LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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PHYSICS ENVIRONMENT MONITORING SYSTEM RELIABILITY PREDICTION REPORT

LIGO Systems Engineering

This is an internal working note
of the LIGO Project.

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ABSTRACT

The LIGO Physics Environment Monitoring System (PEM) is designed to measure disturbances in the physical environment which might affect the interferometers thereby producing spurious signals in the gravitational wave data. The PEM will function as an independent monitoring and calibration system allowing on-line and off-line analyses.

A reliability prediction was performed on the PEM. Vendor data and NPRD-95 data were the primary sources of reliability values for the various equipments comprising the PEM. Where vendor data or NPRD-95 data were not available, engineering estimates were made based upon equipment complexity, NPRD-95 data on similar equipment and vendor data on similar equipment.

NPRD-95 provides failure rate data on a variety of electrical, electromechanical, and mechanical parts and assemblies. The NPRD-95 failure rate data was also collected over a variety of different operating environments. Equivalent LIGO failure rates were calculated by normalizing the NPRD-95 failure rates to the Ground Benign environment.

Availability predictions were performed by developing fault trees using the FaultTree+ software. A fault tree was developed and an Availability prediction was performed on the PEM at the Washington Observatory. The PEM at the Washington Observatory consists of the HIF1 PEM, the HIF2 PEM, and the HCMN PEM. A fault tree was also developed and an Availability prediction was also performed on the PEM at the Louisiana Observatory. The PEM at the Louisiana Observatory consists of the LIF1 PEM.

The PEM primarily consists of units and assemblies which, in the event of failure, can be removed and replaced without disturbing the vacuum environment. Therefore, an MDT of 8.0 hours was used in the PEM availability predictions for both observatories. The previously allocated MDT of 24.0 hours was overly conservative.

The fault tree and detailed calculations for the HIF1 PEM, the HIF2 PEM and the HCMN PEM are provided in Appendix A. The fault tree and detailed calculations for the LIF1 PEM are provided in Appendix B.

Availability predictions were then performed for the three LIGO operating modes. The fault trees and detailed Availability predictions for the three LIGO operating modes are provided in Appendices C through E. The results of the PEM availability predictions for each of the LIGO operating modes are summarized in the table below.

PEM Availability Predictions For The LIGO Operating Modes

Mode of Operation	*Allocated Annual Availability*	*Predicted Annual Availability*
3X	0.9959	0.9924
2X	0.9980	0.9946
1X	1.0000	1.0000

1.0 INTRODUCTION

The LIGO Physics Environment Monitoring System (PEM) is designed to measure disturbances in the physical environment which might affect the interferometers thereby producing spurious signals in the gravitational wave data. The PEM will function as an independent monitoring and calibration system allowing on-line and off-line analyses.

Reliability, repair time and availability calculations were performed on the Physics Environment Monitoring System (PEM) of the Laser Interferometer Gravitational Wave Observatory (LIGO). Failure rate data was obtained from the following sources:

- “Non-Electronic Parts Reliability Data - 1995,” NPRD-95, Reliability Analysis Center.
- Vendor data
- Engineering estimates predicated upon experience with equipments of similar complexity.

The calculations were predicated upon the design information available at the time this report was prepared. This report will be updated to reflect the current design if the differences in design or material/part selection are likely to significantly impact reliability or availability.

2.0 ACRONYMS

A	Operational Availability
BSC	Beam Splitter Chamber
BT	Beam Tube
CMN	Common
CS	Corner Station
EMI	Electro-Magnetic Interference
ES	End Stations
FPMH	Failures Per Million Hours
FTA	Fault Tree Analysis
H	Hanford, Washington site
HAM	Horizontal Access Module
IFO	Interferometer
IF2	Interferometer, 2 km long
IF1	Interferometer, 4 km long
IOO	Input/Output Optics
L	Livingston, Louisiana site
LIGO	Laser Interferometer Gravitational Wave Observatory
MDT	Mean Down Time
MS	Mid Stations
MTBF	Mean Time Between Failure (λ^{-1})
PEM	Physics Environment Monitoring System
PSL	Pre-Stabilized Laser
Q	Operational Unavailability (1-A)
R	Probability of Success, or Reliability
RF	Radio Frequency
RFI	Radio Frequency Interference
RGA	Residual Gas Analyzer
SRD	Science Requirements Document
W	Washington site
λ	Failure Rate

3.0 APPLICABLE DOCUMENTS

The documents containing Physics Environment Monitoring (PEM) System design requirements, PEM design, LIGO reliability requirements and guidelines, reliability modeling and prediction methods, and the software used to perform the reliability predictions and availability calculations are listed in the tables below.

Table 1: Project Documents

LIGO-E960099-B-E	LIGO Reliability Program Plan
LIGO-T960127-02-D	Physics Environment Monitoring Design Requirements Document
LIGO-T970112-00-D	Physics Environment Monitoring Final Design Document
LIGO-G9700242-00-D	Final Design Review Presentation Viewgraphs
LIGO - E950018-02-E	LIGO Science Requirements Document

Table 2: Reliability Standards and Handbooks

MIL-STD-785	Reliability Program for Systems and Equipment Development and Prediction
MIL-STD-756	Reliability Modeling and Prediction
MIL-HDBK-217F	Reliability Prediction For Electronic Equipment
NRPD-95	Non-Electronic Parts Reliability Data 1995, Reliability Analysis Center

Table 3: Reliability Software

RELEX 217	Reliability prediction software; hardware failure rate calculations.
ITEM Software FaultTree+	Fault tree analysis software; Availability calculations

4.0 AVAILABILITY REQUIREMENTS

Quantitative System Level Availability requirements were specified in the LIGO Science Requirements Document. PEM Subsystem Availability requirements, defined in terms of operational performance, were specified in the PEM Design Requirements Document.

4.1 SYSTEM LEVEL

The LIGO system level availability requirements are summarized in Table 4 below:

Table 4: LIGO System Reliability Requirements

Mode of Operation	*Annual Availability*	*Minimum Continuous Operating Period*
3X	0.75%	100 hours
2X	0.85%	100 hours
1X	0.90%	40 hours

The Modes of Operation are defined as:

a. Triple Operations Mode (3X): All three interferometers are operational.

b. Double Operations Mode (2X): At least two interferometers are operational. One of which must be the Louisiana interferometer.

c. Single Operations Mode (1X): At least one of the three interferometers is operational.

As described in the LIGO Reliability Program Plan, the allocated subsystem availability requirements were derived from the observatory availability requirements for the 3X mode of operation. With respect to availability, the 3X mode of operation represents the worst case operating scenario. For the reader's convenience, the subsystem availability requirements are presented in Table 5 on page 9. The PEM availability requirements are highlighted. In the process of allocating the subsystem availability requirements, it was assumed that the 4 km and the 2 km interferometers were of equal complexity. Therefore, since there are two interferometers at the Washington Observatory, the subsystems at the Washington Observatory were assumed to be twice as complex as the respective subsystems at the Louisiana Observatory. As a result, the Washington Observatory subsystem Mean-Time-Between-Mission-Critical-Failure (MTBMCF) values are half of the respective subsystem MTBMCF values at the Louisiana Observatory. The Beam Tube, Facilities Monitoring and Control System, Heating, Ventilation and Air Conditioning, and Electrical Power are exceptions to this rule. These four subsystems were considered to be of equal complexity at each observatory.

MTBMCF is the mean time between subsystem failures which would jeopardize the collection and validation of science data. The MTBMCF takes into consideration equipment redundancies which might be present within the subsystem.

Table 5: Subsystem Availability Allocated Requirements

SUBSYSTEM	*OBSERVATORY*					
	LOUISIANA			*WASHINGTON*		
	MTBMCF (Op. Hours)	*MDT (Hours)*	*A*	*MTBMCF (Op. Hours)*	*MDT (Hours)*	*A*
CDS C&M	17, 600	24	0.9986	8, 800	24	0.9973
CDS DAQ	17, 600	24	0.9986	8, 800	24	0.9973
CDS Infrastructure	17, 600	24	0.9986	8, 800	24	0.9973
VCMS	17, 600	24	0.9986	8, 800	24	0.9973
ASC	20, 000	72	0.9964	10, 000	72	0.9929
LSC	20, 000	72	0.9964	10, 000	72	0.9929
COC	26, 000	72	0.9972	13, 000	72	0.9945
COS	24, 000	72	0.9970	12, 000	72	0.9940
IOO	10, 000	72	0.9929	5, 000	72	0.9858
PSL	5, 000	72	0.9858	2, 500	72	0.9720
SEI	13, 000	72	0.9945	6, 500	72	0.9890
SUS	13, 000	72	0.9945	6, 500	72	0.9890
PEM	**17, 600**	**24**	**0.9986**	**8, 800**	**24**	**0.9973**
BT	35, 000	1, 460	0.9600	35, 000	1, 460	0.9600
FMCS	17, 600	24	0.9986	17, 600	24	0.9986
HVAC	17, 600	72	0.9959	17, 600	72	0.9959
ELEC. PWR.	8, 800	24	0.9973	8, 800	24	0.9973
VE	8, 800	72	0.9919	4, 400	72	0.9839

Mean-Down-Time (MDT) is the total preventive and corrective maintenance time divided by the total number of preventive and corrective maintenance actions for a given subsystem. Logistic delays are included in the calculation of preventive and corrective maintenance times. The subsystem MDT requirements are based upon subsystem. size, complexity, and the fact that some subsystems may require a bake-out following maintenance actions. The MDT requirement should be used as a guide in the development of on-site spares and maintenance support policies.

Availability is defined as the ability of an item, under the combined aspects of its reliability and maintenance, to perform its required function over a given period of time. Mathematically, Availability is approximated as:

$$A = \frac{MTBMCF}{MTBMCF + MDT}$$

Therefore, since availability allows for trade-offs between reliability (MTBMCF) and maintenance (MDT), the subsystem availability allocations are the design constraints which must be met in order to achieve the desired level of observatory availability.

4.2 PEM LEVEL

Table 6 on page 11 lists the PEM availability requirements in terms of operational performance as defined in the PEM Design Requirements Document.

5.0 RELIABILITY ANALYSES

PEM reliability was assessed by means of:

- Reliability Modeling
- Reliability and Availability Predictions
- Fault Tree Analysis

5.1 RELIABILITY MODELING

The PEM Reliability Block Diagram for the LIGO 3X Operating Mode is shown in Figure 1. The Reliability Block Diagram depicts a series model in which it is necessary for the PEM at both of the observatories to be operational for successful LIGO 3X operation. At the Hanford Observatory, PEM equipments monitor the physics environment peculiar to the 4km Interferometer (HIF1 PEM) and the physics environment peculiar to the 2km Interferometer (HIF2 PEM). In addition, there are PEM equipments which monitor the physics environment common to both Interferometers (HCMN PEM). At the Livingston Observatory, the PEM monitors the physics environment of a 4km Interferometer (LIF1 PEM).

Table 6: PEM Equipment Level Availability Requirements

MONITORING FUNCTION	*INSTRUMENT*	*LOCATION*			
		HIF1	*HIF2*	*HCMN*	*LIF1*
Seismic Noise	Seismometers			1/5	1/3
	Tiltmeters			1/5	1/3
	Accelerometers	PSL: 1/3 BSC: 1/6 HAM: 1/3	PSL: 1/3 BSC: 1/3 HAM: 1/3		PSL: 1/3 BSC: 1/3 HAM: 1/3
	Accelerometer Signal Conditioners	CS: 1/5 ES: 2/2	CS: 1/4 MS: 2/2		CS: 1/3 ES: 2/2
Acoustic Noise	Microphones	PSL: 1/1 WBSC1-3: 1/3 WBSC9, 10: 1/1 WHAM1, 6: 1/1 WHAM2: 1/2 WHAM3-5: 1/2	PSL: 1/1 WBSC4-6: 1/3 WBSC7, 8: 1/2 WHAM7: 1/1 WHAM8, 9: 1/2 WHAM11: 1/2 WHAM12: 1/1		PSL: 1/1 LBSC1, 3: 1/2 LBSC2: 1/3 LBSC4, 5: 1/1 LHAM1: 1/1 LHAM2-5: 1/2 LHAM6: 1/1
	Microphone Preamps	PSL: 1/1 WBSC1-3: 1/3 WBSC9, 10: 1/1 WHAM1, 6: 1/1 WHAM2: 1/2 WHAM3-5: 1/2	PSL: 1/1 WBSC4-6: 1/3 WBSC7, 8: 1/2 WHAM7: 1/1 WHAM8, 9: 1/2 WHAM11: 1/2 WHAM12: 1/1		PSL: 1/1 LBSC1, 3: 1/2 LBSC2: 1/3 LBSC4, 5: 1/1 LHAM1: 1/1 LHAM2-5: 1/2 LHAM6: 1/1
Magnetic Field	Magnetometer			1/1	1/1
	Magnetometer Power Supply			1/1	1/1
RF Interference	Antenna			2/2	2/2
	Broadband Receiver			2/4	2/4
	Narrow Band Receiver	PSL: 2/2 IOO: 3/3	PSL: 2/2 IOO: 3/3		1/1
	Fan-Out Circuit			1/1	1/1
Power Line Fluctuations	Current Monitors			1/1	1/1
	Dranetz Power Platform 4300			1/2	1/1
Residual Gas	RGA Heads			5/8	3/6
	RGA Preamps			5/8	3/6
	RGA Controllers			5/5	3/3
	RGA Power Supply			5/5	3/3
Weather	Temperature/ Humidity Transmitters	ES: 1/3	MS: 1/3	BT: 3/5 CS: 1/3	CS: 1/3 ES: 1/3
	Weather Stations			1/5	1/3

Note: “m/n” denotes that “m” out of “n” are required for successful operation.

The PEM Reliability Model for the LIGO 2X Operating Mode is shown in Figure 2. The combination series/parallel model illustrates that the HIF1 PEM or the HIF2 PEM must be operational along with both the HCMN PEM and the LIF1 PEM for successful LIGO 2X operation.

The PEM Reliability Model for the LIGO 1X Operating Mode is shown in Figure 3. This combination series/parallel model illustrates that one, or more, of the following conditions must be met for successful LIGO 1X operation:

- HIF1 PEM “AND” HCMN PEM
- HIF2 PEM “AND” HCMN PEM
- LIF1 PEM

5.2 RELIABILITY PREDICTION

A reliability prediction was performed on the LIGO PEM. Vendor data and NPRD-95 data were the primary sources of reliability values for the various equipments comprising the PEM. Where vendor data or NPRD-95 data were not available, engineering estimates were made based upon equipment complexity, NPRD-95 data on similar equipment and vendor data on similar equipment.

NPRD-95 provides failure rate data on a variety of electrical, electromechanical, and mechanical parts and assemblies. The NPRD-95 failure rate data was also collected over a variety of different operating environments. Table 7 on page 16 lists the NPRD-95 failure rates and the equivalent LIGO equipment failure rates. The equivalent LIGO failure rates were calculated by normalizing the NPRD-95 failure rates to the Ground Benign environment.

Table 8 on page 17 identifies the various PEM equipments, the quantities used in each IFO, the equipment MTBFs and the source of the MTBF values.

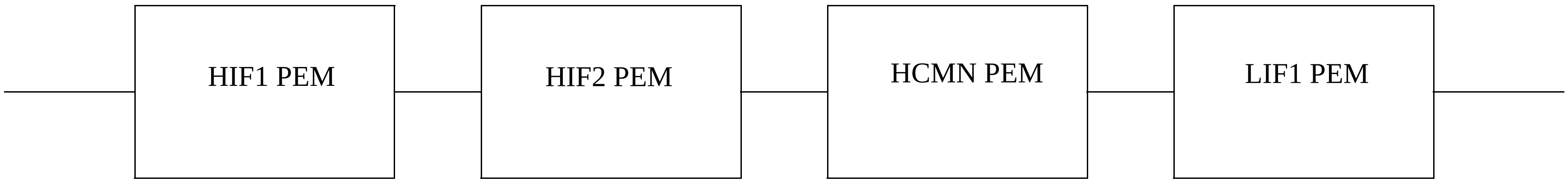


Figure 1: Reliability Block Diagram For The LIGO 3X Operating Mode

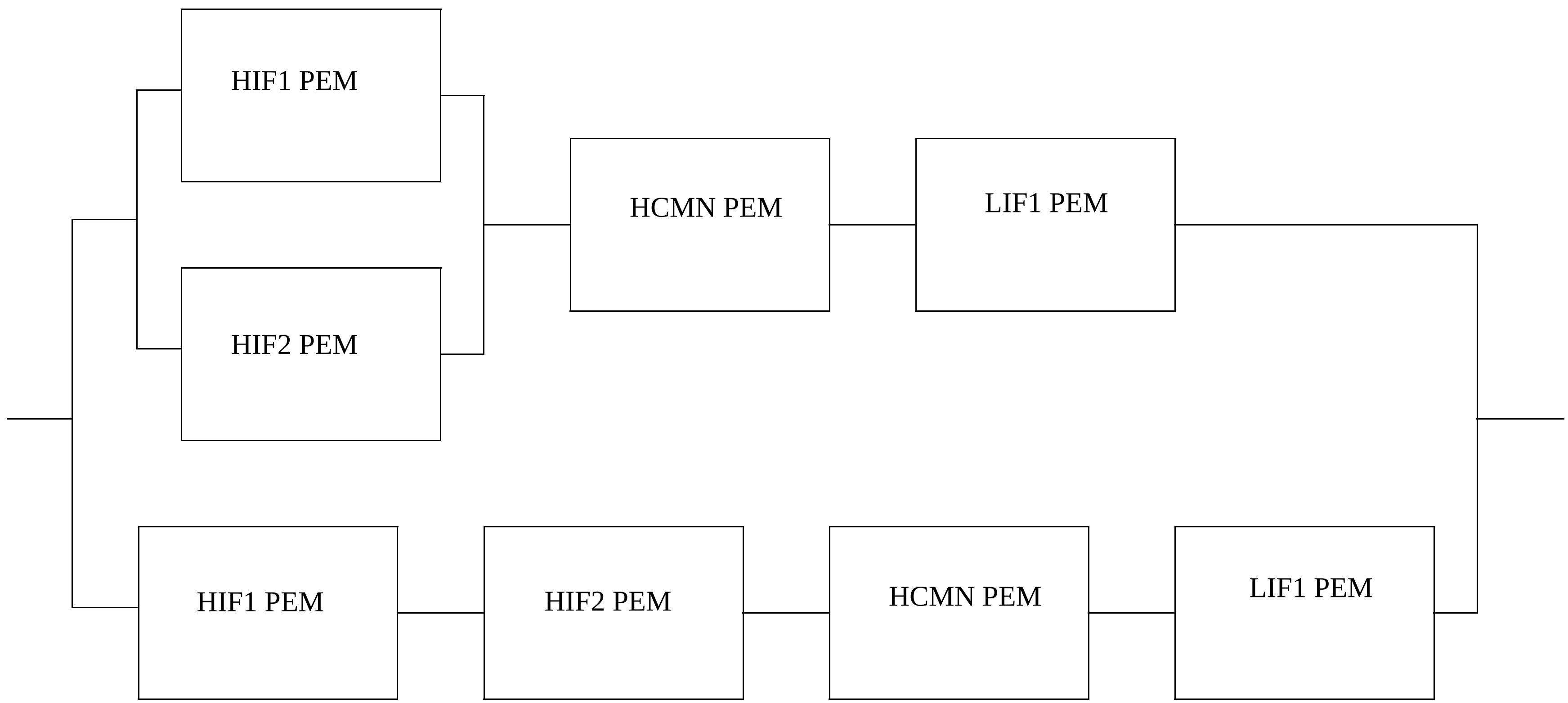


Figure 2: Reliability Block Diagram For The LIGO 2X Operating Mode

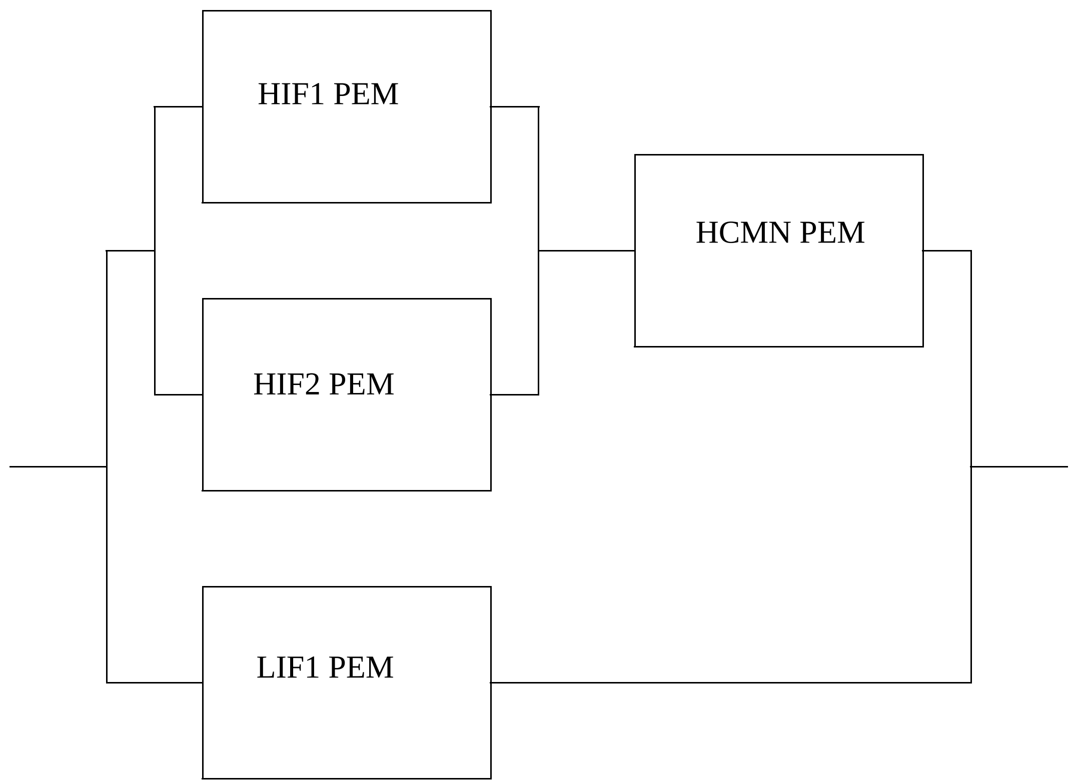


Figure 3: Reliability Block Diagram For The LIGO 1X Operating Mode

Table 7: NPRD-95 vs LIGO Equivalent Failure Rates

NPRD-95			*LIGO*			
Equipment	Env.	λ *(FPMH)*	*Equipment*	*Env. Factor*	λ *(FPMH)*	*MTBF*
Microphone, Dynamic	GB	0.5312	Microphone	1.0	0.5312	1,882,530
Amplifier, Signal	GB	3.1100	Microphone Preamp, RGA Preamp, RGA Controller	1.0	3.1100	321,543
Meter, Power	NS	21.7231	Powerscope	6.1	3.5612	280,807
Antenna	AUT	56.2808	Antenna	15.1	3.7272	268,298
Receiver, Communication	GB	156.0000	RF Multi-Channel Receiver, RF Narrow Band Receiver	1.0	156.0000	6,410
Meter, Position	ARW	1390.0814	Seismometer	24.7	56.2786	17,769
Sensor, Transmitter, Temp./Humidity	GB	14.6525	Temp./Humidity Transmitter	1.0	14.6525	68,248
Meter, Antenna., Tilt	GM	502.7652	Tiltmeter	10.1	49.7787	20,089
Battery	GB	0.6759	Battery	1.0	0.6759	1,479,509
Particle Separator	ARW	921.659	Dust Detector	24.7	37.3141	26,800
Ammeter	GB	1.7520	Current Monitor	1.0	1.7520	570,776

Table 8: PEM Equipment Reliability

EQUIPMENT	MTBF (hours)	HIF1	HIF2	HCMN	LIF1	SOURCE
Accelerometer	122,000	48	36		36	Vendor Data
Accelerometer Signal Conditioner	50,000	7	6		7	Vendor Data
Dust Detector	26,800	1	1		1	NPRD-95
Magnetometer	376,680			1	1	Vendor Data
Magnetometer Power Supply	301,344			1	1	Vendor Data
Microphone	$1.883x10^6$	12	12		12	NPRD-95
Microphone Preamp	321,543	12	12		12	NPRD-95
Power Platforms	280,807			2	1	NPRD-95
RF Broadband Antennas	268,298			2	2	NPRD-95
RF Broadband Receiver	6,410			4	4	NPRD-95
RF Broadband Fan-Out Circuit	100,000			1	1	Engineering Estimate
RF Narrow Band Antenna	268,298	5	5		5	NPRD-95
RF Narrow Band Receiver	6,410	5	5		5	NPRD-95
RGA Head	10,000			8	6	Engineering Estimate
RGA Preamp	321,543			8	6	NPRD-95
RGA Controller	321,543			5	3	NPRD-95
RGA Power Supply	50,000			5	3	Engineering Estimate
Seismometer	17,769			5	3	NPRD-95
Seismometer Digitizer Module	50,000			5	3	Engineering Estimate
Temp./Humidity Transmitters	68,248	6	6	8	9	NPRD-95
Tiltmeter	20,089			5	3	NPRD-95
Current Monitor	570,776			1	1	NPRD-95
Weather Station	4,400			5	3	Engineering Estimate

5.3 AVAILABILITY PREDICTION

Availability predictions were performed by developing fault trees using the FaultTree+ software. A fault tree was developed and an Availability prediction was performed on the PEM at the Washington Observatory. The PEM at the Washington Observatory consists of the HIF1 PEM, the HIF2 PEM, and the HCMN PEM. A fault tree was also developed and an Availability prediction was also performed on the PEM at the Louisiana Observatory. The PEM at the Louisiana Observatory consists of the LIF1 PEM.

The PEM primarily consists of units and assemblies which, in the event of failure, can be removed and replaced without disturbing the vacuum environment. Therefore, an MDT of 8.0 hours was used in the PEM availability predictions for both observatories. The previously allocated MDT of 24.0 hours was overly conservative.

The fault tree and detailed calculations for the HIF1 PEM, the HIF2 PEM and the HCMN PEM are provided in Appendix A. The fault tree and detailed calculations for the LIF1 PEM are provided in Appendix B. A summary of the results are shown in Table 9 below:

Table 9: Interferometer PEM Availability Prediction Results

PEM	*Unavailability (Q)*	*Availability (A = 1-Q)*
HIF1	0.0011	0.9989
HIF2	0.0011	0.9989
HCMN	0.0034	0.9966
LIF1	0.0019	0.9981

Availability predictions were then performed for the three LIGO operating modes. The fault trees and detailed Availability predictions for the three LIGO operating modes are provided in Appendices C through E. The results of the PEM availability predictions for each of the LIGO operating modes are summarized in Table 10 below.

