SYSTEM ASSURANCE ANALYSIS

OF THE

20 TON BRIDGE CRANE

DESHAZO CRANE No. 22015

LOCATED IN

BUILDING H-100
PAYLOAD PROCESSING FACILITY
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VA

Performed by: DESHAZO CRANE COMPANY
May 2004

Cranes - Hoists & Conveyors

Williamson & Wilmer
Incorporated

Steve Oddi

5807 Staples Mill Road
Richmond, VA 23228

Tel: (804) 266-7623
Fax: (804) 261-1884

E-Mail: Steveoddi@Williamson-Wilmer.com

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LIST OF ABBREVIATIONS AND ACRONYMS

AGMA	American Gear Manufacturers Association
ASSY.	Assembly
CA	Catastrophic
CAT.	Category
CIL.	Critical Items List
CN	Controlled
CRIT.	Criticality
CSFP	Critical Single Failure Point
FMN	Failure Mode Number
FMEA	Failure Modes and Effects Analysis
FPM	Feet Per Minute
GSE	Ground Support Equipment
KSC	Kennedy Space Center
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NSTS	National Space Transportation System
NWFC	NASA-Wallops Flight Center
OMD	Operations Maintenance Documentation
OMI	Operations and Maintenance Instruction
ORMSD	Operations and Maintenance Requirement and Specification Document
PCN	Program Control Number
PMN	Program Model Number
PMOMI	Preventative Maintenance Operations and Maintenance Instruction
QTY.	Quantity
REF.	Reference
REV.	Revision
RPM	Revolutions Per Minute
SAA	Systems Assurance Analysis
SHA	System Hazard Analysis
S/S	Station Set
STS	Space Transportation System
W.O.	Work Order

DEVICE TERMINOLOGY LIST

BBC	-	BRIDGE BRAKING CONTACTOR
CFU	-	CONTROL POWER TRANSFORMER FUSED
CPT	-	CONTROL POWER TRANSFORMER
TBC	-	TROLLEY BRAKE CONTACTOR
TCB	-	TROLLEY CIRCUIT BREAKER
BCB	-	BRIDGE CIRCUIT BREAKER
TD	-	THERMAL DETECTOR IN MOTOR WINDING
MC	-	MAINLINE CONTACTOR
MCB	-	MAIN CIRCUIT BREAKER DISCONNECT
BVFD	-	BRIDGE VARIABLE FREQUENCY DRIVE
TVFD	-	TROLLEY VARIABLE FREQUENCY DRIVE
HVFD	-	HOIST VARIABLE FREQUENCY DRIVE
HBC	-	HOIST BRAKE CONTACTOR
HBBC	-	HOIST BACKUP BRAKE CONTACTOR
HCB	-	HOIST CIRCUIT BREAKER
GULS	-	HOIST GEARED UPPER LIMIT SWITCH
GLLS	-	HOIST GEARED LOWER LIMIT SWITCH
WLS	-	HOIST WEIGHTED UPPER LIMIT SWITCH
HCR	-	HOIST BRAKE FAILURE CONTROL RELAY
HLR	-	HOIST LINE REACTOR
BLR	-	BRIDGE LINE REACTOR
TLR	-	TROLLEY LINE REACTOR
HBT	-	HOIST BRAKE TRANSFORMER
BRES	-	HOIST BRAKE RESISTOR
PCLS	-	HOIST POWER CIRCUIT LINIT SWITCH
HBT	-	HOIST DC BRAKE TRANSFORMER
REC	-	HOIST DC BRAKE RECTIFIER
L2, L3	-	HOIST LIMIT SWITCH STATUS LIGHTS
UVR	-	UNDERVOLTAGE RELAY
W	-	POWER AVAILABLE PILOT LIGHT

SECTION I

1.0 SUMMARY OF FINDINGS

1.1 SYSTEM CRITICALITY

The 20 Ton Bridge Crane to be located in the Payload Processing Facility, at Goddard Space Flight Center in Wallops Island, VA is assessed as critical due to its direct interface with flight hardware. A failure could cause damage to flight hardware, and could cause loss of life by fire and/or toxic propellant release.

1.2 MECHANICAL CRITICAL ITEMS

There was one (1) category 1 mechanical Critical Item identified in the critical output functions identified in section iv for this analysis, which are summarized below. See section 5.1 and 5.6 for additional information.

Ref. Des./ Find No.	Nomenclature	Critical Failure Mode	Criticality Category
None	Hoist Gear Reducer	Disengages	1

1.3 ELECTRICAL CRITICAL ITEMS

There were no electrical critical items identified in the critical output functions identified in section iv for this equipment. See section 5.2 for additional information.

1.4 CRITICAL FLEX HOSES

There are no flex hoses associated with this equipment.

1.5 CRITICAL ORIFICES

There are no orifices associated with this equipment.

1.6 CRITICAL FILTERS

There are no filters associated with this equipment.

1.7 CRITICALITY CATEGORY 1R ITEMS

There were no criticality category 1R items identified in this critical output functions identified in section IV for this equipment.

1.8 HAZARDS IDENTIFIED

There were no formal hazards identified during this analysis.

1.9 CRITICAL CONTROL

1.10 SNEAK CIRCUITS IDENTIFIED

There was no Sneak Circuit Analysis performed for this system.

1.11 AREAS OF CONCERN AND RECOMMENDATIONS

There was one area of concern and recommendation to be considered for this system, reference section XI for further information.

SECTION II

2.0 SYSTEM SUMMARY

2.1 HISTORY AND BASELINE

This system is intended for use in the Payload Processing Facility at the Goddard Space Flight Center, in Wallops Island, VA. This facility is a commercial facility and no baseline number is assigned.

2.2 DOCUMENTATION LIST

The following reference documentation and drawings were used in the accomplishment of this system assurance analysis.

Document/Dwg. No.	Rev.	Outstanding EO's	Title
NASA SPECIFICATION 02WCAZ SECT. 14600	03/03	NONE	SPECIAL PAYLOAD PROCESSING FACILITY
NASA DRAWING No. 13879	0	NONE	FLOOR PLAN – LIFTING DEVICES
NASA DRAWING No. 13880	0	NONE	20 TON BRIDGE CRANE SECTION
DeSHAZO Crane Company D-22015-E3	0	NONE	CONTROL WIRING DIAGRAM VARIABLE FREQUENCY TROLLEY & BRIDGE
DeSHAZO Crane Company D-22015-E4	0	NONE	WIRING DIAGRAM FLUX VECTOR HOIST(S)

2.3 SYSTEM DESCRIPTION

2.3.1 GENERAL SYSTEM DESCRIPTION

The 20-Ton Crane is a double girder top running bridge crane manufactured by DeShazo Crane Company. The crane's purpose is for lifting and positioning payloads and flight hardware during processing operations. The crane is composed of three major sub-

systems which are the hoist system, the trolley system and the bridge system. The hoist system is mounted on the trolley and allows the hoisting system to be moved along the length of the bridge. The bridge system allows for longitudinal motion along the length of the runway.

2.3.2 HOIST DRIVE MOTORS

The hoist system is equipped with one (1) 20 horsepower 1200 RPM drive motor. The motor is capable of varying speeds from 0 FPM to 14 FPM with VECTOR variable frequency inverter control, Electromotive VG+.

2.3.3 HOIST BRAKING SYSTEM

The hoist system is equipped with two (2) electro-mechanical shoe brakes, both of which are capable of stopping, and holding 100% of the full rated load of the crane. The brakes are released by energizing a coil at the time the hoist motor is energized. Should electrical power to the motor fail the brakes will set using spring force to drive the braking shoes against the brake drum.

2.3.4 TROLLEY DRIVE ASSEMBLY

The purpose of this unit is to move the main hoist assembly laterally across the width of the bay on the bridge beam rails. This is accomplished by applying torque to the trolley drive wheels. The assembly consists of one (1) 1 ½ horsepower motor. The trolley contains an electro-mechanical disc type brake used to stop and hold the trolley position. The trolley is capable of varying speeds from 0 FPM to 75 FPM. The speed is controlled by an adjustable frequency inverter control, Electromotive G+ that has programmable speeds and programmable acceleration and deceleration between speed set points.

2.3.5 BRIDGE DRIVE ASSEMBLY

The purpose of the bridge drive system is to allow movement of the hoist system along the length of the runway. This is accomplished by applying torque to the bridge drive wheels. The drive assembly consists of two (2) 1 horsepower 1800RPM motors. The bridge contains an electro-mechanical disc type brake used to stop and hold the bridge position. The bridge is capable of varying speeds from 0 FPM to 75 FPM. The speed is controlled by an adjustable frequency inverter control, Electromotive G+ that has programmable speeds and programmable acceleration and deceleration between speed set points.

2.3.6 CRANE CONTROLS

Crane controls is by two (2) parallel exclusive systems. The first is a normal control pendant feed 110 V control signal to the variable frequency hoist control. Electromotive VG+, and the variable frequency bridge and trolley control, electromotive G+. The control pendant functions are shown on the drawing. Pressing the proper button for

desired direction of hoist, bridge, or trolley motion will result in preset acceleration to preset slow speed level. Pressing the proper button farther in to the second detent will result in preset acceleration to medium preset speed level, and pressing the button farther in to the third detent level will result in preset acceleration to preset high speed. Moving back to the first detent position will cause preset deceleration to slow speed, and release will cause preset deceleration to zero speed.

Absence of any signal to the controller will result in no motion of crane and hoist motors and all brakes being set.

A Telmotive Radio transmitter/receiver control system duplicates the pendant controls as an option. The receiver is connected to the variable frequency controllers and the lack of receipt of the unique coded command causes a no output condition and a no crane and hoist condition.

2.3.7 HOIST LIMIT SWITCHES

The hoist is equipped with three (3) limit switches, two (2)geared type limit switches, one (1) upper and one lower, and a final upper limit switch. The final upper limit switch is used in the event the other fails closed. The final limit switch will cut power to the hoist motor by opening the hoist motor leads.

SECTION III

3.0 DEFINITIONS AND GROUND RULES

3.1 DEFINITIONS

Definitions necessary for the clarification of criticality categories, hazard analysis, and "time to effect" are listed below.

a. Criticality Categories:

CRITICALITY	POTENTIAL EFFECT OF FAILURE
1	A single failure which could result in loss of life or flight hardware.
1R	Two (2) redundant hardware items, which if both failed, could result in loss of life or vehicle (or loss of a safety or hazard monitoring system associated).
1S	A single failure in a safety or hazard monitoring system that could cause the system to fail to detect, combat, or operate when needed during the existence of a hazardous condition and could result in loss of life or flight hardware.
2	A single failure which could result in loss (damage) of a flight hardware system.
3	All other effects (i.e. delay or no effect).

NOTE: For this analysis, the term "vehicle" includes payloads, or satellite vehicles.

b. Hazard Report Closure Classification

(1) Eliminated – A hazard that has been eliminated by completely removing the hazard causal factors or by deleting the hazardous operation (e.g. modifying the system/GSE).

(2) Controlled – The likelihood of occurrence has been reduced to an acceptable level by implementing the appropriate Hazard Reduction Precedence Sequence (HRPS) to comply with program requirement (e.g. OMI controls, physical controls).

(3) Accepted Risk – A hazard that has not been completely eliminated or controlled, and the residual risk has been accepted by project/program management on the basis of risk acceptance rationale. These risks are considered a part of doing business and necessary to continue the program phase.

c. Hazard Levels – There are three (3) levels for which a hazard can be identified. Hazard level will be categorized as follows:

(1) Catastrophic (CA) – Hazard could result in a mishap causing fatal injury to personnel, and/or of one or more major elements of the flight vehicle or ground facility (applicable for accepted risk hazards only).

