INDEPENDENT ORBITER ASSESSMENT

ANALYSIS OF THE ELEVON SUBSYSTEM

21 NOVEMBER 1986

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

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Independent Orbiter Assessment
Analysis of the Elevon Subsystem

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 Elevon system hardware.

The elevon actuators are located at the trailing edge of the wing surface as shown in Figure 1. The proper function of the elevons is essential during the dynamic flight phases of ascent and entry. During flight, the Orbiter is controlled, in part, by four aerosurfaces called elevons. An elevon is a control surface which performs the same functions as an elevator and an aileron on a conventional airplane. In the ascent phase of flight, the elevons are used for relieving high wing loads. For entry, the elevons are used to pitch and roll the vehicle.

Specifically, the elevon system hardware comprises the following components:

- Flow Cutoff Valve
- Switching Valve
- Electro-Hydraulic (EH) Servoactuator
- Secondary Delta Pressure Transducer
- Bypass Valve
- Power Valve
- Power Valve Check Valve
- Primary Actuator
- Primary Delta Pressure Transducer
- Primary Actuator Position Transducer

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

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

Summary of IOA Failure Modes By Criticality (HW/F)							
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
Number :	8	9	-	3	-	5	25

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 :	8	9	-	1	-	18

Of the 25 failure modes analyzed, 18 were determined to be PCIs.

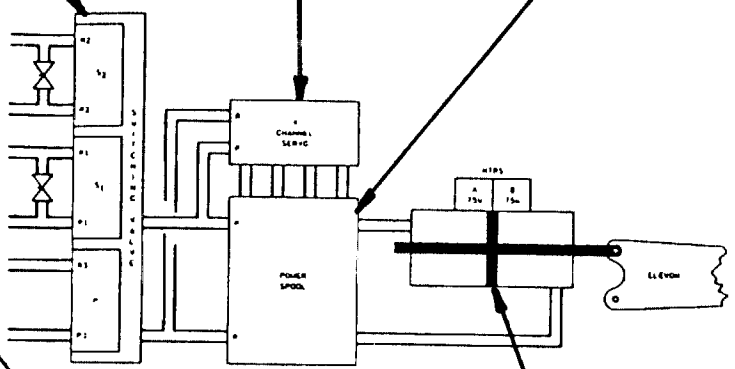
PRIMARY ACTUATOR		
CRIT.	#FM	#PCI
1/1	3	3
3/1R	3	1
3/3	2	0

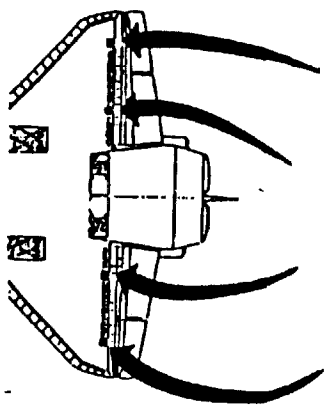
SWITCHING VALVE ASSY (1)		
CRIT.	#FM	#PCI
1/1	1	1
2/1R	2	2
3/3	2	0

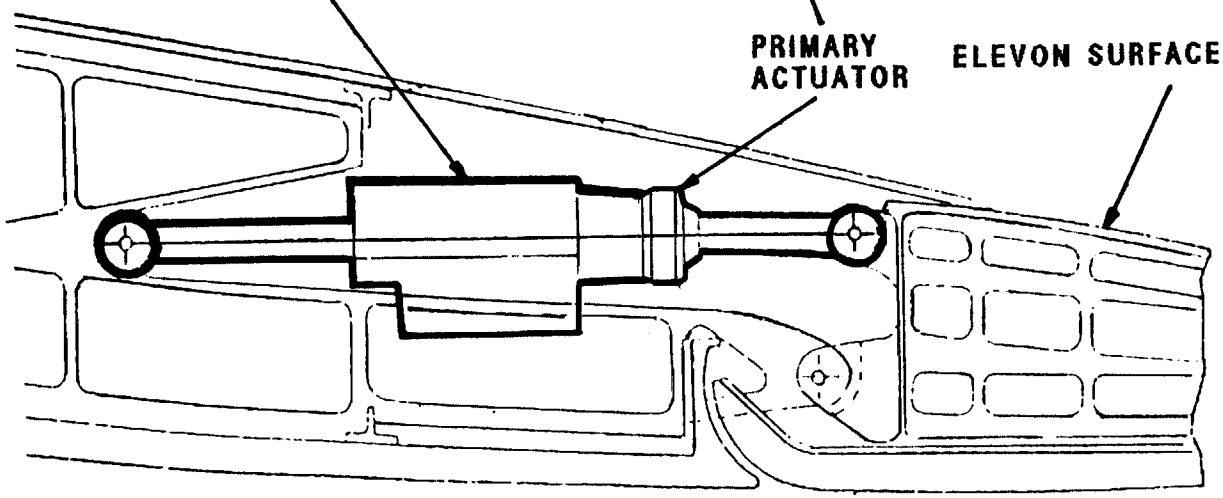
EH SERVOVALVE ASSY (4)		
CRIT.	#FM	#PCI
1/1	1	1
2/1R	6	6
3/3	1	0