Table 10: PEM Availability Predictions For The LIGO Operating Modes

Mode of Operation	*Allocated Annual Availability*	*Predicted Annual Availability*
3X	0.9959	0.9924
2X	0.9980	0.9946
1X	1.0000	1.0000

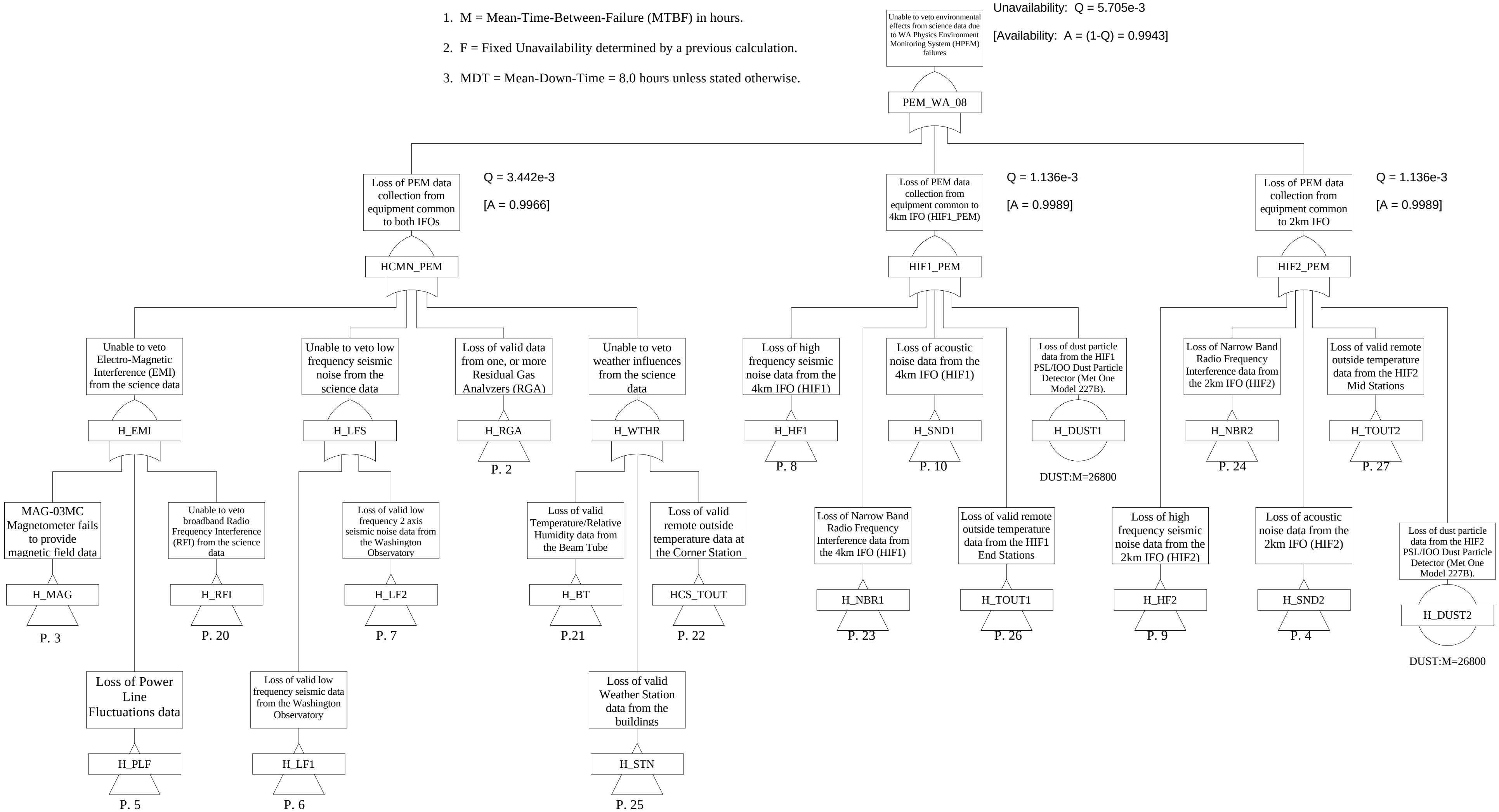
6.0 CONCLUSIONS

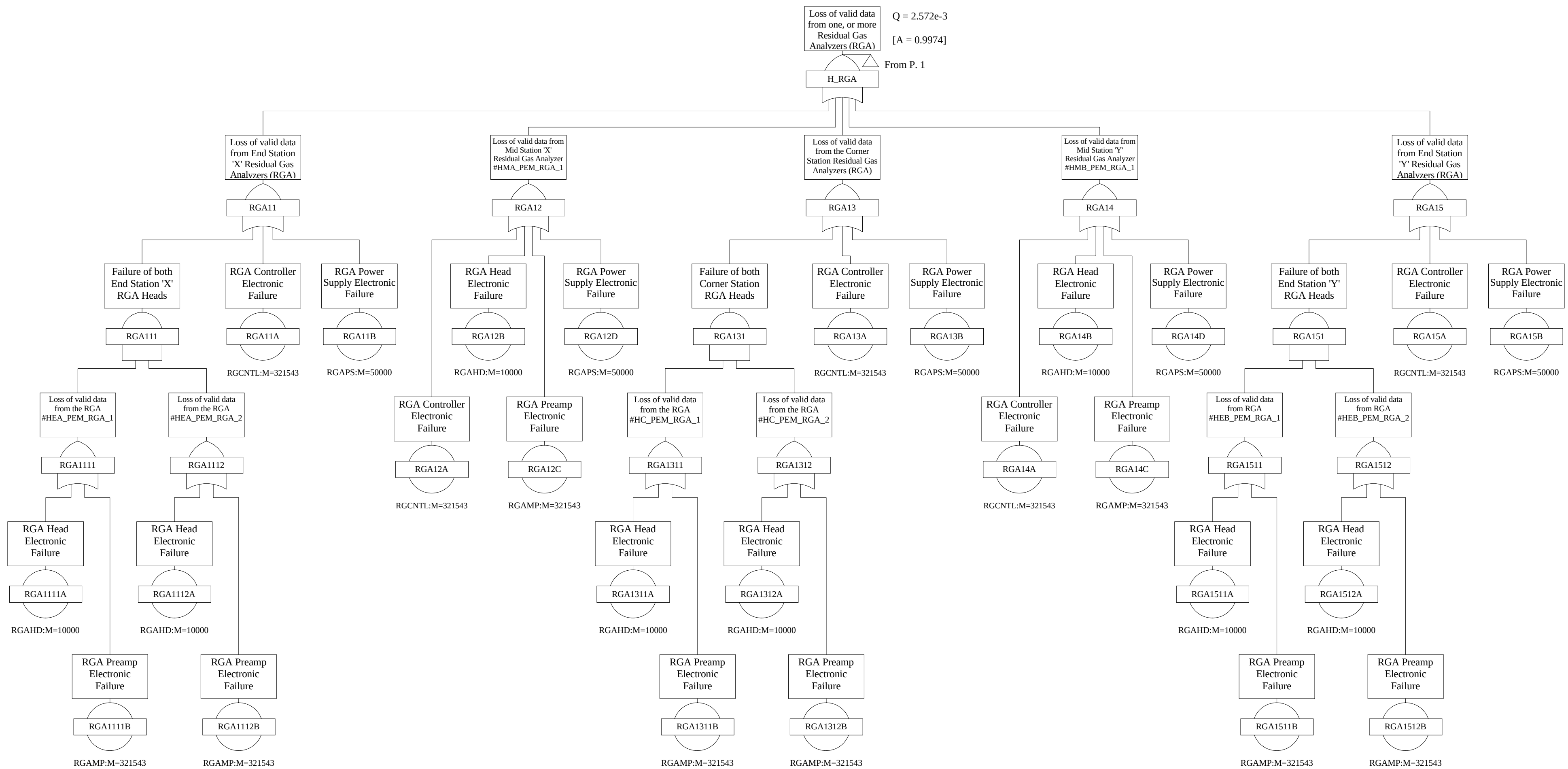
The PEM predicted availability for the LIGO operating modes, for all intents and purposes, meets the PEM allocated availability. As the maintenance and spares policy becomes more defined and as additional vendor reliability data becomes available, refinements may be made to this analysis to more accurately depict PEM availability.

APPENDIX A:
WASHINGTON PEM AVAILABILITY PREDICTION

NOTES:

1. M = Mean-Time-Between-Failure (MTBF) in hours.
2. F = Fixed Unavailability determined by a previous calculation.
3. MDT = Mean-Down-Time = 8.0 hours unless stated otherwise.




Loss of valid data from one, or more Residual Gas Analyzers (RGA)
Q = 2.572e-3
[A = 0.9974]
From P. 1
H_RGA
Loss of valid data from End Station 'X' Residual Gas Analyzers (RGA)
RGA11
Loss of valid data from Mid Station 'X' Residual Gas Analyzer #HMA_PEM_RGA_1
RGA12
Loss of valid data from the Corner Station Residual Gas Analyzers (RGA)
RGA13
Loss of valid data from Mid Station 'Y' Residual Gas Analyzer #HMB_PEM_RGA_1
RGA14
Loss of valid data from End Station 'Y' Residual Gas Analyzers (RGA)
RGA15
Failure of both End Station 'X' RGA Heads
RGA111
RGA Controller Electronic Failure
RGA11A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA11B
RGAPS:M=50000
RGA Controller Electronic Failure
RGA12A
RGCNTL:M=321543
RGA Head Electronic Failure
RGA12B
RGAHD:M=10000
RGA Preamp Electronic Failure
RGA12C
RGAMP:M=321543
RGA Power Supply Electronic Failure
RGA12D
RGAPS:M=50000
Failure of both Corner Station RGA Heads
RGA131
RGA Controller Electronic Failure
RGA13A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA13B
RGAPS:M=50000
RGA Controller Electronic Failure
RGA14A
RGCNTL:M=321543
RGA Head Electronic Failure
RGA14B
RGAHD:M=10000
RGA Preamp Electronic Failure
RGA14C
RGAMP:M=321543
RGA Power Supply Electronic Failure
RGA14D
RGAPS:M=50000
Failure of both End Station 'Y' RGA Heads
RGA151
RGA Controller Electronic Failure
RGA15A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA15B
RGAPS:M=50000
Loss of valid data from the RGA #HEA_PEM_RGA_1
RGA1111
Loss of valid data from the RGA #HEA_PEM_RGA_2
RGA1112
Loss of valid data from the RGA #HC_PEM_RGA_1
RGA1311
Loss of valid data from the RGA #HC_PEM_RGA_2
RGA1312
Loss of valid data from RGA #HEB_PEM_RGA_1
RGA1511
Loss of valid data from RGA #HEB_PEM_RGA_2
RGA1512
RGA Head Electronic Failure
RGA1111A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1112A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1311A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1312A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1511A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1512A
RGAHD:M=10000
RGA Preamp Electronic Failure
RGA1111B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1112B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1311B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1312B
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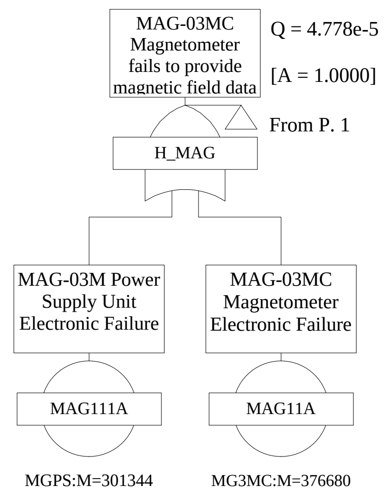
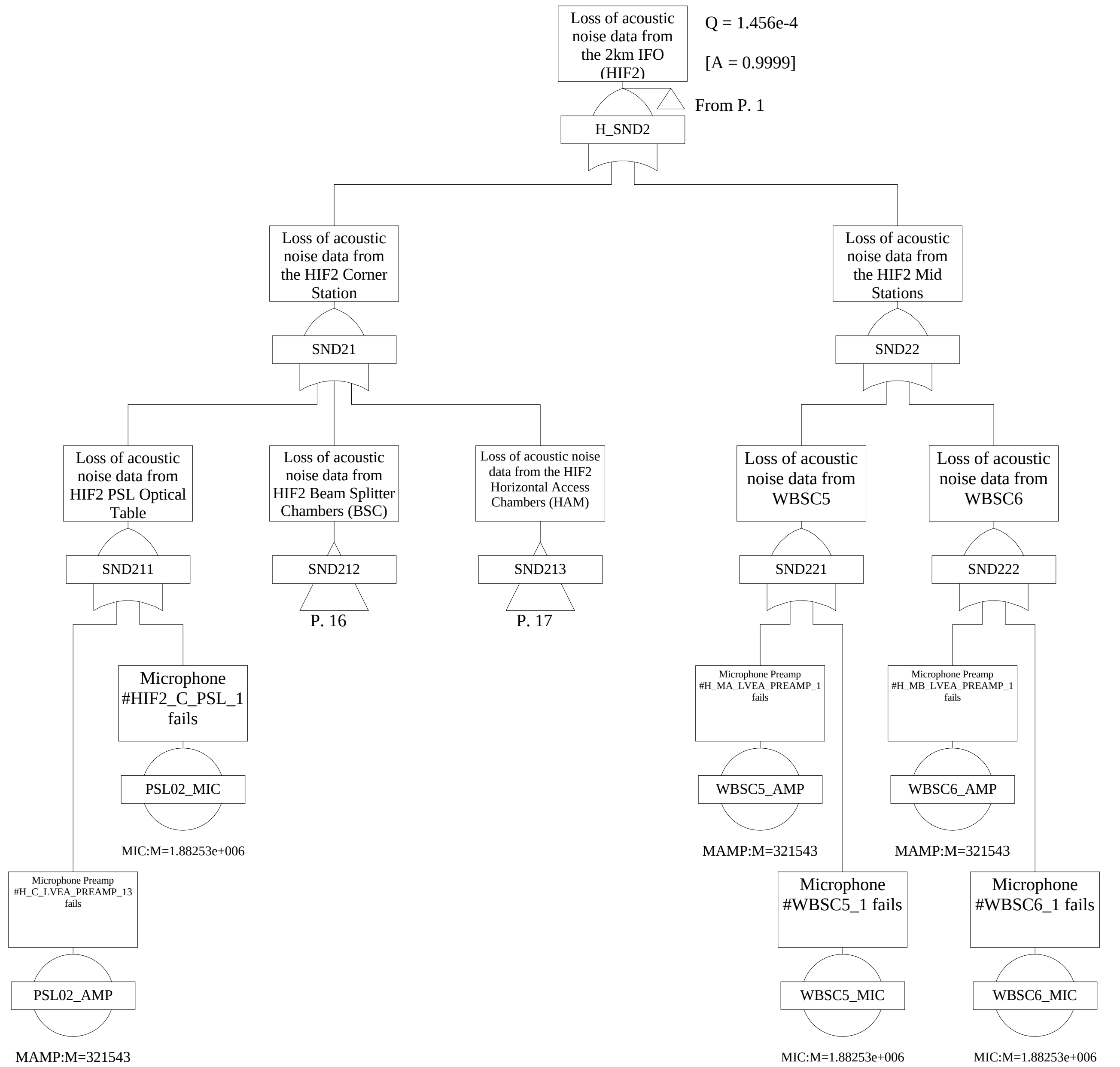
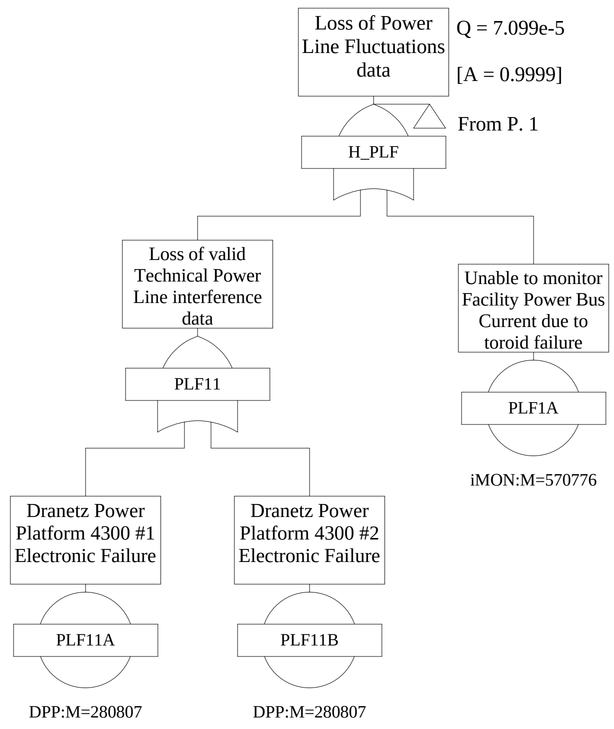
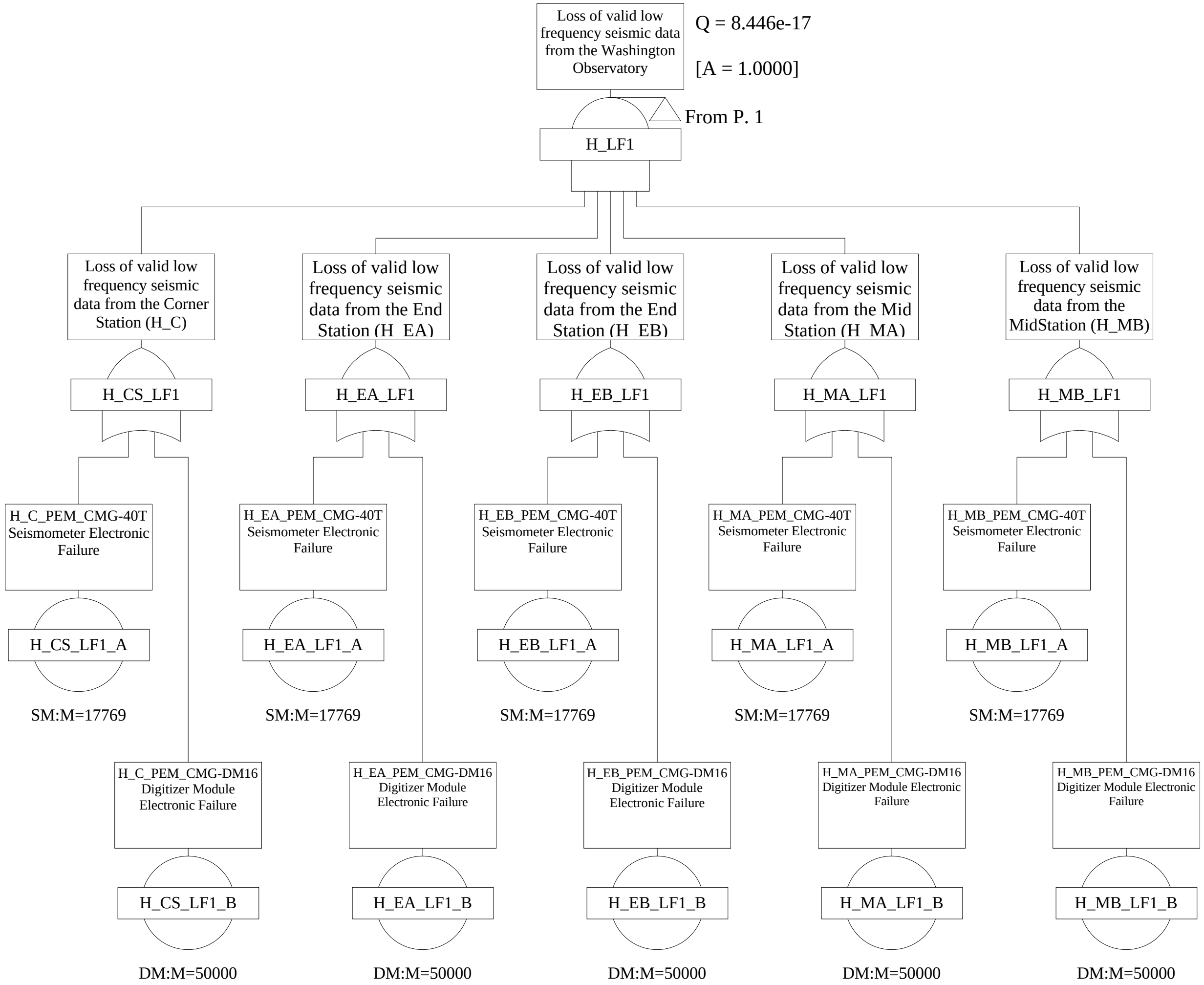
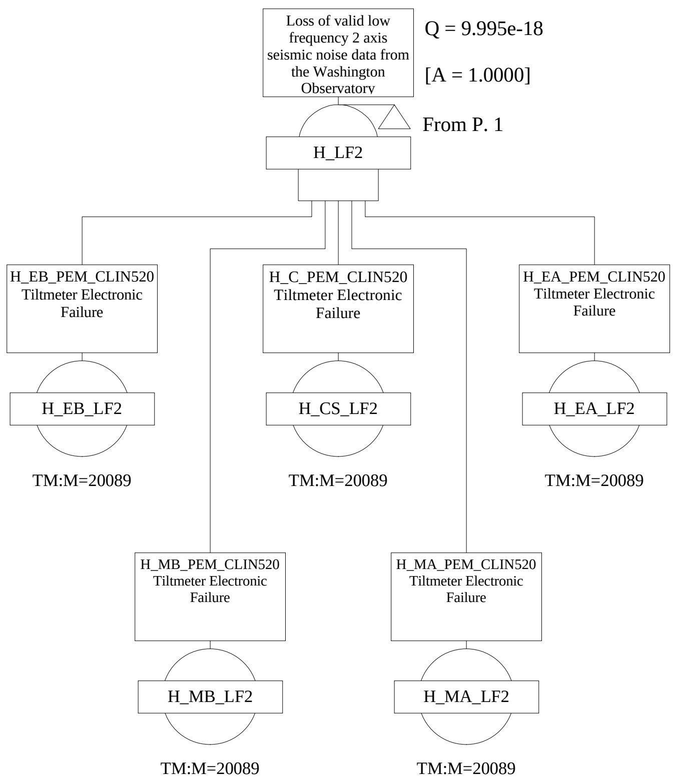
RGA1512B
RGAMP:M=321543

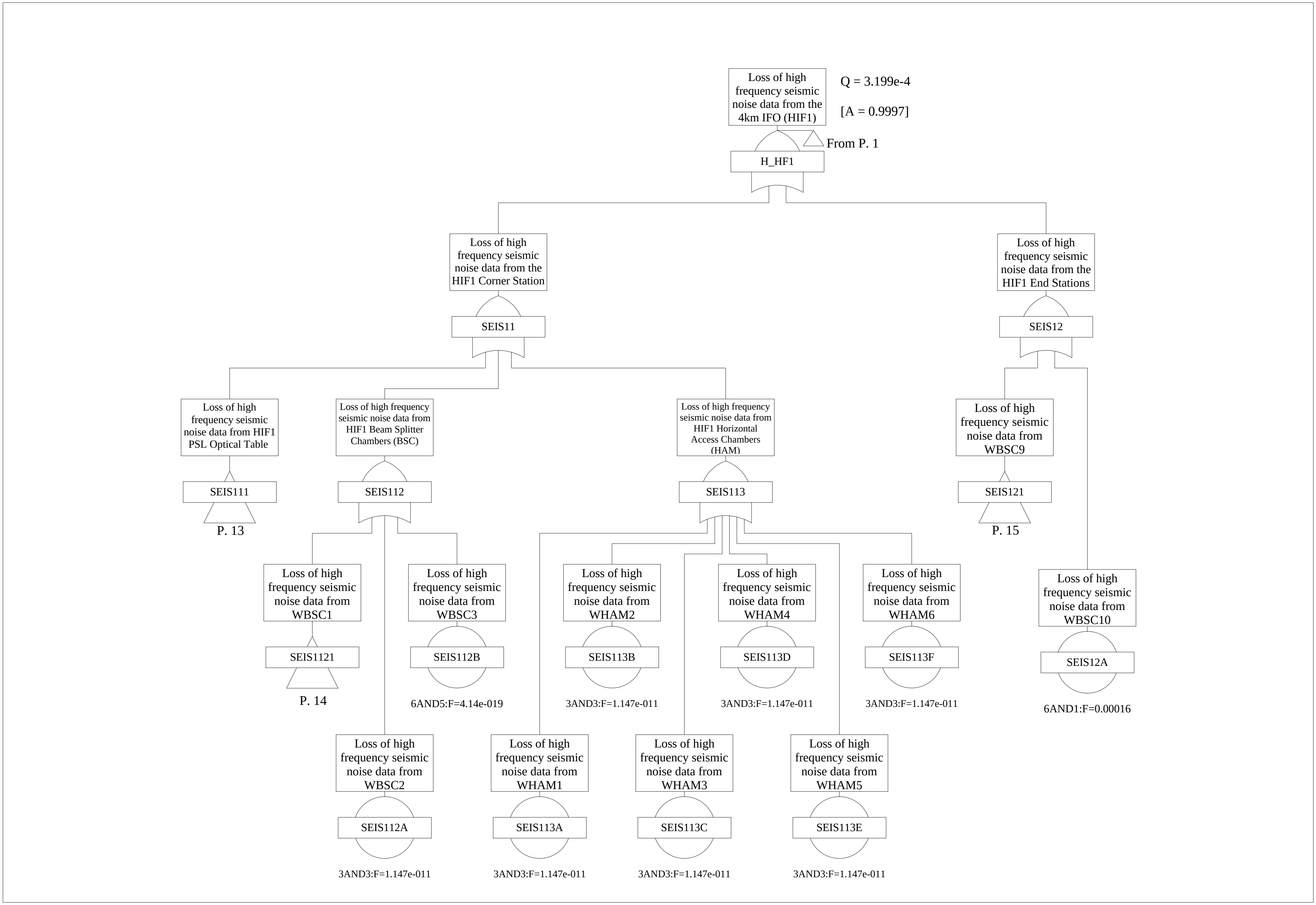

MAG-03MC
Magnetometer
fails to provide
magnetic field data
Q = 4.778e-5
[A = 1.0000]
From P. 1
H_MAG
MAG-03M Power
Supply Unit
Electronic Failure
MAG-03MC
Magnetometer
Electronic Failure
MAG111A
MAG11A
MGPS:M=301344
MG3MC:M=376680

