Bendix Aerospace Systems Division

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ALSEP ARRAY A2 DESCRIPTION INCLUDING THE HEAT FLOW EXPERIMENT

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This ATM provides a brief description of the ALSEP Array A2 system configuration which includes the Heat Flow Experiment.

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1.0 INTRODUCTION

This ATM provides a description of the latest configuration for the ALSEP A2 Array and includes modifications which have been incorporated into the system to include the Heat Flow Experiment. Additionally, functional characteristics unique to this five experiment system are described to indicate differences from other ALSEP arrays.

2.0 GENERAL

With the addition of the HFE, the A-2 Array will include the following five (5) experiments:

Experiment	PDU Power Circuit No.	Ripple-Off Order
PSE	#1	Third
LSM	#2	-
SWS	#3	Second
SIDE	#4	First
HFE	#5	-

The original concept of a third subpackage to accommodate the HFE has been abandoned. As a result, subpackage #2 has been reconfigured to accept the HFE, mounted on a subpallet. The ALHT and ALSD will not be carried on ALSEP but will be stowed elsewhere in LM.

3.0 ELECTRICAL MODIFICATIONS TO CENTRAL STATION

To add the HFE to the System, the experiment must be provided with a connector, power, control signals, commands, analog engineering data channels and a word allocation in the telemetry format. These provisions are to be made with minimum change to the Central Station hardware. They are summarized in Table 2 while System requirements are shown in Table 1.

3.1 POWER SWITCHING

Experiment Power Control Circuit No. 5, within the Power Distribution Unit (PDU) will be disconnected from the Central Station heaters and be assigned to the HFE. The experiment power will be commandable in a manner identical to other experiments. It should be noted that Experiment Power Control No. 5, to which the HFE will be connected, is not included in the ripple sequence. Additionally, this power control circuit is not connected to astronaut switch no. 3; therefore, the HFE can be placed in the operating mode (operating power applied) by command only. Initial conditions for lunar deployment will be to turn on with all experiments in standby and then command to the operate mode when the uplink is established. To retain the systems power management features, the following changes will be made in the power dump and internal dissipation circuits.

a. The thermostatically controlled heater resistors (DSS Heater #3) and the thermostat will be removed. This PDU power control circuit (K18) will be re-assigned to the 10-watt thermal plate heater string (DSS Heater #1) which was connected to Experiment #5 Operate Position. Consequently, Command 024 will turn DSS Heater 1 to the ON condition and Command 025 will turn it OFF. Initial conditions for lunar deployment will be "DDS Heater 1 OFF".

TABLE 1

SYSTEM IMPLICATIONS

	LIMITATION	A-2	A-2 + HFE
SCIENCE DATA	64 WORDS AVAILABLE	64 WORDS ASSIGNED	HFE REQUIRES 1 WORD REDUCE PSE SP FROM 29 TO 28 WORDS
HOUSEKEEPING DATA	90 CHANNELS	78 ASSIGNED TO A2	85 CHANNELS REQUIRED 6 HFE CHANNELS AVAILABLE IN MUX ? 7th Chnl
COMMANDS	100 COMMANDS AVAILABLE	66 COMMANDS ASSIGNED	76 COMMANDS REQUIRED HFE REQUIRES 10 CMDS PRESENTLY AVAILABLE IN CMD DECODER
POWER SWITCHING	5 EXPERIMENT POWER CIRCUITS IN PDU	4 ASSIGNED TO EXP. 1 ASSIGNED TO C/S HTRS	USE ALL 5 CIRCUITS FOR EXP's C/S HTR USE EXISTING BACKUP HTR CMD FOR 10 WATT HTR
EXPERIMENT INTERFACE CONNECTIONS		4 INTERFACE CONNECTORS	HFE REQUIRES ADDITION OF CONNECTOR AND WIRING

TABLE 2

ELECTRICAL IMPLEMENTATION

CONNECTOR PANEL	-	ADD NEW HFE ASTRO MAKE CONNECTOR BESIDE RTG INPUT CONNECTOR: MOVE J24 CONNECTOR TO PROVIDE SPACE
HARNESS	-	39 WIRES FROM HFE CONNECTOR TO NEW PRINTED CIRCUIT BOARDS.