(2) Critical (CR) – Hazard could result in serious injury to personnel and/or damage to flight and ground equipment which could cause mission abort or a significant program delay (applicable for accepted risk hazards only).

(3) Controlled (CN) – Has been counteracted by appropriate design, safety devices, alarm/caution and warning devices, or special automatic/manual procedures (applicable for controlled hazards only).

d. Hazard Report Status

(1) Closed – Corrective action/evaluation has been completed. Operational maintenance, inspection, and other requirements have been identified and closed loop control is established. Governing procedural controls (e.g., OMIs) are in place. In case of hazards which document design deficiencies, the modification has been completed, the modified system configuration has been verified, and the certification has been documented.

(2) Open – Corrective measure/procedural hazard controls are not in place, or evaluation is pending.

e. Likelihood of Occurrence – The probability the hazard will occur, considering the in-place hazard controls. Likelihood of occurrence will be categorized as follows:

Ao: Unlikely – Extremely remote possibility that hazard will occur in the life of the system; strong controls are in place.
Bo: Likely – Could happen in the life of the system, but not expected; controls have minor limitations or uncertainties.
Co: Probable – Expected to happen in the life of the system; controls have significant limitations or uncertainties. Hazard reports with this likelihood of occurrence are considered unacceptable risk.

f. Time to Effect – The analysis shall determine the time for the failure effect to occur, which will be specified as follows:

Immediate	-	less than one (1) second
Seconds	-	one (1) to sixty (60) seconds
Minutes	-	sixty (60) seconds to sixty (60) minutes
Hours	-	sixty (60) minutes to twenty-four (24) hours
Days	-	twenty-four (24) hours to process completion

The descriptor which indicates the shortest credible time or time range available to correct the situation before the effect is manifested shall be identified.

3.2 GROUND RULES

This analysis has been developed in accordance with KHB 5310.9, "Kennedy Space Center Ground systems Safety and Reliability Analyses".

The following ground rules and assumptions were considered during this analysis:

a. Passive components will not be analyzed in the FMEA, but are considered in the Hazard Analysis.

b. Noncompliance to the requirements of NSS/GO-1740.9 NASA Safety Standard For Lifting Devices and Equipment shall be identified in the FMEA.

c. Failure in system setup (e.g., Manual operated devices erroneously lift open) will not be identified a critical items.

d. The worst-case effect of a failed component will be assumed

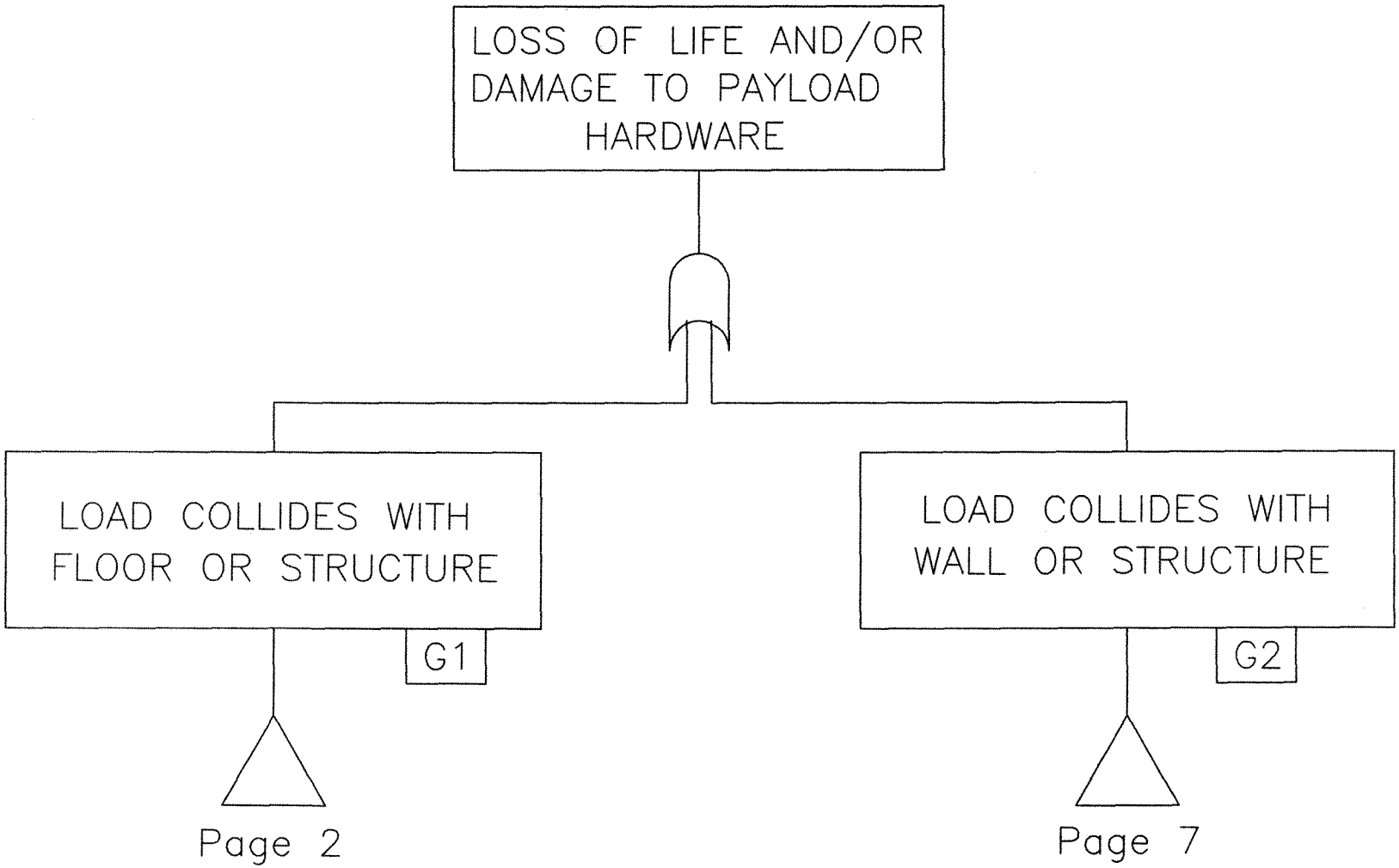
e. For this analysis it is assumed that no flight hardware that contains explosives will be lifted using this crane system. Solid rocket motor propellant and liquid hypergolic propellants are being in quiescent conditions and pose only a five/rapid deflagration under worst case hoist drops.

