INDEPENDENT ORBITER ASSESSMENT

ANALYSIS
OF THE
RUDDER/SPEED BRAKE
SUBSYSTEM

21 NOVEMBER 1986

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

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INDEPENDENT ORBITER ASSESSMENT
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21 November 1986

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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, 10 October 1986. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents (Appendix C) the independent analysis results for the Orbiter Rudder/Speedbrake Actuation Mechanism.

The function of the Rudder/Speedbrake (RSB) is to provide directional control and to provide a means of energy control during entry. The system consists of two panels on a vertical hinge mounted on the aft part of the vertical stabilizer. These two panels move together to form a rudder but split apart to make a speedbrake. The rudder becomes active at Mach 4.2 and is assisted by the Reaction Control System (RCS) yaw jets until Mach 1.0, where the rudder alone becomes the primary yaw control. Between Mach 10 and Mach 4.2 the speedbrake serves to provide pitch trim. Between Mach 4.2 and Mach 0.9 the speedbrake is used to control drag thus energy dissipation. At touchdown the speedbrake is fully opened to provide nose-up pitch movement to aid in nose wheel derotation. The Rudder/Speedbrake Actuation Mechanism consists of the following elements:

- Power Drive Unit (PDU) which is composed of a hydraulic valve module and a hydraulic motor-powered gearbox which contains differentials and mixer gears to provide PDU torque output
- Four geared rotary actuators which apply the PDU generated torque to the rudder/speedbrake panels
- Ten torque shafts which join the PDU to the rotary actuators and interconnect the four rotary actuators

The IOA analysis process utilized available actuator schematics, limited detailed hardware drawings, and sketches which were reviewed with the subsystem manager. From this information the hardware assemblies and components were defined. Each level of hardware was evaluated and analyzed for possible failures and causes. Criticality was assigned based upon the severity of the effect for each failure mode.

Figures 1, 2 and 3 present a summary of the failure criticalities for each of the major elements of the RSB Servoactuator. A summary of the number of failure modes by criticality is presented below with Hardware (HW) criticality first and Functional (F) criticality second.

Summary of IOA Failure Modes By Criticality (HW/F)							
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Number :	12	13	-	4	-	9	38

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

Summary of IOA Potential Critical Items (HW/F)						
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	TOTAL
Number :	12	13	-	2	-	27

Critical RSB failures which result in potential loss of vehicle control were mainly due to loss of hydraulic fluid, fluid contaminators, and mechanical failures in gears and shafts.