POWER & RETURNS	-	17 WIRES
DATA	-	5 WIRES
ANALOG TELEMETRY	-	7 WIRES
COMMAND	-	10 WIRES

DATA PROCESSOR	-	REQUIRES MULTIFORMAT COMMUTATOR CHANGE FOR REALLOCATION OF 1 WORD
C/S HEATER	-	DELETE 10 WATT THERMOSTATICALLY CONTROLLED HEATER, WIRE 5 AND 10 WATT HEATERS TO PDU POWER CONTROLS
POWER DUMP	-	DELETE 7 WATT DUMP AND USE THIS CONTROL CIRCUIT FOR 5 WATT INTERNAL DUMP

b. The PDU Power Control Circuit presently assigned to the 7 watt power dump (PDR #1) will be re-assigned to the 5 watt (DSS Htr #2) thermal plate heater string which was originally connected to the Experiment #5 stby position; therefore, Octal Command 017 will turn the 5 watt thermal plate heater ON and Octal Command 021 will turn it OFF.

In summary, the 10 watt thermostatically controlled heater will be deleted as will the 7 watt power dump. The 14 watt power dump (PDR #2) and the 5 and 10 watt thermal plate heaters will be retained. These changes are accomplished by harness changes and will not require entry into any component.

3.2 CONTROL SIGNALS, COMMANDS AND HOUSEKEEPING

All necessary control signals, commands and analog housekeeping channels are available at component connectors and are provided by adding the necessary harness wires. To interface these copper harness wires with the manganin wires, two small (approx. 2" x 2") printed circuit boards will be added; one on each side of the digital data processor connector. Figure 1 shows the location of these boards and the heater resistors. These PCB's will also provide the RC networks for pulse rise/fall time control. Tables 3 and 4 define the Housekeeping Word and Command Assignments for the A2 Array.

3.3 TELEMETRY WORD ASSIGNMENT

The new telemetry format with HFE assigned to Word 24 is shown in Figure 2. This word was one of 29 words originally assigned to the PSE short period Seismometer. Its re-assignment will very slightly reduce the PSE Short Period data rate.

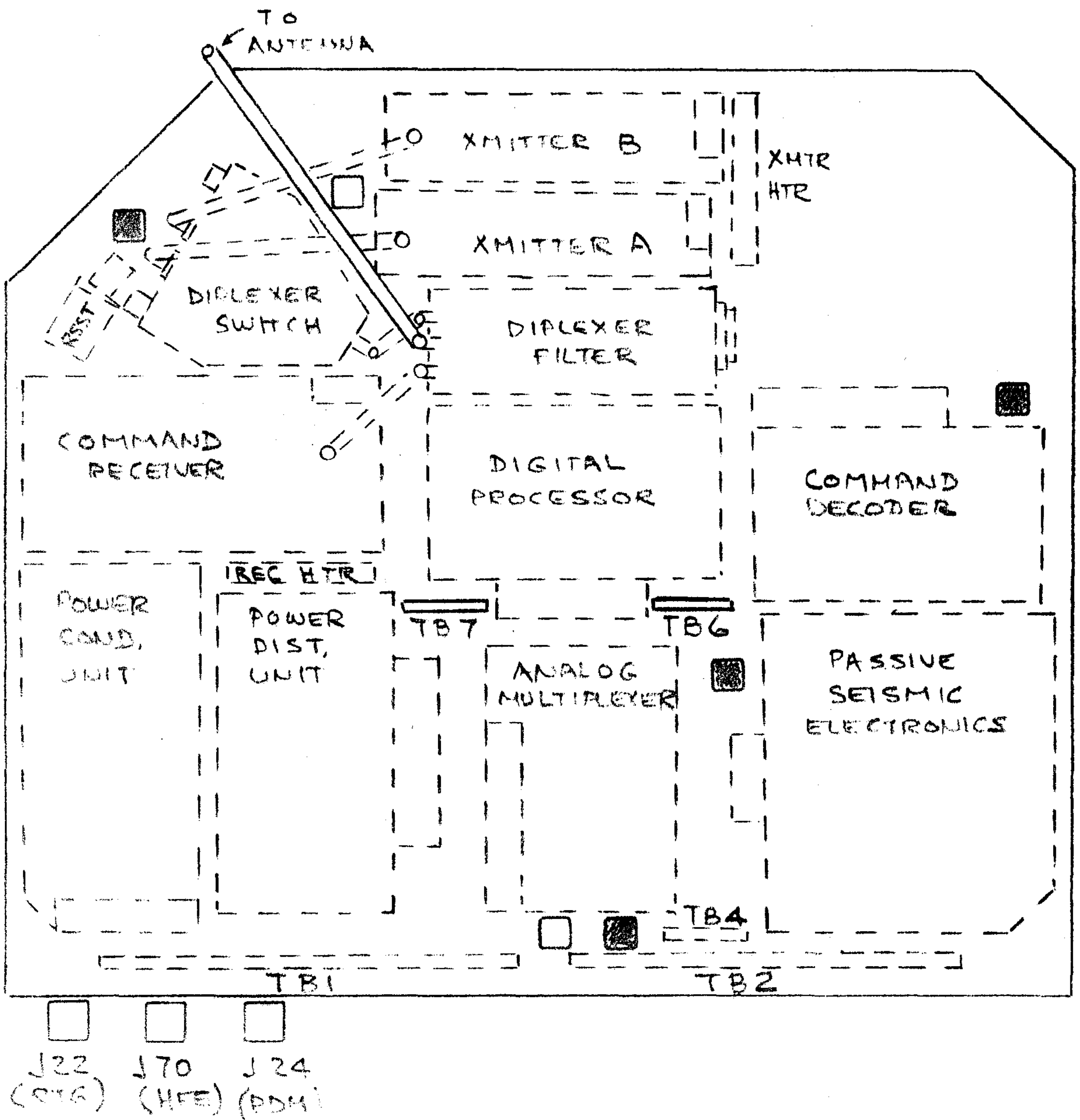
To make the change, the digital data processor's multiformat commutator boards must be modified.