POWER SPOOL VALVE ASSY (1)		
CRIT.	#FM	#PCI
1/1	3	3
2/1R	1	1

ELEVON ANALYSIS SUMMARY		
CRIT.	#FM	#PCI
1/1	8	8
2/1R	9	9
3/1R	3	1
3/2R	0	0
3/3	5	0







PROFILE VIEW OF ACTUATOR (1 OF 4)

Figure 1 - ELEVON ANALYSIS 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 reevaluating the FMEA/CIL for the Space Shuttle design. The MDAC is providing an 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 Elevon Ground Rules and Assumptions

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

3.0 SUBSYSTEM DESCRIPTION

The following sections describe the elevon actuator system hardware. Each of the four elevon actuator systems (Figure 2) comprise the following components: a flow cutoff valve, switching valve, EH servoactuator, secondary pressure transducer, bypass valve, power valve, primary actuator, primary actuator delta pressure transducer, and primary actuator position transducer.

3.1 Elevon Design and Function

The elevon actuators are located at the trailing edge of the wing surface. The proper function of the elevons is essential during the dynamic flight phases of ascent and entry. During flight the Orbiter is controlled, in part, by four aerosurfaces called elevons. An elevon is a control surface which performs the same functions as an elevator and an aileron on a conventional airplane. In the ascent phase of flight, the elevons are used for relieving high wing loads. For entry, the elevons are used to pitch and roll the vehicle.

Each elevon actuator is driven by one primary actuator. Control of the actuator is provided by four EH servovalves. These servovalves are used to create a secondary delta pressure which controls the flow of hydraulic fluid to one power valve. This power valve, when actuated, diverts fluid to the primary actuator (Figure 3).

The flow cutoff valve (or low-pressure bypass valve) is used to circulate hydraulic fluid during certain thermally cold periods. The flow cutoff valve should be opened during circulation pump operations only. The flow cutoff valve must be closed during high-pressure operations or degraded elevon performance will result.

The switching valve diverts pressure from one of the Orbiter's three hydraulic systems to supply adequate fluid and pressure to the primary and secondary elevon hydraulic system. The switching valve (Figure 4) contains two pistons, a primary and a secondary. If the pressure in the primary Orbiter hydraulic system drops below 1200 to 1500 psi, the switching valve primary piston will translate and allow the secondary hydraulic system to provide the required fluid and pressure to the downstream actuators. If the second hydraulic system is unable to provide pressure above 1200 to 1500 psi, the second switching valve piston will translate allowing the third hydraulic system to provide pressure to the actuator and servovalves. Linear Variable Differential Transformers (LVDTs) attached to the switching valve pistons indicate to the crew which hydraulic system is powering the elevon.