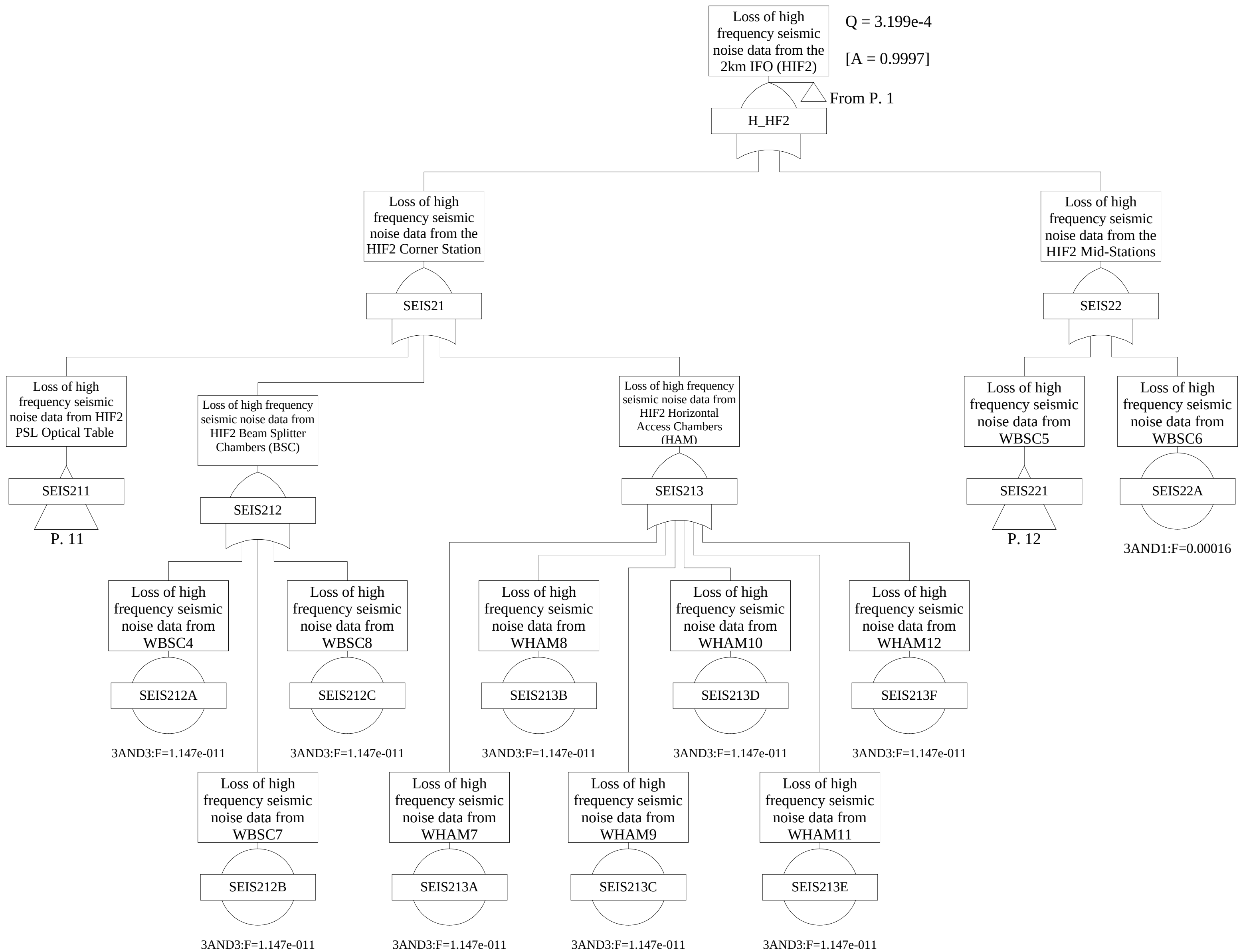

Loss of acoustic noise data from the 2km IFO (HIF2)
Q = 1.456e-4
[A = 0.9999]
From P. 1
H_SND2
Loss of acoustic noise data from the HIF2 Corner Station
SND21
Loss of acoustic noise data from the HIF2 Mid Stations
SND22
Loss of acoustic noise data from HIF2 PSL Optical Table
SND211
Loss of acoustic noise data from HIF2 Beam Splitter Chambers (BSC)
SND212
P. 16
Loss of acoustic noise data from the HIF2 Horizontal Access Chambers (HAM)
SND213
P. 17
Loss of acoustic noise data from WBSC5
SND221
Loss of acoustic noise data from WBSC6
SND222
Microphone #HIF2_C_PSL_1 fails
PSL02_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_13 fails
PSL02_AMP
MAMP:M=321543
Microphone Preamp #H_MA_LVEA_PREAMP_1 fails
WBSC5_AMP
MAMP:M=321543
Microphone #WBSC5_1 fails
WBSC5_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_MB_LVEA_PREAMP_1 fails
WBSC6_AMP
MAMP:M=321543
Microphone #WBSC6_1 fails
WBSC6_MIC
MIC:M=1.88253e+006

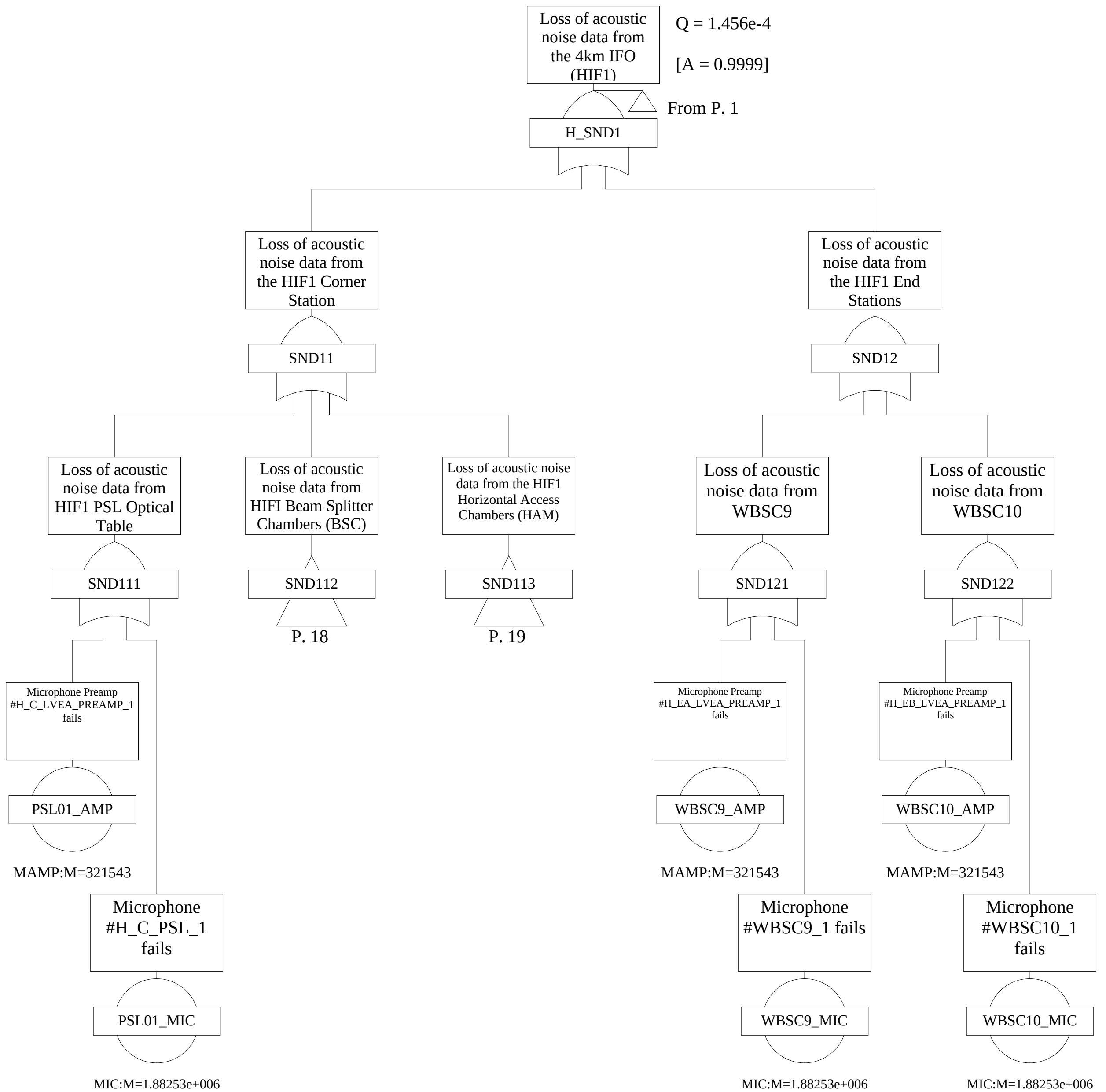

Loss of Power Line Fluctuations data
Q = 7.099e-5
[A = 0.9999]
From P. 1
H_PLF
Loss of valid Technical Power Line interference data
PLF11
Unable to monitor Facility Power Bus Current due to toroid failure
PLF1A
iMON:M=570776
Dranetz Power Platform 4300 #1 Electronic Failure
PLF11A
DPP:M=280807
Dranetz Power Platform 4300 #2 Electronic Failure
PLF11B
DPP:M=280807

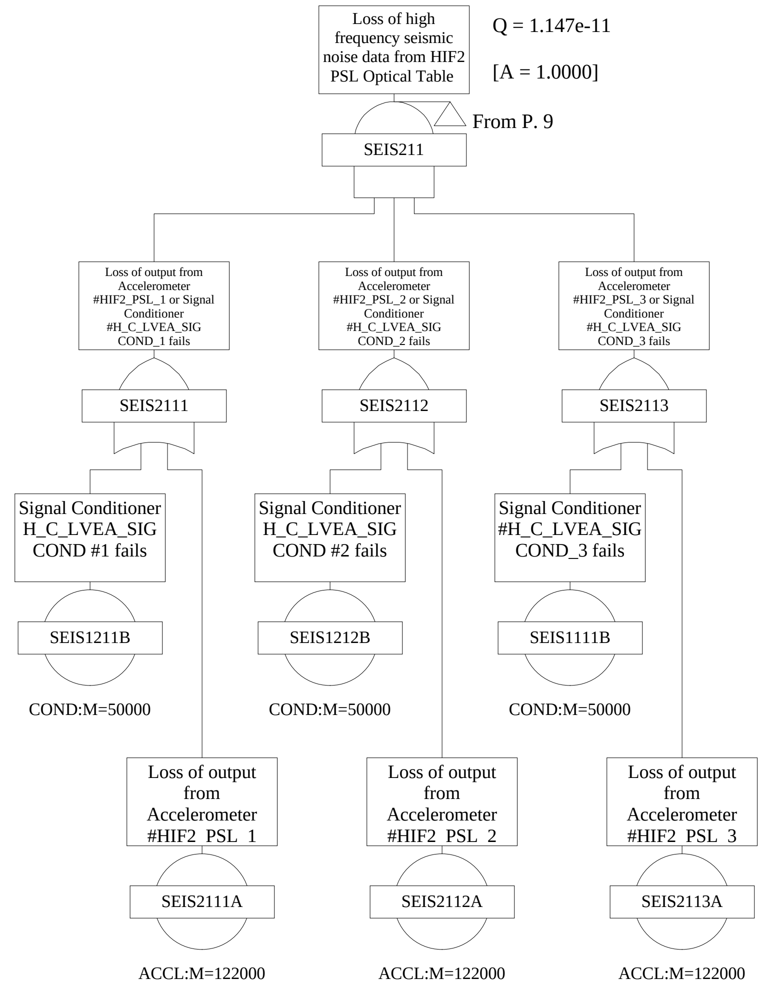

Loss of valid low frequency seismic data from the Washington Observatory
Q = 8.446e-17
[A = 1.0000]
From P. 1
H_LF1
Loss of valid low frequency seismic data from the Corner Station (H_C)
H_CS_LF1
Loss of valid low frequency seismic data from the End Station (H_EA)
H_EA_LF1
Loss of valid low frequency seismic data from the End Station (H_EB)
H_EB_LF1
Loss of valid low frequency seismic data from the Mid Station (H_MA)
H_MA_LF1
Loss of valid low frequency seismic data from the MidStation (H_MB)
H_MB_LF1
H_C_PEM_CMG-40T Seismometer Electronic Failure
H_CS_LF1_A
SM:M=17769
H_EA_PEM_CMG-40T Seismometer Electronic Failure
H_EA_LF1_A
SM:M=17769
H_EB_PEM_CMG-40T Seismometer Electronic Failure
H_EB_LF1_A
SM:M=17769
H_MA_PEM_CMG-40T Seismometer Electronic Failure
H_MA_LF1_A
SM:M=17769
H_MB_PEM_CMG-40T Seismometer Electronic Failure
H_MB_LF1_A
SM:M=17769
H_C_PEM_CMG-DM16 Digitizer Module Electronic Failure
H_CS_LF1_B
DM:M=50000
H_EA_PEM_CMG-DM16 Digitizer Module Electronic Failure
H_EA_LF1_B
DM:M=50000
H_EB_PEM_CMG-DM16 Digitizer Module Electronic Failure
H_EB_LF1_B
DM:M=50000
H_MA_PEM_CMG-DM16 Digitizer Module Electronic Failure
H_MA_LF1_B
DM:M=50000
H_MB_PEM_CMG-DM16 Digitizer Module Electronic Failure
H_MB_LF1_B
DM:M=50000

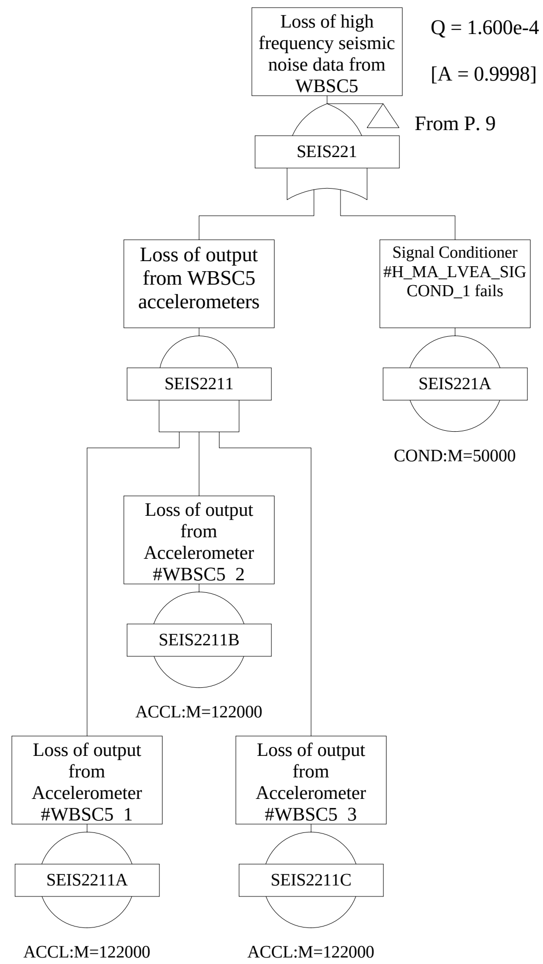

Loss of valid low frequency 2 axis seismic noise data from the Washington Observatory
Q = 9.995e-18
[A = 1.0000]
From P. 1
H_LF2
H_EB_PEM_CLIN520 Tiltmeter Electronic Failure
H_EB_LF2
TM:M=20089
H_C_PEM_CLIN520 Tiltmeter Electronic Failure
H_CS_LF2
TM:M=20089
H_EA_PEM_CLIN520 Tiltmeter Electronic Failure
H_EA_LF2
TM:M=20089
H_MB_PEM_CLIN520 Tiltmeter Electronic Failure
H_MB_LF2
TM:M=20089
H_MA_PEM_CLIN520 Tiltmeter Electronic Failure
H_MA_LF2
TM:M=20089

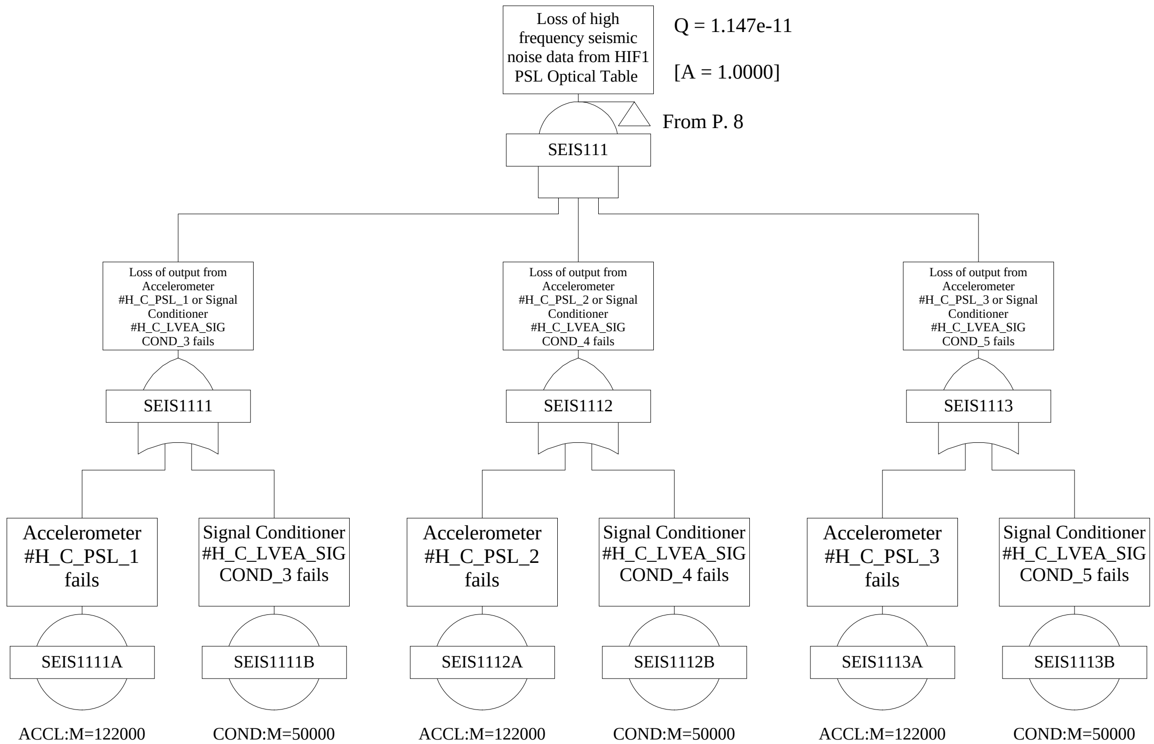

Loss of high frequency seismic noise data from the 4km IFO (HIF1)
Q = 3.199e-4
[A = 0.9997]
From P. 1
H_HF1
Loss of high frequency seismic noise data from the HIF1 Corner Station
SEIS11
Loss of high frequency seismic noise data from the HIF1 End Stations
SEIS12
Loss of high frequency seismic noise data from HIF1 PSL Optical Table
SEIS111
P. 13
Loss of high frequency seismic noise data from HIF1 Beam Splitter Chambers (BSC)
SEIS112
Loss of high frequency seismic noise data from HIF1 Horizontal Access Chambers (HAM)
SEIS113
Loss of high frequency seismic noise data from WBSC9
SEIS121
P. 15
Loss of high frequency seismic noise data from WBSC1
SEIS1121
P. 14
Loss of high frequency seismic noise data from WBSC3
SEIS112B
6AND5:F=4.14e-019
Loss of high frequency seismic noise data from WHAM2
SEIS113B
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM4
SEIS113D
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM6
SEIS113F
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WBSC10
SEIS12A
6AND1:F=0.00016
Loss of high frequency seismic noise data from WBSC2
SEIS112A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM1
SEIS113A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM3
SEIS113C
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM5
SEIS113E
3AND3:F=1.147e-011

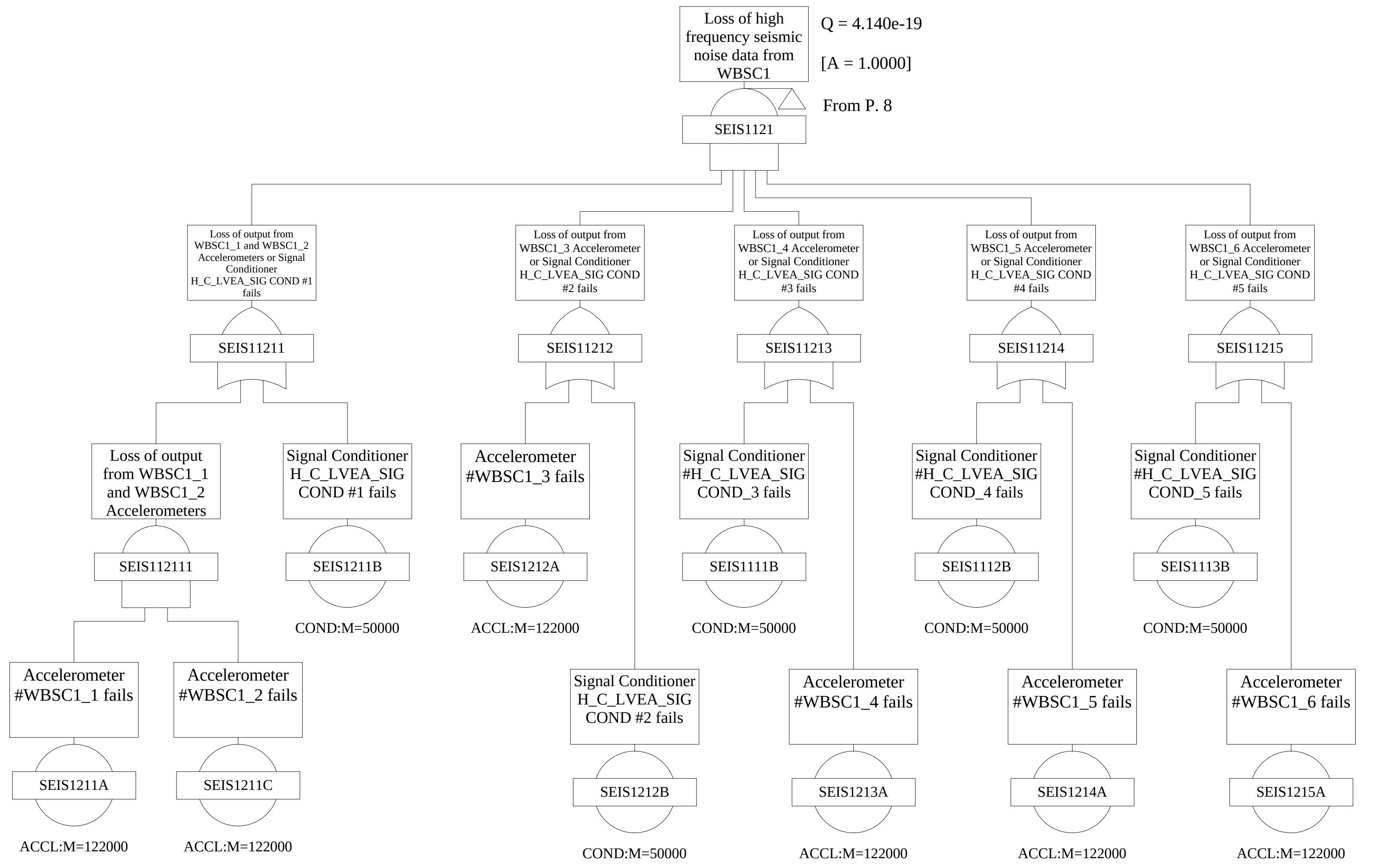

Loss of high frequency seismic noise data from the 2km IFO (HIF2)
Q = 3.199e-4
[A = 0.9997]
From P. 1
H_HF2
Loss of high frequency seismic noise data from the HIF2 Corner Station
SEIS21
Loss of high frequency seismic noise data from the HIF2 Mid-Stations
SEIS22
Loss of high frequency seismic noise data from HIF2 PSL Optical Table
SEIS211
P. 11
Loss of high frequency seismic noise data from HIF2 Beam Splitter Chambers (BSC)
SEIS212
Loss of high frequency seismic noise data from HIF2 Horizontal Access Chambers (HAM)
SEIS213
Loss of high frequency seismic noise data from WBSC5
SEIS221
P. 12
Loss of high frequency seismic noise data from WBSC6
SEIS22A
3AND1:F=0.00016
Loss of high frequency seismic noise data from WBSC4
SEIS212A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WBSC8
SEIS212C
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM8
SEIS213B
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM10
SEIS213D
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM12
SEIS213F
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WBSC7
SEIS212B
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM7
SEIS213A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM9
SEIS213C
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from WHAM11
SEIS213E
3AND3:F=1.147e-011

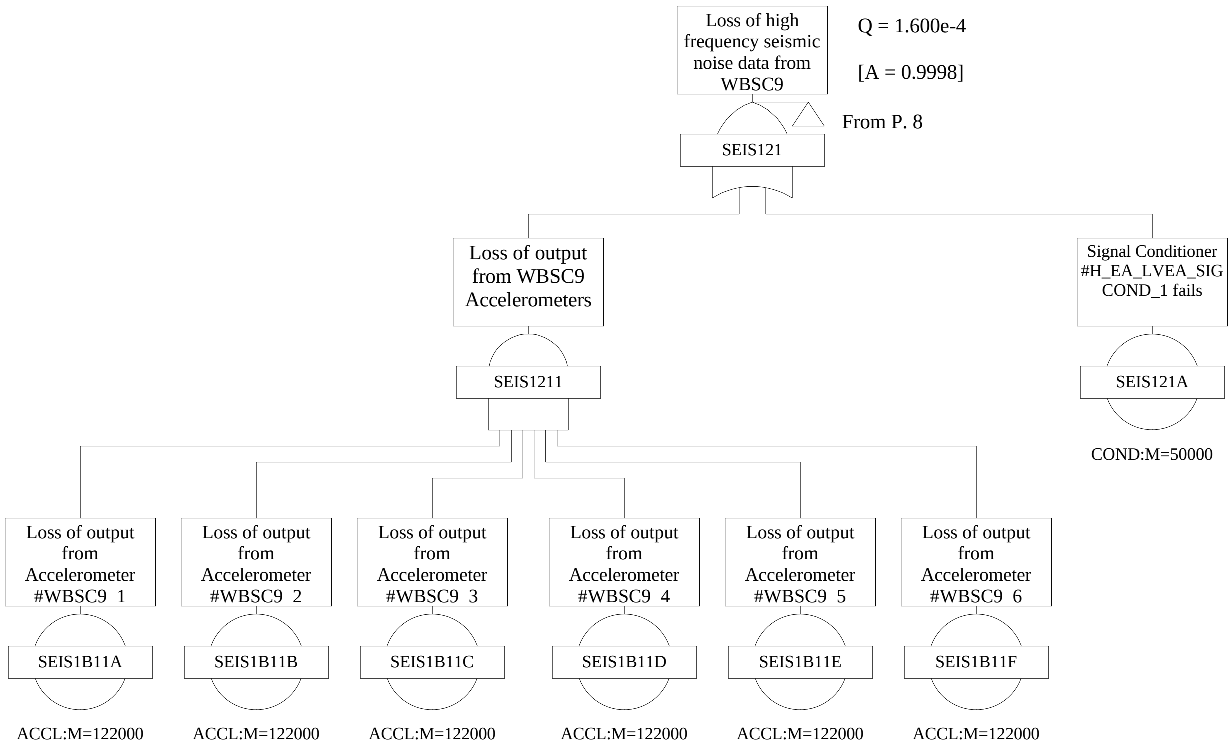

Loss of acoustic noise data from the 4km IFO (HIF1)
Q = 1.456e-4
[A = 0.9999]
From P. 1
H_SND1
Loss of acoustic noise data from the HIF1 Corner Station
SND11
Loss of acoustic noise data from the HIF1 End Stations
SND12
Loss of acoustic noise data from HIF1 PSL Optical Table
SND111
Loss of acoustic noise data from HIFI Beam Splitter Chambers (BSC)
SND112
P. 18
Loss of acoustic noise data from the HIF1 Horizontal Access Chambers (HAM)
SND113
P. 19
Loss of acoustic noise data from WBSC9
SND121
Loss of acoustic noise data from WBSC10
SND122
Microphone Preamp #H_C_LVEA_PREAMP_1 fails
PSL01_AMP
MAMP:M=321543
Microphone #H_C_PSL_1 fails
PSL01_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_EA_LVEA_PREAMP_1 fails
WBSC9_AMP
MAMP:M=321543
Microphone #WBSC9_1 fails
WBSC9_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_EB_LVEA_PREAMP_1 fails
WBSC10_AMP
MAMP:M=321543
Microphone #WBSC10_1 fails
WBSC10_MIC
MIC:M=1.88253e+006