3.4 CONNECTOR

All wires required to meet the HFE interface will be brought to a single connector mounted on the connector panel near J22.

FIGURE 1

HEATER ARRANGEMENT
WITH H. F. E. IN SYSTEM



Legend

□ 5 watt Commandable Heater (DSS Htr 2) Commands 017 & 021

■ 10 watt Commandable Heater (DSS Htr 1) Commands 024 & 025

TB 7 P. C. Board for Power, Housekeeping & Data Lines of H. F. E.

TB 6 P. C. Board for Command Lines (R-C Network) of H. F. E.

TABLE 3

Array A-2/HFE Housekeeping Channel Assignments (Word 33)

00	BLANK
01	PCU INPUT VOLTAGE
02	ADC CALIBRATION 0.25V
03	ADC CALIBRATION 4.75V
04	THERMAL PLATE TEMP #1
05	PCU INPUT CURRENT
06	HOT FRAME 1 TEMP (R1-1)
07	COLD FRAME 1 TEMP (R3-1)
08	RESERVE POWER #1 (CURRENT)
09	RCVR, 1 KHz SUBCARRIER PRESENCE
10	TIMER 18 HOUR STATUS
11	TIMER 1-1/2 MO. #1 STATUS
12	EXP STATUS 1 & 2
13	RESERVE POWER #2 (CURRENT)
14	EXP STATUS 3, 4, & 5
15	BOTTOM STRUCTURE TEMP
16	RCVR L.O. CRYSTAL A TEMP
17	RCVR L.O. CRYSTAL B TEMP
18	XMTR A CRYSTAL TEMP
19	XMTR A HEAT SINK TEMP
20	PCU OUTPUT VOLTAGE (+29V)
21	RCVR, PRE-LIMITING LEVEL
22	XMTR B 29VDC CURRENT
23	PSE LP AMPL GAIN (X &Y)
24	PSE LEV. & COARSE SENSOR MODE
25	DATA PROCESSOR X ON/OFF STATUS
26	DUST CELL #2 OUTPUT
27	SUNSHIELD TEMP #1
28	THERMAL PLATE TEMP #2
29	HEAT FLOW SUPPLY VOLT #1
30	DUST CELL TEMP
31	XMTR B CRYSTAL TEMP
32	XMTR B HEAT SINK TEMP
33	MUX BASE TEMP
34	MUX INTERNAL TEMP
35	PCU OUTPUT VOLTAGE (+15V)
36	RCVR, LOCAL OSC. LEVEL
37	HOT FRAME 2 TEMP (R1-2)
38	PSE LP AMPL GAIN (Z)
39	PSE THERMAL CONTROL STATUS
40	RESERVE POWER #2 (CURRENT)
41	DUST CELL #3 OUTPUT
42	SUNSHIELD TEMP #2
43	THERMAL PLATE TEMP #3
44	RESERVE POWER #1 (CURRENT)
46	DIGITAL D. P. BASE TEMP
47	DIGITAL D. P. INTERNAL TEMP
48	COMMAND DECODER BASE TEMP
49	COMMAND DECODER INTERNAL TEMP
50	PCU OUTPUT VOLTAGE (+12V)
51	XMTR A R.F. POWER
52	HOT FRAME 3 TEMP (R1-3)
53	PSE LEVEL DIRECTION & SPEED
54	PSE CAL STATUS LP & SP
55	HEAT FLOW SUPPLY VOLT #3
56	DUST DET EXTERNAL TEMP
57	HEAT FLOW SUPPLY VOLT #6
58	THERMAL PLATE TEMP #4
59	LEFT SIDE STRUCTURE TEMP
60	INNER MULTILAYER INSULATION TEMP
61	COMMAND DEMODULATOR VCO TEMP
62	PDU BASE TEMP
63	PDU INTERNAL TEMP
64	PCU OSCILLATOR #1 TEMP
65	PCU OUTPUT VOLTAGE (+5V)
66	XMTR B R.F. POWER
67	COLD FRAME 2 TEMP (R3-2)
68	PSE SP AMPL GAIN (Z)
69	PSE UNCAGE STATUS
70	SIDE L.E. DET. COUNT RATE
71	THERMAL PLATE TEMP #5
72	OUTER MULTILAYER INSULATION TEM
73	BLANK
74	HEAT FLOW SUPPLY VOLT #4
75	HEAT FLOW SUPPLY VOLT #7
76	PCU OSCILLATOR #2 TEMP
77	PCU REGULATOR #1 TEMP
78	PCU REGULATOR #2 TEMP
79	PCU OUTPUT VOLTAGE (-12V)
80	PCU OUTPUT VOLTAGE (-6V)
81	XMTR A 29VDC CURRENT
82	COLD FRAME 3 TEMP (R3-3)
83	DUST DET INTERNAL TEMP
84	DUST CELL #1 OUTPUT
85	SIDE H.E. DET. COUNT RATE
86	TIMER 1-1/2 MO. #2 STATUS
87	RIGHT SIDE STRUCTURE TEMP
88	PDM TEMP
89	BLANK