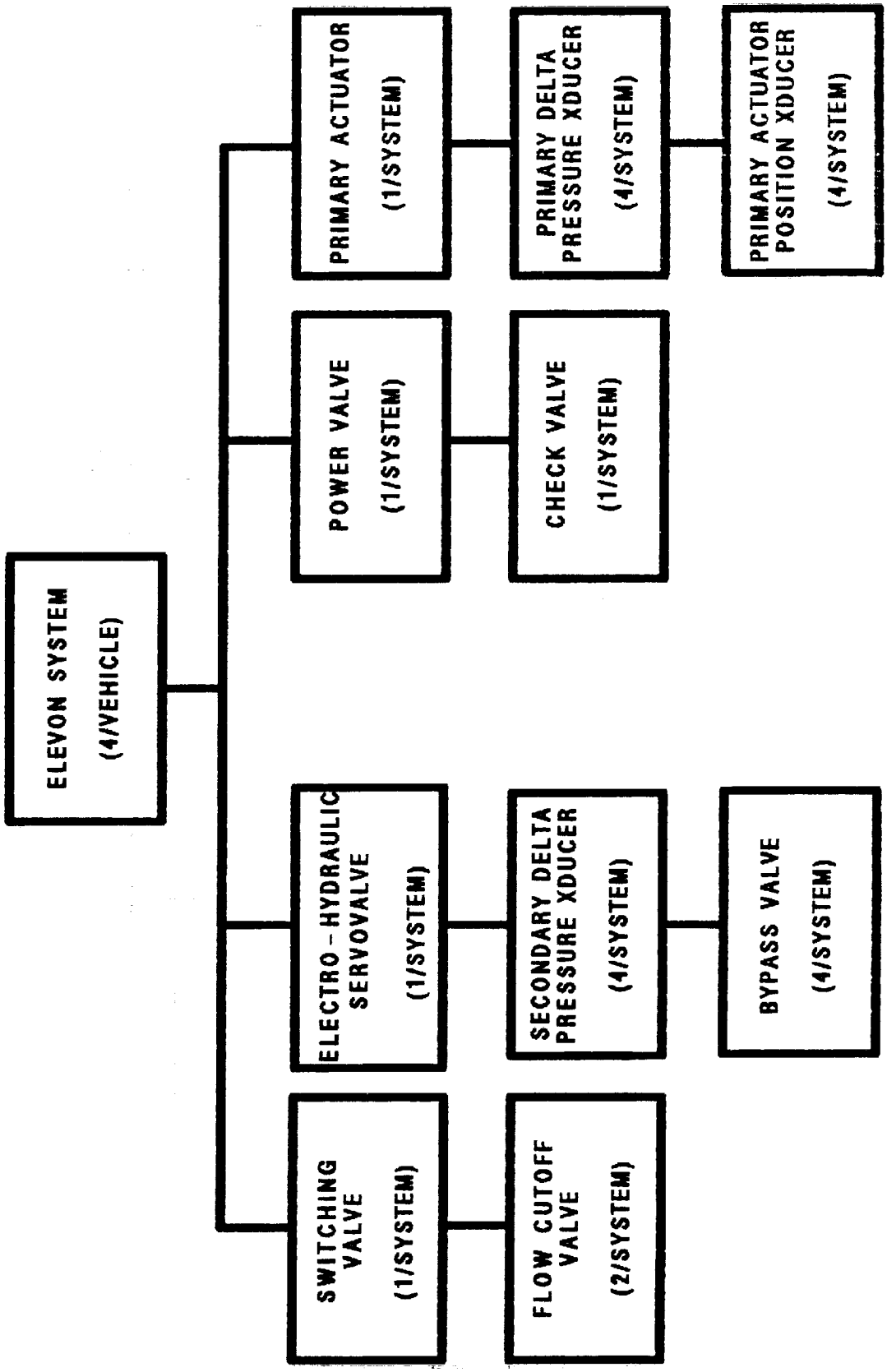


Figure 2 - ELEVON SYSTEM OVERVIEW

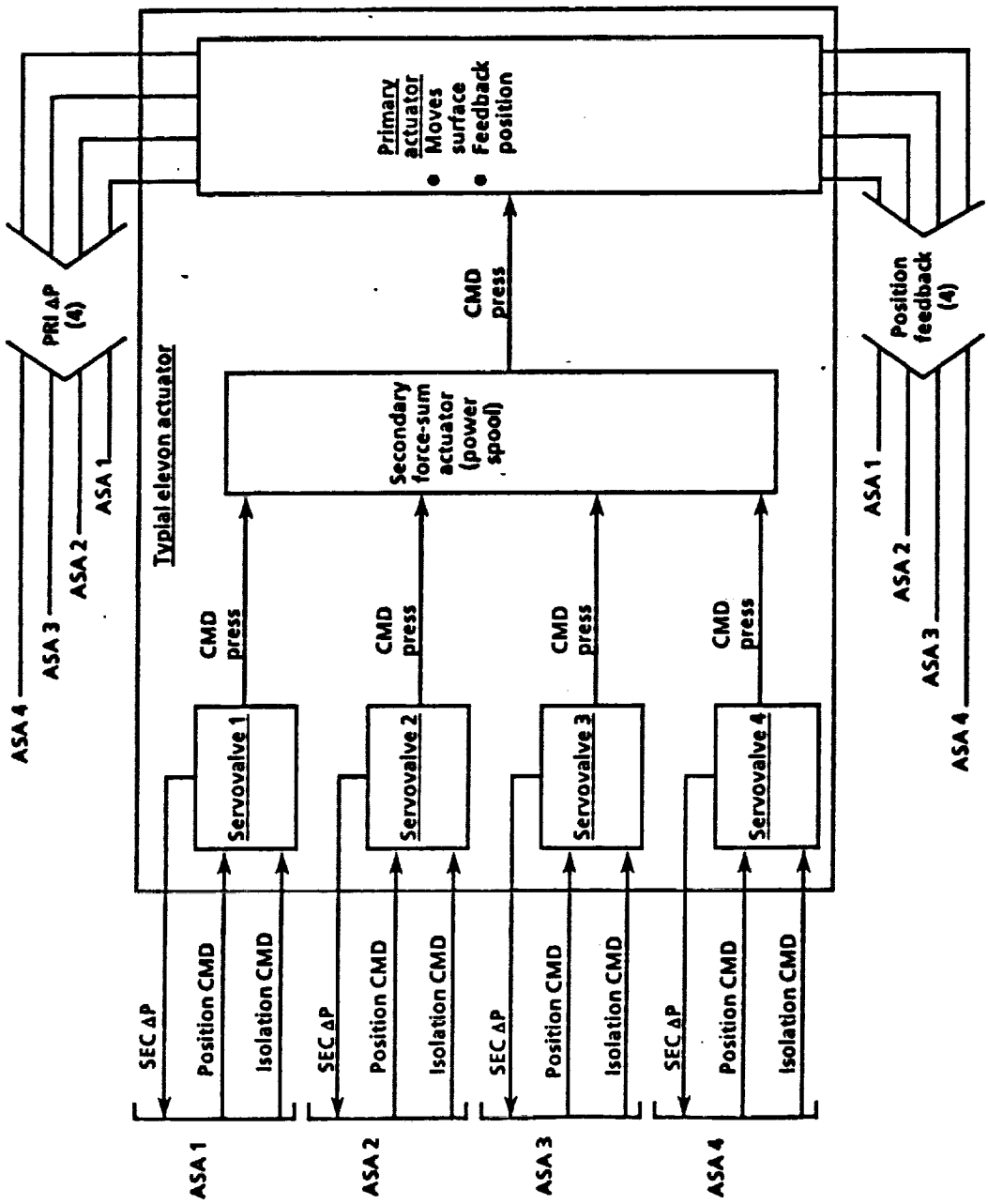


Figure 3 - TYPICAL ELEVON ACTUATION SYSTEM

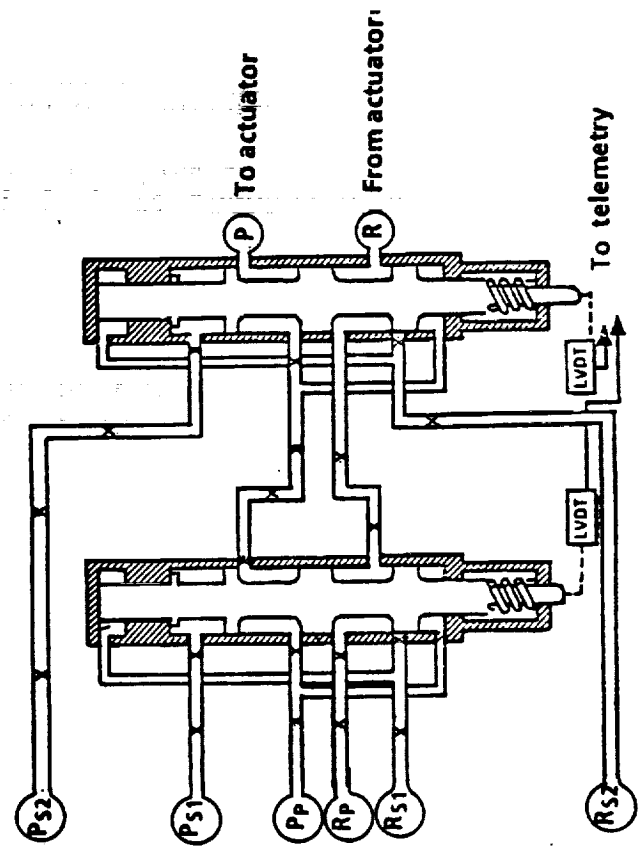


Figure 4 - SWITCHING VALVE

The many small passages, orifices, and restrictions in the secondary side of the servovalve assembly are highly sensitive to contaminants which enter the hydraulic system. A 15 micron filter conditions the hydraulic fluid which supplies the secondary side of the actuation system.

The elevon bypass valve is used to isolate an erroneous servovalve output from influencing the power valve movement. If secondary delta pressure exceeds 2200 psi for 120 milliseconds, the bypass valve diverts fluid away from the power spool to the return, preventing the erroneous or failed channel from creating a potential force-fight or incorrectly influencing power spool and elevon motion.

The secondary delta pressure transducers are used to measure the instantaneous pressure differential between the hydraulic source (nominally 3000 psi) and the servovalve reduced pressure. The transducer comprises a dual-spring balanced piston and a LVDT which transmits a transducer piston position in the form of a voltage to the Aerosurface Servo Amplifier (ASA). The ASA can use this voltage to determine the delta pressure across the corresponding servovalve. This information is used to bias equalization of four servovalve channels and activate their corresponding bypass valves when a channel cutoff is required.

The power valve combines four servovalve induced secondary delta pressures into a translation representing the commanded elevon movement. As the power valve moves, it allows a primary pressure to translate the primary actuator and its corresponding elevon. When one of the four secondary pressures are bypassed or erroneous, the remaining three pressures will overdrive the power valve.

The primary actuator is responsible for the ultimate motion of the elevon. It is controlled by a secondary pressure power valve which diverts primary hydraulic fluid and pressure to the actuator (Figure 5).

The primary delta pressure transducer is used to measure the instantaneous pressure differential across the primary actuator. The transducer comprises a dual-spring balanced piston and a LVDT which transmits a transducer piston position in the form of a voltage to the ASA. The ASA uses this voltage to determine the delta pressure across the primary actuator.

The position feedback transducer feeds the instantaneous position of the elevon to the ASA and General Purpose Computers (GPCs). The transducer consists of a LVDT calibrated to feedback a position voltage to the ASA. This information is used by th ASA for servovalve biasing and to the GPCs for Flight Control System (FCS) and caution and warning inputs. The current elevon position is displayed to the crew on the surface position indicators on Panel F7.

