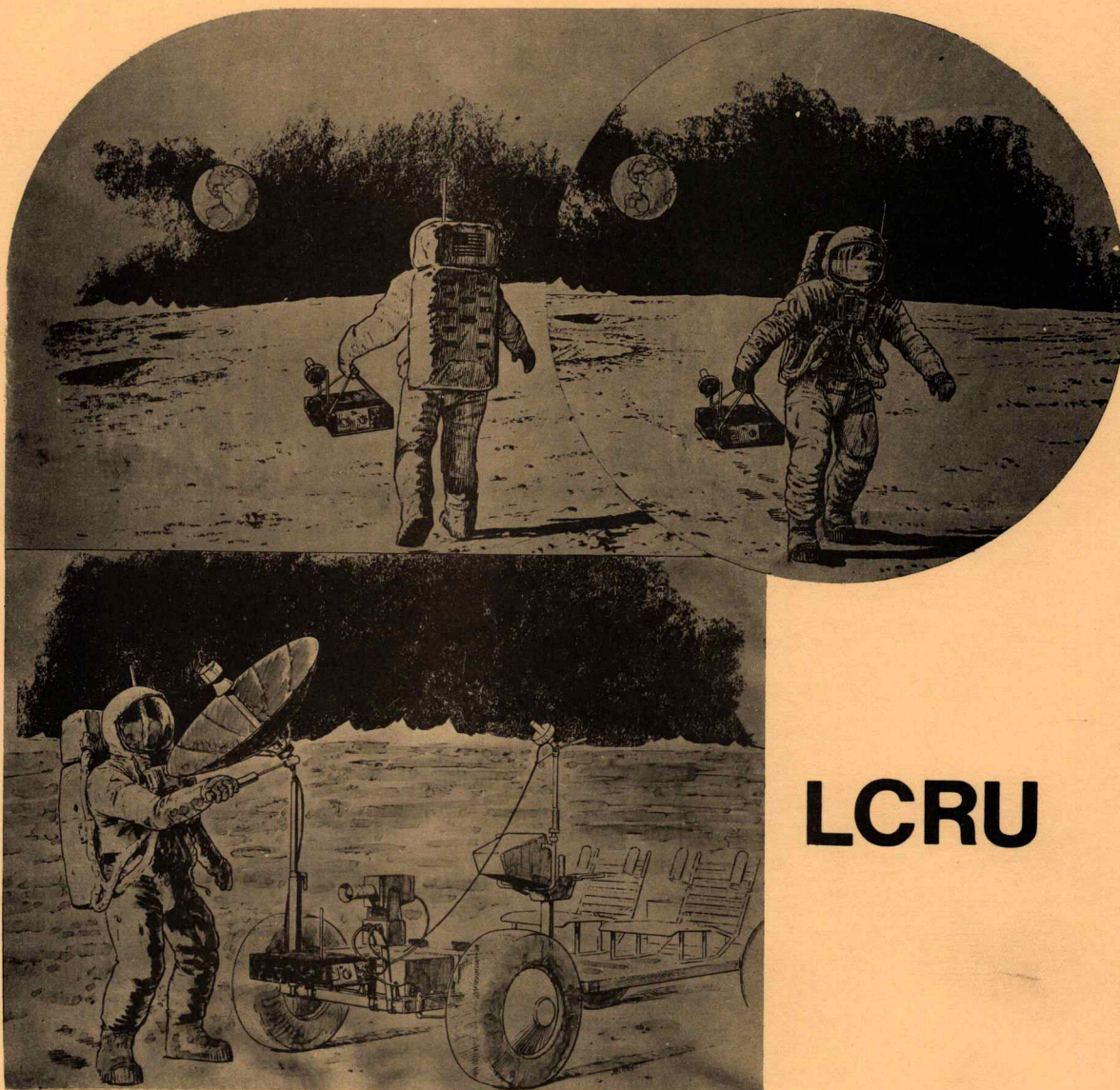




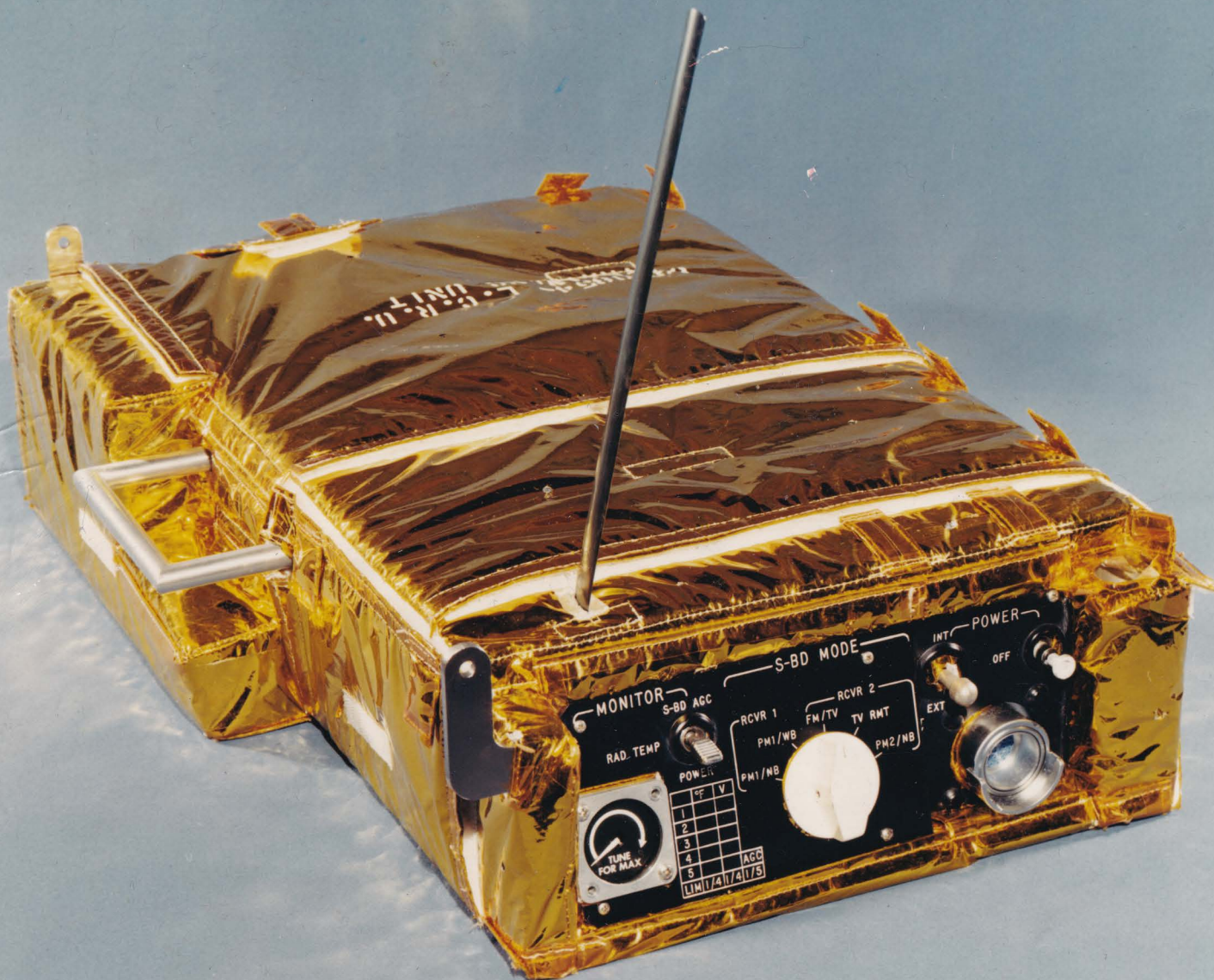
Lunar Communications Relay Unit(LCRU)  
Preliminary Design Review Report  
NASA/MSC, Houston, Texas  
June 3,4, and 5, 1970

Volume I



**LCRU**











LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

PRELIMINARY DESIGN REVIEW REPORT

NASA/MSC HOUSTON, TEXAS

JUNE 3, 4 and 5, 1970

VOLUME I

- Summary of Action Items
- Minutes and Action Items
- Introduction
- Management Overview
- Subcontracts
- Operations
- System Design

LUNAR COMMUNICATIONS RELAY UNIT • PROGRAM MANAGEMENT OFFICE  
RCA • DEFENSE COMMUNICATIONS SYSTEMS, CAMDEN, N. J.



LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

PRELIMINARY DESIGN REVIEW

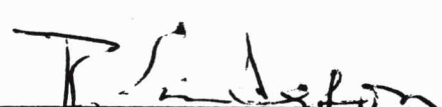
HOUSTON, TEXAS

JUNE 3, 4, 5, 1970

NASA

  
W. SPEIER

NASA

  
R. SINDERSON

RCA

  
H. J. HAMLIN

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



# TABLE OF CONTENTS

## VOLUME I

Agenda Item		Page
	SUMMARY OF ACTION ITEMS . . . . .	v
	ATTENDEES . . . . .	xii
	MINUTES AND ACTION ITEMS . . . . .	1
1.0	Introduction . . . . .	1-1
2.0	Management Overview . . . . .	2-1
3.0	Subcontracts . . . . .	3-1
4.0	Operations . . . . .	4-1
5.0	Systems Design . . . . .	5-1

## VOLUME II

6.0	Electrical Interfaces . . . . .	6-1
7.0	LCRU Electrical Design . . . . .	7-1

## VOLUME III

8.0	LCRU Mechanical Interfaces . . . . .	8-1
9.0	LCRU Mechanical Design . . . . .	9-1
10.0	Thermal Design . . . . .	10-1
11.0	Test Programs . . . . .	11-1
12.0	Test Equipment Design . . . . .	12-1
13.0	Program Support . . . . .	13-1



# SUMMARY OF ACTION ITEMS

	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-1	MSC to advise RCA if and what spares will be required to support training and compatibility testing of the LCRU engineering model and DVT at TI-3.	MSC	TI-3	2.0
PDR-2	RCA to coordinate with Conic Executive management to resolve problems pertaining to propriatory items.	RCA	-	3.0
PDR-3	RCA to investigate the need or desirability of including bonding verification on the sub-assemblies and the need to perform bonding tests via a Shallcross bridge per MIL-D-5087-D and advise MSC by CDR.	RCA	CDR	6.0
PDR-4	RCA to provide source impedance and shunt capacities of DC-DC converter and battery by 6/17.	RCA	6/17	6.0
PDR-5	MSC to provide TV-ICD via CCA subject to discussion with MSC/RCA Contracts.	MSC	-	6.0
PDR-6	RCA to review TV-ICD and advise MSC of total impact of implementation by 6/17.	RCA	6/17	6.0
PDR-7	RCA to provide calibration curves for battery and temperature - 6/19.	RCA	6/19	6.0
PDR-8	RCA to evaluate the impact of disabling manually or via ground command the VHF Transmitter during TV standby. 6/25	RCA	6/25	6.0
PDR-9	RCA to provide flight adapter connector (or cable) with diode protection built in to provide reverse polarity protection during all earth test operations. Preliminary at TI-3, final at CDR.	RCA	Prel. TI-3 Final CDR	7.2.1

	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-10	RCA to evaluate failure potential of CR-1 of DC-DC converter and assure adequate protection. Advise MSC of final approach by 7/7.	RCA	7/7	7.2.1
PDR-11	RCA to review and advise MSC on the voltage ratings of the input capacitors with respect to operation in EMI test environment. 6/15	RCA	6/15	7.2.1
PDR-12	RCA to provide dual temperature monitoring capabilities by CDR.	RCA	CDR	7.2.4
PDR-13	RCA to advise MSC if band edge limiting is incorporated in the 14.5 KHz VCO by 6/15.	RCA	6/15	7.2.4
PDR-14	RCA to replace VR reverse polarity diodes with fuses 7/7/70.	RCA	7/7	7.2.6
PDR-15	RCA to develop techniques for assuring that fused VR's can be checked to assure that neither fuse is blown. Measurement must be from the outside of the LCRU during test 7/7/70.	RCA	7/7	7.2.6
PDR-16	RCA to determine and advise MSC of noise output levels of 70 KHz command line in the absence of uplink signal. 7/7/70	RCA	7/7	7.3.1
PDR-17	RCA to verify effect on vox of audio noise during lack of uplink subcarrier and, if required, implement subcarrier squelch. 7/7/70.	RCA	7/7	7.3.1
PDR-18	RCA to specify to Motorola .8 + 10% radians for modulation and intermod on 70 and 124 KHz subcarrier. 6/15	RCA	6/15	7.3.1
PDR-19	MSC to provide latest information on potting for VHF antenna. 6/15	MSC	6/15	7.3.4



	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-20	MSC to advise RCA of need to change low gain antenna connector 6/12	MSC	6/12	7.3.5
PDR-21	RCA to provide MSC with drawing for RF cabling. 7/7	RCA	7/7	7.4
PDR-22	MSC to provide procedures for repair of circuit breakers. 7/7	MSC	7/7	7.4
PDR-23	RCA to evaluate the battery door design for need for grounding strap and advise MSC of action. 7/7	RCA	7/7	8.1
PDR-24	MSC to redefine the LRV-low gain antenna interface and provide design information to RCA by 6/8.	MSC	6/8	8.1
PDR-25	MSC to provide drawings for LRV tubes and front bumper design. 6/12	MSC	6/12	8.2
PDR-26	MSC to evaluate need for load values in the LRV-ICD and either remove from ICD or update ICD values based upon RCA analysis. 7/15	MSC	7/15	8.2
PDR-27	MSC to reevaluate the LRV vibration requirements in terms of actual or practical values and RCA test level requirements and provide to RCA. 6/8	MSC	6/8	8.2
PDR-28	RCA to provide vibration test level recommendations to MSC. 7/7	RCA	7/7	8.2
PDR-29	MSC to provide LRV-ICD with required thermal interface data as requested in the RCA proposed changes presented at the PDR. 5/13	MSC	5/13	8.3
PDR-30	RCA shall immediately proceed to design the low gain antenna and assembly to interface with the MSC mast and present design at TI-3.	RCA	TI-3	9.0
PDR-31	RCA to provide cost-schedule-design-facilitation impact for pressurizing. 6/26 a. 100% Nitrogen b. 90% Nitrogen 10 Helium c. 100% Nitrogen-double pinch-off with helium filler	RCA	6/26	9.0

	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-32	RCA to advise MSC of impact of incorporating recommended changes. 6/19	RCA	6/19	9.0
PDR-33	MSC to provide RCA information on the mechanical and thermal design of electrical cables for use on the lunar surface. Particularly as applicable to the LCRU TV and power cable the week of 6/15.	MSC	6/15	9.0
PDR-34	RCA will conduct a design thermal analysis of the LCRU with LRV battery covers hinged at the front of the LRV. These analyses will be done with the sun into the front of the LRV. These analyses will be done with the sun into the front and also the back of the LRV. The effects of cover position will be assessed by assuming cover closure at 2 hours and 13 hours after EVA. Results will be available June 22.	RCA	6/22	10.0
PDR-35	NASA is determining the impact of the movement of cover hinges to the rear of the battery and should also evaluate the effect of sun incidence from the back of the LRV. 6/22	NASA	6/22	10.0
PDR-36	Upon resolution of the preferred system orientation RCA will complete a detailed multinode transient analysis of LCRU assembly. 7/7	RCA	7/7	10.0
PDR-37	As a result of the required additional analysis RCA will delay delivery of the thermal analysis until two weeks following determination of system orientation (Item 3). 7/21	RCA	7/21	10.0
PDR-38	RCA to assure that the meter face is black and control panel plate should be gray, radio luminescent lettering by TI-3.	RCA	-	10.0



	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-39	RCA should utilize an iridite finish for all metal surfaces for which anodize is presently planned. If the use of this finish is not practical, then other electrically conductive finishes should be considered. 7/7	RCA	7/7	10.0
PDR-40	RCA to assure that thermal blanket is vented. 7/7	RCA	7/7	10.0
PDR-41	RCA to have top thermal blanket with butt joints. 7/7	RCA	7/7	10.0
PDR-42	RCA to provide thermal blanket flap to cover RF connectors and provide a method for assuring the RF connectors do not become interchanged. For example by color coding and color keying. 7/7	RCA	7/7	10.0
PDR-43	RCA to assure that all control panel items will have an $\alpha/\epsilon$ ratio of less than unity and without bright finish. 7/7	RCA	7/7	10.0
PDR-44	MSC to provide LRV battery cover deployment mechanism for SR-TV tests. 6/15	MSC	6/15	10.0
PDR-45	RCA to submit revised thermal test plan to reduce thermal test program to minimum engineering needs. 6/12	RCA	6/12	10.0
PDR-46	MSC to reserve solar thermal chamber for last two weeks in August.	MSC	-	10.0
PDR-47	RCA to have thermal model (with wax) by August 15 for test start in MSC. 2/15	RCA	2/15	10.0
PDR-48	RCA to provide detailed thermal test plan for thermal test of thermal model (with wax). 7/21	RCA	7/21	10.0
PDR-49	RCA to provide simulated LRV battery covers to support thermal mockup tests at MSC. 6/15	RCA	6/15	10.0
PDR-50	RCA to evaluate EM utilization and advise MSC as to availability of EM to support MSC needs. TI-3	RCA	-	11.0

	ACTION ITEMS	RESP.	DATE	AGENDA ITEM
PDR-51	MSC provide CCA for LM, LRV, TV interface requirements. 6/22	MSC	6/22	11.0
PDR-52	RCA to revise battery thermal and wet stand thermal/vacuum DVT test requirements to be consistent with CCA-5. TI-3	RCA	-	11.0
PDR-53	RCA to add thermal test to battery qualification. TI-3	RCA	-	11.0
PDR-54	RCA modify EMI control plan for audio power line conducted susceptibility tests in accordance with LRV ripple requirements of LRV meeting May 14, 1970. These tests will be included in the EMI DVT and Qualification Test Program. 6/19	RCA	6/19	11.0
PDR-55	RCA to provide to MSC data which specifies which specified performance parameters will be measured during ATP, the tolerances to be imposed as acceptance criteria, and the accuracy of test equipment measurement capability. Prel. TI-3, 8/22/70	RCA	8/22	12.0
PDR-56	MSC to review requirements for test points and/or control circuit access that may be required per MSFN or PIA testing for: 6/22  1. Engineering Models 2. DVT Models 3. Production Models	MSC	6/22	12.0
PRD-57	RCA to evaluate the possibility of utilizing Cutler-Hammer switches as alternate and coordinate with MSC. 6/19	RCA	6/19	13.1
PDR-58	MSC to provide screening and acceptance criteria for TI toggle switch. 6/12	MSC	6/12	13.1
PDR-59	MSC to determine why the NAR toggle switch spec is marked inactive for use and advise RCA. 6/22	MSC	6/22	13.1



	ACTION ITEM	RESP.	DATE	AGENDA ITEM
PDR-60	RCA should change cable lengths as follows:	RCA	-	14.0
	TV - 42"			
	Low Gain 8 feet			
	High Gain 6.5'			

Bellcom

W. J. Benden MAS  
J. McClanahan MA/MO  
J. T. Ralgith MA/MO  
J. T. Raleigh  
B. Storey MA/MO

Boeing

R. C. Buckley  
Roy H. Forsander MSC

GE

N. Bates MSC/REL  
M. Ellinor MSC/REL  
C. T. Kessell HP  
E. E. Vezey MSC/REL

GAC

J. O. Sayler  
R. F. York KSC, Mail Stop 300-12

LEC

A. Bockman  
R. J. Elbert  
B. Frustrro MSC

Philco

R. L. Lutes



NASA

J. M. Allman MAT  
J. D. Alter MSFC/RM-SAT-LRV  
D. R. Brooks CF24  
T. N. Bruce FC6  
G. P. Carr CB  
E. T. Chimenti ES55  
John J. Cunningham JC73  
J. H. Dabbs EE7  
Rocky Duncan  
N. Farmer EE16  
E. I. Fendell FC2  
J. J. Fitzgerald  
W. B. Goekler PD9  
C. M. Haddick  
J. Halcomb MSF/MAO  
M. Hamilton  
L. J. Hastings MSFC  
Roger Hicks PE  
A. W. Joslyn PD9  
J. S. Kelley EE  
C. Klubosh CF72  
H. S. Kobayashi EE2

NASA (Continued)

H. C. Kyle EE  
R. Langley ES12  
Jack Lousma CB  
M. M. Lusk EL3  
C. E. McCullough, Jr. NB5  
J. McKenzie MSC/PD9  
J. D. Miller MSC/EE18  
John W. Orsag ES55  
D. B. Pendley PA  
G. A. Pennington FC2  
W. Perry TCSD EE2  
C. Rittenhouse EE16  
Ralph Sawyer MSC/EE  
H. Schultz EE19  
H. Scott PD5  
R. Sinderson EE16  
W. Speier MSC/PD9  
C. V. Spencer  
A. D. Travis  
K. Thomas MSC/PD  
Douglas Wood

RCA

M. E. Adams  
J. P. Anderson  
W. S. Babcock  
A. M. Burke  
W. L. Carlino  
J. Connelly  
Mark D'Andrea  
E. H. Debaecke  
G. R. Floyd  
G. Grube  
H. J. Hamlin  
H. S. Farcus

RCA (Continued)

R. E. Holston  
S. B. Holt  
G. A. Houck  
S. F. Martorano  
F. J. Nangle  
D. A. Orendac  
O. Ramanis  
H. Rosenthal  
Ralph P. Scott  
B. Shelpuk  
B. Trachtenberg  
R. Virostek



## **MINUTES AND ACTION ITEMS**

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 1.0

SUBJECT Introduction

---

### SUMMARY OF DISCUSSION:

The meeting was opened and introduced by Mr. Holt and Mr. Hamlin. No action items developed during this agenda item.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 2.0

SUBJECT Management Review

---

### SUMMARY OF DISCUSSION:

MSC stated that spares may be required to support LCRU engineering model testing during training operations.

### ACTION ITEMS:

PDR-1 MSC to advise RCA if and what spares will be required to support training and compatibility testing of the LCRU engineering model and DVT at TI-3.

NOTE: These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 3.0

SUBJECT Subcontracts

### SUMMARY OF DISCUSSION:

RCA provided copies of specification control drawings for RCA subcontract items in the meeting as follows:

8555260	S-Band Low Gain Antenna	8555255	1.25 MHz subcarrier SCO LCRU
8555262	S-Band High Gain Antenna	8151116	S-Band PM/PM Transmitter LCRU
8151102	S-Band Diplexer LCRU	8151101	S-Band FM/PM Transmitter LCRU
8151100	S-Band FM Receiver LCRU	Motorola, Inc. 35-25933K - Antenna PLSS	
8151103	Battery LCRU	8547878	Triplexers

In response to MSC question on the effect of changing downlink from 2272.5 to 2250.5 RCA stated the following:

- Low gain antenna - .1 db reduction without design change
- High gain antenna - .1 db reduction or reduced error angle- without design change
- Diplexer - Retunable - reduction of RX/TX isolation by approx. 5 db.
- Transmitters - New crystals and component changes.

For no impact on DVT and flight hardware authorization is required by June 15. Not included in above is effect on test equipment and work-around requirements on the engineering model. Cost would be less than 50 K not including cost of additional sub-assemblies to support engineering model work-around.

### ACTION ITEMS:

PDR-2 RCA to coordinate with Conic Executive management to resolve problems pertaining to proprietary items.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 4.0

SUBJECT Operations

---

### SUMMARY OF DISCUSSION:

MSC indicated that operational routines will undergo many changes and will be finalized during training exercises. RCA provided handout LCRU 1104 entitled "LCRU operation and timeline".

### ACTION ITEMS:

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 5.0

SUBJECT System Design

---

### SUMMARY OF DISCUSSION:

MSC requested RCA to format link analyses differently but after some discussion it was determined that this was not necessary.

### ACTION ITEMS:

NOTE: These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 6.0  
SUBJECT Electrical Interfaces

---

### SUMMARY OF DISCUSSION:

MSC questioned the suitability of chassis to chassis hard mount and bolt down (particularly on iridite surfaces) for bonding purposes.

MSC stated that LCRU power source impedance to TV is required by June 17th.

With regard the TV-ICD conflicts MSC stated that the ICD was mailed on 5/28 with letter of technical direction. RCA stated that based upon that direction an amplifier would be added and the -5 volt regulator would be modified to enable interface with the TV 1 volt video interface. In addition, the changes would not now be made to the engineering model-to be cut in later, and the change will be cut in on the first DVT.

MSC stated that PRN ranging may trip vox causing interference with VHF ranging. MSC is investigating and will advise RCA.

### ACTION ITEMS:

- PDR-3 RCA to investigate the need or desirability of including bonding verification on the sub-assemblies and the need to perform bonding tests via a Shall-cross Bridge per MIL-D-5087-D and advise MSC by CDR.
- PDR-4 RCA to provide source impedance and shunt capacities of DC-DC converter and battery by 6/17.
- PDR-5 MSC to provide TV-ICD via CCA subject to discussion with MSC/RCA contracts.
- PDR-6 RCA to review TV-ICD and advise MSC of total impact of implementation by 6/17.
- PDR-7 RCA to provide calibration curves for battery and temperature by 6/19.
- PDR-8 RCA to evaluate the impact of disabling manually or via ground command the VHF Transmitter during TV standby. 6/25

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.0

SUBJECT LCRU Electrical Design

---

### SUMMARY OF DISCUSSION:

The minutes and action items from this agenda item are presented with the sub-agenda item with which they are associated as follows:

- 7.2.1 DC-DC Converters
- 7.2.4 Downlink Signal Processor
- 7.2.6 Voltage Regulator
- 7.3.1 S-Band Receiver
- 7.3.2 S-Band Transmitter
- 7.3.4 VHF Antenna
- 7.3.5 Low Gain Antenna
- 7.3.6 Battery
- 7.3.7 High Gain Antenna
- 7.4 LCRU Assembly

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3.70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.2.1  
SUBJECT DC-DC Converter

---

### SUMMARY OF DISCUSSION:

MSC questioned the function of CR-1. RCA stated it is for reverse polarity protection and for surge protection and its purpose is to trip circuit breakers. MSC stated that some circuit breaker (on test equipment) may be quite large possibly resulting in CR-1 failing, resulting in a DC-DC converter failed mode.

### ACTION ITEMS:

- PDR-9 RCA to provide flight adapter connector (or cable) with diode protection built in to provide reverse polarity protection during all earth test operations. Preliminary at T1-3, final at CDR.
- PDR-10 RCA to evaluate failure potential of CR-1 of DC-DC converter and assure adequate protection. Advise MSC of final approach by 7/7.
- PDR-11 RCA to review and advise MSC on the voltage ratings of the input capacitors with respect to operation in EMI test environment. 6/15

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.2.4

SUBJECT Downlink Signal Processor

---

### SUMMARY OF DISCUSSION:

RCA stated that there was a potential single point failure in the event that the temperature sensor, or zeners, or FET failed and the voltage FET failed. RCA recommended separate temperature sensor (for meter and telemetry) but not to change the voltage measurement.

MSC questioned whether the 14.5 KHz VCO has band edge limiting.

### ACTION ITEMS:

- PDR-12 RCA to provide dual temperature monitoring capabilities by CDR.
- PDR-13 RCA to advise MSC if band edge limiting is incorporated in the 14.5 KHz VCO by 6/15.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.2.6  
SUBJECT Voltage Regulator

---

### SUMMARY OF DISCUSSION:

RCA stated that the VR has a single point failure mode at the input filter capacitor and recommended that fuses be inserted in place of the reverse polarity protection diodes thereby improving also the efficiency of the VR. MSC stated that this must be accompanied with techniques to assure that either fuse is not blown - determined externally.

### ACTION ITEMS:

- PDR-14 RCA to replace VR reverse polarity diodes with fuses 7/7/70.
- PDR-15 RCA to develop techniques for assuring that fused VR's can be checked to assure that neither fuse is blown. Measurement must be from the outside of the LCRU during test 7/7/70.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.3.1

SUBJECT S-Band Receiver

---

### SUMMARY OF DISCUSSION:

MSC questioned the output level of the 70 KHz command line in the S-band receiver when there is no uplink signal.