TABLE 4

ARRAY A-2/HFE COMMAND ASSIGNMENTS (OCTAL)

003	ACTIVE SEISMIC ON
[illegible]	ACTIVE SEISMIC OFF
[illegible]6	NORMAL DATA RATE
007	SLOW DATA RATE
011	RESET X AND Y PROCESSOR
012	XMTR A SELECT
013	XMTR ON
014	XMTR OFF
015	XMTR B SELECT
017	DSS HTR 2 (5W) ON
021	DSS HTR 2 (5W) OFF
022	PDR LOAD 2 (14W) ON
023	PDR LOAD 2 (14W) OFF
024	DSS HTR 1 (10W) ON
025	DSS HTR 1 (10W) OFF
027	DUST DETECTOR ON
[illegible]1	DUST DETECTOR OFF
[illegible]2	TIMER OUTPUT ACCEPT
[illegible]33	TIMER OUTPUT INHIBIT
034	DATA PROCESSOR X ON
035	DATA PROCESSOR Y ON
036	EXP 1 POWER ON
037	EXP 1 POWER STANDBY
041	EXP 1 STANDBY OFF
042	EXP 2 POWER ON
043	EXP 2 POWER STANDBY
044	EXP 2 STANDBY OFF
045	EXP 3 POWER ON
046	EXP 3 POWER STANDBY
050	EXP 3 STANDBY OFF
153	EXP 4 POWER ON
053	EXP 4 POWER STANDBY
[illegible]4	EXP 4 STANDBY OFF
[illegible]5	EXP 5 POWER ON
056	EXP 5 POWER STANDBY
057	EXP 5 STANDBY OFF
060	SET 1 (PCU 1 SELECT)
062	SET 2 (PCU 2 SELECT)
[illegible]63	CHANGE GAIN LPX-LPY (PSE)
[illegible]4	GAIN CHANGE LPZ (PSE)
[illegible]65	CAL S. P. (PSE)
066	CAL L. P. (PSE)
067	GAIN CHANGE SPZ (PSE)
070	LEVELING POWER X MOTOR (PSE)
07[illegible]	LEVELING POWER Y MOTOR (PSE)