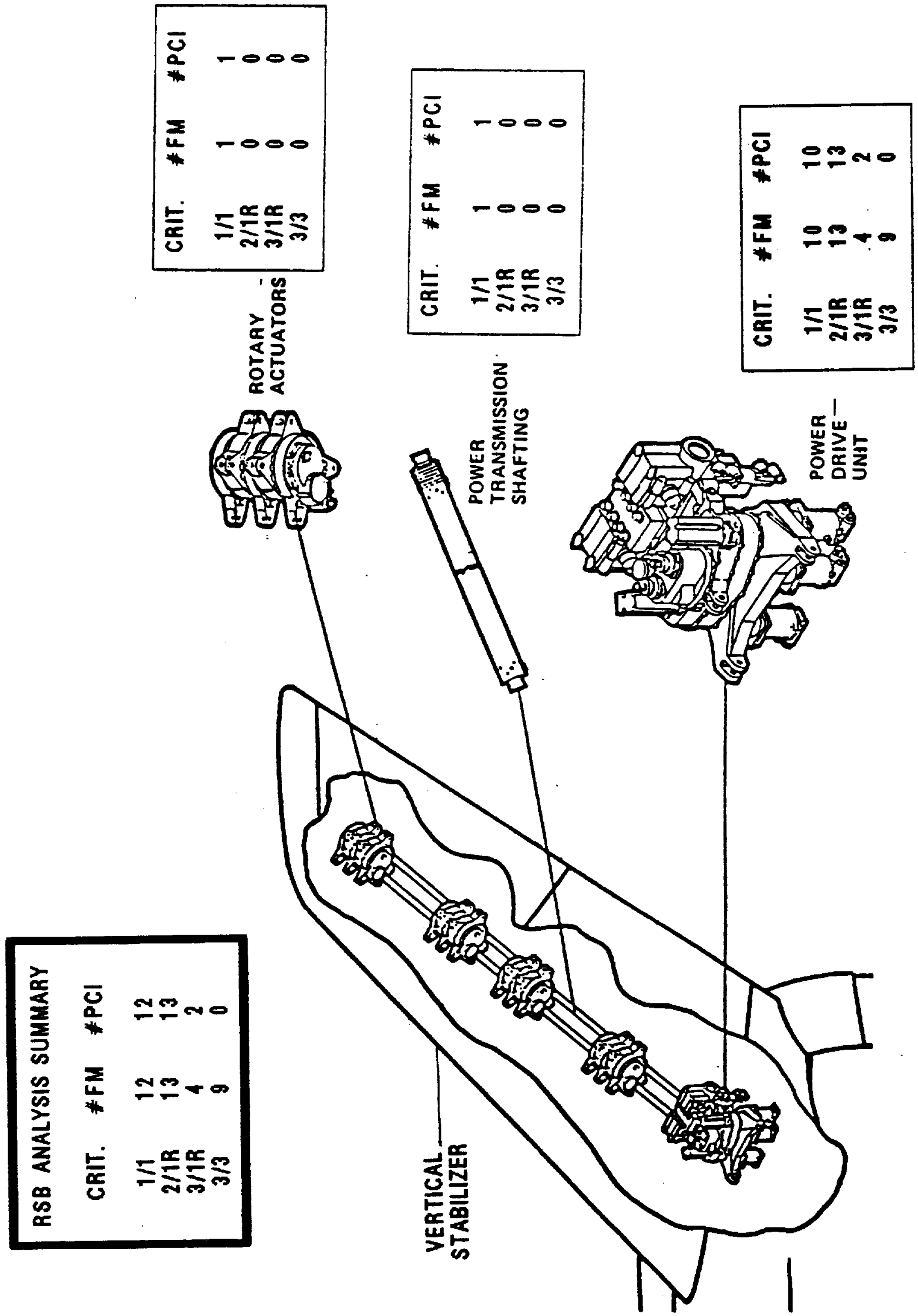

Figure 1 - RSB ACTUATOR SUBSYSTEM

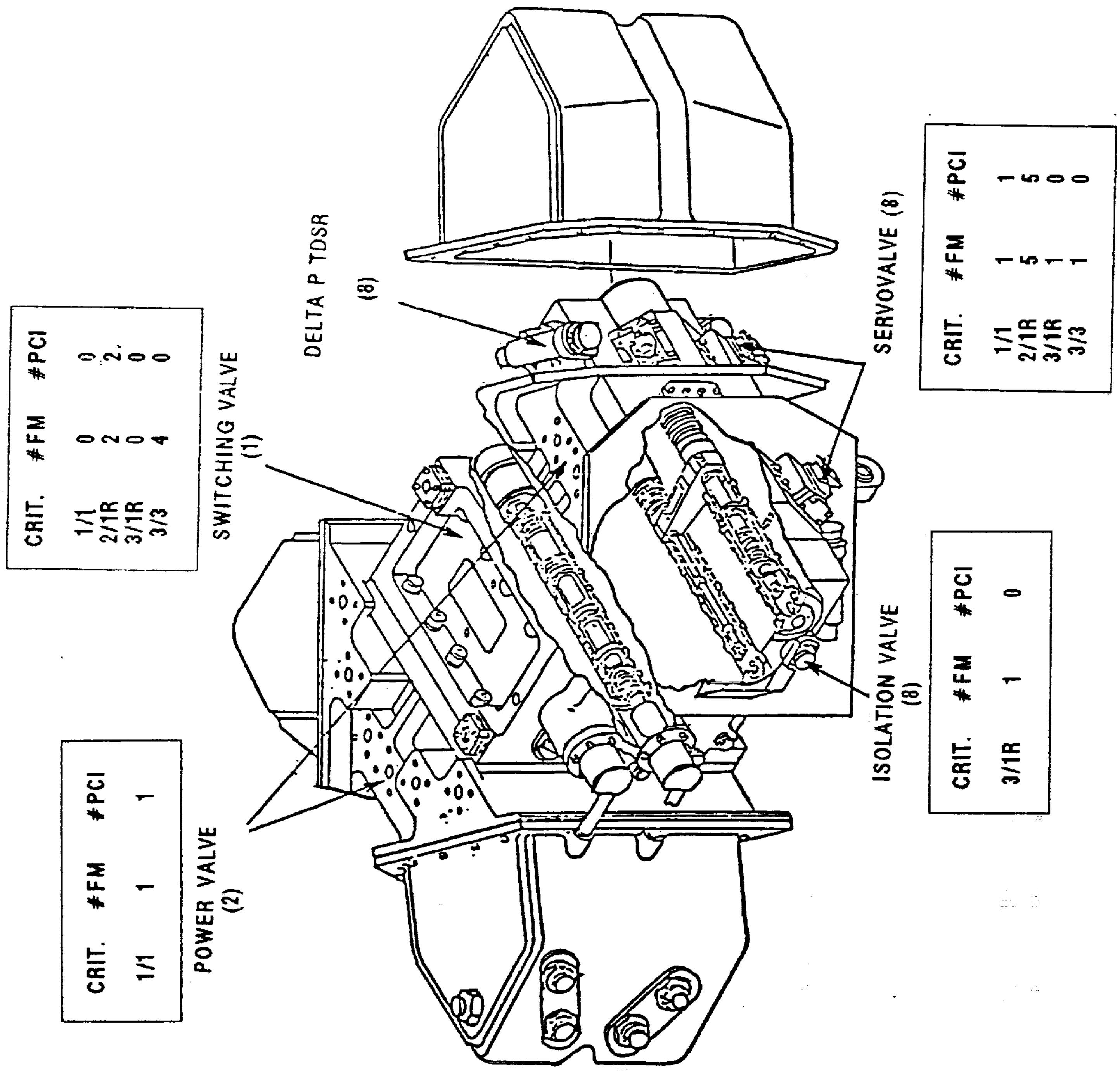

Figure 2 - HYDRAULIC VALVE MODULE

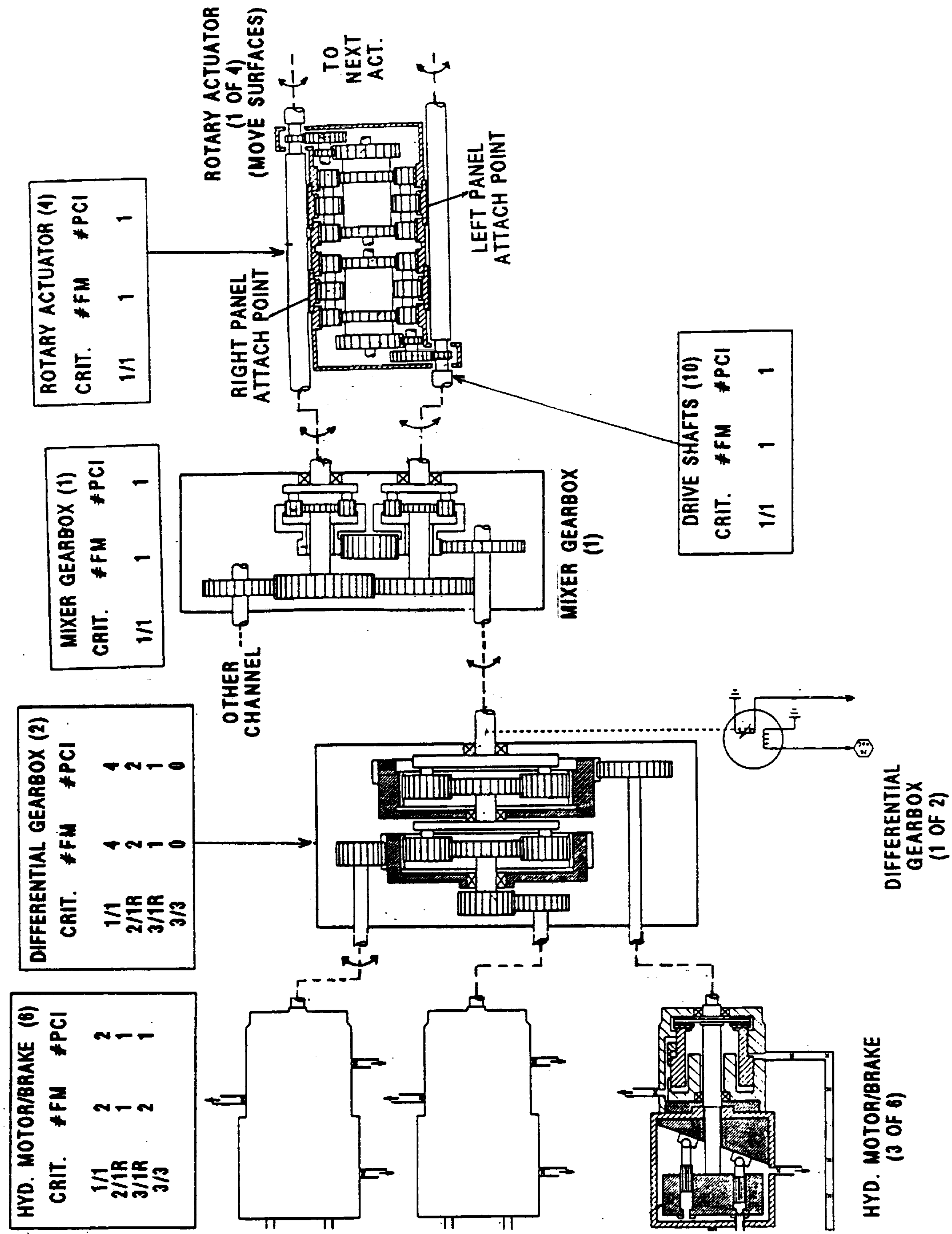

Figure 3 - MOTOR/MECHANICAL DRIVE

2.0 INTRODUCTION

2.1 Purpose

The 51-L Challenger accident prompted the NASA to readdress safety policies, concepts, and rationale being used in the National Space Transportation System (NSTS). The NSTS Office has undertaken the task of reevaluating the FMEA/CIL for the Space Shuttle design. The MDAC is providing the independent assessment of the 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 NASA and Prime Contractor FMEA/CIL reevaluation results. The IOA analysis approach is summarized in the following Steps 1.0 through 3.0. Step 4.0 summarizes the assessment of the NASA and Prime Contractor FMEAs/CILs that is performed and documented at a later date.

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

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

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

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

2.4 Rudder/Speedbrake Ground Rules and Assumptions

The RSB ground rules, and assumptions used in this IOA are defined in Appendix B.1 and B.2. 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 inputed 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 4 shows the RSB PDU block diagram. Figures 5 through 9 show individual components which were analyzed for failure modes.

