INDEPENDENT ORBITER ASSESSMENT

ASSESSMENT
OF THE
RUDDER/SPEED BRAKE
SUBSYSTEM

05 FEBRUARY 1988

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

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INDEPENDENT ORBITER ASSESSMENT
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05 FEBRUARY 1988

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PREPARED BY: R.E. Wilson
Senior Analyst
Independent Orbiter Assessment

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

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

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.

The IOA effort first completed an analysis of the Rudder/Speed Brake (RSB) 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 along with the proposed Post 51-L CIL updates included. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter RSB hardware.

The IOA product for the RSB analysis consisted of thirty-eight failure mode "worksheets" that resulted in twenty-seven potential critical items being identified. Comparison was made to the NASA baseline (as of 7 December 1987) which consisted of (Note 1) thirty-four FMEAs and eighteen CIL items. The comparison determined if there were any results which had been found by the IOA but were not in the NASA baseline. This comparison produced agreement on all CIL items. Based on the Pre 51-L baseline, all non-CIL FMEAs were also in agreement. Based on discussions with the NASA subsystem manager, no additional non-CIL FMEAs are anticipated for the past 51-L update. Figure 1 presents a comparison of the proposed Post 51-L NASA baseline, with the IOA recommended baseline, and any issues.

Note 1. The comparison of NASA FMEA Non-CIL items is based on the Pre 51-L baseline since all Post 51-L FMEAs have not been received as the date of this report.

The issues 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 discrepancies found that were not already identified by NASA, and the remaining issues may be attributed to differences in ground rules.

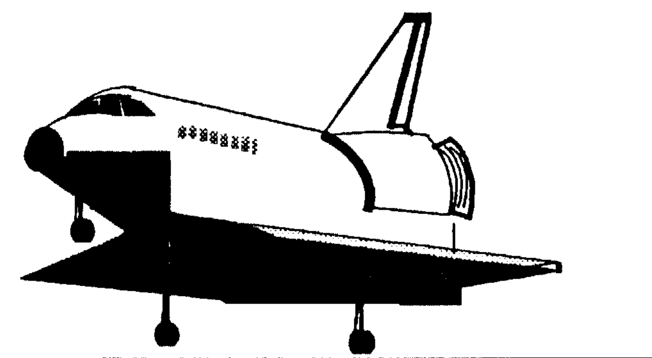
RSB ACTUATOR ASSESSMENT OVERVIEW

RSB ACTUATOR ASSESSMENT SUMMARY							
ORIGINAL ASSESSMENT*				FINAL RESOLUTION**			
	IOA	NASA	ISSUES		IOA	NASA	ISSUES
FMEA	38	33	5	FMEA	34	34	0
CIL	27	20	7	CIL	18	18	0

POWER DRIVE UNIT	IOA	NASA	ISSUES
FMEA	36	30	5
CIL	25	18	7

ROTARY ACTUATOR	IOA	NASA	ISSUES
FMEA	1	1	0
CIL	1	1	0

DRIVE SHAFT	IOA	NASA	ISSUES
FMEA	1	1	0
CIL	1	1	0



* *NASA PROPOSED BASELINE AS OF 20 MAY 1987*

** *FINAL NASA CIL ITEMS BASELINE AS OF 7 DEC 1987 AND NASA NON-CIL FMEAs - PRE 51-L BASELINE*

Figure 1 - RSB FMEA/CIL ASSESSMENT SUMMARY

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. There were no subsystem specific ground rules and assumptions used in this analysis.

3.0 SUBSYSTEM DESCRIPTION

3.1 Design and Function

The Rudder/Speedbrake Actuation Subsystem consists of that hardware required to provide both directional and energy control of the Orbiter during entry. The RSB subsystem consists of the following components.

1. A PDU is made up of two halves which are identical in makeup and operation: one for rudder and one for speedbrake. A switching valve determines which of the three Orbiter hydraulic systems supplies the PDU electro-hydraulic Servo VLV (E-H Servo VLV). There are eight E-H Servo VLVs: four in each PDU half. Each half of the PDU is controlled by four E-H Servo VLVs which receive commands from four Aerosurface Amplifiers/Flight Control System (ASA/FCS) channels.

   Each E-H Servo VLV receives from its ASA a position error command which it changes to a hydraulic pressure command. This is ported to a triplex power valve where the pressure (secondary Delta P) along with pressures from the three other E-H Servo VLVs command two valves that control pressure to three hydraulic motor/brake assemblies. These motors are used to drive a differential gearbox which sums all three motor torques and outputs it to a single drive shaft. The shaft is connected to a mixer gearbox. The mixer gearbox takes the drive shaft inputs from both the rudder and speedbrake channels, mixes them, and outputs them to a set of four rotary actuators which move the vertical panels. When the output shafts rotate in the same direction, the two panels move in the same direction thus providing rudder control. When the output shafts rotate in the opposite direction, the two panels move in opposite direction thus acting as a speedbrake.

   For each E-H Servo VLV there is an isolation valve which will isolate a failed E-H Servo VLV when its secondary delta P fails the ASA fault detection limits. The isolation valve can be commanded from the ASA, a crew keyboard input or an FCS switch taken to off. The crew can also inhibit an ASA isolation valve command by placing a FCS switch in the ORIDE position. If a problem develops within an E-H Servo VLV or its commanded position is different than the others, secondary delta P should begin to rise. Each channel has a secondary delta P transducer (LVDT) which sends Delta P to the ASA. Once the ASA detects secondary delta P at or above 2200 PSI for more than 120 msec, it will send an isolation command to the appropriate isolation valve which bypasses hydraulic pressure to the E-H Servo VLV causing its commanded pressure to the power spool to drop to zero.

Position from the Rotary Variable Differential Transformer (RVDT) on the differential gearbox are sent to the ASA and to the crew displays. Position is not used by the ASA for failure detection; it is used only to modify (negative feedback) the position command generated by the General Purpose Computer (GPC). The following is a list of the components of the PDU which were reviewed and analyzed for failure modes.

a. Switching Valve
b. Standby Hydraulic Circulation Valve
c. E-H Servo VLV
d. E-H Servo VLV Filter
e. Bypass Valve
f. Secondary Delta P Transducer
g. Triplex Power Valve
h. Hydraulic Motor/Brake Assembly
i. Differential Gearbox
j. Position Transducer
k. Mixer Gearbox

2. There are four geared rotary actuators which drive the two aerosurface panels. Commands from the PDU mixer gearbox are transmitted via two shaft outputs to the two columns of aluminum drive shafts connecting the four rotary actuators. Internal gears pick up the drive shaft inputs and move the brackets that contain the aerosurface fastening points. The Orbiter fastening points are fixed, attached to Orbiter structure. Each rotary actuator is made up of two driver gear assemblies, a series of satellite gear assemblies, and two center drum assemblies which drive independently of each other. Driveshaft rotations in the same direction will turn the center drums and therefore the aerosurface fastening in the same direction (rudder control). Driveshaft rotations in the opposite directions drive the center drums in opposite directions (speedbrake control).

3.2 Interfaces and Locations

The RSB interfaces with the four ASAs which receive commands via four FA MDM's from the four GPCs. Crew initiated inputs; Rudder Pedal Transducer Assembly (RPTA), Speedbrake Translation Controller (SBTC), and Rotation Hand Controller (RHC), are inputted to the GPCs. The crew can turn power on or off to any ASA channel, can place a FCS channel switch in ORIDE which bypasses the ASA fault detection circuitry, and send bypass inhibit commands to the ASA via keyboard entry.

The RSB actuation mechanism is physically located in the vertical stabilizer. The ASAs which provide position commands to the actuators are located in avionics bays 4, 5, and 6. The Surface Position Indicator (SPI) provides a gauge type display for the crew to check aerosurface position. It is located between Cathode Ray Tubes (CRTs) 1 and 2 on panel F7. The following CRT displays are available to the crew: GNC System Summary 1 (PASS and BFS), Spec 53 Entry Control Display, FCS Dedicated Display Checkout (during OPS 8) and the Caution and Warning (Panel F7) (FCS Saturation, FCS Channel and Backup C/W Alarm). The two sets of switches which provide crew inputs to the actuator ASA system are the FCS channel monitor switches on Panel C-3 and the ASA power switches on Panels 014, 015, and 016.

3.3 Hierarchy

Figure 2 shows the RSB PDU block diagram. Figures 3 through 9 show individual components which were analyzed for failure modes.