MSC questioned the amount of noise output during strong uplink carrier but without 124 KHz subcarrier. MSC stated that (on LM) such a situation opened the vox making communication between astronauts impossible. RCA stated that a subcarrier squelch system would resolve this situation and that Motorola currently is evaluating this and other techniques as a result of a Motorola PDR action item.

RCA indicated that Motorola is presently spec'd for .7 radians on 70 and 124 KHz subcarriers and .9 radians for intermod. MSC stated that it should be  $.8 \pm 10\%$  radians.

RCA indicated that in implementing the TV-ICD the Motorola spec will be revised to pickup the effects of 30 KHz subcarriers and the change to 1.1 radians, including effects of PRN in the 70 KHz subcarrier.

### ACTION ITEMS:

- PDR-16 RCA to determine and advise MSC of noise output levels of 70 KHz command line in the absence of uplink signal. 7/7/70
- PDR-17 RCA to verify effect on vox of audio noise during lack of uplink subcarrier and, if required, implement subcarrier squelch. 7/7/70
- PDR-18 RCA to specify to Motorola  $.8 \pm 10\%$  radians for modulation and intermod on 70 and 124 KHz subcarrier. 6/15

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.3.2

SUBJECT S-Band Transmitter

---

### SUMMARY OF DISCUSSION:

RCA stated that a limit of  $T_j$  on the 2N5921 of  $150^{\circ}\text{C}$  is being utilized as compared to normal derated temperature of  $100^{\circ}\text{C}$ . The transistor supplier normally guarantees  $12^{\circ}\text{C/W}$  (DC), and will guarantee  $10^{\circ}\text{C/W}$  (DC) for LCRU applications. Conic screens the 2N5921 using RF measurement techniques. If screening results of  $5$  or  $6^{\circ}\text{C/W}$  (RF) can be achieved then  $T_j$  of  $150^{\circ}\text{C}$  can probably be met. Conic indicates that their screening will do this.

With respect to Action Item TI-2-24, RCA stated that the 2N5921 has a rated  $V_{cbo}$  of 50 volts and removal of the S-band transmitter voltage regulator can cause exceedance of rated  $V_{cbo}$  and potential failure. RCA thus recommends that the voltage regulator not be removed. AI TI-2-24 is closed.

### ACTION ITEMS:

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7,3,4  
SUBJECT VHF Antenna

---

### SUMMARY OF DISCUSSION:

MSC stated that the PLSS antenna has experienced breakage at the base and requires tuning. MSC provided procedure MSC/SESD Test Procedure No. EE33/68-37 which was used to tune the PLSS antenna.

### ACTION ITEMS:

PDR-19 MSC to provide latest information on potting for VHF antenna. 6/15

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.3.5

SUBJECT Low Gain Antenna

---

### SUMMARY OF DISCUSSION:

MSC stated that the right angle connector on the low gain antenna may be required to become a straight connector in the event the new low gain mast is adopted.

### ACTION ITEMS:

PDR-20 MSC to advise RCA of need to change low gain antenna connector. 6/12

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.3.6

SUBJECT Battery

---

### SUMMARY OF DISCUSSION:

RCA provided a technical report (prepared by Yardney) on LCRU Battery temperature profile at 6 hours.

### ACTION ITEMS:

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.3.7  
SUBJECT High Gain Antenna

---

### SUMMARY OF DISCUSSION:

In response to an MSC question, RCA stated that the high gain antenna will not have a TNC connector in the center shaft as indicated but will instead have a pigtail lead and connector approximately 9-inches long.

RCA stated that the rear mounted sight might have an impact on the storage container requiring an increase of storage container diameter to accommodate the antenna rear mounted sight. The mesh has no significant effect thermally, mechanically, optically on the rear sight provided a 7 nettle mesh is used instead of 14 presented in the PDR and the plating will be left off in the area of the sight.

RCA provided a handout entitled "High Gain Antenna Structural Analysis."

### ACTION ITEMS:

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 7.4  
SUBJECT LCRU Assembly

---

### SUMMARY OF DISCUSSION:

MSC questioned the manufacturing and test methods for RF cable.

MSC stated that the circuit breaker proposed is repairable without removing the circuit breaker from the panel.

### ACTION ITEMS:

PDR-21 RCA to provide MSC with drawing for RF cabling. 7/7

PDR-22 MSC to provide procedures for repair of circuit breakers. 7/7

NOTE: These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 8.0

SUBJECT LCRU Mechanical Interfaces

---

### SUMMARY OF DISCUSSION:

The minutes and action items from this Agenda Item are presented with the sub-agenda item with which they are associated as follows:

- 8.1 Mechanical Interface
- 8.2 Vibration Analysis
- 8.3 Thermal Interface.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 8.1  
SUBJECT Mechanical Interface

---

### SUMMARY OF DISCUSSION:

RCA stated that the LCRU/LRV interface fixture was shipped to Boeing on 6/1/70.

RCA stated that the LRV-ICD should not have loads specified - but limit it to the environment.

RCA provided the following handouts:

1. LCRU/LRV Mechanical Interface  
Case I Loose tolerances on LRV.
2. LCRU/LRV Mechanical Interface  
Case II Tight tolerances on LRV.

### ACTION ITEMS:

- PDR-23 RCA to evaluate the battery door design for need for grounding strap and advise MSC of action. 7/7
- PDR-24 MSC to redefine the LRV-low gain antenna interface and provide design information to RCA by 6/8.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 8.2

SUBJECT Vibration Analysis

---

### SUMMARY OF DISCUSSION:

RCA provided a handout entitled

LCRU Antenna System - Design Study-Nodal Dynamic Model  
Dynamic Response to Sinusoidal Vibration

RCA stated that details on LRV design are required to enable accurate mechanical simulation and vibration test results.

MSC provided the following vibration requirements for LRV.

Fore, Aft, Lateral

.25g 0-peak 2-20 hz

Vertical

.65g 0-peak 2-10 hz

1.0g 0-peak 10-20 hz

} 8-12 hz ramp acceptable

3 octaves/min

total 30 min/axis (90 minutes total)

Hard mount to shaker

### ACTION ITEMS:

- PDR-25 MSC to provide drawings for LRV tubes and front bumper design. 6/12
- PDR-26 MSC to evaluate need for load values in the LRV-ICD and either remove from ICD or update ICD values based upon RCA analysis. 7/15
- PDR-27 MSC to reevaluate the LRV vibration requirements in terms of actual or practical values and RCA test level requirements and provide to RCA. 6/8
- PDR-28 RCA to provide vibration test level recommendations to MSC. 7/7

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 8.3

SUBJECT Thermal Interface

---

### SUMMARY OF DISCUSSION:

RCA stated that the thermal analysis to be presented is based upon LRV rear hinged blankets and that forward hinges add too much heat to the LCRU. MSFC stated that the blankets cannot be hinged at the rear for design reasons. This aspect is discussed further in item 10.

### ACTION ITEMS:

PDR-29 MSC to provide LRV-ICD with required thermal interface data as requested in the RCA proposed changes presented at the PDR. 5/13

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

RECOMMENDED CHANGES:

1. Provide alignment marks for HGA Mount (To Ball Joint)
2. Locking Handle Position for HGA mast should be straight down.
3. Make HGA deployment drum longer.
4. Remove or reduce size of HGA deployment drum ridge.
5. Put tabs on all blanket flaps (1-inch wide, 1-1/2" long).
6. Reduce spring tension on battery door.
7. Provide some method for keeping dust off radiator while changing battery (possibly separate flap for battery).
8. Provide PLSS type of VHF antenna stowage.
9. Hinge RF connector blanket flap down.
10. Provide rigid handle for hand carry mode.
- \*11. Reduce HGA deployment drum diameter.

\* Contingent on further evaluation at Rover/LCRU crew station review.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 9.0

SUBJECT LCRU Mechanical Design

---

### SUMMARY OF DISCUSSION:

MSC stated that the low gain antenna will be mounted on the MSC designed mast.

MSC questioned the utilization of Argon gas for pressurization and the likelihood for corona occurring during lunar operations - damage leaks, etc. RCA stated that nitrogen leak rate detection facilitation would take 5 to 6 months and have cost impact.

MSC stated that the design safety factor against limit loads should be 1.5 instead of 1.4.

RCA provided design drawings in support of the PDR as indicated in the attached sheets.

RCA indicated that the high gain and low gain antenna mockups will be left at MSC to support the LRV meeting in Huntsville during w/o June 8. MSC indicated they will return them to RCA about .

RCA provided 45 photographs taken of the mechanical components provided in the PDR. These will not be included in the PDR Report unless presented in viewgraph.

MSC provided comments to the mockups provided at the PDR as indicated in the attached "Recommended Changes".

### ACTION ITEMS:

PDR-30 RCA shall immediately proceed to design the low gain antenna and assembly to interface with the MSC mast and present design at TI-3.

PDR-31 RCA to provide cost-schedule-design-facilitation impact for pressurizing.  
6/26

- a. 100% Nitrogen
- b. 90% Nitrogen 10 Helium
- c. 100% Nitrogen-double pinch-off with helium filler

PDR-32 RCA to advise MSC of impact of incorporating recommended changes. 6/19

PDR-33 MSC to provide RCA information on the mechanical and thermal design of electrical cables for use on the lunar surface. Particularly as applicable to the LCRU TV and power cable the week of 6/15.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 10.0

SUBJECT Thermal Design

---

### SUMMARY OF DISCUSSION:

RCA presented the results of the thermal analysis stating that it was based upon the LRV battery covers being hinged at the rear. MSFC stated that this is not the LRV design. RCA stated that forward hinged blankets caused an added 40-60 watts heat impingement into the LCRU. After some discussion it was determined that MSFC should evaluate the possibility of parking the LRV away from the sun and that RCA would have to perform additional thermal analysis reflecting actual LRV design and orientation. RCA stated that this will result in a delay in submittal of thermal analysis report.

MSC stated that the control panel should be gray, the meter face black. RCA stated that the meter may not be able to handle the heat developed through the black face. MSC questioned the use of anodize since it is an insulator.

RCA stated that the various battery heat sink methods (none - side, sides, bottom) show that the worst case cell temp would be 180° (for no heat sink) and approx. 135° for best case (bottom). Yardney maintains that operation at 180° F is satisfactory. SE-C-0043A states 145° F max.

RCA therefore proposes to heat sink on two sides but may not be able to achieve 3 BTU/hr/°F. - under which circumstance battery temperature may go above 145°.

A separate splinter meeting on the LCRU thermal mockup was held on 6/4. Minutes of that meeting are included with these minutes.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 10. (cont'd)  
SUBJECT Thermal Design

---

### SUMMARY OF DISCUSSION:

RCA stated that there is the intent to run additional thermal testing on the thermal mockup after installation of the wax packets - presently estimated for August 15. Details of test have not yet been formulated. As part of these tests and the present thermal tests attempts will be made to evaluate thermal and electrical characteristics of thermal conducting materials. MSC stated that LRV battery cover simulation is required for thermal mockup testing.

With regard the charts presented entitled "Temperatures of highest power dissipating components", RCA stated that this was simply to illustrate these parts that are "standing high" on the basis of part application. The analysis is preliminary and worst case. It is based upon 160°F on subassembly baseplate, for example, which RCA's revised overall thermal analysis indicates won't happen and in fact won't even reach 145°F except under very worst lunar conditions and then only if permitted-since the Astronaut and earth monitors temperature and has means for controlling temperature. The analysis is further based upon probable worst case gradients to the components, and further are based upon component supplier guaranteed heat dissipation characteristics. Conic Corp. for example screens 2N5921 in the actual circuit application and indicates an actual transistor junction temperature rise of 5-6°C/W. In summary RCA stated that final designs and analyses will show component applications within derated requirements in most if not all cases and this chart is simply to indicate the components that are closest to being a problem.

In any event any component that is ultimately shown to exceed deratings is handled through to MSC as a deviation and substantiation on an individual part basis is supplied at that time.

For additional clarification a modified version of this chart reflecting latest LCRU thermal analysis data and latest estimates of transistor heat dissipation data was provided and discussed via marked up viewgraph.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 10. (cont'd)

SUBJECT THERMAL ANALYSIS ACTION ITEMS

---

### SUMMARY OF DISCUSSION:

#### THERMAL ANALYSIS ACTION ITEMS:

- PDR-34 RCA will conduct a design thermal analysis of the LCRU with LRV battery covers hinged at the front of the LRV. These analyses will be done with the sun into the front and also the back of the LRV. The affects of cover position will be assessed by assuming cover closure at 2 hours and 13 hours after EVA. Results will be available June 22.
- PDR-35 NASA is determining the impact of the movement of cover hinges to the rear of the battery and should also evaluate the effect of sun incidence from the back of the LRV. 6/22
- PDR-36 Upon resolution of the preferred system orientation RCA will complete a detailed multinode transient analysis of LCRU assembly. 7/7
- PDR-37 As a result of the required additional analysis RCA will delay delivery of the thermal analysis until two weeks following determination of system orientation (Item 36). 7/21
- PDR-38 RCA to assure that the meter face is black and control panel plate should be gray, radio luminescent lettering by TI-3.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 10. (cont'd)

SUBJECT \_\_\_\_\_

---

### SUMMARY OF DISCUSSION:

### ACTION ITEMS:

- PDR-39 RCA should utilize an irridite finish for all metal surfaces for which anodize is presently planned. If the use of this finish is not practical, then other electrically conductive finishes should be considered. 7/7
- PDR-40 RCA to assure that thermal blanket is vented. 7/7
- PDR-41 RCA to have top thermal blanket with butt joints. 7/7
- PDR-42 RCA to provide thermal blanket flap to cover RF connectors and provide a method for assuring the RF connectors do not become interchanged. For example by color coding and color keying. 7/7
- PDR-43 RCA to assure that all control panel items will have an  $\frac{e}{e}$  ratio of less than unity and without bright finish. 7/7
- PDR-44 MSC to provide LRV battery cover deployment mechanism for SR-TV tests. 6/15
- PDR-45 RCA to submit revised thermal test plan to reduce thermal test program to minimum engineering needs. 6/12
- PDR-46 MSC to reserve solar thermal chamber for last two weeks in August.
- PDR-47 RCA to have thermal model (with wax) by August 15 for test start in MSC. 8/15
- PDR-48 RCA to provide detailed thermal test plan for thermal test of thermal model (with wax). 7/21
- PDR-49 RCA to provide simulated LRV battery covers to support thermal mockup tests at MSC. 6/15

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



MINUTES OF LCRU THERMAL MOCKUP  
SOLAR SIMULATION/THERMAL VACUUM MEETING

Held on June 4, 1970

at MSC

ATTENDEES

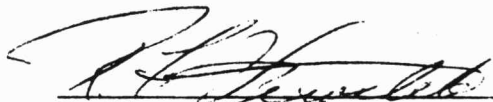
<u>Name</u>	<u>Orig.</u>	<u>Phone</u>
M. M. Lusk	EL3	4866
G. A. Udvardy	BR-N	5324
A. Bockman	LEC-EE16	3761
B. Fraustro	LEC-EE16	3761
R. Redman	EL2	3888
L. E. Birdsong	EL25	4226
W. W. Killingsworth	EL25	4226
E. T. Chimenti	ES55	3676
Ralph Scott	RCA-AEO	609-448-3400-x2493
John Miller	EE18	4507
R. F. Virostek	RCA-PMO	609-W03-8000 XPC-3840
A. W. Joslyn	PD9	3441

The test plan/procedure of the LCRU Thermal mockup was reviewed.  
The following comments are referenced to the document paragraphs:

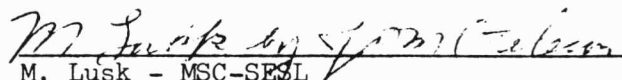
1. Section 3.2a, and 4.4.5 - MSC-SETD are to run a Johnson curve and distribution on June 8, 1970. This data will be made available to RCA for their test log.
2. Section 4.5.1. c & d - MSC-SETD to provide a distribution plot of the levels to an accuracy of +5%.
3. Section 4.5.1e - MSC-SETD can provide data to an accuracy of +5%.
4. Section 5.2. 9 & 10 - MSC-TCSD to provide this support.
5. Section 6.1.1. b - The local pointing vectors data is not available but the information is part of 6.1.1.a.
6. Section 6.1.4 - RCA to install externally mounted thermocouples.

7. MSC to present temperature data in °F.
8. Temperature data to be presented on computer printout. All stabilization temperature data will be hand plotted.
9. Section 6.2.2 - MSC-SETD will arrange for a portable reflectometer.
10. Appendix A - RCA to define Lurain Angle equivalent temperatures.
11. RCA's estimated operating time is 8 hours per test with 30 tests being planned - Total 240 hours.

MSC-SETD estimates a chamber recycle time of 36 hours for each pump down and repressurize. A total of 3 recycles is planned.
12. RCA is required to provide a list of material (type of material only) of the components going into the test chamber.
13. RCA expects to have the thermal mockup at MSC on June 15, 1970.
14. MSC will have the test chamber available on June 15, 1970. The chamber will be in use through June 12, 1970, supporting another test.

  
R. Virostek - RCA

  
J. Miller - MSC-TCSD

  
M. Lusk - MSC-SESL

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 11.0

SUBJECT Test Program

---

### SUMMARY OF DISCUSSION:

MSC stated that the engineering model is scheduled at MSC during November 15 to December 1, based upon RCA's presented utilization, and periodic utilization after that period. It is desired during September 15 - October 1 for combined LRV-EMI. EMI should include the TV changes.

RCA stated that adequate contractual direction on the LM, LRV, TV interface and/or environmental requirements thereon is still required.

MSC questioned the 3 day, 95% humidity test - i.e., it is contrary to specification. RCA explained it was agreed to in the December 17, 1969 meeting, and shortens test time. MSC concurred with the change. MSC questioned the battery thermal and wet stand/thermal-vacuum tests during DVT.

The LCRU-EMI Control Plan, LRPL-EMI-1, dated May 26, 1970, was reviewed and discussed in a splinter meeting. MSC suggested that the specification method of bonding subassemblies to the LCRU chassis should be listed in the RCA manufacturing drawings/processes.

A separate splinter meeting on Dust, mechanical and vibration was held - minutes of which are enclosed herein.

### ACTION ITEMS:

- PDR-50 RCA to evaluate EM utilization and advise MSC as to availability of EM to support MSC needs. TI-3
- PDR-51 MSC provide CCA for LM, LRV, TV interface requirements. 6/22
- PDR-52 RCA to revise battery thermal and wet stand thermal/vacuum DVT test requirements to be consistent with CCA-5. TI-3
- PDR-53 RCA to add thermal test to battery qualification. TI-3
- PDR-54 RCA modify EMI control plan for audio power line conducted susceptibility tests in accordance with LRV ripple requirements of LRV meeting May 14, 1970. These tests will be included in the EMI DVT and Qualification Test Program. 6/19

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

MINUTES OF LCRU DUST TESTING (MECHANICAL) AND VIBRATION  
MEETING

Held

June 5, 1970

ATTENDEES

J. Miller	TCSD
L. Williams	ASPO
H. Schultz	TCSD
W. Speier	ASPO
R. Virostek	RCA - Camden

1. MSC can supply simulated lunar dust suitable for mechanical testing of LCRU Ancillary items upon RCA request. (up to 5 lbs)

2. MSC recommended that the ancillary items be baked (preferably in thermal vacuum chamber for 4 hours minimum and +100°F) prior to dusting. Also, bake dust prior to use.

3. Dust should be sprinkled via a coarse (less than 0.1 inch) screening mechanism.

4. For the high gain antenna, MSC recommended 10 dustings with about 10 flexing cycles between dusting. Force limits should be established and measured with torque wrenches for accept/reject criteria.

5. For the low gain antenna mechanism, dust the upper hinge joint once and operate 10 times. For the bottom insert, apply dust and rotate the shaft approximately  $\pm 180^\circ$  from nominal rearward projection 10 times between dustings. Total number of dustings to be ten. Force limits should be established as accept/reject criteria. Simulated LRV socket is required. Recommend dust cap on LRV low gain antenna shaft and through hole on LRV low gain antenna socket.

6. For the battery, sprinkle with dust, brush with the virgin (soft) nylon bristle brush and insert into LCRU.

7. For LCRU assembly, sprinkle dust on all control panel switches, cycle through each switch position and check torque. Repeat 10 times.



Minutes of LCRU dust testing (mechanical) - meeting - June 5, 1970

8. For the LCRU legs, dust the legs, insert into LCRU and torque. Sprinkle additional dust and check torque required to remove legs.

9. RCA will prepare a plan for dust testing and present plan at next at next T.I. meeting.

LRV SUBSTITUTE VIBRATION

MSC indicated that an acceptable substitute sinusoidal vibration test for the LRV vibration DVT and qualification tests are:

Fore/Aft/Lateral

2 to 20 Hz at 0.25 g peak

Vertical -

2 to 8 Hz at 0.65 g peak

8 to 12 Hz 0.65 to 1.0g



12 to 20 Hz 1.0 g

Sweep rate to be 3 octaves/minutes for 30 minutes per axis for a total of 90 minutes.

The above levels assume a hard mount to vibration table. These limits are acceptable substitutes for the LRV ICD requirements.

RCA will review and advise MSC of impact, if any.

  
R, Virostek - RCA

  
W. Speier - MSC ASPO 

## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 12.0

SUBJECT Test Equipment Design

---

### SUMMARY OF DISCUSSION:

A separate splinter meeting was held on LCRU testing at KSC. Minutes of that meeting are included herein.

### ACTION ITEMS:

- PDR-55 RCA to provide to MSC data which specifies which specified performance parameters will be measured during ATP, the tolerances to be imposed as acceptance criteria, and the accuracy of test equipment measurement capability. Prel. TI-3, 8/22/70
- PDR-56 MSC to review requirements for test points and/or control circuit access that may be required per MSFN or PIA testing for: 6/22
1. Engineering Models
  2. DVT Models
  3. Production Models

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

MINUTES OF MEETING

ON


LCRU KSC - TESTING

June 4, 1970

ATTENDEES

Ed DeBaecke	RCA
R. Whitson	KSC
R. Virostek	RCA
B. Fraustro	LEC
R. York	GAC
J. Miller	MSC

1. KSC need stands to mount LCRU for lab test and pad test.
2. KSC should consider cooling of LCRU during test. Requirements to be defined by RCA.
3. It was agreed that the thermal radiator surface shall be cleaned prior to flight.
4. GAC gave RCA Vol #1 CTS support manual.
5. Based on design and test information from PDR, KSC will develop test information for PIA procedure.
6. RCA to investigate use of dummy battery with diode protection and GSE interface test connector.

 6/7/70  
J. Miller - MSC-TCSD

 6/9/70  
R. Whitson - KSC

  
R. Virostek - RCA

## MINUTES OF MEETING

DATE 6-3-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 13.0

SUBJECT Program Support

---

### SUMMARY OF DISCUSSION:

The minutes and action items from this agenda item are presented with the sub-agenda item with which they are associated as follows:

- 13.1 Reliability
- 13.3 Quality Assurance

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.



## MINUTES OF MEETING

DATE 6-4-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 13.1  
SUBJECT Reliability

---

### SUMMARY OF DISCUSSION:

MSC stated that the toggle switches made by TI (and qualified for Apollo) have a high failure history primarily of a manufacturing process type. Cutler-Hammer makes an environmentally sealed switch may be applicable for LCRU. Otherwise RCA must exercise careful QC surveillance on TI to assure the quality of the product. It was agreed that RCA/MSD would jointly evaluate the possibility of using the Cutler-Hammer switch in place of the TI switch.

The chart on part applications was revised to reflect the latest LCRU thermal analysis results and latest estimates of 2N5921 dissipation.

### ACTION ITEMS:

- PDR-57 RCA to evaluate the possibility of utilizing Cutler-Hammer switches as alternate and coordinate with MSD. 6/19
- PDR-58 MSD to provide screening and acceptance criteria for TI toggle switch. 6/12
- PDR-59 MSD to determine why the NAR toggle switch spec is marked inactive for use and advise RCA. 6/22

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-5-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 13.3

SUBJECT Quality Assurance

---

### SUMMARY OF DISCUSSION:

RCA stated that DCAS has injected mandatory inspections (presently indicated as temporary) into the manufacturing process which is contrary to MSC/RCA discussions from the December 17, 1969 meeting and the conditions of RCA's proposal. MSC stated that the mandatory inspections were injected by DCAS on the basis of start-up process and would affect the first ten percent of product. RCA stated that accept-reject criteria has not been specified by DCAS. RCA further stated that they understand the position of DCAS on this subject but nevertheless it provides some additional concern in terms of schedule commitments and special provisions must be made to assure adequate DCAS support when needed-including support during RCA multishift and overtime operations. MSC stated they intend to, and will, maintain close surveillance in this area and assure RCA gets all the DCAS support they need.

RCA stated that subcontractor subassembly engineering models will have test parameter concurrence and review by RCA before test and shipment to RCA and test data will be provided with the subassemblies.

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

## MINUTES OF MEETING

DATE 6-5-70 MEETING NUMBER LCRU-PDR AGENDA ITEM 14.0

SUBJECT Minutes and Action Item Review

---

### SUMMARY OF DISCUSSION:

MSC stated that a meeting at MSFC will be held on

June 10 - Pre- CDR - Electrical and EMI

June 11-12 - Crew Station Review

RCA stated they would support the meeting.

MSC/RCA agreed to support a TI on 7/7/70 in Camden.

RCA stated that RCA is presently on strike (as of June 2) and impact on the LCRU program is not yet determinable.