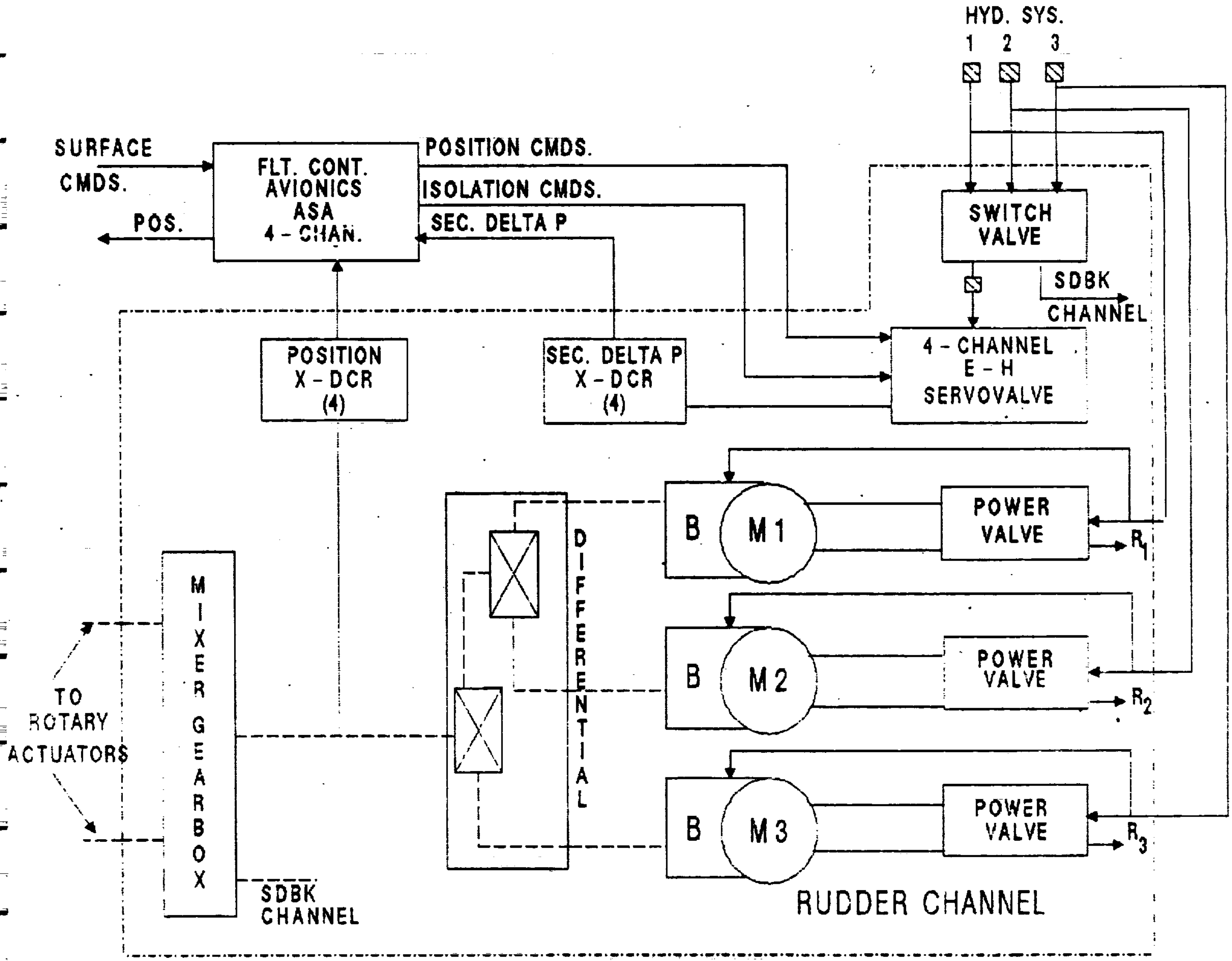

Figure 4 - RSB PDU BLOCK DIAGRAM

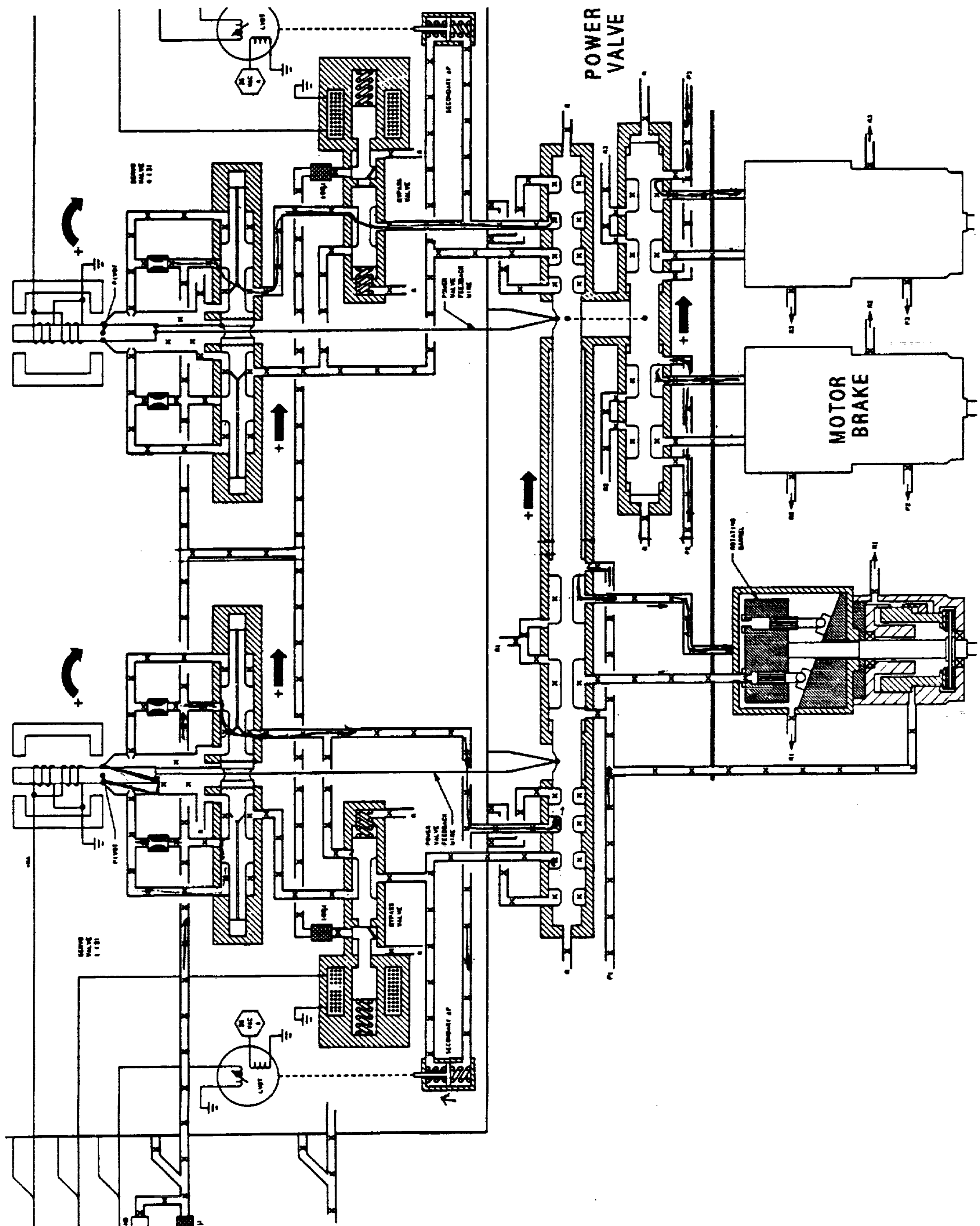

Figure 5 - HYDRAULIC DRIVE LOOP

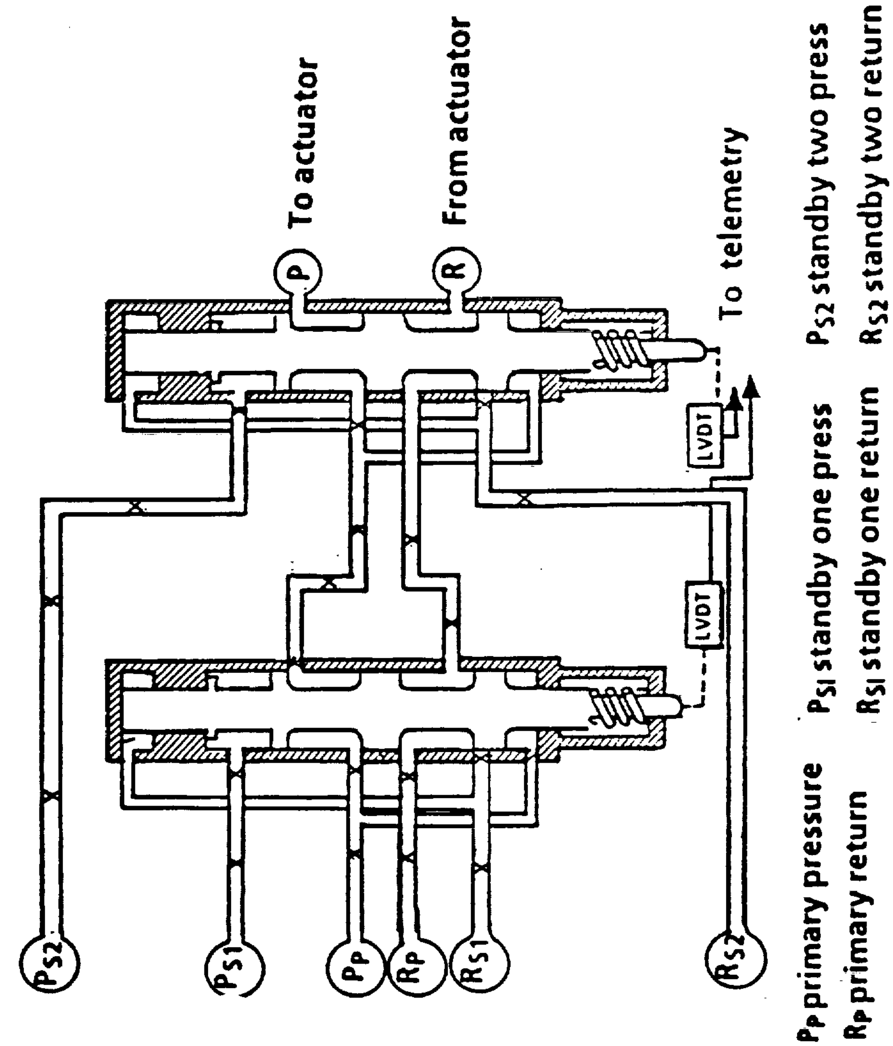

Figure 6 - SWITCHING VALVE

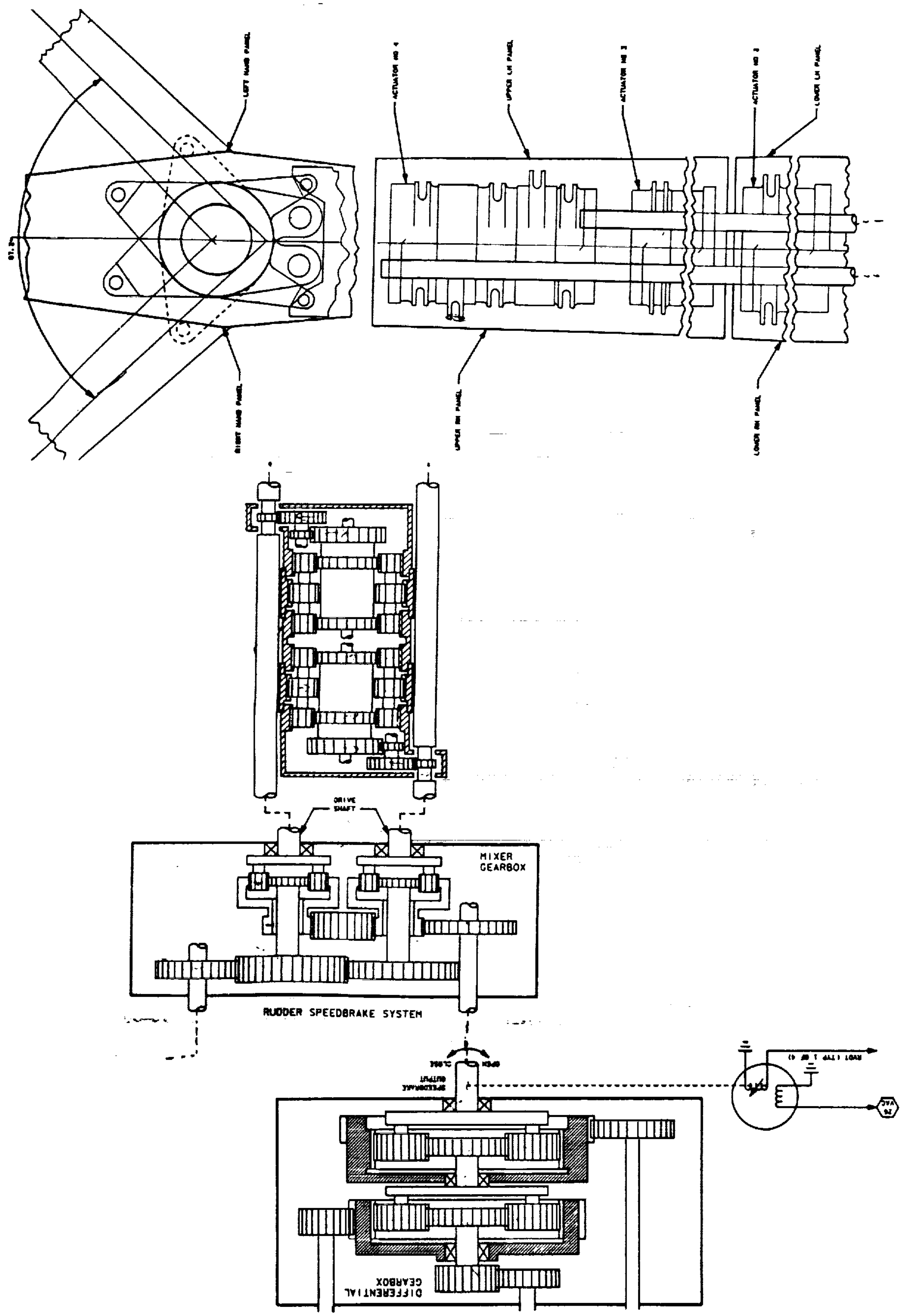

Figure 7 - MECHANICAL DRIVE

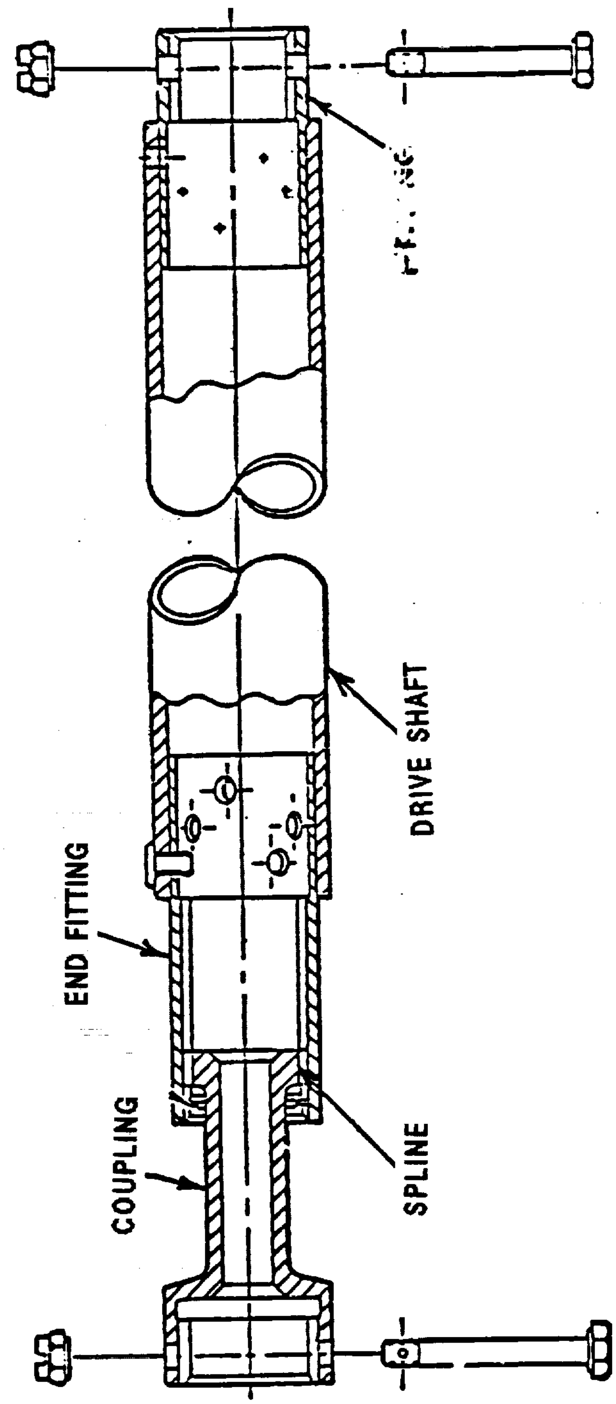

Figure 8 - RSB AND BF TORQUE TUBE CONFIGURATION

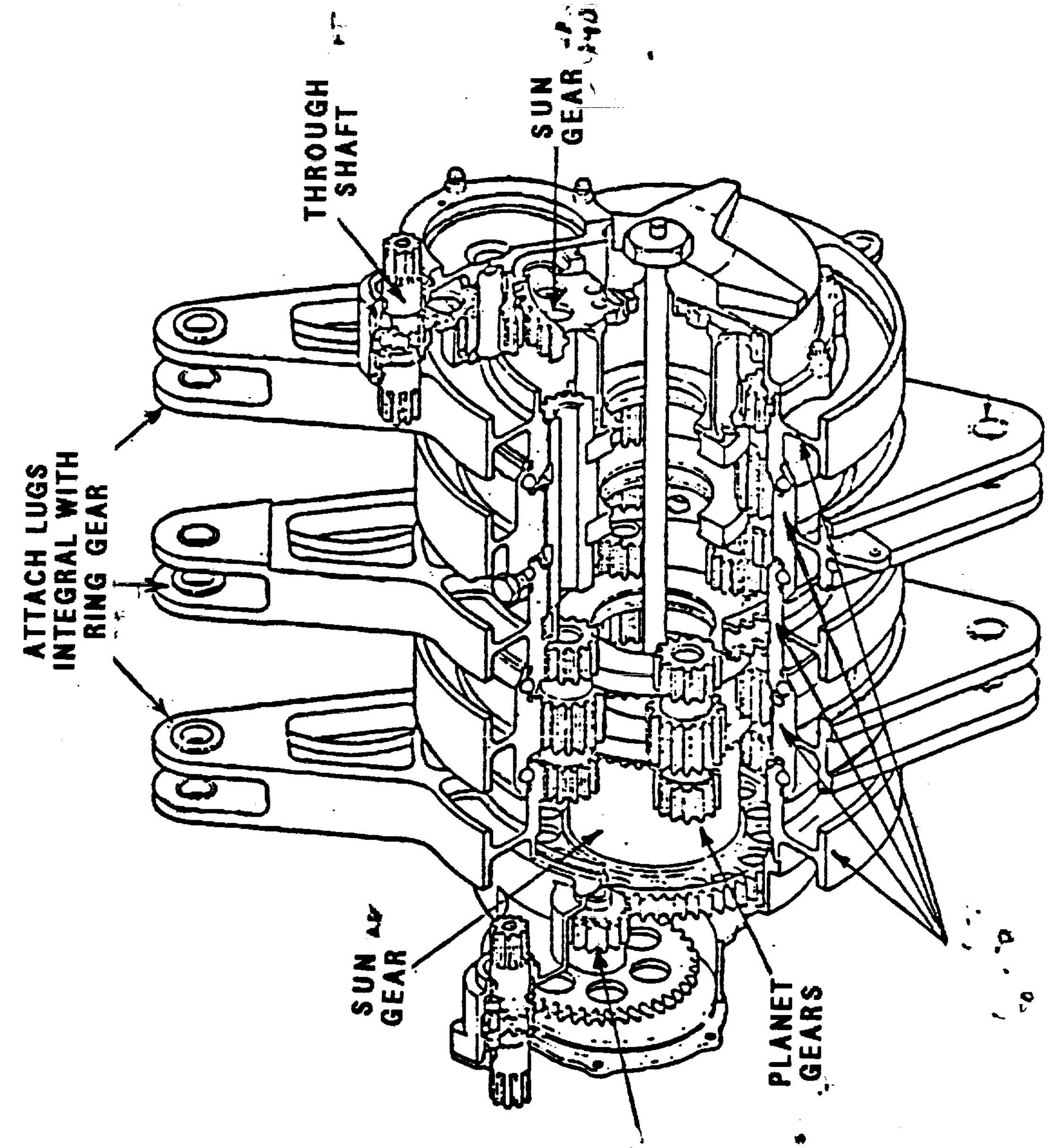

Figure 9 - RSB ROTARY ACTUATOR CUT-AWAY

4.0 ANALYSIS RESULTS

Detailed analysis results for each of the identified failure modes are presented in Appendix C. Table I presents a summary of the criticalities for the PDU, the components which make up the PDU, the rotary actuators, and the interconnect drive shafts.

Table I Summary of IOA Component Failure Modes and Criticalities

Criticality (HDW/FUNC)	1/1	2/1R	2/2	3/1R	3/2R	3/3	Total
o PDU	1	2	-	-	-	4	7
PDU Elements							
Switching VLV	-	2	-	-	-	2	4
Recirculation VLV	-	-	-	-	-	2	2
E-H Servo VLV	-	5	-	-	-	-	5
Bypass VLV	-	-	-	1	-	-	1
E-H Servo VLV Filter	1	-	-	-	-	1	2
Secondary Delta P Transducer	-	1	-	-	-	-	1
Triplex Power VLV	1	-	-	-	-	-	1
Hydraulic Motor/ Brake	2	1	-	2	-	-	5
Differential Gearbox	3	1	-	1	-	-	5
Position Transducer	1	1	-	-	-	-	2
Mixer Gearbox	1	-	-	-	-	-	1
o ROTARY ACTUATOR	1	-	-	-	-	-	1
o DRIVE SHAFT	1	-	-	-	-	-	1
Total	12	13	-	4	-	9	38

Of the 38 failure modes analyzed, 27 failures were determined to be PCIs. A summary of PCIs is presented in Table II. Appendix D presents a cross reference between each PCI and a specific worksheet in Appendix C.

TABLE II Summary of IOA Potential Critical Items

Criticality:	1/1	2/1R	2/2	3/1R	3/2R	TOTAL
PDU	10	13	-	2	-	25
Rotary Actuator	1	-	-	-	-	1
Drive Shaft	1	-	-	-	-	1
Total	12	13	-	2	-	27

4.1 Analysis Results - Power Drive Unit

