HENEX Failure Analysis

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1. Purpose

The purpose of the HENEX Failure Analysis is to (a) establish criteria for categorizing and ranking possible failure modes according to probability and consequences; (b) identify, categorize, and rank possible HENEX failure modes; (c) mitigate the probability and the consequences of failure based on the design of the instrument. Failure Analysis and risk management are implemented and accomplished during the instrument design phase. The intent of this Failure Analysis is to help the project produce a reliable instrument within the constraints of cost and schedule. The HENEX design benefits from the knowledge gained by the design and deployment of the Hard X-Ray Spectrometer (HXS) at LLE.

2. Definitions

Component - The HENEX components, for the purpose of Failure Analysis, are Nosecone, Spectrometer, Sensor, Battery, Electronics, and Cables (fiber optics).

Priority - The priority of the possible failure mode based on the probability of occurrence and the consequences of failure. The priority levels are 1=High, 2=Moderate, and 3=Low.

Probability - The estimated probability, in % units, of occurrence during the first year of instrument usage.

Event - Description of the failure event.

Effect - The consequences of failure.

Management - The steps taken during the instrument design phase to mitigate the failure probability and consequences.

Comment - Comment may be relevant to the assignment of the priority or probability, the design steps taken to mitigate the failure, or the experience with the HXS instrument.

Component	Priority	Probability	Event	Effect	Management	Comment
Nosecone	3	20	Misalignment of the pointer or the DIM to the source position.	Shift of the spectra on the sensors.	Implement attenuation filters and compute new energy scale using absorption edge positions.	Analytic expressions for the energy scales have been derived.
Nosecone	2	20	Entrance filter bursts.	Additional x-ray flux and visible light reach the sensor. Filter must be replaced.	The filter supports are designed for easy filter replacement.	Most likely for the thin filter on the lowest energy channel.
Spectrometer	3	10	Crystal breaks.	Crystal must be replaced.	Spectrometer is detached from the instrument, disassembled, and the new crystal and mount are inserted.	The crystal thickness is chosen to accommodate the bending radius.
Sensor	3	10	Sensor filter bursts.	Additional x-ray flux and visible light reach the sensor. Filter must be replaced.	Sensor/filter module is designed to be easily withdrawn, and the filter is replaced.	Unlikely because the sensor's filter is protected by the crystal and the entrance filter.
Sensor	3	10	Sensor fails because of EMI.	Destruction of the sensor.	EMI shielding is implemented. Sensor module is easily withdrawn, and the sensor can be replaced.	EMI shielding was successful for HXS.
Battery	1	<<1	Battery pressure vessel fails.	Dispersal of contaminants into the target chamber.	Engineering analysis indicates the battery pressure vessel is structurally over designed by at least a factor of 100.	Tiny probability, huge consequences.
Electronics	3	10	Electronics fails because of EMI.	Destruction of the electronics.	EMI shielding is implemented.	EMI shielding was successful for HXS.
Cables	2	30	Trigger failure because of signal loss in the fiber optics.	No data are recorded.	Trigger and data links are verified prior to the shot.	Trigger failure occurred during HXS operations.

Power Supply	2	1	Loss of data	Voltages and temperatures are monitored in telemetry. Over-voltage protection for down-stream circuitry	Historical trends will likely indicate impending failure.
Analog Interface	3	1	No temp, voltages	None	System can function normally without this board
Foreman	3	1	Loss of data No control over DE	Temperature is monitored in telemetry.	Successful communication is a good indication of healthy board. Self-test should find any failures.
Instrument Modem	3	1	No Data No control over DE	Transmit current is limited and monitored in telemetry.	System was used for HXS
Secondary Control	3	1	Loss of data	Temperature is monitored in telemetry	Successful communication is a good indication of healthy board. Self-test should find any failures.
HS Download/Trigger	3	1	Possible loss of data	Down load of data could be done through instrument modem	Self-test should find any failures.
CMOS Sensor Driver Board	3	1	Possible loss of data on that channel	One per sensor—any single failure will not preclude use of the instrument.	All boards do not need to be in the system, for the system to function.
Primary Motherboard	3	>>1	Possible loss of data	Likely failure components have little impact on operation.	Few active components
Secondary Motherboard	3	>>1	Loss of data	Likely failure components have little impact on operation.	Few active components
DIU Processor	3	>>1	Loss of data	Trigger RSSI is reported in telemetry	Self-test should find any failures.
GSE F/O Modem	3	>>1	Loss of Control over DE	Transmit current is limited and monitored in telemetry	Visual indicator on front panel Self-test should find any failures
HS Receiver	3	>>1	Loss of data	Receiver RSSI is reported in telemetry	Self-test should find any failures
COTS Power Supply	3	>>1	Loss of data	Voltage is monitored	Visual indicator on front panel
DCP	3	1	Loss of data	Commercial electronics in a relatively benign environment.	DAS will see no heat-beat from DCP
High-speed Serial	3	1	Possible loss of data	Down load of data could be done through instrument modem	Commercial electronics in a relatively benign environment. Self-test should find any failures