The purpose of this ATM is to comment on the results of the single point failure analysis conducted on the lunar surface gravimeter experiment.

It is to be noted that this ATM does not include single point failure analysis on the La Coste and Romberg sensor.

Prepared by: R. Van Hoorde
LSG Reliability P. E.

Approved by: S. J. Ellison, Manager
ALSEP Reliability

INTRODUCTION

This Single Point Failure Analysis Summary identifies those potential modes constituting single point failures or critical failures peculiar to the Lunar Surface Gravimeter.

The reliability of the Lunar Surface Gravimeter is: Criticality I = .92781, Criticality I plus II = .92084, Criticality I plus II plus III = .91220 (for two years mission).

Failure modes listed in the following analysis are limited only to modes which:

a. Cause the loss of all scientific data (criticality rank = I)

b. Cause the loss of power (criticality rank = I)

c. Cause the loss of housekeeping data (criticality rank = III)

d. Cause the loss of the heater control system (criticality rank = I)

e. Partial loss of scientific data (criticality rank = II)

Failure modes with a criticality rank of "I" are termed LSG system single point failure modes. Those with a ranking of "II" are termed "critical". Failure modes with criticality rank III are less serious since scientific data is being returned.

Critical failures are defined as those causing operational degradation of the LSG.

SUMMARY

The summary of the Single Point Failure Analysis is as follows:

Criticality I = 24

Criticality II = 6

Criticality III = 1

CONCLUSIONS

Single point failures with rating of Criticality I, can only be eliminated by the use of redundancy. The fact is that power, weight, and volume budgets requirements are a constraint to the use of redundancy, but by the use of excellence in Quality Procedures, improvements in inspection and manufacturing processes, the application of high reliability component parts and accepted materials, and by the use of highly reliability design techniques, a high degree of confidence exists for successfully operating on the moon for 2 years.

ANALYSIS

1. Fixed Gain Preamplifier - Failure will cause loss of the capability to obtain the sensor output. (Criticality I)

2. Post-amplifier - Failure will cause the loss of further amplification of the sensor output signal. (Criticality I)

3. Oscillator Bridge - Failure will result in the loss of the balanced AC voltage to the two fixed plates of the differential sensor, as well as the reference signal for later phase sensitive detection of the sensor AC output signal. (Criticality I)

4. Demodulator - Failure will result in the loss of capability to convert the AC input signal to the DC output signal. This signal is proportional to the sensor displacement and its polarity indicates the direction of the displacement. All scientific data will be lost (tidal, lunar free oscillation, lunar seismic activity, and the drift of the lunar gravimeter sensor). Criticality I)

5. Integrator - Failure will result in the loss of capability of supplying a feedback voltage to restore the beam to a null position and is the output signal for lunar tidal variations. It will result in inability to record the effects of inherent gravimeter drift. (Criticality I)

6. Free modes filter - Failure will result in the anibility to accept the integrator output for filtering and further amplification. The scientific data output from the filter represents the lunar free modes of oscillation. (Criticality II)

7. Seismic Amplifier and Filter - Failure will result in inability to accept the seismic phase sensitive detector output in the demodulator. In a degraded mode seismic information can be measured at the output of the Seismic Buffer. The scientific data output from this filter represents the seismic information. (Criticality II)

8. Tilt servo - Failure will result in the inability to provide means of making small changes in the angular alignment of the gravimeter sensor in order to affect the sensitivity of the sensor. The fine adjustment of gravimeter sensitivity will most likely be used in conjunction with the screw servo to optimize gravimeter performance. (Criticality I)

9. Screw servo - Failure will result in the inability to position the sensor beam to a null, Failure of the screw servo motors will cause this effect. The failure will be catastrophic in nature if it occurs before initial adjustments and set up on the lunar surface. (Criticality I)

10. Mass change servo - Failure will result in the inability to power the motors which operate the mass change mechanism within the gravimeter. The failure will be catastrophic in nature if it occurs prior to initial set up on the lunar surface. (Criticality I)

11. Caging Control - Catastrophic failure will result in the inability to uncage the sensor beam. (Criticality I)

12. Shaft Encoder Electronics - Failure will result in the loss of data as to the position of the servo screw and loss of the relative of measurement. (Criticality II)

13. Temperature and Pressure Monitoring - Failure will result in the inability to monitor the gravimeter temperature and pressure. (If the gravimeter temperature cannot be held constant (50°C) then the failure of the temperature monitor is cataloged as criticality I).

