Bendix

Aerospace Systems Division

NO.	REV. NO.
ATM 868	A

Failure Modes and Effects Analysis - LRRR

PAGE 1 OF 11

DATE 20 August 1970

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CONTENTS

1.0 INTRODUCTION

The purpose of the Failure Modes and Effects Analysis (FMEA) is to discover critical failure areas in the LRRR experiment and to remove susceptibility to such failures. Each possibility of failure is considered in light of its probability of occurrence and its effect on mission success. Corrective action may then be recommended for the critical failure areas.

ATM 868 contains the results of a final FMEA for the LRRR experiment.

2.0 SUMMARY

Since an LRRR was successfully deployed on the moon as a part of the Apollo 11 mission, this FMEA will not dwell on the aspects of the Apollo 14 LRRR which are identical to those of Apollo 11. The primary area of interest is the completely redesigned supporting structure and the consequent change in method of deployment.

3.0 DISCUSSION

The approach in this analysis is as follows:

1. Define LR^3 mission functions to be performed.
2. Define hardware elements performing each function.
3. Define the ways in which these hardware elements may fail to perform, the effect on experiment success, and the probability of such failure occurring.
4. Select those items from (3) which have significant effect on experiment success plus significant probability of occurring. These items may then be the basis for reliability improvement recommendations.

3.1 Mission Functions and Associated Hardware

Figure 1 summarizes the major functions to be performed in connection with LRRR from launch through 10 years on the lunar surface.

Table I summarizes the significant failure modes within the experiment and is referenced to Figure 1 through the symbols assigned to the blocks. Where applicable, Table I specifies the hardware element, or elements, associated with a specified mission function.

3.2 Failure Modes and Effects Summary

In Table I, under both the Seriousness and Probability of Occurrence columns, only two entries appear--Negligible and Significant. This approach has been taken under the following rationale: The usual approach would be to assign a numerical rating to both Seriousness and Probability of Occurrence, then to multiply one by the other to arrive at a measure of criticality. These criticality rankings would then be ordered and corrective action applied in accordance with the ordered criticality. With this type of approach, considerable effort is expended on the assignment of numbers to items which have little chance of requiring corrective action. In effect, the decision on where corrective action will be applied is delayed until all items are ranked and even then there is the question of how critical an item must be ranked in order to receive attention. The negligible vs. Significant approach requires a decision on an as-you-go basis. To label something Negligible states immediately that nothing further will be done on the item. To label it Significant (both on seriousness and probability of occurrence) is to say that an attempt must be made to upgrade the reliability of this item.

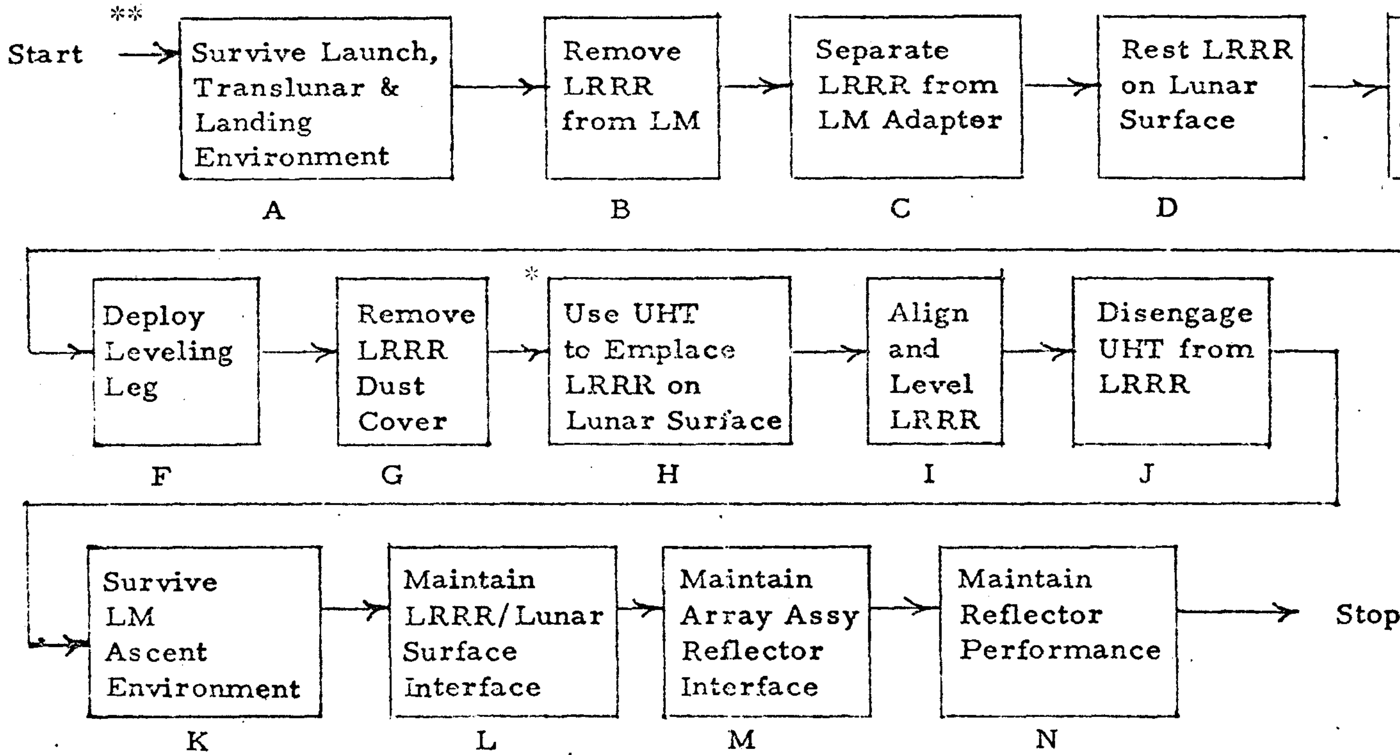
This column labeled "Detectable During" is used to indicate those tasks within the program which can add to (or subtract from) confidence in the experiment reliability. Therefore both analysis and test are included where applicable.