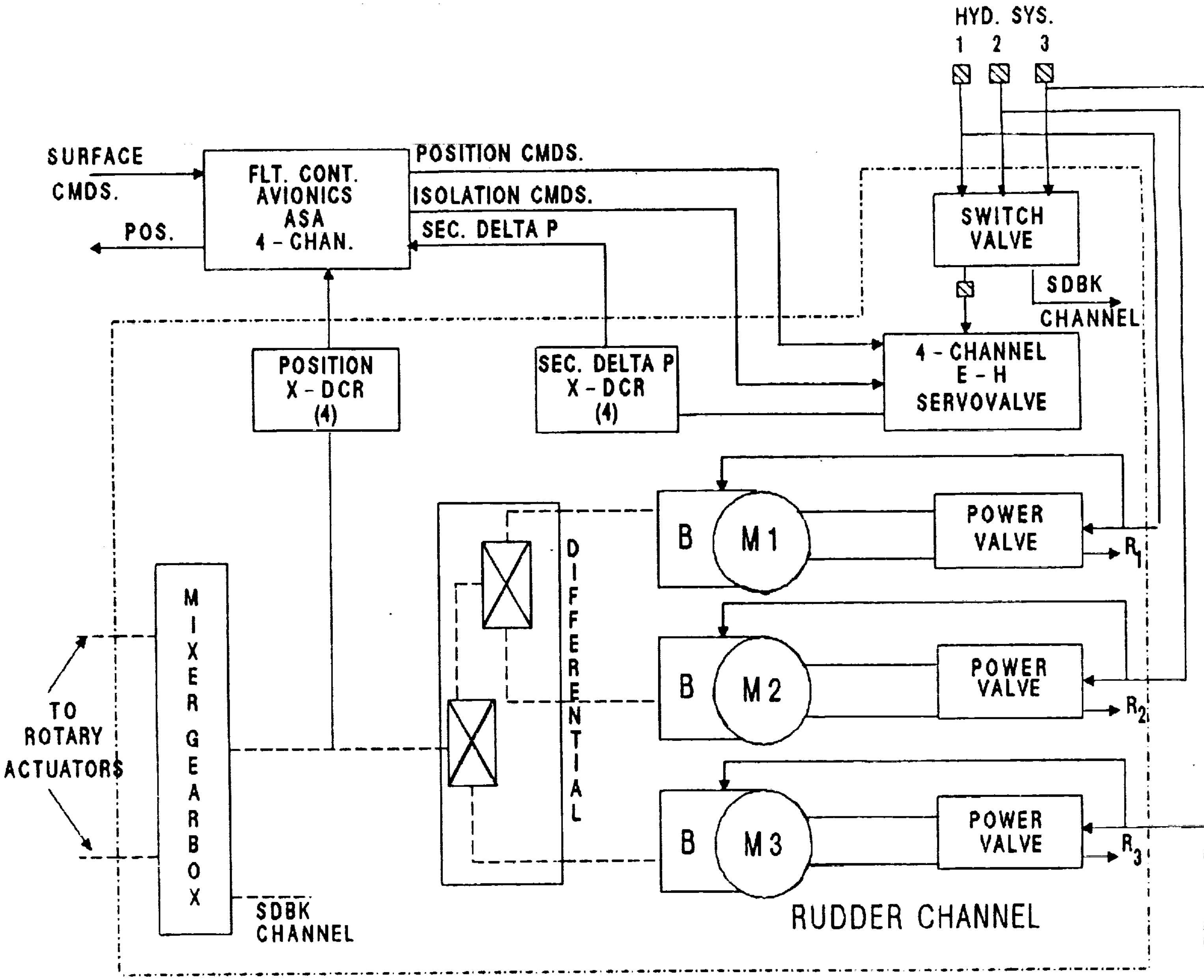


Figure 2 - RSB PDU BLOCK DIAGRAM

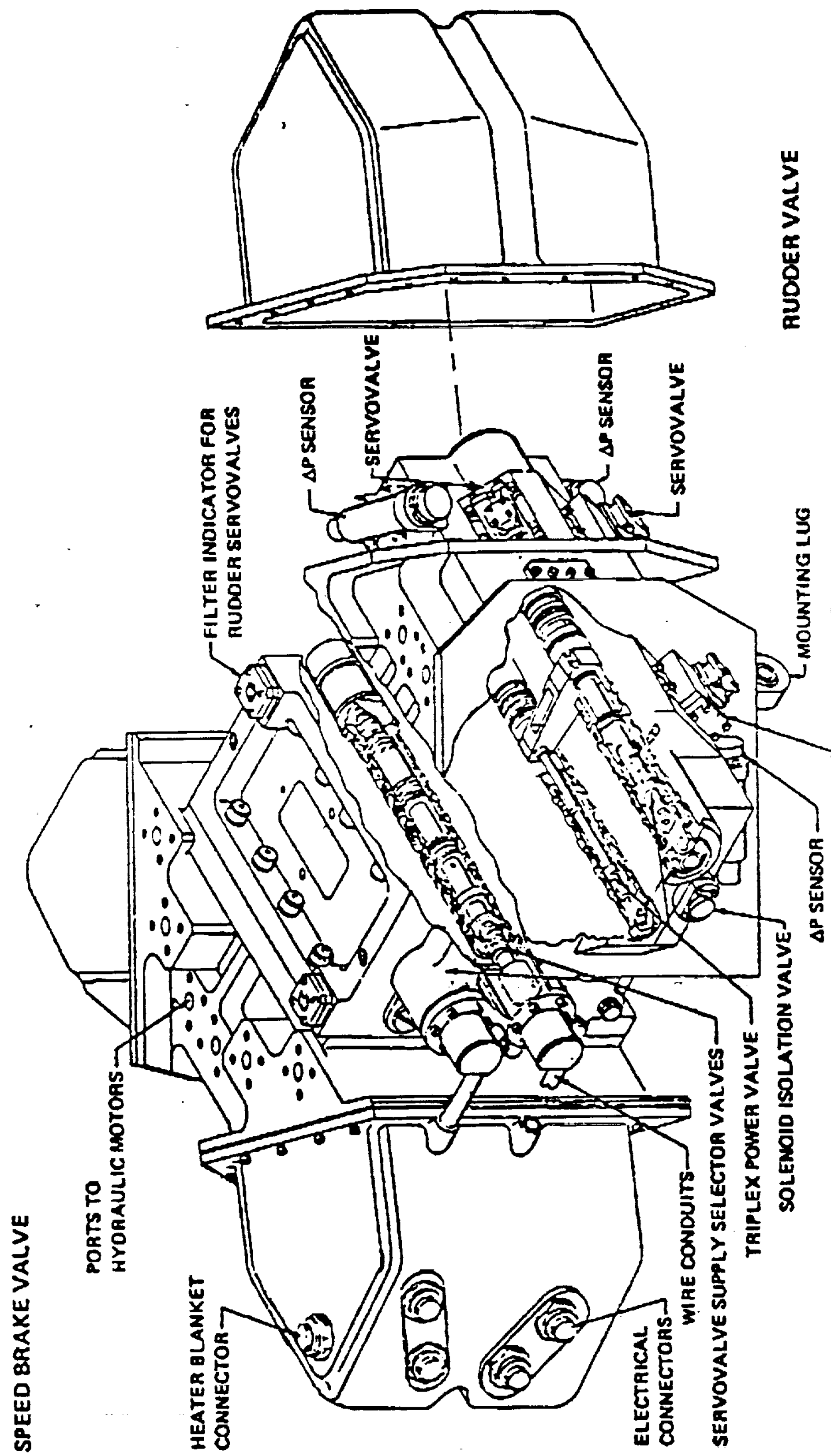


Figure 3 - HYDRAULIC VALVE MODULE

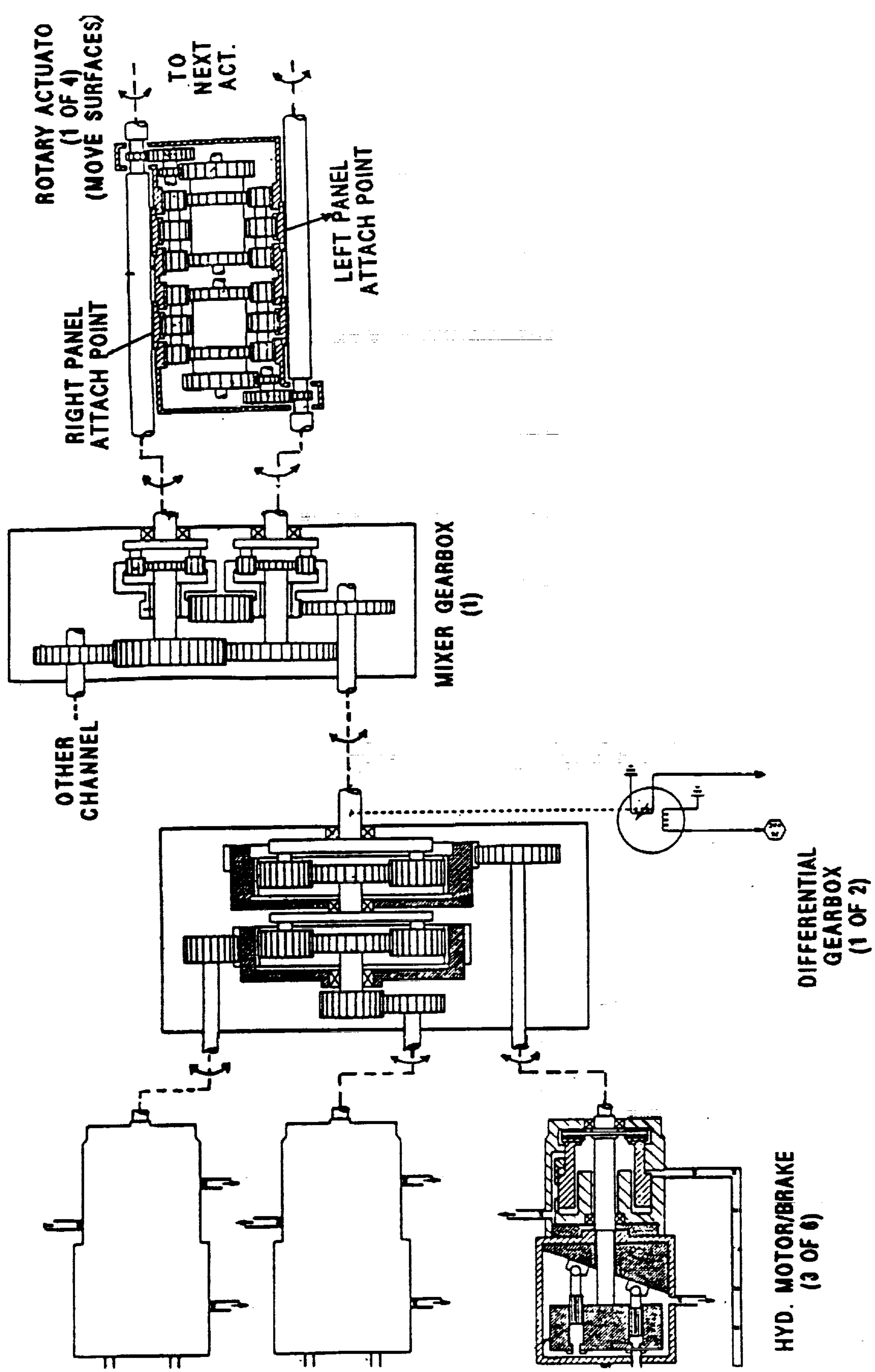


Figure 4 - MOTOR/MECHANICAL DRIVE

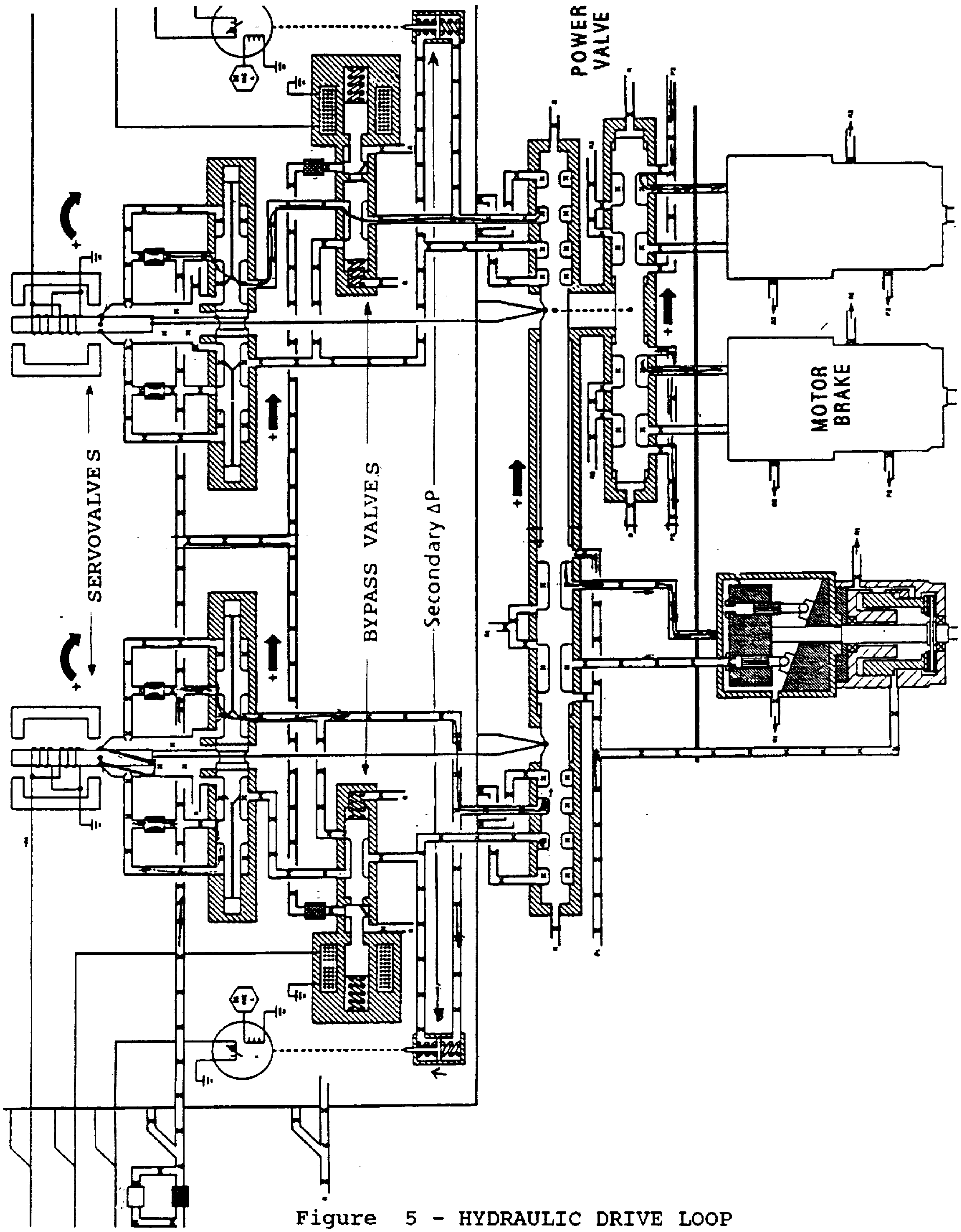


Figure 5 - HYDRAULIC DRIVE LOOP

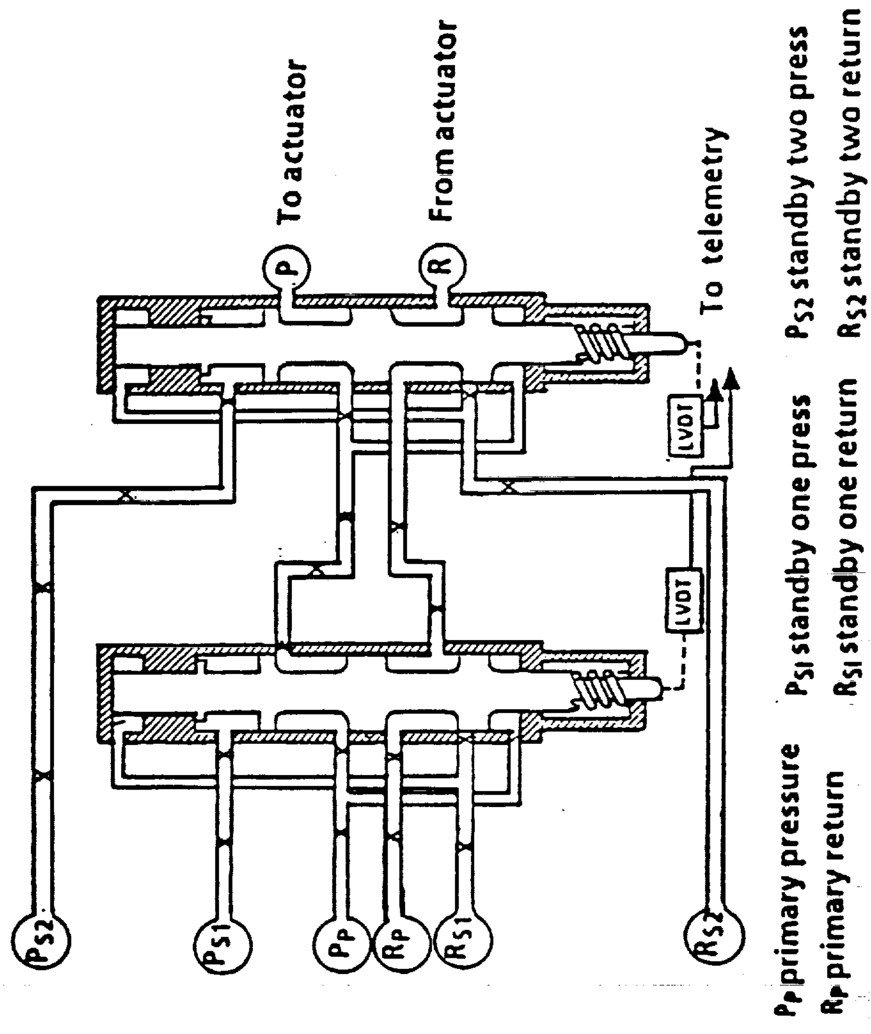


Figure 6 - SWITCHING VALVE

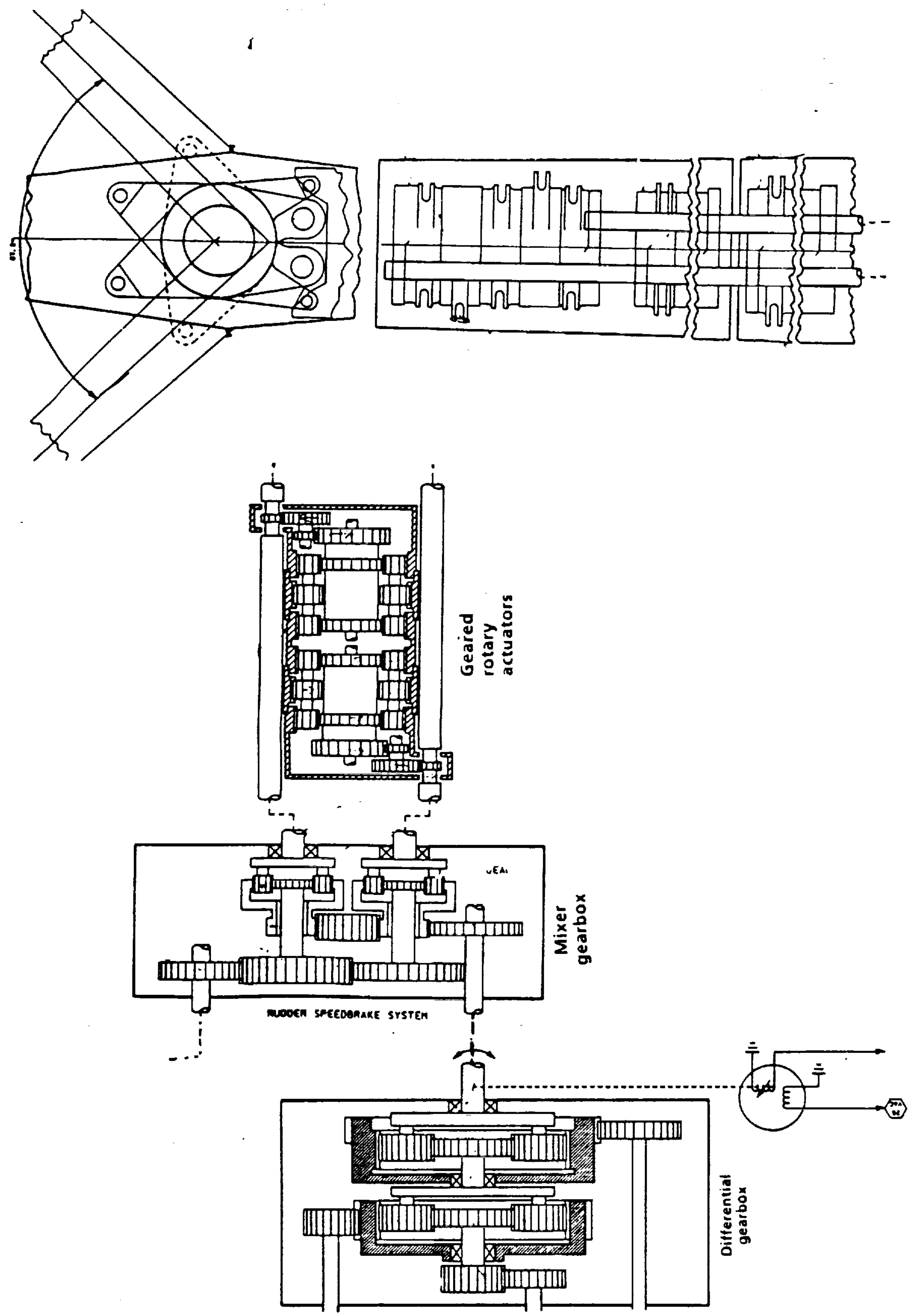


Figure 7 - MECHANICAL DRIVE

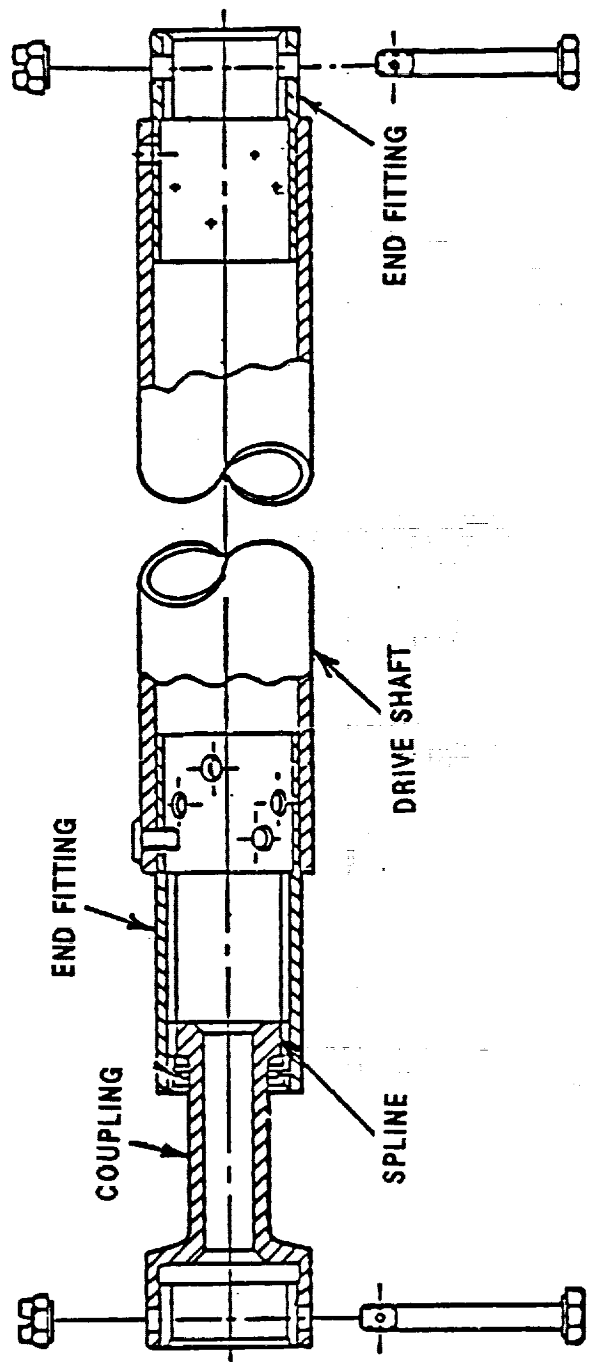


Figure 8 - RSB AND BF TORQUE TUBE CONFIGURATION

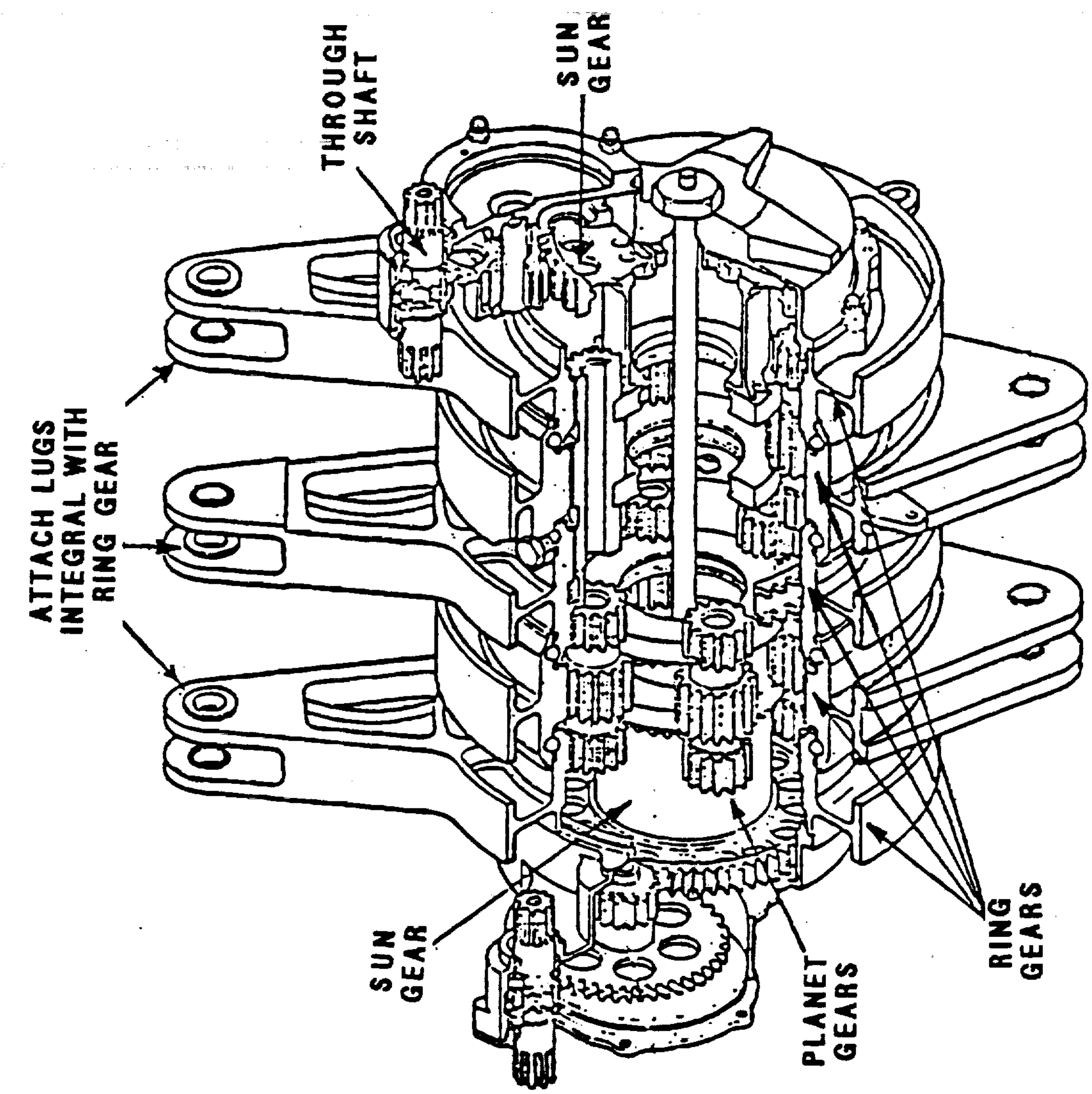


Figure 9 - ROTARY ACTUATOR CUT AWAY

4.0 ASSESSMENT RESULTS

The IOA analysis of the RSB hardware initially generated thirty-eight failure mode worksheets and identified twenty-seven Potential Critical Items (PCIs) before starting the assessment process. These analysis results were compared to the proposed NASA Post 51-L baseline (20 May 1987) of (Note 1) thirty-four FMEAs and twenty CIL items, and the updated (7 December 1987) version of (Note 1) thirty-four FMEAs and eighteen CIL items. The discrepancy between the number of IOA and NASA FMEAs can be explained by the different approach used by NASA and IOA to group failure modes. Upon completion of the assessment and after discussions with the NASA subsystem manager, an agreement between the NASA FMEA/CIL items and the IOA failure modes was reached.