Failures which were related to the PDU as an entity were first analyzed. Critical failures were due to loss of hydraulic fluid, gross and slow leaks, and mechanical failures. Noncritical failures involved redundant heater blankets: a failure of nonfunctionally critical components.

Components which make up the PDU were individually analyzed. Most critical failures of these components included loss of command signal input, valve failure due to contamination, filter clogged, loss of hydraulic pressure, mechanical failures in gears and shafts, and inability to detect failures by the ASA fault detection circuitry.

4.2 Analysis Results - Rotary Actuator

Analysis of the actuator indicated that either an open or a jam in any of the gear trains resulted in loss of the actuator. Loss of the actuator would result in overloading the other actuators which would cause loss of vehicle control.

4.3 Analysis Results - Drive Shafts

Critical failures of the drive shaft, shaft fracture, and/or gear shearing from the shaft, result in loss of drive to or between the four rotary actuators which results in loss of vehicle 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 (FEMA) 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
GRT	-	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

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.

APPENDIX B
DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.3 RSB Specific Ground Rules and Assumptions

None.

APPENDIX C
DETAILED ANALYSIS

This section contains the IOA analysis worksheets generated during the analysis of this subsystem. The information on these worksheets is intentionally similar to the NASA FMEAs. Each of these sheets identifies the hardware item being analyzed, and parent assembly, as well as the function. For each failure mode, the possible causes are outlined, and the assessed hardware and functional criticality for each mission phase is listed, as described in the NSTS 22206, Instructions for Preparation of FMEA and CIL, 10 October 1986. Finally, effects are entered at the bottom of each sheet, and the worst case criticality is entered at the top.