### ACTION ITEMS:

PDR-60 RCA should change cable lengths as follows:

TV - 42"

Low gain 8 feet

High gain 6.5'

**NOTE:** These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

# LCRU PRELIMINARY DESIGN REVIEW

6/3/70, 6/4/70, 6/5/70

## DRAWING PACKAGE/LIST OF DRAWINGS

	DRAWING NO.	NAME
	8670924	Family Tree LCRU
PL	8151108	Parts List Res. Bd. Assy.
	8151108	Res. Bd. Assy.
	8151109	Spacer
PL	8151113	Parts List Bracket
	8151113	Bracket
PL	8151114	Parts List Bracket, Bd. MTG.
	8151114	Bracket, Bd. MTG
PL	8151115	Parts List, Bracket, Test Point
	8151115	Bracket, Test Point
PL	8151117	Parts List, Bracket
	8151117	Bracket
	8151119	Nut, Special
	8151121	Bushing
	8151122	Slug
	8151123	Ball Post
	8151124	Ring
	8151125	Ring Assembly
	8151126	Ball Post, Hi Gain Antenna
	8151127	Slug
	8151128	Plate Locking
	8151129	Pin Locking
	8151130	Pin Mtg. LCRU
	8151131	Cap, Tube
	8151132	Stop
	8151133	Ring
	8151134	Cap, Handle
	8151135	Clamp
	8151136	Bushing
	8151137	Tube, Lower
	8151138	Bushing
	8151139	Handle



# LCRU PRELIMINARY DESIGN REVIEW

## LIST OF DRAWINGS (Continued)

DRAWING NO.	NAME
8151140	Tube, Extending
8151141	Washer, Bearing
8151142	Pin, Retaining
8151143	Pin, Guide
8151144	Sleeve, High Gain Antenna
8151145	Sleeve
8151146	Washer
8151147	Pin, Hi Gain Antenna
8151148	Post
8151149	Shaft, Mounting, H.G. Antenna
8151150	Plug, Ant., H.G.
8151151	Rod, Center
8151152	Center, Shaft Handle
8151153	Handle
8151154	Ring, Retaining
8151156	CAM
8151159	Pin, Lever Stop
PL 8370850	Receiver, AM 259-7 MHz Parts List
8370850	Assy. Dwg., RCVR. AM 259.7 MHz
PL 8370851	Parts List, Transmitter, AM 296.8 MHz
8370851	Assy. Dwg., Transmitter, AM 296.8 MHz
PL 8370852	Pts. List, Sig. Processor (UP-LINK)
PL 8370853	Pts. List, Sig. Processor (DN-LINK)
PL 8370858	Chassis Rivited, XMTR AM
8370858	Assy. Dwg. Chassis Rivited, XMTR AM
8370859	Assy. Dwg. Chassis XMTR, (2 pages)
PL 8370860	Pts. List, Chassis Sig. Proc. (UP-LINK)
PL 8370861	Pts. List, AMP., RF-Mixer (259.7 MHz)
8370861	Assy. Dwg., AMP. RF-Mixer (259.7 MHz)
PL 8370862	Pts. List, Chassis, Rivited, AMP., IF/Audio (AM)
8370862	Chass., Rivited, AMP., IF/Audio (AM) (Assy. Duty)
8370863	(O&M) Chass., Rivited, AMP. IF/Audio (AM)

# LCRU PRELIMINARY DESIGN REVIEW

## LIST OF DRAWINGS (Continued)

DRAWING NO.	NAME
PL 8370864	Pts. List, AMP., IF Audio (259.7 MHz)
8370864	Ass. Dwg. AMP., IF Audio (259.7 MHz)
PL 8370865	Chass., Rivited, Amp., RF Mixer AM (Parts List)
8370865	Chass., Rivited, Amp., RF Mixer AM (Ass. Dwg)
8370866	Chass., Rivited, Amp., RF Mixer AM (O&M Dwg)
PL 8370867	Pts. List, Cordwood Assy., Amp., Audio Squelch (259.7 MHz RCVR)
8370867	Assy. Dwg.
PL 8370868	Parts List, Bd. Assy., Baseband Cond., (DN.LINK)
8370868	Assy. Dwg., Bd. Assy., Baseband Cond., (DN.LINK)
PL 8370869	Pts. List, Chassis Sig. Processor (DN. LINK)
8370869	Assy. Dwg., Chassis Sig. Processor (DN.LINK)
PL 8370870	Pts. List, Chass. Volt. Reg.
8370870	O&M, Chass. Volt. Reg.
8370871	O&M, Chass. Rivited, Volt. Reg.
PL 8370872	Pts. List, Volt. Reg.
8370872	Assy. Dwg., Volt. Reg.
8370874	O&M Cover, LCRU Pressurized
8370879	Cover, Volt. Reg. Chassis
8370882	Stowage, Body
8370883	Cover, Support
PL 8670597	Cable Assy., LCRU/LRV/TV (Parts List)
8670677	Battery, Special
8670900	Cover, Transmitter Chassis
8670901	Cover, Chassis
8670902	Cover, Chassis, Sig. Processor (DN. LINK)
8670903	Schematic Wiring Dwg., Amp. Audio Squelch (259.7 MHz RCVR)
8670904	Sch. Wir. Diag. Baseband Cond. DN.LINK
8670905	*Swd Amp., IF/Audio (259.7 MHz RCVR)
8670906	Bd. Printed Wiring, Amp. Audio Sq. (AM RCVR) Top Bd.
8670907	Bd. Printed Wiring, Amp. Audio Sq. (AM RCVR) Bottom Bd.
8670908	Bd. Printed Wiring, Baseband Cond., (DN LINK) Top Bd.
8670909	Bd. Printed Wiring, Baseband Cond., (DN LINK) Bottom Bd.

# LCRU PRELIMINARY DESIGN REVIEW

## LIST OF DRAWINGS (Continued)

DRAWING NO.	NAME
8670912	Cover, LCRU
8670913	*SWD, DN. LINK Shape Filter
PL 8670914	Bd. Assy Shape Filter, (Parts List)
8670914	Bd. Assy., Shape Filter, Down Link
8670916	Bd., Printed Wiring, Shape Filter, DN.LINK
8670917	*SWD, Time Share Sensor SW., LCRU
PL 8670918	Pts. List, Time Share Sensor Sw., LCRU
8670918	Bd. Assy., Time Share Sensor SW., LCRU
8670920	Bd. Pr. Wiring, Time Share Sensor Sw., LCRU
8670921	Cover
8670922	*SWD, Reg. Volt., Redundant
8670923	Interconnection Diag., Sig. Process (Uplink)
8670924	Family Tree LCRU
8670925	*SWD Sig. Processor (Downlink)
8670928	*SWD Amp., RF Mixer (259.7 MHz)
8670929	*SWD XMTR AM (296.8 MHz)
8670931	Grommet Strain Relief
8670934	Cover, Chassis RF Mixer
8670935	Cover, Chassis IF Audio
PL 8670937	Pts. List, Cordwood Assy., Sig. Processor, VOX-AGC
8670937	Assy. Dwg., Cordwood Assy., Sig. Processor, VOX-AGC
PL 8670938	Pts. List, Cordwood Assy., Sig. Processor, Sig Audio XFMR/Filter
8670938	Assy Dwg., Cordwood Assy., Sig. Processor, Sig. Audio XFMR/Filter
8670940	Outline Mtg. (O&M) Receiver, AM (259.7 MHz)
PL 8670944	Pts. List, Plate Mtg.
8670944	Assy. Dwgs., Plate Mtg.
PL 8670945	Pts. List, Control Panel Assy.
8670947	Cover, XMTR Chassis

\*Schematic Wiring Diagram

# LCRU PRELIMINARY DESIGN REVIEW

## LIST OF DRAWINGS (Continued)

DRAWING NO.	NAME
8670950	Door, Battery Access
8670953	Screw, Assembly
8670954	Handle Assy.
8670956	Support-Tube
8670964	Handle
8670965	Cap, End, Outboard
8670966	Cap, End, Inboard
PL 8670967	Pts. List, Cable Assy., Ant., S-Band, Hi&Lo Gain
PL 8779301	Pts. List, Bd. Assy (Component Mtg.)
8779301	Assy Dwg., Bd. Assy (Component Mtg.)
8779302	Cover, Chassis Sig. Processor Up Link
PL 8779303	Pts. List, Support OSC. Mtg.
8779305	*SWD, RCVR., AM (259.7 MHz)
PL 8779306	Pts. List, Shield Chassis
8779306	Assy Dwg., Shield Chassis
PL 8779307	Pts. List, Cable Assy, St. Angle Conn., Mixer RF (259.7 MHz)
8779307	Assy Dwg., Cable Assy, St. Angle Conn., Mixer RF (259.7 MHz)
PL 8779308	Pts. List, Board Assy.
8779308	Assy. Dwg., Board, Terminal
8779309	Cover Chassis, Sig. Processor (DN LINK)
PL 8779310	Pts. List, KNOB
8779310	Assy. Dwg., KNOB
8779311	Bracket
8779312	Housing, Connector
8779313	Cover, Terminal Connector
8779314	Guide, Positioning Battery
8779315	Guide, Positioning Battery
8779316	Guide, Positioning Battery
8779317	Bracket, Support, Battery
8779318	Slug
8779319	Bracket



# LCRU PRELIMINARY DESIGN REVIEW

## LIST OF DRAWINGS (Continued)

DRAWING NO.	NAME
8779320	Housing, Ball
8779321	Post
8779322	Housing, Hi Gain Antenna
8779323	Bushing, Hi Gain Antenna
8779324	Housing, Cable
8779325	Stop Assembly, Lower
8779326	Stop Housing, Lower
8779329	Shaft Assembly
8779330	Shaft
8779331	Arm
8779332	Fitting, LCRU Mast
8779333	Housing
PL 8779336	Pts. List, Latching Device
PL 8779337	Cover Assy., Connector
8555251	Transistor Field Effect, N-Channel

## **1.0 INTRODUCTION**

**LCRU** Lunar  
Communications  
Relay  
Unit

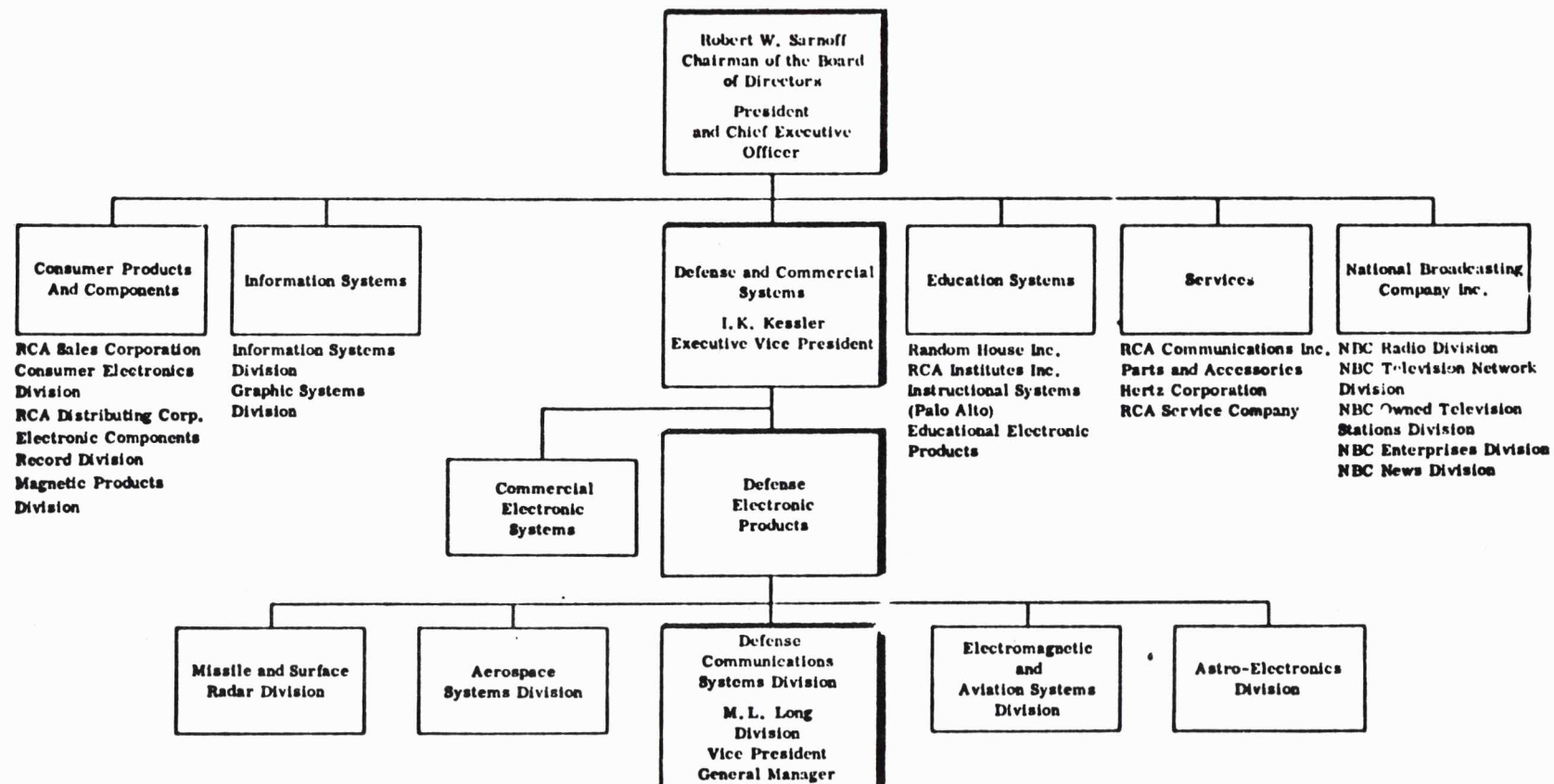
PRELIMINARY DESIGN REVIEW

**RCA**





## CORPORATE STRUCTURE





Defense Communications  
Systems Division  
M.L. Long  
Div. Vice Pres. and Gen. Mgr.

Product  
Assurance  
H.D. Greiner  
Manager

Operations  
Control  
L. Slutzky  
Manager

Marketing Dept.  
J.W. Kinnally  
Manager

Radio  
Equipment  
Operations  
M.R. Amsler  
Manager

Engineering  
Department  
D.J. Parker  
Chief Engineer

Manufacturing  
A.J. Barrett  
Plant Manager

Personnel  
E.P. Tangney  
Manager

Community  
Relations  
and Resources  
Utilization  
S.Z. Daroff  
Manager

Integrated  
Communication  
Systems  
J.M. Osborne  
Manager

Electronic  
Warfare  
M.C. Myers  
Manager

Aerospace Programs  
S.B. Holt  
Manager

Recording  
Equipment  
J.D. Rittenhouse  
Manager

Transmission  
Systems  
M.L. Long  
Act. Manager

LM COMMUNICATIONS  
SUBSYSTEM

D.T. VERMILYE

EVCS

R.D. DEVANTIER

LCRU

H.J. HAMLIN

FINANCIAL  
OPERATIONS

J. IDEMA

OTHERS:  
DOCUMENTATION  
DATA LINK  
ADVANCED PROJECTS  
SYSTEMS



AGENDA  
LUNAR COMMUNICATIONS RELAY UNIT  
PRELIMINARY DESIGN REVIEW

JUNE 3, 4, 5 - 1970

9 AM 6-3-70	1.0	INTRODUCTION	H.J. Hamlin
	1.1	Purpose	
	1.2	What we were to do	
	1.3	What you will see	
	2.0	MANAGEMENT OVERVIEW	H.J. Hamlin
	2.1	Organization	
	2.2	Schedule	
	2.3	Problems	
	2.4	Weight Budget	
	2.5	Power Budget	
	3.0	SUBCONTRACTS	D.A. Orendac
	4.0	OPERATIONS	A.M. Burke
	4.1	Operations Sequence and Mission Timelines	
	4.2	Mode Switching	
	4.3	Circuit Margin Summary	
1 PM 6-3-70	5.0	SYSTEM DESIGN	B.M. Trachtenberg
	5.1	Signal Design	
		EVCS/LCRU/MSFN	
		TV/LCRU/MSFN	
		MSFN/LCRU/EVCS	
		MSFN/LCRU/TV	
	5.2	Link Analysis	
		EVCS/LCRU	
		LCRU/EVCS	
		LCRU/MSFN	
	Primary		
	Secondary		
	TV Voice		
	MSFN/LCRU		
	Voice		
	TV Standby		
	MSFN/LM MSFN/LCRU		
	5.3	Sub System Configuration (through CCA-6)	

9 AM 6-4-70	6.0	ELECTRICAL INTERFACES		
	6.1	Electrical		J. J. Connelly
		LRV (Incl. Cables)		
		EMI & Grounding		J. J. Connelly/G. Houck
	6.2	TV		B. M. Trachtenberg
	7.0	LCRU ELECTRICAL DESIGN		
	7.1	Electrical Design (Overall)		J. J. Connelly
	7.2	RCA Build Assembly		
		7.2.1 DC-DC Converter		J. J. Connelly
		7.2.2 VHF Triplexer		E. DeBaecke
		7.2.3 VHF Receiver		E. DeBaecke
		7.2.4 Down-Link Signal Processor (Include 14.5 & 1.25 VCO)		E. DeBaecke
		7.2.5 VHF Transmitter		E. DeBaecke
		7.2.6 Voltage Regulator		E. DeBaecke
		7.2.7 Up-Link Signal Processor		O. Ramanis
	7.3	Subcontract Assemblies		
		7.3.1 S-Band Receiver		O. Ramanis
		7.3.2 S-Band Transmitter		O. Ramanis
		7.3.3 S-Band Diplexer		E. DeBaecke
		7.3.4 VHF Antenna		E. DeBaecke
		7.3.5 Low Gain Antenna		E. DeBaecke
		7.3.6 Battery		M. Adams
		7.3.7 High Gain Antenna		F. Nangle
	7.4	LCRU Assembly		
		7.4.1 RF losses budget		O. Ramanis
		7.4.2 Case electrical including signal flow and grounding		J. J. Connelly
		7.4.3 Control Panel		J. J. Connelly
		7.4.4 Cabling		J. J. Connelly
		7.4.5 LCRU Power Utilization		J. J. Connelly
	7.5	FMEA		H. Farcus
	8.0	LCRU MECHANICAL INTERFACES		
	8.1	Mechanical, LM, LRV		R. Holston
	8.2	Vibration Analysis		R. Holston
	8.3	Thermal, LM, LRV, TV		G. Grube
	9.0	LCRU MECHANICAL DESIGN		R. Holston
	9.1	Subassembly Arrangement		
	9.2	LCRU Weight Analysis		

9.3	Subassemblies	R. Holston
9.3.1	VHF Receiver	
9.3.2	VHF Transmitter	
9.3.3	VHF Triplexer	
9.3.4	Down Link Processor	
9.3.5	Up Link Processor	
9.3.6	Voltage Regulator	
9.3.7	Battery	
9.3.8	S-Band Receiver	
9.3.9	S-Band Transmitters	
	FM/PM	
	PM/PM	
9.3.10	Diplexer	
9.3.11	VHF Antenna	
9.3.12	Low Gain Antenna	
9.3.13	Antenna Connectors	
9.3.14	DC-DC Converter	
9.4	Case Design	
9.5	Cover Design	
9.6	Pressurization Design	
9.7	Wax Package Configurations	
9.7.1	Radiator Wax Package	
9.7.2	Front Wax Package	
9.7.3	Internal Wax Package	
9.8	Control Panel Design	
9.9	Case Design Modifications	
9.10	LCRU Mounting Post	
9.11	High Gain Antenna Mast	
9.12	Antenna Positioning Mechanisms	
9.13	Stowage Container	W. Babcock
	9.13.1 Layout	
	9.13.2 Weight Analysis	
	9.13.3 Structural Design	
1 PM 6/4/70	10.0 THERMAL DESIGN	
	10.1 System Analysis	R. Scott
	10.1.1 Preliminary Multinode	B. Shelpuk
	10.1.2 Temperature Gradients	B. Shelpuk
	10.2 Thermal Design	B. Shelpuk
	10.2.1 Phase Change Package	B. Shelpuk
	10.2.2 Radiator	B. Shelpuk
	10.2.3 Thermal Blanket	G. Grube
	10.2.4 Thermal Finishes	G. Grube
	10.2.5 Component Temperatures	G. Grube



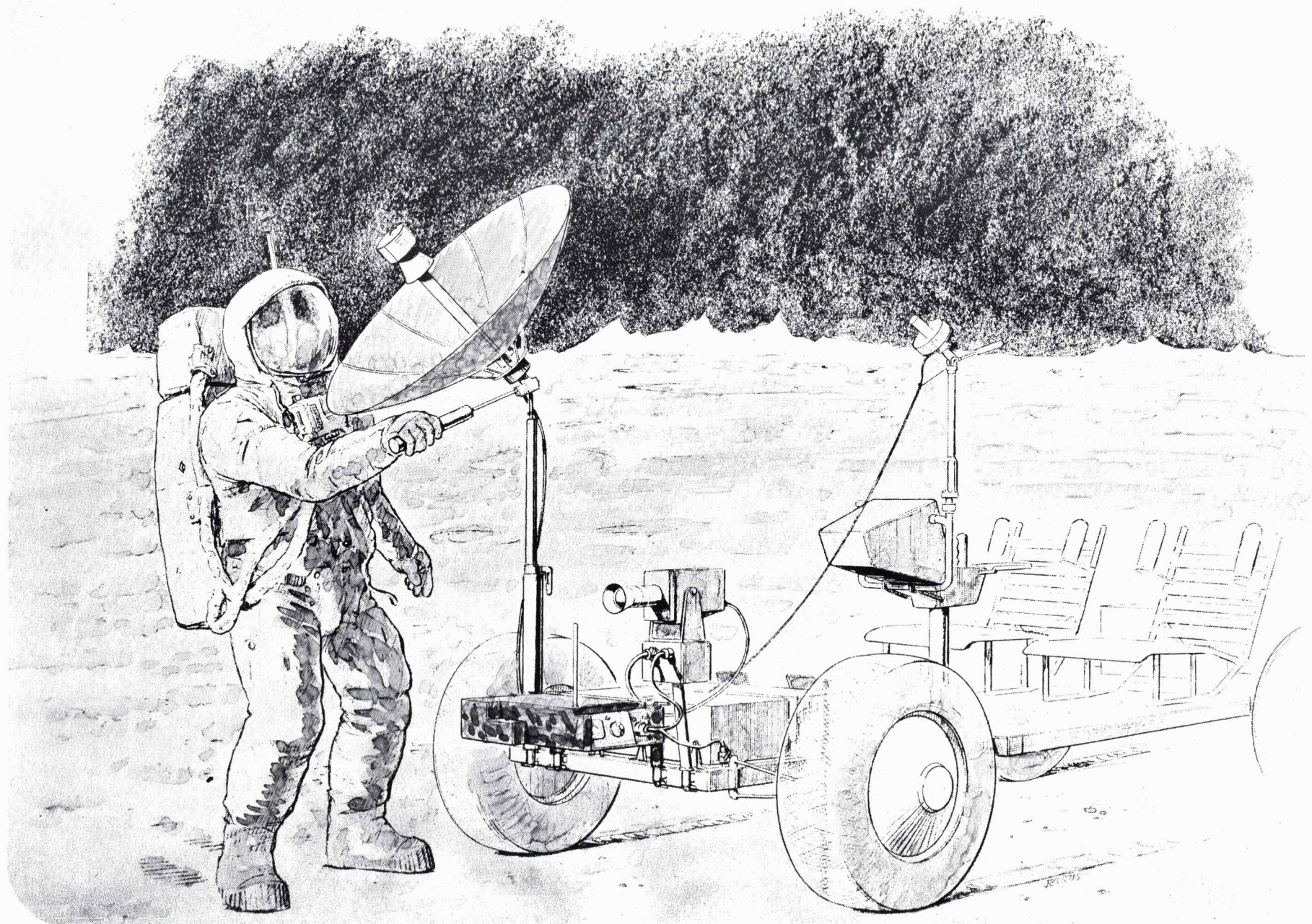
3 PM 6/4/70	11.0	TEST PROGRAM	R. Virostek
		11.1 Thermal	
		11.2 Engineering Model	
		11.3 DVT	
		11.4 QT	
		11.5 ATP	
		11.6 EMI Control Plan	
	12.0	TEST EQUIPMENT DESIGN	R. Virostek
9 AM 6/5/70	13.0	PROGRAM SUPPORT	W.L. Carlino
		13.1 Reliability	
		13.1.1 Organization	
		13.1.2 Program Status	
		13.1.3 Subcontractor Reliability Status	
		13.1.4 Parts Qual Status	H. Farcus
		13.1.5 Parts Application	H. Farcus
		13.2 Configuration Control	W.L. Carlino
		13.2.1 Program Control & Status	
		13.3 Quality Assurance	G. Floyd
		13.3.1 RCA Quality Plan and Program Status	
		13.3.2 Subcontractors Controls and Status	
		13.3.3 Parts-Approved Vendors	
		13.3.4 Equipment Flow Charts Inspection Instructions Environmental Control	
1 PM 6/5/70	14.0	MINUTES AND ACTION ITEM REVIEW	



**RCA**

## LCRU/LRV INTERFACE

1-8

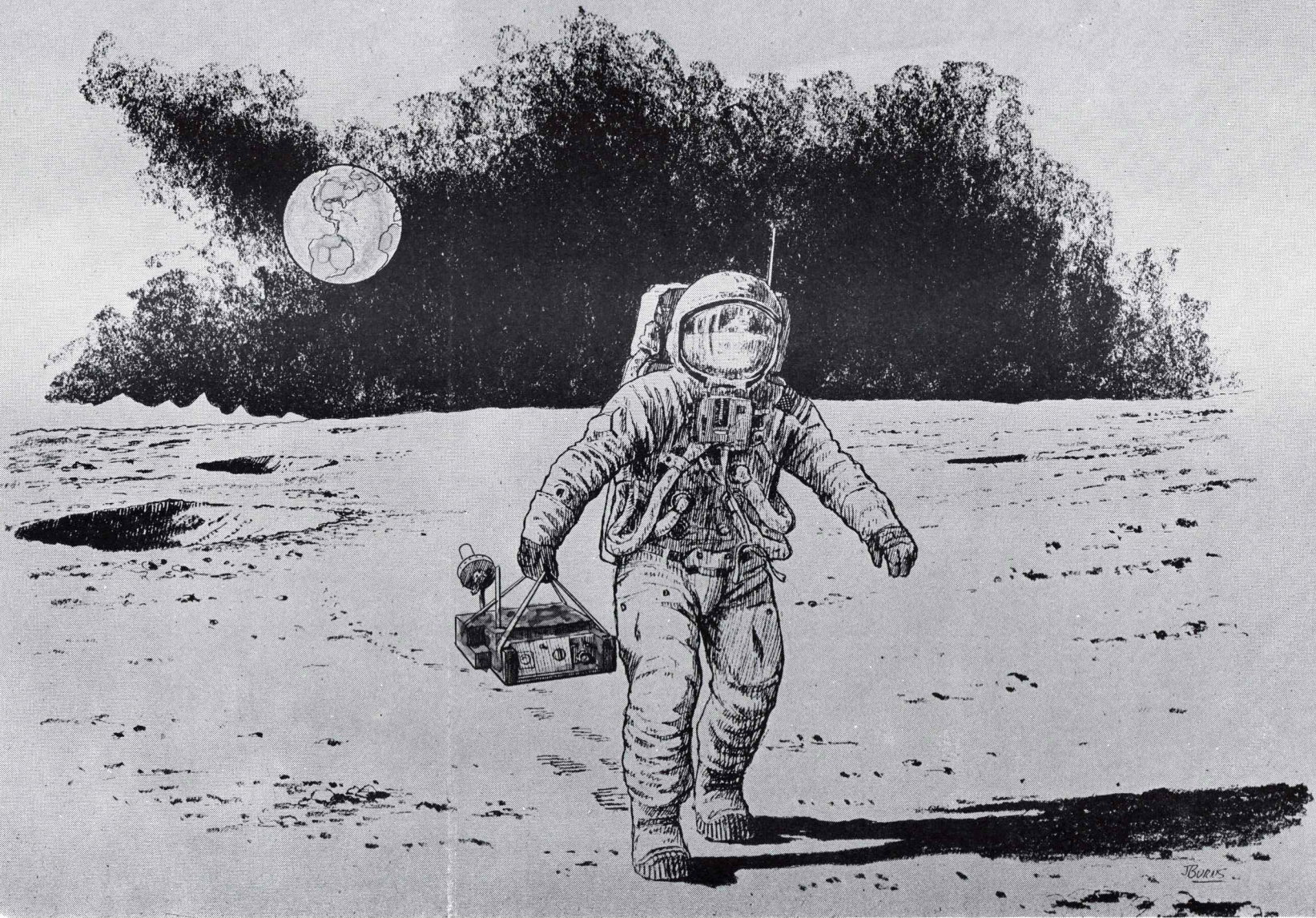




**RCA**

**LCRU RIGHT HAND CARRY MODE**

1-9

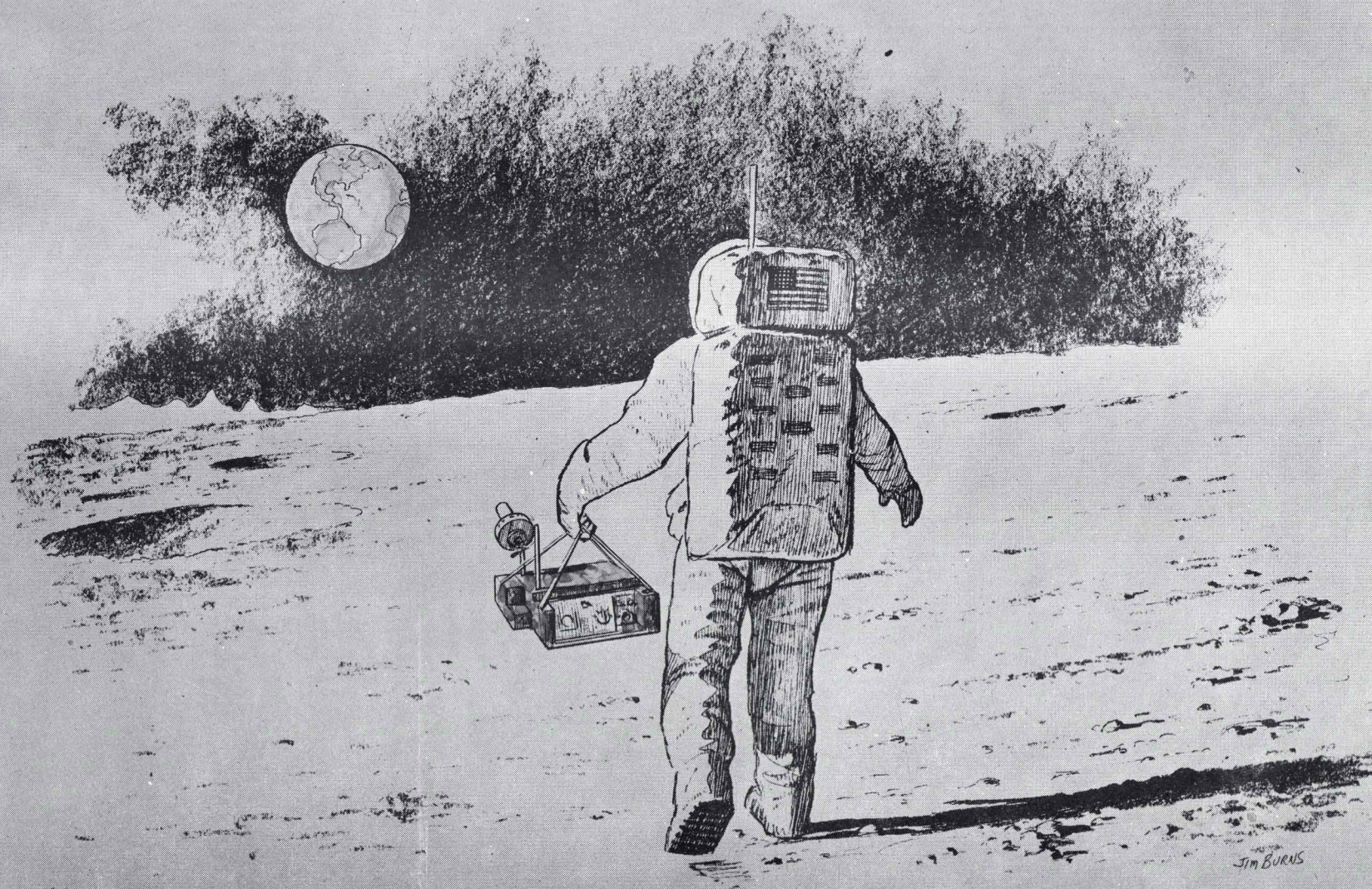




**RCA**

**LCRU LEFT HAND CARRY MODE**

1-10







PURPOSE OF THE PDR -

- TO PRESENT THE PRELIMINARY DESIGN AND PROVE ITS FEASIBILITY
- TO PROVIDE CURRENT PROGRAM STATUS
- TO REVIEW CURRENT PROBLEMS AND ASSIGN ACTION ITEMS WITH RESPONSIBILITY DESIGNATED
- TO RECEIVE CONCURRENCE IN THE DESIGN APPROACH OR DIRECTION IN CASE OF DIFFERENCES