Note 1. Have received Post 51-L items only. Have not received all the Post 51-L NASA FMEAs as of the date of this request. Non-CIL items comparison was based on review of NASA Pre 51-L baseline and IOA correlation and analysis.

In the following, the unmapped IOA column is the raw number of IOA failure modes. The mapped IOA column is the number of IOA failure modes after they have been mapped into the NASA FMEAs. The issues column is the IOA failure modes that were unable to be mapped onto NASA FMEA.

RSB Elements	IOA Unmapped	IOA Mapped	NASA	Issues
PDU	36	32	32	0
Rotary Actuator	1	1	1	0
Drive Shaft	1	1	1	0
	38	34	34	0

Appendix C presents the detailed assessment worksheets for each failure modes identified assessed. Appendix D highlights to the NASA critical items and corresponding IOA worksheet ID. Appendix E contains IOA analysis worksheets supplementing previous analysis results reported in STS Engineering and Operations Support (STSEOS) Working Paper 1.0-SP-VA86001-04, Analysis of the RSB, 3 December 1986. No supplemental analysis worksheets were generated for the RSB assessment. Appendix F provides a cross-reference between the NASA FMEA and corresponding IOA worksheets. IOA recommendations are also summarized.

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
o PDU	7	7	0
PDU Elements			
o Switch Valve	4	4	0
o Recirculation Valve	2	2	0
o EH Servovalve	2	2	0
o By-Pass Valve	1	1	0
o Filter	2	2	0
o Secondary Delta P X-DCER	1	1	0
o Power Valve	1	1	0
o Motor/Brake	5	5	0
o Differential Gearbox	4	4	0
o Position X-DCER	2	2	0
o Mixer Gearbox	1	1	0
o Rotary Actuator	1	1	0
o Drive Shaft	1	1	0
TOTAL	34	34	0

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
o PDU	2	2	0
PDU Elements			
o Switch Valve	1	1	0
o Recirculation Valve	-	-	0
o EH Servovalve	2	2	0
o By-Pass Valve	-	-	0
o Filter	1	1	0
o Secondary Delta P	-	-	0
X-DCER			0
o Power Valve	1	1	0
o Motor/Brake	4	4	0
o Differential Gearbox	3	3	0
o Position X-DCER	1	1	0
o Mixer Gearbox	1	1	0
o Rotary Actuator	1	1	0
o Drive Shaft	1	1	0
TOTAL	18	18	0

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
o PDU	2	-	-	1	-	4	7
PDU Elements							
o Switch Valve	-	1	-	2	-	1	4
o Recirculation Valve	-	-	-	-	-	2	2
o EH Servovalve	-	1	-	1	-	-	2
o By-Pass Valve	-	-	-	1	-	-	1
o Filter	1	-	-	-	-	1	2
o Sec. Delta P X-DCER	-	-	-	1	-	-	1
o Power Valve	1	-	-	-	-	-	1
o Motor/Brake	2	1	-	1	-	1	5
o Differential Gearbox	2	1	-	1	-	-	4
o Position X-DCER	1	-	-	1	-	-	2
o Mixer Gearbox	1	-	-	-	-	-	1
o Rotary Actuator	1	-	-	-	-	-	1
o Drive Shaft	1	-	-	-	-	-	1
TOTAL	12	4	-	9	-	9	34

Of the failure modes analyzed, eighteen 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 Failure Criticalities							
