CRaTER FMEA Worksheet **32-04009.01**

Revision	Date	Description
0.01	06/06/06	Crater I-CDR Initial release

Component	Mission Phase	Failure Mode Number	Identification of Item or Function	Failure	Failure Effects	Severity Category	Remarks
				a. Mode b. Cause	a. Local or Subsystem b. Next Higher Level - System c. End Effect - Mission	NC=Not Credible	a. Failure Detection Method b. Compensating Features/Actions c. Other
01.01.01 01.01.02 Electronics and Telescope Housing	I&T Launch Orbit	01-01-01-01	**MLI Blankets** that provide radiative thermal isolation between the CRaTER instrument and it's view of space, lunar surface, sun and spacecraft	a. Loss of thermal radiative properties b. Severe degradation of blanket properties or total loss of blanket	a. Change in temperaure and emmisivity of blanket b. Instrument parts may see out of temperature range conditions. May permenatly damage parts or resutl in degraded science data	3	a. Monitor temperature Housekeeping b. Operate instrument at times allowed by orbital conditional c. The MLI blankets have multiple attach points so some external event would have to account for the blanket loss scenerio
01.01.01 Electronics Housing	I&T Launch	01-01-01-02	**Fasteners** that secure instrument to spacecraft	a. Failure of a single structural mounting screw b. Bolt breaks or backs out	b. Remaiing bolts will see larger loads, but still have sufficient margin. c. Remaining propulsion model inserts will see higher loads c. Bolt could be a debris hazard if not contained by MLI blacket	4	a. Visually Inspectable at I&T,not detectable after launch b. Design maintains margin even with loss of a single fastener c. For a fastener to come out, there would need to be atleast two failures. The first would be application of improper torque and the second the failure of the spot bond c. Note that these particular fasteners are provided by the spacecraft and installed during I&T by NASA
01.01.01 Electronics Housing	I&T Launch	01-01-01-03	External Spacecraft Electrical **Connectors**	a. Connector becomes unplugged b. FMEA guidelines state that this is the only connector failure mode to be considered			
		01-01-01-03.1	Input/Survival Power from Spacecraft (J1)	"	a. No power input to instrument DC/DC converters b. No science or housekeeping data produced c. No power dissipated in instrument, survival heaters active during cold cases	3	a. After Launch , during activation, the instrument will not be able to send any diagnostic information. Spacecraft diagnostics of power line will need to be used. b. There is no way to compensate, as the power input to the instrument is single string.
		01-01-01-03.2	1 Hertz Timing Pulse/PRT (J2)	"	See 01-01-02-02 Timing Pulse fault a & b. Instrument does not use information from PRT c. Mission would not have direct access to instrument electronic box wall temperature	3	a. See 01-01-02-02 for Timing Pulse b. When instrument is turned on, mission would have access to internal temperatures read out in instrument housekeeping
		01-01-01-03.3	1553 Interfaces (J3 & J4)	"	No detrimental effects for a-c as there are redundant cables/connectors for the 1553 interface	4	a. On the ground, detection of diconnected cable is visual. Cannot detect during launch and on orbit.
01.01.01 01.01.02 Electronics and Telescope Housing	Launch	01-01-01-04	Externally exposed **fasteners**	a. Failure of a single non-structural external fastener b. Fastener breaks or backs out	b. None c. None c. Fasterner could be a debris hazard if not contained by MLI blacket	4	a. Visually Inspectable at I&T, not detectable after launch b. Design maintains margin even with loss of a single fastener c. For a fastener to come out, there would need to be atleast two failures. The first would be application of improper torque and the second the failure of the spot bond
01.01.01 01.01.02 Electronics and Telescope Housing	I&T Launch Orbit	01-01-01-05	Instrument Housing **Panels**	a. Penetration by instrument wall by foreign object b. Dropped screwdriver, micrometeorite, etc	It is not readily predictable what would happen with an energetic enough micrometeorite hit, but worse has is the instrument becomes non-functional and is powered off by the spacecraft, resulting in loss of science data.	NC	The thinest wall section of the instrument is 0.030" and is not considered readily susceptable to damage of this sort. Note this does not imply that a full micrometeorite susceptability study was done, just that the "telescope" aperatures, which are the thinest wall sections, have a minimum of 0.030" of Al which provides significant protection.