LEGEND FOR IOA ANALYSIS WORKSHEETS

Hardware Criticalities:
- 1 = Loss of life or vehicle
- 2 = Loss of mission 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

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 101

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

ITEM: POWER DRIVE UNIT (PDU)
FAILURE MODE: GROSS FLUID LOSS (3 SYSTEMS) BETWEEN SWITCH VALVE AND POWER VALVE MODULES

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: COMPLETE SEAL FAILURE OR RUPTURE OF SERVO VALVE BODY, ISOLATION VALVE BODY, AP TRANSDUCER BODY, MANIFOLD LINES, RETURN LINES

EFFECTS/RATIONALE:
LOSS OF HYDRAULIC FLUID TO DRIVE HYDRAULIC MOTORS, RESULTS IN LOSS OF POWER TO DRIVE ROTARY ACTUATORS. THIS CAUSES LOSS OF CONTROL, AND .
LOSS OF CREW/VEHICLE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 102

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: POWER DRIVE UNIT (PDU)
FAILURE MODE: GROSS HYDRAULIC FLUID LOSS (1 SYSTEM)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: HYDRAULIC LINE TO MOTOR RUPTURE, IMPROPERLY SWAGED JOINTS

EFFECTS/RATIONALE:
LOSS OF ONE OF THREE REDUNDANT HYDRAULIC MOTOR DRIVES. HYRAULIC MOTOR BRAKE IS SET ON LOSS OF PRESSURE WHICH LOCKS SHAFT TO SUMMER DIFFERENTIAL GEAR BOX PREVENTING BACKDRIVE OF OTHER TWO MOTORS. WORST CASE EFFECT IS LOSS OF HOLDING TORQUE FROM THE MOTOR/BRAKE. OTHER TWO MOTORS WILL BACKDRIVE IF BRAKE DOES NOT SET (THIS IS CONSIDERED TO BE A SMART FAILURE).

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 103

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: POWER DRIVE UNIT (PDU)
FAILURE MODE: INTERNAL LEAK

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [3] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: SEAL FAILURE SWITCH VALVE SPOOL/SLEEVE, SW VALVE MODULE, STRUCTURAL JOINTS.