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
o PDU	2	-	-	-	-	-	2
PDU Elements							
o Switch Valve	-	1	-	-	-	-	1
o Recirculation Valve	-	-	-	-	-	-	-
o EH Servovalve	-	1	-	1	-	-	2
o By-Pass Valve	-	-	-	-	-	-	-
o Filter	1	-	-	-	-	-	1
o Sec. Delta P X-DCER	-	-	-	-	-	-	-
o Power Valve	1	-	-	-	-	-	1
o Motor/Brake	2	1	-	1	-	-	4
o Differential Gearbox	2	1	-	-	-	-	3
o Position X-DCER	1	-	-	-	-	-	1
o Mixer Gearbox	1	-	-	-	-	-	1
o Rotary Actuator	1	-	-	-	-	-	1
o Drive Shaft	1	-	-	-	-	-	1
TOTAL	12	4	-	2	-	-	18

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

Table V IOA Worksheet Numbers	
Component	IOA ID Number
o PDU	RSB-101 thru RSB-103; RSB-106 thru RSB-109,
o Hydraulic Valve Module	RSB-104, 105, RSB-110 thru RSB-123
o Hydraulic Motor/Brake	RSB-124 thru RSB-128
o Differential Gearbox	RSB-129 thru RSB-134; RSB-138
o Mixer Gearbox	RSB-135
o Rotary Actuator	RSB-136
o Drive Shaft	RSB-137

4.1 PDU Assessment Results

Failures which were related to the PDU as an entity were analyzed. Critical failures resulting in loss of vehicle/crew were associated with gross loss of hydraulic fluid due to complete seal failure, rupture of servoactuator in and downstream of the switching valve (manifold, return lines, LEE plugs) and hydraulic supply line rupture (one system). These failures result in depletion of all three hydraulic supplies.