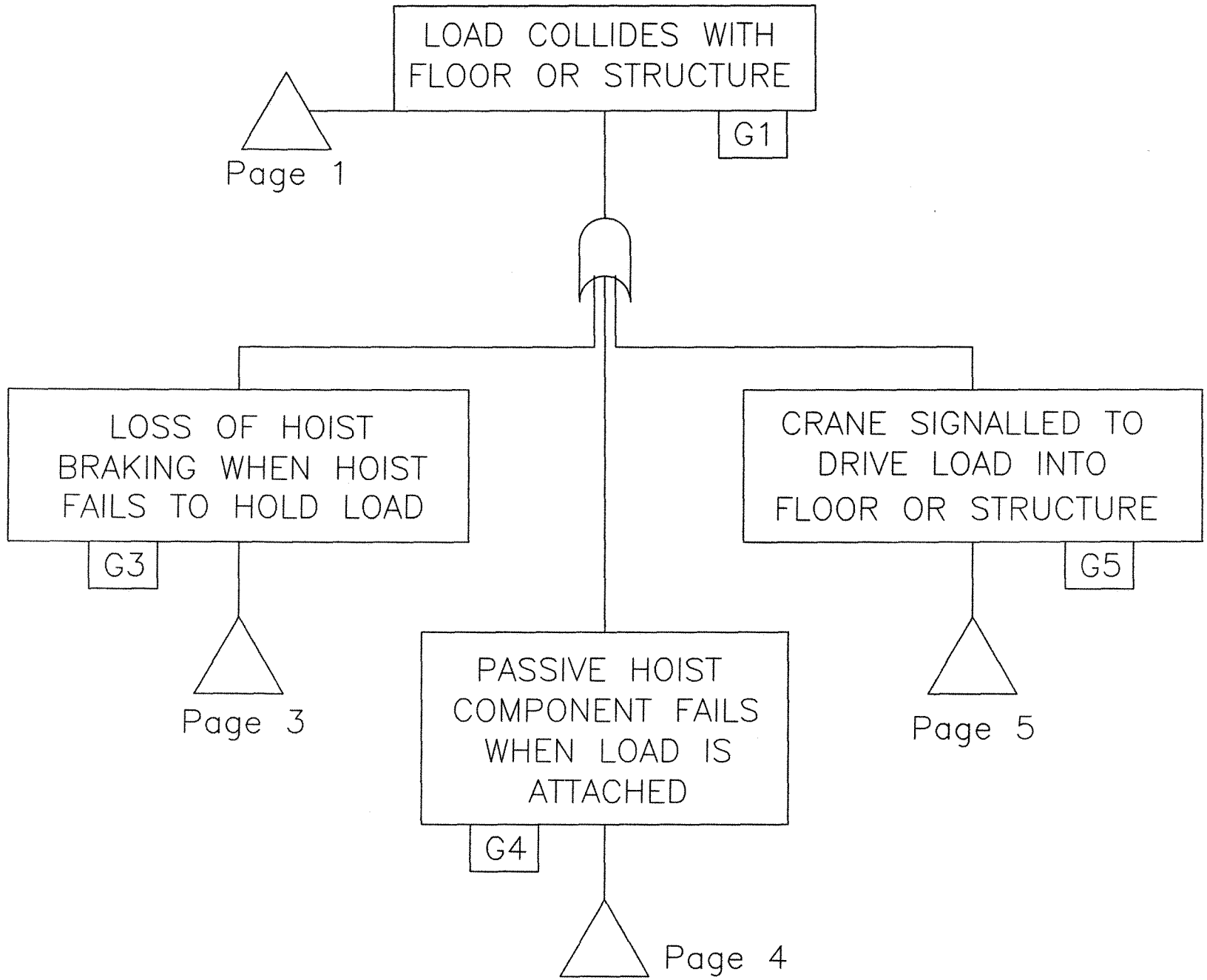
SECTION IV

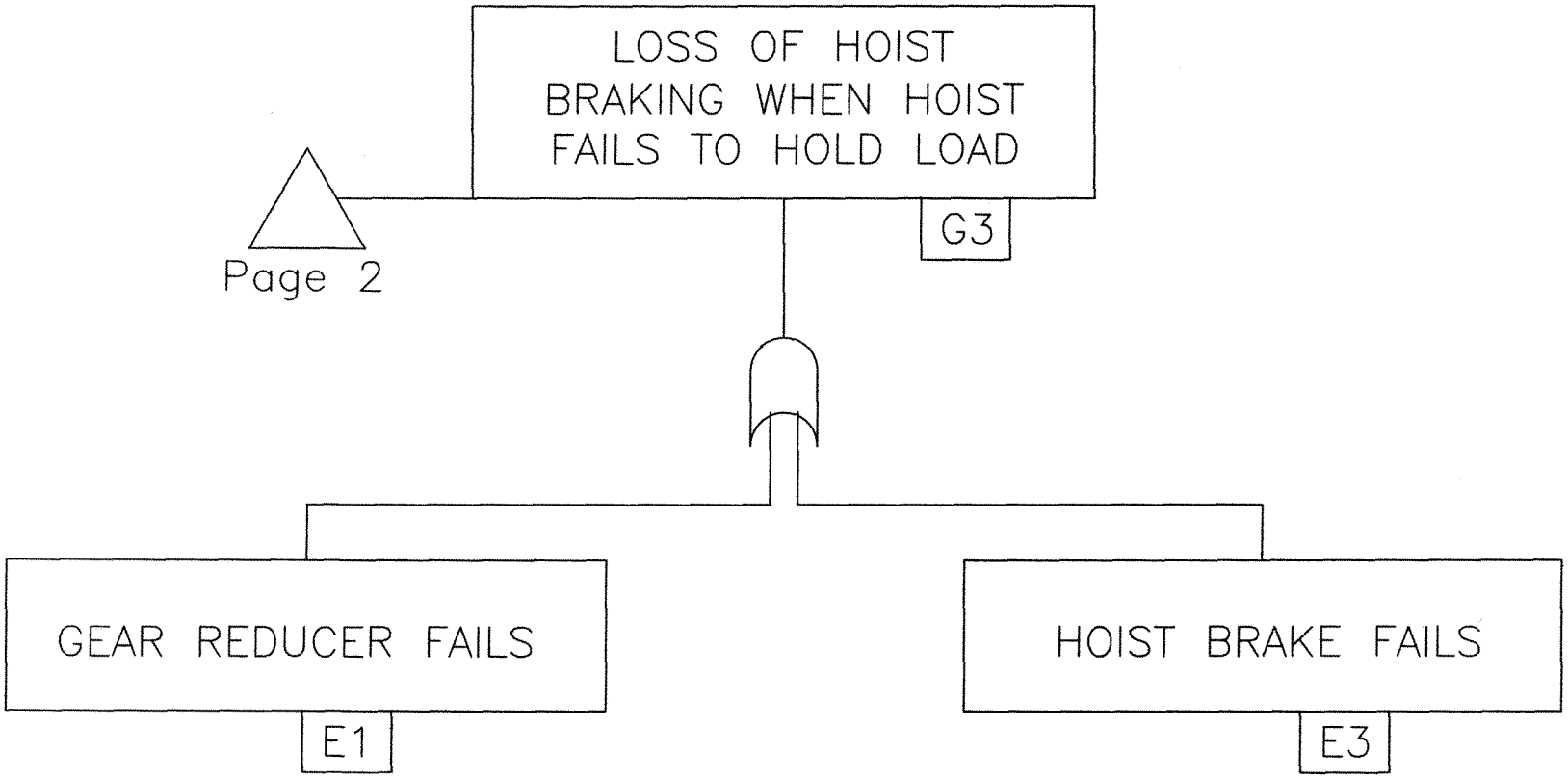
4.0 CRITICALITY ASSESSMENT

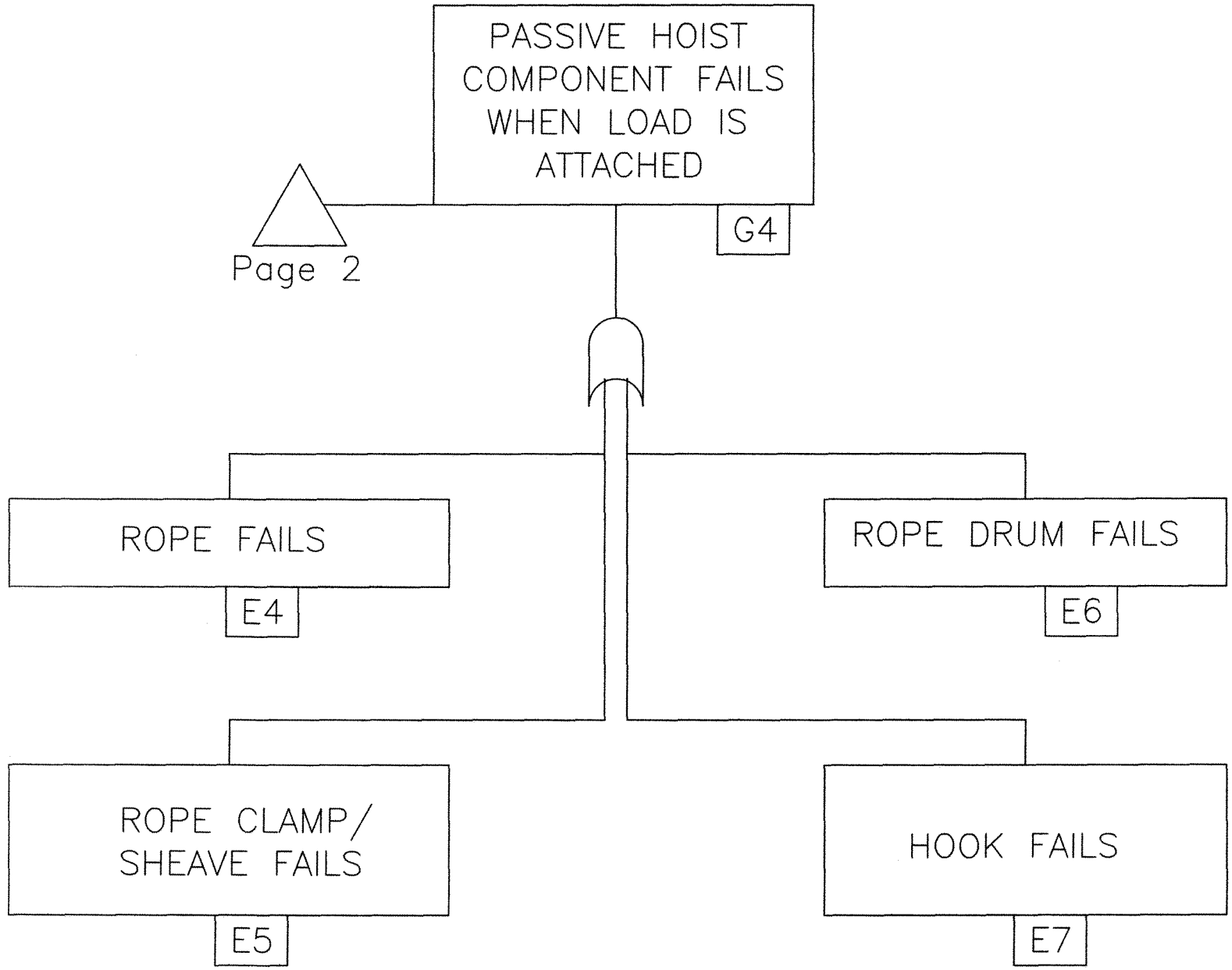
4.1 HARDWARE/RELIABILITY BLOCK DIAGRAM

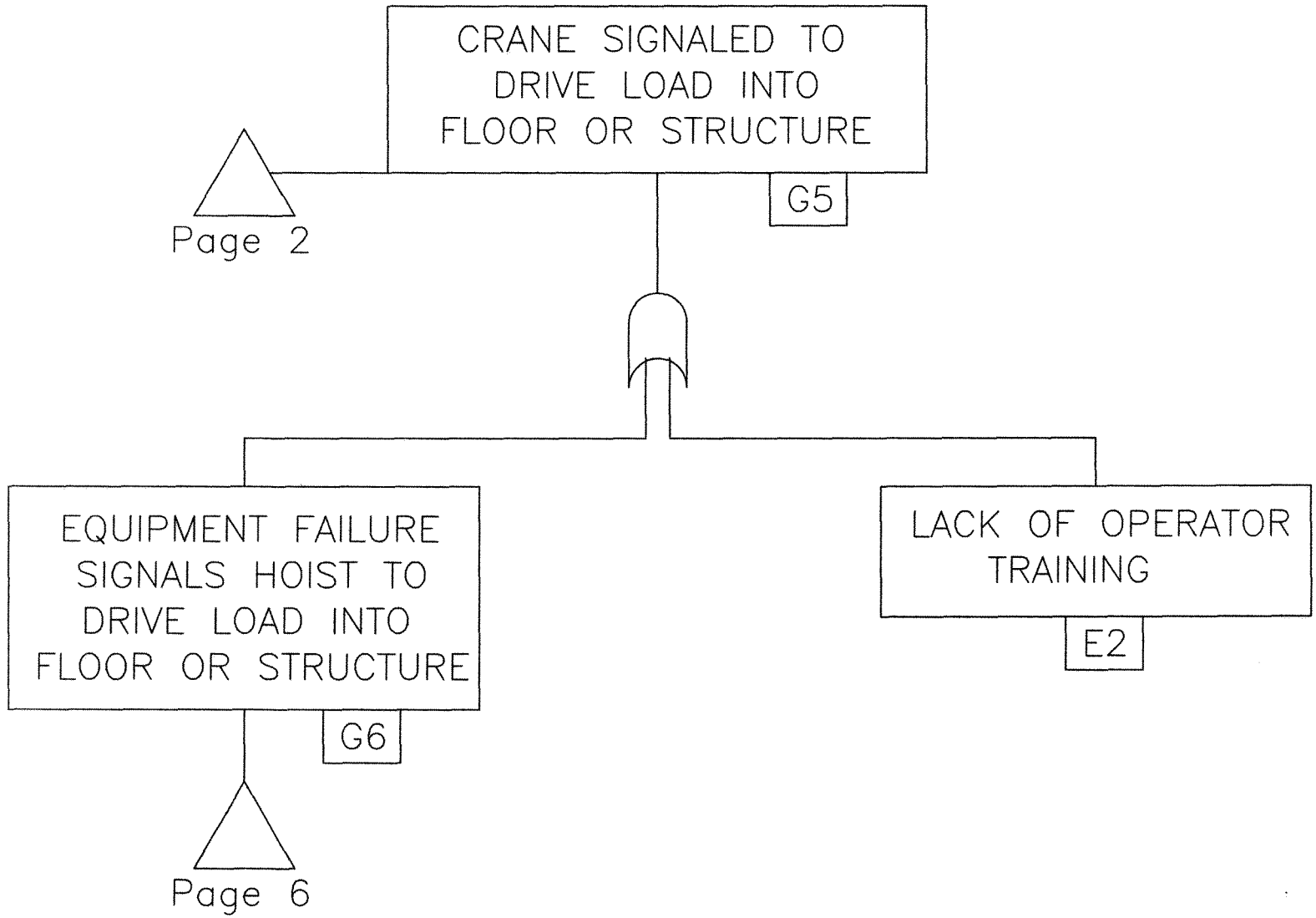
This system input and output functions are identified from the following Hardware/Reliability Block Diagrams.