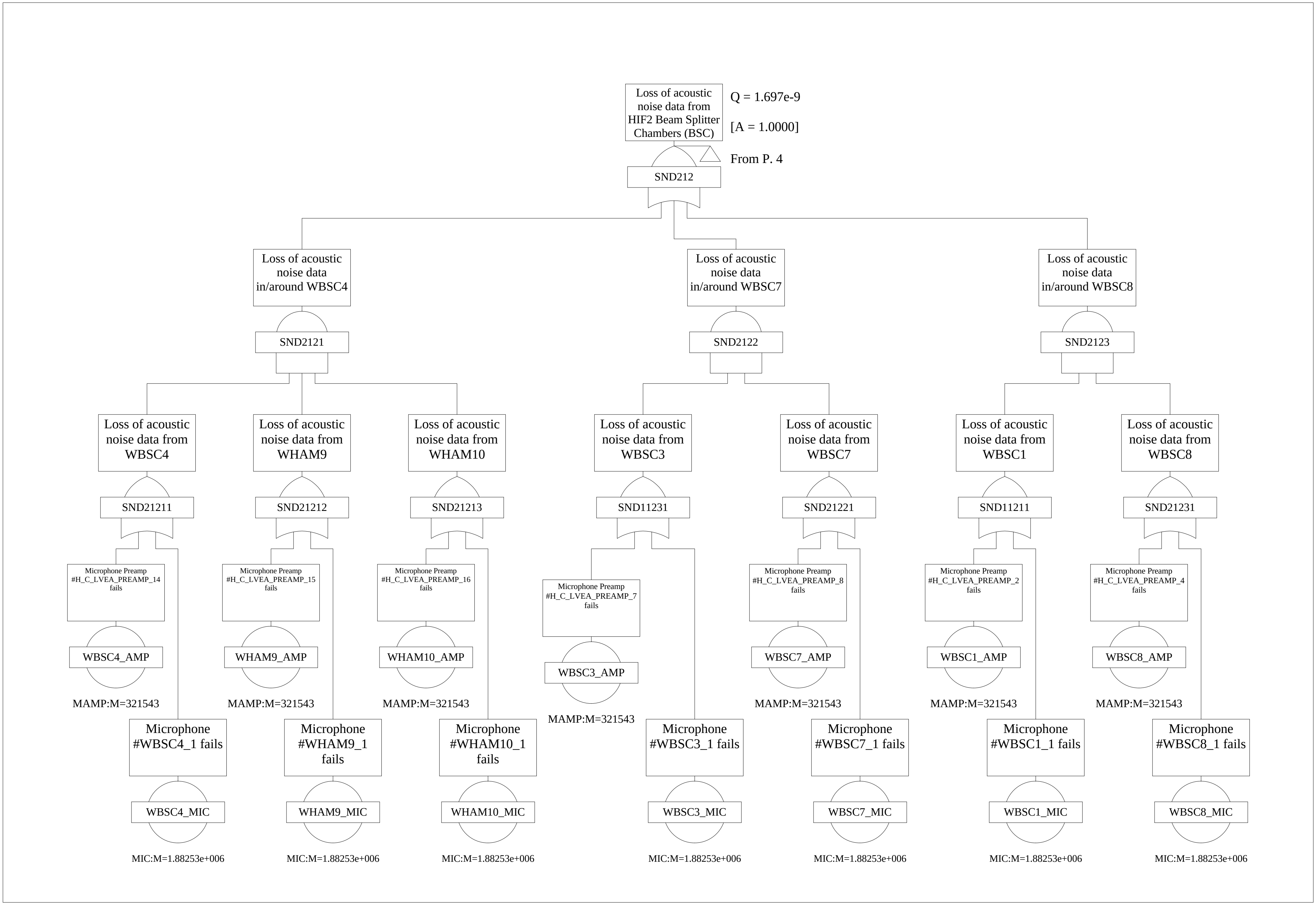

Loss of high frequency seismic noise data from HIF2 PSL Optical Table
Q = 1.147e-11
[A = 1.0000]
From P. 9
SEIS211
Loss of output from Accelerometer #HIF2_PSL_1 or Signal Conditioner #H_C_LVEA_SIG COND_1 fails
SEIS2111
Loss of output from Accelerometer #HIF2_PSL_2 or Signal Conditioner #H_C_LVEA_SIG COND_2 fails
SEIS2112
Loss of output from Accelerometer #HIF2_PSL_3 or Signal Conditioner #H_C_LVEA_SIG COND_3 fails
SEIS2113
Signal Conditioner H_C_LVEA_SIG COND #1 fails
SEIS1211B
COND:M=50000
Signal Conditioner H_C_LVEA_SIG COND #2 fails
SEIS1212B
COND:M=50000
Signal Conditioner #H_C_LVEA_SIG COND_3 fails
SEIS1111B
COND:M=50000
Loss of output from Accelerometer #HIF2_PSL_1
SEIS2111A
ACCL:M=122000
Loss of output from Accelerometer #HIF2_PSL_2
SEIS2112A
ACCL:M=122000
Loss of output from Accelerometer #HIF2_PSL_3
SEIS2113A
ACCL:M=122000

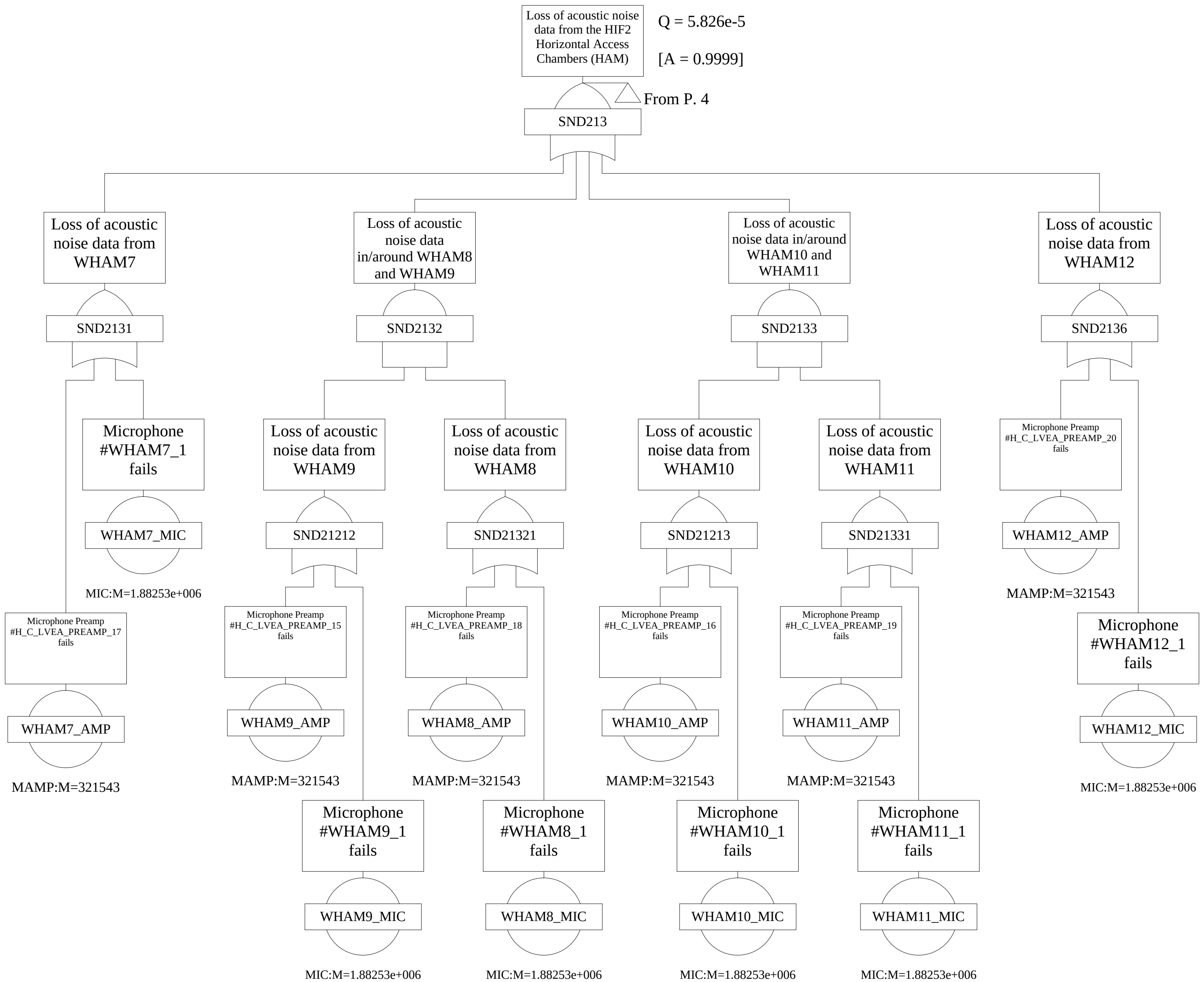

Loss of high frequency seismic noise data from WBSC5
Q = 1.600e-4
[A = 0.9998]
From P. 9
SEIS221
Loss of output from WBSC5 accelerometers
Signal Conditioner #H_MA_LVEA_SIG COND_1 fails
SEIS2211
SEIS221A
COND:M=50000
Loss of output from Accelerometer #WBSC5_2
SEIS2211B
ACCL:M=122000
Loss of output from Accelerometer #WBSC5_1
Loss of output from Accelerometer #WBSC5_3
SEIS2211A
SEIS2211C
ACCL:M=122000
ACCL:M=122000

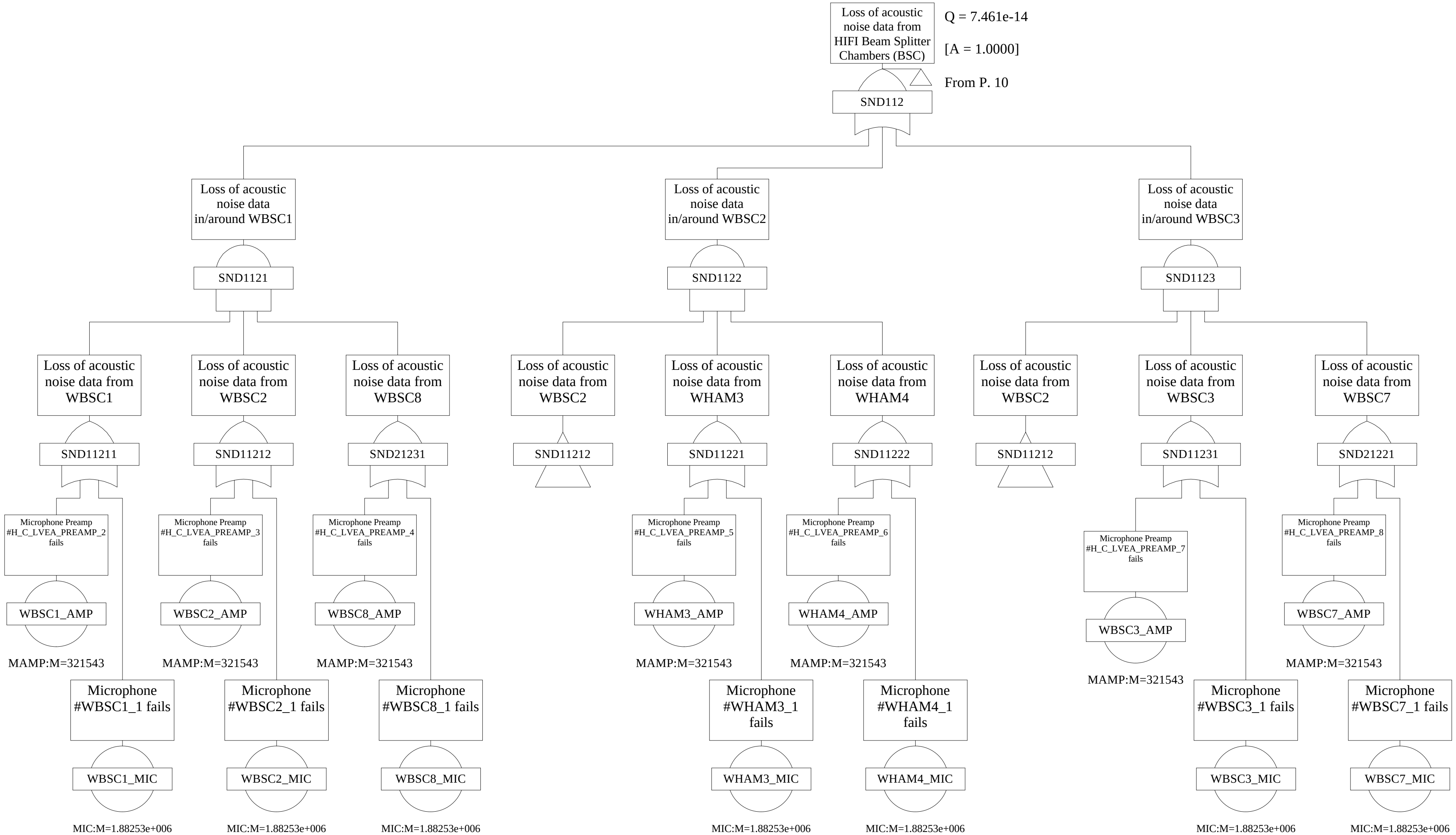

Loss of high frequency seismic noise data from HIF1 PSL Optical Table
Q = 1.147e-11
[A = 1.0000]
From P. 8
SEIS111
Loss of output from Accelerometer #H_C_PSL_1 or Signal Conditioner #H_C_LVEA_SIG COND_3 fails
SEIS1111
Loss of output from Accelerometer #H_C_PSL_2 or Signal Conditioner #H_C_LVEA_SIG COND_4 fails
SEIS1112
Loss of output from Accelerometer #H_C_PSL_3 or Signal Conditioner #H_C_LVEA_SIG COND_5 fails
SEIS1113
Accelerometer #H_C_PSL_1 fails
SEIS1111A
ACCL:M=122000
Signal Conditioner #H_C_LVEA_SIG COND_3 fails
SEIS1111B
COND:M=50000
Accelerometer #H_C_PSL_2 fails
SEIS1112A
ACCL:M=122000
Signal Conditioner #H_C_LVEA_SIG COND_4 fails
SEIS1112B
COND:M=50000
Accelerometer #H_C_PSL_3 fails
SEIS1113A
ACCL:M=122000
Signal Conditioner #H_C_LVEA_SIG COND_5 fails
SEIS1113B
COND:M=50000

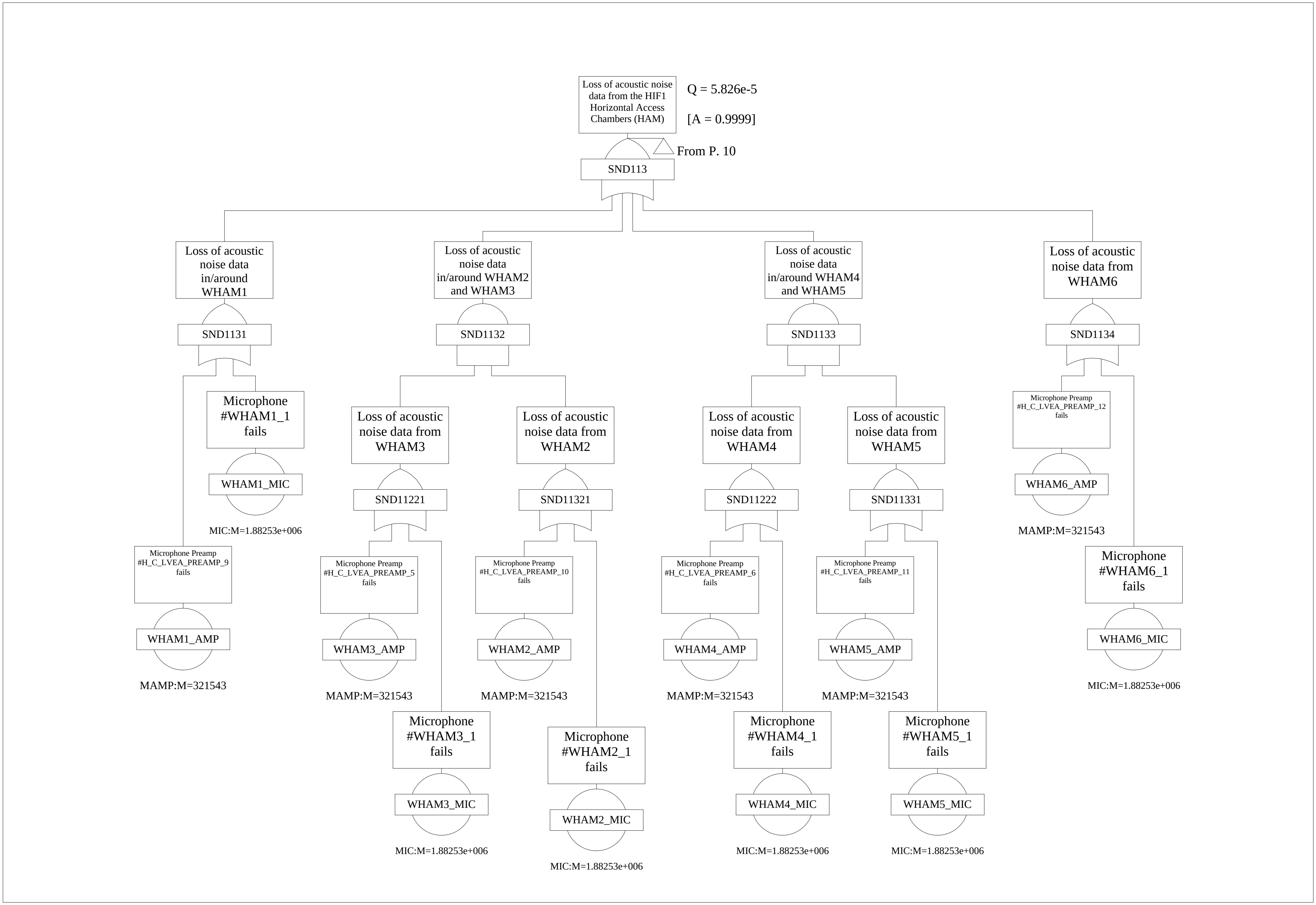

Loss of high frequency seismic noise data from WBSC1
Q = 4.140e-19
[A = 1.0000]
From P. 8
SEIS1121
Loss of output from WBSC1_1 and WBSC1_2 Accelerometers or Signal Conditioner H_C_LVEA_SIG COND #1 fails
SEIS11211
Loss of output from WBSC1_3 Accelerometer or Signal Conditioner H_C_LVEA_SIG COND #2 fails
SEIS11212
Loss of output from WBSC1_4 Accelerometer or Signal Conditioner H_C_LVEA_SIG COND #3 fails
SEIS11213
Loss of output from WBSC1_5 Accelerometer or Signal Conditioner H_C_LVEA_SIG COND #4 fails
SEIS11214
Loss of output from WBSC1_6 Accelerometer or Signal Conditioner H_C_LVEA_SIG COND #5 fails
SEIS11215
Loss of output from WBSC1_1 and WBSC1_2 Accelerometers
SEIS112111
Signal Conditioner H_C_LVEA_SIG COND #1 fails
SEIS1211B
COND:M=50000
Accelerometer #WBSC1_3 fails
SEIS1212A
ACCL:M=122000
Signal Conditioner #H_C_LVEA_SIG COND_3 fails
SEIS1111B
COND:M=50000
Signal Conditioner #H_C_LVEA_SIG COND_4 fails
SEIS1112B
COND:M=50000
Signal Conditioner #H_C_LVEA_SIG COND_5 fails
SEIS1113B
COND:M=50000
Accelerometer #WBSC1_1 fails
SEIS1211A
ACCL:M=122000
Accelerometer #WBSC1_2 fails
SEIS1211C
ACCL:M=122000
Signal Conditioner H_C_LVEA_SIG COND #2 fails
SEIS1212B
COND:M=50000
Accelerometer #WBSC1_4 fails
SEIS1213A
ACCL:M=122000
Accelerometer #WBSC1_5 fails
SEIS1214A
ACCL:M=122000
Accelerometer #WBSC1_6 fails
SEIS1215A
ACCL:M=122000

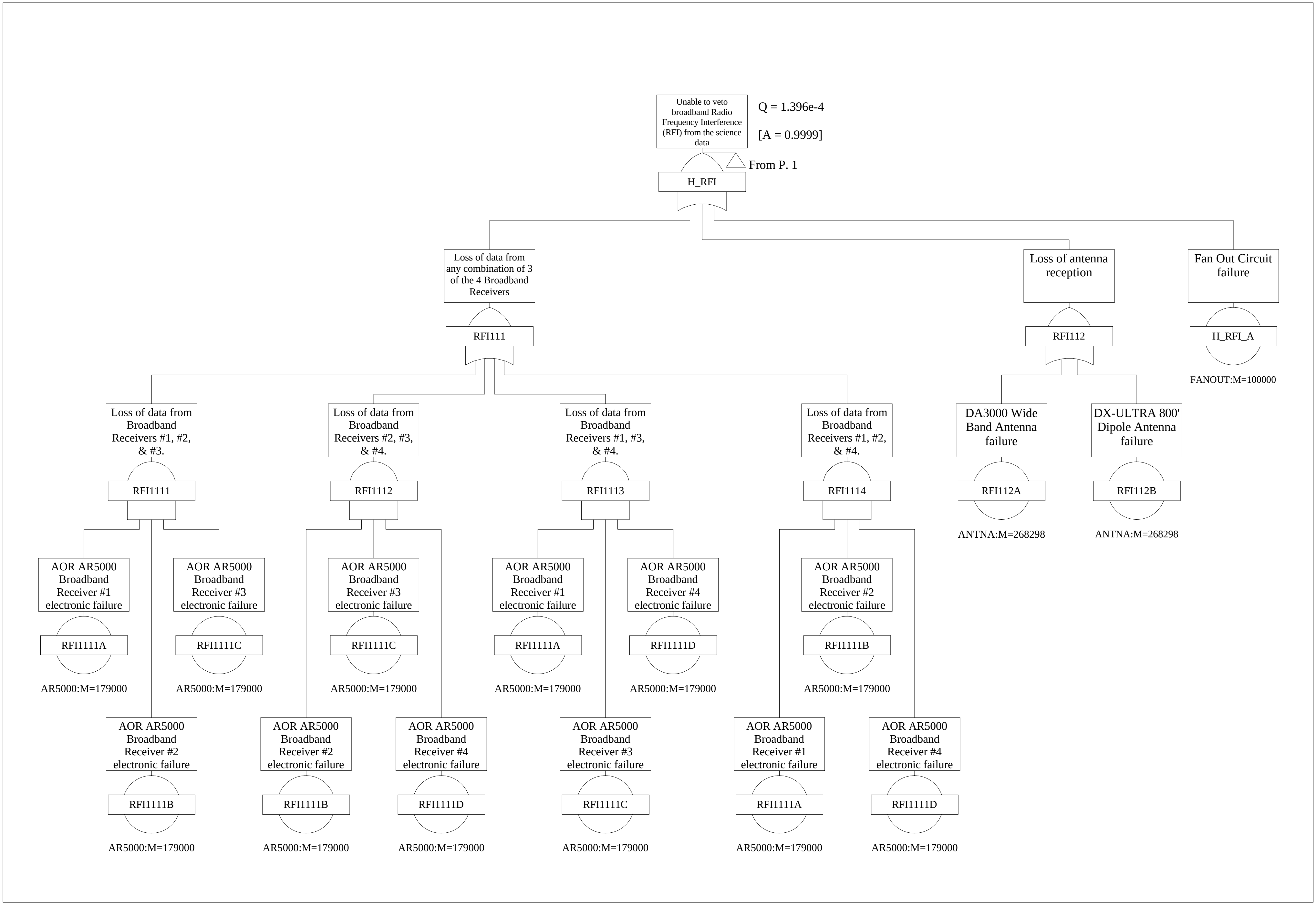

Loss of high frequency seismic noise data from WBSC9
Q = 1.600e-4
[A = 0.9998]
From P. 8
SEIS121
Loss of output from WBSC9 Accelerometers
SEIS1211
Signal Conditioner #H_EA_LVEA_SIG COND_1 fails
SEIS121A
COND:M=50000
Loss of output from Accelerometer #WBSC9_1
SEIS1B11A
ACCL:M=122000
Loss of output from Accelerometer #WBSC9_2
SEIS1B11B
ACCL:M=122000
Loss of output from Accelerometer #WBSC9_3
SEIS1B11C
ACCL:M=122000
Loss of output from Accelerometer #WBSC9_4
SEIS1B11D
ACCL:M=122000
Loss of output from Accelerometer #WBSC9_5
SEIS1B11E
ACCL:M=122000
Loss of output from Accelerometer #WBSC9_6
SEIS1B11F
ACCL:M=122000

