2-1A-103-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4605
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE, IOA CONCURS WITH NASA POST 51L FMEA. UPGRADE IOA CRIT TO 1/1.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4606
NASA FMEA #: P2-1A-103-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4606
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4607
NASA FMEA #: P2-1A-104-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4607
ITEM: THRUSTER ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4608
NASA FMEA #: P2-1A-107-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4608
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[NA]	[NA]	[P]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[ ]	[ ]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. IOA CONCURS WITH THE NASA FMEA. RECOMMEND DOWNGRADING THE CRIT OF THIS FMEA TO 2/1R.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4609
NASA FMEA #: P2-1A-107-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4609
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4651
NASA FMEA #: 02-3-F3-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4651
ITEM: SHEAR BOLT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4652
NASA FMEA #: 02-3-F3-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4652
ITEM: SHEAR BOLT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4653
NASA FMEA #: 02-3-F1-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4653
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[NA]	[NA]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA FMEA SCREEN C.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4654
NASA FMEA #: 02-3-F1-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4654
ITEM: PRESSURE CARTRIDGE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4655
NASA FMEA #: 02-3-A4-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4655
ITEM: FRANGIBLE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4656
NASA FMEA #: 02-3-A4-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4656
ITEM: FRANGIBLE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4657
NASA FMEA #: 02-3-A6-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4657
ITEM: DETONATOR BOOSTER (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[NA]	[NA]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA SCREEN C.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4658
NASA FMEA #: 02-3-A6-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4658
ITEM: DETONATOR BOOSTER (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4661
NASA FMEA #: 02-3-U4-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4661
ITEM: FRANGIBLE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4662
NASA FMEA #: 02-3-U4-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4662
ITEM: FRANGIBLE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4663
NASA FMEA #: 02-3-U1-1

NASA DATA:
BASELINE [ ]
NEW [x]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4663
ITEM: DETONATOR

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[NA]	[NA]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA FMEA SCREEN C.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4664
NASA FMEA #: 02-3-U1-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4664
ITEM: DETONATOR

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[ ]	[ ]	[ ]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4701
NASA FMEA #: 02-4-R103-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4701
ITEM: GUILLOTINE ASSY, PYROTECHNIC

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[F]	[P]	[P]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4702
NASA FMEA #: 02-4-R103-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4702
ITEM: GUILLOTINE ASSY, PYROTECHNIC

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /2]	[P]	[F]	[P]	[X] *
IOA	[2 /2]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4703
NASA FMEA #: NONE

NASA DATA:
BASELINE [ ]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4703
ITEM: PRESSURE CARTRIDGE (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[/]	[ ]	[ ]	[ ]	[ ] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

[2 /1R]	[NA]	[NA]	[NA]	[X] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
RECOMMEND THAT A NASA FMEA BE GENERATED FOR THIS FAILURE MODE FOR THIS COMPONENT.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4704
NASA FMEA #: NONE

NASA DATA:
BASELINE [ ]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4704
ITEM: PRESSURE CARTRIDGE (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[/]	[ ]	[ ]	[ ]	[ ] *
IOA	[2 /2]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

[2 /2]	[ ]	[ ]	[ ]	[X] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
RECOMMEND THAT A NASA FMEA BE GENERATED FOR THIS FAILURE MODE FOR THIS COMPONENT.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4705
NASA FMEA #: 02-4-R104-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4705
ITEM: RELEASE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[P]	[F]	[P]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4706
NASA FMEA #: 02-4-R104-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4706
ITEM: RELEASE NUT

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[P]	[F]	[P]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4707
NASA FMEA #: NONE

NASA DATA:
BASELINE [ ]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4707
ITEM: PRESSURE CARTRIDGE (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[/]	[ ]	[ ]	[ ]	[ ] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

[2 /1R]	[ ]	[ ]	[ ]	[X] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
RECOMMEND THAT A NASA FMEA BE GENERATED FOR THIS FAILURE MODE FOR THIS COMPONENT.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4708
NASA FMEA #: NONE

NASA DATA:
BASELINE [ ]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4708
ITEM: PRESSURE CARTRIDGE (2)

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[/]	[ ]	[ ]	[ ]	[ ] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[N /N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