Non-critical failures were associated with internal components which leaked hydraulic fluid. These leaks are contained within the PDU and do not cause depletion of the hydraulic system supplies. Other failures which were not critical were associated with the PDU heater blankets which are considered redundant.

4.2 PDU Elements

Components which make up the PDU were individually analyzed. In most cases, failures were included under one common assessment when the failures of a component had the same effect on the system operation. Those component failures which were analyzed separately and had the system effect were correlated with the NASA FMEA/CIL which combined like failures. Criticality 1 failures were associated with contamination of hydraulic fluid which clogged filters and caused jamming of the hydraulic power valve spool. Both failures result in loss of the RSB function. Mechanical failures (sheared shaft/spline or damaged barrel/valve plate) of the hydraulic motor/brake assembly resulted in criticality 1 failures resulting in loss of the RSB function. Mechanical failures also result in loss of the differential and mixer gearboxes causing loss of the RSB function. The failures were caused by fractures of gear shafts, splines or gears and seized bearings. The failure of the position transducer assembly (four transducers ganged together) also results in loss of the RSB function. A mechanical failure in the transducer drive train will result in loss of all four position transducers.

In summary, criticality I failures were due to 1) hydraulic contamination and 2) mechanical failures in gear drive trains.

4.3 Rotary Actuators

Analysis of the rotary actuators which provide the torque required to move the RSB surfaces showed that either an open (gear shaft spline sheared, gear teeth broken) or a jam (seized gear or bearing, overload resulted in the loss of an actuator. loss of any one of the four actuators would result in overloading the remaining actuators causing them to fail with the resultant loss of the RSB function hence loss of vehicle control.

4.4 Drive Shafts

The ten drive shafts transmit RPM/torque between the PDU and the rotary actuators. Critical failures of the shafts were fractures and gears shearing from the shaft spline. Three failures result in loss of drive to or between the four rotary actuators with resultant loss of RSB control.

5.0 REFERENCES

Reference documentation available from NASA and Rockwell was used in the analysis. The documentation used included the following:

1. FCS/Effectors Training Manual 2102 02-86
2. Space Shuttle Systems Handbook, JSC 11174, 09-13-86
3. SD72-SH-0102 System Definition Manual, Mechanical Systems, Hydraulics, 10-28-75
4. R/I Integrated Schematics (V370-580996)
5. Shuttle Master Measurement List
6. FDF (Ascent, On-Orbit, Entry) (Several Different Missions)
7. OMRSD/OMI, FCS Cross Reference - V58AGO, V79ANO, V79ADO, V58AZO 04-08-86
8. Mechanical Console Handbook JSC18341, Feb 86
9. GN&C Console Handbook, JSC12843, 4/25/86
10. Sketches, drawings reviewed with subsystem manager
11. Handouts from preboard reviews 10-10-86
12. SD72-SH-0102-9 Requirements Definition Document, Aero Flight Control Subsystem
13. NSTS 22206, Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) 10-10-86

APPENDIX A
ACRONYMS

ASA	-	Aerosurface Amplifier
BFS	-	Backup Flight System
C&W	-	Caution and Warning
CIL	-	Critical Items List
CRT	-	Cathode Ray Tube
delta P	-	Differential Pressure
E-H Servo VLV	-	Electro-Hydraulic Servovalve
F	-	Functional
FA	-	Flight Aft
FCS	-	Flight Control System
FMEA	-	Failure Modes Effects Analysis
GNC	-	Guidance Navigation and Control
GPC	-	General Purpose Computer
HW	-	Hardware
IOA	-	Independent Orbiter Assessment
LVDT	-	Linear Variable Differential Transducer
MDAC	-	McDonnell Douglas Astronautics Company
MDM	-	Multiplexer/Demultiplexer
OMRSD	-	Operational Maintenance Requirements and Specifications Document
OPS	-	Operational Sequence
ORIDE	-	Override
PASS	-	Primary Avionics Software System
PDU	-	Power Drive Unit
RI	-	Rockwell International
RPTA	-	Rudder Pedal Transducer Assembly
RHC	-	Rotation Hand Controller
RSB	-	Rudder Speedbrake
RVDT	-	Rotating Variable Differential Transducer
SBTC	-	Speedbrake Translation Controller
SPI	-	Surface Position Indicator
VLV	-	Valve

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

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 RSB Specific Ground Rules and Assumptions

The IOA analysis was performed to the component or assembly level of the RSB subsystem. The analysis considered the worst case effects of the hardware or functional failure on the subsystem, and crew and vehicle safety.

APPENDIX C
DETAILED ASSESSMENT

This section contains the IOA assessment worksheets generated during the Assessment of the Rudder/Speed Brake 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: 12/07/87
ASSESSMENT ID: RSB-101
NASA FMEA #: 02-4C-011100-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 101
ITEM: POWER DRIVE UNIT (PDU)

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-102
NASA FMEA #: 02-4C-011100-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 102
ITEM: POWER DRIVE UNIT (PDU)

LEAD ANALYST: R. WILSON

ASSESSMENT:

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

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
NO ISSUE. LOSS OF HYDRAULIC PRESSURE TO ONE MOTOR/BRAKE ASSEMBLY RESULTS IN THE OTHER TWO MOTORS BACKDRIVING THE FAILED MOTOR RESULTING A COMPLETE TORQUE SPILLANT THUS LOSING THE RSB FUNCTION.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-103
NASA FMEA #: 02-4C-011100-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 103
ITEM: POWER DRIVE UNIT (PDU)

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[2 /1R]	[F]	[F]	[P]	[X]
COMPARE	[N /]	[N]	[N]	[ ]	[N]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
AGREE WITH NASA. INTERNAL LEAK IS CONTAINED WILL NOT DEPLETE HYDRAULIC SYSTEM SUPPLY.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-104
NASA FMEA #: 02-4C-011102-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 104
ITEM: FILTER

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

[3 /3]	[NA]	[NA]	[NA]	[ ] (ADD/DELETE)

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
FAILURE IS CONSIDERED TO BE A NON-CREDIBLE FAILURE. NO KNOWN CONDITIONS COULD EXIST WHICH WOULD RUPTURE THE FILTER - NASA PRE-BOARD REVIEW, CHANGE CRITICALITY TO 3/3. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-105
NASA FMEA #: 02-4C-011102-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 105
ITEM: FILTER

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-106
NASA FMEA #: 02-4C-011118-01

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 106
ITEM: HEATER BLANKET

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-107
NASA FMEA #: 02-4C-011118-02

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 107
ITEM: HEATER BLANKET

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-108
NASA FMEA #: 02-4C-011118-03

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 108
ITEM: HEATER BLANKET

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-109
NASA FMEA #: 02-4C-011118-04

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 109
ITEM: HEATER BLANKET

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-110
NASA FMEA #: 02-4C-011101-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 110
ITEM: SWITCH VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

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

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [X]
INADEQUATE [ ]

REMARKS:
NO ISSUE. CONCUR WITH NASA.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-111
NASA FMEA #: 02-4C-0111XX-X