# RCA

WHAT WE WERE TO DO -

BUILD MECHANICAL MOCKUP

PLACE ALL SUBCONTRACTS

RESOLVE LM INTERFACE

RESOLVE LRV INTERFACE

RESOLVE TV INTERFACE

RELEASE AND START BUILD OF EM

RELEASE DVT MATERIAL

CONDUCT VENDOR PDR'S

PROVIDE VENDOR SCD'S

CONDUCT RELIABILITY EVALUATION

BREADBOARD AND TEST RCA BUILD ITEMS

THERMAL DESIGN MODIFICATION



WHAT YOU WILL SEE -

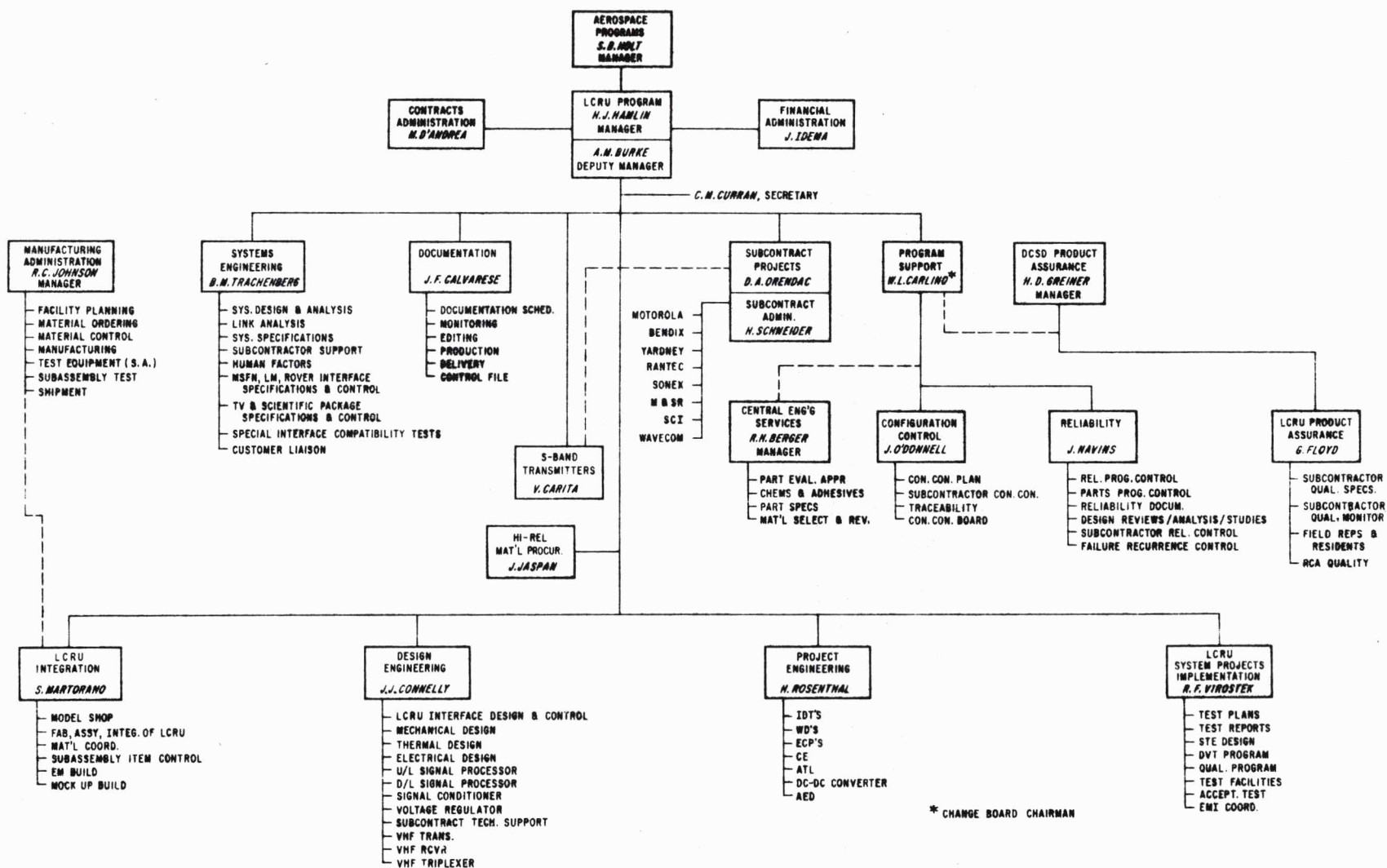
- PROGRAM OVERVIEW
- INTERFACE DESIGN STATUS
- LCRU MECHANICAL MOCK-UP INCLUDING ANTENNAS
- STOWAGE CONTAINER MECHANICAL MOCK-UP
- ANTENNA POSITIONING MECHANISMS MOCK-UPS
- MOCK-UP OF HI-GAIN ANTENNA POSITIONING MECHANISM
- LCRU MOON WEIGHT MOCK-UP
- STOWAGE CONTAINER MOON WEIGHT MOCK-UP
- LRV BUMPER ASSEMBLY MOCK-UP
- TV CAMERA MOCK-UP
- LCRU DESIGN DRAWINGS
- LCRU DESIGN DATA AND ANALYSIS
- EMI DESIGN
- SUBCONTRACTOR SOURCE CONTROL DRAWINGS
- FMEA & RELIABILITY STATUS



## **2.0 MANAGEMENT OVERVIEW**



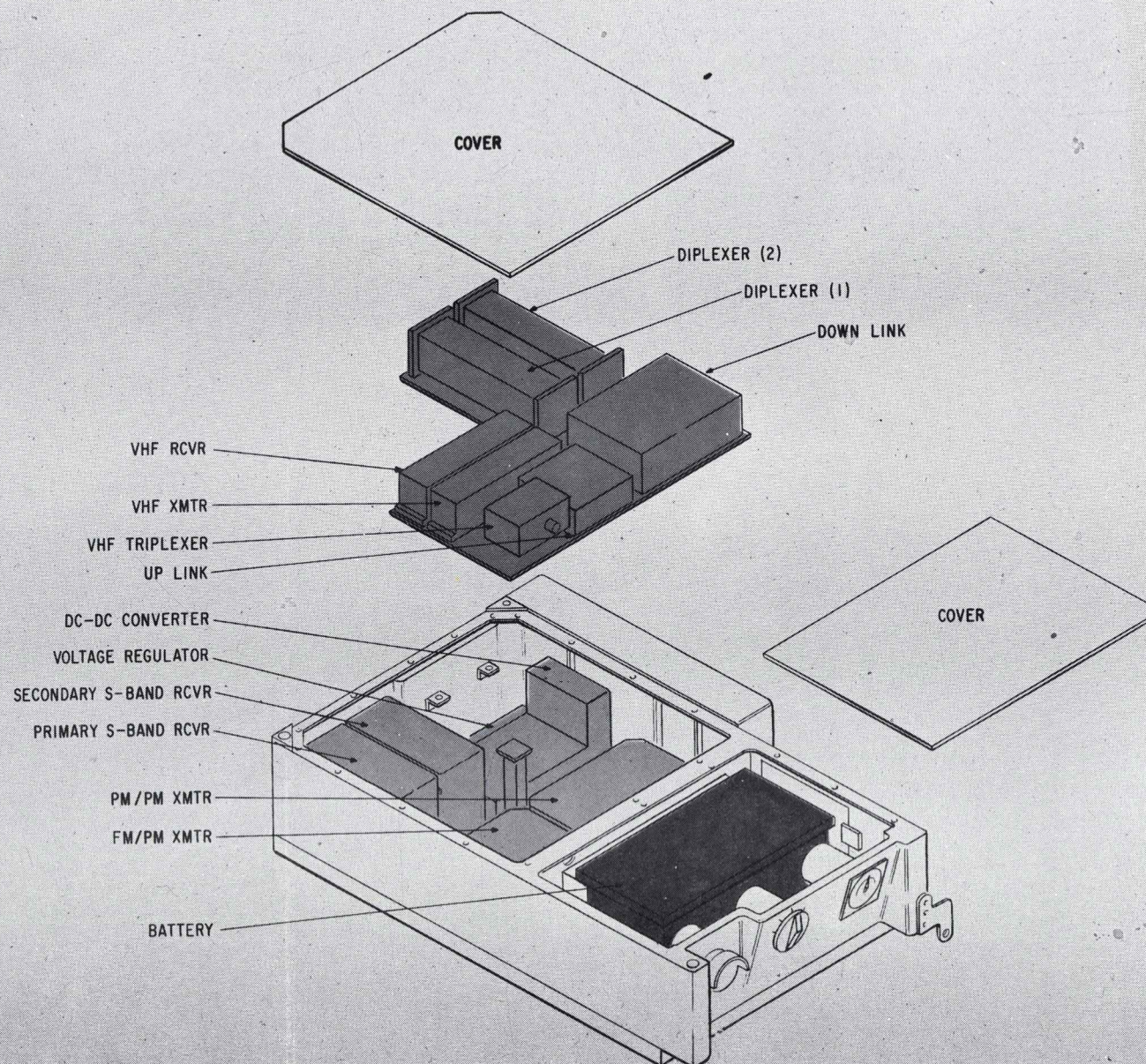
## LCRU PROGRAM ORGANIZATION







## LCRU SUBASSEMBLY ARRANGEMENT



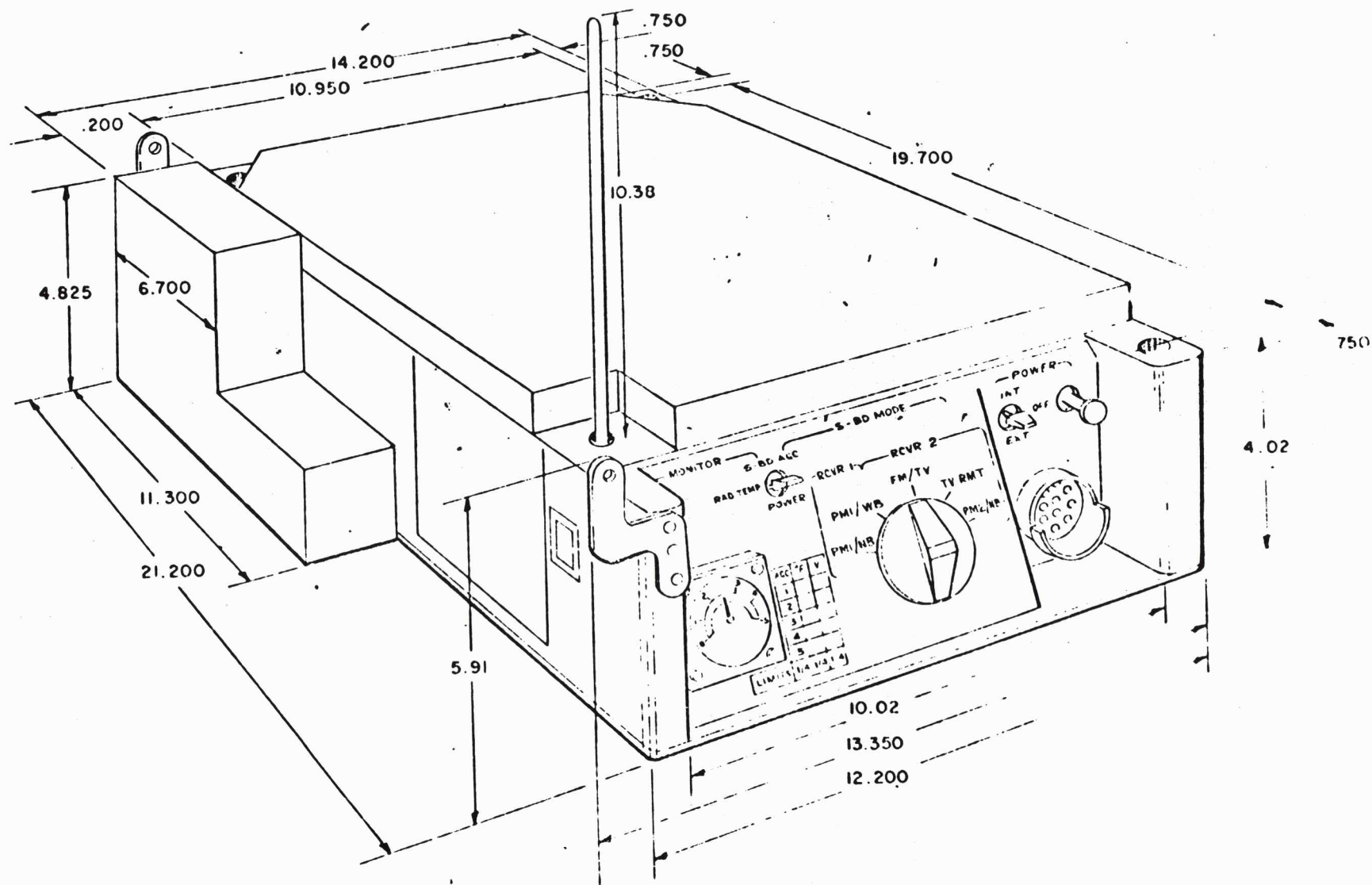


# RCA

## LCRU UNIT

### MECHANICAL MOCK UP WITHOUT BLANKET

2-3



# LCRU - EQUIPMENT MILESTONES AND DELIVERIES

			1970								1971											
			MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT		
1	THERMAL MOCKUP	(RCA)		◆	▽	---	---	▽												▽ SCHEDULE	1	
2																				◇ POTENTIAL	2	
3	MECHANICAL MOCKUP	(RCA)		▽																◇ SLIP	3	
4																				◆ SLIP	4	
5	ENGINEERING MODEL	(RCA)		◆	—	◇	—	▽												▽ COMPLETE	5	
6																					6	
7	ENGINEERING MODEL	(MSC - 1 wk.)					◇														7	
8																					8	
9	DVT #1	(RCA)								◇	▽										9	
10																					10	
11	DVT #2	(MSC)									◇	▽									11	
12																					12	
13	QUAL TEST MODEL	(RCA)											◇	▽							13	
14																					14	
15	FLIGHT MODEL	#1														▽					15	
16																					16	
17		#2															▽				17	
18																					18	
19		#3																▽			19	
20																					20	
21		#4																	▽		21	
22																					22	
23		#5																		▽	23	
24																					24	
25																					25	
26																					26	
27																					27	
28																					28	
29																					29	
30																					30	
31																					31	
32																					32	
33																					33	
34																					34	
35																					35	
36																					36	
37																					37	
38																					38	
39																					39	
40																					40	

MODIFIED THROUGH CCA-3 4/2/70

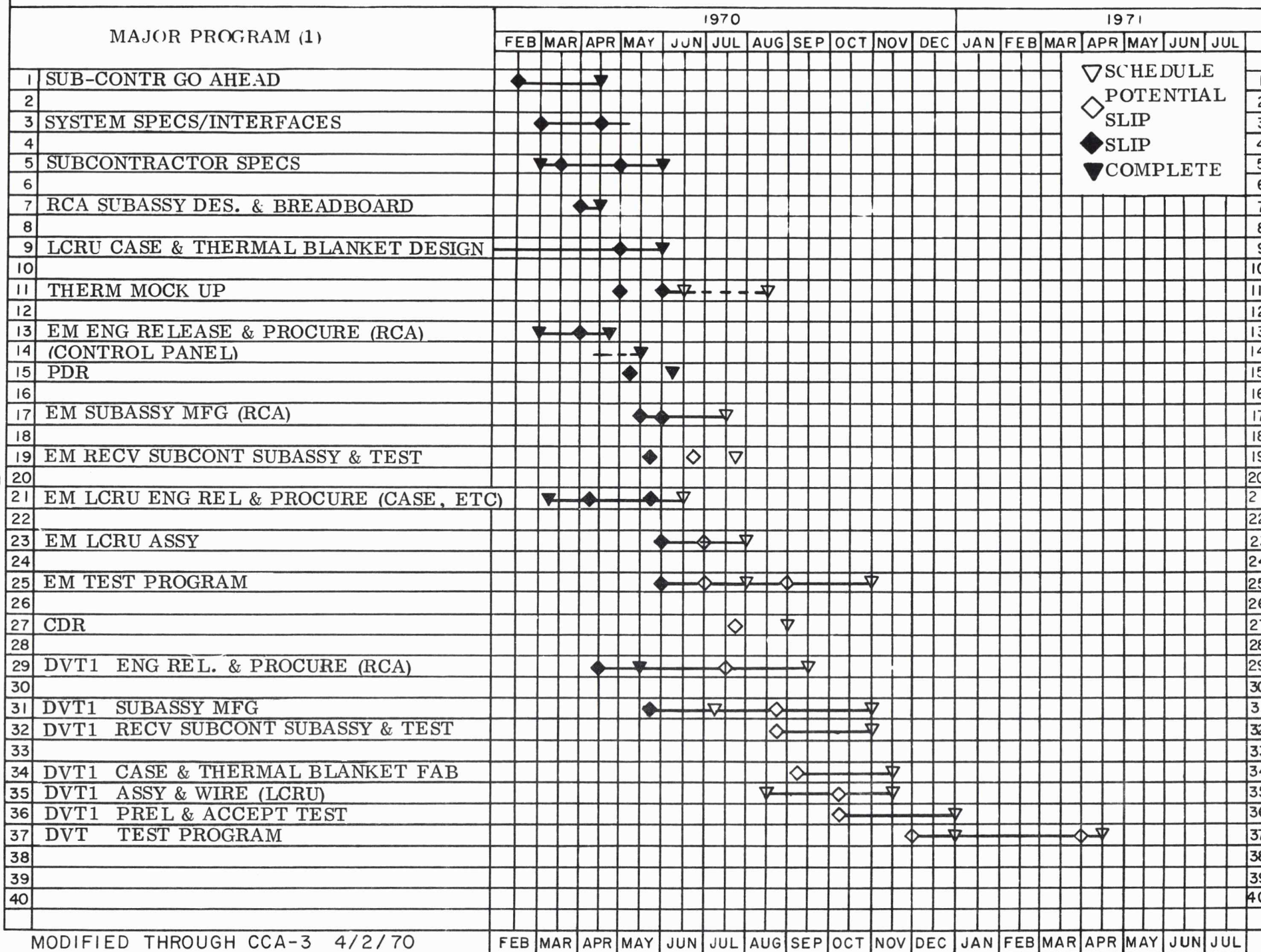
MAYJUNJULAUGSEPNOVDECJANFEBMARAPRMAYJUNJULAUGSEPNOVDEC

MODIFIED THROUGH CCA-3 4/2/70

MODIFIED THROUGH CCA-5 5/4/70



# LCRU MAJOR PROGRAM MILESTONES



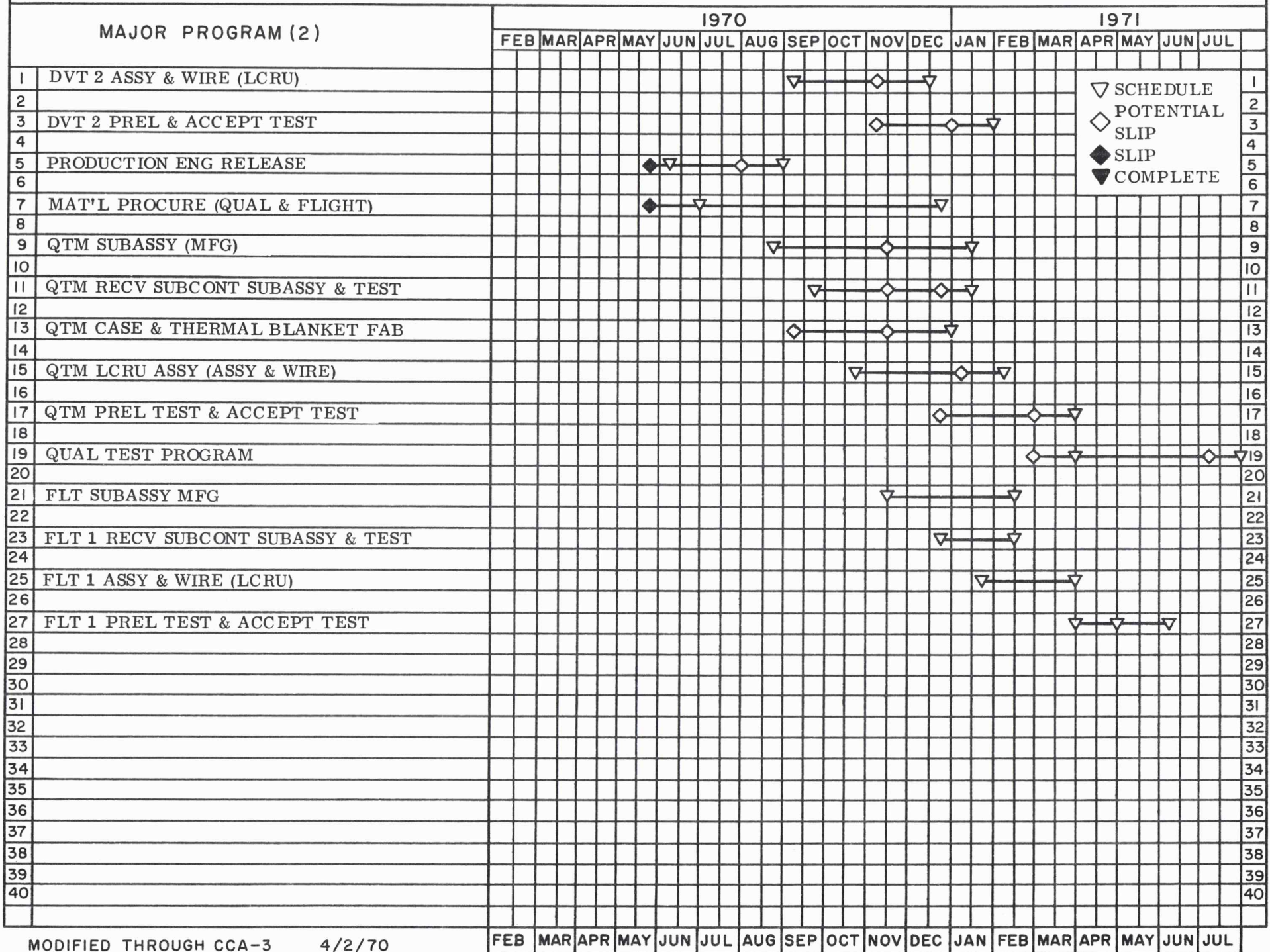
MODIFIED THROUGH CCA-3 4/2/70

MODIFIED THROUGH CCA-5 5/4/70

FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL



# LCRU MAJOR PROGRAM MILESTONES



MODIFIED THROUGH CCA-3 4/2/70  
 MODIFIED THROUGH CCA-5 5/4/70

LCRU SUB-CONTRACT 1			1970												1971						
			FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	
S-BAND RECEIVER - MOTOROLA	START		▼			M&T															
MOCKUPS - EM				▼		▼	◇		▼												
DVT & FLIGHT MODELS (2 PER SYSTEM)									▼	▼			▼	▼	▼	▼	▼				
VHF TRIPLEXER (RANTEC)	START		◆	▼																	
MOCKUP - EM						▼			2	2	2	2									
DVT & FLIGHT MODELS									▼	▼	▼	▼									
BATTERY (YARDNEY)	START		◆	▼		M	T														
MOCKUP - EM					◆	▼	▼	▼	▼												
DVT & FLIGHT MODELS									▼	▼				▼	▼	▼	▼	▼	▼	▼	
14.5 KHZ VCO (SONEX)	START		▼		M	T															
MOCKUP - EM					▼	▼	◆	▼													
DVT & FLIGHT MODELS									2		2	2	2								
S-BAND DIPLEXER (WAVECOM)	START		▼		M&T																
MOCKUP - EM					▼	▼	▼			2		2	2	2							
DVT & FLIGHT MODELS									◇	◇	▼	▼	▼	▼							
S-BAND XMTRS PM/FM PM/PM (CONIC)	START		▼		M&T																
MOCKUP - EM					▼		▼														
DVT & FLIGHT MODELS										◇	▼	◇	▼	▼	▼	▼	▼	▼	▼	▼	
VHF ANT. (MOTOROLA)	START		▼																		
MOCKUP - EM							▼														
DVT & FLIGHT MODELS								▼	▼	▼	▼	▼	▼	▼	▼						
HI GAIN ANT. (MS&R)	START		▼		M		D														
MOCKUP - EM					▼		▼		◇												
DVT & FLIGHT MODELS												▼	▼		▼		▼	▼	▼	▼	
LCRU SUB-CONTRACT 2																					
LOW GAIN ANT. (BENDIX)	START		▼		M																
MOCKUP - EM					▼			▼													
DVT & FLIGHT MODELS										▼	▼			▼	▼	▼	▼	▼	▼	▼	
1.25 MHZ VCO (SCI)	START			▼		M&T															
MOCKUP - EM						▼		▼													
DVT & FLIGHT MODELS											▼	▼		▼	▼	▼	▼	▼	▼	▼	
DC-DC CONVERTER	START			▼		M&T															
MOCKUP - EM						▼		▼													
DVT & FLIGHT MODELS											▼	▼		▼	▼	▼	▼	▼	▼	▼	