14. Instrument Housing Temperature Controller - Failure will result in the inability to control the current in a heater coil mounted on the external surface of the instrument housing so as to maintain the 0.5° ± 0.05°C temperature differential between external surfaces of the heater box and instrument hok sing. (Criticality I)

15. Heater Box Temperature Controller - Failure will result in the inability to control the current to the heater coil so as to maintain the set point within control limits. (Criticality I)

16. Power Converter - Failure will result in the inability to provide the required regulation, interference control, and isolation of all power functions within the LSC. Failure will be catastrophic in nature. (Criticality I)

17. Analog Multiplexer and A/D Converter - A failure of the analog multiplexer will result in the loss of capability to select any of the four signals. (Seismic, tide, free modes and temperature data). A failure of the A/D converter will result in the loss of capability to digitize the analog signal selected by the analog multiplexer when it is demanded. (Criticality I).

18. Digital Multiplexer and Ten-Bit Shift Register - Failure will result in the loss of capability to control and gate the flow of information from the four possible sources of data (from the A/D converter) into the shift register and then to the Central Station (ALSEP). (Criticality I)

19. Analog Output Buffers - Failure will result in the loss of ability to transmit to the ALSEP Central Station a portion of the ten analog data channels. (Criticality III)

20. Command Register, Decoder and Driver - Failure will result in the loss of capability of remotely programming the LSG to perform a specific operation. (Criticality I).

21. Digital Line Buffers and Receivers - Failure will result in the loss of buffering of the ALSEP command signals and timing and control pulses to LSG and the loss of command logics to the command counter, command decoder and driver and the loss of fan out capability of the timing and control pulses to all experiment functions. (Criticality I)

22. Conectors - Serves as electrical link between the electronics package and EEE parts internal to the instrument housing. Must withstand pressure between outside environment and instrument housing environment, failure of the counectors will result in the LSG failure (Criticality I)

23. Arrestment Drive - Provides caging service for sensor. Must operate to start experiment. If failure occur prior to uncaging the LSG experiment it will be catastrophic (Criticality I)

24. Mass Changing Drive - Provides three discrete balance points. Connects for local "g" level. Must operate initially for set-up. May be called upon to correct for changes in local "g" level during experiment. Failure will result in the inability to change mass resulting in LSG catastrophic failure (Criticality I)

25. Potentiometer - Provides three position indicators for mass changing/balance system. Failure will be catastrophic to LSG and result in inability to change mass. (Criticality I).

26. Screw Drive (Coarse) - Provides coarse balance point positioning. Servo loop control thru electro-static beam position output. Failure will be catastrophic to the LSG (Criticality I).

27. Screw Drive (fine) - Provides fine balance point positioning otherwise same as in item 26. Failure willbe catastrophic to LSG (Criticality I).

28. Leveling Drive - Provides a total of ±6 minutes of arc connection to align with gravity vector. Failure will be lesser than critical. (Criticality II).

29. Gimbal Suspension - Provides ± 3° of pendulous freedom permitting sensor to align with gravity vector. Subject to stiction and wire torque restrictions. Failure will be greater than 6 minutes catastrophic to the LSG operation (Criticality I).

30. Thermal Control - Provides stable temperature environment for sensor. Failure will result in the inability to maintain temperature environment. It will compromise experimental results (Criticality I).

31. Pressure System - Consits of the instrument housing seals, and pressure monitoring sensor. Failure will compromise sensor data (Criticality II).

32. Encoder - Provides means of converting source sensor data into binary form for transmittal back to earth receiving station. Failure will be critical to LSG operation (Criticality II).