	[1 /1]	[ ]	[ ]	[ ]	[X] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
RECOMMEND THAT A NASA FMEA BE GENERATED FOR THIS FAILURE MODE FOR THIS COMPONENT.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4751
NASA FMEA #: 02-5-J01-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4751
ITEM: RETRACTOR - MANIPULATOR ARM RELEASE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4752
NASA FMEA #: 02-5-J01-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4752
ITEM: RETRACTOR - MANIPULATOR ARM RELEASE

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4753
NASA FMEA #: 02-5-J02-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4753
ITEM: GUILLOTINE ASSY PYRO

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4754
NASA FMEA #: 02-5-J02-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4754
ITEM: GUILLOTINE ASSY PYRO

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4755
NASA FMEA #: 02-5-J04-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4755
ITEM: GUILLOTINE ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4756
NASA FMEA #: 02-5-J04-2

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4756
ITEM: GUILLOTINE ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /2]	[ ]	[ ]	[ ]	[X] *
IOA	[2 /2]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4801
NASA FMEA #: 07-48051-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4801
ITEM: OUTER WINDOW ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4802
NASA FMEA #: 07-48052-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4802
ITEM: OUTER WINDOW ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[1 /1]	[NA]	[NA]	[NA]	[X] *
IOA	[1 /1]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NONE

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4803
NASA FMEA #: 07-48053-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4803
ITEM: ENERGY TRANSFER SYSTEM

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[F]	[F]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA SCREENS.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4804
NASA FMEA #: 07-48054-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4804
ITEM: INITIATOR ASSY PYRO

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[F]	[F]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA SCREENS.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4805
NASA FMEA #: 07-48055-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4805
ITEM: 0.3-SEC TIME DELAY CARTRIDGE ASSY

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[F]	[F]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

	[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA SCREENS.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 2/04/88
ASSESSMENT ID: PYRO-4806
NASA FMEA #: 07-48056-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: PYROTECHNICS
MDAC ID: 4806
ITEM: THRU BULKHEAD INITIATOR

LEAD ANALYST: W. W. ROBINSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[2 /1R]	[F]	[F]	[P]	[X] *
IOA	[2 /1R]	[NA]	[NA]	[NA]	[X]
COMPARE	[/]	[N]	[N]	[N]	[ ]

RECOMMENDATIONS: (If different from NASA)

[/]	[ ]	[ ]	[ ]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)
ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CORRECT IOA SCREENS.

APPENDIX D

CRITICAL ITEMS

APPENDIX D

CRITICAL ITEMS

NASA FMEA	IOA ID	ITEM	FAILURE MODE
P2-1A-015-2	4601	THRUSTER ASSY	FAILS TO OPERATE
P2-1A-035-1	4602	PRESSURE CARTRIDGE	FAILS TO OPERATE
P2-1A-035-2	4603	PRESSURE CARTRIDGE	INADVERTENT OPERATION
P2-1A-097-1	4604	THRUSTER ASSY	FAILS TO OPERATE
P2-1A-103-1	4605	PRESSURE CARTRIDGE	FAILS TO OPERATE
P2-1A-103-2	4606	PRESSURE CARTRIDGE	FIRES INADVERTENTLY
P2-1A-104-1	4607	THRUSTER ASSY	FAIL TO OPERATE
P2-1A-107-1	4608	PRESSURE CARTRIDGE	FAIL TO OPERATE
P2-1A-107-2	4609	PRESSURE CARTRIDGE	FIRES INADVERTENTLY
02-3-F3-1	4651	SHEAR BOLT	PREMATURE FRACTURE
02-3-F3-2	4652	SHEAR BOLT	FAIL TO FRACTURE
02-3-F1-1	4653	PRESSURE CARTRIDGE	FAIL TO FUNCTION
02-3-F1-2	4654	PRESSURE CARTRIDGE	INADVERTENT OPERATION
02-3-A4-1	4655	FRANGIBLE NUT	PREMATURE FRACTURE
02-3-A4-2	4656	FRANGIBLE NUT	FAIL TO FRACTURE
02-3-A6-1	4657	DETONATOR BOOSTER (2)	FAILS TO FIRE
02-3-A6-2	4658	DETONATOR BOOSTER (2)	INADVERTENT OPERATION
02-3-U4-1	4661	FRANGIBLE NUT	FAIL TO FRACTURE
02-3-U4-2	4662	FRANGIBLE NUT	PREMATURE FRACTURE
02-3-U1-1	4663	DETONATOR	FAIL TO FIRE
02-3-U1-2	4664	DETONATOR	INADVERTENT OPERATION
02-4-R103-1	4701	GUILLOTINE ASSY, PYRO	FAIL TO FUNCTION
02-4-R103-2	4702	GUILLOTINE ASSY, PYRO	INADVERTENT OPERATION
NONE	4703	PRESSURE CARTRIDGE (2)	FAIL TO FUNCTION
NONE	4704	PRESSURE CARTRIDGE (2)	INADVERTENT OPERATION
02-4-R104-1	4705	RELEASE NUT	FAIL TO FUNCTION
02-4-R104-2	4706	RELEASE NUT	INADVERTENT OPERATION
NONE	4707	PRESSURE CARTRIDGE (2)	FAIL TO FUNCTION
NONE	4708	PRESSURE CARTRIDGE (2)	INADVERTENT OPERATION
02-5-J01-1	4751	RETRACTOR - MANIP ARM	FAILS TO FUNCTION
02-5-J01-2	4752	RETRACTOR - MANIP ARM	INADVERTENT OPERATION
02-5-J02-1	4753	GUILLOTINE ASSY PYRO	FAILS TO FUNCTION
02-5-J02-2	4754	GUILLOTINE ASSY PYRO	INADVERTENT OPERATION
02-5-J04-1	4755	GUILLOTINE ASSY	FAILS TO FUNCTION
02-5-J04-2	4756	GUILLOTINE ASSY	INADVERTENT OPERATION
07-48051-1	4801	OUTER WINDOW ASSY	FAILS TO OPEN
07-48052-1	4802	OUTER WINDOW ASSY	FAILS TO OPEN
07-48053-1	4803	ENERGY TRANSFER SYSTEM	REDUCED OR NO OUTPUT
07-48054-1	4804	INITIATOR ASSY PYRO	NO OUTPUT
07-48055-1	4805	0.3-SEC TIME DEL CART	NO OUTPUT, X-S DELAY
07-48056-1	4806	THRU BULKHEAD INIT	NO OUTPUT