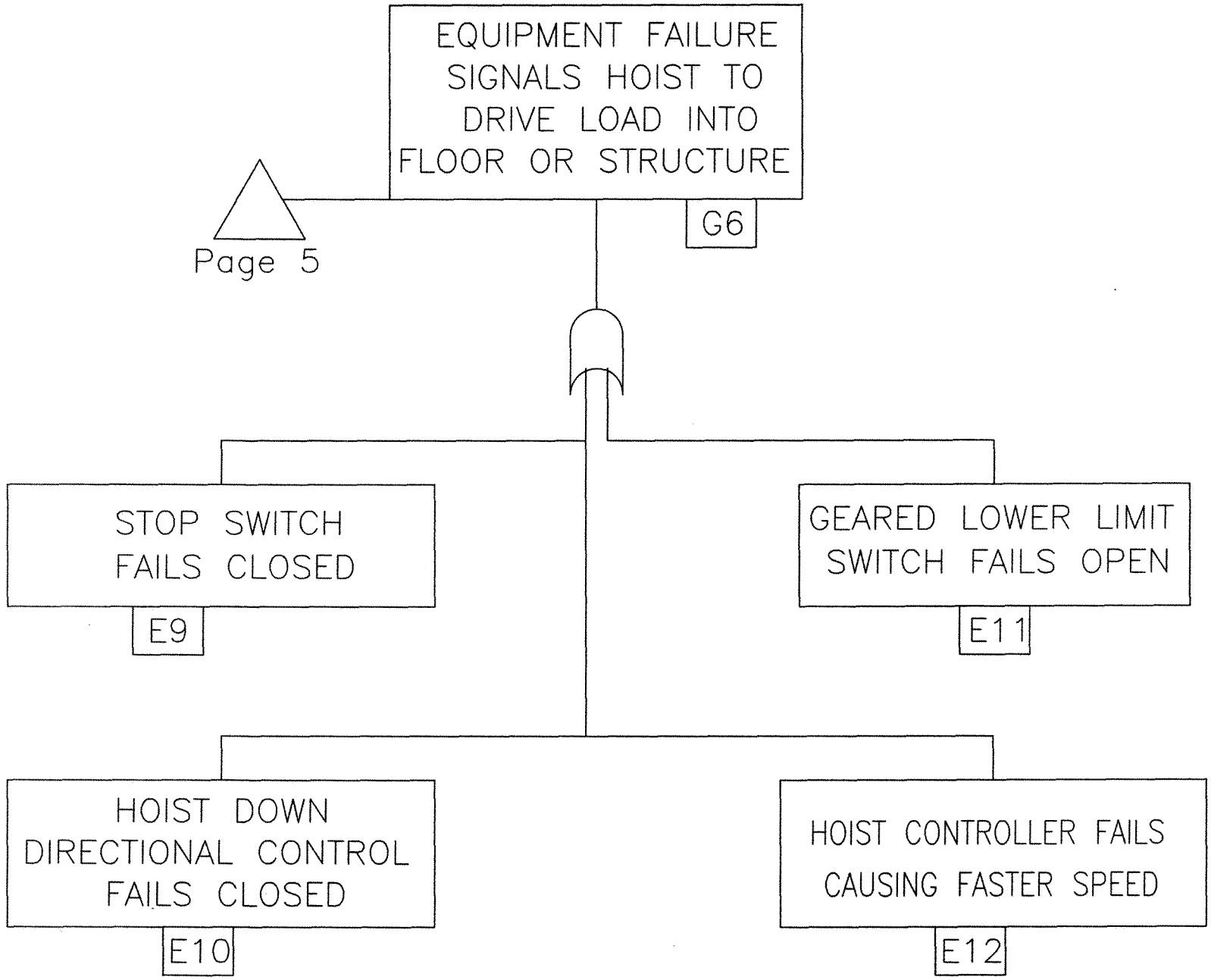

LOSS OF LIFE AND/OR DAMAGE TO PAYLOAD HARDWARE
LOAD COLLIDES WITH FLOOR OR STRUCTURE
G1
Page 2
LOAD COLLIDES WITH WALL OR STRUCTURE
G2
Page 7

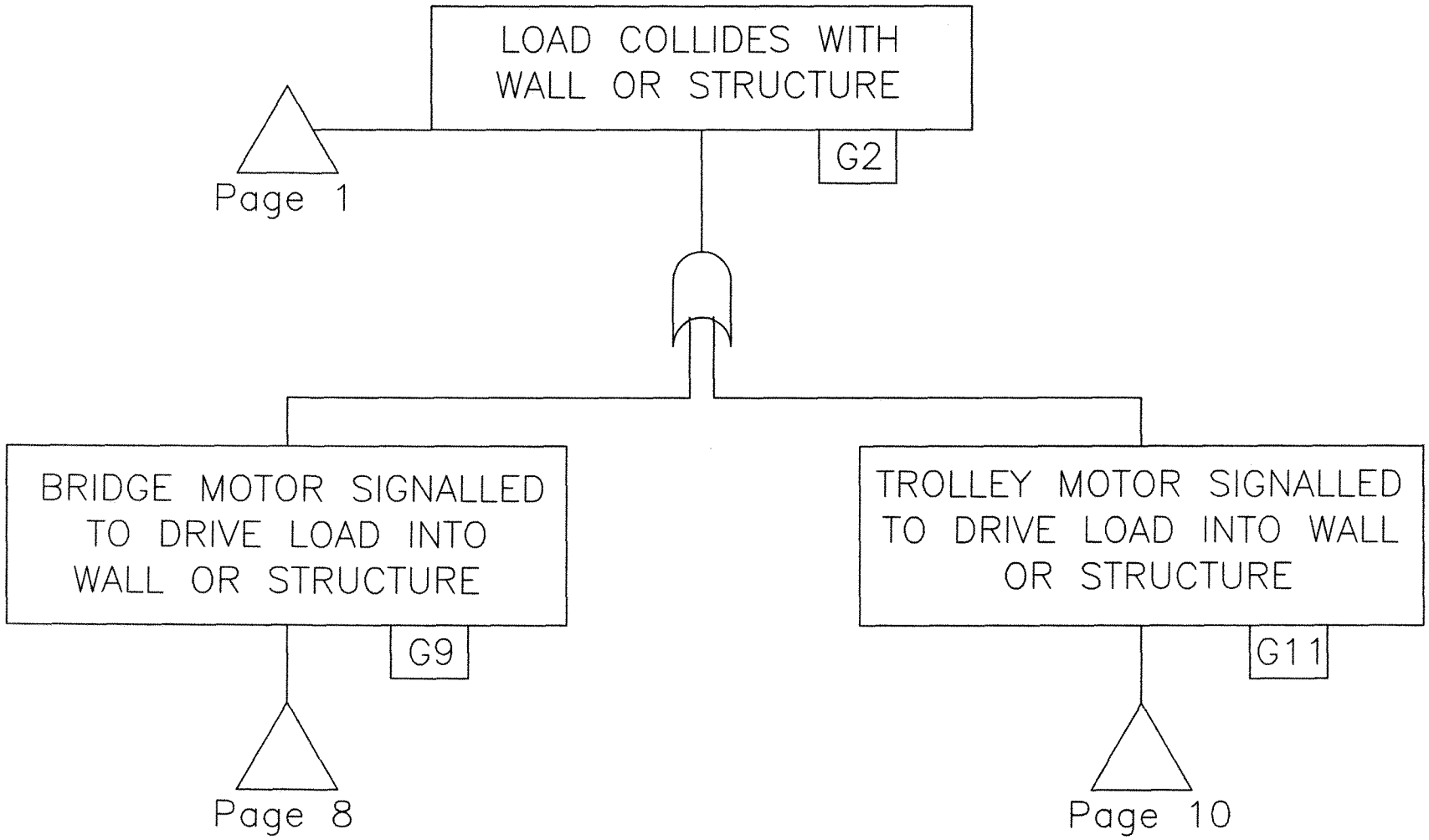

LOAD COLLIDES WITH FLOOR OR STRUCTURE
G1
Page 1
LOSS OF HOIST BRAKING WHEN HOIST FAILS TO HOLD LOAD
G3
Page 3
PASSIVE HOIST COMPONENT FAILS WHEN LOAD IS ATTACHED
G4
Page 4
CRANE SIGNALLED TO DRIVE LOAD INTO FLOOR OR STRUCTURE
G5
Page 5