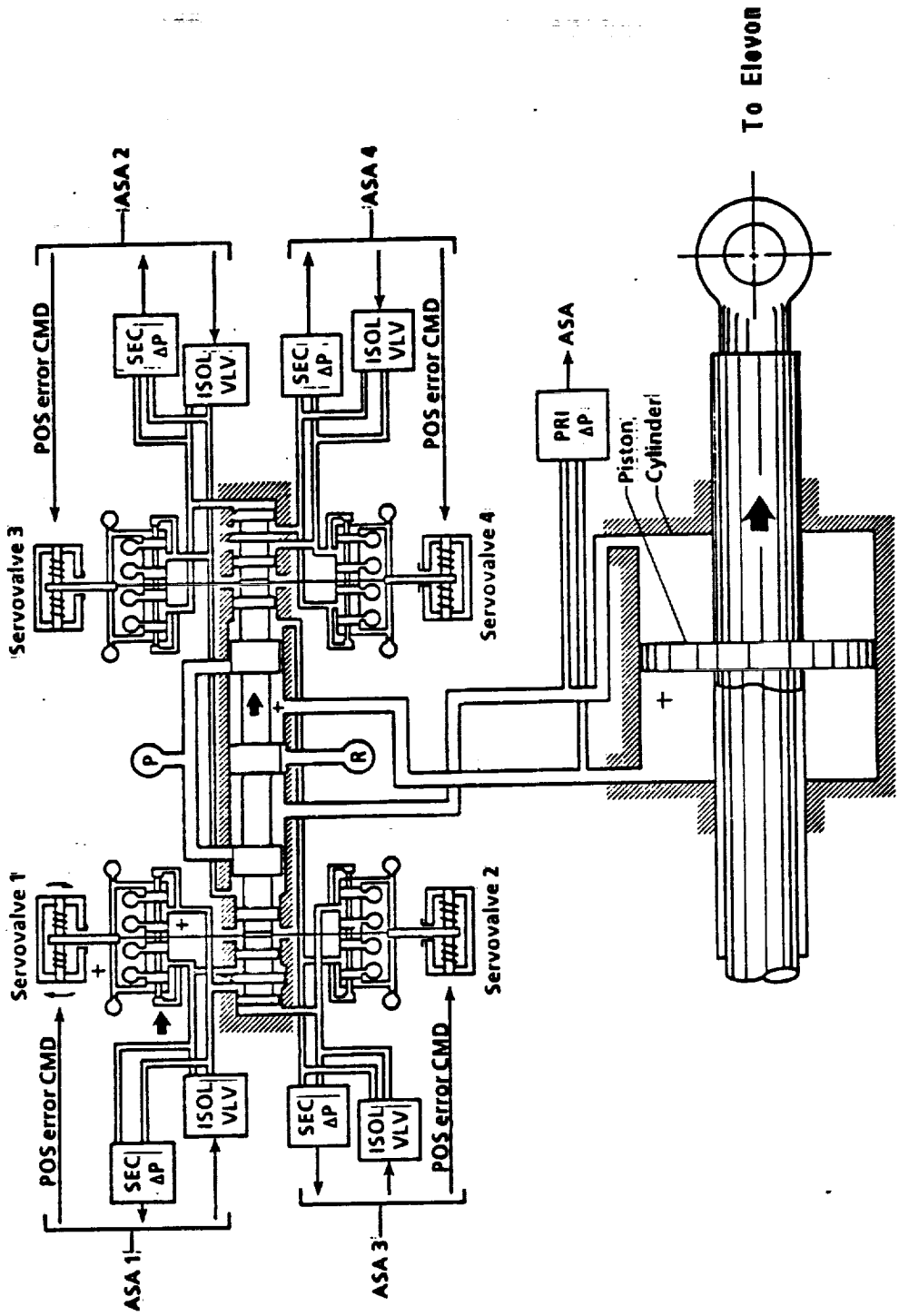


Figure 5 - ELEVON ACTUATOR

3.2 Interfaces and Locations

The elevon system hardware is located at the trailing edge of the Orbiter's wings. The elevon system interfaces with the Orbiter's three hydraulic systems, each corresponding to one Auxiliary Power Unit (APU). The elevon system hardware interfaces with the ASAs which in turn interface with the FCS portion of the GPCs for system control, fault detection, actuation and feedback.

3.3 Hierarchy

Figure 2 illustrates the hierarchy of the elevon hardware and corresponding subcomponents. Figures 3 through 5 comprise the detailed system representations.

4.0 ANALYSIS RESULTS

The elevon system schematic is depicted in Figure 2. The functional representation of the major system components is shown in Figures 3 and 4.

Detailed analysis results for each of the identified failure modes are presented in Appendix C. Table I presents a summary of the failure criticalities. Note that the tables below are divided into two groups: one for the primary actuator and related components and one for the secondary actuator and associated control items. Further discussion of each of these subdivisions and the applicable failure modes is provided in subsequent paragraphs.

4.1 Primary Actuator Analysis

This section describes failure modes analyzed in the primary actuator, primary actuator heaters, primary actuator delta pressure transducer and primary actuator position transducer. The failures analyzed for these components includes: internal and external leakage, structural failure, loss of or erroneous output, and heaters failing on or off.

4.2 Secondary Actuator Control Analysis

This section describes failure modes analyzed in the flow cutoff valve, switching valve, secondary system filter, EH servo valve, secondary delta pressure transducer, bypass valve, power valve and the power valve check valve. The failures analyzed for these components includes: internal leakage, seal failure, restricted flow, component rupture, jammed piston or valves, failure to switch, loss of output, and units failing open or closed.

TABLE I Summary of IOA Failure Modes and Criticalities

Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
o Primary Actuator							
Primary Actuator	2	-	-	1	-	2	5
Primary DP Transducer	-	-	-	2	-	-	2
Prim. Act. Position Transducer	1	-	-	-	-	-	1
o Secondary Actuator							
Flow Cutoff Valve	-	-	-	-	-	2	2
Switching VLV	1	2	-	-	-	-	3
EH Servo VLV	1	3	-	-	-	1	5
Secondary DP Transducer	-	1	-	-	-	-	1
Bypass VLV	-	2	-	-	-	-	2
Power VLV	2	-	-	-	-	-	2
Power VLV Check VLV	1	1	-	-	-	-	2
TOTAL	8	9	-	3	-	5	25

Of these 25 failure modes analyzed, 18 were determined to be PCIs. A summary of the PCIs is presented in Table II. Appendix D contains a cross-reference between each PCI and a specific analysis worksheet in Appendix C.