▼ SCHEDULE  
◇ POTENTIAL  
◇ SLIP  
▼ COMPLETE

▼ SCHEDULE  
 ◇ POTENTIAL  
 ◇ SLIP  
 ▼ COMPLETE





# LCRU DOCUMENTATION SCHEDULE

QTMO-----J

DVT1 O-----J

DVT2 Δ

EQUIPMENT DELIVERY-----

PDR

CDR

FM Δ Δ Δ Δ Δ

1 2 3 4 5

REF.	ITEM	T Y P E	1970												1971											
			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O		
EXHIB. A																										
5.1	MONTHLY LETTER PROGRESS REPORT					▲	▲	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ		
5.2	DESIGN DOCUMENTATION																									
a	CONFIGURATION CONTROL PLAN	I		▲			▲																	Δ NASA DELIVERY		
b	SUBASSEMBLY SPECIFICATIONS (SUBCONTRACT ITEMS)	II					▲		Δ															▲ SHIPPED		
c	THERMAL ANALYSIS REPORT	II							Δ															Δ REV/UPDATE		
d	EMI CONTROL PLAN	II						▲																○ IN-HOUSE DELIVERY		
e	FAILURE MODE AND EFFECT ANALYSIS	II					▲			Δ																
* f	DESIGN DRAWINGS	II					▲			Δ					Δ											
5.3	TEST DOCUMENTATION																									
a	DESIGN VERIFICATION TEST PLAN/PROCEDURE	I								PLAN Δ			Δ PROC.													
a	DESIGN VERIFICATION TEST REPORT	I																			Δ					
b	QUALIFICATION TEST PLAN/PROCEDURE	I												PLAN Δ			Δ PROC.									
b	QUALIFICATION TEST REPORT	I																			PARTIAL Δ		Δ FINAL			
c	PRE-DELIVERY ACCEPTANCE TEST PLAN/PROCED.	I								PLAN Δ			Δ PROC													
d	PRE-INSTALLATION ACCEPTANCE TEST PROCED.	I											Δ													
* e	TRAINING MANUAL	I											Δ													
5.4	QUALITY ASSURANCE DOCUMENTATION																									
a	QUALITY PROGRAM PLAN	I		▲			▲																			
b	MATERIAL & PROCESS SPECIFICATIONS	III	ON REQUEST →																							
c	EQUIPMENT (END-ITEM) DATA PACKAGE	II															DVT O <sub>1</sub> Δ <sub>2</sub>			O <sub>QTM</sub>	FM Δ <sub>1</sub> Δ <sub>2</sub> Δ <sub>3</sub> Δ <sub>4</sub> Δ <sub>5</sub>					
5.5	RELIABILITY ASSURANCE DOCUMENTATION																									
a	RELIABILITY & PARTS PROGRAM PLAN	I		▲		▲																				
b	ELECTRICAL PARTS LIST (QPL/APL)	II					▲				Δ															
c	PARTS PROCUREMENT & SCREENING SPECIFICATIONS	III									○															
d	PARTS APPLICATION REVIEWS	III									○															
e	(1) PARTS QUALIFICATION TEST REPORTS	II	AS REQUIRED →																							
e	(2) PARTS QUALIFICATION TEST PLANS	I	AS REQUIRED →																							
* f	RELIABILITY EVALUATION REPORT / WITH ECP's	I								Δ																
* g	PARTS PROCUR. & SCREENING LAB. REPORT	I	AS REQUIRED →																							
-	SPECIAL STUDY REPORTS																									
APPEN. A																										
2.1.g.1	QUALIFICATION STATUS LIST	II																			Δ					
2.1.g.2	DRAWING LIST	II																			Δ					
*REFLECTS DAN 1654 & THROUGH CCA-5			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O		
			1970												1971											





- LCRU DESIGN STATUS -

- LCRU MECHANICAL MOCK-UP COMPLETE.
- ENGINEERING MODEL IN-HOUSE SUBASSEMBLIES IN PRELIMINARY TEST. ALL DATA TAKEN TO DATE IS WITHIN DESIGN LIMITS.
- DESIGN APPROACH FOR LCRU AND HIGH GAIN ANTENNA MAST MOUNTING MECHANISM HAS BEEN FINALIZED.
- ENGINEERING MODEL DRAWINGS APPROXIMATELY 80% COMPLETE.
- IN-HOUSE DVT SUBASSEMBLY PARTS RELEASED-COMPLETE. CONTROL PANEL AND CASE DVT PARTS RELEASE SCHEDULED FOR 6/8/70.
- THERMAL MOCK-UP COMPLETION SCHEDULED FOR 6/8/70.
- DC/DC CONVERTER BREADBOARD DATA ALL WITHIN SPECIFICATION LIMITS.
- PRELIMINARY LCRU VIBRATION ANALYSIS AND TEST DATA COMPLETE.
- PRELIMINARY THERMAL DESIGN ANALYSIS COMPLETE.



## ENGINEERING MODEL- STATUS SUMMARY

### RCA MAKE ITEMS-% COMPLETION

	VHF TRANSMITTER	VHF RECEIVER	UP LINK SIGNAL PROCESSOR	DOWN LINK SIGNAL PROCESSOR	VOLTAGE REGULATOR	CASE	CONTROL PANEL
SKETCHES	95	95	95	90	95	80	90
FABRICATION	COMPLETE	COMPLETE	COMPLETE	COMPLETE	COMPLETE	55	55
WIRING	COMPLETE	80	60	40	70	NOT STARTED	NOT STARTED
MODULE TEST	70	30	80	30	60	NOT STARTED	NOT STARTED

MECHANICAL MOCKUP COMPLETE

THERMAL MOCKUP 75% COMPLETE



## DVT MODEL STATUS SUMMARY

DRAWINGS	70% COMPLETE
PARTS RELEASES	
A. CASE	6/1/70
B. SUBASSEMBLIES	90% COMPLETE
FABRICATION RELEASE	6/15/70
ASSEMBLY RELEASE	7/15/70



	<u>ACTION ITEM</u>	<u>RESP.</u>	<u>DATE</u>	<u>AGENDA ITEM</u>	
TI-2-1	RCA to determine and/or correct VHF antenna insert to assure S-Band reradiation does not occur.	RCA	PDR	2.0	1
TI-2-2	RCA to support LM-MESA-CCSR on 5/14 with a storage container mock-up, and LCRU and battery if possible. Provide Velcro provision with container - including Work Table Straps.	RCA	5/14/70	2.0	2
		closed 1098-10.1 5/20			
TI-2-3	RCA to provide battery handle retention for battery storage in LM-MESA.	RCA	PDR	2.0	3
TI-2-4	RCA/NASA to jointly review potential damage to LCRU during insertion and withdrawal in the MESA at CCSR on 5/14/70 to assure damage cannot occur.	RCA/NASA	5/14/70	2.0	4
		closed 1098-10.1 5/20			
TI-2-5	MSC/GAC to define stowage container handling requirements as function of MESA.	MSC/GAC	5/14/70	2.0	5
		closed 1098-10.1 5/20			
TI-2-6	MSC/GAC to define stowage container handle and dimensional requirements.	MSC/GAC	5/14/70	2.0	6
		closed 1098-10.1 5/20			
TI-2-7	MSC to determine feasibility of moving Lo Gain antenna closer to Astronaut-rearward.	MSC	5/13/70	3.1	1
		open 1088-2.1			
TI-2-8	RCA to provide impact of implementing Low Gain Antenna Pointing #3 design concept.	RCA	<del>5/13/70</del> PDR	3.1	2
		1098- .1 5/20			
TI-2-9	RCA to provide double locking LCRU/LRV mounting legs preferably with lever action. Protrusion below LRV mount is not permitted.	RCA	PDR	3.1	3
TI-2-10	RCA to provide leg (LRV) forces data to MSC to enable LRV mounting structural analysis and design.	RCA	PDR	3.1	4
TI-2-11	RCA to implement straight through mounting interface for high gain antenna/LRV Interface (lever or equiv. 1/4 turn-locking). No protrusion below LRV chassis permitted.	RCA	PDR	3.1	5

	<u>ACTION ITEM</u>	<u>RESP</u>	<u>DATE</u>	<u>AGENDA</u>	<u>ITEM</u>
TI-2-12	MSC to advise on 10 <sup>th</sup> force acceptance for high gain antenna deployment.	MSC <i>closed 5/12</i> <i>1088-2.1</i>	5/11/70	3.1	6
TI-2-13	RCA to evaluate optical sight and assure that minimum $\pm 10^\circ$ earth field of view is obtained and that image observation is possible three feet from sight and accurate pointing can occur at $\pm 20^\circ$ from optical center line.	RCA <i>OPEN</i> <i>NO. 11 THE 6/6</i>	PDR	3.1	7
TI-2-14	RCA to evaluate effect on image (pointing capability and brightness effects) when sun is $10^\circ$ and further from earth.	RCA <i>N/A</i>	PDR	3.1	8
TI-2-15	MSC to determine amount of LRV deflection and effect on antenna pointing of LRV operations: such as rock loading, payload activity, camera removal, etc.	MSC	5/13/70 <i>OPEN</i>	3.1	9
TI-2-16	MSC to advise RCA of estimated Astronaut hand loading effects of high gain antenna pointing (effects on LRV chassis and deflection changes when Astronaut removes hand).	MSC	5/13/70 <i>OPEN</i>	3.1	10
TI-2-17	MSC to specify DC-DC/LRV source impedance and/or relaxation of EMI requirements to enable the DC-DC converter to work to a higher source impedance.	MSC <i>closed net</i> <i>TI-2-19</i> <i>and LRV-ICD-IRV A-2</i> <i>dated 5/19</i>	5/13/70	3.2	1
TI-2-18	MSC to take action to assure the LRV-ICD provides adequate thermal interface definitions.	MSC	5/13/70 <i>OPEN</i>	4.0	1
TI-2-19	RCA to provide to MSC a detailed LRV interface-mechanically and thermally for subsequent MSFC review and action at LRV CDR	RCA <i>closed</i> <i>1098-10.1</i> <i>5/30</i>	5/9/70	4.0	2
TI-2-20	MSC to provide TV-ICD which includes thermal interface characteristics.	MSC	5/18/70 <i>OPEN</i>	4.0	3

ACTION ITEM	RESP.	DATE	AGENDA ITEM
TI-2-21 MSC to review APEX/Band pass filter design in connection with frequency stability of 1.25 MHz VCO and advise RCA of adequacy/inadequacy.	MSC <i>closed 5/12</i> 1088-2.1	5/12/70	5.1 1
TI-2-22 RCA to advise MSC of impact of redesign of Sensor Switch to enable 3:1 ratio.	RCA <i>closed 5/12</i> 1088-2.1 1098-10.1 - 5/20	5/8/70	5.1 2
TI-2-23 RCA to evaluate S-Band TX 28 Volt lines for feasible means of eliminating single point failure.	RCA <i>closed</i> 1098-10.1 5/20	5/8/70	5.1 3
TI-2-24 RCA to perform evaluation of Conic Transmitter to determine advantages/disadvantages of deletion of high power regulator and make recommendations to MSC.	RCA	PDR	5.1 4
TI-2-25 MSC to evaluate the LCRU pressure/gas recommendations of RCA and advise of acceptability by PDR.	MSC	PDR	5.2 1
TI-2-26 MSC to advise RCA of delivery dates of GFE test equipment.	MSC <i>closed 5/12</i> 1088-2.1	5/8/70	6.0 1
TI-2-27 MSC to advise RCA of Dust (mechanical) test requirements.	MSC	PDR	6.0 2
TI-2-28 MSC to supply LM-CTS data to support PIA test Proc.	MSC	8/13/70	6.0 3
TI-2-29 RCA to review the MSC GSE block diagram to verify that the MSC equipment is adequate to support the RCA DVT and qualification testing of solar-simulation/thermal vacuum in the MSC chamber facility.	RCA <i>closed</i> 3119-4.1 5/25	5/20/70	7.0 1
TI-2-30 RCA to review grounding scheme (including TV/EXT Power Interface) and present at PDR.	RCA	PDR	8.0 1
TI-2-31 RCA to evaluate effect of changing TV cable from 22 inches to 5 feet.	RCA <i>closed</i> 1098-10.1 5/20	5/11/70	8.0 2



<u>ACTION ITEM</u>	<u>RESP.</u>	<u>DATE</u>	<u>AGENDA ITEM</u>
TI-2-32 MSC to specify in TV ICD the DC voltage from the Camera which represents center frequency (e.g., center of camera signal excursion).	MSC <i>closed</i> TV-ICD 5/20	5/18/70	8.0 3
TI-2-33 RCA to provide by the PDR an analysis of all deviations and "hardware buildup" tolerances for the PM and FM transmission modes.	RCA	PDR	8.0 4
TI-2-34 RCA to submit "parts for qualification" list at PDR	RCA	PDR	10 1
TI-2-35 MSC to advise RCA of decision with regard VHF failure mode.	MSC <i>closed per</i> <i>Tolson R.S/H.J.H 5/12</i>	ASAP	10 2
TI-2-36 MSC to determine the need for Apollo Operations Handbook type of document for LCRU.	MSC	PDR	12 1
TI-2-37 MSC to advise RCA when Z G connectors can be provided.	MSC	PDR	14 1
TI-2-38 RCA shall work around on all connectors on assumption that MSC cannot supply the Z G connectors.	RCA <i>closed</i> 1098-10.1 5/20	5/7/70	14 2
TI-2-39 MSC to advise RCA of isolated vs non-isolated DC-DC converter	MSC <i>closed</i> 1098-10.1 5/20	5/13/70	5.1 1



PROBLEMS -

CASE PRESSURIZATION

TV INTERFACE

INTERFACE CABLES (LONGER)

LGA MOUNTING MAST

HGA SIGHT

LRV VIBRATION (& FACILITATION)

LM VIBRATION (GAC TESTS &  
AMPLIFICATION)

BATTERY (CAPACITY & THERMAL)

DOWN LINK FREQUENCY

S-BAND TRANSMITTERS

LRV BATTERY COVERS

ZERO-G CONNECTOR

CONTROL PANEL SWITCHES (DVT)

THERMAL INTERFACES (TV & LRV)

STOWAGE CONTAINER DESIGN

DUST TESTING



## LCRU EMERGENCY MODE

### HAND CARRY WEIGHT

LCRU	54.790
LOW GAIN ANTENNA	.820
LOW GAIN ANTENNA POSITIONING MECHANISM AND ARM	.440
CABLE	<u>.756</u>
TOTAL	56.806

9.5 LB MOON WEIGHT





## LCRU UNIT WEIGHT ANALYSIS

<u>SUBASSEMBLY</u>	<u>WEIGHT, LB.</u>	<u>SUBASSEMBLY</u>	<u>WEIGHT, LB.</u>
VHF TRIPLEXER	0.300	DC DC CONVERTER	2.500
VHF TRANSMITTER	0.500	VOLTAGE REGULATION	0.250
VHF RECEIVER	0.500	BATTERY	9.400
SEC S-BAND RECEIVER	1.500	WAX PACKAGE 1	10.50*
PRI S-BAND RECEIVER	1.500	WAX PACKAGE 2	
FM/PM TRANSMITTER	2.620	WAX PACKAGE 3	
PM/PM TRANSMITTER	2.620	VHF ANTENNA	.250
DIPLEXER (1)	1.000	CASE, COVERS AND PANEL	14.000
DIPLEXER (2)	1.000	CONTROL PANEL PARTS	1.750
UPLINK	0.500	THERMAL BAG	2.100
DOWN LINK	1.000	INTERNAL CABLING	1.000
			<hr/>
			54.795

ESTIMATED  
WEIGHT:

\* ORIGINAL DESIGN CRITERIA WAS 11.0 LB - FINAL DESIGN WEIGHT ESTIMATE IS LESS THAN 10.0 LB

NOTE: PRESENT MECHANICAL MOCK UP IS 51.0 LB



## LRV INTERFACE

### LCRU/LRV STOWED WEIGHT, LB

●	LCRU UNIT	54.790
●	LCRU UNIT MOUNTING LEGS	1.200
●	HIGH GAIN ANTENNA	3.510
●	HIGH GAIN ANTENNA POSITIONING MECHANISM	.600
●	HIGH GAIN ANTENNA MAST	2.400
●	LOW GAIN ANTENNA	.820
●	LOW GAIN ANTENNA POSITIONING MECHANISM AND ARM	.440
●	CABLES	
	HIGH GAIN ANTENNA	.680
	LOW GAIN ANTENNA	.756
	POWER/TV INTERFACE	1.000
	TOTAL	<hr/> 66.196

**RCA**

**LM INTERFACE**

**STOWED WEIGHT**

	<u>WT. LBS.</u>	<u>ICD</u>
● LCRU UNIT	54.790	55.0
● STOWAGE CONTAINER	17.106	18.0
	<u>71.896</u>	

**NOTE: REPLACABLE BATTERIES NOT INCLUDED**



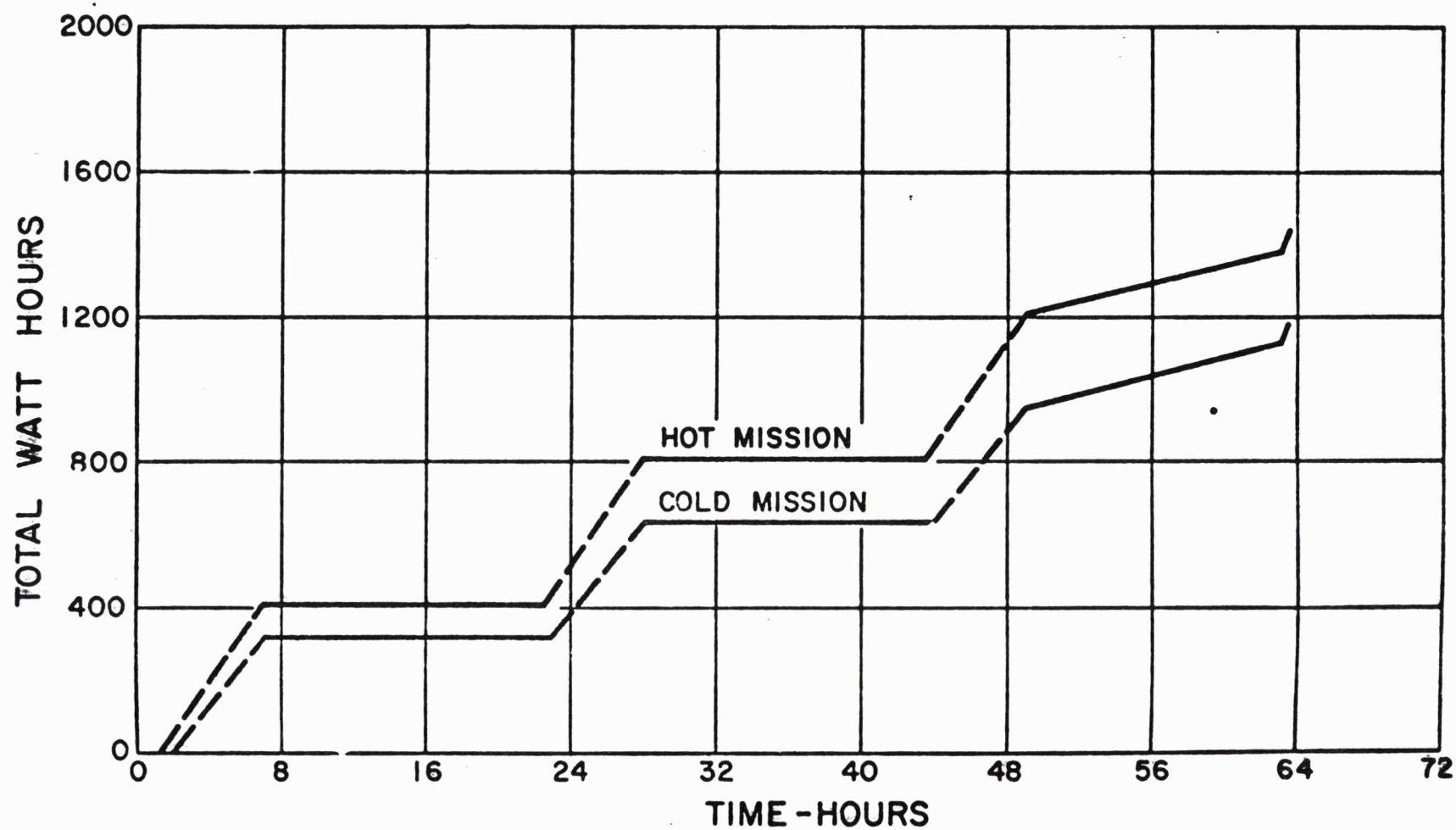


## STOWAGE TUBE WEIGHT ANALYSIS

	LB
● LCRU UNIT MOUNTING LEGS (2)	1.200
● HIGH GAIN ANTENNA	3.510
● HIGH GAIN ANTENNA POSITIONING MECHANISM	0.600
● HIGH GAIN ANTENNA MAST	2.400
● LOW GAIN ANTENNA	0.820
● LOW GAIN ANTENNA POSITIONING MECHANISM AND ARM	0.440
● CABLES	
HIGH GAIN ANTENNA	0.680
LOW GAIN ANTENNA	0.756
POWER TV INTERFACE	1.000
● STOWAGE TUBE	5.700
<hr/>	
TOTAL STOWAGE TUBE W/CONTENTS	17.106
ICD WT	18.000

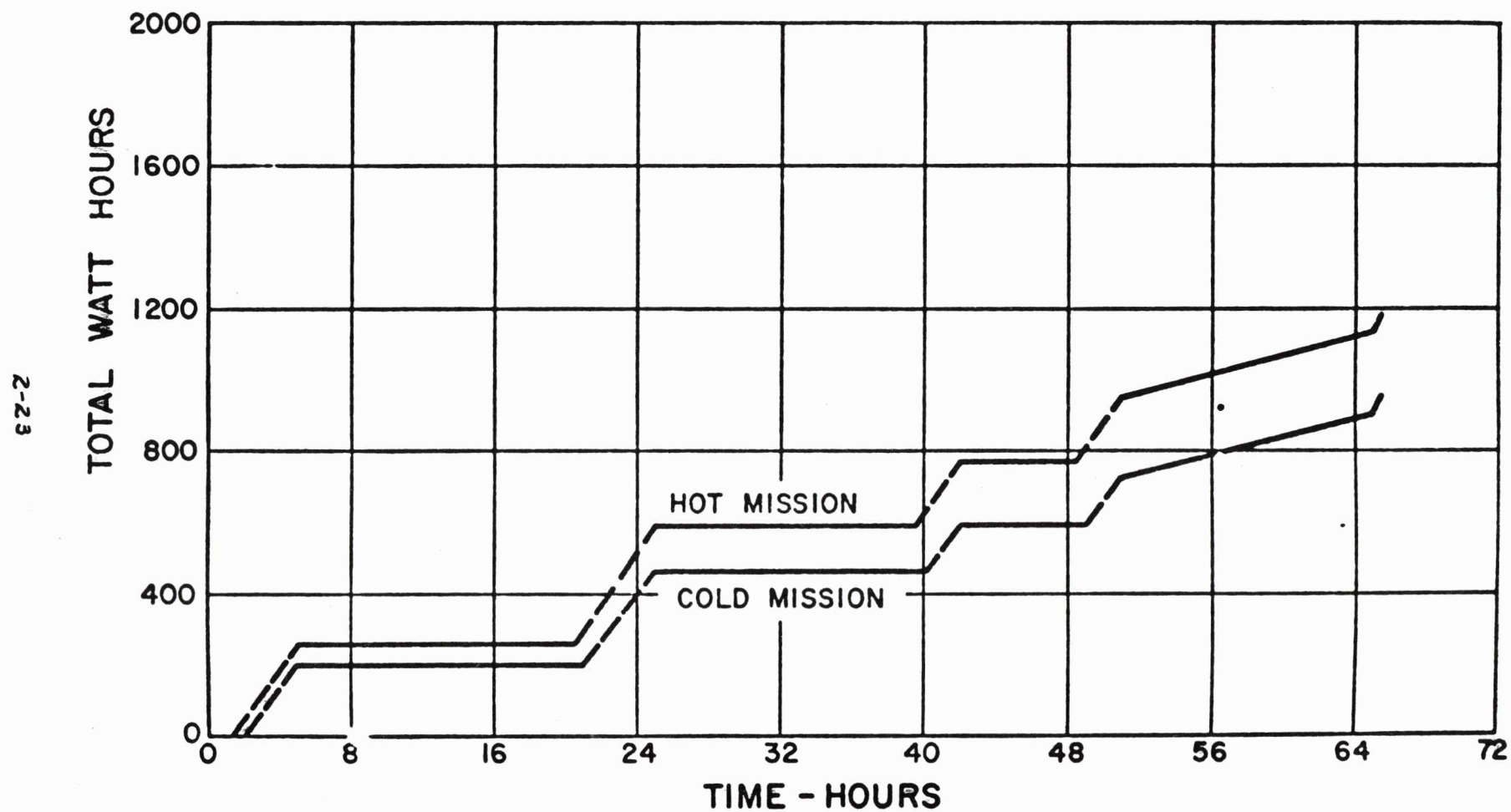


## WATT HOURS VS TIME TIMELINE I





## WATT HOURS VS TIME TIMELINE 2







## LCRU POWER REQUIREMENTS - WATTS

SUBASSEMBLY	MODE 1 PM1/NB	MODE 2 PM1/WB	MODE 3 FM/TV	MODE 4 TV RMT (STANDBY)	MODE 5 PM2/NB
VHF RECEIVER	1.17	1.17	1.17	1.17	1.17
VHF TRANSMITTER	4.10	4.10	4.10	.35	4.10
S-BAND RECEIVER	1.00	1.00	1.00	1.00	1.00
PM/PM TRANSMITTER	47.8	47.8	0.29	0.29	0.29
FM/PM TRANSMITTER	0.29	0.29	53.7	0.29	53.7
UP LINK SIGNAL PROCESSOR	0.15	0.15	0.15	0.15	0.15
DOWN LINK     "     "	0.76	1.46	1.46	1.46	0.76
VOLTAGE REGULATOR	2.20	2.35	2.35	2.35	2.20
CAMERA ASSEMBLY (STILL)	-	-	21.0	6.00	-
CAMERA ASSEMBLY (IN MOTION)	-	-	21.0+2.0		-
TOTAL					
WATTS AT NOMINAL BATTERY VOLTAGE	57.5	58.4	87.2	13.1	63.4
POWER REQUIREMENTS USING EXTERNAL POWER					
LCRU	57.5	58.4	87.2	13.1	63.4
DC-DC CONVERTER	11.5	11.7	17.5	2.6	12.7
TOTAL WATTS	69.0	70.1	104.7	15.7	76.1

2-27



## LCRU HEAT DISSIPATION - WATTS - INTERNAL BATTERY

## WORST CASE - MAXIMUM VOLTAGE SUPPLY

SUBASSEMBLY	MODE 1 PM1/NB	MODE 2 PM1/WB	MODE 3 FM/TV	MODE 4 TV RMT (STANDBY)	MODE 5 PM2/NB
VHF RECEIVER	1.17	1.17	1.17	1.17	1.17
VHF TRANSMITTER	3.45	3.45	3.45	0.35	3.45
S-BAND RECEIVER	1.00	1.00	1.00	1.00	1.00
PM TRANSMITTER	46.6	46.6	0.29	0.29	0.29
FM/PM TRANSMITTER	0.29	0.29	52.0	0.29	52.0
UP-LINK SIGNAL PROCESSOR	0.15	0.15	0.15	0.15	0.15
DOWN-LINK " "	0.76	1.46	1.46	1.46	0.76
VOLTAGE REGULATOR	3.45	3.45	3.70	3.70	3.45
DC-DC CONVERTER IDLER	3.00	3.00	3.00	3.00	3.00
TOTAL	59.9	50.6	66.2	11.4	65.3

## NOMINAL VOLTAGE SUPPLY

VHF RECEIVER	1.17	1.17	1.17	1.17	1.17
VHF TRANSMITTER	3.45	3.45	3.45	0.35	3.45
S-BAND RECEIVER	1.00	1.00	1.00	1.00	1.00
PM TRANSMITTER	41.0	41.0	0.29	0.29	0.29
FM/PM TRANSMITTER	0.29	0.29	45.7	0.29	45.7
UP LINK SIGNAL PROCESSOR	0.15	0.15	0.15	0.15	0.15
DOWN LINK " "	0.76	1.46	1.46	1.46	0.76
VOLTAGE REGULATOR	2.20	2.35	2.35	2.35	2.35
DC-DC CONVERTER IDLER	3.00	3.00	3.00	3.00	3.00
TOTAL	53.0	53.9	58.6	10.1	57.7