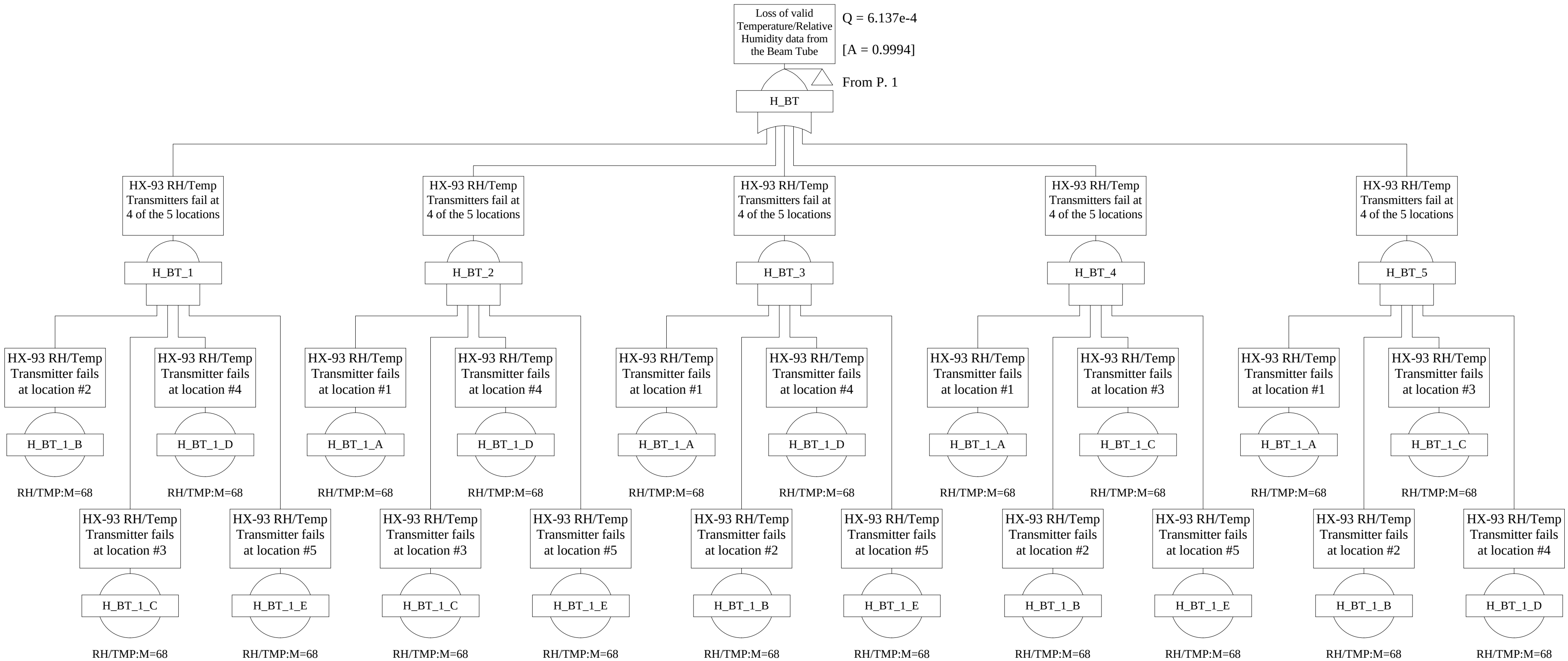

Loss of acoustic noise data from HIF2 Beam Splitter Chambers (BSC)
Q = 1.697e-9
[A = 1.0000]
From P. 4
SND212
Loss of acoustic noise data in/around WBSC4
SND2121
Loss of acoustic noise data in/around WBSC7
SND2122
Loss of acoustic noise data in/around WBSC8
SND2123
Loss of acoustic noise data from WBSC4
SND21211
Loss of acoustic noise data from WHAM9
SND21212
Loss of acoustic noise data from WHAM10
SND21213
Loss of acoustic noise data from WBSC3
SND11231
Loss of acoustic noise data from WBSC7
SND21221
Loss of acoustic noise data from WBSC1
SND11211
Loss of acoustic noise data from WBSC8
SND21231
Microphone Preamp #H_C_LVEA_PREAMP_14 fails
WBSC4_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_15 fails
WHAM9_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_16 fails
WHAM10_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_7 fails
WBSC3_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_8 fails
WBSC7_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_2 fails
WBSC1_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_4 fails
WBSC8_AMP
MAMP:M=321543
Microphone #WBSC4_1 fails
WBSC4_MIC
MIC:M=1.88253e+006
Microphone #WHAM9_1 fails
WHAM9_MIC
MIC:M=1.88253e+006
Microphone #WHAM10_1 fails
WHAM10_MIC
MIC:M=1.88253e+006
Microphone #WBSC3_1 fails
WBSC3_MIC
MIC:M=1.88253e+006
Microphone #WBSC7_1 fails
WBSC7_MIC
MIC:M=1.88253e+006
Microphone #WBSC1_1 fails
WBSC1_MIC
MIC:M=1.88253e+006
Microphone #WBSC8_1 fails
WBSC8_MIC
MIC:M=1.88253e+006

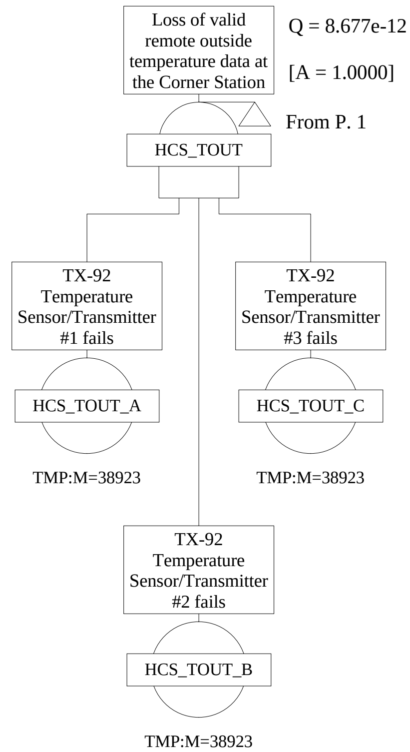

Loss of acoustic noise data from the HIF2 Horizontal Access Chambers (HAM)
Q = 5.826e-5
[A = 0.9999]
From P. 4
SND213
Loss of acoustic noise data from WHAM7
SND2131
Loss of acoustic noise data in/around WHAM8 and WHAM9
SND2132
Loss of acoustic noise data in/around WHAM10 and WHAM11
SND2133
Loss of acoustic noise data from WHAM12
SND2136
Microphone #WHAM7_1 fails
WHAM7_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_17 fails
WHAM7_AMP
MAMP:M=321543
Loss of acoustic noise data from WHAM9
SND21212
Loss of acoustic noise data from WHAM8
SND21321
Loss of acoustic noise data from WHAM10
SND21213
Loss of acoustic noise data from WHAM11
SND21331
Microphone Preamp #H_C_LVEA_PREAMP_20 fails
WHAM12_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_15 fails
WHAM9_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_18 fails
WHAM8_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_16 fails
WHAM10_AMP
MAMP:M=321543
Microphone Preamp #H_C_LVEA_PREAMP_19 fails
WHAM11_AMP
MAMP:M=321543
Microphone #WHAM12_1 fails
WHAM12_MIC
MIC:M=1.88253e+006
Microphone #WHAM9_1 fails
WHAM9_MIC
MIC:M=1.88253e+006
Microphone #WHAM8_1 fails
WHAM8_MIC
MIC:M=1.88253e+006
Microphone #WHAM10_1 fails
WHAM10_MIC
MIC:M=1.88253e+006
Microphone #WHAM11_1 fails
WHAM11_MIC
MIC:M=1.88253e+006

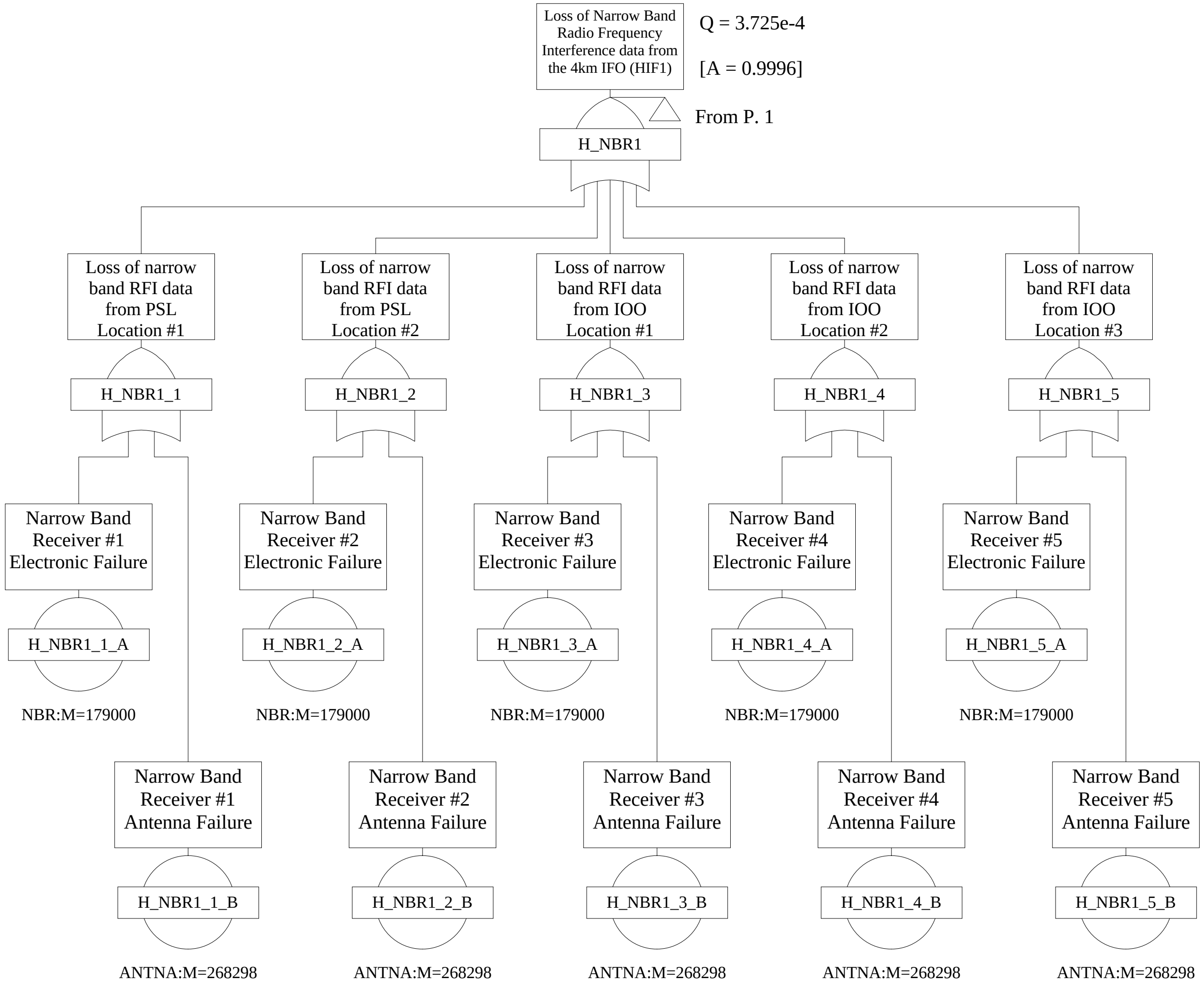

Loss of acoustic noise data from HIFI Beam Splitter Chambers (BSC)
Q = 7.461e-14
[A = 1.0000]
From P. 10
SND112
Loss of acoustic noise data in/around WBSC1
SND1121
Loss of acoustic noise data in/around WBSC2
SND1122
Loss of acoustic noise data in/around WBSC3
SND1123
Loss of acoustic noise data from WBSC1
SND11211
Loss of acoustic noise data from WBSC2
SND11212
Loss of acoustic noise data from WBSC8
SND21231
Loss of acoustic noise data from WBSC2
SND11212
Loss of acoustic noise data from WHAM3
SND11221
Loss of acoustic noise data from WHAM4
SND11222
Loss of acoustic noise data from WBSC2
SND11212
Loss of acoustic noise data from WBSC3
SND11231
Loss of acoustic noise data from WBSC7
SND21221
Microphone Preamp #H_C_LVEA_PREAMP_2 fails
WBSC1_AMP
MAMP:M=321543
Microphone #WBSC1_1 fails
WBSC1_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_3 fails
WBSC2_AMP
MAMP:M=321543
Microphone #WBSC2_1 fails
WBSC2_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_4 fails
WBSC8_AMP
MAMP:M=321543
Microphone #WBSC8_1 fails
WBSC8_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_5 fails
WHAM3_AMP
MAMP:M=321543
Microphone #WHAM3_1 fails
WHAM3_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_6 fails
WHAM4_AMP
MAMP:M=321543
Microphone #WHAM4_1 fails
WHAM4_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_7 fails
WBSC3_AMP
MAMP:M=321543
Microphone #WBSC3_1 fails
WBSC3_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_8 fails
WBSC7_AMP
MAMP:M=321543
Microphone #WBSC7_1 fails
WBSC7_MIC
MIC:M=1.88253e+006

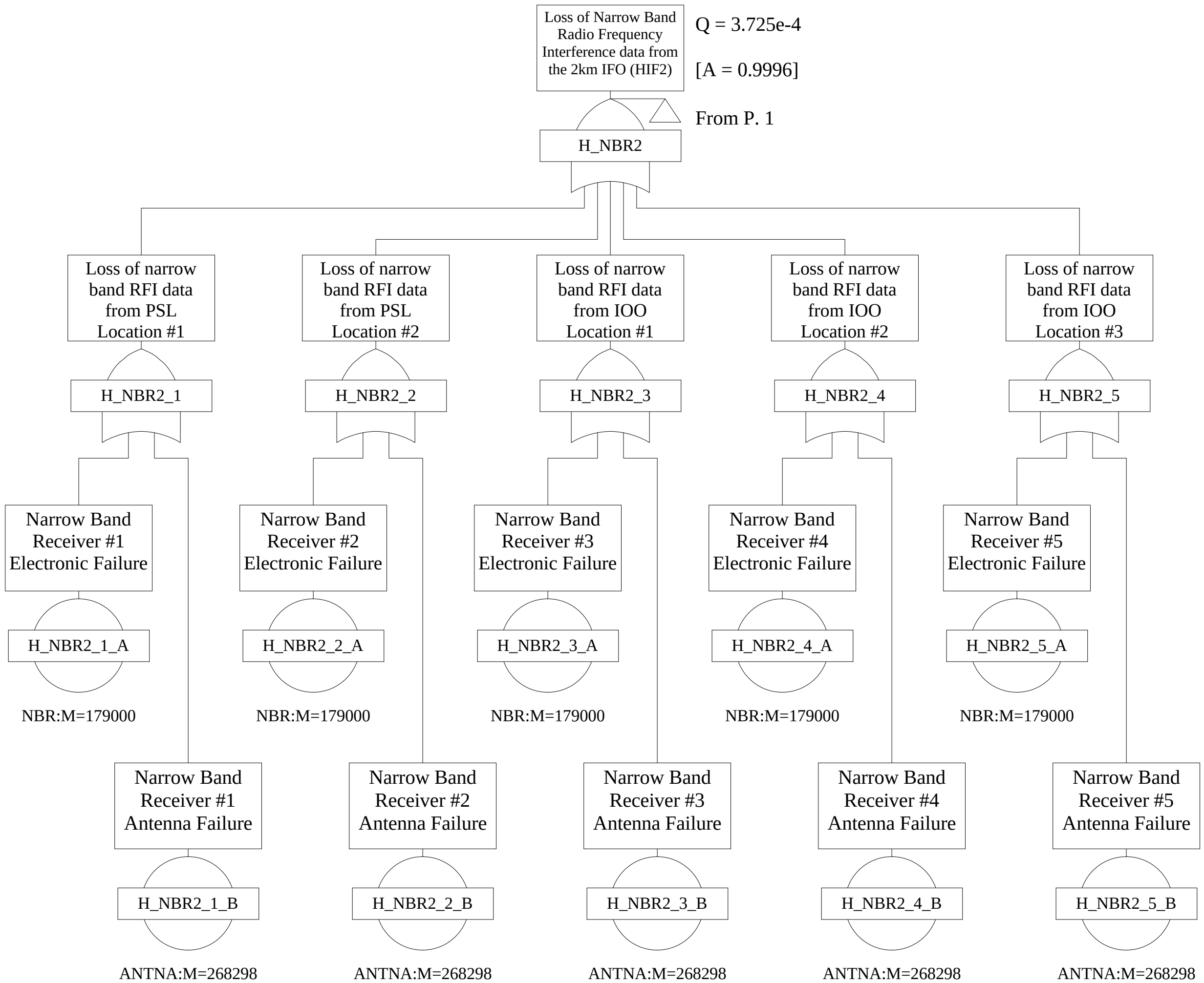

Loss of acoustic noise data from the HIF1 Horizontal Access Chambers (HAM)
Q = 5.826e-5
[A = 0.9999]
From P. 10
SND113
Loss of acoustic noise data in/around WHAM1
SND1131
Loss of acoustic noise data in/around WHAM2 and WHAM3
SND1132
Loss of acoustic noise data in/around WHAM4 and WHAM5
SND1133
Loss of acoustic noise data from WHAM6
SND1134
Microphone #WHAM1_1 fails
WHAM1_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_9 fails
WHAM1_AMP
MAMP:M=321543
Loss of acoustic noise data from WHAM3
SND11221
Microphone Preamp #H_C_LVEA_PREAMP_5 fails
WHAM3_AMP
MAMP:M=321543
Microphone #WHAM3_1 fails
WHAM3_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from WHAM2
SND11321
Microphone Preamp #H_C_LVEA_PREAMP_10 fails
WHAM2_AMP
MAMP:M=321543
Microphone #WHAM2_1 fails
WHAM2_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from WHAM4
SND11222
Microphone Preamp #H_C_LVEA_PREAMP_6 fails
WHAM4_AMP
MAMP:M=321543
Microphone #WHAM4_1 fails
WHAM4_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from WHAM5
SND11331
Microphone Preamp #H_C_LVEA_PREAMP_11 fails
WHAM5_AMP
MAMP:M=321543
Microphone #WHAM5_1 fails
WHAM5_MIC
MIC:M=1.88253e+006
Microphone Preamp #H_C_LVEA_PREAMP_12 fails
WHAM6_AMP
MAMP:M=321543
Microphone #WHAM6_1 fails
WHAM6_MIC
MIC:M=1.88253e+006

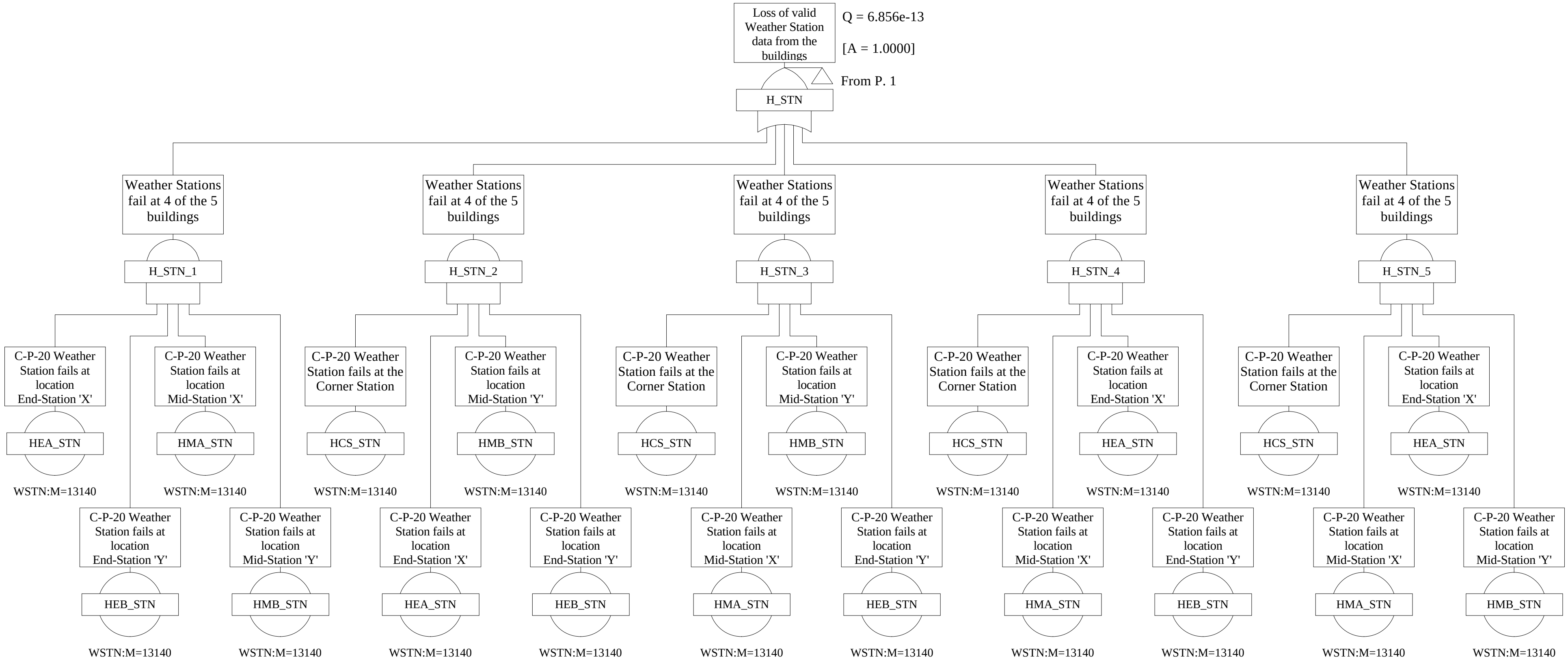

Unable to veto broadband Radio Frequency Interference (RFI) from the science data
Q = 1.396e-4
[A = 0.9999]
From P. 1
H_RFI
Loss of data from any combination of 3 of the 4 Broadband Receivers
RFI111
Loss of antenna reception
RFI112
Fan Out Circuit failure
H_RFI_A
FANOUT:M=100000
Loss of data from Broadband Receivers #1, #2, & #3.
RFI1111
Loss of data from Broadband Receivers #2, #3, & #4.
RFI1112
Loss of data from Broadband Receivers #1, #3, & #4.
RFI1113
Loss of data from Broadband Receivers #1, #2, & #4.
RFI1114
DA3000 Wide Band Antenna failure
RFI112A
ANTNA:M=268298
DX-ULTRA 800' Dipole Antenna failure
RFI112B
ANTNA:M=268298
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000

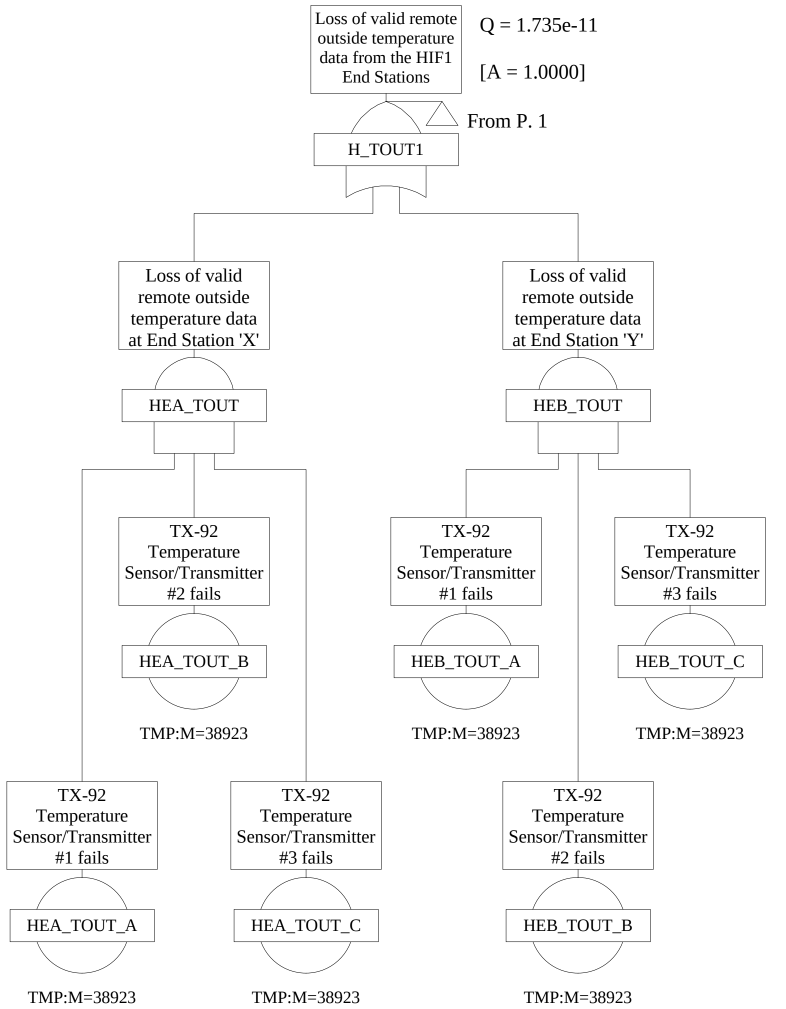

Loss of valid Temperature/Relative Humidity data from the Beam Tube
Q = 6.137e-4
[A = 0.9994]
From P. 1
H_BT
HX-93 RH/Temp Transmitters fail at 4 of the 5 locations
H_BT_1
H_BT_2
H_BT_3
H_BT_4
H_BT_5
HX-93 RH/Temp Transmitter fails at location #1
HX-93 RH/Temp Transmitter fails at location #2
HX-93 RH/Temp Transmitter fails at location #3
HX-93 RH/Temp Transmitter fails at location #4
HX-93 RH/Temp Transmitter fails at location #5
H_BT_1_A
H_BT_1_B
H_BT_1_C
H_BT_1_D
H_BT_1_E
RH/TMP:M=68

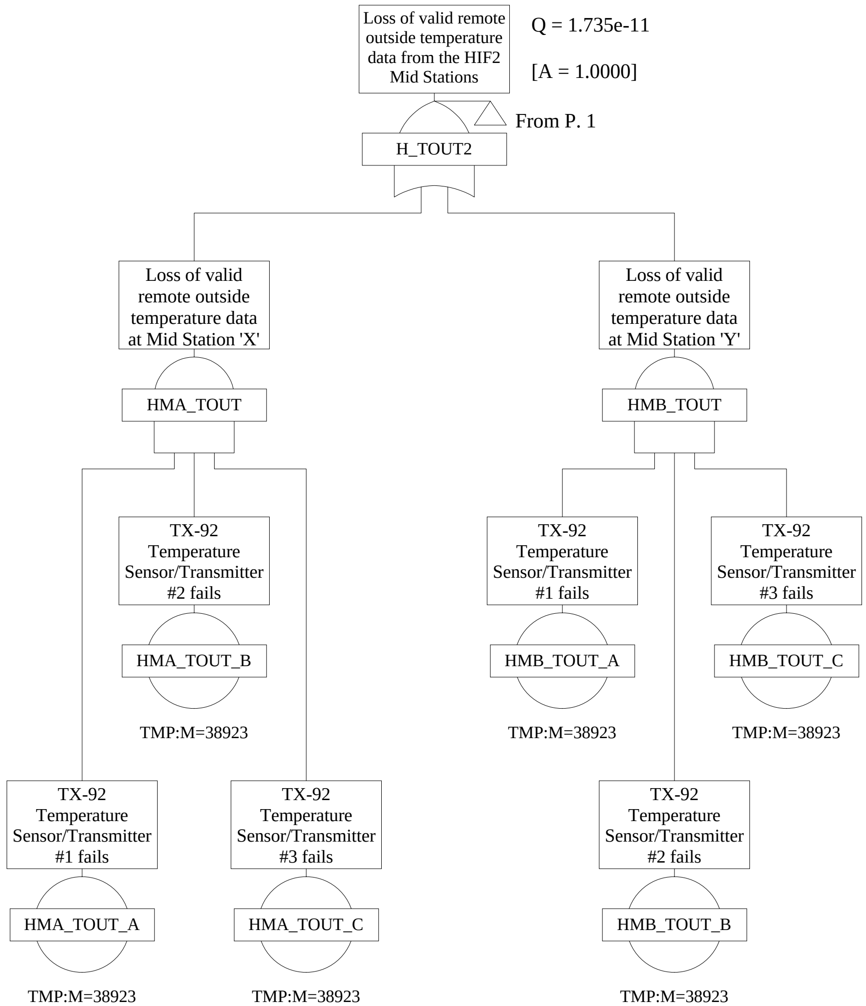

Loss of valid remote outside temperature data at the Corner Station
Q = 8.677e-12
[A = 1.0000]
From P. 1
HCS_TOUT
TX-92 Temperature Sensor/Transmitter #1 fails
HCS_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
HCS_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
HCS_TOUT_B
TMP:M=38923


