This EATM contains preliminary reliability predictions which reflect performance of the PSE and central station when deployed on the lunar surface and activated by solar cell power.

The probabilities of successfully transmitting data through the downlink, surviving lunar night and turning on the next lunar morning are presented.

Prepared by: R. Jones
Ralph Jones
Reliability Engineer

Approved by: James E. McGrath
James McGrath
EASEP Reliability Manager

RJ:vsw
Standard Distribution

1.0 OBJECTIVES

This initial prediction was undertaken to analyze through Reliability math model techniques, the probability of obtaining worthwhile experiment and engineering data from the EASEP PSE and the central station. Because of the different temperature environments between ALSEP and EASEP, particularly the lower thermal plate temperatures, a more severe trial of the microcircuit flatpacks and the tantalum capacitors is anticipated. Accordingly, failure rates for both types have been adjusted to reflect the latest test data available at this time. Recognizing the end effect of using such failure rates, EASEP reliability has a parallel effort underway to test a representative lot of these components to EASEP environments and fully investigate the data from other sources. Accomplishing this, the prediction will then be updated and republished.

2.0 SUMMARY OF RESULTS

A reliability prediction for the EASEP PSEP subsystem has been made considering the anticipated lunar thermal environment ranging from +140° F to -65° F. Because of the effect that the low temperatures have on increasing the failure rate of flatpacks and tantalum capacitors, the reliability model considers the lunar day and lunar night predictions separately to show the comparative success probabilities. These are combined to give subsystem reliability for the complete lunar cycle. The block diagram of the model shows those subassemblies in EASEP that contain and are most affected by the changing failure rates from lunar day to lunar night.

For the EASEP PSEP subsystem, the reliability for the day portion of the lunar cycle was determined to be

$$R_1 = .991$$

For the night portion, $R_2 = .521$.

The probability that the EASEP PSEP subsystem will turn on the second lunar day and be fully operational is equal to the probability, R_{LC}, of the total system surviving, without a failure, the complete lunar cycle, where

$$R_{LC} = .516.$$

The reliability numbers obtained with this model are most pessimistic since they do not reflect possible degraded modes of EASEP operation.

A downlink reliability model for EASEP-PSE subsystem was also developed assuming the 90 channel Analog Multiplexer and the Passive Seismic Experiment to operate in parallel redundancy. This models the successful transmission to earth of either housekeeping or scientific data and excludes the Command Decoder and Command Receiver from the computations since the downlink transmission is not dependent on either of these subassemblies. For a complete lunar cycle, the probability of being able to establish downlink the second lunar morning is

$$R_T = .902.$$

3.0 ASSUMPTIONS

Several assumptions regarding the nature of the failure rates used in this prediction are as follows:

1. ALSEP failure rates apply directly to EASEP for the day portion of the lunar cycle.

2. Flatpack failure rates for the lunar night are based on a preliminary analysis of Goddard Space Flight Center test data which indicated a rate of .0024 failure/lunar night. This failure rate is regarded as pessimistic because it reflects only the rate at which flatpacks "drop out" during the low temperature portion of the cycle. It does not reflect the probability of recovery during the high temperature swing. This phenomenon has been observed in the so-called old-process flatpacks. However, insufficient data are presently available upon which a quantitative assessment can be made.

3. Tantalum failure rates for lunar night are a factor of 10 greater than that for lunar day from Vendor discussions of tantalum failure mechanism.

4. Only flatpacks and tantalum capacitor failure rates are adversely affected by the temperatures of lunar night.

5. Isotope heater reliability is assumed to be 1.0 for calculation purposes.

6. Lunar Day = Lunar Night = 14 twenty-four hour earth days.

It should be noted that those decode gates in the Command Decoder and the Experiment Power Control Circuits in the PDU have been excluded from the calculations since they would have no effect on EASEP reliability although they are part of the ALSEP Data Subsystem.

4.0 CONCLUSIONS

The predictions made for this subsystem were made without consideration of the possible degraded modes of operation. Further reliability prediction efforts should center around investigating some of these alternate operating modes of interest, namely:

(a) Probability of being able to shut off the transmitter via uplink command capability after 12 lunar cycles.

(b) Probability that it will be necessary to turn off the transmitter after 12 lunar cycles.

(c) Other potentially interesting operational modes.

