Bendix

Aerospace Systems Division

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EQUIPMENT CONSTRAINTS ON ALSEP DEPLOYMENT SEQUENCE

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Summary

The major equipment constraints on the ALSEP deployment sequence are defined and basic background material for the constraints is presented.

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Major equipment constraints on the sequence of ALSEP deployment events are summarized in Table I. The table includes both critical timing requirements and events which require two-way voice communications between LM crewmen and the MCC ground controller. Brief discussions of these constraints follow:

1. Fuel RTG. - The time at which RTG fueling is completed is significant information required in prediction of RTG performance during the early period of ALSEP operation on the lunar surface. It is also necessary as an item of historical data for correlation with performance parameters in the planning of succeeding ALSEP missions.

The time is logged by the MCC controller upon receipt of a simple voice message from the LM crewman, e.g., "RTG fueled". Receipt of time mark is acknowledged by MCC by voice link to the LM crew.

2. Connection of RTG to Central Station. - There are two significant reportable items associated with this event:

a. The reading of the RTG short-circuit current indicator.

b. The time at which the RTG connector is electrically connected to the Central Station.

The short-circuit current reading is important as an indicator of RTG performance during the early minutes after fueling. The reading is reported by the LM crewman in a simple voice message, e.g., "RTG current reads 6", which is acknowledged by MCC and logged. NOTE: Meter reads directly in amperes.

The time of connection of the RTG is important information because this action starts the ALSEP timer. Contained within the RTG plug is a jumper which, when the plug is engaged, enables the timer oscillator. Counting of the 96-hour delay of the ALSEP Delayed Command Sequencer begins at this time. The time of connection is indicated by the LM crewman in a simple voice message, e.g., "RTG connected", which is acknowledged and logged by MCC.

3. Opening of RTG Shorting Switch. - The time of opening of the RTG shorting switch must also be reported. This information permits the calculation of the duration of the short-circuited period of RTG operation, which, in turn, permits prediction of early operational performance of the RTG.