TABLE II Summary of IOA Potential Critical Items

Criticality:	1/1	2/1R	2/2	3/1R	3/2R	TOTAL
o Primary Actuator						
Primary Actuator	2	-	-	1	-	3
Prim. Act. DP Transducer	-	-	-	-	-	-
Prim. Act. Position Transducer	1	-	-	-	-	1
o Secondary Actuator						
Flow Cutoff Valve	-	-	-	-	-	-
Switching VLV	1	2	-	-	-	3
EH Servo VLV	1	3	-	-	-	4
Secondary DP Transducer	-	1	-	-	-	1
Bypass VLV	-	2	-	-	-	2
Power VLV	2	-	-	-	-	2
Power VLV Check VLV	1	1	-	-	-	2
TOTAL	8	9	-	1	-	18

5.0 REFERENCES

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

1. NSTS 22206: Instructions for Preparation of FMEA and CIL October 10, 1986.

2. FCS/EFF 2102: The FCS/Effectors Training Manual February 1982

3. JSC11174: MOD Drawings - applicable pages

4. VS70-580996: Rockwell Drawings

5. STS82-0039A: Applicable CIL Sections

6. NASA CP-2342: Space Shuttle Technical Conference Part 2, pp. 861-871, June 28-30, 1983.

7. SD72-SH-0102-9: Requirements/Definition Document Aero Flight Control Mechanisms Rockwell International, Volume 2-9, October 28, 1975

The following references have been ordered, but were unavailable for the independent assessment:

1. SD72-SH-0102-6: Requirements/Definition Document Hydraulic Subsystem Rockwell International

APPENDIX A
ACRONYMS

APU	- Auxiliary Power Unit
ASA	- Aerosurface Servo Amplifier
ASSY	- Assembly
CIL	- Critical Items List
EH	- Electro-Hydraulic
FCS	- Flight Control System
FM	- Failure Mode
FMEA	- Failure Modes and Effects Analysis
F	- Functional
GFE	- Government Furnished Equipment
GPC	- General Purpose Computer
HW	- Hardware
IOA	- Independent Orbiter Assessment
LVDT	- Linear Variable Differential Transformer
MDAC	- McDonnell Douglas Astronautics Company
NA	- Not Applicable
NASA	- National Aeronautics and Space Administration
NSTS	- National Space Transportation System
PCI	- Potential Critical Item
psi	- Pounds Per Square Inch
psid	- Pounds Per Square Inch Differential
RI	- Rockwell International
VLV	- Valve
xducer	- Transducer

APPENDIX B

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

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

APPENDIX B
DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.1 Definitions

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

INTACT ABORT DEFINITIONS:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

OPS - software operational sequence

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

PHASE DEFINITIONS:

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

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

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

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

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

APPENDIX B
DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.2 IOA Project Level Ground Rules and Assumptions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B.3 Elevon-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: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/3
MDAC ID: 101 ABORT: 3/3

ITEM: FLOW CUTOFF VALVE
FAILURE MODE: FAILS OPEN

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3)
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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
FAILS OPEN DURING HIGH PRESSURE OPERATION-SLIGHT LOSS OF SYSTEM PRESSURE; NOMINALLY OPEN AT LOW PRESSURE OPERATION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/3
MDAC ID: 102 ABORT: 3/3

ITEM: FLOW CUTOFF VALVE
FAILURE MODE: FAILS CLOSED

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3)
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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
FAILS DURING LOW PRESSURE OPERATION; HEATERS CONDITION THE SYSTEM-NO OPERATIONAL AFFECT. NOMINALLY CLOSED AT HIGH PRESSURE OPERATION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 103 ABORT: 2/1R

ITEM: SWITCHING VALVE
FAILURE MODE: SEAL FAILURE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING 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:	/NA	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
SEAL IN SWITCHING VALVE FAILS; LOSS OF FLUID IN ONE HYDRAULIC SYSTEM. SYSTEM OPERATES NORMALLY ON SECONDARY SYSTEM.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 104 ABORT: 2/1R

ITEM: SWITCHING VALVE
FAILURE MODE: FAILS TO SWITCH

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING 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:	/NA	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: BROKEN OR FAILED SPRING; CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
SPRING FAILS TO MAINTAIN RESTORING FORCE, PRIMARY SWITCHING VALVE CANNOT MAINTAIN POSITION FOR PRIMARY PRESSURE. SECONDARY SIDE OF SWITCHING VALVE CONTROLS PRESSURE TO ELEVON SYSTEM. SYSTEM OPERATES NOMINALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 105 ABORT: 1/1

ITEM: SWITCHING VALVE
FAILURE MODE: COMPONENT RUPTURE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
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:	/NA	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: FATIGUE

EFFECTS/RATIONALE:
COMPONENT HOUSING FAILS DOWNSTREAM OF SWITCHING VALVE. LOSS OF HYDRAULIC FLUID AND ELEVON MOTION/CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86
SUBSYSTEM: ELEVON
MDAC ID: 106

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

ITEM: CHECK VALVE
FAILURE MODE: FAILS CLOSED

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) CHECK VALVE
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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
PRIMARY ACTUATOR STARVED OF HYDRAULIC FLUID AND PRESSURE. LOSS OF ELEVON MOVEMENT AND CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 107 ABORT: 2/1R