EASEP PSEP SUBSYSTEM RELIABILITY MODEL REFLECTING UPLINK AND DOWNLINK CAPABILITY

R_1 = EASEP Probability of no Failures for Day Portion of the Lunar Cycle

$$= \prod_{i=1}^{6} R_{1i} = .99108$$

$R_{11} = .999996$	$R_{12} = .9993$	$R_{13} = .99826$	$R_{14} = .99785$	$R_{15} = .99856$	$R_{16} = .99711$
Transmitter Control Flatpack $n_1 = 1$	Command Decoder $T_2 = 12$ $n_2 = 347$	Data Processor $T_3 = 4$ $n_3 = 276$	PDU $T_4 = 4$ $n_4 = 17$	Central Station P/0 $T_5 = 72$ $n_5 = 1$	PSE $T_6 = 41$ $n_6 = 50$
$R_{21} = .9976$	$R_{22} = .65181$	$R_{23} = .9471$	$R_{24} = .9583$	$R_{25} = .99666$	$R_{26} = .88603$

*t = 692 = C/S Flatpac[k]

R_2 = EASEP Probability of no Failures for Night Portion of Lunar Cycle

$$R_2 = \prod_{i=1}^{6} R_{2i} = .52115$$

$R(x)_{LC} = (R_1 \times R_2)^x$ = Probability of no Failures for x Complete Lunar Cycles

	x = 1	x = 2	x = 4	x = 6	x = 8	x = 12
$R(x)_{LC}$ =	.51650	.26677	.07117	.01899	.00506	.00036

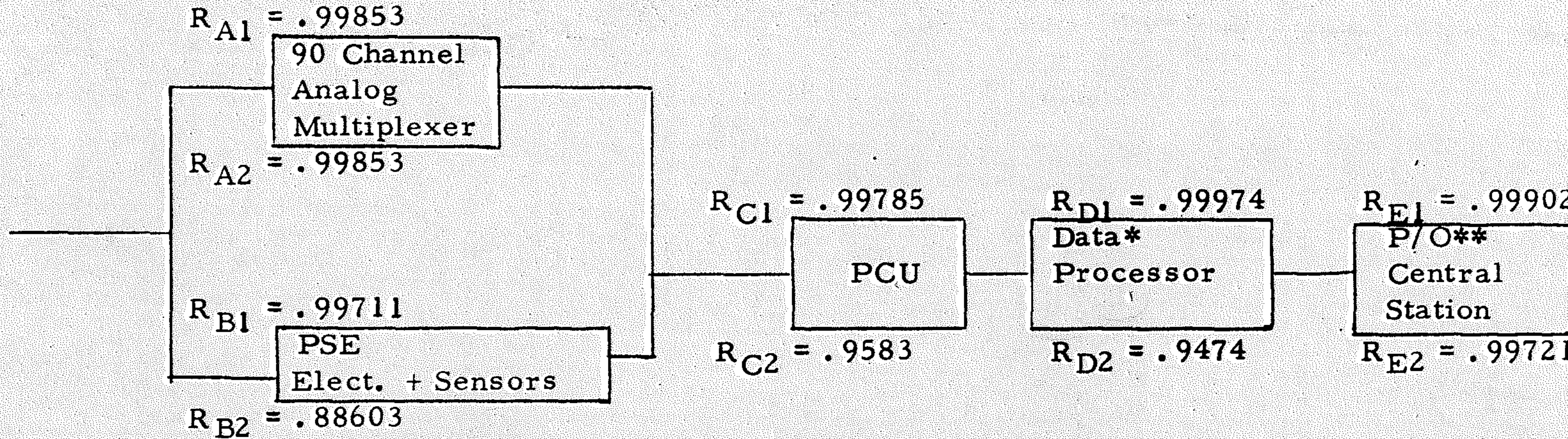
FIGURE 1

n_i = number of flatpacks in the ith subassembly
n_t = total number of flatpacks = 692
T = tantulum capacitor distribution in the i^{th} subassembly.

* This part of the Central Station includes the antenna, diplexer filter, command receiver, transmitter PCU, structural-thermal and the solar cell array subassemblies.

EASEP DOWNLINK RELIABILITY MODEL

Success Probability, R_T, for Maintaining Downlink on EASEP, i.e., Transmitting Valid Engineering Housekeeping or Scientific Data Assuming the Command Link is Functioning.



$$R_T = (R_A + R_B - R_A R_B) R_C \cdot R_D \cdot R_E$$

Lunar Day $R_{T1} = (.999996)(.99785)(.99974)(.99902) = .99660$

Lunar Night $R_{T2} = (.99984)(.9583)(.9474)(.99721) = .90521$

R_T (A Lunar Cycle) $= R_{T1} \times R_{T2} = .90213$

FIGURE 2

* - 90 channel multiplexer not included in this block

** - this part of the Central Station includes the antenna, diplexer filter, transmitter and transmitter control, PCU structural-thermal and solar cell array subassemblies

R_{T1} = Lunar Day Probability of Success

R_{T2} = Lunar Night Probability of Success

Success Probability, R_T*, for Maintaining Downlink on EASEP, i.e., Transmitting Valid Engineering Housekeeping or Scientific Data Assuming No Command Link Exists

$$R_{T1} = (.999996)\,(.99785)\,(.99834)\,(.99817) = .99436$$

$$R_{T2} = (.99984)\,(.9583)\,(.7129)\,(.99634) = .68057$$

$$R_T = .67673$$

FIGURE 3