01.01.01 01.01.02 Electronics and Telescope Housing	I&T Launch	01-01-01-06	Internal **fasteners**	a. Failure of a single non-structural external fastener b. Bolt breaks or backs out	b. Could cause a electrical short hazard inside the instrument c. The fastener is fully contained by the instrument housing c. See the analysis on electrical shorts later in the FMEA for potential impacts	3	a. Not necessarily detectable I&T, not detectable after launch b. Mechanical design maintains margin even with loss of a single fastener c. For a fastener to come out, there would need to be atleast two failures. The first would be application of improper torque and the second the failure of the spot bond d. In the particlarly sensitive detector area where bare silicon detectors and bond wires are exposed, a stray fastener cannot physically find it's way into that volume. e. In the other internal areas, there is some, but not complete, level of protection from stray fasteners due to the conformal coating on all the PCBs.
01.01.02 Digital Board	I&T Orbit	01-01-02-01	Instrument to Spacecraft **Mil-Std 1553** Interface	a. Complete Loss of communications between instrument and spacecraft b. Failure of 1553 Bus Controller I.C.	a. Commands cannot be received from spacecraft or data sent to spacecraft. b. Crater Science Instrument would not produce any science data c. No ill effects on the operation of the spacecraft or the other payloads.	3	a. Failure is detectable during all phases, but not necessarily localized on orbit (During I&T, disassembly would be necessary to localize) b. No compensation on orbit c. There is a redundant "b" channel in the 1553 communications design to provide some level of protection from partial failure
01.01.02 Digital Board	I&T Orbit	01-01-02-02	Spacecraft to instrument **1 Hz Timing Pulse**	a. Loss of timing pulse to instrument b. Failure of receiver IC	a. Digital board logic cannot properly time stamp data b. Science data and housekeeping data will be telemetered without correct timestamp information c. The spacecraft does not use the time stamped data in it's operation. Ground processing of science data will be degraded	4	
01.01.02 Digital Board	I&T Orbit	01-01-02-03	**Instrument Commanding**	a. Invalid (malformed) Command sent to instrument	a. If the 1553 command packet it malformed, then the instrument 1553 controller will reject it. b. If the incapsulated instrument command is invalid or malformed, it may be interpreted as valid in the case where only a certain subset of the bits are being used for a given subaddress. In that case, a logical fault can occur and posibly cause the instrument to produce corrupted or no data until valid commands are issued correcting the problem.	4	No permanent damage will result from malformed or invalid commands to the instrument.
01.01.03 Seconday Power	I&T Orbit	01-01-02-01	Spacecraft to instrument **28V Primary Power** Supply	a. Over/Under Voltage Condition b. Cause undefined, but not caused by instrument	a&b. The is some margin in the design on the allowable input voltage range. Voltages below the dc/dc converter specification range can cause erratic, corrupted or no output on the 1553 bus or the current draw can increase to the point causing the spacecraft SSPC to shut it down. Voltage above the dc/dc converter specification can also cause erratic, corrupted or no output on the 1553 bus or it can cause perminant damage to the instrument. c. Undervolage may cause higher current draw from the spacecraft power for CRaTER (SSPC 1amp OM2-#8), which inturn may shut it off. If shut off, power to the survival heaters may be drawn to keep the instrument within it's cold survival limit.	3/4	Guidelines for the FMEA preperation state that nominal power input is to be assummed, but a general discussion was held on the off nominal conditions and is reported here
01.01.03 Seconday Power	I&T Orbit	01-01-02-02	Spacecraft to instrument **28V Primary Power** Supply	a. Short Circuit Condition b. Caused by the instrument, such as a short circuit within the dc/dc converter component	a. A dead short circuit on the primary power to the instrument will result in the instrument to be effectivley in the off state. b. Will result in a short condition on the OM2#8 power service from the spacecraft c. A non-clearable short on the 28V primary power to the instrument will result in loss of all CRaTER Science Data from that point on.	3	There is no circuitry within the CRaTER instrument to protect the primary power bus from an over-current condidtion (fuse,circuilt breaker, current limiter, etc). The spacecraft power system will have to protect itself from a short on the 28V power caused by the instrument.

01.01.03 Secondary Power	I&T Orbit	01-01-02-03	**Secondary Power** to Digital and Analog Boards	a. Short/Open Circuit Condition b. Caused by a short/open circuit within the instrument PCBs	a&b/ A dead short on either of the +5 or +/-5 will likely result in loss of functionality of the crater instrument. On the high voltage supplies, shorts within the detector or on the detector board will result in loss of data from that particular detector. Shorts on the high voltage power supplies prior to the devider network on the analog board or on the digital board will result in the loss of data from all 6 detectors. c. Degraded or total loss of science data from instrument	3/4	For the most part, there is no circuitry within the CRaTER instrument to protect itself from short circuits within itself, with the exception of the high voltage at the immediate interface to the detectors. Smart or partial shorts can have unpredicable behaviors, that can result in invalid or no science data being produced and unsually high or low power levels being drawn from the spacecraft 28V power proved to CRaTER.