101	FEEDBACK FILTER (PSE)
102	COARSE SENSOR (PSE)
103	LEVELING MODE (PSE)
104	OCTAL COMMAND 104 (SIDE)
105	OCTAL COMMAND 105 (SIDE)
106	OCTAL COMMAND 106 (SIDE)
107	OCTAL COMMAND 107 (SIDE)
110	OCTAL COMMAND 110 (STROBE)
111, 112, 113, 114, 115, 117, 120, 121	CPLEE-NOT USED ON A2
122	DUST COVER REMOVAL (SWS)
123	RANGE SELECT (LSM)
124	STEADY FIELD OFFSET (LSM)
125	STEADY FIELD HOLD (LSM)
127	FLIP CALIBRATE INHIBIT (LSM)
131	FLIP CALIBRATE INITIATE (LSM)
132	FILTER FAILURE BYPASS (LSM)
133	SITE SURVEY (LSM)
134	THERMAL CONTROL SELECT (LSM)
135	NORMAL (GRADIENT) MODE SELECT (HFE)
136	RING-SOURCE CONDUCTIVITY MODE (HFE)
140	HEAT-PULSE CONDUCTIVITY MODE SELECT (HFE)
141	FULL SEQUENCE (HFE)
142	PROBE 1 SELECT (HFE)
143	PROBE 2 SELECT (HFE)
144	MEASUREMENT SELECT OCTAL 144 (HFE)
145	MEASUREMENT SELECT OCTAL 145 (HFE)
146	MEASUREMENT SELECT OCTAL 146 (HFE)
150	TIMER RESET
152	HEATER ADVANCE (HFE)
156, 160, 162, 163, 164, 165, 166, 170	ASE-NOT USED ON A2

TABLE 4 (CONT'D)
ARRAY A-2/HFE COMMAND ASSIGNMENTS (Octal)

[illegible]	UNCAGE (PSE)
074	LEVELING DIRECTION (PSE)
075	LEVELING SPEED (PSE)
076	THERMAL CONTROL MODE (PSE)
172	UNASSIGNED
174	SOLAR WIND SPARE

FIGURE 2

ARRAY A-2 WITH HFE

1 x	2 x	3 x	4 X	5 O	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 O	18 X	19 O	20 X	21 O	22 X	23 S	24 HF
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 o	36 X	37 o	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 1	48 X
49 O	50 X	51 O	52 X	53 O	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

Legend			Number of Words Per Frame
x	-	Control	3
X	-	Passive Seismic - Short Period	28
-	-	Passive Seismic - Long Period Seismic	12
o	-	Passive Seismic - Long Period Tidal and One Temperature	2
O	-	Magnetometer	7
S	-	Solar Wind	4
I	-	Suprathermal Ion Detector	5
CV	-	Command Verification (upon command, otherwise all zeros)	1
H	-	Housekeeping	1
HF	-	Heat Flow Experiment	1
		TOTAL	64

Each box contains one 10 bit word
Total bits per frame - 10 x 64 = 640 bits

3.5 FLAT CABLE LOCATIONS

This modification provides for permanent location and holding of the flat manganin cable assemblies relative to the thermal plate and thermal bag. This change is being implemented to eliminate the potential pinching of wires during the assembly of the central station.

3.6 RSST 3-MONTH OUTPUT OVERRIDE

A circuit is being included in the A-2 Harness which enables override of the transmitter off relay function in the RSST. This feature has been incorporated to permit continued operation of the system in the event of failure to reset RSST logic or premature time out of the RSST transmitter off function. The mechanization is such that if the transmitter is commanded off by the RSST function, a transmitter ON command will re-apply DC input power to the transmitter to re-establish the telemetry signal.

3.7 DATA PROCESSOR/MULTIPLEXER INTERFACE

The A-2 Harness and terminal board assembly includes a circuit to provide timing interface compatibility between the Data Processor and Multiplexer. This modification results in system performance identical to that in previous ALSEP Arrays. The new Multiplexer Design includes full redundancy on all 90 channels for both multiplexer and A/D converter.

Additionally, status telemetry has been added to identify the ON-OFF condition of the X Data Processor/Multiplexer. Channel 25 is used for this bi-level status information, with a high level indicating operation on the X side and a zero level indicating X side off or Y side on. The five (5) volt supply line from the PDU/DDP interface is used for this telemetry channel.

3.8 EXPERIMENT #4 POWER ON COMMAND

The command which controls the experiment #4 operate power functions in the PDU has been changed from Octal 52 to Octal 153. This change eliminates an automatic turn on of SIDE at 18-hour intervals resulting from the Resettable Solid State Timer and Delayed Command Sequencer operation. All other functions of the delayed command sequencer remain unchanged.