Loss of Narrow Band Radio Frequency Interference data from the 4km IFO (HIF1)
Q = 3.725e-4
[A = 0.9996]
From P. 1
H_NBR1
Loss of narrow band RFI data from PSL Location #1
H_NBR1_1
Loss of narrow band RFI data from PSL Location #2
H_NBR1_2
Loss of narrow band RFI data from IOO Location #1
H_NBR1_3
Loss of narrow band RFI data from IOO Location #2
H_NBR1_4
Loss of narrow band RFI data from IOO Location #3
H_NBR1_5
Narrow Band Receiver #1 Electronic Failure
H_NBR1_1_A
NBR:M=179000
Narrow Band Receiver #2 Electronic Failure
H_NBR1_2_A
NBR:M=179000
Narrow Band Receiver #3 Electronic Failure
H_NBR1_3_A
NBR:M=179000
Narrow Band Receiver #4 Electronic Failure
H_NBR1_4_A
NBR:M=179000
Narrow Band Receiver #5 Electronic Failure
H_NBR1_5_A
NBR:M=179000
Narrow Band Receiver #1 Antenna Failure
H_NBR1_1_B
ANTNA:M=268298
Narrow Band Receiver #2 Antenna Failure
H_NBR1_2_B
ANTNA:M=268298
Narrow Band Receiver #3 Antenna Failure
H_NBR1_3_B
ANTNA:M=268298
Narrow Band Receiver #4 Antenna Failure
H_NBR1_4_B
ANTNA:M=268298
Narrow Band Receiver #5 Antenna Failure
H_NBR1_5_B
ANTNA:M=268298


Loss of Narrow Band Radio Frequency Interference data from the 2km IFO (HIF2)
Q = 3.725e-4
[A = 0.9996]
From P. 1
H_NBR2
Loss of narrow band RFI data from PSL Location #1
H_NBR2_1
Loss of narrow band RFI data from PSL Location #2
H_NBR2_2
Loss of narrow band RFI data from IOO Location #1
H_NBR2_3
Loss of narrow band RFI data from IOO Location #2
H_NBR2_4
Loss of narrow band RFI data from IOO Location #3
H_NBR2_5
Narrow Band Receiver #1 Electronic Failure
H_NBR2_1_A
NBR:M=179000
Narrow Band Receiver #2 Electronic Failure
H_NBR2_2_A
NBR:M=179000
Narrow Band Receiver #3 Electronic Failure
H_NBR2_3_A
NBR:M=179000
Narrow Band Receiver #4 Electronic Failure
H_NBR2_4_A
NBR:M=179000
Narrow Band Receiver #5 Electronic Failure
H_NBR2_5_A
NBR:M=179000
Narrow Band Receiver #1 Antenna Failure
H_NBR2_1_B
ANTNA:M=268298
Narrow Band Receiver #2 Antenna Failure
H_NBR2_2_B
ANTNA:M=268298
Narrow Band Receiver #3 Antenna Failure
H_NBR2_3_B
ANTNA:M=268298
Narrow Band Receiver #4 Antenna Failure
H_NBR2_4_B
ANTNA:M=268298
Narrow Band Receiver #5 Antenna Failure
H_NBR2_5_B
ANTNA:M=268298


Loss of valid Weather Station data from the buildings
Q = 6.856e-13
[A = 1.0000]
From P. 1
H_STN
Weather Stations fail at 4 of the 5 buildings
H_STN_1
H_STN_2
H_STN_3
H_STN_4
H_STN_5
C-P-20 Weather Station fails at location End-Station 'X'
C-P-20 Weather Station fails at location Mid-Station 'X'
C-P-20 Weather Station fails at location End-Station 'Y'
C-P-20 Weather Station fails at location Mid-Station 'Y'
C-P-20 Weather Station fails at the Corner Station
HEA_STN
HMA_STN
HEB_STN
HMB_STN
HCS_STN
WSTN:M=13140


Loss of valid remote outside temperature data from the HIF1 End Stations
Q = 1.735e-11
[A = 1.0000]
From P. 1
H_TOUT1
Loss of valid remote outside temperature data at End Station 'X'
HEA_TOUT
Loss of valid remote outside temperature data at End Station 'Y'
HEB_TOUT
TX-92 Temperature Sensor/Transmitter #2 fails
HEA_TOUT_B
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
HEB_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
HEB_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
HEA_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
HEA_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
HEB_TOUT_B
TMP:M=38923


Loss of valid remote outside temperature data from the HIF2 Mid Stations
Q = 1.735e-11
[A = 1.0000]
From P. 1
H_TOUT2
Loss of valid remote outside temperature data at Mid Station 'X'
HMA_TOUT
Loss of valid remote outside temperature data at Mid Station 'Y'
HMB_TOUT
TX-92 Temperature Sensor/Transmitter #2 fails
HMA_TOUT_B
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
HMB_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
HMB_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
HMA_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
HMA_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
HMB_TOUT_B
TMP:M=38923

APPENDIX B:
LOUISIANA PEM AVAILABILITY PREDICTION

NOTES:

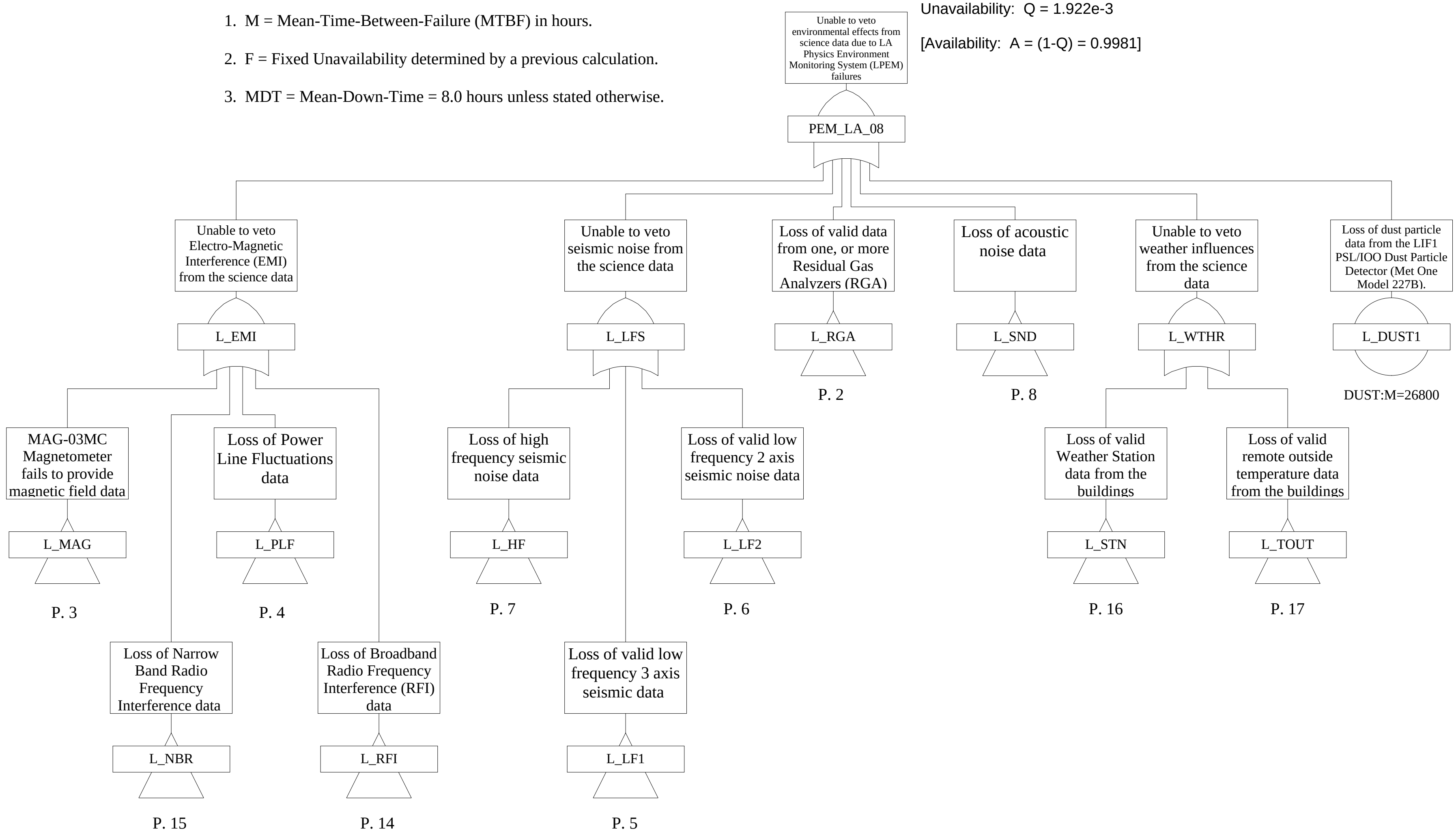
1. M = Mean-Time-Between-Failure (MTBF) in hours.

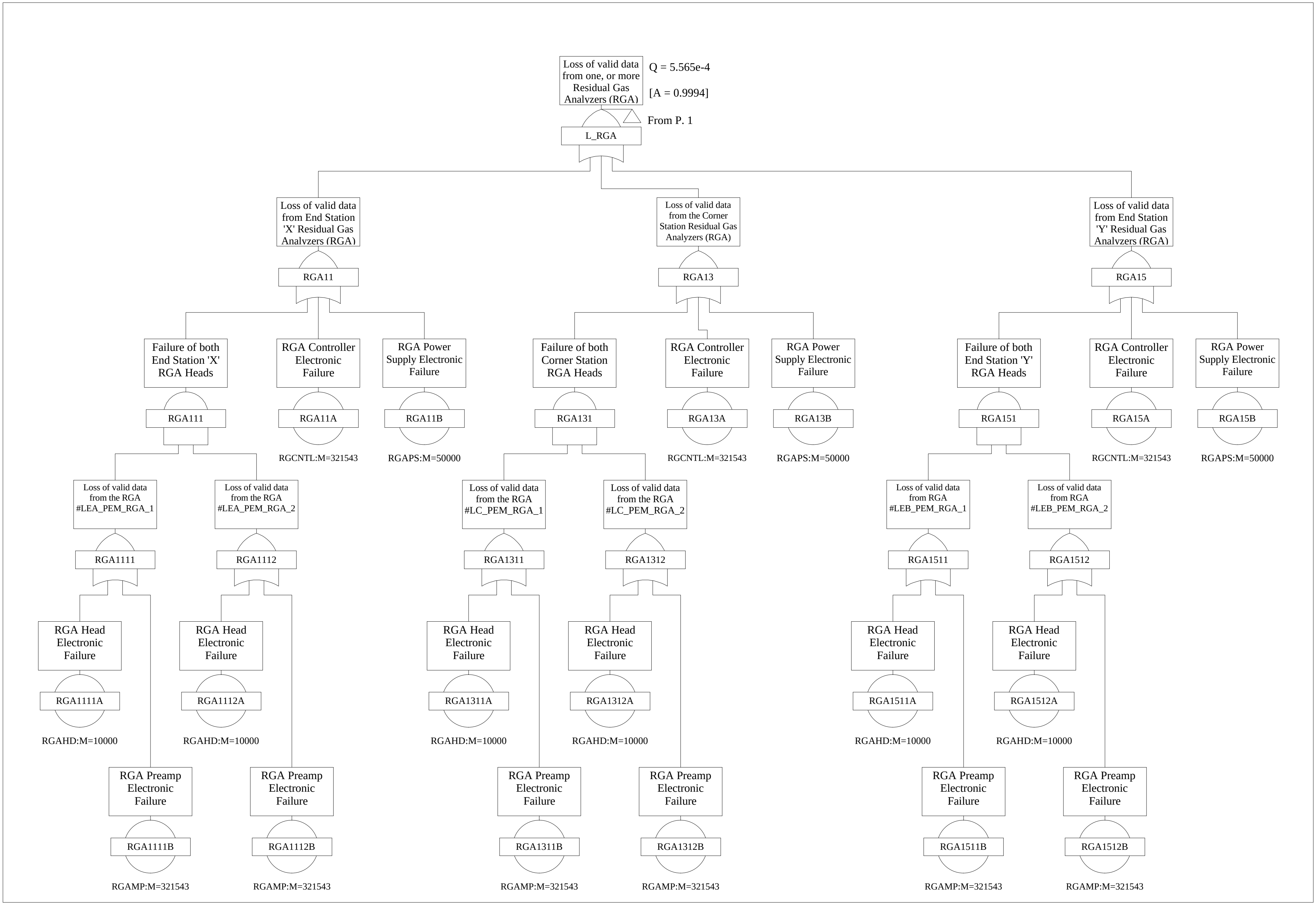
2. F = Fixed Unavailability determined by a previous calculation.

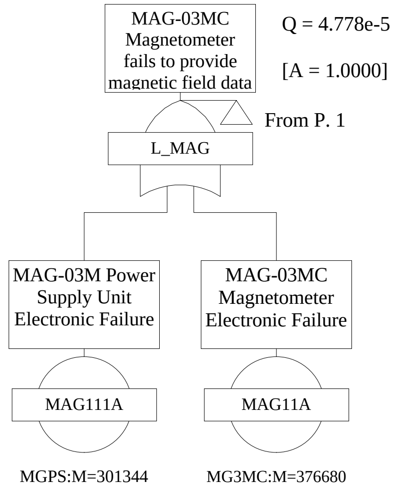
3. MDT = Mean-Down-Time = 8.0 hours unless stated otherwise.

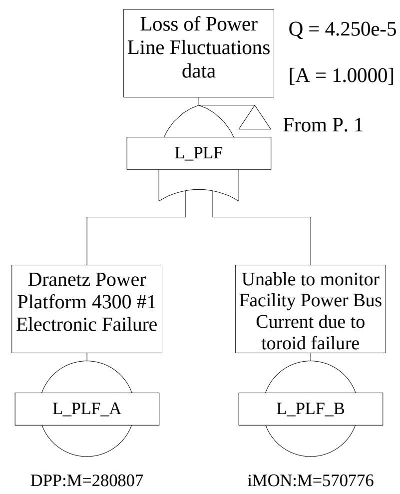
Unavailability: Q = 1.922e-3

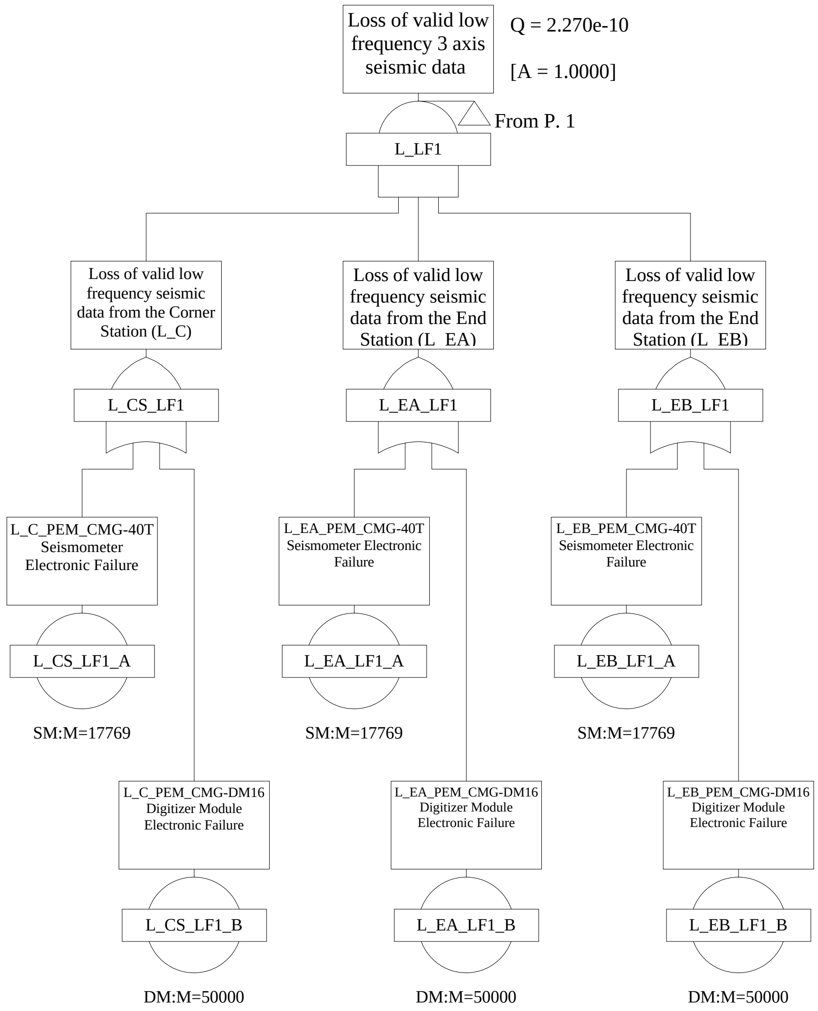
[Availability: A = (1-Q) = 0.9981]

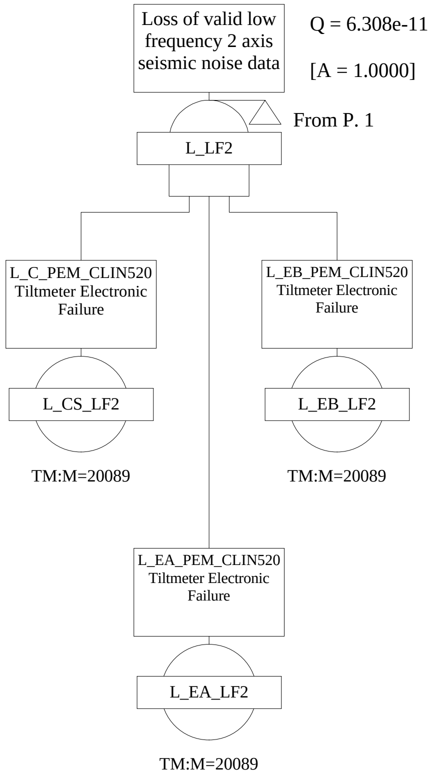


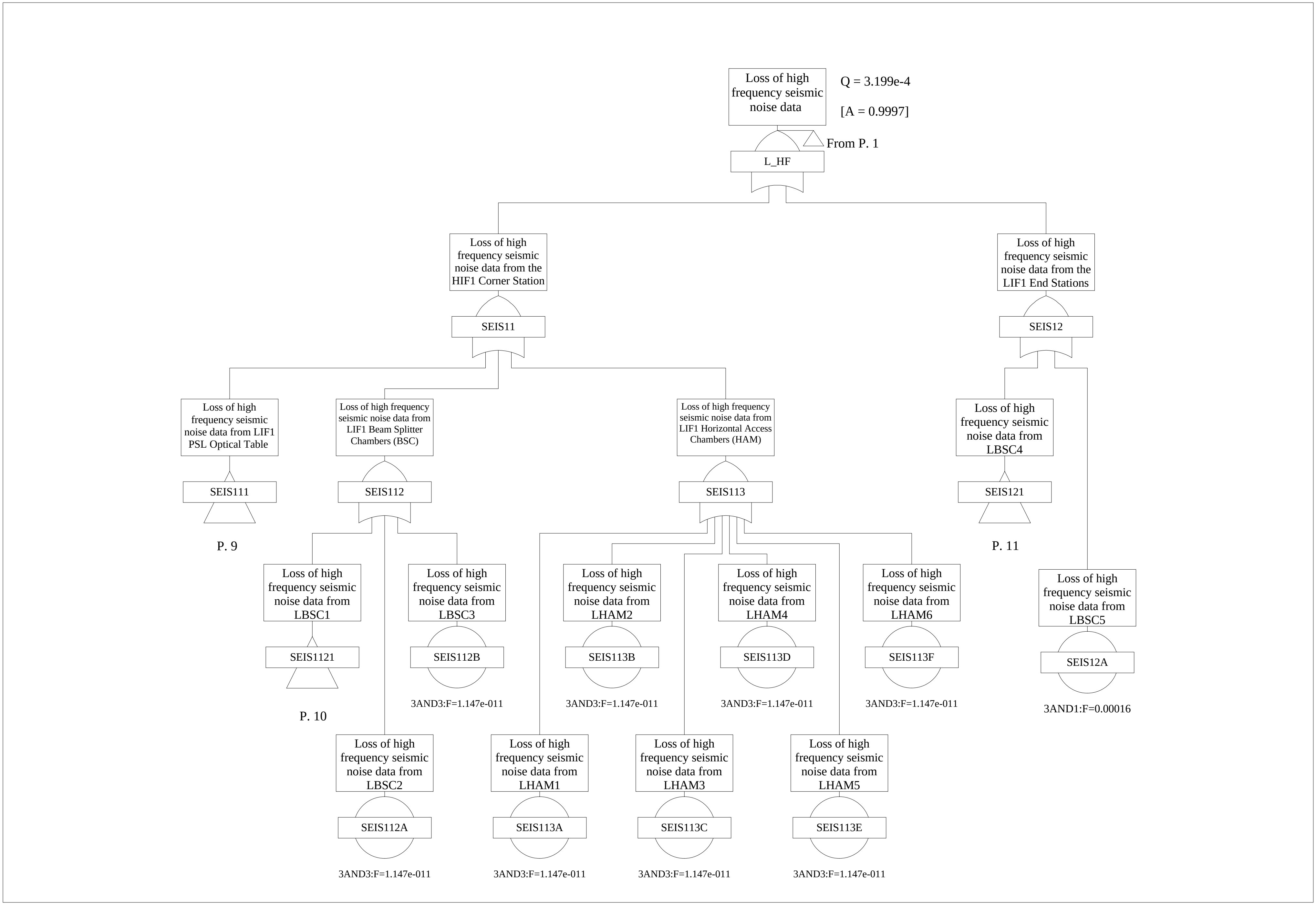

Loss of valid data from one, or more Residual Gas Analyzers (RGA)
Q = 5.565e-4
[A = 0.9994]
From P. 1
L_RGA
Loss of valid data from End Station 'X' Residual Gas Analyzers (RGA)
RGA11
Loss of valid data from the Corner Station Residual Gas Analyzers (RGA)
RGA13
Loss of valid data from End Station 'Y' Residual Gas Analyzers (RGA)
RGA15
Failure of both End Station 'X' RGA Heads
RGA111
RGA Controller Electronic Failure
RGA11A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA11B
RGAPS:M=50000
Failure of both Corner Station RGA Heads
RGA131
RGA Controller Electronic Failure
RGA13A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA13B
RGAPS:M=50000
Failure of both End Station 'Y' RGA Heads
RGA151
RGA Controller Electronic Failure
RGA15A
RGCNTL:M=321543
RGA Power Supply Electronic Failure
RGA15B
RGAPS:M=50000
Loss of valid data from the RGA #LEA_PEM_RGA_1
RGA1111
Loss of valid data from the RGA #LEA_PEM_RGA_2
RGA1112
Loss of valid data from the RGA #LC_PEM_RGA_1
RGA1311
Loss of valid data from the RGA #LC_PEM_RGA_2
RGA1312
Loss of valid data from RGA #LEB_PEM_RGA_1
RGA1511
Loss of valid data from RGA #LEB_PEM_RGA_2
RGA1512
RGA Head Electronic Failure
RGA1111A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1112A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1311A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1312A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1511A
RGAHD:M=10000
RGA Head Electronic Failure
RGA1512A
RGAHD:M=10000
RGA Preamp Electronic Failure
RGA1111B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1112B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1311B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1312B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1511B
RGAMP:M=321543
RGA Preamp Electronic Failure
RGA1512B
RGAMP:M=321543

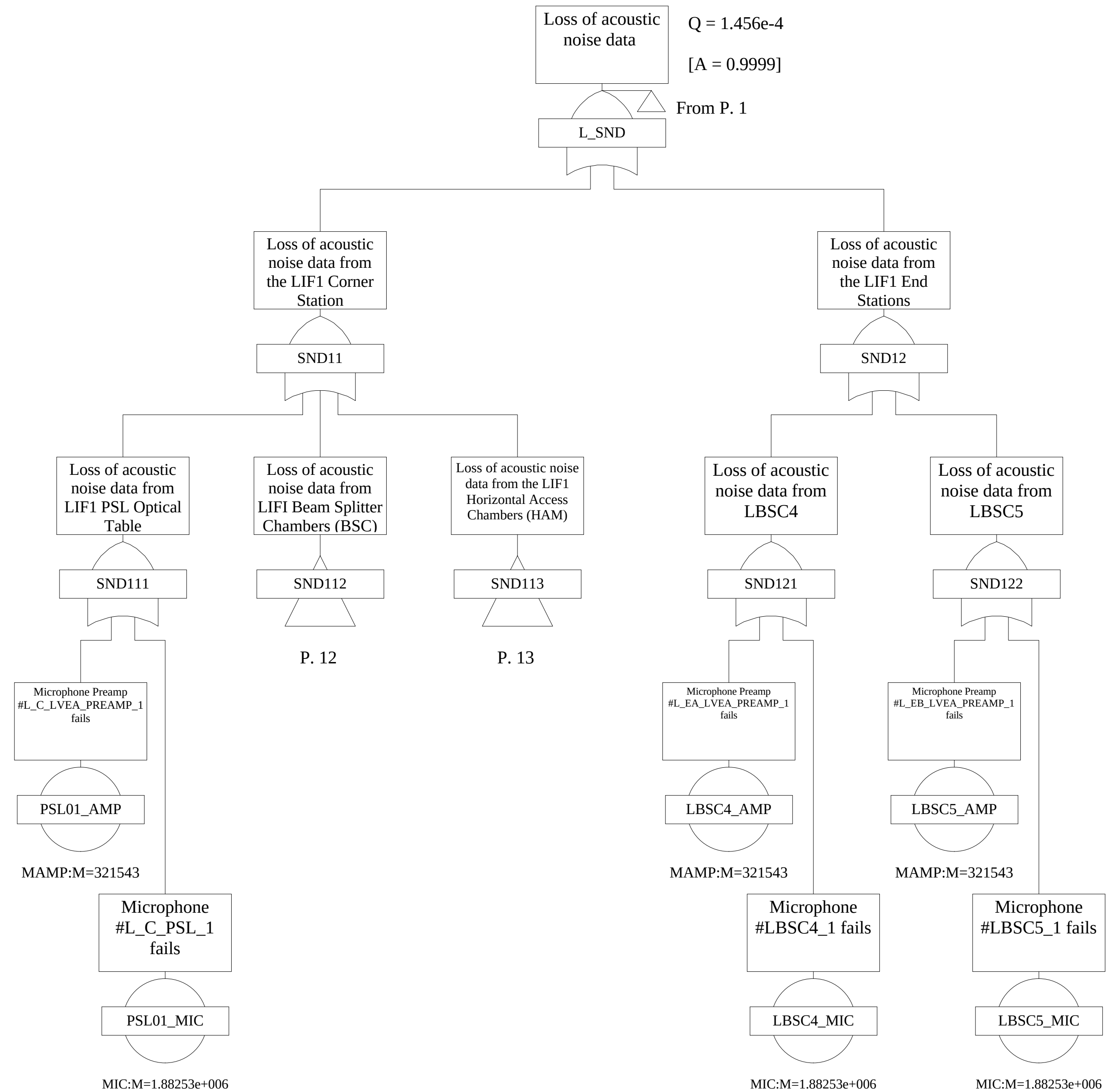

MAG-03MC
Magnetometer
fails to provide
magnetic field data
Q = 4.778e-5
[A = 1.0000]
From P. 1
L_MAG
MAG-03M Power
Supply Unit
Electronic Failure
MAG-03MC
Magnetometer
Electronic Failure
MAG111A
MAG11A
MGPS:M=301344
MG3MC:M=376680