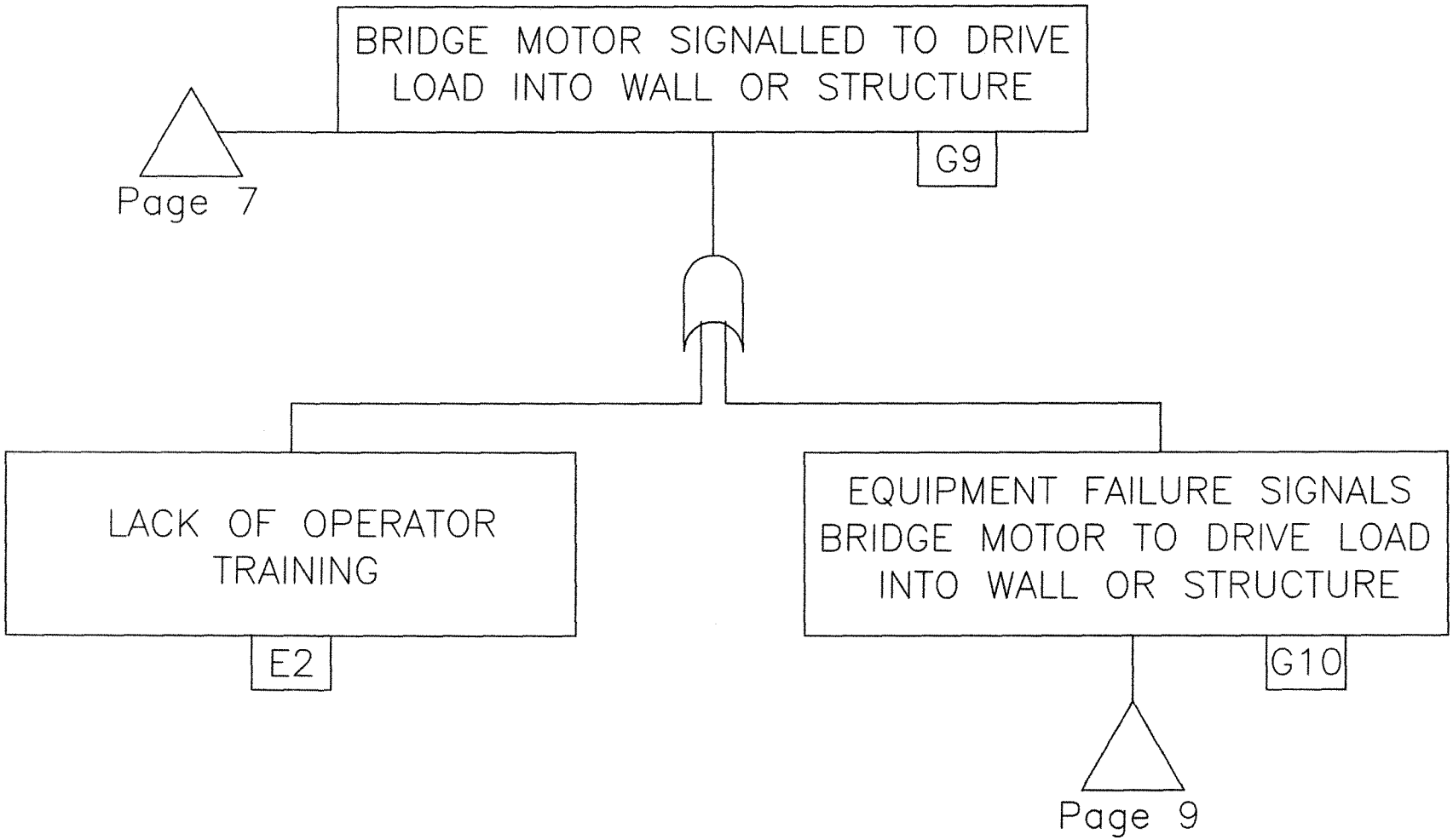

LOSS OF HOIST BRAKING WHEN HOIST FAILS TO HOLD LOAD
G3
Page 2
GEAR REDUCER FAILS
E1
HOIST BRAKE FAILS
E3

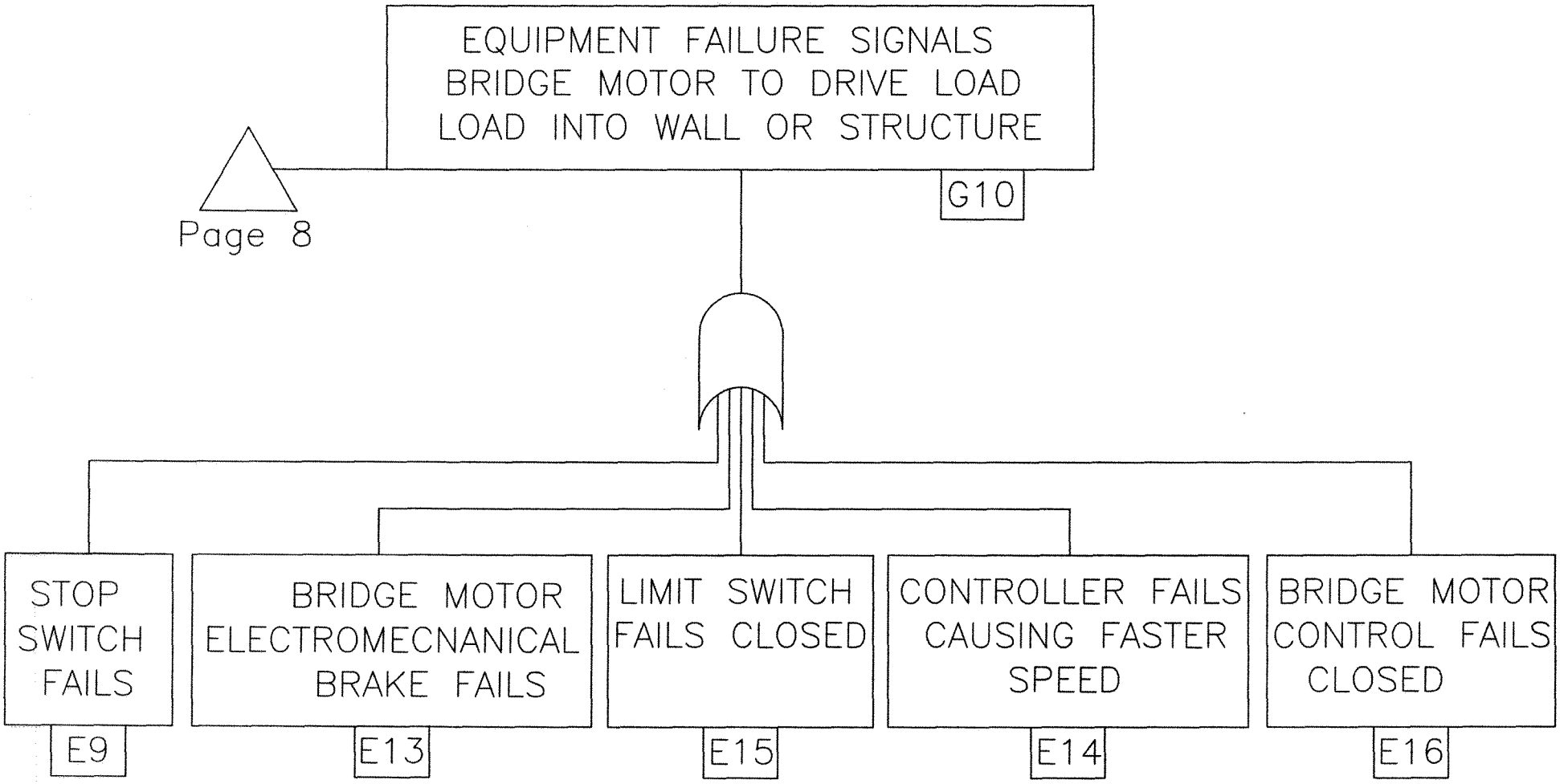

PASSIVE HOIST COMPONENT FAILS WHEN LOAD IS ATTACHED
G4
Page 2
ROPE FAILS
E4
ROPE DRUM FAILS
E6
ROPE CLAMP/ SHEAVE FAILS
E5
HOOK FAILS
E7

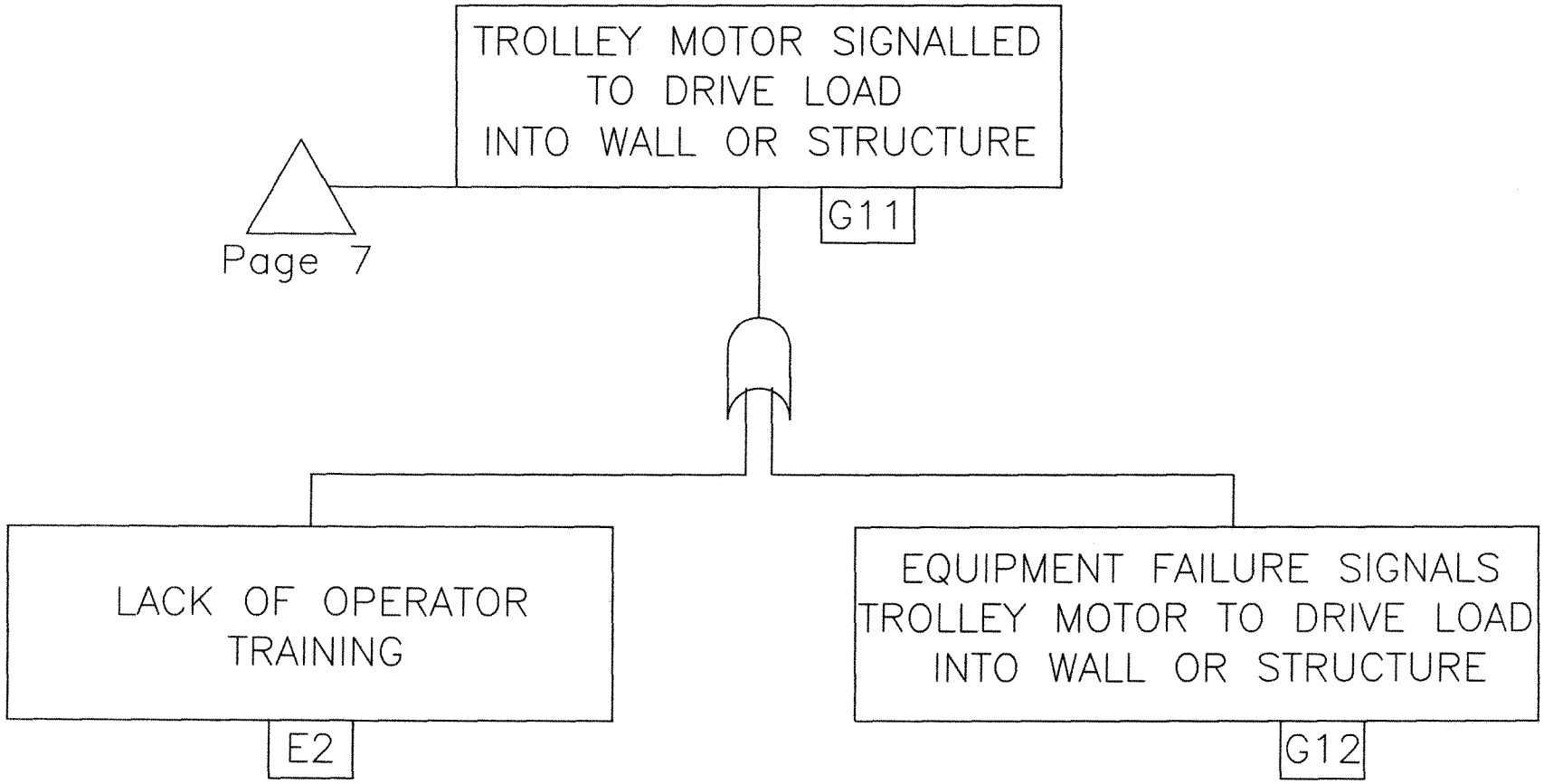

CRANE SIGNALED TO DRIVE LOAD INTO FLOOR OR STRUCTURE
G5
Page 2
EQUIPMENT FAILURE SIGNALS HOIST TO DRIVE LOAD INTO FLOOR OR STRUCTURE
G6
Page 6
LACK OF OPERATOR TRAINING
E2

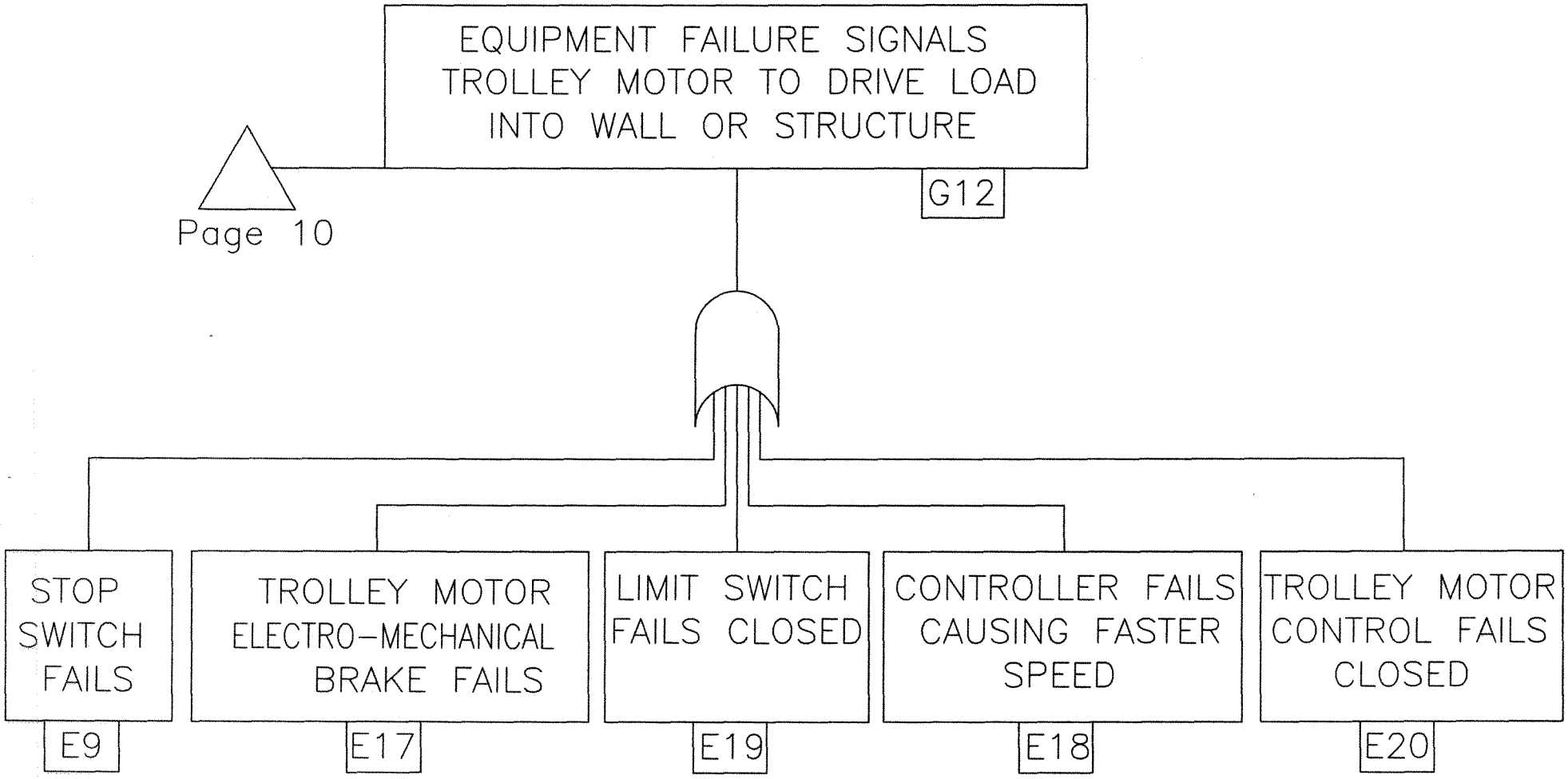

EQUIPMENT FAILURE SIGNALS HOIST TO DRIVE LOAD INTO FLOOR OR STRUCTURE
G6
Page 5
STOP SWITCH FAILS CLOSED
E9
GEARED LOWER LIMIT SWITCH FAILS OPEN
E11
HOIST DOWN DIRECTIONAL CONTROL FAILS CLOSED
E10
HOIST CONTROLLER FAILS CAUSING FASTER SPEED
E12