APPENDIX E
DETAILED ANALYSIS

This appendix contains the IOA analysis worksheets supplementing previous results reported in STSEOS Working Paper 1.0-WP-VA85001-01, Analysis of the Pyrotechnics Subsystem FMEA/CIL (01 January 1988). Prior results were obtained independently and documented before starting the FMEA/CIL assessment activity. Supplemental analysis was performed to address failure modes not previously considered by the IOA. Each sheet identifies the hardware item being analyzed, parent assembly and function performed. For each failure mode possible causes are identified, and hardware and functional criticality for each mission phase are determined as described in NSTS 22206, Instructions for Preparation of FMEA and CIL, 10 October 1986. Failure mode effects are described at the bottom of each sheet and worst case criticality is identified at the top.

LEGEND FOR IOA ANALYSIS WORKSHEETS

Hardware Criticalities:
- 1 = Loss of life or vehicle
- 2 = Loss of mission or next failure of any redundant item (like or unlike) could cause loss of life/vehicle
- 3 = All others

Functional Criticalities:
- 1R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of life or vehicle.
- 2R = Redundant hardware items (like or unlike) 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
- NA = Not Applicable

Redundancy Screens B and C:
- P = Passed Screen
- F = Failed Screen
- NA = Not Applicable

APPENDIX F

NASA FMEA TO IOA WORKSHEET CROSS REFERENCE/RECOMMENDATIONS

This section provides a cross reference between the NASA FMEA and corresponding IOA analysis worksheet(s) included in Appendix E. The Appendix F identifies: NASA FMEA Number, IOA Assessment Number, NASA criticality and redundancy screen data, and IOA recommendations.