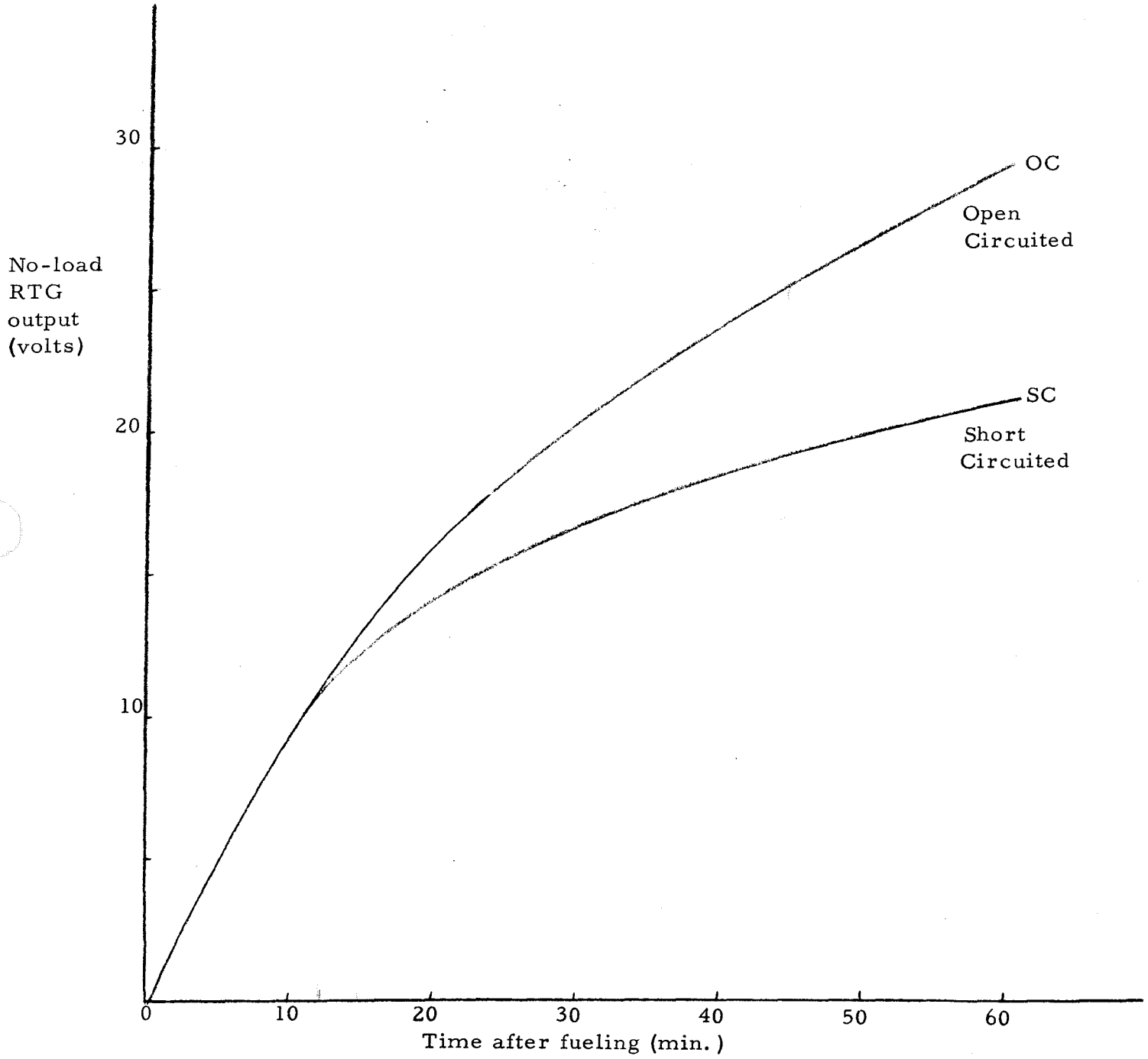

Figure 1 RTG Warm-Up Characteristics

Short-circuiting of the RTG provides a cooling effect on the RTG's thermal junction and slows the rise to full operational temperature. Figure 1 is a plot of no-load voltage vs. time for warm-up of a typical RTG under open-circuited and under short-circuited conditions. As the curves indicate, the effect of the short circuit is progressively greater beyond a period of about 11 minutes. Therefore, it is important that the shorting switch be opened as soon after 11 minutes after fueling as is practical (or before this time), to ensure rapid warm-up of the RTG.

The time of switch opening is indicated by the LM crewman in a simple voice message, e.g., "Shorting switch opened". The report is acknowledged and logged by MCC.

NOTE: After opening of the shorting switch, the RTG voltage, which typically follows the open-circuit curve of Figure 1, appears on the Survival Power lines of experiments 1, 3 and 4 (PSE, SWE, and SIDE).

4. Deploy Sunshield. - In its stowed position, the sunshield effectively closes off the ALSEP radiators. Therefore, before any appreciable thermal dissipation is encountered in the Central Station, the sunshield must be deployed.

Figure 2 shows a plot of Central Station thermal dissipation vs. time during the RTG warm-up period. The Central Station can tolerate the low-level dissipation before start-up of the PCU converter. However, the sunshield must be deployed to accommodate the increased dissipation after PCU turn-on. Curve 2 represents Central Station dissipation with the PCU started by the LM crewman's actuation of ASTRONAUT SWITCH No. 1, while Curve 1 beyond point B represents the dissipation encountered under automatic turn-on by the PCU's integral "hold-off" circuit.

The ground rule derived from this set of equipment constraints is this: The LM crewman must deploy the sunshield before actuation of ASTRONAUT SWITCH No. 1 and should endeavor to achieve deployment of the sunshield within 46 minutes after fueling of the RTG.

5. Assemble and Orient Antenna. - The entire ALSEP mission depends upon the performance of the two-way S-band RF link between the Central Station and the MSFN. A key link in this chain is the ALSEP directional antenna which is stowed in an unusable position for transit to the lunar surface. As a precaution against the contingency of abortion of the ALSEP deployment for reasons of personnel safety, the antenna should be assembled and aligned as early in the deployment sequence as possible. This will permit return of usable scientific data even though some of the experiments are not fully deployed.