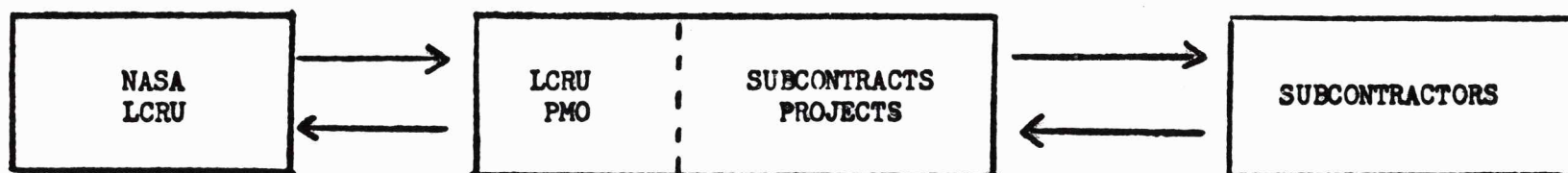


## **3.0 SUBCONTRACTS**





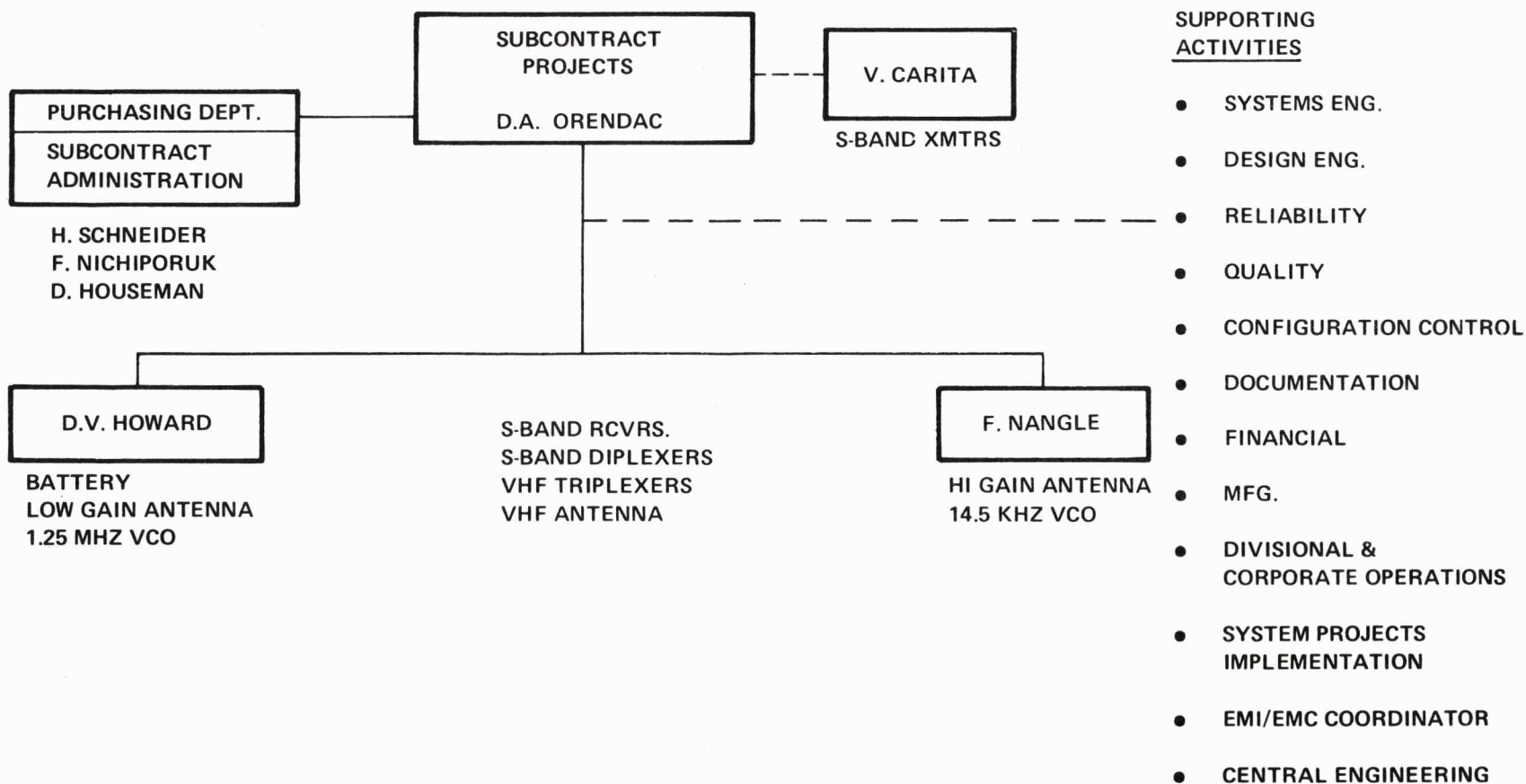
## SUBCONTRACT PROJECTS



PROVIDES MANAGEMENT AND TECHNICAL DIRECTION OF  
SUBCONTRACTOR CONSISTENT WITH LCRU PMO AND OVERALL NASA REQUIREMENTS  
AND FUNCTIONS AS AN INTEGRAL PART OF THE LCRU PMO.



## LCRU SUBCONTRACT PROJECT ORGANIZATION





## LCRU SUBCONTRACT CONTROL DOCUMENTATION

- |     |   |                             |
|-----|---|-----------------------------|
| 1.  | PURCHASE ORDER  | RCA PO G9-829__-0001-80-D71 |
| 2.  | EXHIBIT "A" (TO THE P.O.)                                 | LRPO - __ -1                |
| 3.  | EQUIPMENT SPECIFICATION (SOURCE CONTROL DRAWING)          |                             |
| 4.  | SUBCONTRACTOR RELIABILITY CONTROL SPECIFICATION           | LRSP - SB/RL-1              |
| 4a. | SUBCONTRACTOR RELIABILITY CONTROL REQUIREMENTS SUPPLEMENT | LRSS - __ /RL-1             |
| 5.  | SUBCONTRACTOR QUALITY CONTROL SPECIFICATION               | LRSP-SB/QA-1                |
| 5a. | SUBCONTRACTOR QUALITY CONTROL REQUIREMENTS SUPPLEMENT     | LRSS - __ /QA-1             |
| 6.  | SUBCONTRACTOR CONFIGURATION CONTROL SPECIFICATION         | LRSP-SB/CC-1                |
| 6a. | SUBCONTRACTOR CONFIGURATION CONTROL SUPPLEMENT            | LRSS - __ -/CC-1            |





## LCRU SUBCONTRACT STATUS

May 28, 1970

ITEM	VENDOR	GO AHEAD	PDR COMPLETION	CDR DATES
S-BAND RCVR	MOTOROLA	2/17/70	5/18,19	8/3,4*
VHF TRIPLEXER	RANTEC	3/13/70	NA	NA
BATTERY	YARDNEY	3/19/70	5/8	7/28
14.5 KHZ VCO	SONEX	3/19/70	4/22	7/16
HIGH GAIN ANTENNA	RCA MS&R	4/1/70	5/8	7/23
S-BAND XMTRS	CONIC	3/30/70	4/30, 5/1	8/7
VHF ANTENNA	MOTOROLA	3/24/70	NA	NA
S-BAND DIPLEXERS	WAVECOM	3/23/70	5/4	6/29
LOW GAIN ANTENNA	BENDIX	4/6/70	5/27,28	7/15
1.25 MHZ VCO	SCI	4/3/70	5/13,14	8/24

3-4



## LCRU SUBCONTRACT DELIVERY SCHEDULE

5/28/70

SUBASSEMBLY	QTY/ LCRU	MECH MOCKUP	THERMAL MOCKUP	ENG MODEL	DVT MODEL	FM 1 (QUAL.)	FM 2
S-BAND RECEIVER (ALSEP)	2	RCVD <del>4-15</del> 6-1 NEW UNIT	RCVD <del>4-15</del> 6-15 NEW UNIT	7-17/7-24	8-15	11-15	11-30
VHF TRIPLEXER	1	-	-	5-30	8-17	9-17	9-17
BATTERY	1	RCVD <del>5-4</del>	6-1	6-15	8-14	9-15	1-4
14.5 KHZ VCO	1	RCVD	RCVD <del>5-4</del>	5-18	8-17	9-21	9-21
S-BAND DIPLEXER	2	RCVD <del>5-1</del>	RCVD <del>5-1</del>	5-12	8-24	10-19	10-19
S-BAND XMTR (FM/PM)	1	RCVD <del>5-11</del>	RCVD <del>5-11</del>	6-22	9-21	12-6	1-6
S-BAND XMTR (PM/FM)	1	RCVD <del>5-11</del>	RCVD <del>5-11</del>	6-22	9-21	12-6	1-6
VHF ANT.	1	-	-	6-15	7-5	8-15	9-15
HI GAIN ANTENNA	1	RCVD <del>5-29</del>	-	7-15	10-15	1-15	3-15
LOW GAIN ANTENNA	1	RCVD <del>5-15</del>	-	7-10	9-15	1-4	2-1
1.25 MHZ VCO	2	RCVD <del>5-26</del>	RCVD <del>5-26</del>	7-9*	10-5*	12-24	1-7