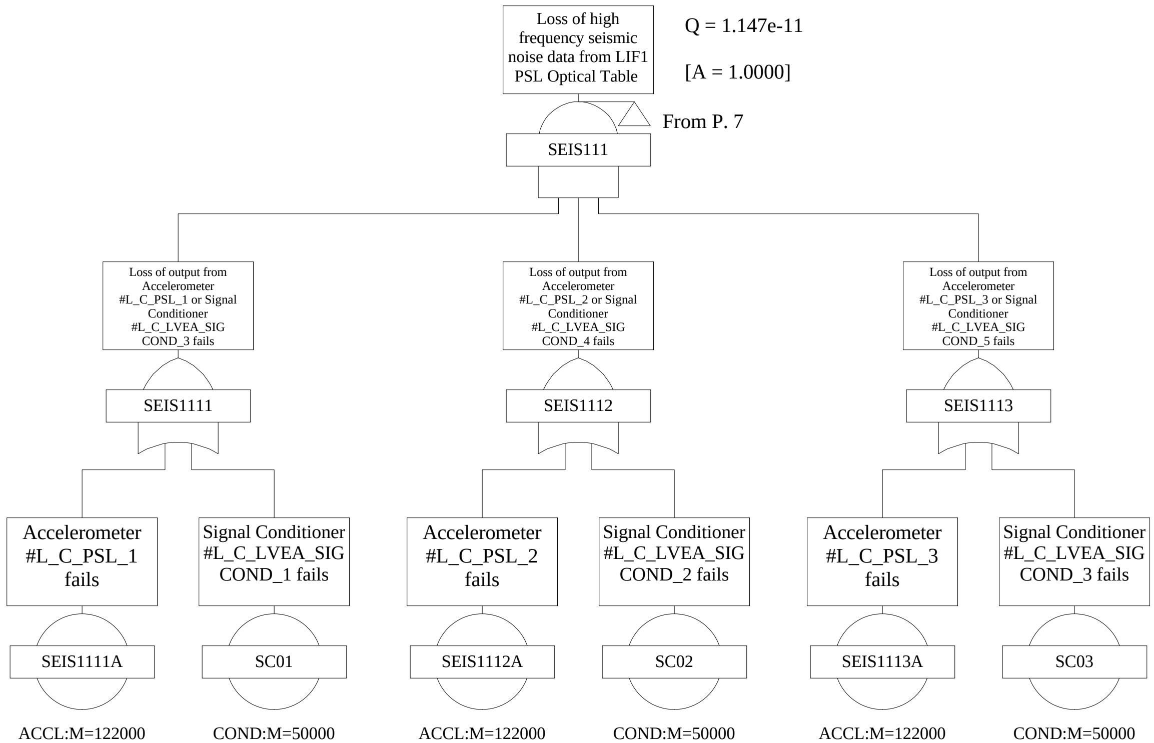

Loss of Power Line Fluctuations data
Q = 4.250e-5
[A = 1.0000]
From P. 1
L_PLF
Dranetz Power Platform 4300 #1 Electronic Failure
L_PLF_A
DPP:M=280807
Unable to monitor Facility Power Bus Current due to toroid failure
L_PLF_B
iMON:M=570776

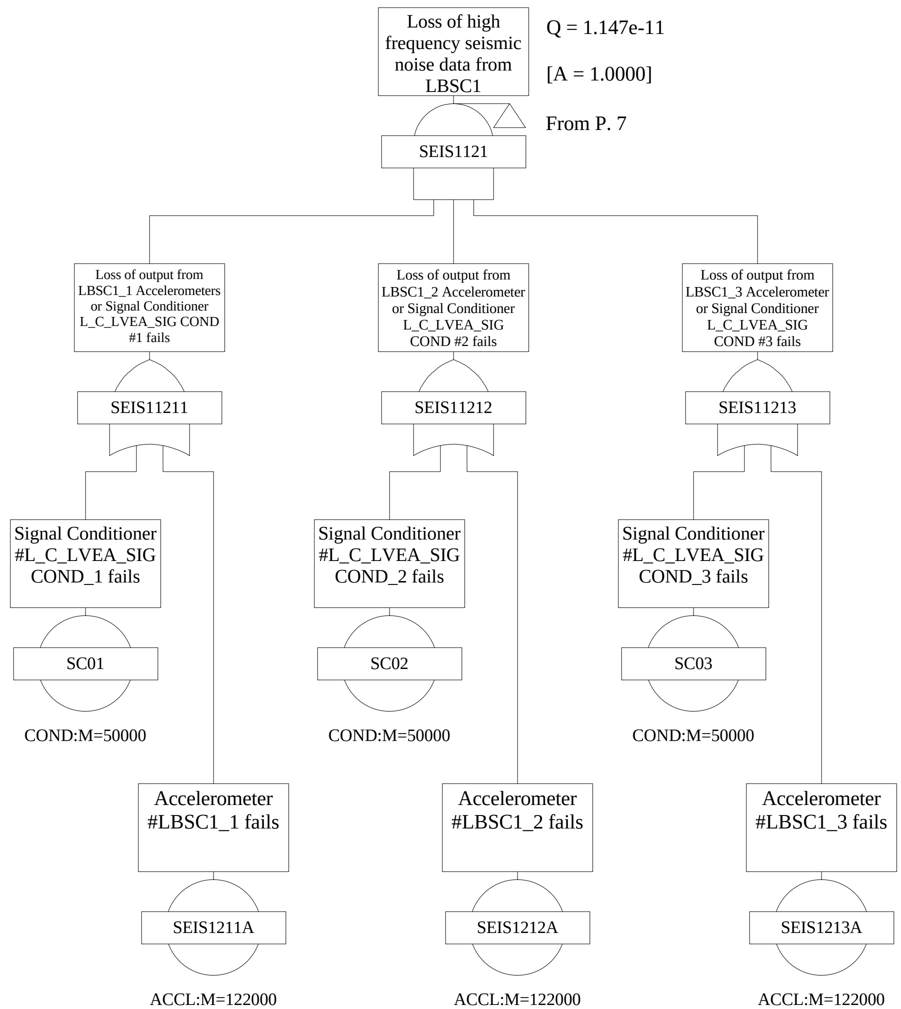

Loss of valid low frequency 3 axis seismic data
Q = 2.270e-10
[A = 1.0000]
From P. 1
L_LF1
Loss of valid low frequency seismic data from the Corner Station (L_C)
L_CS_LF1
Loss of valid low frequency seismic data from the End Station (L_EA)
L_EA_LF1
Loss of valid low frequency seismic data from the End Station (L_EB)
L_EB_LF1
L_C_PEM_CMG-40T Seismometer Electronic Failure
L_CS_LF1_A
SM:M=17769
L_EA_PEM_CMG-40T Seismometer Electronic Failure
L_EA_LF1_A
SM:M=17769
L_EB_PEM_CMG-40T Seismometer Electronic Failure
L_EB_LF1_A
SM:M=17769
L_C_PEM_CMG-DM16 Digitizer Module Electronic Failure
L_CS_LF1_B
DM:M=50000
L_EA_PEM_CMG-DM16 Digitizer Module Electronic Failure
L_EA_LF1_B
DM:M=50000
L_EB_PEM_CMG-DM16 Digitizer Module Electronic Failure
L_EB_LF1_B
DM:M=50000

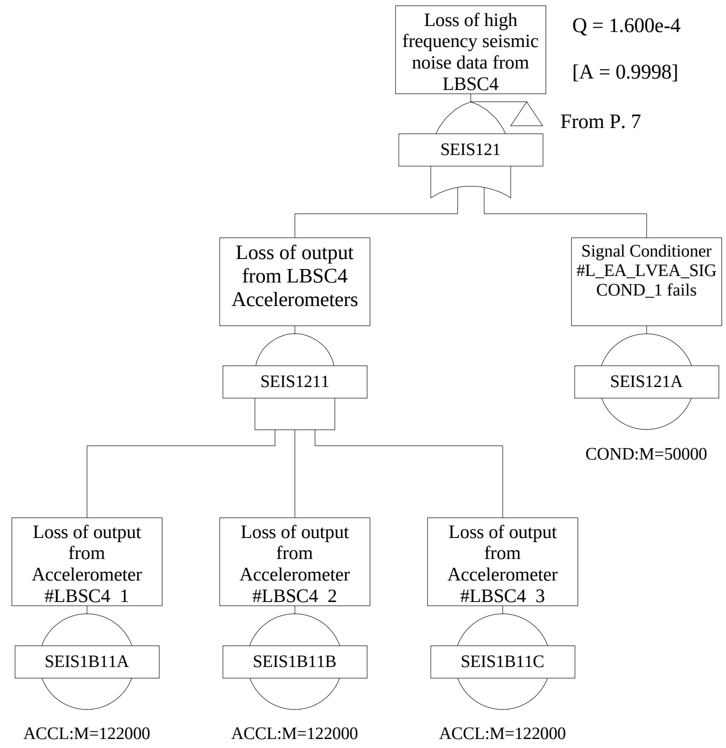

Loss of valid low frequency 2 axis seismic noise data
Q = 6.308e-11
[A = 1.0000]
From P. 1
L_LF2
L_C_PEM_CLIN520
Tiltmeter Electronic Failure
L_CS_LF2
TM:M=20089
L_EB_PEM_CLIN520
Tiltmeter Electronic Failure
L_EB_LF2
TM:M=20089
L_EA_PEM_CLIN520
Tiltmeter Electronic Failure
L_EA_LF2
TM:M=20089

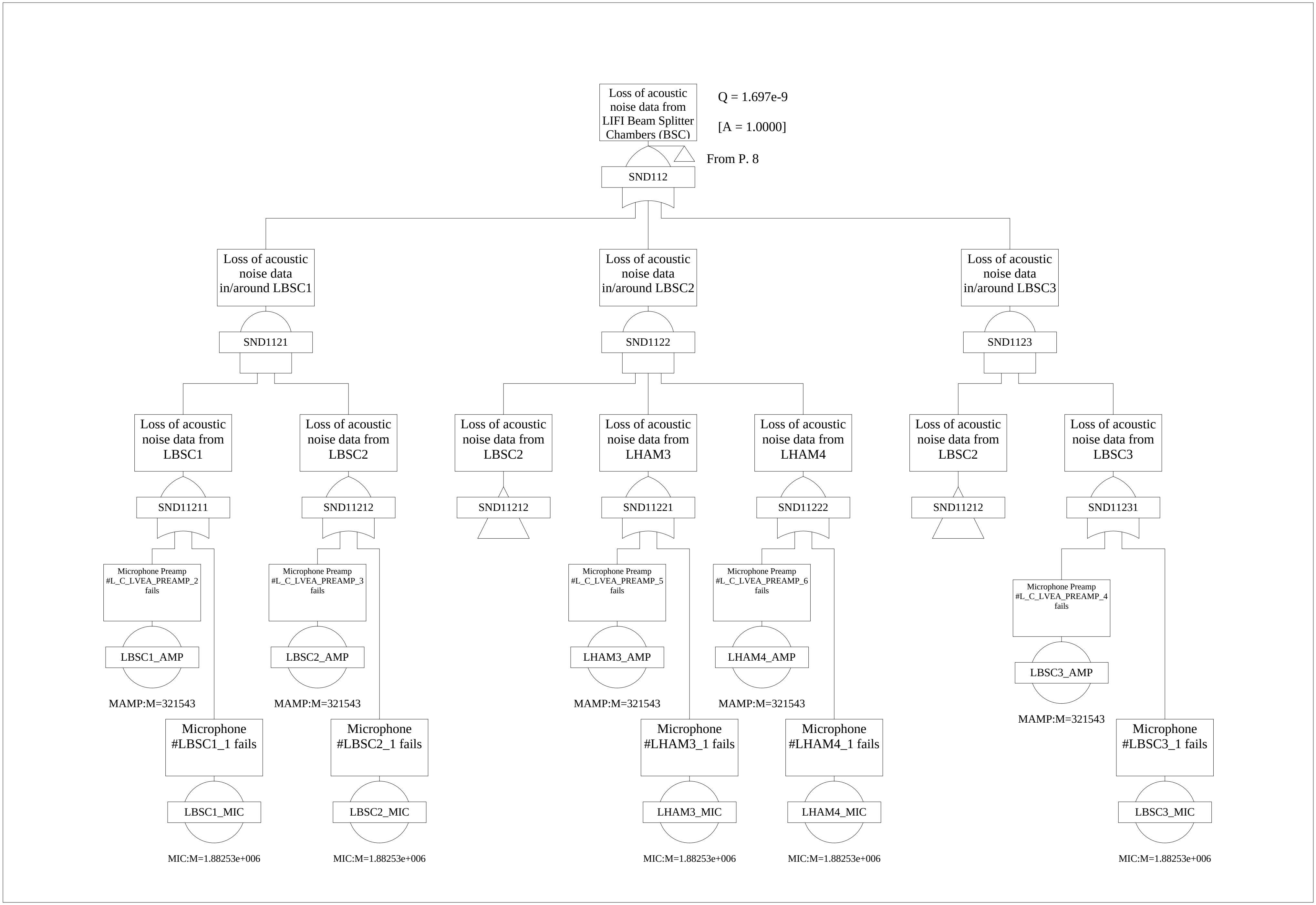

Loss of high frequency seismic noise data
Q = 3.199e-4
[A = 0.9997]
From P. 1
L_HF
Loss of high frequency seismic noise data from the HIF1 Corner Station
SEIS11
Loss of high frequency seismic noise data from the LIF1 End Stations
SEIS12
Loss of high frequency seismic noise data from LIF1 PSL Optical Table
SEIS111
P. 9
Loss of high frequency seismic noise data from LIF1 Beam Splitter Chambers (BSC)
SEIS112
Loss of high frequency seismic noise data from LIF1 Horizontal Access Chambers (HAM)
SEIS113
Loss of high frequency seismic noise data from LBSC4
SEIS121
P. 11
Loss of high frequency seismic noise data from LBSC1
SEIS1121
P. 10
Loss of high frequency seismic noise data from LBSC3
SEIS112B
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM2
SEIS113B
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM4
SEIS113D
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM6
SEIS113F
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LBSC5
SEIS12A
3AND1:F=0.00016
Loss of high frequency seismic noise data from LBSC2
SEIS112A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM1
SEIS113A
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM3
SEIS113C
3AND3:F=1.147e-011
Loss of high frequency seismic noise data from LHAM5
SEIS113E
3AND3:F=1.147e-011

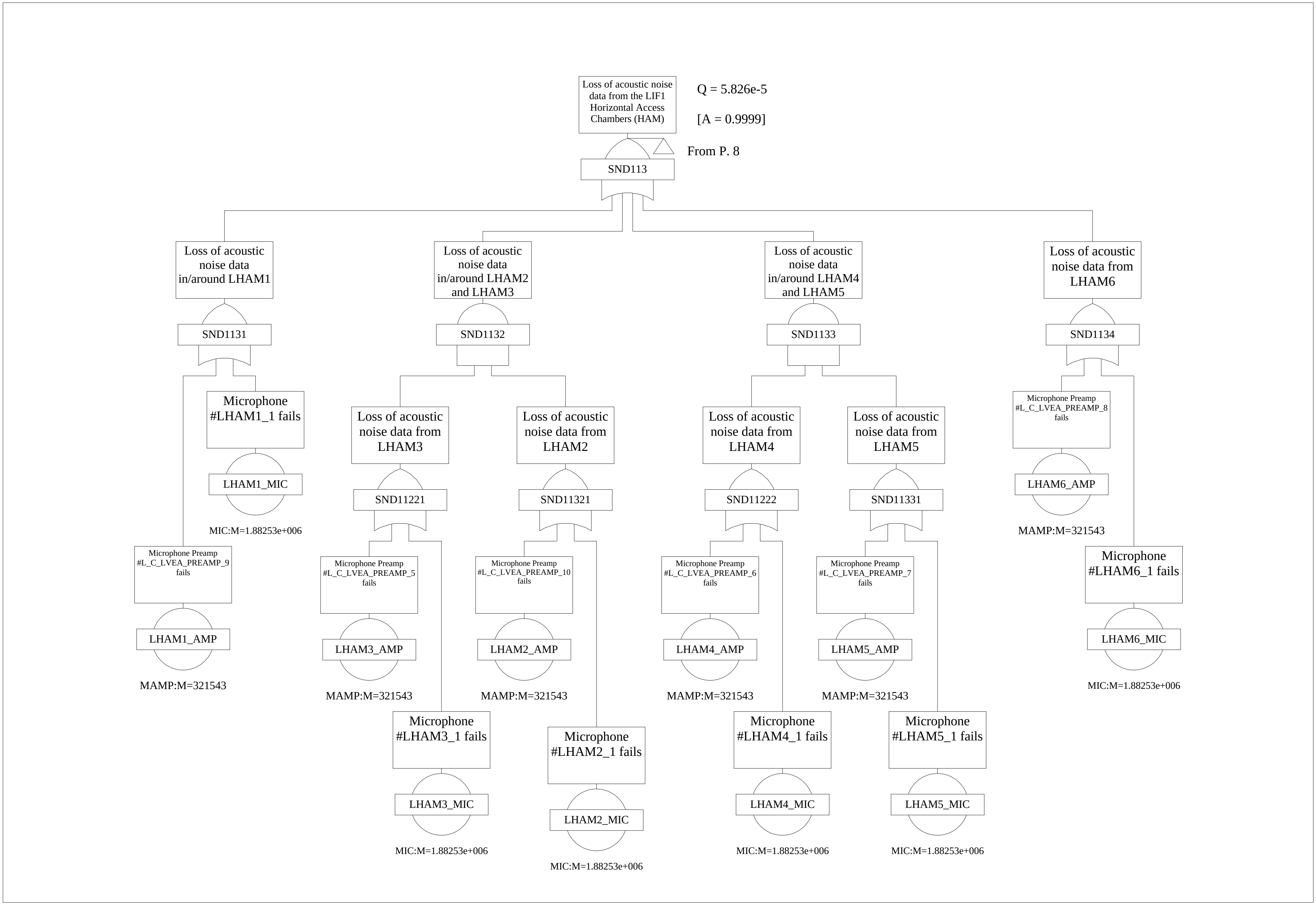

Loss of acoustic noise data
Q = 1.456e-4
[A = 0.9999]
From P. 1
L_SND
Loss of acoustic noise data from the LIF1 Corner Station
SND11
Loss of acoustic noise data from the LIF1 End Stations
SND12
Loss of acoustic noise data from LIF1 PSL Optical Table
SND111
Loss of acoustic noise data from LIFI Beam Splitter Chambers (BSC)
SND112
P. 12
Loss of acoustic noise data from the LIF1 Horizontal Access Chambers (HAM)
SND113
P. 13
Loss of acoustic noise data from LBSC4
SND121
Loss of acoustic noise data from LBSC5
SND122
Microphone Preamp #L_C_LVEA_PREAMP_1 fails
PSL01_AMP
MAMP:M=321543
Microphone #L_C_PSL_1 fails
PSL01_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_EA_LVEA_PREAMP_1 fails
LBSC4_AMP
MAMP:M=321543
Microphone #LBSC4_1 fails
LBSC4_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_EB_LVEA_PREAMP_1 fails
LBSC5_AMP
MAMP:M=321543
Microphone #LBSC5_1 fails
LBSC5_MIC
MIC:M=1.88253e+006

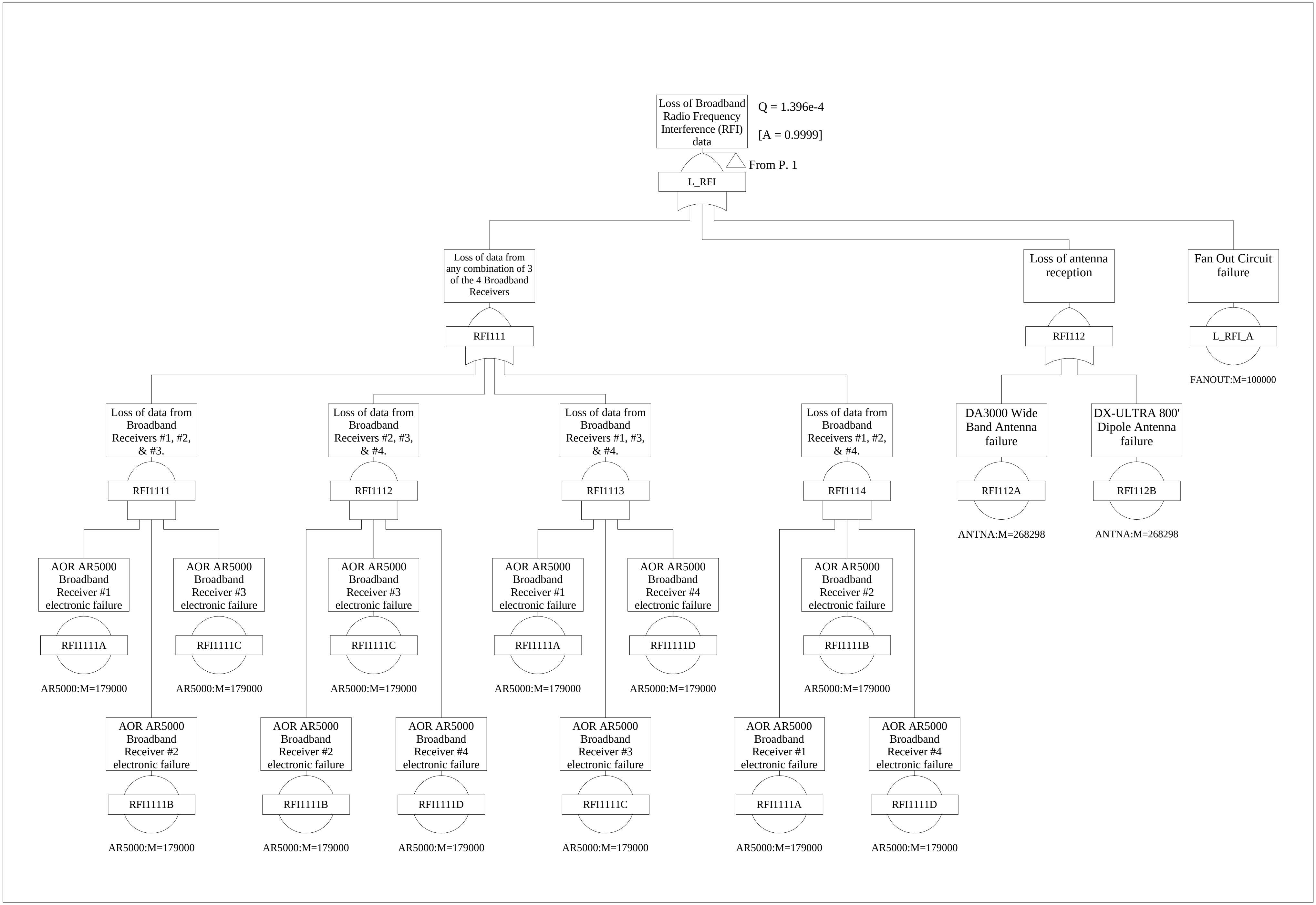

Loss of high frequency seismic noise data from LIF1 PSL Optical Table
Q = 1.147e-11
[A = 1.0000]
From P. 7
SEIS111
Loss of output from Accelerometer #L_C_PSL_1 or Signal Conditioner #L_C_LVEA_SIG COND_3 fails
SEIS1111
Loss of output from Accelerometer #L_C_PSL_2 or Signal Conditioner #L_C_LVEA_SIG COND_4 fails
SEIS1112
Loss of output from Accelerometer #L_C_PSL_3 or Signal Conditioner #L_C_LVEA_SIG COND_5 fails
SEIS1113
Accelerometer #L_C_PSL_1 fails
SEIS1111A
ACCL:M=122000
Signal Conditioner #L_C_LVEA_SIG COND_1 fails
SC01
COND:M=50000
Accelerometer #L_C_PSL_2 fails
SEIS1112A
ACCL:M=122000
Signal Conditioner #L_C_LVEA_SIG COND_2 fails
SC02
COND:M=50000
Accelerometer #L_C_PSL_3 fails
SEIS1113A
ACCL:M=122000
Signal Conditioner #L_C_LVEA_SIG COND_3 fails
SC03
COND:M=50000