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 111
ITEM: SWITCH VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[2 /1R]	[P]	[P]	[P]	[X]
COMPARE	[N /]	[ ]	[ ]	[ ]	[N]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
IF THE PRIMARY VALVE FAILS TO SWITCH TO STANDBY HYDRAULIC SYSTEM ON LOSS OF THE PRIMARY HYDRAULIC SYSTEM, VALVE 2 WILL SWITCH TO STANDBY 2 HYDRAULIC SYSTEM. A LOSS OF PRESSURE FROM STANDBY 2 HYDRAULIC SYSTEM WILL RESULT IN LOSS OF HYDRAULIC PRESSURE TO THE SERVOVALVES WHICH RESULTS IN LOSS OF RSB CONTROL. THE INITIAL IOA ANALYSIS CONSIDERED THIS FAILURE TO HAVE A 2/1R CRITICALITY. HOWEVER, AS THE RESULT OF FURTHER ANALYSIS DURING THE ASSESSMENT PERIOD THE FAILURE CRITICALITY CAN BE DOWNGRADED TO 3/1R. THIS FAILURE CAN BE DETECTED AND REQUIRES THREE FAILURES BEFORE THERE IS ANY EFFECT ON THE ACTUATOR.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-112
NASA FMEA #: 02-4C-011101-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 112
ITEM: SWITCH VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[3 /1R]	[P]	[P]	[P]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-113
NASA FMEA #: 02-4C-011101-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 113
ITEM: SWITCH VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-114
NASA FMEA #: 02-4C-011104-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 114
ITEM: HYDRAULIC VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[2 /1R]	[P]	[F]	[P]	[X]
COMPARE	[N /]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
NASA INCLUDEDS THIS FAILURE AMONT OTHERS HAVING THE SAME EFFECT IN ONE FMEA. IOA CONSIDERED AS A SEPARATE MODE SINCE EACH FAILURE WAS CONSIDERED SEPARATELY. NO DISAGREEMENT OR ISSUE. MDAC-117, MDAC-115, AND MDAC-118 ARE INCLUDED IN THE NASA/RI FMEA. AGREE WITH CRITICALITY, REMAINING THREE CHANNELS ARE UTILIZED FOR FLIGHT CONTROL. POSSIBLE LOSS OF CREW/VEHICLE AFTER THREE FAILURES.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-115
NASA FMEA #: 01-4C-011104-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 115
ITEM: HYDRAULIC VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[2 /1R]	[P]	[P]	[P]	[X]
COMPARE	[N /]	[ ]	[N]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
FMEA 02-4C-011104-1 (MDAC ID 114) CONSIDERED FAILING TO MOVE VALVE FROM NULL WHEN COMMANDED. AFTER THE VALVE HAS MOVED TO A COMMANDED POSITION, FAILURE TO RETURN TO NULL IS CONSIDERED TO BE A POSSIBLE FAILURE, HOWEVER BOTH FAILURES CAUSE THE SAME EFFECT. AGREE TO COMBINING UNDER ONE FMEA/CIL.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-116
NASA FMEA #: 02-4C-011104-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 116
ITEM: HYDRAULIC VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

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

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
CONCUR WITH NASA. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-117
NASA FMEA #: 02-4C-011104-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 117
ITEM: TORQUE MOTOR ASSEMBLY

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[2 /1R]	[P]	[F]	[P]	[X]
COMPARE	[N /]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
NASA INCLUDES THIS FAILURE AMONG OTHER HAVING THE SAME EFFECT UNDER 02-4C-011104-1. MDAC IOA CONSIDERED AS A SEPARATE FAILURE MODE SINCE EACH COMPONENT WAS ANALYZED SEPARATELY. NO DISAGREEMENT OR CONFLICT WITH NASA. INCLUDE AS A FAILURE UNDER MDAC- 114. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-118
NASA FMEA #: 02-4C-011104-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 118
ITEM: TORQUE MOTOR ASSEMBLY

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[2 /1R]	[P]	[F]	[P]	[X]
COMPARE	[N /]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [X]
INADEQUATE [ ]

REMARKS:
NASA INCLUDES THIS FAILURE AMONG OTHERS HAVING THE SAME EFFECT UNDER 02-4C-011104-1. MDAC IOA CONSIDERED AS A SEPARATE FAILURE MODE SINCE EACH COMPONENT WAS ANALYZED SEPARATELY. NO DISAGREEMENT OR CONFLICT WITH NASA. INCLUDE AS A FAILURE UNDER MDAC- 114. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-119
NASA FMEA #: 02-4C-011104-4

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 119
ITEM: SECONDARY DELTA P TRANSDUCER (4R, 4SB)

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[2 /1R]	[P]	[F]	[P]	[X]
COMPARE	[N /]	[ ]	[N]	[ ]	[N]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:
AGREE THAT FAILURE IS DETECTABLE. THREE REMAINING TRANSDUCERS PROVIDE ADEQUATE FEEDBACK TO ASA. TAKES THREE FAILURES TO CAUSE LOSS OF CONTROL FUNCTIONS.
NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-120
NASA FMEA #: 02-4C-011104-X

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 120
ITEM: ISOLATION VALVE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[3 /1R]	[P]	[P]	[P]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-121
NASA FMEA #: 02-4C-011119-01

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 121
ITEM: RECIRCULATION VALVE (1R, 1SB)

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-122
NASA FMEA #: 02-4C-011119-02

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 122
ITEM: RECIRCULATION VALVE (1R, 1SB)

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /3]	[NA]	[NA]	[NA]	[ ]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-123
NASA FMEA #: 02-4C-011106-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 123
ITEM: TRIPLEX POWER VALVE

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-124
NASA FMEA #: 02-4C-011108-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 124
ITEM: HYDRAULIC MOTOR

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-125
NASA FMEA #: 02-4C-011108-1

NASA DATA:
BASELINE [X]
NEW [ ]

SUBSYSTEM: RSB
MDAC ID: 125
ITEM: HYDRAULIC MOTOR

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /3]	[NA]	[NA]	[NA]	[ ] *
IOA	[3 /1R]	[P]	[F]	[P]	[X]
COMPARE	[/N]	[N]	[N]	[N]	[N]

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [ ]
INADEQUATE [ ]

REMARKS:

NASA CONSIDERS THIS FAILURE TO HAVE A 3/3 CRITICALITY SINCE THE MOTOR IS STILL FUNCTIONALLY OPERATIONAL EVEN AT REDUCED RATE. THERE IS NO WAY THAT ANY LEAKAGE COULD OCCUR THAT WOULD DEGRADE THE MOTOR OUTPUT TO THE POINT THAT IT COULD BE BACK DRIVEN THROUGH THE DIFFERENTIAL GEARBOX BY THE OTHER TWO MOTORS.

BASED ON DISCUSSIONS WITH THE SUBSYSTEM MANAGER, THERE IS AGREEMENT THAT THERE IS NO FUNCTIONAL CRITICALITY FOR THIS FAILURE MODE. CRITICALITY BECOMES 3/3.

NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-126
NASA FMEA #: 02-4C-011110-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 126
ITEM: HYDRAULIC BRAKE

LEAD ANALYST: R. WILSON

ASSESSMENT:

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

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-127
NASA FMEA #: 02-4C-011110-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 127
ITEM: HYDRAULIC BRAKE

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[F]	[P]	[X] *
IOA	[3 /1R]	[P]	[F]	[P]	[X]
COMPARE	[/]	[ ]	[ ]	[ ]	[ ]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-128
NASA FMEA #: 02-4C-011110-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 128
ITEM: HYDRAULIC BRAKE

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-129
NASA FMEA #: 02-4C-011112-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 129
ITEM: SUMMER DIFFERENTIAL GEARBOX

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:
THIS FMEA ALSO COVERS MDAC-130. NO DISAGREEMENT WITH COMBINING THESE FAILURE MODES.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-130
NASA FMEA #: 02-4C-011112-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 130
ITEM: SUMMER DIFFERENTIAL GEARBOX

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:
THIS FAILURE IS COVERED UNDER ONE FMEA/CIL (MDAC-129). NO DISAGREEMENT WITH COMBINING FAILURES UNDER ONE FMEA/CIL.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-131
NASA FMEA #: 02-4C-011112-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 131
ITEM: SUMMER DIFFERENTIAL GEARBOX

LEAD ANALYST: R. WILSON

ASSESSMENT:

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

RECOMMENDATIONS: (If different from NASA)

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

* CIL RETENTION RATIONALE: (If applicable)

ADEQUATE [X]
INADEQUATE [ ]

REMARKS:
NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-132
NASA FMEA #: 02-4C-011112-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 132
ITEM: SUMMER DIFFERENTIAL GEARBOX

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[3 /1R]	[P]	[F]	[P]	[X]
COMPARE	[/]	[ ]	[N]	[ ]	[N]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
CONCUR WITH NASA CRIT, AND ALSO THAT FAILURE PASSES SCREEN B. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-133
NASA FMEA #: 02-4C-011114-2

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 133
ITEM: POSITION TRANSDUCER

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-134
NASA FMEA #: 02-4C-011114-3

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 134
ITEM: POSITION TRANSDUCER

LEAD ANALYST: R. WILSON

ASSESSMENT:

	CRITICALITY FLIGHT HDW/FUNC	REDUNDANCY SCREENS A	B	C	CIL ITEM
NASA	[3 /1R]	[P]	[P]	[P]	[ ] *
IOA	[2 /1R]	[P]	[F]	[P]	[X]
COMPARE	[N /]	[ ]	[N]	[ ]	[N]

RECOMMENDATIONS: (If different from NASA)

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

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

REMARKS:
THERE IS AGREEMENT THAT THE CRITICALITY IS 3/1R AND PASSES B REDUNDANCY SCREEN. THE INITIAL IOA WAS BASED ON ASSUMING THAT THE ASA ELECTRONICS WOULD NOT DETECT THE FAILURE WHEN COMMANDING AT OR NEAR THE NULL POSITION. POSITION DATA IS NOT USED IN THE ASA AND IS READILY DETECTABLE IN FLIGHT. NO ISSUE.