3-5

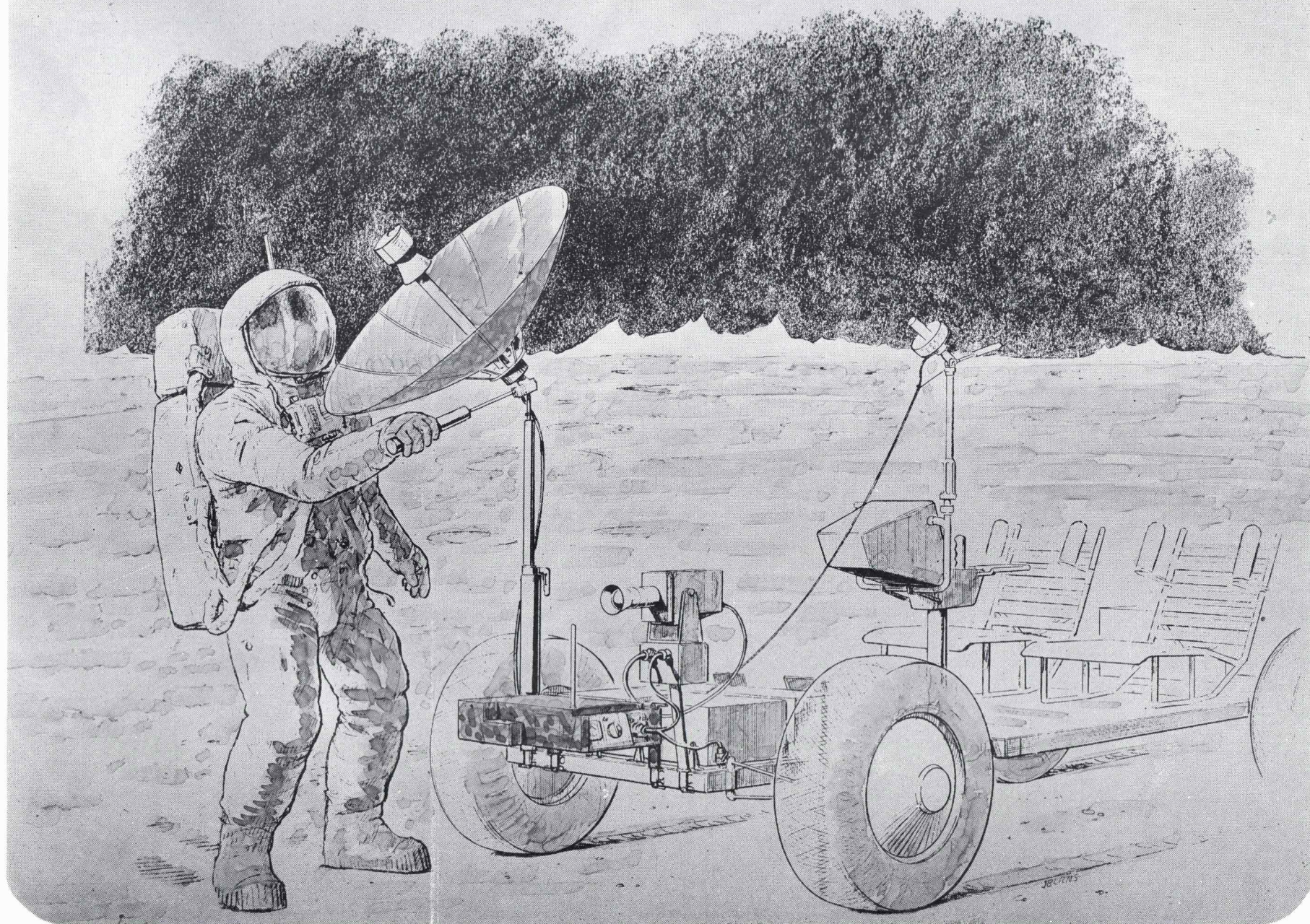
## **4.0 OPERATIONS**



**RCA**

## LCRU/LRV INTERFACE

4-1

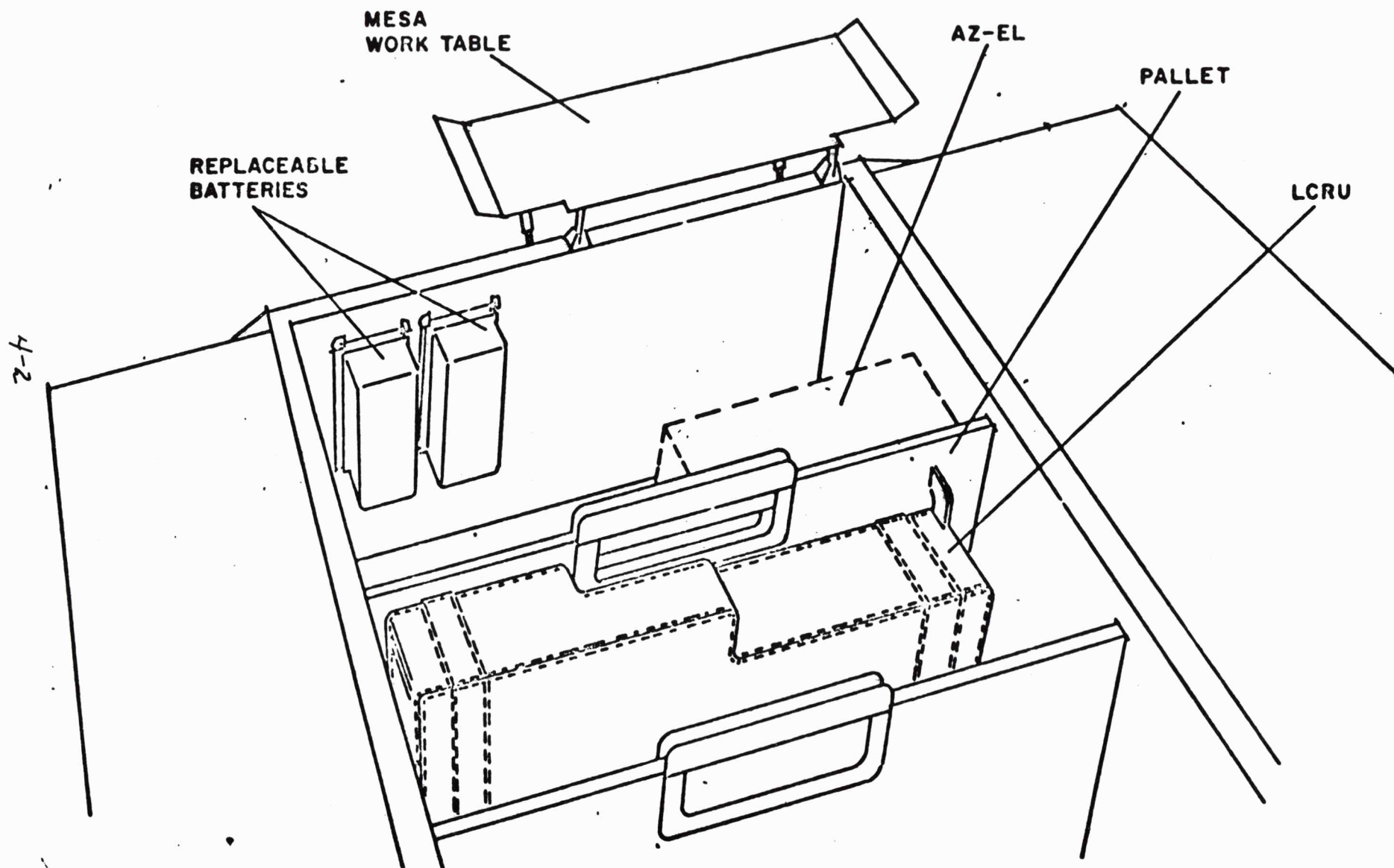




# RCA

## AZ-EL STORAGE ON PALLET & BATTERY

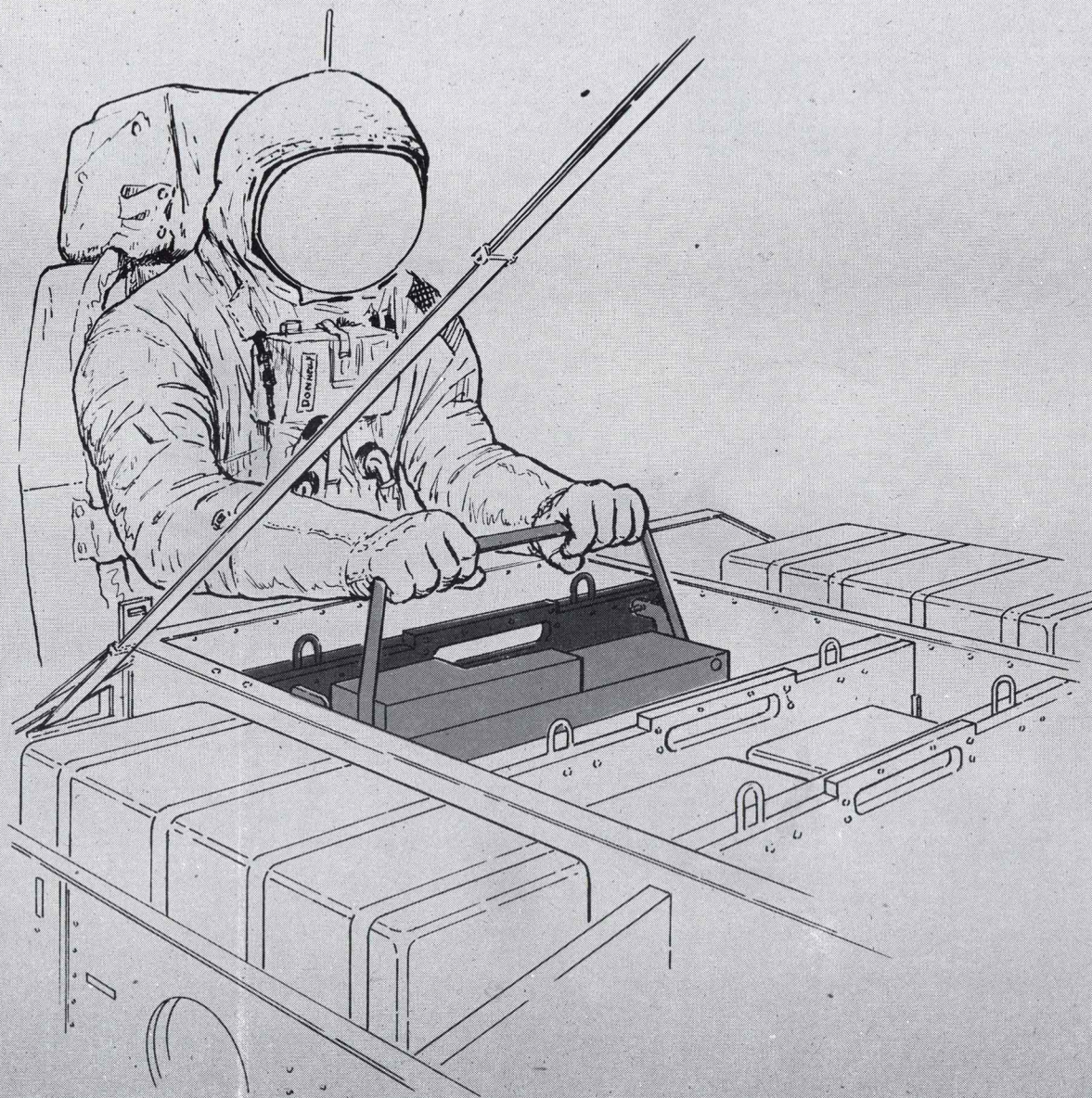
### ATTACHMENT TO INSIDE WALL OF MESA





**RCA**

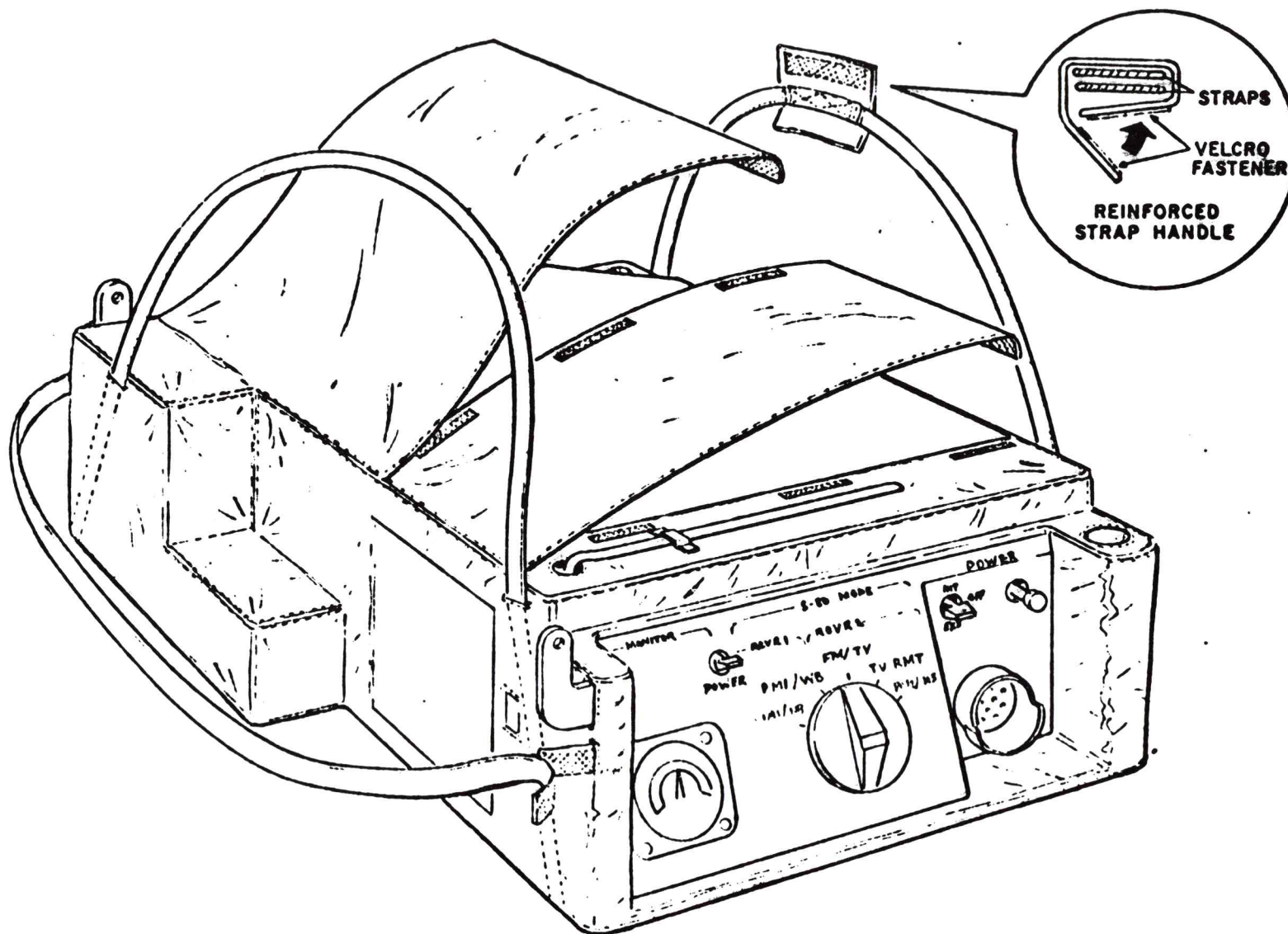
## LCRU CASE REMOVAL WITHOUT PALLET





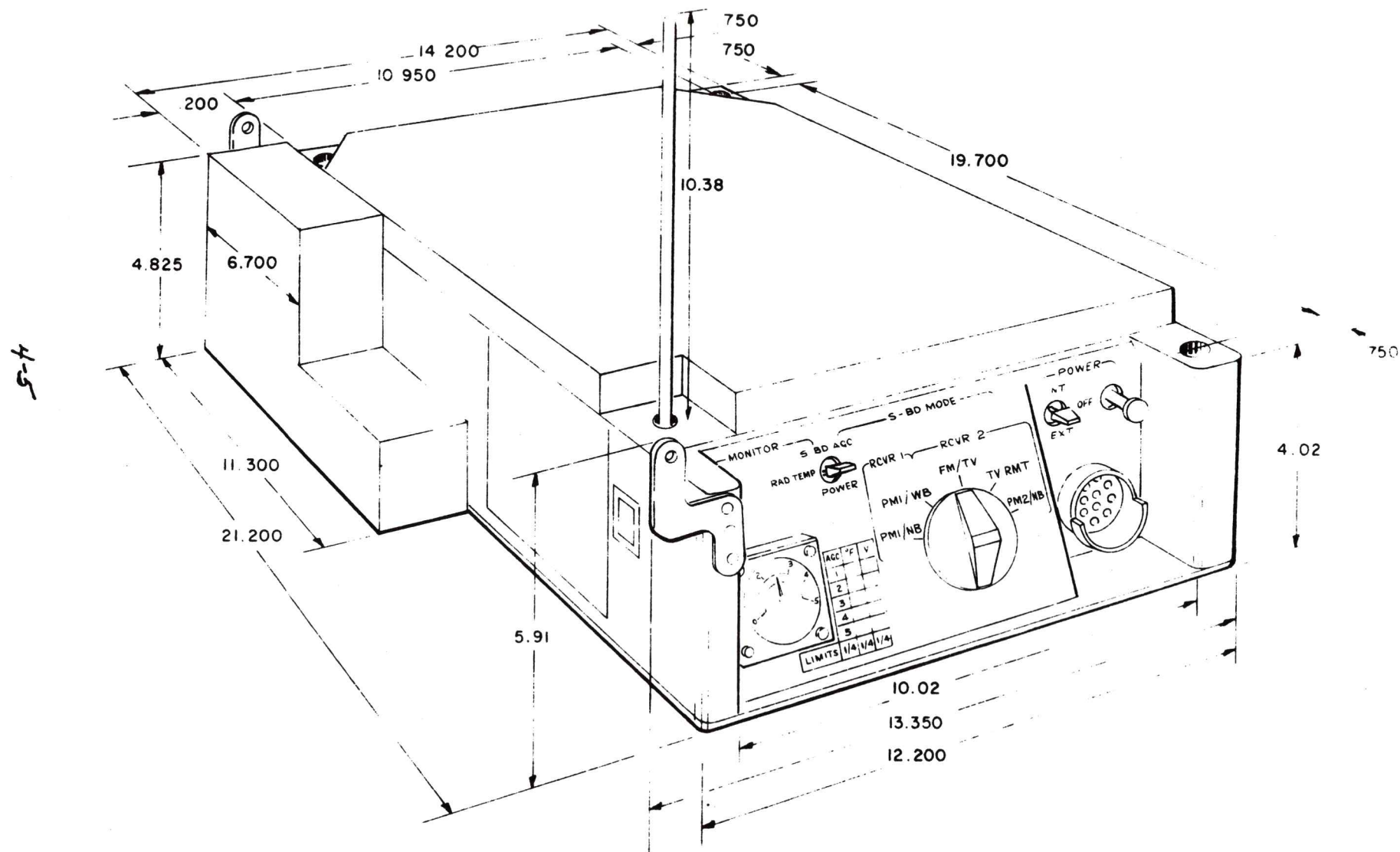
**RCA**

# LCRU THERMAL BLANKET



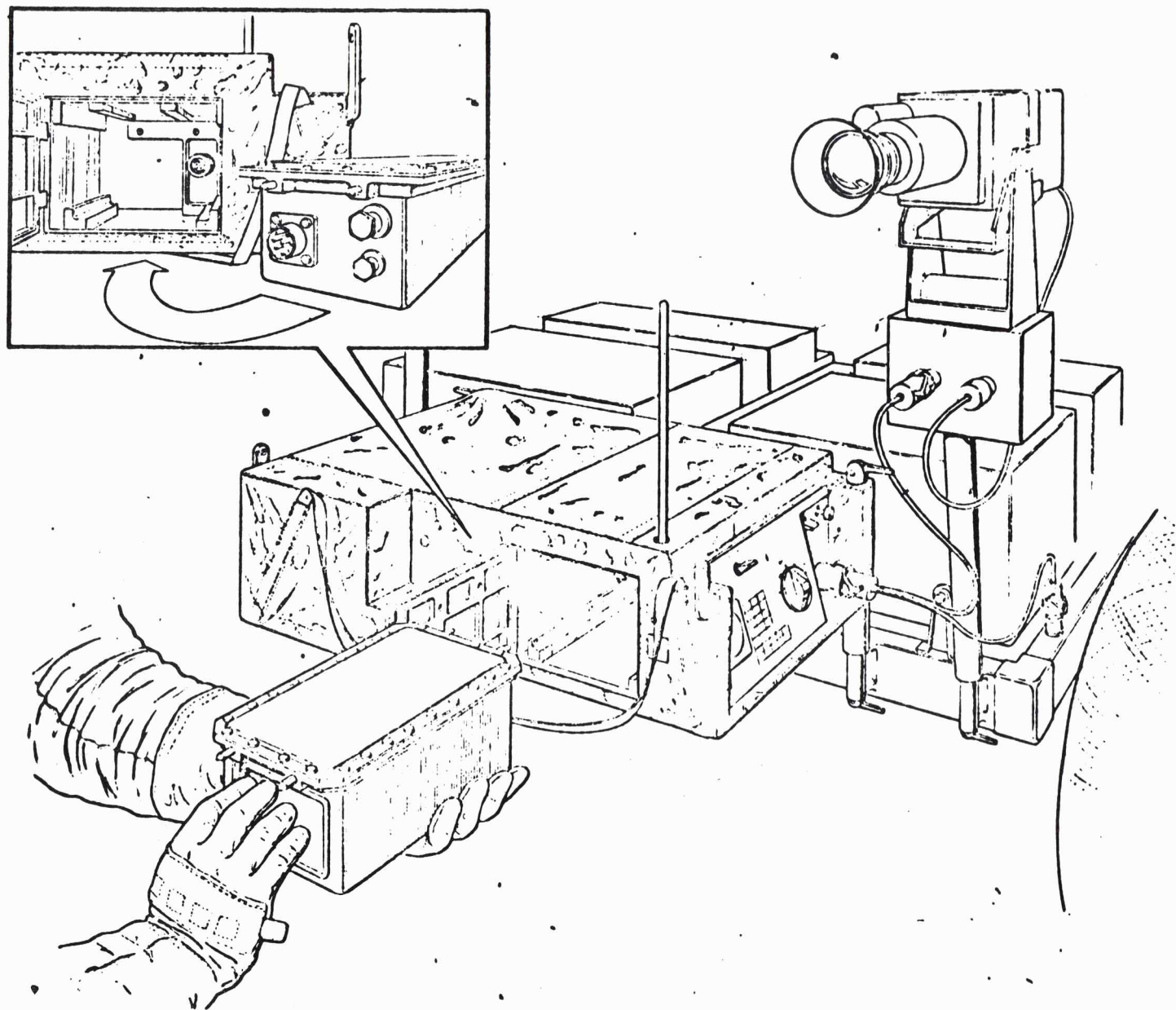
# RCA

## LCRU UNIT



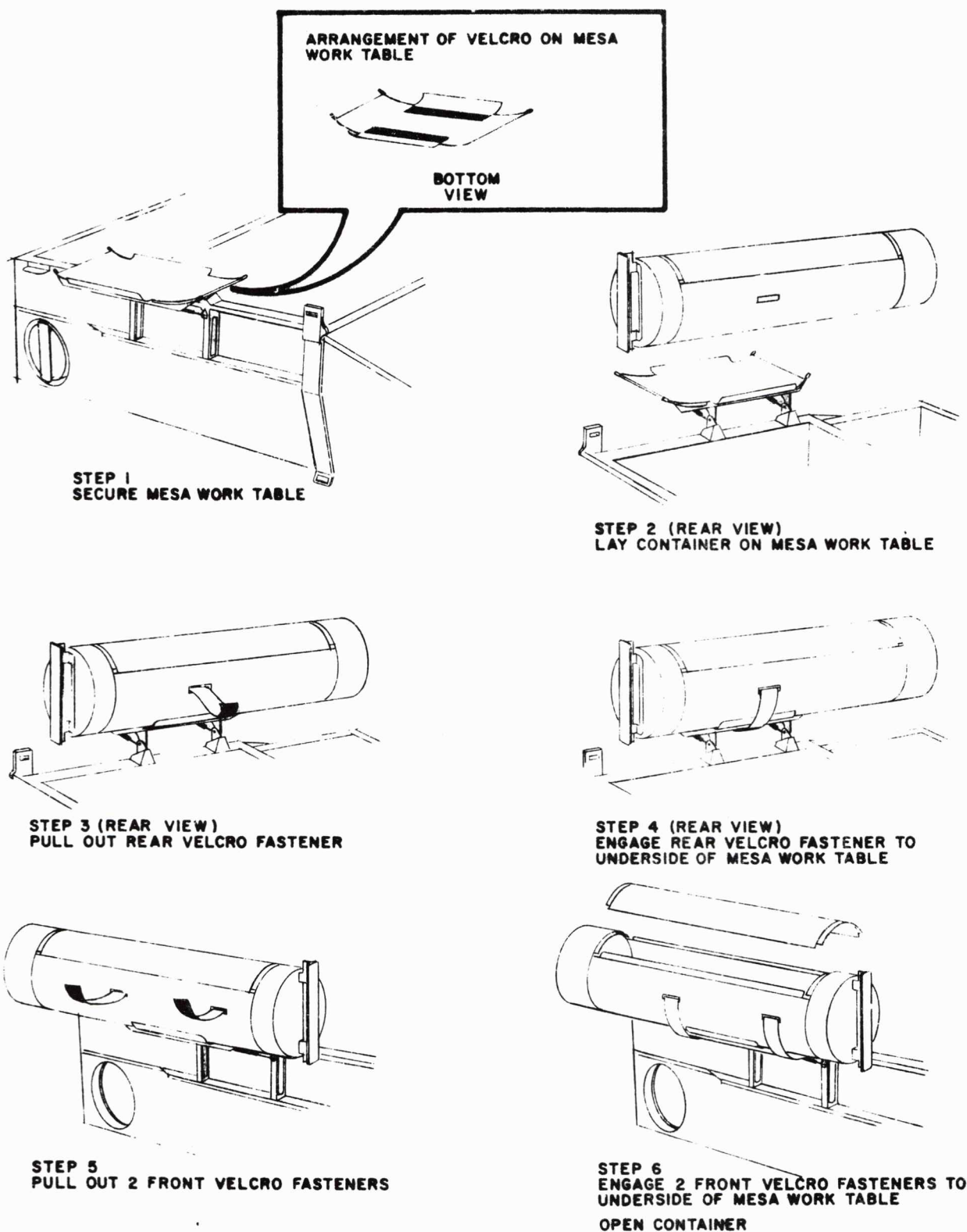
**RCA**

## REPLACEMENT BATTERY CONCEPT



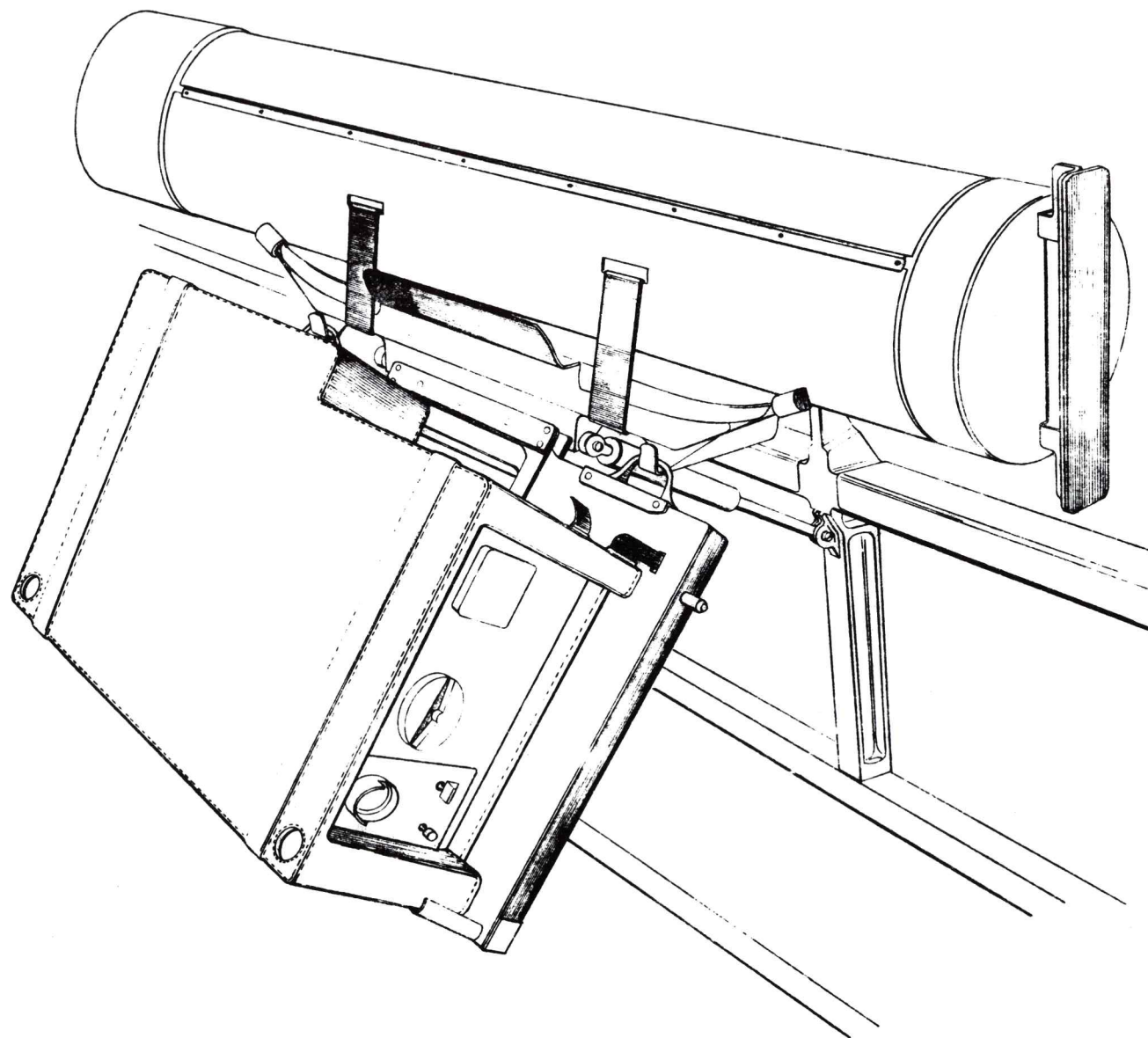


## STORAGE CONTAINER/WORK TABLE INTERFACE



**RCA**

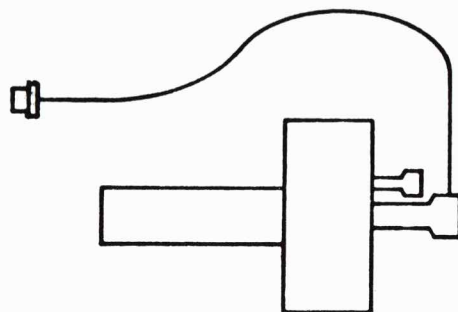
LCRU PALLET & STOWAGE CONTAINER  
ON WORK TABLE



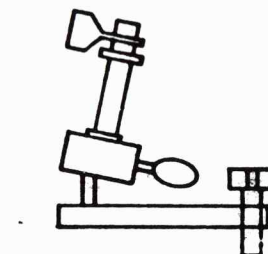
4-7



## LCRU STOWAGE ANCILLARY ITEMS



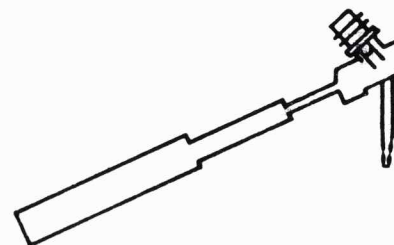
LOW GAIN ANTENNA



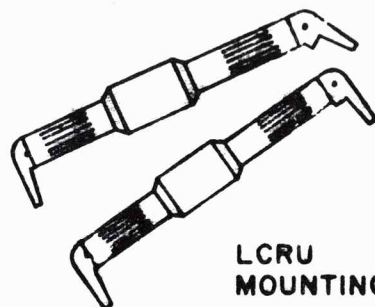
MOUNTING ARM &  
BALL JOINT FOR  
LOW GAIN ANTENNA



HIGH GAIN ANTENNA



HIGH GAIN ANTENNA ARM &  
BALL JOINT POSITIONING  
MECHANISM



LCRU  
MOUNTING POST



HIGH  
GAIN  
ANTENNA  
MAST





## STOWAGE CONTAINER UNSTOWING SEQUENCE

### REMOVAL SEQUENCE

COVER

LEGS

HIGH GAIN ANTENNA  
MAST AND POINTING  
MECHANISM

HIGH GAIN ANTENNA

LOW GAIN ANTENNA

LOW GAIN ANTENNA  
POINTING MECHANISM  
AND ARM

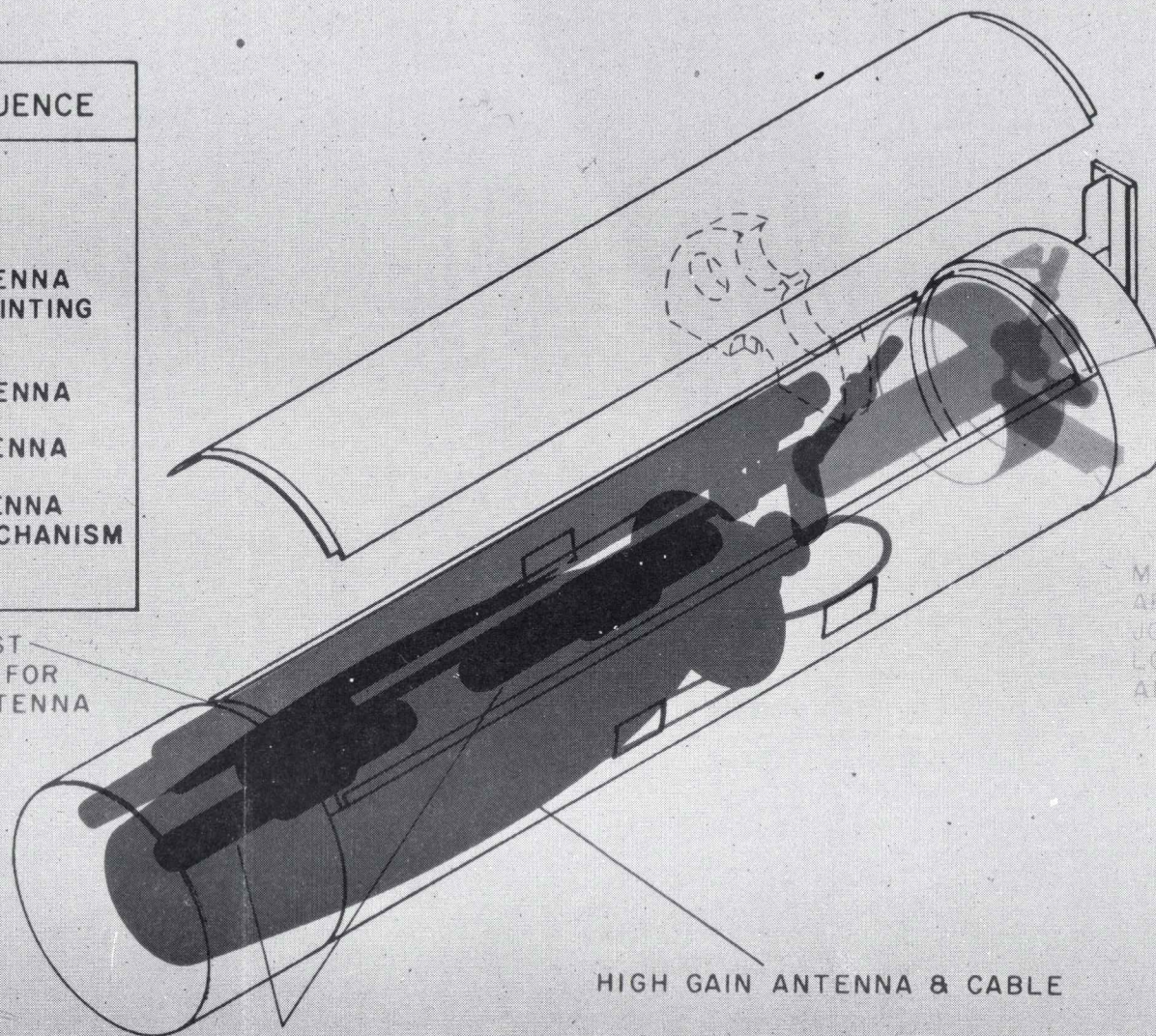
MOUNTING POST  
& BALL JOINT FOR  
HIGH GAIN ANTENNA

HIGH GAIN ANTENNA & CABLE

LCRU MOUNTING LEGS

MOUNTING  
ARM & BALL  
JOINT FOR  
LOW GAIN  
ANTENNA

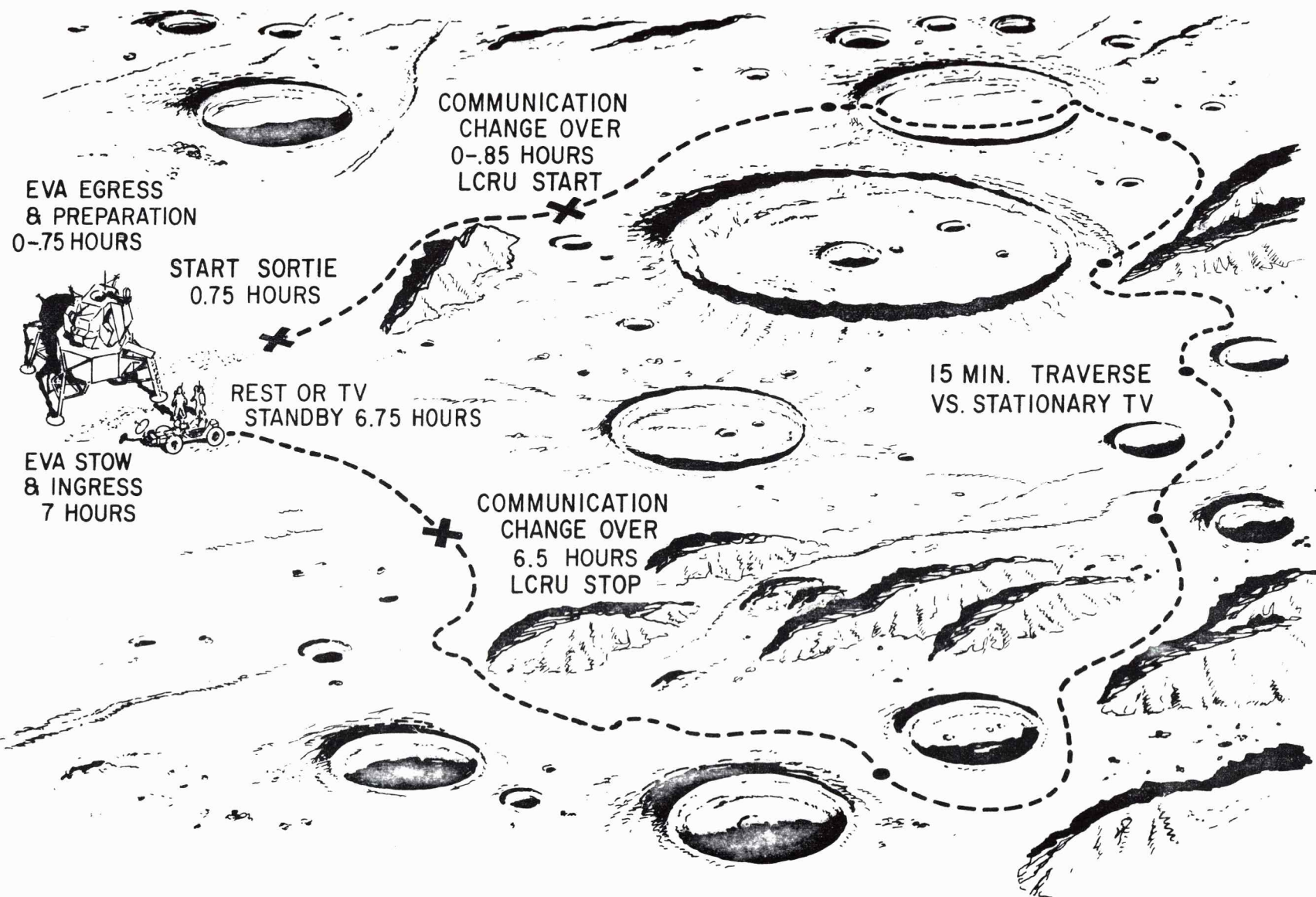
LOW GAIN  
ANTENNA  
AND CABLE





# RCA

## TYPICAL SORTIE



4-11







# LCRU ASSEMBLY TIME FOR ROVER MISSION

	TIME SEC.
1. START WITH MESA AND WORK TABLE DEPLOYED.	-
2. REMOVE STOWAGE CONTAINER CLEVIS PINS, REMOVE STOWAGE CONTAINER FROM MESA AND STAND AGAINST MESA.	15
3. REMOVE LCRU PALLET AND HANG ON WORK TABLE HOOKS.	15
4. PLACE STOWAGE CONTAINER ON MESA WORK TABLE.	10
5. DEPLOY VELCRO STRAPS FROM CONTAINER AND SECURE TO WORK TABLE.	10
6. REMOVE CONTAINER COVER AND DISCARD.	10
7. REMOVE LCRU MOUNTING LEGS FROM CONTAINER AND PLACE IN TUBES ON LRV.	20
8. REMOVE LCRU/PALLET CLEVIS PINS.	05
9. LIFT LCRU FROM PALLET USING THE EMERGENCY MODE CARRYING STRAPS AND PLACE ON LCRU MOUNTING LEGS ON LRV.	25
10. OPERATE CLAMP ON TOP OF LEGS TO SECURE LCRU TO LRV.	10
11. REMOVE HIGH GAIN ANTENNA MAST FROM CONTAINER AND ATTACH TO LRV TUBE, OPERATE LATCH.	20



## LCRU ASSEMBLY TIME FOR ROVER MISSION (CONT'D)

12.	REMOVE HIGH GAIN ANTENNA POINTING MECH AND ATTACH TO MAST.	20
13.	REMOVE HIGH GAIN ANTENNA AND ATTACH TO POINTING MECHANISM. (ANTENNA RIBS STOWED)	20
14.	REMOVE PROTECTIVE CAP FROM HIGH GAIN ANTENNA CABLE CONNECTOR AND MATE CONNECTOR TO LCRU.	05
15.	REMOVE LOW GAIN ANTENNA AND POINTING MECHANISM AND ARM FROM CONTAINER AND ASSEMBLE TOGETHER AT WORK TABLE.	20
16.	DEPLOY LOW GAIN ANTENNA ASSEMBLY ON LRV CONSOLE AND POINT.	25
17.	DEPLOY LOW GAIN ANTENNA CABLE BETWEEN LRV BATTERIES TO LCRU.	15
18.	REMOVE PROTECTIVE CONNECTOR COVERS AND CONNECT LOW GAIN ANTENNA CABLE TO LCRU.	05
19.	REMOVE TV/POWER CABLE FROM CONTAINER AND CONNECT BETWEEN LRV/LCRU/TV AZ-EL.	40
20.	POSITION THERMAL BLANKET FOR START OF MISSION.	05
21.	SET CONTROLS FOR LOW GAIN VOICE PRIMARY MODE OPERATION.	05
TOTAL		295

41-14



LCRU START OPERATIONS (WHILE MOVING)

- |  |            |
|--|------------|
| 1. Pre-sortie setup for moving start                         | 5 seconds  |
| 2. Point low gain antenna                                    | 5 seconds  |
| 3. Energize LCRU Circuit Breaker on LRV Console              | -----      |
| 4. Verify down link/up link                                  | 15 seconds |
| 5. Continue Sortie to first stop                             | -----      |
| 5.a Astronaut walks to LCRU                                  | 15 seconds |
| 6. Check temp., battery, signal and verify down link/up link | 15 seconds |
| 7. Switch to LCRU battery                                    | -----      |
| 8. Verify down link/up link                                  | 10 seconds |

4-15





LCRU START OPERATIONS (WHILE HALTED)

- |  |            |
|--|------------|
| 1. Adjust low gain antenna toward earth                            | 5 seconds  |
| 1.a Astronaut walks to LCRU  | 15 seconds |
| 2. Switch LCRU to desired mode and turn LCRU on                    | 5 seconds  |
| 3. Check temp., battery, signal level and verify down link/up link | 15 seconds |
| 4. Adjust Thermal Blanket if required                              | 5 seconds  |
| 5. Return to LRV and continue traverse                             | 15 seconds |

4-16



### LCRU START OPERATION (TV)

1.	ASTRONAUT WALK TO LCRU	15 SECONDS	
2.	CHECK TEMP., SIGNAL, BATTERY		10 SECONDS
3.	ADJUST THERMAL BLANKET IF NECESSARY	5 SECONDS	
4.	ASTRONAUT WALKS TO HIGH GAIN ANTENNA	5 SECONDS	
5.	HIGH GAIN ANTENNA DEPLOYMENT		10 SECONDS
6.	POINT HIGH GAIN ANTENNA AND OPTICS		20 SECONDS
7.	FINE POINT HIGH GAIN ANTENNA		20 SECONDS
8.	ASTRONAUT WALKS TO LCRU	5 SECONDS	
9.	SWITCH TO TV OPERATION		-----
10.	CHECK TEMP., SIGNAL, BATTERY AND VERIFY DOWN LINK-UP LINK		15 SECONDS
11.	EARTH VERIFIES TV COMMAND AND OPERATION	15 SECONDS	



LCRU CONTINUE TRAVERSE (TV TO NORMAL TRAVERSE)

- |  |                 |            |
|--|-----------------|------------|
| 1. Check temp., power, battery                             |                 | 10 seconds |
| 2. Adjust thermal blanket if required                      | 5 seconds       |            |
| 3. Adjust low gain antenna to earth                        |                 | 5 seconds  |
| 4. Switch to PMI/WB mode                                   |                 | -----      |
| 5. Check temp., signal, power and verify up link-down link |                 | 15 seconds |
| 6. Astronaut walks to Hi-Gain Antenna                      | 5 seconds       |            |
| 7. Adjusts Hi-Gain Antenna for traverse                    |                 | 55 seconds |
| 8. Astronauts walk to LRV and remount                      | 15 seconds each |            |

81-4





### LCRU CHANGEOVER AFTER SORTIE

- |   |            |            |
|---|------------|------------|
| 1. ASTRONAUT DISMOUNTS FROM LRV         | 15 SECONDS |            |
| 2. CHECK TEMP., POWER, SIGNAL           |            | 10 SECONDS |
| 3. ADJUST THERMAL BLANKET - IF REQUIRED | 5 SECONDS  |            |
| 4. TURN LCRU OFF                        |            | 5 SECONDS  |
| 5. VERIFY UP-LINK/DOWN LINK (LM)        |            | 15 SECONDS |
| 6. ASTRONAUT RETURNS TO LRV             | 15 SECONDS |            |

4-19



## LCRU SECURE AFTER SORTIE

- |  |            |
|--|------------|
| 1. CHECK TEMP. AND TURN LCRU OFF                         | 5 SECONDS  |
| 2. OPEN THERMAL BLANKET, REMOVE BATTERY, REPLACE BLANKET | 20 SECONDS |
| 3. ADJUST THERMAL BLANKET IF REQUIRED                    | 5 SECONDS  |
| 4. WALK TO HIGH GAIN ANTENNA                             | 5 SECONDS  |
| 5. ADJUST ANTENNA FROM SUN                               | 5 SECONDS  |



## LCRU OPERATION --- TV STANDBY

- |    |   |            |
|----|---|------------|
| 1. | ASSURE LRV CIRCUIT BREAKER IS ON                    | .....      |
| 2. | WALK TO HIGH GAIN ANTENNA                           | 5 SECONDS  |
| 3. | POINT HIGH GAIN ANTENNA AND OPTICS                  | 20 SECONDS |
| 4. | FINE POINT HIGH GAIN ANTENNA                        | 20 SECONDS |
| 5. | WALK TO LCRU CONTROL PANEL                          | 5 SECONDS  |
| 6. | ADJUST TV CAMERA IF REQUIRED                        | 5 SECONDS  |
| 7. | SWITCH MODE SWITCH TO TV REMOTE AND<br>POWER TO EXT | 5 SECONDS  |
| 8. | VERIFY TV REMOTE OPERATION                          | 15 SECONDS |



5/27/70

LCRU OPERATIONS AND TIMELINE

The purpose of this memorandum is to describe the assembly and operational routines for LCRU set-up and operation on the Moon. The operations as described are divided into three major periods consisting of:

- A. Initial Assembly - MESA operation
- B. Normal Lunar Operation - LCRU operation
- C. Post Lunar Operation - Preparation for Liftoff

#### A. INITIAL ASSEMBLY - MESA OPERATIONS

The following sequence of events describes the basic actions and operations required to be performed by the astronaut to deploy the LCRU system on the LRV. The starting point is with the LM MESA and work table in the deployed position.