LOAD COLLIDES WITH WALL OR STRUCTURE
G2
Page 1
BRIDGE MOTOR SIGNALLED TO DRIVE LOAD INTO WALL OR STRUCTURE
G9
Page 8
TROLLEY MOTOR SIGNALLED TO DRIVE LOAD INTO WALL OR STRUCTURE
G11
Page 10


BRIDGE MOTOR SIGNALLED TO DRIVE LOAD INTO WALL OR STRUCTURE
G9
Page 7
LACK OF OPERATOR TRAINING
E2
EQUIPMENT FAILURE SIGNALS BRIDGE MOTOR TO DRIVE LOAD INTO WALL OR STRUCTURE
G10
Page 9


EQUIPMENT FAILURE SIGNALS BRIDGE MOTOR TO DRIVE LOAD LOAD INTO WALL OR STRUCTURE
G10
Page 8
STOP SWITCH FAILS
E9
BRIDGE MOTOR ELECTROMECNANICAL BRAKE FAILS
E13
LIMIT SWITCH FAILS CLOSED
E15
CONTROLLER FAILS CAUSING FASTER SPEED
E14
BRIDGE MOTOR CONTROL FAILS CLOSED
E16


TROLLEY MOTOR SIGNALLED TO DRIVE LOAD INTO WALL OR STRUCTURE
G11
Page 7
LACK OF OPERATOR TRAINING
E2
EQUIPMENT FAILURE SIGNALS TROLLEY MOTOR TO DRIVE LOAD INTO WALL OR STRUCTURE
G12


EQUIPMENT FAILURE SIGNALS TROLLEY MOTOR TO DRIVE LOAD INTO WALL OR STRUCTURE
G12
Page 10
STOP SWITCH FAILS
E9
TROLLEY MOTOR ELECTRO-MECHANICAL BRAKE FAILS
E17
LIMIT SWITCH FAILS CLOSED
E19
CONTROLLER FAILS CAUSING FASTER SPEED
E18
TROLLEY MOTOR CONTROL FAILS CLOSED
E20

4.2 CRITICALITY ASSESSMENT WORKSHEETS

This system input and output functions are assessed on the following Criticality Assessment Summary sheet.

The Criticality Assessment Worksheets are performed to determine whether the GSE or facility system is Critical or Non Critical in terms of reliability impact. If loss or improper performance of any one of the system's functions, without regard to redundancy, could result in loss of life or loss of flight hardware or damage to flight hardware, the total system is assessed as Critical. If loss or improper performance of all of the system's functions could not result in any of the aforementioned effects, the system will be considered Non Critical.

SYSTEM CRITICALITY ASSESSMENT SUMMARY WORKSHEET				SHEET 1 OF 1
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE		SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY		PREPARED BY: T.G. SCARBORO	DATE: MAY 2004	
INPUT/OUTPUT	FUNCTION	EFFECT OF LOSS, FAILURE	CRIT CAT	NOTE
INPUT				
ELECTRICAL POWER - 480 VOLTS - 3 PHASE - 60 HERTZ	SUPPLIES POWER TO OPERATE MOTOR AND BRAKE FOR HOIST SYSTEM	ALL HOIST MOTION WOULD STOP, ALL HOIST SYSTEM BRAKES WOULD ENGAGE AND HOLD LOAD. DELAY IN PROCESSING OPERATIONS	C	SEE FEMA WORKSHEETS
CONTROLS				
- UP/DOWN	OPERATES HOIST IN SPECIFIED DIRECTION	UNABLE TO RAISE/LOWER LOAD AS REQUIRED. LIMIT SWITCHES AND E-STOP INHIBIT UNDESIRED MOTION	C	SEE FEMA WORKSHEETS
BRIDGE/TROLLEY TRANSLATION	POSITIONS HOIST AND MOVES LIFTED LOADS	UNABLE TO TRANSLATE HOIST, EITHER LOADED OR NOT LOADED	C	SEE FEMA WORKSHEETS
E-STOP/OFF	PROVIDES EMERGENCY STOP CAPABILLITY	FAILURE OF E-STOP WOULD CAUSE LOSS OF ABILITY TO OVERIDE A CONTROL FAILURE	C	SEE FEMA WORKSHEETS
STRUCTURAL SUPPORT	SUPPORTS 20 TON BRIDGE CRANE	FAILURE OF THE CRANE STRUCTURAL SUPPORT COULD CAUSE DAMAGE TO FLIGHT HARDWARE, INJURY OR LOSS OF LIFE	C	FEMA NOT REQUIRED PER KHB 5310.9
OUTPUT				
HOIST MOTION	RAISE/LOWER AND POSITION LOAD	A FAILURE OF THE HOIST SYSTEM COULD CAUSE DAMAGE TO FLIGHT HARDWARE, INJURY OR LOSS OF LIFE	C	SEE FEMA WORKSHEETS N.C. = NOT CRITICAL C. = CRITICAL

SECTION V

5. FAILURE MODES AND EFFECT ANALYSIS

5.1 MECHANICAL FMEA WORKSHEETS

The mechanical components of the critical output functions identified in section IV for this system were identified from documents and diagrams references in the Documentation List and are analyzed on the following FMEA Worksheets. A passive items list precedes the FMEA Worksheets and is contained on the following page.

MECHANICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET					SHEET 1 OF 2	
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY			PREPARED BY: T.G. SCARBORO		DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
NONE	GEAR REDUCER, HOIST	PROVIDES MECHANICAL LINKAGE/ADVANTAGE BETWEEN THE HOIST MOTORS AND THE ROPE DRUM	A1. DISENGAGES B1. BROKEN TOOTH C. UNDETECTABLE D. CORRECTING ACTION, N/A E. IMMEDIATELY	FAILURE OF THE GEAR REDUCER DOWNSTREAM OF THE ELECTRO-MECHANICAL SHOE BRAKE WILL CAUSE THE LOAD TO DROP	LOAD WILL DROP, COULD CAUSE DAMAGE TO FLIGHT HARDWARE, INJURY, OR LOSS OF LIFE	1
			A2. GEARS LOCK UP B2 LACK OF LUBRICATION, EXCESSIVE WEAR	HOIST SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3
NONE	ELECTRO-MECHANICAL BRAKES	PROVIDES TORQUE FOR STOPPING AND HOLDING LOAD WHEN POWER IS TURNED OFF	A1. FAILS TO ENGAGE B1. EXCESSIVE WEAR OF FRICTION MATERIAL	NO EFFECT, A SECOND ELECTRO-MECHANICAL BRAKE WILL STOP AND HOLD THE LOAD. IF BOTH BRAKES FAIL THE LOAD WILL DROP. REQUIRES DOUBLE FAILURE.	DELAY FOR REPAIRS	3
			A2. FAILS TO DISENGAGE B2. INTERNAL PARTS FAILURE	HOIST SYSTEM INOPERATIVE	DELAY FOR REPAIRS	

MECHANICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET					SHEET 2 OF 2	
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY			PREPARED BY: T.G. SCARBORO		DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
NONE	ELECTRO-MECHANICAL BRAKE, TROLLEY, MULTI DISC TYPE	PROVIDES TORQUE FOR STOPPING TROLLEY ONCE THE POWER IS TURNED OFF. SPRING ENGAGED, ELECTRICALLY D1SENGAGED.	A1. FAILS TO ENGAGE B1. EXCESSIVE WEAR OF FRICTION MATERIAL	TROLLEY MAY COAST A SHORT DISTANCE, TROLLEY IS EQUIPPED WITH MECHANICAL END STOPS.	DELAY FOR REPAIRS	3
			A2. FAILS TO DISENGAGE B2 INTERNAL PARTS FAILURE	TROLLEY SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3
NONE	ELECTRO-MECHANICAL BRAKE, BRIDGE, MULTI DISC TYPE	PROVIDES TORQUE FOR STOPPING TROLLEY ONCE THE POWER IS TURNED OFF. SPRING ENGAGED, ELECTRICALLY DISENGAGED.	A1. FAILS TO ENGAGE B1. EXCESSIVE WEAR OF THE FRICTION MATERIAL	BRIDGE SYSTEM MAY COAST A SHORT DISTANCE, BRIDGE IS EQUIPPED WITH MECHANICAL END STOPS.	DELAY FOR REPAIRS	3
			A2. FAILURE TO DISENGAGE B2. INTERNAL PARTS FAILURE	DRIDGE SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3

FAILURE MODES AND EFFECTS ANALYSIS
FOR THE
20 TON BRIDGE CRANE LOCATED IN BUILDING H-100
PAYLOAD PROCESSING FACILITY
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VA

The following components were considered passive in the analysis of this section.

Nomenclature		Find Number
1.	Wire Rope	None
2.	Wire Rope Drum	None
3.	Hook	None
4.	Hook Block	None
5.	Bridge Drive Shafts	None
6.	Bridge and Trolley Support Structure	None
7.	Hoist Gear Reducer Shafts	None
8.	Trolley Gear Reducer Shafts	None
9.	Bridge Gear Reducer Shafts	None
10.	Trolley Drive Wheels	None

5.2 ELECTRICAL FMEA WORKSHEETS

The electrical components of the critical output functions identified in secton IV for this equipment were identified from the documents and diagrams referenced in the Documentation List and are analyzed on the following FMEA worksheets.