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-135
NASA FMEA #: 02-4C-011116-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 135
ITEM: MIXER GEARBOX (1)

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-136
NASA FMEA #: 02-4C-011300-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 136
ITEM: GEAR ROTARY ACTUATOR (4)

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-137
NASA FMEA #: 02-4C-011200-1

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 137
ITEM: DRIVE SHAFTS

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:

APPENDIX C
ASSESSMENT WORKSHEET

ASSESSMENT DATE: 12/07/87
ASSESSMENT ID: RSB-138
NASA FMEA #: 02-4C-011112-5

NASA DATA:
BASELINE [ ]
NEW [X]

SUBSYSTEM: RSB
MDAC ID: 138
ITEM: DIFFERENTIAL GEAR BOX

LEAD ANALYST: R. WILSON

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 [X]
INADEQUATE [ ]

REMARKS:
AT THE NASA PRE-BOARD REVIEW, THIS WAS TO BE ADDED TO A FMEA/CIL. ACCEPTED BY PRE-BOARD. NO DISAGREEMENT OR CONFLICT.

APPENDIX D
POTENTIAL CRITICAL ITEMS

NASA FMEA	MDAC-ID	ITEM	FAILURE MODE
02-4C-011100-1	101	PDU	EXTERNAL LEAKAGE, COMPONENT RUPTURE; GROSS FLUID LOSS 3 SYSTEMS
02-4C-011100-3	102	PDU	EXTERNAL LEAKAGE, LINE RUPTURE; GROSS FLUID LOSS 1 SYSTEM
02-4C-011102-2	105	FILTER	CLOGGED
02-4C-011101-1	110	SWITCH VALVE	SECONDARY VALVE FAILS TO SWITCH
02-4C-011104-1	114	EH SERVOVALVE	FAILS AT NULL UNDETECTED BY ASA
01-4C-011104-1	115	EH SERVOVALVE	FAILS TO RETURN TO NULL - UNDETECTED BY ASA
02-4C-011104-3	116	EH SERVOVALVE	NO ERRONEOUS OUTPUT
02-4C-011104-1	117	EH SERVOVALVE	TORQUE MOTOR FAIL UNDETECTED BY ASA
02-4C-011104-1	118	EH SERVOVALVE	FLAPPER VALVE FAIL UNDETECTED BY ASA
02-4C-011106-1	123	POWER VALVE	FAILS, DRIVE OPEN/ DRIVE CLOSED
02-4C-011108-2	124	HYDRAULIC MOTOR	NO RPM/TORQUE OUTPUT, OPEN DRIVELINE
02-4C-011110-2	126	HYDRAULIC BRAKE	FAILS TO BRAKE
02-4C-011110-3	127	HYDRAULIC BRAKE	FAILS TO RELEASE
02-4C-011110-1	128	HYDRAULIC BRAKE	OPEN DRIVELINE
02-4C-011112-1	129	SUMMER DIFFERENTIAL	OPEN OR PARTIAL JAMMED DRIVELINE
02-4C-011112-1	130	SUMMER DIFFERENTIAL	OUTPUT JAMMED - 2ND STAGE
02-4C-011112-2	131	SUMMER DIFFERENTIAL	PARTIAL JAM - SINGLE DIFFERENTIAL GEAR MESH JAM
02-4C-011114-2	133	POSITION TRANSDUCER	FAIL ALL FOUR; LOSS OF MECHANICAL INPUT, ELECTRICAL OUTPUT
02-4C-011116-1	135	MIXER GEARBOX	OPEN, JAMMED ONE OR BOTH SHAFTS
02-4C-011300-1	136	ROTARY ACTUATOR	JAMMED, OPEN DRIVELINE
02-4C-011200-1	137	DRIVE SHAFTS	OPEN OR JAMMED SHAFT
02-4C-011112-5	138	SUMMER DIFFERENTIAL	1ST DIFFERENTIAL SHAFT OPEN - 1ST STAGE

APPENDIX E
DETAILED ANALYSIS

This appendix contains the IOA analysis worksheets supplementing previous results reported in STSEOS Working Paper 1.0-WP-VA86001-04, Analysis of the RSB, (3 December 1986). 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. There were no supplemental analysis worsheets, generated for the RSB.

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

This section provides a cross reference between the NASA FMEA and corresponding 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 Resolution/Issue/Rational Codes

Code Definition

1. IOA concurs - NASA CCB considers this a non-credible failure - delete.

   All other initial IOA criticality and redundancy screen differences were resolved with the NASA subsystem manager. In addition, the combining of like failures under one FMEA were agreed to.

APPENDIX F

NASA FMEA TO IOA WORKSHEET CROSS REFERENCE / RECOMMENDATIONS

IDENTIFIERS		NASA		IOA RECOMMENDATIONS *			
NASA FMEA NUMBER	IOA ASSESSMENT NO.	CRIT HW/F	SCREENS A B C	CRIT HW/F	SCREENS A B C	OTHER (SEE LEGEND CODE)	ISSUE
01-4C-011104-1	RSB-115	3/1R	P F P	/			
02-4C-011100-1	RSB-101	1/1	NA NA NA	/			
02-4C-011100-2	RSB-103	3/1R	P P P	/			
02-4C-011100-3	RSB-102	1/1	NA NA NA	/			
02-4C-011101-1	RSB-110	2/1R	P NA P	/			
02-4C-011101-2	RSB-112	3/1R	P P P	/			
02-4C-011101-3	RSB-113	3/3	NA NA NA	/			
02-4C-011102-1	RSB-104	3/1R	P F P	3/3	NA NA NA	1	X
02-4C-011102-2	RSB-105	1/1	NA NA NA	/			
02-4C-011104-1	RSB-114	3/1R	P F P	/			
	RSB-117	3/1R	P F P	/			
	RSB-118	3/1R	P F P	/			
02-4C-011104-3	RSB-116	2/1R	P F P	/			
02-4C-011104-4	RSB-119	3/1R	P P P	/			
02-4C-011104-X	RSB-120	3/1R	P P P	/			
02-4C-011106-1	RSB-123	1/1	NA NA NA	/			
02-4C-011108-1	RSB-125	3/3	NA NA NA	/			
02-4C-011108-2	RSB-124	1/1	NA NA NA	/			
02-4C-011110-1	RSB-128	1/1	NA NA NA	/			
02-4C-011110-2	RSB-126	2/1R	P NA P	/			
02-4C-011110-3	RSB-127	3/1R	P F P	/			
02-4C-011112-1	RSB-129	1/1	NA NA NA	/			
	RSB-130	1/1	NA NA NA	/			
02-4C-011112-2	RSB-131	2/1R	P F P	/			
02-4C-011112-3	RSB-132	3/1R	P P P	/			
02-4C-011112-5	RSB-138	1/1	NA NA NA	/			
02-4C-011114-2	RSB-133	1/1	NA NA NA	/			

NASA FMEA TO IOA WORKSHEET CROSS REFERENCE / RECOMMENDATIONS

IDENTIFIERS		NASA		IOA RECOMMENDATIONS *			
02-4C-011114-3	RSB-134	3/1R	P P P	/			
02-4C-011116-1	RSB-135	1/1	NA NA NA	/			
02-4C-011118-01	RSB-106	3/3	NA NA NA	/			
02-4C-011118-02	RSB-107	3/3	NA NA NA	/			
02-4C-011118-03	RSB-108	3/3	NA NA NA	/			
02-4C-011118-04	RSB-109	3/3	NA NA NA	/			
02-4C-011119-01	RSB-121	3/3	NA NA NA	/			
02-4C-011119-02	RSB-122	3/3	NA NA NA	/			
02-4C-0111XX-X	RSB-111	3/1R	P P P	/			
02-4C-011200-1	RSB-137	1/1	NA NA NA	/			
02-4C-011300-1	RSB-136	1/1	NA NA NA	/			