ITEM: CHECK VALVE
FAILURE MODE: FAILS OPEN

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) CHECK VALVE
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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
PRIMARY ACTUATOR ENCOUNTERS A HIGH HINGE MOMENT BACK-PRESSURING THE UPSTREAM SYSTEM. THE SWITCHING VALUE CANNOT OPERATE IF A HYDRAULIC SYSTEM IS LOST DURING THIS PERIOD. POSSIBLE LOSS OF LIFE AND VEHICLE.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/22/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 108 ABORT: 1/1

ITEM: FILTER - 15 MICRON
FAILURE MODE: RESTRICTED FLOW

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
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:	/NA	AOA:	1/1
DEORBIT:	1/1	ATO:	1/1
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: HYDRAULIC SYSTEM CONTAMINATED

EFFECTS/RATIONALE:
SECONDARY SIDE OF SYSTEM DEPRIVED OF FLUID AND PRESSURE; LOSS OF PRIMARY ACTUATOR CONTROL/MOTION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/22/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 109 ABORT: 2/1R

ITEM: SERVO VALVE
FAILURE MODE: JAMMED PISTON; FLAPPER VALVE FAILS

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
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:	/NA	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATION IN SYSTEM, LOSS OF ASA CHANNEL

EFFECTS/RATIONALE:
ONE OF FOUR SERVO VALVES BIND; REMAINING THREE SERVO VALVES OVERDRIVE THE JAMMED SYSTEM. PRIMARY ACTUATOR FUNCTIONS NOMINALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/01/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/3
MDAC ID: 110 ABORT: 3/3

ITEM: SERVO VALVE
FAILURE MODE: INTERNAL LEAKAGE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
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:	/NA	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: DAMAGED SEALS-FOREIGN MATERIALS IN HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
BARRIER SEALS PREVENT LEAKAGE OF FLUID EXTERNAL TO COMPONENTS; SYSTEM OPERATES NORMALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/22/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 111 ABORT: 2/1R

ITEM: SERVO VALVE RESTRICTOR
FAILURE MODE: PLUGGED

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) SERVO VALVE RESTRICTOR
7)
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
NO DELTA PRESSURE ACROSS SERVO VALVE; LOSS OF ONE SERVO VALVE, THREE REMAINING VALVES OPERATE ELEVON NOMINALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/22/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 112 ABORT: 2/1R

ITEM: BYPASS VALVE
FAILURE MODE: FAILS TO OPEN/CLOSE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7)
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: JAMMED SPOOL, BROKEN SPRING, LOSS OF ASA SIGNAL

EFFECTS/RATIONALE:
THREE REMAINING SERVO VALVES OVERDRIVE THE SYSTEM IF BYPASS VALVE DOES NOT OPEN WHEN SECONDARY DELTA PRESSURE >2200 PSID. SYSTEM FUNCTIONS NOMINALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/24/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 113 ABORT: 2/1R

ITEM: BYPASS VALVE FILTER-100 MICRON
FAILURE MODE: PLUGGED

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) FILTER - 15 MICRON
4) SERVO VALVE
5) BYPASS VALVE
6) BYPASS VALVE FILTER-100 MICRON
7)
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: HYDRAULIC SYSTEM CONTAMINATED

EFFECTS/RATIONALE:
BYPASS VALVE UNABLE TO RELIEVE SECONDARY HYDRAULIC PRESSURE FROM QUAD CHANNELS; REMAINING SYSTEMS OVERDRIVES THE NON OPERATIONAL SERVO CHANNEL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/24/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 114 ABORT: 2/1R

ITEM: SECONDARY DELTA PRESSURE TRANSDUCER
FAILURE MODE: LOSS OF OUTPUT

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) SECONARY DELTA PRESSURE TRANSDUCER
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: BROKEN OR BINDING SPRING; LOSS OF ASA CHANNEL

EFFECTS/RATIONALE:
BYPASS VALVE OPENS REMOVING SERVO VALVE FROM LOOP. THREE REMAINING SECONDARY SYSTEMS OVERDRIVE THE FAULTY CHANNEL. FULL ACTUATOR FUNCTION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/24/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 115 ABORT: 1/1

ITEM: POWER VALVE
FAILURE MODE: RUPTURED HOUSING

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: FATIGUE

EFFECTS/RATIONALE:
LOSS OF ALL HYDRAULIC FLUID, SECONDARY PRESSURE, AND ASSOCIATED PRIMARY ACTUATOR MOTION CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/24/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 116 ABORT: 1/1

ITEM: POWER VALVE
FAILURE MODE: JAMMED

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8)
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: HYDRAULIC SYSTEM CONTAMINATED

EFFECTS/RATIONALE:
LOSS OF ALL DOWNSTREAM MOTION; UNABLE TO CONTROL OR MOVE ELEVON.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/24/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 117 ABORT: 1/1

ITEM: PRIMARY ACTUATOR
FAILURE MODE: EXTERNAL LEAKAGE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATION IN SYSTEM, CRACKED HOUSING, GROSS LEAKAGE, SEAL FAILURE

EFFECTS/RATIONALE:
LOSS OF ELEVON MOTION AND CONTROL.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/30/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 118 ABORT: 1/1

ITEM: LVDT
FAILURE MODE: LOSS OF OUTPUT

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER 15 - MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: FRACTURE OF LVDT SUPPORT BASE