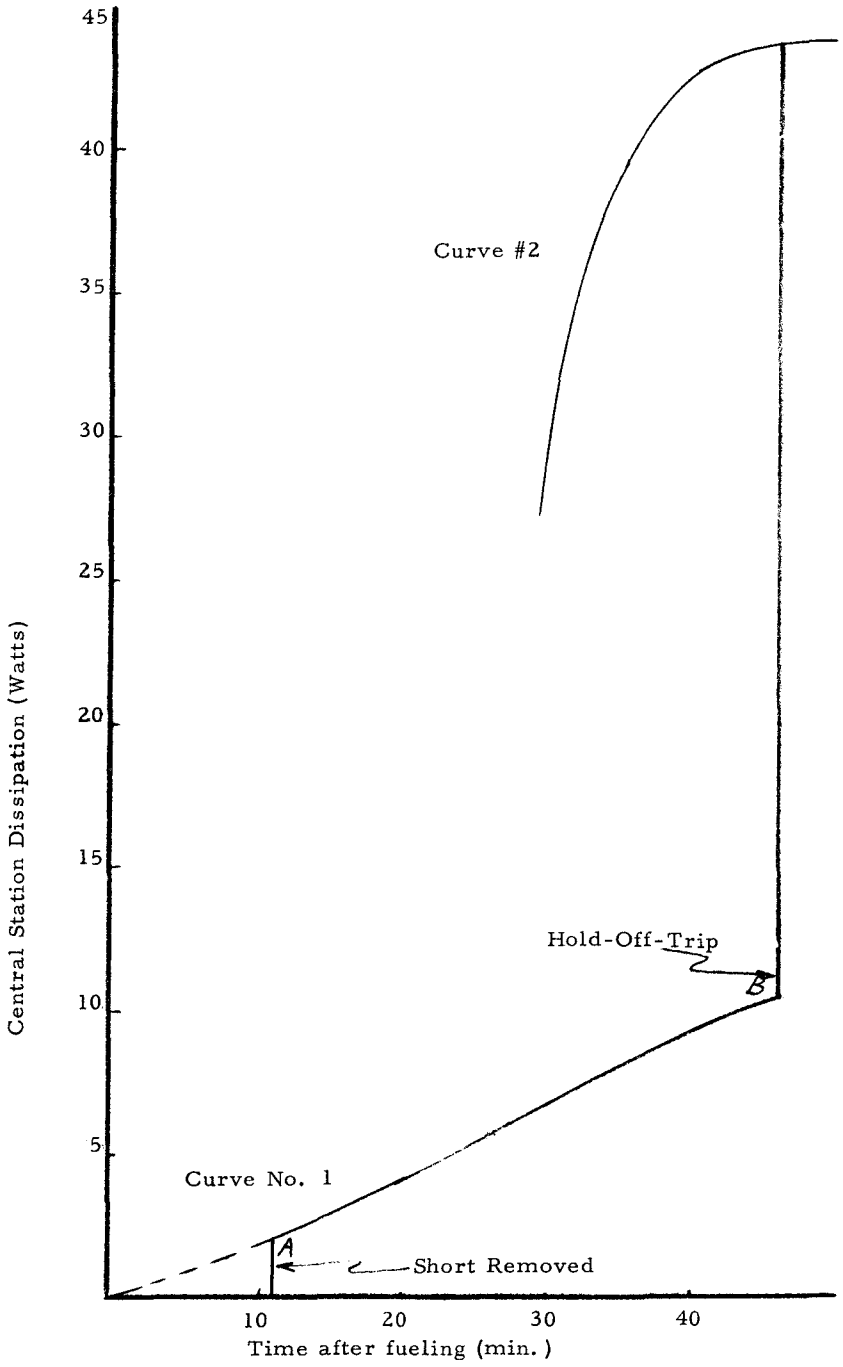

Figure 2 Central Station Dissipation During RTG Warm-Up

Antenna pointing angles should be confirmed by voice link to ensure optimum orientation.