5.3 CRITICAL ITEMS LIST

1 ITEM – Hoist Gear Reducer

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 1 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO		DATE: May-04
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
	MOTOR, HOIST	PRIME MOVER FOR HOIST. PROVIDES REQUIRED TORQUE NEEDED FOR RAISING OR LOWERING LOAD.	A1. FAILS DURING OPERATION B1. DEFECTIVE WINDINGS	HOIST SYSTEM INOPERATIVE TORQUE FOR HOLDING LOAD DEPENDANT ON ELECTRO-MECHANICAL SHOE BRAKES.	DELAY FOR REPAIRS	3
			A2. FAILS TO OPERATE B2. INTERNAL PARTS FAILURE	HOIST SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3
	MOTOR, TROLLEY	PRIME MOVER FOR THE TROLLEY SYSTEM	A1. FAILS DURING OPERATION B1. DEFECTIVE WINDINGS	TROLLEY SYSTEM INOPERATIVE, TROLLEY BRAKE WILL STOP ALL TROLLEY MOTION.	DELAY FOR REPAIRS	3
			A2. FAILS TO OPERATE B2. INTERNAL PARTS FAILURE	TROLLEY SYSTEM INOPERATIVE,	DELAY FOR REPAIRS	3
	MOTOR, BRIDGE	PROVIDES MOTIVE POWER TO THE BRIDGE SYSTEM.	A1. FAILS DURING OPERATION B1. DEFECTIVE WINDINGS	BRIDGE SYSTEM INOPERATIVE, BRIDGE BRAKE WILL STOP BRIDGE.	DELAY FOR REPAIRS	3
			A2. FAILS TO OPERATE B2. INTERNAL PARTS FAILURE	BRIDGE SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 2 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESING FACILITY				PREPARED BY: T.G. SCARBORO		DATE: May-04
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
	UP PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE HOIST IN THE UP DIRECTION OF TRAVEL.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	HOIST INOPERATIVE IN THE UP DIRECTION OF TRAVEL.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	HOIST WILL CONTINUE TO MOVE UPWARDS, OPERATOR CAN STOP HOIST BY USING STOP BUTTON. ALSO HOIST LIMIT SWITCH WILL TERMINATE ALL HOIST POWER. REQUIRES MULTIPLE FAILURES	DELAY FOR REPAIRS	3
	STOP PUSH BUTTON	PROVIDES A MEANS OF TERMINATING CRANE POWER	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	CRANE SYSTEM INOPERATIVE,	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF ABILITY TO TERMINATE CRANE SYSTEM CONTROL POWER. REQUIRES MULTIPLE FAILURES	DELAY FOR REPAIRS	3
	DOWN PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE HOIST IN THE DOWN DIRECTION OF TRAVEL, AT MEDIUM AND HIGH SPEEDS THROUGH VFC CONTROLLER OUTPUTS	A1. FAILS CLOSED B1. INTERNAL PARTS FAILURE	HOIST INOPERATIVE IN THE DOWN DIRECTION OF TRAVEL.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	HOIST WILL CONTINUE TO MOVE SOWNWARDS, OPERATOR CAN STOP HOIST BY USING STOP BUTTON. ALSO HOIST LIMIT SWITCH WILL TERMINATE ALL HOIST POWER. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 3 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO	DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
	TROLLEY FORWARD PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE TROLLEY MOTOR IN THE FORWARD DIRECTION OF TRAVEL, AT MEDIUM AND HIGH SPEEDS THROUGH VFC CONTROLLER OUTPUTS	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	TROLLEY INOPERATIVE IN THE FORWARED DIRECTION OF TRAVEL.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	TROLLEY WILL CONTINUE TO MOVE FORWARD AFTER OPERATOR RELEASES CONTROL BUTTON. OPERATOR CAN STOP TROLLEY BY USING STOP BUTTON. ALSO TROLLEY LIMIT SWITCH WILL TERMINATE ALL TROLLEY POWER. REQUIRES MULTIPLE FAILURES	DELAY FOR REPAIRS	3
	TROLLEY REVERSE PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE TROLLEY MOTOR IN THE REVERSE DIRECTION OF TRAVEL, AT MEDIUM AND HIGH SPEEDS THROUGH VFC CONTROLLER OUTPUTS	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	TROLLEY INOPERATIVE IN THE REVERSE DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	TROLLEY WILL CONTINUE TO MOVE IN REVERSE AFTER OPERATOR RELEASES CONTROL BUTTON. OPERATOR CAN STOP TROLLEY BY USING STOP BUTTON, ALSO TROLLEY LIMIT SWITCH WILL TERMINATE ALL POWER TO THE TROLLEY. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 4 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO	DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
	PUSH BUTTON, POWER SUPPLY	PROVIDES ABILITY TO ENERGIZE CRANE CONTROL SYSTEM.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	CRANE SYSTEM INOPERATIVE	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF ABILITY TO TERMINATE CRANE CONTROL POWER, POWER MAY BE CUT AT THE MAIN DISCONNECT. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
	BRIDGE FORWARD PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE BRIDGE MOTOR IN THE FORWARD DIRECTION OF TRAVEL, AT MEDIUM AND HIGH SPEEDS THROUGH VFC CONTROLLER OUTPUTS	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	BRIDGE INOPERATIVE IN THE FORWARD DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	BRIDGE WILL CONTINUE TO MOVE FORWARD AFTER OPERATOR RELEASES CONTROL BUTTON. OPERATOR CAN STOP BRIDGE BY USING STOP SWITCH. ALSO BRIDGE LIMIT SWITCH WILL TERMINATE ALL POWER TO THE BRIDGE SYSTEM. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET					SHEET 5 OF 9	
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO	DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
	BRIDGE REVERSE PUSH BUTTON, THREE DETENT	PROVIDES CIRCUITRY TO ENERGIZE BRIDGE MOTOR IN THE REVERSE DIRECTION OF TRAVEL, AT MEDIUM AND HIGH SPEEDS THROUGH VFC CONTROLLER OUTPUTS	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	BRIDGE INOPERATIVE IN THE REVERSE DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	BRIDGE WILL CONTINUE TO MOVE IN REVERSE AFTER OPERATOR RELEASES CONTROL BUTTON. OPERATOR CAN STOP BRIDGE BY USING STOP SWITCH. ALSO BRIDGE LIMIT SWITCH WILL TERMINATE ALL POWER TO THE BRIDGE SYSTEM REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
PCLS	UPPER LIMIT SWITCH	PROVIDES PROTECTION AGAINST HOIST OVER-TRAVEL IN THE UP DIRECTION. ACTIVATION WILL OPEN HOIST MOTOR POWER LEADS.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	HOIST INOPERATIVE.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF OVERTRAVEL PROTECTION HOIST IS PROTECTED BY GEARED UPPER LIMIT SWITCH AS A REDUNDANT BACKUP. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
TFLS	FORWARD LIMIT SWITCH (TROLLEY)	PROVIDES PROTECTION AGAINST OVERTRAVEL DURING TROLLEY OPERATIONS.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	TROLLEY INOPERATIVE IN THE FORWARD DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF TROLLEY OVERTRAVEL PROTECTION. OPERATOR CAN STOP TROLLEY BY USING THE STOP SWITCH ON THE PENDANT.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 6 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO		DATE: May-04
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
BFLS	LIMIT SWITCH	PROVIDES OVERTRAVEL PROTECTION FOR THE BRIDGE SYSTEM IN THE FORWARD DIRECTION OF TRAVEL.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	BRIDGE INOPERATIVE IN THE FORWARD DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF OVERTRAVEL PROTECTION, STOP SWITCH WILL TERMINATE ALL CRANE CONTROL POWER. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
BRLS	LIMIT SWITCH	PROVIDES OVERTRAVEL PROTECTION FOR THE BRIDGE SYSTEM IN THE REVERSE DIRECTION OF TRAVEL.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	BRIDGE SYSTEM INOPERATIVE IN THE REERSE DIRECTION OF TRAVEL.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF OVERTRAVEL PROTECTION, STOP SWITCH WILL TERMINATE ALL CRANE CONTROL POWER. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
BVFD		PROVIDES CIRCUITRY TO ENERGIZE BRIDGE IN BOTH DIRECTIONS OF TRAVEL.	B1. INTERNAL PARTS FAILURE	BRIDGE INOPERATIVE IN BOTH DIRECTIONS OF TRAVEL.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET					SHEET 7 OF 9	
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO	DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
GLLS	GEARED LOWER LIMIT SWITCH	PROVIDES OVERTRAVEL PROTECTION FOR THE HOIST SYSTEM IN THE DOWNWARD DIRECTION OF TRAVEL.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	HOIST INOPERATIVE IN THE DOWNWARD DIRECTION OF TRAVEL	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF OVERTRAVEL PROTECTION, OPERATOR CAN STOP HOIST BY USING STOP SWITCH. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3
GULS	GEARED UPPER LIMIT SWITCH	PROVIDES OVERTRAVEL PROTECTION FOR THE HOIST SYSTEM IN THE UPWARD DIRECTION OF TRAVEL.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	HOIST INOPERATIVE IN HIGH SPEED MODE OF OPERATION.	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	LOSS OF OVERTRAVEL PROTECTION WHILE IN HIGH SPEED MODE. THE HOIST CONTAINS TWO OTHER REDUNDANT UPPER LIMIT SWITCHES WHICH WILL PREVENT TWO BLOCKING OF THE HOIST.	DELAY FOR REPAIRS	3
TRLS	REVERSE LIMIT SWITCH (TROLLEY)	PROVIDES PROTECTION AGAINST OVERTRAVEL DURING TROLLEY OPERATIONS.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	TROLLEY INOPERATIVE IN THE REVERSE DIRECTION OF TRAVEL.	DELAY FOR REPAIRS	3
			A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	LOSS OF TROLLEY OVERTRAVEL PROTECTION. OPERATOR CAN STOP TROLLEY BY USING THE STOP SWITCH ON THE PENDANT. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 8 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO	DATE: May-04	
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
TVFD		PROVIDES CIRCUITRY TO ENERGIZE TROLLEY IN BOTH DIRECTIONS OF OF TRAVEL.	B1. INTERNAL PARTS FAILURE	TROLLEY INOPERATIVE IN BOTH DIRECTIONS OF TRAVEL	DELAY FOR REPAIRS	3

ELECTRICAL FAILURE MODE AND EFFECT ANALYSIS WORKSHEET						SHEET 9 OF 9
SYSTEM/SUBSYSTEM: 20 TON BRIDGE CRANE				SCHEMATIC DWG. NO. VENDOR DRAWINGS		
LOCATION: WFF PAYLOAD PROCESSING FACILITY				PREPARED BY: T.G. SCARBORO		DATE: May-04
Part No. Find No.	Part Name	Part Function	A. Failure Mode(s) B. Cause(s) C. Detection Method D. Correcting Method E. Time To Effect	Failure Effect On System Performance	Failure Effect on Vehical Launch And/or Personnel Safety	Criti Categ
TBC	CONTACTOR	PROVIDES CIRCUITRY TO ENERGIZE TROLLEY BRAKE COIL ALLOWING RELEASE OF BRAKE.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	TROLLEY BRAKE WILL REMAIN ENGAGED, TROLLEY INOPERATIVE	DELAY FOR REPAIRS	3
			A2. FAILS CLOSED B2. WELDED CONTACTS	TROLLEY BRAKE WILL NOT ENGAGE. TROLLEY MAY COAST A SHORT DISTANCE. OPERATOR CAN APPLY BRAKE BY USING STOP SWITCH. REQUIRES MULTIPLE FAILURES	DELAY FOR REPAIRS	3
	TRANSFORMER (STEP DOWN)	DROPS LINE VOLTAGE TO 110 VOLTS FOR USE IN THE CONTROL PENDANT. OF TRAVEL.	A1. FAILS OPEN B1. DEFECTIVE WINDINGS	CRANE SYSTEM INOPERATIVE.	DELAY FOR REPAIRS	3
			A2. FAILS SHORTED B2. THERMAL OVERLOAD	CRANE SYSTEM INOPERATIVE.	DELAY FOR REPAIRS	3

FAILURE MODES AND EFFECTS ANALYSIS
FOR THE
20 TON BRIDGE CRANE LOCATED IN BUILDING H100
PAYLOAD PROCESSING FACILITY
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VA

The following electrical components were considered passive in the analysis for this section.