Appendix F Legend

<u>Code</u> <u>Definition</u>

1 IOA recommends Upgrading the FMEA Crit from 2/1R to 1/1.

2. IOA recommends that a NASA FMEA be generated for this failure mode for this component.

3. IOA recommends correcting the screens on this IOA FMEA.

4. IOA recommends Downgrading the FMEA Crit from 1/1 to 2/1R.

APPENDIX F

NASA FMEA TO IOA WORKSHEET CROSS REFERENCE/RECOMMENDATIONS

IDENTIFIERS		NASA						IOA						RECOMMEND	
NASA FMEA NUMBER	IOA ASSESSMENT NO.	CRIT HW/F	SCREENS A	B	C			CRIT HW/F	SCREENS A	B	C			RES CODES	ISSUE
P2-1A-015-2	PYRO-4601	1/1						1/1	NA	NA	NA				
P2-1A-035-1	PYRO-4602	1/1						1/1	NA	NA	NA				
P2-1A-035-2	PYRO-4603	1/1						1/1	NA	NA	NA				
P2-1A-097-1	PYRO-4604	1/1						2/1R	NA	NA	NA			1	
P2-1A-103-1	PYRO-4605	1/1						2/1R	NA	NA	NA			1	
P2-1A-103-2	PYRO-4606	1/1						1/1	NA	NA	NA				
P2-1A-104-1	PYRO-4607	1/1						1/1	NA	NA	NA				
P2-1A-107-1	PYRO-4608	1/1						1/1	NA	NA	NA				
P2-1A-107-2	PYRO-4609	1/1						1/1	NA	NA	NA				
02-3-F3-1	PYRO-4651	1/1						1/1	NA	NA	NA				
02-3-F3-2	PYRO-4652	1/1						1/1	NA	NA	NA				
02-3-F1-1	PYRO-4653	2/1R	NA	NA	P			2/1R	NA	NA	NA			3	

IDENTIFIERS		NASA					IOA					RECOMMEND	
NASA FMEA NUMBER	IOA ASSESSMENT NO.	CRIT HW/F	SCREENS A	B	C		CRIT HW/F	SCREENS A	B	C		RES CODES	ISSUE
02-3-F1-2	PYRO-4654	1/1					1/1	NA	NA	NA			
02-3-A4-1	PYRO-4655	1/1					1/1	NA	NA	NA			
02-3-A4-2	PYRO-4656	1/1					1/1	NA	NA	NA			
02-3-A6-1	PYRO-4657	2/1R	NA	NA	P		2/1R	NA	NA	NA		3	
02-3-A6-2	PYRO-4658	1/1					1/1	NA	NA	NA			
02-3-U4-1	PYRO-4661	1/1					1/1	NA	NA	NA			
02-3-U4-2	PYRO-4662	1/1					1/1	NA	NA	NA			
02-3-U1-1	PYRO-4663	2/1R	NA	NA	P		2/1R	NA	NA	NA		3	
02-3-U1-2	PYRO-4664	1/1					1/1	NA	NA	NA			
02-4-R103-1	PYRO-4701	1/1	F	P	P		1/1	NA	NA	NA			
02-4-R103-2	PYRO-4702	2/2	P	F	P		2/2	NA	NA	NA			
X1	PYRO-4703	/					2/1R	NA	NA	NA		2	X
X2	PYRO-4704	/					2/2	NA	NA	NA		2	X
02-4-R104-1	PYRO-4705	1/1	P	F	P		1/1	NA	NA	NA			
02-4-R104-2	PYRO-4706	1/1	P	F	P		1/1	NA	NA	NA			

IDENTIFIERS		NASA				IOA				RECOMMEND	
NASA FMEA NUMBER	IOA ASSESSMENT NO.	CRIT HW/F	SCREENS A	B	C	CRIT HW/F	SCREENS A	B	C	RES CODES	ISSUE
X3	PYRO-4707	/				2/1R	NA	NA	NA	2	X
X4	PYRO-4708	/				1/1	NA	NA	NA	2	X
02-5-J01-1	PYRO-4751	1/1	NA	NA	NA	1/1	NA	NA	NA		
02-5-J01-2	PYRO-4752	1/1	NA	NA	NA	1/1	NA	NA	NA		
02-5-J02-1	PYRO-4753	1/1	NA	NA	NA	1/1	NA	NA	NA		
02-5-J02-2	PYRO-4754	1/1	NA	NA	NA	1/1	NA	NA	NA		
02-5-J04-1	PYRO-4755	1/1	NA	NA	NA	1/1	NA	NA	NA		
02-5-J04-2	PYRO-4756	2/2				2/2	NA	NA	NA		
07-48051-1	PYRO-4801	1/1	NA	NA	NA	1/1	NA	NA	NA		
07-48052-1	PYRO-4802	1/1	NA	NA	NA	1/1	NA	NA	NA		
07-48053-1	PYRO-4803	2/1R	F	F	P	2/1R	NA	NA	NA	3	
07-48054-1	PYRO-4804	2/1R	F	F	P	2/1R	NA	NA	NA	3	
07-48055-1	PYRO-4805	2/1R	F	F	P	2/1R	NA	NA	NA	3	
07-48056-1	PYRO-4806	2/1R	F	F	P	2/1R	NA	NA	NA	3	