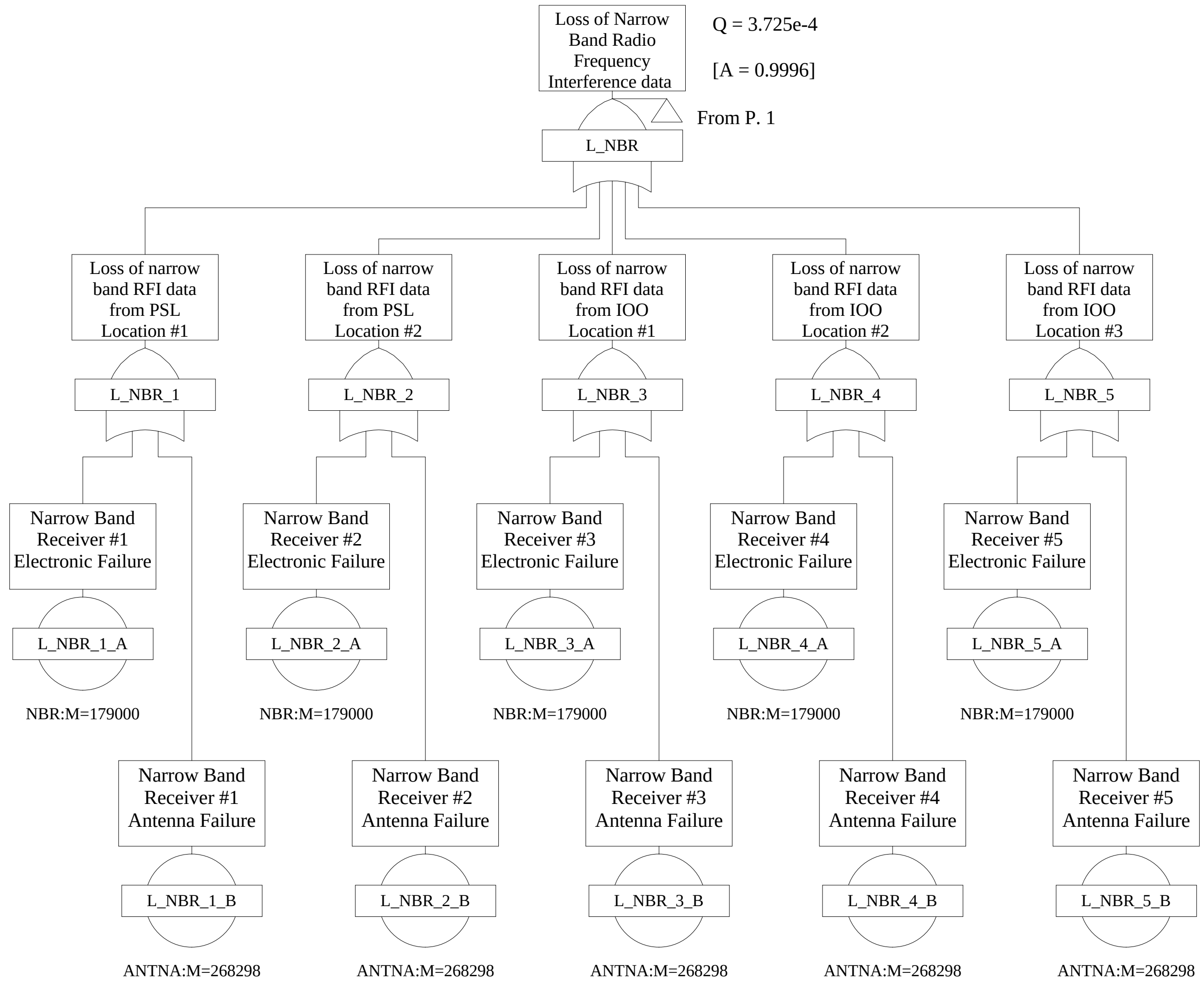

Loss of high frequency seismic noise data from LBSC1
Q = 1.147e-11
[A = 1.0000]
From P. 7
SEIS1121
Loss of output from LBSC1_1 Accelerometers or Signal Conditioner L_C_LVEA_SIG COND #1 fails
SEIS11211
Loss of output from LBSC1_2 Accelerometer or Signal Conditioner L_C_LVEA_SIG COND #2 fails
SEIS11212
Loss of output from LBSC1_3 Accelerometer or Signal Conditioner L_C_LVEA_SIG COND #3 fails
SEIS11213
Signal Conditioner #L_C_LVEA_SIG COND_1 fails
SC01
COND:M=50000
Signal Conditioner #L_C_LVEA_SIG COND_2 fails
SC02
COND:M=50000
Signal Conditioner #L_C_LVEA_SIG COND_3 fails
SC03
COND:M=50000
Accelerometer #LBSC1_1 fails
SEIS1211A
ACCL:M=122000
Accelerometer #LBSC1_2 fails
SEIS1212A
ACCL:M=122000
Accelerometer #LBSC1_3 fails
SEIS1213A
ACCL:M=122000

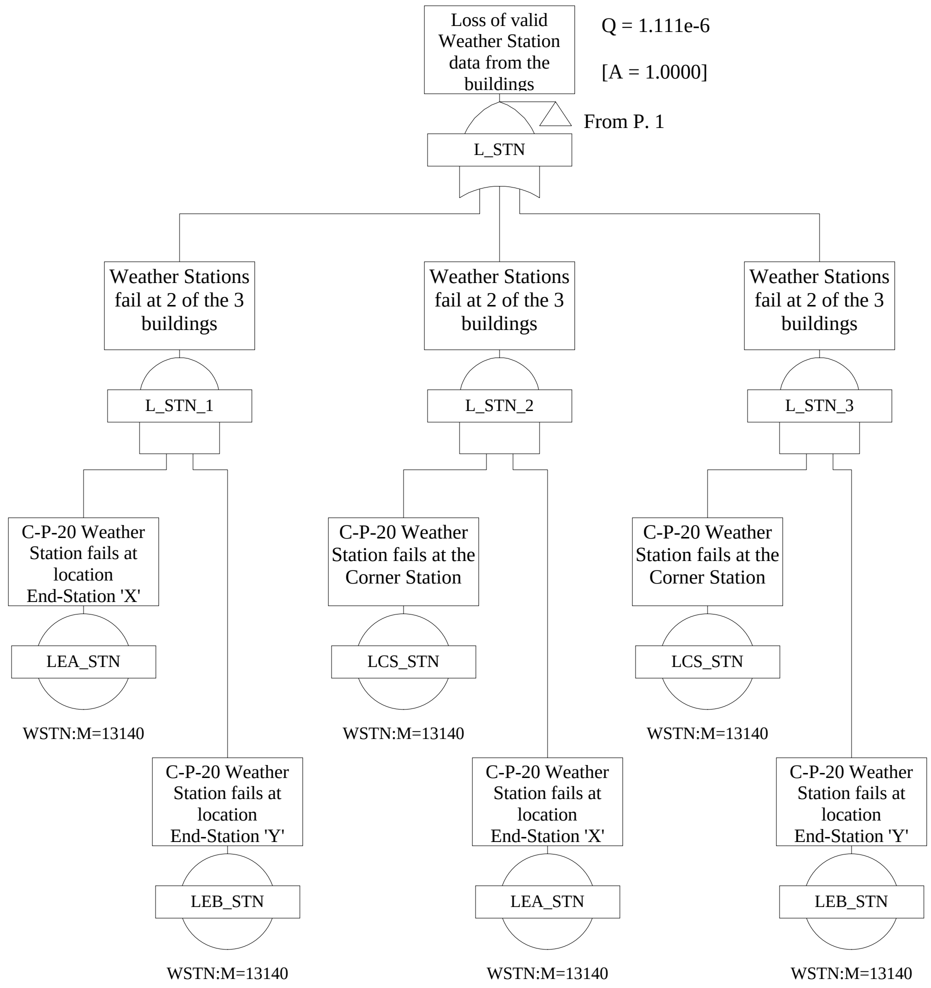

Loss of high frequency seismic noise data from LBSC4
Q = 1.600e-4
[A = 0.9998]
From P. 7
SEIS121
Loss of output from LBSC4 Accelerometers
SEIS1211
Signal Conditioner #L_EA_LVEA_SIG COND_1 fails
SEIS121A
COND:M=50000
Loss of output from Accelerometer #LBSC4_1
SEIS1B11A
ACCL:M=122000
Loss of output from Accelerometer #LBSC4_2
SEIS1B11B
ACCL:M=122000
Loss of output from Accelerometer #LBSC4_3
SEIS1B11C
ACCL:M=122000

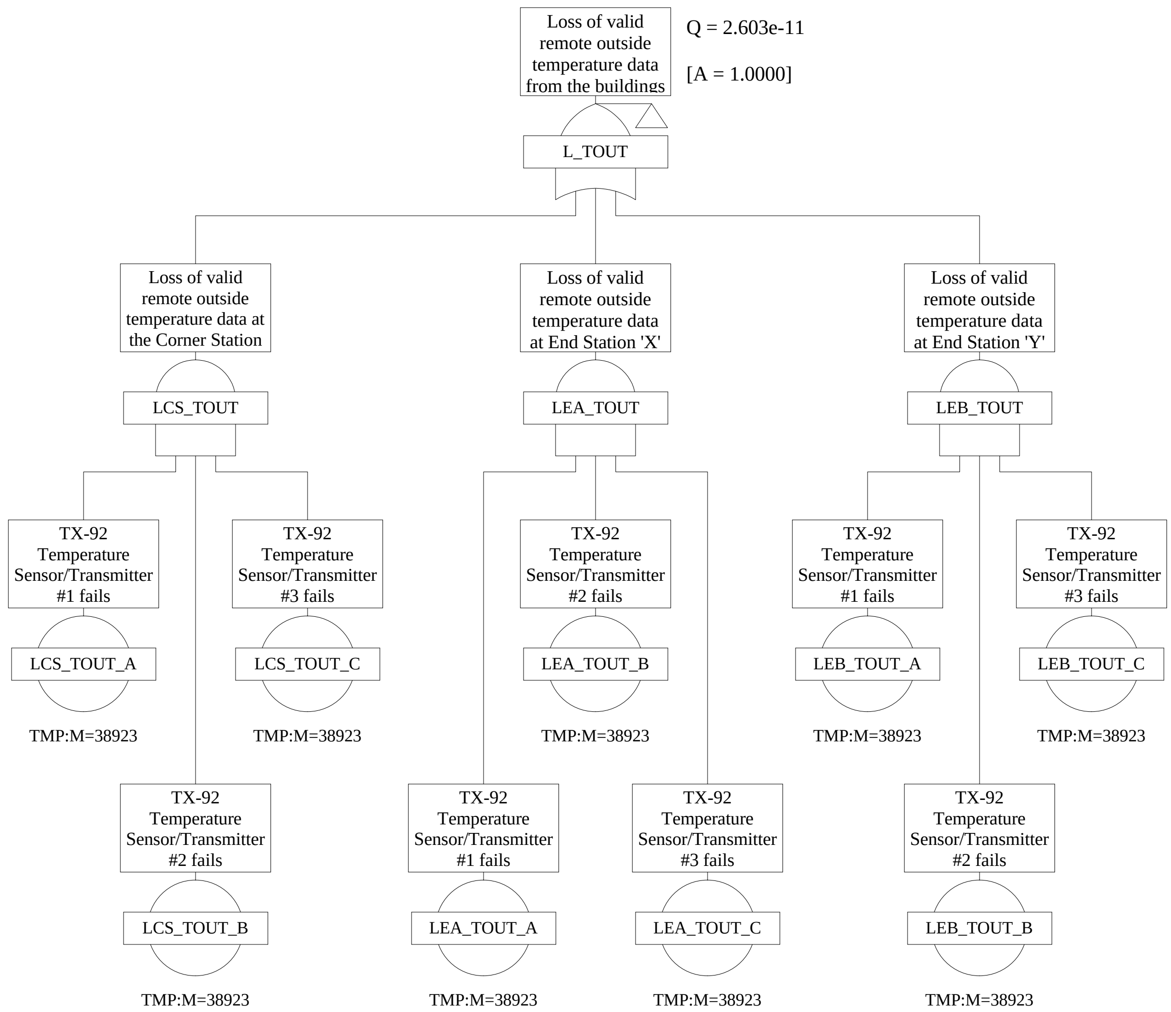

Loss of acoustic noise data from LIFI Beam Splitter Chambers (BSC)
Q = 1.697e-9
[A = 1.0000]
From P. 8
SND112
Loss of acoustic noise data in/around LBSC1
SND1121
Loss of acoustic noise data in/around LBSC2
SND1122
Loss of acoustic noise data in/around LBSC3
SND1123
Loss of acoustic noise data from LBSC1
SND11211
Loss of acoustic noise data from LBSC2
SND11212
Loss of acoustic noise data from LBSC2
SND11212
Loss of acoustic noise data from LHAM3
SND11221
Loss of acoustic noise data from LHAM4
SND11222
Loss of acoustic noise data from LBSC2
SND11212
Loss of acoustic noise data from LBSC3
SND11231
Microphone Preamp #L_C_LVEA_PREAMP_2 fails
LBSC1_AMP
MAMP:M=321543
Microphone #LBSC1_1 fails
LBSC1_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_C_LVEA_PREAMP_3 fails
LBSC2_AMP
MAMP:M=321543
Microphone #LBSC2_1 fails
LBSC2_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_C_LVEA_PREAMP_5 fails
LHAM3_AMP
MAMP:M=321543
Microphone #LHAM3_1 fails
LHAM3_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_C_LVEA_PREAMP_6 fails
LHAM4_AMP
MAMP:M=321543
Microphone #LHAM4_1 fails
LHAM4_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_C_LVEA_PREAMP_4 fails
LBSC3_AMP
MAMP:M=321543
Microphone #LBSC3_1 fails
LBSC3_MIC
MIC:M=1.88253e+006


Loss of acoustic noise data from the LIF1 Horizontal Access Chambers (HAM)
Q = 5.826e-5
[A = 0.9999]
From P. 8
SND113
Loss of acoustic noise data in/around LHAM1
SND1131
Microphone #LHAM1_1 fails
LHAM1_MIC
MIC:M=1.88253e+006
Microphone Preamp #L_C_LVEA_PREAMP_9 fails
LHAM1_AMP
MAMP:M=321543
Loss of acoustic noise data in/around LHAM2 and LHAM3
SND1132
Loss of acoustic noise data from LHAM3
SND11221
Microphone Preamp #L_C_LVEA_PREAMP_5 fails
LHAM3_AMP
MAMP:M=321543
Microphone #LHAM3_1 fails
LHAM3_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from LHAM2
SND11321
Microphone Preamp #L_C_LVEA_PREAMP_10 fails
LHAM2_AMP
MAMP:M=321543
Microphone #LHAM2_1 fails
LHAM2_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data in/around LHAM4 and LHAM5
SND1133
Loss of acoustic noise data from LHAM4
SND11222
Microphone Preamp #L_C_LVEA_PREAMP_6 fails
LHAM4_AMP
MAMP:M=321543
Microphone #LHAM4_1 fails
LHAM4_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from LHAM5
SND11331
Microphone Preamp #L_C_LVEA_PREAMP_7 fails
LHAM5_AMP
MAMP:M=321543
Microphone #LHAM5_1 fails
LHAM5_MIC
MIC:M=1.88253e+006
Loss of acoustic noise data from LHAM6
SND1134
Microphone Preamp #L_C_LVEA_PREAMP_8 fails
LHAM6_AMP
MAMP:M=321543
Microphone #LHAM6_1 fails
LHAM6_MIC
MIC:M=1.88253e+006

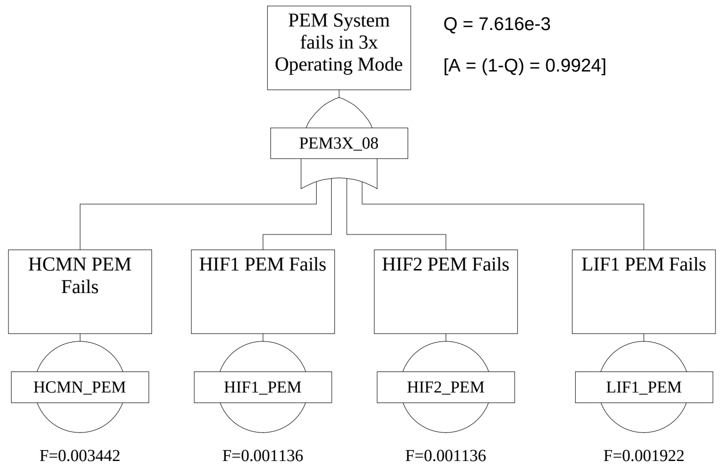

Loss of Broadband Radio Frequency Interference (RFI) data
Q = 1.396e-4
[A = 0.9999]
From P. 1
L_RFI
Loss of data from any combination of 3 of the 4 Broadband Receivers
RFI111
Loss of antenna reception
RFI112
Fan Out Circuit failure
L_RFI_A
FANOUT:M=100000
Loss of data from Broadband Receivers #1, #2, & #3.
RFI1111
Loss of data from Broadband Receivers #2, #3, & #4.
RFI1112
Loss of data from Broadband Receivers #1, #3, & #4.
RFI1113
Loss of data from Broadband Receivers #1, #2, & #4.
RFI1114
DA3000 Wide Band Antenna failure
RFI112A
ANTNA:M=268298
DX-ULTRA 800' Dipole Antenna failure
RFI112B
ANTNA:M=268298
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #2 electronic failure
RFI1111B
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000
AOR AR5000 Broadband Receiver #3 electronic failure
RFI1111C
AR5000:M=179000
AOR AR5000 Broadband Receiver #1 electronic failure
RFI1111A
AR5000:M=179000
AOR AR5000 Broadband Receiver #4 electronic failure
RFI1111D
AR5000:M=179000


Loss of Narrow Band Radio Frequency Interference data
Q = 3.725e-4
[A = 0.9996]
From P. 1
L_NBR
Loss of narrow band RFI data from PSL Location #1
L_NBR_1
Loss of narrow band RFI data from PSL Location #2
L_NBR_2
Loss of narrow band RFI data from IOO Location #1
L_NBR_3
Loss of narrow band RFI data from IOO Location #2
L_NBR_4
Loss of narrow band RFI data from IOO Location #3
L_NBR_5
Narrow Band Receiver #1 Electronic Failure
L_NBR_1_A
NBR:M=179000
Narrow Band Receiver #2 Electronic Failure
L_NBR_2_A
NBR:M=179000
Narrow Band Receiver #3 Electronic Failure
L_NBR_3_A
NBR:M=179000
Narrow Band Receiver #4 Electronic Failure
L_NBR_4_A
NBR:M=179000
Narrow Band Receiver #5 Electronic Failure
L_NBR_5_A
NBR:M=179000
Narrow Band Receiver #1 Antenna Failure
L_NBR_1_B
ANTNA:M=268298
Narrow Band Receiver #2 Antenna Failure
L_NBR_2_B
ANTNA:M=268298
Narrow Band Receiver #3 Antenna Failure
L_NBR_3_B
ANTNA:M=268298
Narrow Band Receiver #4 Antenna Failure
L_NBR_4_B
ANTNA:M=268298
Narrow Band Receiver #5 Antenna Failure
L_NBR_5_B
ANTNA:M=268298

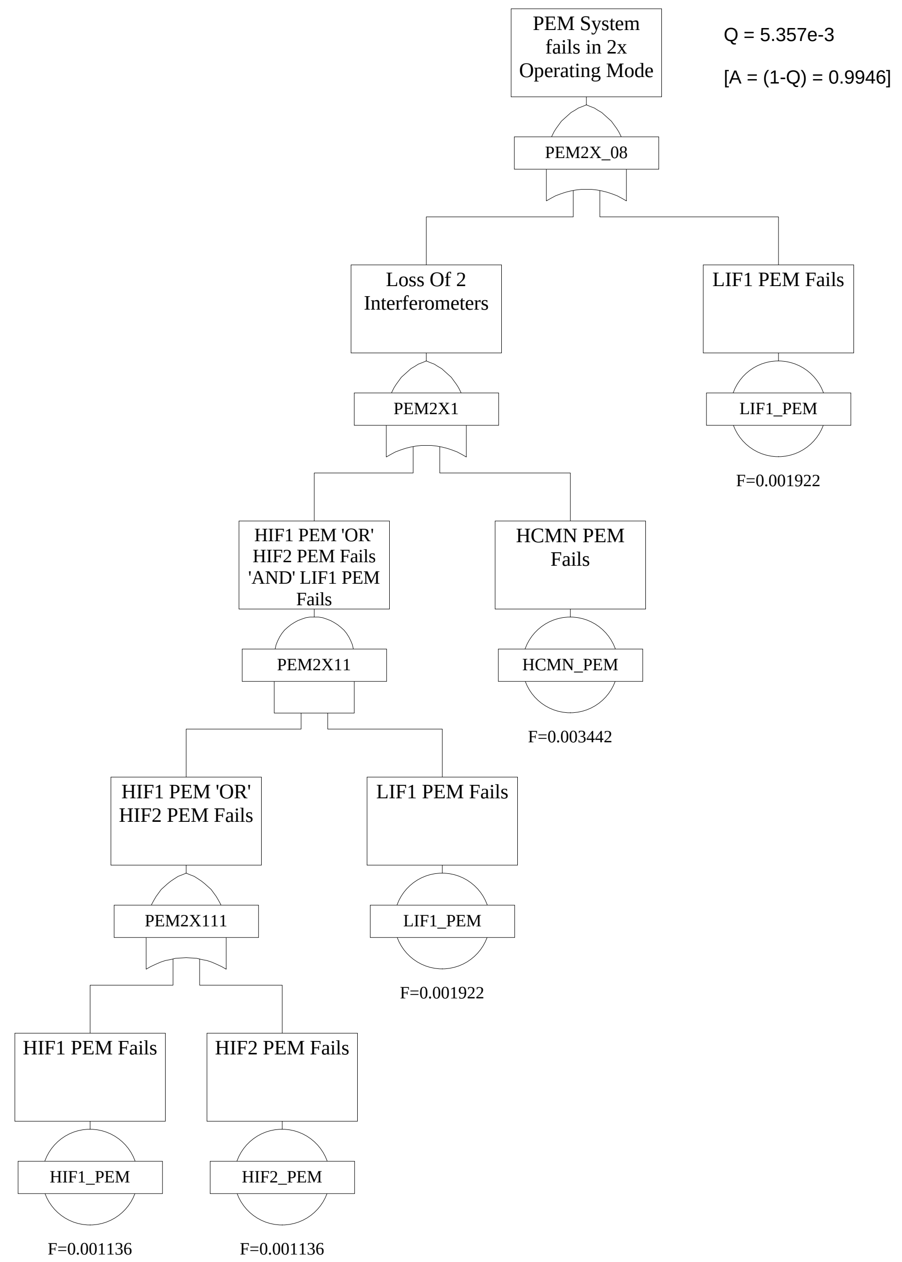

Loss of valid Weather Station data from the buildings
Q = 1.111e-6
[A = 1.0000]
From P. 1
L_STN
Weather Stations fail at 2 of the 3 buildings
L_STN_1
Weather Stations fail at 2 of the 3 buildings
L_STN_2
Weather Stations fail at 2 of the 3 buildings
L_STN_3
C-P-20 Weather Station fails at location End-Station 'X'
LEA_STN
WSTN:M=13140
C-P-20 Weather Station fails at location End-Station 'Y'
LEB_STN
WSTN:M=13140
C-P-20 Weather Station fails at the Corner Station
LCS_STN
WSTN:M=13140
C-P-20 Weather Station fails at location End-Station 'X'
LEA_STN
WSTN:M=13140
C-P-20 Weather Station fails at the Corner Station
LCS_STN
WSTN:M=13140
C-P-20 Weather Station fails at location End-Station 'Y'
LEB_STN
WSTN:M=13140


Loss of valid remote outside temperature data from the buildings
Q = 2.603e-11
[A = 1.0000]
L_TOUT
Loss of valid remote outside temperature data at the Corner Station
LCS_TOUT
Loss of valid remote outside temperature data at End Station 'X'
LEA_TOUT
Loss of valid remote outside temperature data at End Station 'Y'
LEB_TOUT
TX-92 Temperature Sensor/Transmitter #1 fails
LCS_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
LCS_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
LEA_TOUT_B
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
LEB_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
LEB_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
LCS_TOUT_B
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #1 fails
LEA_TOUT_A
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #3 fails
LEA_TOUT_C
TMP:M=38923
TX-92 Temperature Sensor/Transmitter #2 fails
LEB_TOUT_B
TMP:M=38923

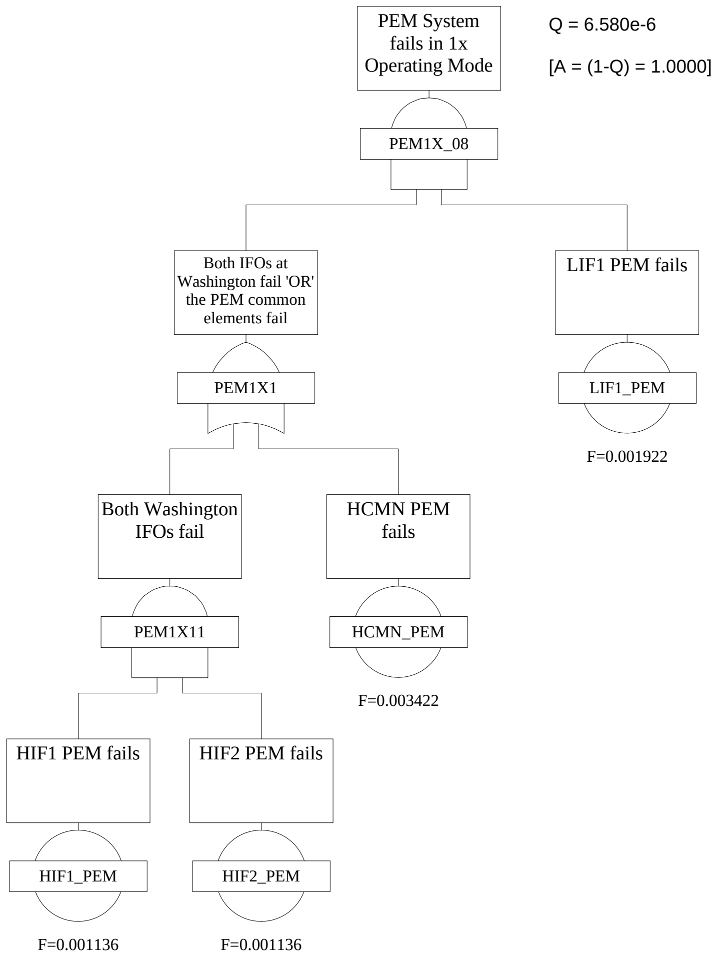
APPENDIX C:
LIGO 3X PEM AVAILABILITY PREDICTION


PEM System fails in 3x Operating Mode
Q = 7.616e-3
[A = (1-Q) = 0.9924]
PEM3X_08
HCMN PEM Fails
HIF1 PEM Fails
HIF2 PEM Fails
LIF1 PEM Fails
HCMN_PEM
HIF1_PEM
HIF2_PEM
LIF1_PEM
F=0.003442
F=0.001136
F=0.001136
F=0.001922

APPENDIX D:
LIGO 2X PEM AVAILABILITY PREDICTION


PEM System fails in 2x Operating Mode
Q = 5.357e-3
[A = (1-Q) = 0.9946]
PEM2X_08
Loss Of 2 Interferometers
LIF1 PEM Fails
PEM2X1
LIF1_PEM
F=0.001922
HIF1 PEM 'OR' HIF2 PEM Fails 'AND' LIF1 PEM Fails
HCMN PEM Fails
PEM2X11
HCMN_PEM
F=0.003442
HIF1 PEM 'OR' HIF2 PEM Fails
LIF1 PEM Fails
PEM2X111
LIF1_PEM
F=0.001922
HIF1 PEM Fails
HIF2 PEM Fails
HIF1_PEM
HIF2_PEM
F=0.001136
F=0.001136

APPENDIX E:
LIGO 1X PEM AVAILABILITY PREDICTION


PEM System fails in 1x Operating Mode
Q = 6.580e-6
[A = (1-Q) = 1.0000]
PEM1X_08
Both IFOs at Washington fail 'OR' the PEM common elements fail
PEM1X1
LIF1 PEM fails
LIF1_PEM
F=0.001922
Both Washington IFOs fail
PEM1X11
HCMN PEM fails
HCMN_PEM
F=0.003422
HIF1 PEM fails
HIF1_PEM
F=0.001136
HIF2 PEM fails
HIF2_PEM
F=0.001136