Nomenclature		Find Number
1.	Electrical Wire	None
2.	Terminal Strips	None
3.	Connector	None
4.	Electrical Control Boxes	None

SECTION VI

6. SYSTEMS HAZARD ANALYSIS

SYSTEM HAZARD ANALYSIS (SHA)

SYSTEM: 20 TON BRIDGE CRANE
WFF PAYLOAD PROCESSING FACILITY

ENGINEER: T.G. SCARBORO
DATE: MAY 2004
SHEET: 1 OF 5

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/ CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G1) Load collides with floor or structure	(G3) Loss of hoist braking when hoist fails to engage load.	(G0) Loss of life and/or flight hardware	Ca - Loss of personnel, vehicle, equipment	All safety requirements pertaining to lifting devices at NWFC are found in NSS/GO 1740.9, the NASA Safety Requirement for Lifting Devices and Equipment.	See (G3) Under Hazardous Conditions	Ao - Unlikely
(G1) Load collides with floor or structure	(G4) Passive hoist component fails when load is attached	(G0) Loss of life and/or flight hardware	Ca - Loss of personnel, vehicle, equipment	All safety requirements pertaining to lifting devices at NWFC are found in NSS/GO 1740.9, the NASA Safety Requirement for Lifting Devices and Equipment.	See (G4) Under Hazardous Conditions	Ao - Unlikely
(G1) Load collides with floor or structure	(G5) Crane signaled to drive load into floor or other structure	(G0) Loss of life and/or flight hardware	Ca - Loss of personnel, vehicle, equipment	All safety requirements pertaining to lifting devices at NWFC are found in NSS/GO 1740.9, the NASA Safety Requirement for Lifting Devices and Equipment.	See (G5) Under Hazardous Conditions	Ao - Unlikely
(G3) Loss of hoist braking when hoist fails to engage load	(E1) Gear reducer fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.c. requires that hoist gears must be AGMA rated.	Gear train designed with AGMA rated gearing with 1.5 safety factor.	Ao - Unlikely
(G3) Loss of hoist braking when hoist fails to engage load	(E3) Electro-Mechanical brake fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.c. requires critical hoists must have two means of braking the load and that each must be capable of bringing rated load to zero speed and holding it.	Safety SOP requires testing of each brake before use.	Ao - Unlikely
(G4) Passive hoist component fails when load is attached	(E4) Rope fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6. And 2.3 lists the requirements for design and testing of mechanical components of critical lifting devices.	Safety SOP requires testing and inspection of rope before initial use, and after any major modifications.	Ao - Unlikely
(G4) Passive hoist component fails when load is attached	(E5) Rope clamp/sheave fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.k. lists the requirements for rope attachment design.	Safety SOP requires testing and inspection of rope clamp/sheave before initial use, and after any major modifications.	Ao - Unlikely
(G4) Passive hoist component fails when load is attached	(E6) Rope drum fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6. lists the requirements for mechanical components of critical lifting devices.	Safety SOP requires testing and inspection of drum before initial use, and after any majr mdifications.	Ao - Unlikely
(G4) Passive hoist component fails when load is attached	(E7) Hook fails	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6. lists the requirements for critical lifting device hooks.	Safety SOP requires testing and inspection of hook before initial use, and after any major modifications.	Ao - Unlikely

See"Hardware Reliability Block Diagrams" - Sect.-4.1 for hazard identification nomenclature (G1) (E5) etc.

SYSTEM HAZARD ANALYSIS (SHA)

SYSTEM: 20 TON BRIDGE CRANE
WFF PAYLOAD PROCESSING FACILITY

ENGINEER: T.G. SCARBORO
DATE: MAY 2004
SHEET: 2 OF 5

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/ CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G5) Crane signaled to drive load into floor or structure	(E2) Lack of operator training	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.6 requires training and certification of critical crane operators, and Section 2.7 spells out critical lifting procedures.	Safety SOP defines requirements for training, certification and verification.	Ao - Unlikely
(G5) Crane signaled to drive load into floor or structure	(G6) Equipment failure signals hoist to drive load into floor or structure.	(G1) Load collides with floor or structure	Ca - Loss of personnel, vehicle, equipment	See (G6) under Hazardous Condition below.	See (G6) Under Hazardous Conditions	Ao - Unlikely
(G6) Equipment failure signals hoist to drive load into floor/structure.	(E9) Stop switch fails closed	(G1) Load collides with floor or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9 Section 2.2.6.j. and a., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switch is a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G6) Equipment failure signals hoist to drive load into floor/structure.	(E10) Hoist "down" button fails closed.	(G1) Load collides with floor or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9 Section 2.2.6.j. and a., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that failure of the hoist control is backed up by the stop switch. Remote power kill switch add another level of backup.	Ao - Unlikely
(G6) Equipment failure signals hoist to drive load into floor/structure.	(E11) Lower limit switch fails open	(G1) Load collides with floor or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9 Section 2.2.6.j. and a., and 7.d.f.h.j. and k. set the requirements for electrical controls. bringing rated load to zero speed and holding it.	Examination of DeShzo Wiring Diagram indicates that the limit switch is a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G6) Equipment failure signals hoist to drive load into floor/structure.	(E12) Controller fails causing faster speed.	(G1) Load collides with floor or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.f. requires that design to be fail safe, such that any failure will not cause the crane to operate faster than commanded. Fail safe operation for the control is stated but not demonstrated.	Examination of DeShzo Wiring Diagram indicates that the stop switch is a safety designed to back up any other system electrical failure. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G2) Load collides with wall or structure	(G9) Bridge motor signaled to drive load into wall or structure	(G0) Loss of life and/or flight hardware	Ca - Loss of personnel, vehicle, equipment	See (G6) under Hazardous Condition below.	See (G9) Under Hazardous Conditions below.	Ao - Unlikely
(G2) Load collides with wall or structure	(G11) Trolley motor signaled to drive load into wall or structure	(G0) Loss of life and/or flight hardware	Ca - Loss of personnel, vehicle, equipment	See (G11) under Hazardous Condition below.	See (G9) Under Hazardous Conditions below.	Ao - Unlikely

See"Hardware Reliability Block Diagrams" - Sect.-4.1 for hazard identification nomenclature (G1) (E5) etc.

SYSTEM HAZARD ANALYSIS (SHA)

SYSTEM: 20 TON BRIDGE CRANE
WFF PAYLOAD PROCESSING FACILITY

ENGINEER: T.G. SCARBORO
DATE: MAY 2004
SHEET: 3 OF 5

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/ CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G9) Bridge notor signaled to drive load into wall or structure	(E2) Lack of operator training	(G2) Load collides with wall or structure	Ca - Loss of personnel, vehicle, equipment	Refer to (E2) under Hazard Cause above	Refer to (E2) under Hazard Cause above.	Ao - Unlikely
(G9) Bridge notor signaled to drive load into wall or structure	(G10) Equipment failure signals bridge motor to drive load into wall or structure	(G2) Load collides with wall or structure	Ca - Loss of personnel, vehicle, equipment	See (G10) under Hazardous Condition below.	See (G10) Under Hazardous Conditions. below.	Ao - Unlikely
(G10) Equipment failure signals bridge motor to drive load into wall or structure	(E9) Stop switch fails	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	Refer to E9) under Hazard Cause above	Refer to (E9) under Hazard Cause above.	Ao - Unlikely
(G10) Equipment failure signals bridge motor to drive load into wall or structure	(E13) Bridge motor wlectro-mechanical brake fails	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9 Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup. Loss of power sets brakes.	Ao - Unlikely
(G10) Equipment failure signals bridge motor to drive load into wall or structure	(E15) Limit switch fails closed.	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9 Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G10) Equipment failure signals bridge motor to drive load into wall or structure	(E14) Controller fails causing faster speed.	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.k. lists the requirements for rope attachment design.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely

See"Hardware Reliability Block Diagrams" - Sect.-4.1 for hazard identification nomenclature (G1) (E5) etc.

SYSTEM HAZARD ANALYSIS (SHA)

SYSTEM: 20 TON BRIDGE CRANE
WFF PAYLOAD PROCESSING FACILITY

ENGINEER: T.G. SCARBORO
DATE: MAY 2004
SHEET: 4 OF 5

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/ CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G10) Equipment failure signals bridge motor to drive load into wall or structure	(E16) Bridge motor control fails closed.	(G2) Load collides with wall or structure if other failures also occur.	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G11) Trolley motor signaled to drive load into wall or structure	(E2) Lack of operator training	(G2) Load collides with wall or structure	Ca - Loss of personnel, vehicle, equipment	Refer to (E9) under Hazard Cause above	Refer to (E2) under Hazard Cause above.	Ao - Unlikely
(G11) Trolley motor signaled to drive load into wall or structure wall or structure	(G12) Equipment failure signals trolley motor to drive load into wall or structure	(G2) Load collides with wall or structure.	Ca - Loss of personnel, vehicle, equipment	See (G12) under Hazardous Condition below.	See (G12) Under Hazardous Conditions. below.	Ao - Unlikely
(G12) Equipment failure signals trolley motor to drive load into wall or structure	(E9) Stop switch fails	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	Refer to (E9) under Hazard Cause above	Refer to (E9) under Hazard Cause above.	Ao - Unlikely
(G12) Equipment failure signals trolley motor to drive load into wall or structure	(E17) Trolley motor electromechanical brake fails	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G12) Equipment failure signals trolley motor to drive load into wall or structure	(E19) Limit switch fails open.	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the limit switch is a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely

See"Hardware Reliability Block Diagrams" - Sect.-4.1 for hazard identification nomenclature (G1) (E5) etc.

SYSTEM HAZARD ANALYSIS (SHA)

SYSTEM: 20 TON BRIDGE CRANE
WFF PAYLOAD PROCESSING FACILITY

ENGINEER: T.G. SCARBORO
DATE: MAY 2004
SHEET: 5 OF 5

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/ CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G12) Equipment failure signals trolley motor to drive load into wall or structure	(E18) Controller fails causing faster speed	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the stop switchis a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely
(G12) Equipment failure signals trolley motor to drive load into wall or structure	(E20) Trolley control fails closed.	(G2) Load collides with wall or structure if other failure also occurs	Ca - Loss of personnel, vehicle, equipment	NSS/GO 1740.9, Section 2.2.6.j. and n., and 7.d.f.h.j. and k. set the requirements for electrical controls.	Examination of DeShzo Wiring Diagram indicates that the limit switch is a safety device to back up potential failures of other electrical components. Remote power kill switch adds another level of backup.	Ao - Unlikely

See"Hardware Reliability Block Diagrams" - Sect.-4.1 for hazard identification nomenclature (G1) (E5) etc.

SECTION VII

7.0 CONTROL LOGIC ANALYSIS

7.1 WIRING AND CONTROLLER DESCRIPTION

The control wiring diagram for the Trolley and Bridge is shown on DeSHAZO Crane Company drawing D-2215-E3.

The control wiring diagram for the Hoist is shown on DeSHAZO Crane Company drawing D-2215-E4.

Control logic within the Electromotive VG+ and G+ variable frequency controllers was not analyzed. Industry experience is that the devices are fail safe but no known demonstration or studies are yet available.

Controllers do not accept dual commands or produce conflicting outputs.

The Telemotive radio controller duplicates identically the inputs to the Electromotive controllers, when substituted for the pendant transmitter.

SECTION VIII

8.0 EMERGENCY SAFING ANALYSIS

8.1 SAFING SITUATION REQUIREMENTS

The only safing situation requirements is for a method of removing the load into a suitable work stand for crane repair in the event failure mode is such that repairs to either of the hoist brakes or the gear reducer require load to be removed.

SECTION IX

9.0 SNEAK CIRCUIT ANALYSIS

No sneak circuit analysis was performed, due to use of industry standard hardware.

SECTION X

10.0 END – TO – END ANALYSIS

No end – to – end analysis was performed, due to use of industry standard hardware.

SECTION XI

11.0 AREAS OF CONCERN AND RECOMMENDATION

11.1 AREAS OF CONCERN

One area of concern is that a study be performed or a policy established to limit the time that a hazardous payload could remain on the hook of the hoist when it is disabled and operations delayed for repair. A suitable load removal method needs to be identified.

A second area of concern is that interference from other higher powered radio frequency transmissions should be established as not feasible by discussions and analysis as necessary, jointly with 30SW/SE.

11.2 RECOMMENDATIONS

Acceptance of the single Criticality 1 Failure potential is recommended. The Hoist Gear Reducer is industry proven, designed conservatively to American Gear Manufacturing Association and ANSI standards, and has an extensive history of no failures according to recent NASA crane failure database inquiry.