This ATM documents the Reliability Prediction for the LEAM. It reflects the information available at the PDR of the subcontractor, Time Zero.

This preliminary ATM will be updated for CDR.

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1.0 INTRODUCTION

This Reliability Prediction is prepared in accordance with the requirements of paragraph 5.5.2 of the Reliability Program Plan for ALSEP Flight Array E, BSR 3024, ALSEP RA-08. The prediction is a numerical probability of success for the Lunar Ejecta and Meteorite Experiment (LEAM). The prediction covers the Flight Unit.

1.1 Conditions

The following conditions are basic and obligatory when λ (Failure Rate) is employed as a unit of measurement for reliability. Mathematically, λ is defined in the equation:

$$R = e^{-t\lambda}$$

Where R is the desired probability of success
e is the base of naperian logarithms
T is the length of time for which failure-free operation is desired
λ is failure rate.

1.1.1 Condition 1

It is assumed that there exists a constant hazard rate for the equipment under use for the entire period during which data are gathered; i.e., there is no wearout occurring in the equipment, except for certain portions of the Squib section.

1.1.2 Condition 2

It is assumed that all failures are random; i.e., failures are statistically independent.

1.1.3 Condition 3

It is assumed that the environment in which the equipment is operating during the entire period is at a temperature of less than +65°C and the time under which the equipment is subjected to increase stress due to launch, orbit or landing is extremely short compared to the mission life of two years. This period of stress is estimated at 0.1 hours so that increase failure rates when compared to 17,520 hours is insignificant.

1.1.4 Condition 4

It is assumed that, upon repair, 100 percent restoration of life for the entire equipment occurs and that the equipment is in proper working order at the start of mission life.

1.1.5 Condition 5

It is assumed that each failure has a criticality proportional to the amount of information it would prevent the LEAM from passing to the central station. These categories of failures, CR1, CR2, CR3 and CR4 are defined in paragraph 2.1.

1.1.6 Condition 6

It is assumed that all failures are independent in both cause and effect; i.e., each failure can be totally isolated and repaired.

1.1.7 Condition 7

When redundancy is applied it is assumed that a failure of a portion of the equipment will not affect other portions. In order to apply redundancy the switch over must be automatic or capable of being switched over from an external source. Operation at reduced capability does not imply full performance but reduced to a stated figure, without secondary effects.

1.1.8 Condition 8

The voltage, current, power, or other electrical stress applied to each component part is within the region recommended for reliable operation.

1.2 Referenced Time Zero Drawing

This prediction is preliminary and is based upon drawing, parts list and sketches that are not released documents. In addition, BxA has drawn upon the PDR copies of the TZ preliminary reliability prediction and FMECA. In determining the number of piece parts in some sections it was necessary to estimate the quantity and types.

2.0 DESCRIPTION OF EXPERIMENT

The experiment consists of two identical dual sensors, each supplying 40 bits of information that make up four words and a single sensor with 18 bits for two words. The total word count is 10 with each word consisting of 10 bits. The system is designed to provide this information in a series form so that the data is transferred to ALSEP as a series (single line). This arrangement is shown in Figure 1, system functional block diagram.

3.0 RELIABILITY CALCULATIONS

3.1 Preliminary Considerations

The probability of success of the LEAM can be defined as the probability of the LEAM returning some percent of the scientific data collected, to the central station, for 2 years.

The normal way of calculating this would be to first, construct a reliability logic diagram following the hardware breakdown shown in the FMECA. Figure 2 is this diagram.

Each block is identified with a name, Q number, a block criticality number and an identifying number.

The block criticality number identifies the sensitivity of the block to the amount of scientific data returned:

CR1 parts are those whose failure will result in loss of all data.

CR2 parts are those whose failure will result in the loss of more than 50% of the data but less than all data.

CR3 parts are those whose failure will result in the loss of some data but less than 50%.

CR4 parts are those whose failure will result in a loss of no data.

The Q number is the "weight" of the block, a measure of the of the failure probability. It is defined as follows;

$Q = \alpha\lambda T$ Where α is a modifier that refers to types of failure

λ is the failure rate

T is the time operation, (17520 hours)

3.2 Reliability Calculations

The reliability of the LEAM for 100% of data return (referring to figure 2) can be calculated by considering all CR1, CR2 and CR3 blocks in series;

$$R_{(AB)\ (\text{All Data})} = \begin{matrix} R1\ R2\ R3\ R3.1\ R4\ R5\ R6\ R7\ R8\ R9\ R10 \\ R11.1\ R11.2\ R12\ R13\ R16\ R17\ R18\ R19\ R20 \end{matrix}$$

Similarly, the Reliability of LEAM for over 50% of data return can be calculated by considering all CR1 and CR2 blocks in series;

$$R_{(AB)\ (>50\%\ \text{Data})} = R11.1\ \ R12\ \ R16\ \ R17\ \ R18\ \ R19$$

BxA feels that a meaningful reliability number cannot be calculated at this time for several reasons;

1. The FMECA does not include all components.
2. The logic gate failure rates have not been sufficiently defined.
3. The Power Supply inductor and transformer failure rate have not been adequately defined.
4. The thermistor failure rates have not been adequately defined.
5. The effect of heater control on the ultimate success has not been adequately defined.