3.9 RESERVE POWER

Two spare telemetry channels have been allocated to increase the sampling rate of reserve power. Multiplexer channels 8 and 44 are now assigned to monitor PCU #1 reserve power and channels 13 and 40 monitor PCU #2 reserve power.

4.0 THERMAL CONSIDERATIONS

Tables 5 and 6 present predicted thermal plate and PDM panel temperatures, respectively, for the Littrow Rille Landing site and for the C/S power profile at the beginning of the mission. The tables also show the effect on thermal performance of an equatorial landing site. Note that thermal plate temperatures are listed for both the open and closed side 2 C/S configurations at the equatorial location to show the 10°F improvement in performance of the open design over the closed design. The closed design is thermally superior to the open design at Littrow Rille.

The following operating conditions are covered in the tables;

1. Lunar noon with no PDM dump and all experiments operating.
2. Lunar noon with the 14-watt PDM dump activated and all experiments operating.
3. Lunar night with no heater activated and all experiments operating.
4. Lunar night with the SWE and SIDE on standby and with the 5-watt heater activated.

The table values are based on input powers of 72.0 watts during the day and 72.5 watts during the night.

Table 5 shows that lunar noon thermal plate temperatures can be reduced 8°F by activating the 14-watt dump. In deriving the Table 5 values, the sizes of the thermal plate insulation masks were adjusted to produce 0°F lunar night temperature levels with all experiments operating; the final design will provide an optimized masking configuration.

As shown by Table 6, PDM panel temperatures for nominal operation are expected to fluctuate more for ALSEP Flight A-2 (-178°F to 296°F) than for Flight 1 (-100° to 282°F) due to the increased landing site latitude and to the decrease in reserve power for Array A-2. Even though a lower reserve power at noon reduces the PDM power load, the high solar load at the Littrow Rille site more than offsets the lower PDM power dissipation. At lunar night, the effect of lower reserve power is very pronounced as indicated by the 78°F drop in temperature. If the 14-watt dump would be activated to reduce thermal plate temperatures, the PDM panel temperature would rise more than 20°F at lunar noon.

TABLE 5

THERMAL PLATE AVERAGE TEMPERATURE

		THERMAL PLATE AVERAGE TEMPERATURE - °F			
		NOON		NIGHT	
LANDING SITE	C/S DESIGN	NO DUMP	14 WATT DUMP	NO HEATER ALL EXPERIMENTS ON	5 W HEATER ON SWE AND SIDE STANDBY
EQUATOR	OPEN	143	135	0	20
EQUATOR	CLOSED SIDE 2	153	145	0	20
LITTROW RILLE (E 29° - N 22°)	CLOSED SIDE 2	148	140	0	20

NOTES: 1. VALUES APPLY FOR BEGINNING OF MISSION (BOM) CONDITIONS.

2. VALUES CORRESPOND TO OPTIMIZED MASK DESIGN WITH ALL EXPERIMENTS OPERATING.

TABLE 6

POWER DISSIPATION MODULE (PDM) PANEL TEMPERATURE

	PDM PANEL TEMPERATURE - °F			
	NOON		NIGHT	
LANDING SITE	NO DUMP	14 WATT DUMP	NO HEATER ALL EXPERIMENTS ON	5W HEATER ON SWE AND SIDE STANDBY
EQUATOR	218	248	-178	-178
LITTROW RILLE (E 29° - N 22°)	296	319	-178	-178

NOTES: 1. VALUES APPLY FOR BOTH THE OPEN AND CLOSED SIDE 2 DESIGNS.

2. LUNAR NOON VALUES WILL INCREASE IF ANY EXPERIMENTS GO ON A STANDBY CONDITION.

5.0 POWER SUMMARY

Table 7 summarizes the total ALSEP power required with 5 experiments in various operating and standby configurations. The required power is compared to the estimated power available from the SNAP-27 RTG from the beginning-of-mission (B-O-M) to the end-of-mission (E-O-M). The B-O-M power will permit all 5 experiments to operate during the lunar night. Placing certain experiments in standby at night, as shown, produces enough reserve power to turn-on a central station heater. The Table assumes that the PSE heater power is increased 3.0 watts and that there is no increase in the LSM heater power.

TABLE 7

ARRAY A-2 POWER - 5 EXPERIMENTS