EFFECTS/RATIONALE:
LOSS OF ALL OUTPUT AND POSITION FEEDBACK FROM PRIMARY ACTUATOR; INABILITY TO DETERMINE ELEVON POSITION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/01/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 1/1
MDAC ID: 119 ABORT: 1/1

ITEM: PRIMARY ACTUATOR
FAILURE MODE: STRUCTURAL FAILURE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: FATIGUE

EFFECTS/RATIONALE:
ACTUATOR PISTON COMPONENTS (RODEND, TAILSTOCK, RETAINER, ETC.) FAILS; LOSS OF ELEVON CONTROL AND MOTION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/01/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/3
MDAC ID: 120 ABORT: 3/3

ITEM: PRIMARY ACTUATOR
FAILURE MODE: INTERNAL LEAKAGE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9)

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: DAMAGED SEALS-FOREIGN MATERIAL IN HYDRAULIC SYSTEM.

EFFECTS/RATIONALE:
BARRIER SEALS PREVENT LEAKAGE OF FLUID EXTERNAL TO COMPONENT; SYSTEM OPERATES NORMALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/01/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/1R
MDAC ID: 121 ABORT: 3/1R

ITEM: PRIMARY DELTA PRESSURE TRANSDUCER
FAILURE MODE: LOSS OF OUTPUT

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9) PRIMARY DELTA PRESSURE TRANSDUCER

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: BROKEN OR BINDING SPRING; LOSS OF ASA CHANNEL

EFFECTS/RATIONALE:
LOSS OF PRIMARY CHANNEL, FULL FUNCTION ON THREE REMAINING CHANNELS.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 9/25/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/1R
MDAC ID: 122 ABORT: 3/1R

ITEM: PRIMARY ACTUATOR DELTA PRESSURE TRANSDUCER
FAILURE MODE: ERRONEOUS OR NO OUTPUT

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9) PRIMARY DELTA PRESSURE TRANSDUCER

CRITICALITIES

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

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: LOSS OF ASA CHANNEL OR POWER; OPEN LEAD

EFFECTS/RATIONALE:
THREE REMAINING SYSTEMS FEEDBACK ACTUATOR POSITION; SYSTEM OPERATES NORMALLY.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86
SUBSYSTEM: ELEVON
MDAC ID: 123

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

ITEM: HEATER
FAILURE MODE: FAILS ON

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9) HEATER

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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: VIBRATION

EFFECTS/RATIONALE:
HEATING ELEMENT CONTINUOUSLY POWERED; AN OVER-TEMPERATURE HEATER RESULTS; SYSTEM DESIGNED TO WITHSTAND EXCESS HEAT LOAD.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/02/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 3/3
MDAC ID: 124 ABORT: 3/3

ITEM: HEATER
FAILURE MODE: FAILS OFF

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO VALVE
6) BYPASS VALVE
7) POWER VALVE
8) PRIMARY ACTUATOR
9) HEATER

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: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: VIBRATION OPENS LEAD TO UNIT; LOSS OF POWER TO HEATER

EFFECTS/RATIONALE:
HEATING ELEMENT DOES NOT RECEIVE POWER; BACKUP HEATER CONDITIONS ACTUATOR OR SYSTEM CAN BE EXCERCISED TO PREVENT UNDER TEMPERATURE SITUATION.

REFERENCES:

INDEPENDENT ORBITER ASSESSMENT
ORBITER SUBSYSTEM ANALYSIS WORKSHEET

DATE: 10/03/86 HIGHEST CRITICALITY HDW/FUNC
SUBSYSTEM: ELEVON FLIGHT: 2/1R
MDAC ID: 125 ABORT: 2/1R

ITEM: SERVO ACTUATOR
FAILURE MODE: INTERNAL LEAKAGE

LEAD ANALYST: J. RICCIO SUBSYS LEAD: J. RICCIO

BREAKDOWN HIERARCHY:
1) ELEVON
2) FLOW CUTOFF VALVE
3) SWITCHING VALVE
4) FILTER - 15 MICRON
5) SERVO ACTUATOR
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:	/NA	AOA:	2/1R
DEORBIT:	2/1R	ATO:	2/1R
LANDING/SAFING:	3/3		

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

LOCATION: WING TRAILING EDGE
PART NUMBER: MC621-0014

CAUSES: CONTAMINATED HYDRAULIC SYSTEM

EFFECTS/RATIONALE:
SEAL FAILURE-ANY COMPONENT IN SERVO ACTUATOR SYSTEM; BARRIER SEAL DESIGN ON ALL SEALS-SYSTEM OPERATES NORMALLY.

REFERENCES:

APPENDIX D
POTENTIAL CRITICAL ITEMS

MDAC ID	ITEM	FAILURE MODE
103	Switching valve	Seal failure
104	Switching valve	Fails to switch
105	Switching valve	Component rupture
106	Check valve	Fails closed
107	Check valve	Fails open
108	Filter - 15 miron	Restricted flow
109	Servovalve	Jammed piston
111	Servovalve restrictor	Plugged
112	Bypass valve	Fails to open/close
113	Filter - 100 micron	Plugged
114	Secondary delta P xducer	Loss of output
115	Power valve	Ruptured housing
116	Power valve	Jammed
117	Primary actuator	External leakage
118	LVDT	Loss of output
119	Primary actuator	Structural failure
124	Heater	Fails off
125	Servo actuator	Internal leakage