6. Deploy LSM. - During the deployment of the LSM, the LM crewman must level and orient the instrument. Having finished the alignment, the crewman is able to determine the relative sun angle by means of the shadowgraph to a resolution of 1^{o}. This reading must be available to the Principle Investigator to ensure optimum interpretation of the returned magnetic field data. The report should be given in a simple voice message, e.g., "Shadowgraph reads plus one".

7. Actuate ASTRONAUT SWITCH NO. 1. - ASTRONAUT SWITCH No. 1 provides a means of starting the PCU converter at the completion of deployment. This function would be performed automatically by the PCU hold-off circuit (which monitors the RTG voltage and trips at a level of approximately 24 volts) at about 46 minutes after fueling. However, deployment will probably be completed before automatic turn-on occurs, and, to avoid having the crewmen wait for this event, turn-on is accomplished by actuation of ASTRONAUT SWITCH No. 1.

The preset operating mode of ALSEP, as it arrives at the lunar surface, has all experiments in the STANDBY ON mode. Under these conditions the nominal load on the RTG is approximately 30 watts. Figure 3 shows the power available from a typical RTG at 16.1 volts as a function of time after fueling. The curve shows that 30 watts are available at a time of about 29 minutes after fueling.

The crewman, having completed deployment, may actuate SWITCH No. 1 at any time after this critical period.

NOTE: The 29-minute figure assumes that the shorting switch was opened at, or before, 11 minutes after fueling. If the short was removed later, the 30-watt level is reached at: $26.2 + .181t + .0065t^2$, where t is in minutes after fueling.

Actuation of the switch is reported in a simple voice message, e.g., "ASTRONAUT SWITCH No. 1 ON" and is acknowledged by MCC.

8. Transmitter Turn-On. - Turn-on of the ALSEP transmitter is accomplished by ground command, initiated by MCC, after report of the actuation of ASTRONAUT SWITCH No. 1. Turn-on is confirmed by receipt of an RF signal from ALSEP at the MSFN station.