EFFECTS/RATIONALE:
ABORT DECISION. THERE IS A POSSIBLE LOSS OF ONE HYDRAULIC SYSTEM OVER AN EXTENDED PERIOD OF TIME. HOWEVER, THERE IS ADEQUATE POWER FROM THE REMAINING TWO HYDRAULIC SYSTEMS TO DRIVE THE ACTUATORS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 104

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/3
ABORT: 3/3

ITEM: FILTER
FAILURE MODE: FAILS TO FILTER

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) FILTER (2/1R CHANNEL, 1 SB CHANNEL)
4)
5)
6)
7)
8)
9)

	CRITICALITIES		
FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: RUPTURED FILTER

EFFECTS/RATIONALE:
NONE. THE 15 MICRON FILTER IS SIZED FOR VEHICLE LIFE. THIS IS CONSIRERED TO BE A NONCREDIBLE FAILURE SINCE NO KNOWN CAUSES COULD RUPTURE THE FILTER WHICH IS RATED AT 4500-PSI.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 105

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

ITEM: FILTER
FAILURE MODE: NO FLOW TO SERVOVALVE

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) FILTER (2/1R CHANNEL, 1 SB CHANNEL)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: CLOGGED

EFFECTS/RATIONALE:
FAILURE CAUSES LOSS OF HYDRAULIC PRESSURE NECESSARY TO DRIVE SERVOVALVES. THIS RESULTS IN LOSS OF RSB CONTROL THEREBY RESULTING IN LOSS OF VEHICLE/CREW.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 106

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	3/3
ABORT:	3/3

ITEM: HEATER BLANKET
FAILURE MODE: LOW TEMPERATURE SW. CLOSED (FAIL TO OPEN)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) HEATER BLANKET
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: CONTAMINATION, CONTACTS RUSTED TOGETHER, PIECE PART FAILURE

EFFECTS/RATIONALE:
NONE-OVERTEMP (HIGH) BREAKS CIRCUIT. REDUNDANT HEATERS-ONE HEATER IS ADEQUATE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 107

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	3/3
ABORT:	3/3

ITEM: HEATER BLANKET
FAILURE MODE: OVER TEMP. SW. CLOSED (FAILS TO OPEN)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) HEATER BLANKET
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: CONTAMINATION, CONTACTS RUSTED TOGETHER, PIECE PART FAILURE

EFFECTS/RATIONALE:
NONE-THREE TEMPERATURE SENSORS WILL VERIFY ACTUAL OVERTEMP - SHOULD TEMP. EXCEED LIMIT, POWER CAN BE REMOVED FROM FAULTY CIRCUIT. ONE HEATER IS ADEQUATE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 108

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/3
ABORT: 3/3

ITEM: HEATER BLANKET
FAILURE MODE: OPEN (FAILS TO ENERGIZE) LOW TEMP SW., HIGH TEMP SW., BLANKET HEATER ELEMENT

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) HEATER BLANKET
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN LEADS, BROKEN HEATER ELEMENT

EFFECTS/RATIONALE:
NONE-CIRCUIT A & CIRCUIT B ARE INDEPENDENT. ONE HEATER IS ADEQUATE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 109

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/3
ABORT: 3/3

ITEM: HEATER BLANKET
FAILURE MODE: TEMP SENSOR ERRONEOUS READING

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) HEATER BLANKET
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN BROKEN WIRE ELEMENT, SHORT IN SENSING ELEMENT

EFFECTS/RATIONALE:
LOSS OF SENSING UNIT ONLY. HEATERS CONTINUE TO OPERATE. DATA IS USED FOR DISPLAY ONLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 110

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: SWITCH VALVE
FAILURE MODE: SECONDARY VALVE FAILS TO SWITCH

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) SWITCH VALVE
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [P] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED TRANSFER SPOOL, CONTAMINATION

EFFECTS/RATIONALE:
WORST CASE FAILURE IS FAILURE OF SECOND SPOOL TO TRANSFER FROM 2ND STANDBY (PS2) HYDRAULIC SOURCE. SUBSEQUENT FAILURE OF PS2 RESULTS IN LOSS OF RSB CONTROL AND POTENTIAL LOSS OF CREW/VEHICLE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 111

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: SWITCH VALVE
FAILURE MODE: 1ST VALVE FAILS TO SWITCH ON LOSS OF PRIMARY HYD. SUPPLY

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) SWITCH VALVE
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	3/3	ATO:	2/1R
LANDING/SAFING:	2/1R		

REDUNDANCY SCREENS: A [2] B [P] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED TRANSFER SPOOL, CONTAMINATION

EFFECTS/RATIONALE:
NONE. THE SECOND VALVE WHICH IS TIED TO PS-2 WILL SWITCH TO PROVIDE HYRAULIC PRESSURE TO THE SEROVALVES. HOWEVER A SUBSEQUENT LOSS OF PS-2 WILL RESULT IN LOSS OF RSB CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 112

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/1R
ABORT: 3/1R

ITEM: SWITCH VALVE
FAILURE MODE: NO OUTPUT FLOW ACTIVE STAGE

LEAD ANALYST: R. WILSON   SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) SWITCH VALVE
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	3/3	TAL:	3/1R
ONORBIT:	3/3	AOA:	3/1R
DEORBIT:	3/1R	ATO:	3/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2]   B [P]   C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: LOSS OF ASSOCIATED HYRAULIC PRESSURE Pp, PS1 OR PS2

EFFECTS/RATIONALE:
NONE. VALVE SWITCHES TO ONE OF THE TWO REMAINING HYDRAULIC SYSTEMS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 113

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/3
ABORT: 3/3

ITEM: SWITCH VALVE
FAILURE MODE: VALVE POSITION TRANSDUCER FAILURE

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) SWITCH VALVE
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: LVDT-BROKEN/SHORTED ELECTRICAL LEAD

EFFECTS/RATIONALE:
INSTRUMENT LIGHT SHOWS TRANSFER OF HYDRAULIC SYSTEM. LIGHT IS INDICATION OF VALVE POSITION ONLY AND HAS NO EFFECT ON THE SERVO SYSTEM. A SECOND FAILURE IS REQUIRED BEFORE SWITCHING TO ANOTHER HYDRAULIC SOURCE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	2/1R
MDAC ID:	114	ABORT:	2/1R

ITEM: HYDRAULIC VALVE
FAILURE MODE: FAILS AT NULL OR OSCILLATORY (UNDETECTED BY ASA)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) HYRAULIC VALVE (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED SPOOL (CONTAMINATION), LOSS OF OF SIGNAL TO TORQUE MOTOR, TORQUE MOTOR FAILS

EFFECTS/RATIONALE:
NONE. LOSS OF 1 OF 4 CHANNELS (RUDDER AND/OR SPEEDBRAKE). THERE IS A POSSIBLE LOSS OF CONTROL AFTER LOSS OF ANOTHER CHANNEL. THE ASA CANNOT FAULT ISOLATE REMAINING CHANNELS IF ANOTHER FAILURE OCCURS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 115

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	2/1R
ABORT:	2/1R

ITEM: HYDRAULIC VALVE
FAILURE MODE: FAILS TO RETURN TO NULL

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) HYRAULIC VALVE (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [P] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED SPOOL (CONTAMINATION), LOSS OF OF SIGNAL TO TORQUE MOTOR, TORQUE MOTOR FAILS

EFFECTS/RATIONALE:
LOSS OF 1 OF 4 CHANNELS (RUDDER AND/OR SPEEDBRAKE). THERE IS A POSSIBLE LOSS OF CONTROL AFTER LOSS OF ANOTHER CHANNEL. THE ASA CANNOT FAULT ISOLATE 2 REMAINING CHANNELS IF ANOTHER FAILURE OCCURS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	2/1R
MDAC ID:	116	ABORT:	2/1R

ITEM: HYDRAULIC VALVE
FAILURE MODE: NO OR ERRONEOUS OUTPUT TO POWER VALVE

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) HYRAULIC VALVE (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: FAULT DETECTION TRANSDUCER OPEN, OR SHORT CIRCUIT ELECTRICAL OPEN IN ASA, MOTOR FLAPPER BROKEN.

EFFECTS/RATIONALE:
NONE. LOSS OF 1 OF 4 CHANNLES. THE HARDWARE FAILURE MODE IS 3/1R, HOWEVER THE ASA FAILURE MODE IS 2/1R. TWO ASA FAILURES CAN CAUSE LOSS OF CONTROL IF DETECTED. THE ASA CANNOT FAULT ISOLATE REMAINING CHANNELS IF ONE FAILS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 117

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: TORQUE MOTOR ASSEMBLY
FAILURE MODE: MOTOR FAILS

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) TORQUE MOTOR ASSEMBLY (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN/SHORT IN MOTOR WINDINGS, LOSS OF SIGNAL FROM ASA.