3.3 Continuing Effort

In order that a meaningful reliability number can be calculated prior to CDR the following actions are now under way:

1. The FMECA is being revised and expanded to consider all circuit elements to the piece part level. The revised and completed FMECA should be ready at CDR.
2. Additional usage data for the logic gates is being collected and will be documented at CDR.
3. The basic failure rates of inductors and transformers are being reevaluated in light of the apparently rigorous quality control effort at the subcontractor's.
4. The failure rate and reliability modeling of the thermistors are being reevaluated. This reevaluation should be completed prior to CDR.
5. The effect of no heat and alternate heater control is being investigated and should be completed prior to CDR.

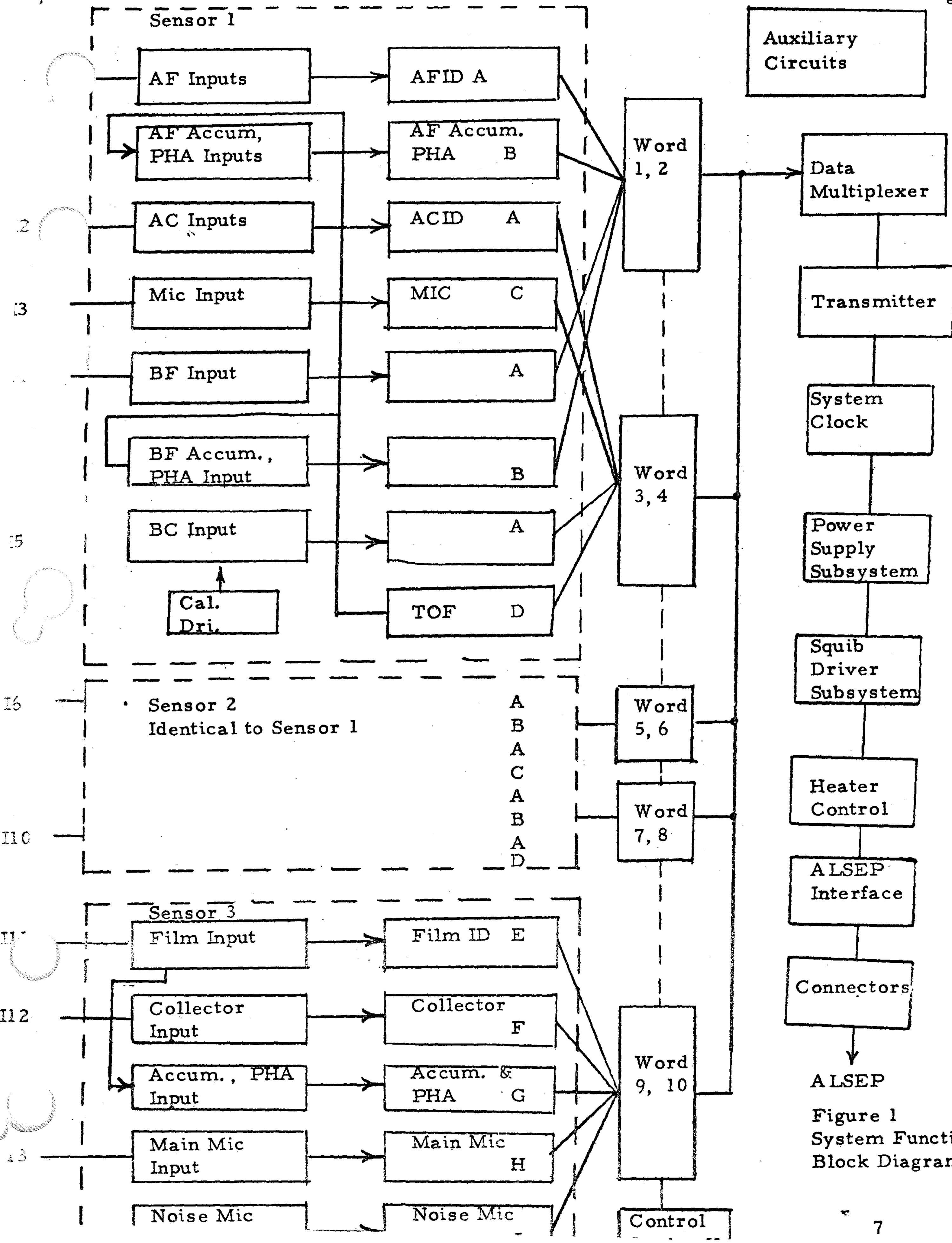
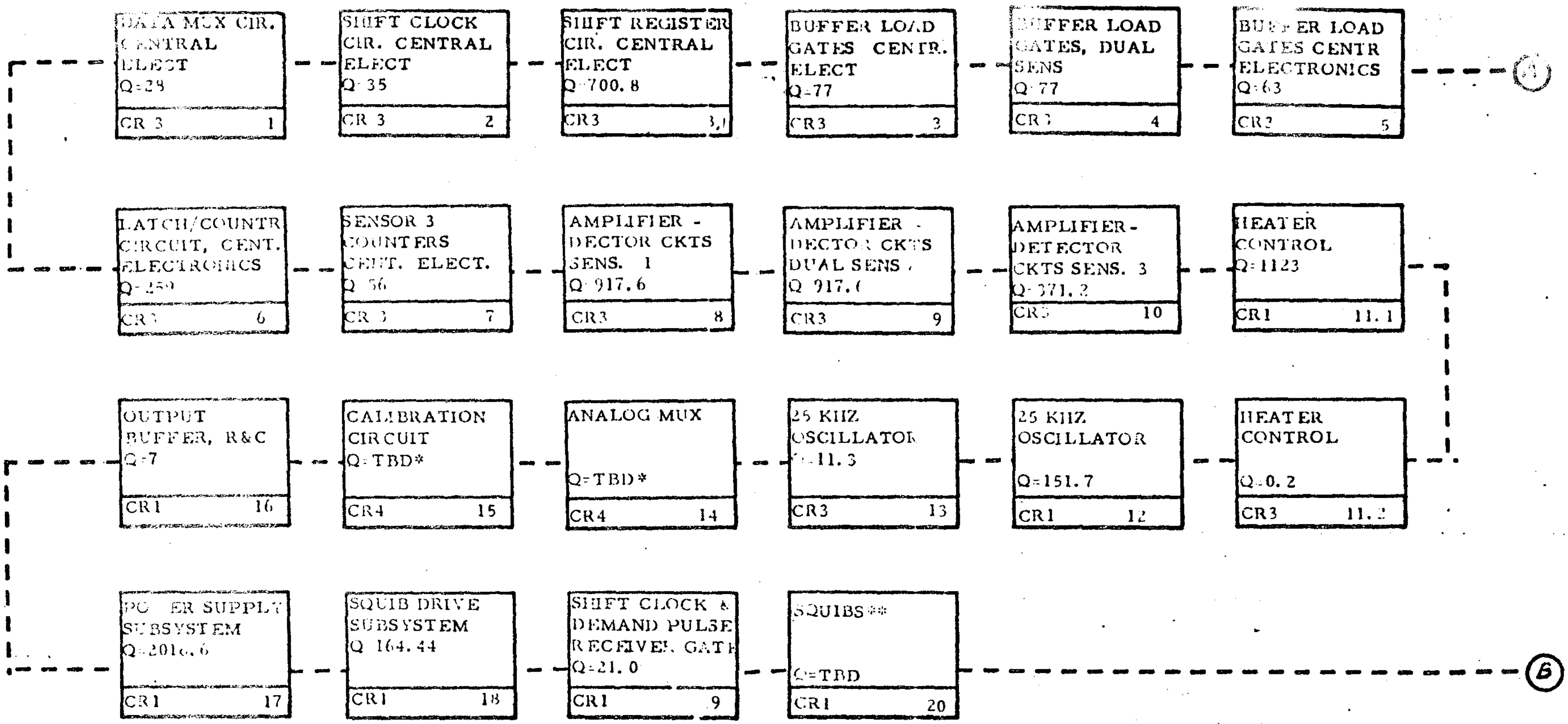


Figure 1
System Functional
Block Diagram



$$R_{(AB)} = \prod_{1}^{20} e^{-Q \times 10^{-5}}$$

*BECAUSE THESE ITEMS ARE CR4 THEY WILL NOT BE USED IN THE RELIABILITY CALCULATION.

**THIS ITEM WAS NOT INCLUDED IN THE ANALYSIS BECAUSE OF REDUNDANCY.

FIG 2.

RELIABILITY
SINGLE THREAD ANALYSIS
OF THE PROBABILITY OF
RETURN OF 100% OF LEAM
DATA FOR TWO YEARS