4.0 RESULTS AND CONCLUSIONS

The results of the analysis are summarized in Table I. Because of the structural nature of the hardware and its inherent tolerance to predictable mechanical stresses, Table I does not include entries pertaining to the prelanded environments. In addition, analysis relating to the Array, blocks M and N, is omitted since this hardware is essentially identical to that which is currently operational on the lunar surface. Items which are GFE and therefore beyond our control are also not included.

The failure modes and effects of blocks O through F are tabulated in Table I. Of these, only D requires further investigation. If in the process of resting the LRRR on the lunar surface, the assembly is tilted in excess of 13° toward the array side, it will tip over onto the top face of array. The angle for tipover onto the support side is 27°. Of these two possibilities, tipover onto the array side could result in lunar dust collecting on the dust cover and possibly at the dust cover/array interface. This may lead to possible dust deposits on the array face when the dust cover is removed. Tipover onto the structure side is not considered to be a problem since the array would not come into contact with the lunar surface and the package can be righted by the astronaut.

Concerning blocks E through J, failure of the associated hardware for any of these mission functions is considered to be serious. The probability of occurrence, however, is negligible.



* UHT is implaced in UHT Socket Interface prior to removal of LRRR Dust Cover

** The loss of corners due to environmental stress during transportation to the lunar surface would result in a linear degradation of the return signal to earth. A design safety factor has been included in the Array to preclude the probability of corners fracturing due to environmental stress.

Figure 1 Mission Functions for LRRR

TABLE I
SUMMARY OF LRRR FAILURE MODES
AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrance	Detectable During	Contingencies
Rest LRRR on Lunar Surface	D	Back Rest Assembly	Tip over onto Array	Significant	Significant	Crew Training	Astronaut should partially inbed back rest assembly in lunar surface to prevent LRRR from tipping over. In the event LRRR tips over to Array, Astronaut must use handle end of UHT to retrieve experiment.
			Tipover onto pallet	Negligible	Significant	Crew Training	Astronaut must use handle end of UHT to retrieve experiment.
Carry LRRR to Deployment Site	E	Handle	None Assumed	N/A	N/A	N/A	None

TABLE I (cont)
SUMMARY OF LRRR FAILURE MODES
AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrence	Detectable During	Contingencies
Deploy Leveling Leg	F	Pull Pin	Stuck Pin	Significant	Negligible	Functional Tests	In the event astronaut cannot remove pull pin to deploy leveling leg, he should use lunar soil or lunar rock and bubble leveler to deploy LRRR.
		Latching Mechanism	Spring Failure	Significant	Negligible	Functional Tests	In the event of spring failure in latching mechanism, astronaut should use lunar soil or lunar rock and bubble leveler to deploy LRRR.

TABLE I (cont)
SUMMARY OF LRRR FAILURE MODES
AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrence	Detectable During	Contingencies
*Remove LRRR Dust Cover	G	Lanyard	Broken Lanyard	Significant	Negligible	Crew Training	If lanyard breaks, astronaut should attempt to manually remove Dust Cover using MESA tool or UHT. Dust Cover is transparent, therefore inability to remove Dust Cover would result in degradation of scientific data, but some data would be available.
Use UHT to Emplace LRRR on Lunar	H	UHT/UHT Socket Interface	Failure of Tool to Engase Socket	Significant	Negligible	Functional Tests	Second UHT Socket available. If astronaut still unable to engage UHT into second socket, he should use handle of UHT to tilt experiment over.

*Engaging UHT to UHT Socket Interface is performed prior to removal of Dust Cover.

TABLE I (cont)
SUMMARY OF LRRR FAILURE MODES
AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrence	Detectable During	Contingencies
Align & Level LRRR	I	UHT/UHT Socket Interface	Fracture of Tool and/or Socket at Interface	Significant	Negligible	Crew Training	If UHT disengages from Socket, astronaut should attempt to align and level LRRR using second socket. If astronaut unable to engage UHT to second socket, he can physically align LRRR using boot.
		Gnomen/ Sun Compass	Bent Gnomen	Significant	Significant	Functional Tests	Return signal to Earth has tolerance of 4 miles. If Gronmen bent sufficently, experiment may be an abort.
		Bubble Level	Fracture	Significant	Negligible	Note 1	

NOTE 1 - Identical Level Survived Apollo 11 Missions.

TABLE I (cont)
SUMMARY OF LRRR FAILURE MODES AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrence	Detectable During	Contingencies
Disengage UHT from LRRR	J	UHT/UHT Socket Interface	Failure of Tool to Disengage from Socket	Significant	Negligible	Crew Training	None