EFFECTS/RATIONALE:
NONE. LOSS OF 1 OF 4 CHANNELS (RUDDER OR SPEEDBRAKE). THE HARDWARE FAILURE MODE IS 3/1R. TWO ASA FAILURES CAN CAUSE LOSS OF CONTROL IF UNDETECTED. ASA FAILURE MODE IS 2/1R SINCE ASA CANNOT FAULT ISOLATE REMAINING CHANNELS IF ONE FAILS.
(SEE MDAC ID. 114)

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 118

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: TORQUE MOTOR ASSEMBLY
FAILURE MODE: FLAPPER FAILS TO CLOSE OFF ORIFICE TO DIRECT HYD. PRESSURE TO SERVOVALVE

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) TORQUE MOTOR ASSEMBLY (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: FLAPPER BROKEN, FATIGUE

EFFECTS/RATIONALE:
LOSS OF 1 OF 4 CHANNELS (RUDDER OR SPEEDBRAKE). SEE MDAC ID. 116

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 119

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	2/1R
ABORT:	2/1R

ITEM: SECONDARY DELTA P TRANSDUCER (4R, 4SB)
FAILURE MODE: LOSS OR ERRONEOUS OUTPUT (1 OF 4 OUTPUTS FROM R OR SB)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) SECONDARY DELTA P TRANSDUCER
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	1/R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN COIL OR LEAD; FAULTY TRANSDUCER, DRIFT, ELECTRICAL SHORT, OPEN IN ASA.

EFFECTS/RATIONALE:
LOSS OF 1 OF 4 CHANNELS. THE HARDWARE FAILURE MODE IS 3/1R. TWO ASA FAILURES CAN CAUSE LOSS OF CONTROL IF UNDECTED. ASA FAILURE MODE IS 2/1R. ASA CANNOT FAULT ISOLATE LAST CHANNELS IF ONE FAILS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	3/1R
MDAC ID:	120	ABORT:	3/1R

ITEM: ISOLATION VALVE
FAILURE MODE: VALVE FAILS TO ISOLATE BAD SERVOVALVE CHANNEL

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) ELECTRO HYDRAULIC SERVOVALVE ASSEMBLY
4) ISOLATION VALVE (4R, 4SB)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	3/3	TAL:	3/1R
ONORBIT:	3/3	AOA:	3/1R
DEORBIT:	3/1R	ATO:	3/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [P] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED SPOOL, CONTAMINATION, ELECTRICAL OPEN IN SOLENOID, LOSS OF SIGNAL FROM ASA.

EFFECTS/RATIONALE:
NONE. HVM IS DESIGNED WITH CAPABILITY OF 2 CHANNELS TO OVERRIDE FAILED UNISOLATED CHANNEL IN HARDOVER CONDITION. FULL CONTROL AUTHORITY IS MAINTAINED.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 121

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/3
ABORT: 3/3

ITEM: RECIRCULATION VALVE (1R, 1SB)
FAILURE MODE: FAILS OPEN, HYDRAULIC FLUID FLOWS AT ALL TIMES

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) RECIRCULATION VALVE (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED, CONTAMINATION

EFFECTS/RATIONALE:
NONE - NON-CRITICAL BACKUP. FLOW RESTRICTOR IN RETURN LINES WILL KEEP FLOW AT AN ACCEPTABLE LEVEL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	3/3
MDAC ID:	122	ABORT:	3/3

ITEM: RECIRCULATION VALVE (1R, 1SB)
FAILURE MODE: FAILS CLOSED, LOW OR NO HYDRAULIC FLOW

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATORS
2) PDU (1)
3) RECIRCULATION VALVE (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAMMED, CONTAMINATION, BORKEN SPRING, CLOGGED ORIFICE, CONTAMINATION

EFFECTS/RATIONALE:
NONE - NON-CRITICAL BACKUP. VALVE IS A SECOND BACKUP TO PDU HEATERS AND LINE HEATERS. DE-ORBIT PREPARATION MOVES FLIGHT CONTROL SURFACES & CIRCULATES WARM FLUID THROUGH THE ACTUATORS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	1/1
MDAC ID:	123	ABORT:	1/1

ITEM: TRIPLEX POWER VALVE
FAILURE MODE: FAILS CLOSED/OPEN

LEAD ANALYST: R. WILSON   SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) ACT. MECH. RSB
2) PDU (1)
3) TRIPLEX POWER VALVE (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: SEIZED DUE TO THERMAL EFFECTS, CHIPS IN VALVE

EFFECTS/RATIONALE:
FAILS CLOSED. THERE IS A LOSS OF FLUID TO DRIVE THE MOTORS WHICH RESULTS IN LOSS OF FUNCTION. FAILS OPEN. SURFACES WILL DRIVE TO STOPS WHICH COULD CAUSE INTERNAL DAMAGE WITH SUBSEQUENT LOSS OF FUNCTION.
EITHER FAILURE RESULTS IN LOSS OF VEHICLE CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	1/1
MDAC ID:	124	ABORT:	1/1

ITEM: HYDRAULIC MOTOR
FAILURE MODE: MOTOR SHAFT WHICH PROVIDES TORQUE TO SUMMER DIFFERENTIAL OPEN.

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) HYDRAULIC MOTOR/BRAKE ASSEMBLY (3R, 3SB)
4) HYRAULIC MOTOR
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: SHAFT SHEARED OR SPLINE SHEARED

EFFECTS/RATIONALE:
THIS IS A LOSS OF FUNCTION AND A LOSS OF CONTROL WHICH RESULTS IN LOSS OF VEHICLE/CREW. IF A SHAFT TO THE SUMMER DIFFERENTIAL IS FREE TO ROTATE, THE OTHER TWO MOTORS WILL DRIVE THE BAD SHAFT IN REVERSE, WHICH CAUSES A TORQUE SPILLOUT SO THAT THERE IS IS NO OUTPUT FROM THE GEARBOX TO THE MIXER GEARBOX.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 125

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	3/1R
ABORT:	3/1R

ITEM: HYDRAULIC MOTOR
FAILURE MODE: DEGRADED MOTOR OUTPUT

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) HYDRAULIC MOTOR/BRAKE ASSEMBLY (3R, 3SB)
4) HYRAULIC MOTOR
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	3/3	TAL:	3/1R
ONORBIT:	3/3	AOA:	3/1R
DEORBIT:	3/1R	ATO:	3/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: INTERNAL FAILURE (BY-PASS LEAKAGE)

EFFECTS/RATIONALE:
LEAKAGE RESULTS IN DEGRADED CAPABILITY ONLY WITH SOME LOSS OF REDUNDANCY. THE SYSTEM WILL FUNCTION NORMALLY. A COMPLETE FAILURE OF A MOTOR LEAVES TWO ACTIVE MOTORS WHICH PROVIDE FULL CONTROL CAPABILITY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 126

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: HYDRAULIC BRAKE
FAILURE MODE: FAILS TO BRAKE (WITH LOSS OF HYDRAULIC PRESSURE)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) HYDRAULIC MOTOR/BRAKE ASSEMBLY (3R, 3SB)
4) HYRAULIC BRAKE
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: FRACTURED ACTUATION-SPRING; PRESSURE PLATE, BRAKE PLATE, SHEARED BRAKE PLATE SPLINE.

EFFECTS/RATIONALE:
NONE (HYDRAULIC MOTOR STILL PROVIDES TORQUE TO DIFFERENTIAL GEAR BOX). SECOND FAILURE OR LOSS OF PRESSURE OF SAME SYSTEM CAUSES LOSS OF RSB.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 127

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 3/1R
ABORT: 3/1R

ITEM: HYDRAULIC BRAKE
FAILURE MODE: FAILS TO RELEASE

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) HYDRAULIC MOTOR/BRAKE ASSEMBLY (3R, 3SB)
4) HYRAULIC BRAKE
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	3/3	TAL:	3/1R
ONORBIT:	3/3	AOA:	3/1R
DEORBIT:	3/1R	ATO:	3/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: INTERNAL BY-PASS LEAK FAST PISTON TO RETURN, STUCK BRAKE, BLOCKED PRESSURE

EFFECTS/RATIONALE:
LOSS OF 1 SYSTEM. ONE MOTOR OUT - FULL RATE; 2 MOTORS OUT HALF RATE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 128

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

ITEM: HYDRAULIC BRAKE
FAILURE MODE: OPEN

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) HYDRAULIC MOTOR/BRAKE ASSEMBLY (3R, 3SB)
4) HYRAULIC BRAKE
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: INTERNAL SPLINE OR SHAFT SHEARED

EFFECTS/RATIONALE:
LOSS OF RSB. (BRAKE IS SET ONLY IF HYDRAULIC PRESSURE IS LOST.) SHEARED SPLINE OR SHAFT - NO RPM/TORQUE TO DIFFERENTIAL GEARBOX. DIFFERENTIAL BACK DRIVES - NO OUTPUT TO MIXER GEAR BOX. NOTE: IF A HYD. FAILURE OCCURRED & THE MOTOR DRIVESHAFT WAS FREE TO ROTATE, THE ACTION OF THE OTHER 2 GOOD MOTORS THROUGH THE DIFFERENTIAL GEARBOX WOULD DRIVE THE BAD ONE IN REVERSE. IT WOULD TRY TO ACT LIKE A HYD. PUMP AND THIS IN TURN WOULD TRANSMIT AN OPPOSITE TORQUE INTO THE GEARBOX.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 129