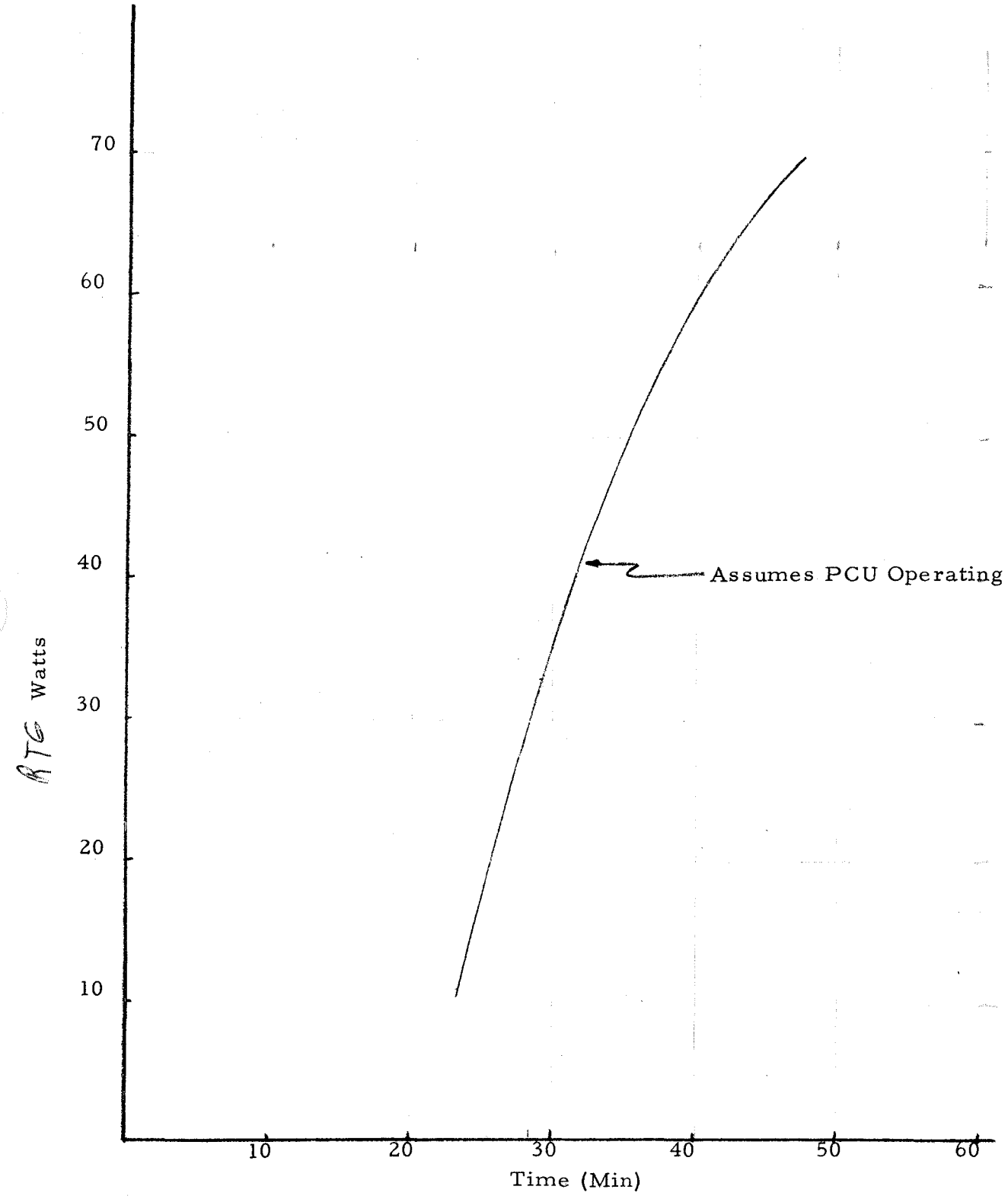

Figure 3 Power Available During Warm-Up

The LM crewman stands by at the ALSEP site for confirmation of transmitter turn-on. If no RF signal is detected at the MSFN station, he will be instructed by MCC to actuate ASTRONAUT SWITCH No. 2.

Turn-on of the transmitter is reported in a simple voice message by MCC, e.g., "Transmitter is ON" and the report is acknowledged by the LM crewman.

9. Experiment Turn-On. - Turn-on of Experiment No. 1 (PSE) is accomplished by ground command, initiated by MCC, after successful transmitter turn-on. Turn-on is confirmed by receipt of meaningful PSE telemetry at MCC.

The LM crewman stands by at the ALSEP site for confirmation of Experiment turn-on. If attempts at ground commanding experiments ON are unsuccessful, he may be instructed to actuate ASTRONAUT SWITCH No. 3.

Turn-on of the experiment is reported in a simple voice message by MCC, e.g., "Experiment is ON" and is acknowledged by the LM crewman.

This step concludes the ALSEP crew-constraining activity.

TABLE I

DEPLOYMENT SEQUENCE CONSTRAINTS

1. Fuel RTG.	1. Crewman report time mark at completion of fueling operation. Acknowledged by MCC.
2. Connection of RTG to Central Station.	2. Crewman report ammeter reading and time mark. Acknowledged by MCC.
3. Opening of RTG shorting switch.	3. Accomplish within eleven (11) minutes after fueling, if feasible. Report time mark. Acknowledged.
4. Deploy sunshield.	4. Deploy before actuation of ASTRONAUT SWITCH No. 1 and within 46 minutes after fueling of RTG.
5. Assemble and orient antenna.	5. Accomplish as early in sequence as possible. Confirm pointing angles.
6. Deploy LSM.	6. Crewman report azimuth alignment to 1^{o} resolution.
7. Actuate ASTRONAUT SWITCH No. 1.	7. Accomplish after deployment is complete, 29 minutes or more after fueling of RTG. Time mark reported and acknowledged.
8. Transmitter turn-on.	8. Accomplish by ground command with crewman standing by after 7. above. Status reported by MCC and acknowledged by LM crew.
9. Experiment turn-on.	9. Accomplish by ground command with crewman standing by after 8. above. Status reported by MCC and acknowledged by LM crew.