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

ITEM: SUMMER DIFFERENTIAL GEARBOX
FAILURE MODE: OPEN - NO RPM/TORQUE OUTPUT

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: ONE OF THREE SPLINED SHAFTS DISENGAGES, SPLINE OR GEAR FAILURE

EFFECTS/RATIONALE:
GEARBOX SUMS 3 MOTOR TORQUES TO SINGLE OUTPUT SHAFT TO DRIVE MIXER GEARBOX. LOSS OF OUTPUT - LOSS OF CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 130

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

ITEM: SUMMER DIFFERENTIAL GEARBOX
FAILURE MODE: DIFFERENTIAL OUTPUT JAM

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: GEAR MESH JAMMED BY BROKEN TOOTH, SEIZED BEARING

EFFECTS/RATIONALE:
LOSS OF OUTPUT TO MIXER - LOSS OF CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 131

HIGHEST CRITICALITY HDW/FUNC
FLIGHT: 2/1R
ABORT: 2/1R

ITEM: SUMMER DIFFERENTIAL GEARBOX
FAILURE MODE: REDUCED TORQUE OUTPUT

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: JAM ONE SET OF GEARS OF ONE DIFFERENTIAL

EFFECTS/RATIONALE:
JAMS 2 MOTORS - 1 MOTOR PROVIDE OUTPUT AT 1/2 RATE. LOSS OF OTHER MOTOR - CAUSE LOSS OF RSB CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 132

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	3/1R
ABORT:	3/1R

ITEM: SUMMER DIFFERENTIAL GEARBOX
FAILURE MODE: JAMMED - 1 INPUT SHAFT

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	3/3	TAL:	3/1R
ONORBIT:	3/3	AOA:	3/1R
DEORBIT:	2/1R	ATO:	3/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: GEAR MESH JAMMED SEIZED BEARING

EFFECTS/RATIONALE:
NONE - 2 MOTORS DRIVE AT FULL RATE. 2ND FAILURE/MOTOR DRIVE AT 1/2 RATE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 133

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

ITEM: POSITION TRANSDUCER
FAILURE MODE: LOSS OF OUTPUT (ALL TRANSDUCERS)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: SHEARED SHAFT; DRIVE TRAIN FAILURE (GEAR SHAFT TO X-DUCER SHAFT)

EFFECTS/RATIONALE:
LOSS OF INPUT TO ASA'S. LOSS OF RSB CONTROL. NOTE: RESULT OF 102 TEARDOWN-RI FOUND THAT AN INTERNAL BOLT WHICH HOLDS THE ASSY TOGETHER, HAD A LOCK WASHER WITH TAB THAT PEEPS BOLT FROM BACKING OFF HAD A CRACK.
(IF TAB FELL OFF COULD JAM X-DUCER (1/1 CRIT). RI (SUNSTRAND) HAS GONE TO ERB PROPOSING A FIX-WILL PRESENT A NASA CCB FOR GO-AHEAD APPROVAL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 134

HIGHEST CRITICALITY	HDW/FUNC
FLIGHT:	2/1R
ABORT:	2/1R

ITEM: POSITION TRANSDUCER
FAILURE MODE: LOSS OR ERRONEOUS OUTPUT (ONE OF FOUR OUTPUTS)

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) SUMMER DIFFERENTIAL GEARBOX (1R, 1SB)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	2/1R
LIFTOFF:	3/3	TAL:	2/1R
ONORBIT:	3/3	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

REDUNDANCY SCREENS: A [2] B [F] C [P]

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN COIL, LEAD, FAULTY X-DUCER, DRIFT, ELECTRICAL SHORT, OPEN IN ASA.

EFFECTS/RATIONALE:
NONE - FAILURE MODE IS 3/1R. 2 ASA FAILURES CAN REULT IN LOSS OF CREW/VEHICLE IF UNDETECTED. ASA FAILURE MODE IS 2/1R.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE:	10/16/86	HIGHEST CRITICALITY	HDW/FUNC
SUBSYSTEM:	RSB	FLIGHT:	1/1
MDAC ID:	135	ABORT:	1/1

ITEM: MIXER GEARBOX (1)
FAILURE MODE: NO OUTPUT, BOTH SHAFTS

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) PDU (1)
3) MIXER GEARBOX (1)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: OPEN/JAMMED ONE/BOTH SHAFTS, GEAR FRACTURE PARTS LODGED IN GEAR MESH, SEIZED BEARINGS

EFFECTS/RATIONALE:
LOSS OF RSB FUNCTIONS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 136

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

ITEM: GEAR ROTARY ACTUATOR (4)
FAILURE MODE: JAMMED

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) GEAR ROTARY ACTUATOR (4)
3)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0049, 0040, 0041, 0042

CAUSES: BROKEN TEETH, PART LODGED IN GEAR MESH, SEIZED BEARINGS, CONTAMINATION LOSS OF LUBRICANT MATERIAL DEFECT, MANUFACTURING DEFECT, FRACTURED SHAFT (FATIGUE, OVERLOAD)

EFFECTS/RATIONALE:
LOSS OF FUNCTION. LOSS OF RSB. LOSS OF CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 137

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

ITEM: DRIVE SHAFTS
FAILURE MODE: OPEN, NO POWER TRANSMISSION

LEAD ANALYST: R. WILSON   SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RSB SERVO ACTUATOR
2) DRIVE SHAFTS (10)
3)
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053

CAUSES: ALL TEETH SHEARED ON SPLINE, SHEARED BOLT, SHEARED RIVETS, SHEARED SHAFT

EFFECTS/RATIONALE:
TRANSFERS RPM/TORQUE BETWEEN PDU AND ROTARY ACTUATORS AND BETWEEN ROTARY ACTUATORS. LOSS OF FUNCTION. LOSS OF CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/16/86
SUBSYSTEM: RSB
MDAC ID: 138

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

ITEM: DIFFERENTIAL GEAR BOX
FAILURE MODE: INPUT SHAFT FROM 1ST DIFFERENTIAL TO 2ND DIFFERENTIAL OPEN

LEAD ANALYST: R. WILSON SUBSYS LEAD: R. WILSON

BREAKDOWN HIERARCHY:
1) RUDDER/SPEEDBRAKE SERVO ACTUATOR
2) POWER DRIVE UNIT
3) DIFFERENTIAL GEAR BOX
4)
5)
6)
7)
8)
9)

CRITICALITIES

FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	1/1
LIFTOFF:	3/3	TAL:	1/1
ONORBIT:	3/3	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: VERTICAL STABILIZER
PART NUMBER: MC621-0053-0048

CAUSES: SPLINED SHAFT DISENGAGES, SPLINE OR GEAR FRACTURE

EFFECTS/RATIONALE:
LOSS OF CONTROL. LOSS OF VEHICLE/CREW . 2ND DIFFERENTIAL BACKDRIVES FROM ONE REMAINING INPUT SINCE THERE IS NO RESTRAINING TORQUE. NO OUTPUT FROM DIFFERENTIAL TO MIXER GEARBOX.

REFERENCES:

APPENDIX D
POTENTIAL CRITICAL ITEMS

MDAC-ID	ITEM	FAILURE MODE
101	PDU	Gross fluid loss, 3 systems
102	PDU	Gross fluid loss, 1 system
103	PDU	Internal leak
105	Filter	Clogged
110	Switching Valve	Secondary spool fails to switch
111	Switch Valve	Primary spool fails to switch
114	Servovalve	Fails at null
115	Servovalve	Fails to return to null
116	Servovalve	No or erroneous output
117	Torque Motor Assembly	Motor fails, open/short, loss of signal
118	Torque Motor Assembly	Flapper broken
119	Secondary delta-P Transducer	Loss of or erroneous output (1 of 4)
123	Power Valve	Fails open/closed
124	Hydraulic Motor	Open
126	Hydraulic Brake	Fails to brake
127	Hydraulic Brake	Fails to release
128	Hydraulic Brake	Open
129	Summer Differential	Open
130	Summer Differential	Output jammed
131	Summer Differential	Partial jam
132	Summer Differential	Jam, 1 input shaft
133	Position Transducer	Fail all 4
134	Position Transducer	Loss of erroneous output (1 of 4)
135	Mixer Gearbox	Open; jammed
136	Drive Shaft	Open
137	Rotary Actuator	Jammed
138	Summer Differential	First differential shaft-open