Remove the two clevis pins that connect the stowage container handle to the LM MESA, grasp the handle of the stowage container in one hand and withdraw axially from the MESA. With the handle at the top, lean the stowage container against the front of the MESA with the lower end of the container in contact with the lunar surface.

Grasp the pallet handle of the out-board pallet in the MESA. Squeeze the handle (thereby releasing the pallet mounting pins) and withdraw the pallet and its contents vertically out of the MESA. Hang the pallet on the work table hooks with the LCRU outboard. Grasp stowage container in one hand and support the CG with the other hand. Place the stowage container on the work table with the container cover up, and the handle to the crewmen's right. Make sure the container is approximately centrally located on the work table. Steady the container with one hand. Reach over the container to the rear and withdraw fully the velcro strap at the approximate midpoint of the container. Pass the strap down under the work table and secure it to the velcro material that is permanently fixed under the rear of the work table. Withdraw (using both hands) the two velcro straps along the opposite edge of the container. Pull these two straps down simultaneously, apply slight tension and pass them over the front edge of the table making contact with the velcro material that is permanently attached to the work table forward edge. The stowage container is now attached to the work table and ready to have the contents removed.

Pull velcro tabs that secure cover latch strip lanyards. Pull lanyards approximately 1/4" to release cover latch strips. The latch strips fall free of the container. Lift cover free of container (vertically) by engaging fingers in centrally located slot in



cover. The cover is no longer required and may be appropriately discarded. Pull velcro retaining straps that hold LCRU mounting legs in place. Place the legs in the two center mounting tubes on the LRV.

Using the LCRU carrying straps to pick up the weight of the LCRU in one hand, pull the lanyards that release the pins that secure the LCRU to the pallet. Lift the LCRU vertically off the lower pallet pins and carry it via the emergency mode strap to the LRV. Lower the LCRU down over the legs that are on the LRV. Rotate the top and bottom clamps on both legs  $90^{\circ}$  to secure the LCRU to the LRV.

Remove the velcro strap that secures the high gain antenna mast in the container. Carry the mast to the LRV, place the bottom end in the appropriate LRV mounting tube. Operate the lever on the bottom of the mast to secure the mast to the LRV.

Pull velcro retaining strap and remove the high gain antenna pointing assembly. Place pointing assembly on top of LRV mast by inserting in tapered hole at end of mast.

Release velcro strap securing high gain antenna. Remove high gain antenna from mast, (cable is attached). Attach the high gain antenna to the pointing assembly by holding the high gain antenna vertically. Dress the cable through the slot in the pointing mechanism collar then insert the bottom of the antenna into the collar and rotate the tightening knot approximately two turns until secure. Wrap the cable once around the mast, remove protective cover from mating face of connector and mate into LCRU. To raise and lower the high gain antenna mast, grasp the mast in one hand at the base of the pointing mechanism and rotate the locking lever at the mid-point of the mast with the other hand. Slide the telescoping section of the mast up or down as desired. Lock the mast by counter rotating the locking lever.

Release velcro strap in the stowage container securing the low gain antenna in its nest. Place the low gain antenna approximately in the center of the container. Discard pillow block. Release velcro strap and withdraw pointing mechanism and arm assembly from its nest. Assemble antenna to pointing mechanism by pinching tilt lock flange and sliding the units together. Transport the low gain antenna and its

positioning arm to the LRV console and place in the mounting tube on the console. Slide square tube of arm to full extension and insert into hole in LRV console. With arm pointing laterally, tighten T-nut to lock. Rotate the locking lever on the top of the pointing mechanism supporting arm to secure the low gain antenna to the LRV. Dress the cable on the low gain antenna between the LRV batteries and to the right side of the LRV between the LCRU and the LRV battery. Remove protective cap from cable connector and mate with connector on the side of the LCRU adjacent to the high gain antenna connector.

Remove velcro strip in the stowage container securing the TV/Power cable. Engage the common connector of this cable to its mate on the LCRU control panel. Engage the power leg of the cable to the LRV power connector. Engage the TV leg of the cable to the appropriate connector on the TV AZEL unit. Position thermal blanket for start of mission. Set controls on control panel for low gain voice primary mode operation.

## B. NORMAL LUNAR OPERATION - LCRU OPERATIONS

The following sequence of events involve the operation of the LCRU on the LRV. Prior to the sequences presented herein both astronauts have egressed from the LM, opened the MESA and removed and installed all LCRU components on the LRV.

### 1. LCRU Start Operations (while moving)

This sequence of events is intended to demonstrate the steps involved in switching to LCRU operations while in motion or without the necessity of the astronaut disembarking from the LRV. As a prelude it is assumed that pre-sortie checkout of the LCRU has been accomplished satisfactorily.

1. Astronaut assures LCRU power circuit breaker on LRV control panel is OFF.
2. Astronaut places LCRU mode switch in desired mode (Primary mode PMI/WB)
3. Astronaut places LCRU Power switch to EXT.
4. Astronaut assures LCRU circuit breaker is ON.
5. Astronauts mount LRV and start traverse.

NOTE: Upon reaching reduced communication limit from LM the astronaut will request or be requested to prepare for communication to LCRU operation.

6. LCRU starboard astronaut aligns low gain antenna to best pointing toward earth. LRV may be stopped or remain in motion.
7. Upon earth command astronaut energizes LCRU circuit breaker on LRV control panel.
8. Astronaut awaits verification from earth that LCRU down-link communications are established and responds with verification that up-link communication is established.
9. Astronauts continue sortie until desired stop point, maintaining low gain antenna pointed toward earth.



10. Astronauts orient LRV from sun, stop and set navigational gyros.
11. Astronauts dismount from LRV and walk to front of LRV and observe LCRU control panel.
12. Astronaut energizes monitor switches to check temperature, battery and signal level - transmitting such data to earth. Upon command from earth or based upon operating procedures thermal blanket is adjusted to desired position.
13. Upon earth command, to utilize LCRU battery, astronaut switches LCRU power switch to INT and awaits verification from earth that LCRU down-link communication is re-established and responds with verification that up-link communication is re-established.
14. Astronaut energizes monitor switches to check temperature, battery and signal level - transmitting such data to earth.

## 2. LCRU Start Operations (While halted)

This sequence of events is intended to demonstrate the steps involved in switching to LCRU operations while the LRV is halted. As a prelude it is assumed that pre-sortie checkout of the LCRU has been accomplished satisfactorily, that astronaut requested or was requested by earth to prepare for conversion to LCRU operation; and that appropriate navigational gyro resetting has been accomplished.

1. Starboard astronaut adjusts low gain antenna to best pointing toward earth.
2. Port astronaut dismounts from the LRV and walks to front of LRV and observes LCRU control panel.
3. Astronaut places LCRU mode switch in desired mode (Primary mode PMI/WB) and assures that circuit breaker is ON.
4. Astronaut advises earth that he is ready to switch to LCRU operation.
5. Upon earth command astronaut switches LCRU power switch to INT.

6. Earth advises astronaut that down-link communication is established.
7. Astronaut operates monitor switch and advises earth of signal strength, temperature and power readings.
8. Upon command from earth, or per operating procedure, thermal blanket is adjusted.
9. Upon command astronaut mounts LRV and continues on Transverse.
10. Astronaut maintains low gain antenna pointing in direction of earth.

### 3. LCRU Start Operation (TV)

This sequence of events is intended to demonstrate the steps involved in switching to LCRU TV operations. As a prelude it is assumed that pre-sortie checkout of the LCRU has been accomplished satisfactorily, that astronaut requested or was requested by earth to prepare for fixed site operations (TV), that the astronauts were previously on LCRU operations utilizing the low gain antenna, the LRV is stopped, and that appropriate navigational gyro resetting has been accomplished.

1. Astronauts assure : that the low gain antenna is best pointing toward earth.
2. Astronauts dismount from the LRV.
3. Astronaut walks to front of LRV and observes LCRU control panel.
4. Astronaut operates monitor switch to check signal strength, temperature and power.
5. Upon command from earth, or per operating procedures, thermal blanket is adjusted.
6. Either Astronaut walks to location of high gain antenna.
7. Astronaut grasps antenna deployment ring with one hand and antenna ball joint handle near base with the other hand.

8. Astronaut turns antenna deployment ring thirty degrees and slides ring approximately two inches to snap lock position and turns ring thirty degrees back to lock - thereby fully deploying antenna.
  9. Astronaut grasps high gain antenna handle and twists to unlock pointing mechanism.
  10. Astronaut roughly points antenna in direction of earth - should be within 10 degrees.
  11. Astronaut turns antenna optical sight to point in direction most comfortable for viewing and final pointing. Earth will appear in optical sight.
  12. Astronaut moves high gain antenna handle while viewing optical sight until earth image is in reticle center.
  13. Astronaut twists high gain antenna handle to lock antenna such that earth image is in center of reticle.
  14. Upon command from earth TV camera may be oriented as required.
  15. Astronaut advises earth that preparations are complete for TV operations and walks to LCRU control panel.
  16. Upon command from earth astronaut switches LCRU mode switch to FM/TV.
  17. Earth verifies to astronaut that TV down-link operation is established.
  18. Astronaut operates monitor switch and observes signal strength, temperature, and power and advises earth that up-link communications is established.
  19. Earth exercises TV command for TV Azimuth, elevation, zoom, IRIS operation and advises astronauts that fixed site operations can proceed.
4. LCRU Continue Traverse Operation (TV to normal Traverse)

This sequence of events is intended to demonstrate the steps involved in switching from LCRU operation (TV) to LCRU operation normal traverse. As a prelude it is assumed that the LCRU has been operating in the LCRU TV operational mode and the astronauts have requested or have been requested to return to traverse.



1. Astronauts return to LRV and observe LCRU Control panel.
2. Astronaut operates monitor switch to check signal strength, temperature and power.
3. Upon command from earth, or per operating procedure, thermal blanket is adjusted.
4. Astronaut assures that low gain antenna is best pointing toward earth.
5. Upon command astronaut switches LCRU mode switch to Primary Mode (PMI/WB)
6. Earth verifies that down-link communication is established.
7. Astronaut verifies that up-link communication is established.
8. Astronaut operates monitor switch to check signal strength, temperature, and power.
9. Upon command from earth Astronaut secures TV and high gain antenna for normal traverse operation.
10. Upon command from earth astronauts return to the LRV.
11. Astronauts check that low gain antenna is best pointing toward earth and proceed with traverse.

#### 5. LCRU Changeover After Sortie

This sequence of events is intended to demonstrate the steps involved in changeover to EVCS/LM operation upon return from sortie. As a prelude it is assumed that the LCRU has been operating in the PMI/WB low gain mode.

1. Upon approach to the LM earth determines that changeover from LCRU operation to LM operation should be accomplished.

2. Upon command from earth the LRV is stopped.

NOTE: Since a single 4-6 hour sortie effectively exhausts the LCRU battery so that it cannot be safely used for other sorties the astronaut/earth has the option of returning directly to LM without LCRU shut down or stopping for LM changeover when LM/EVCS communication range is established.

3. Port astronaut dismounts from the LRV and walks to front of LRV.
4. Astronaut observes LCRU control panel and operates monitor switch to observe signal strength, temperature and power.
5. Upon command from earth, or per operating procedure, thermal blanket is adjusted.
6. Upon command from earth LCRU Power-switch is turned to OFF.
7. Earth verifies EVCS/LM down-link communication is established.
8. Astronaut verifies that MSFN-LM up-link communication is established.
9. Astronaut mounts LRV and upon earth command returns to LM.

#### 6. LCRU Secure After Sortie

This sequence of events is intended to demonstrate the steps involved in securing the LCRU between sorties. It is assumed that the LCRU has been turned off after the sortie and that the LRV is oriented for between-sortie park.

1. Astronaut walks to front of LRV and observes control panel.
2. Astronaut switches power to INT and observes LCRU temperatures and advises earth of temperature reading.
3. Upon earth command, or per operational procedure, astronaut adjusts thermal blanket for between-sortie park.

4. Astronaut turns power-switch to OFF.
5. Astronaut depresses battery cover release button. Cover swings open.
6. Astronaut grasps battery handle, removes battery, and closes battery cover.
7. Astronaut disposes of battery. LCRU is secure.
8. Astronaut grasps high gain antenna handle and twists to unlock pointing mechanism.
9. Astronaut points antenna away from sun and twists antenna to lock pointing mechanism.
10. LCRU is secure.



### C. POST LUNAR OPERATION - PREPARATION FOR LIFTOFF - TV STANDBY

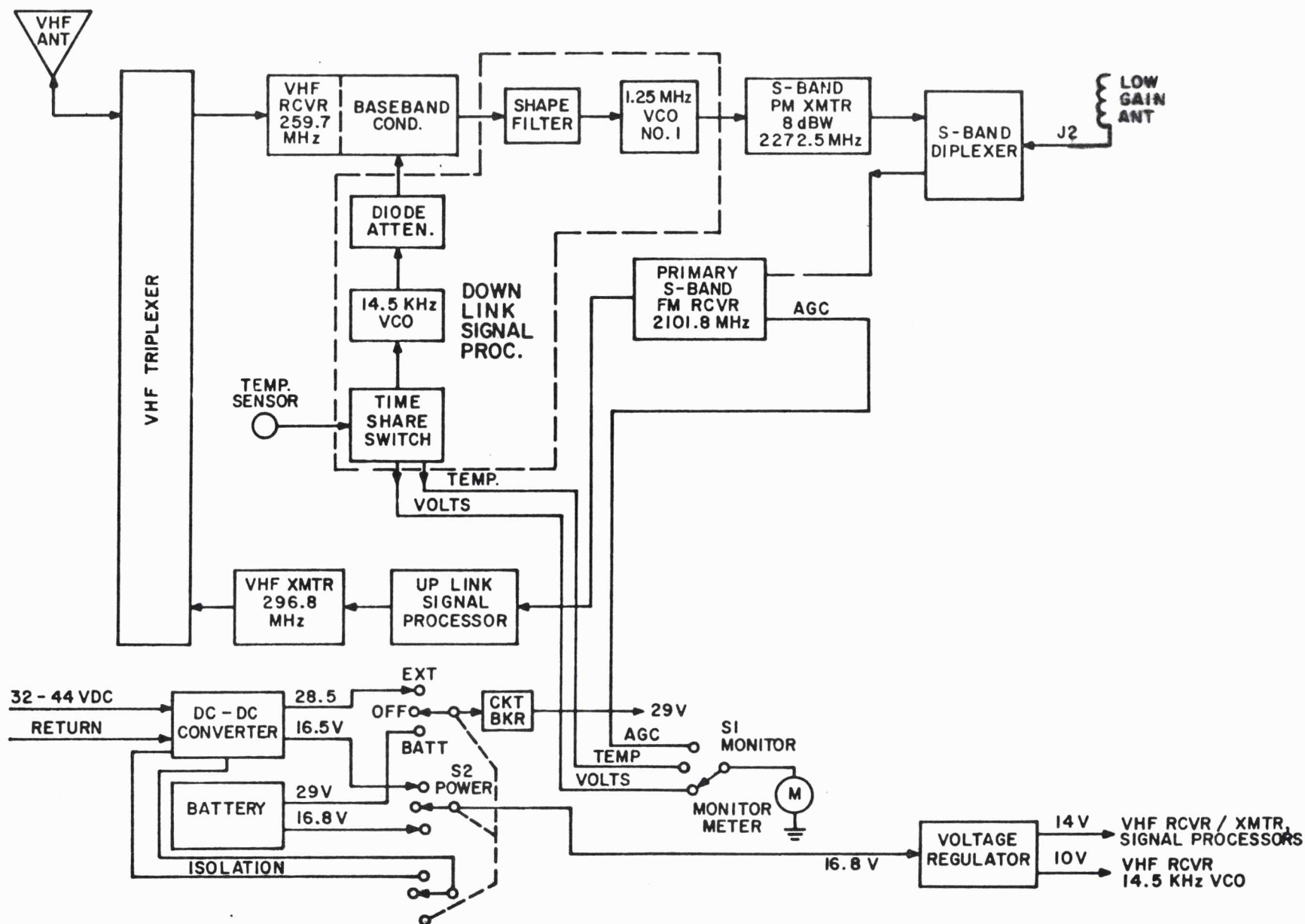
This sequence of events is intended to demonstrate the steps involved in preparing the LCRU for TV standby and remote control operation. As a prelude, it is assumed that the LCRU batteries will not be utilized for this mode of operation, the LCRU power switch is OFF, that the LRV has been located a safe distance from the LM in a direction capable of observing LM liftoff and ascent, and Astronaut communications are through the LM.

1. Astronaut assures that the LCRU power circuit breaker on the LRV control panel is on.
2. Astronaut dismounts from the LRV and walks to the front of the LRV.
3. Astronaut grasps high gain antenna handle and twists to unlock pointing mechanism.
4. Astronaut roughly points antenna in direction of earth - should be within 10 degrees.
5. Astronaut turns antenna optical sight to point in direction most comfortable for viewing and final pointing. Earth will appear in optical sight.
6. Astronaut moves high gain antenna handle while viewing optical sight until earth image is in reticle center.
7. Astronaut twists high gain antenna handle to lock antenna such that earth image is in center of reticle.
8. Astronaut returns to LCRU control panel location.
9. Astronaut adjusts TV Camera to desired pointing angle if required
10. Astronaut places mode switch in TV-RMT position.
11. Astronaut advises earth that LCRU is ready for TV remote standby.

12. Upon command from earth Astronaut starts TV Remote operation by placing Power Switch in EXT position.
13. Astronaut operates power switch and observes signal strength, temperature and power and provides data to Earth.
14. Astronaut adjust thermal blanket upon command from earth or per operating procedures.
15. Astronaut waits while Earth verifies TV remote capability and TV AZ-EL-IRIS-Zoom Operation.
16. Astronaut returns to LM.

# RCA

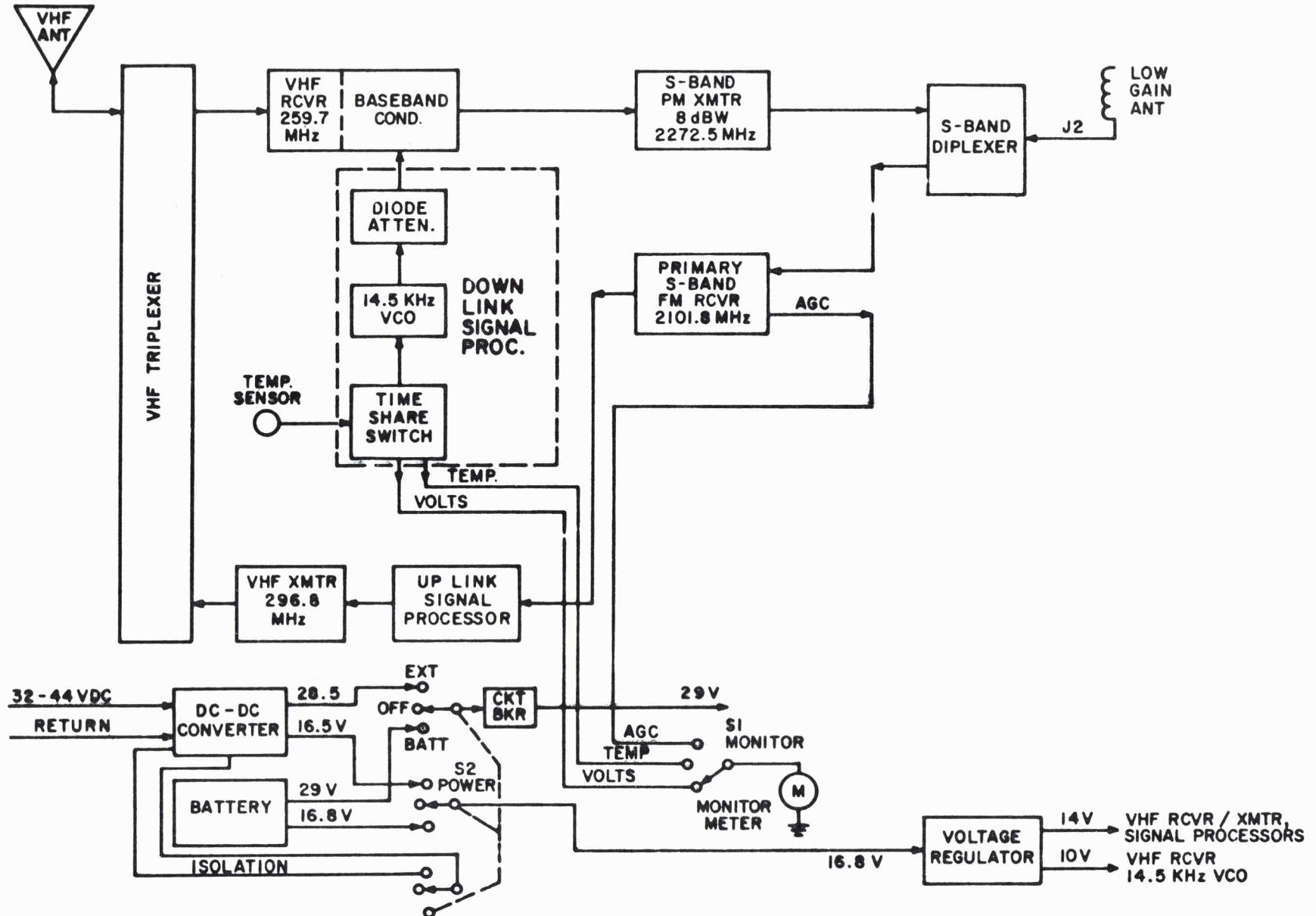
## LCRU BLOCK DIAGRAM MODE 2 PMI /WB





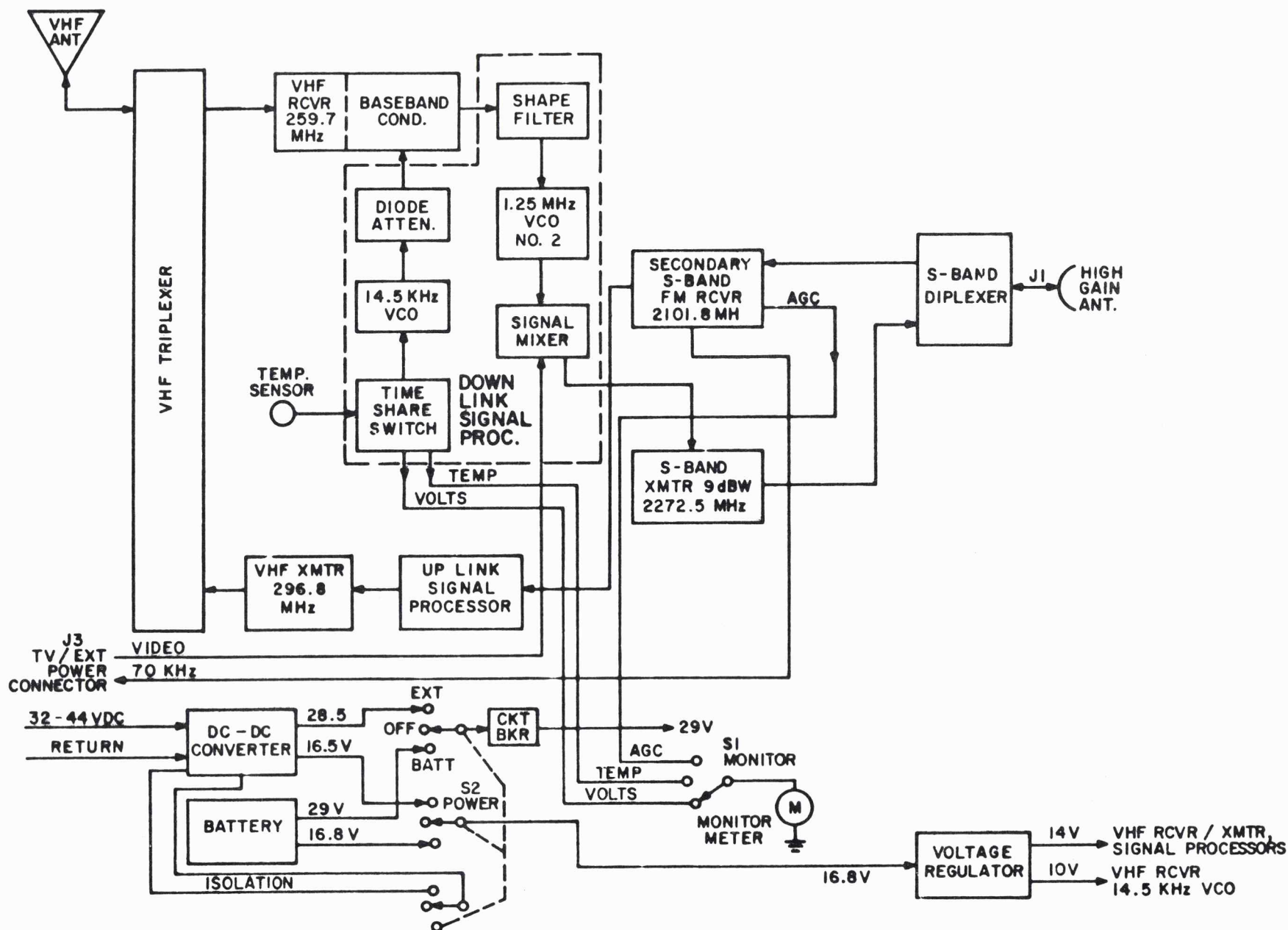


# LCRU BLOCK DIAGRAM MODE I PMI /NB



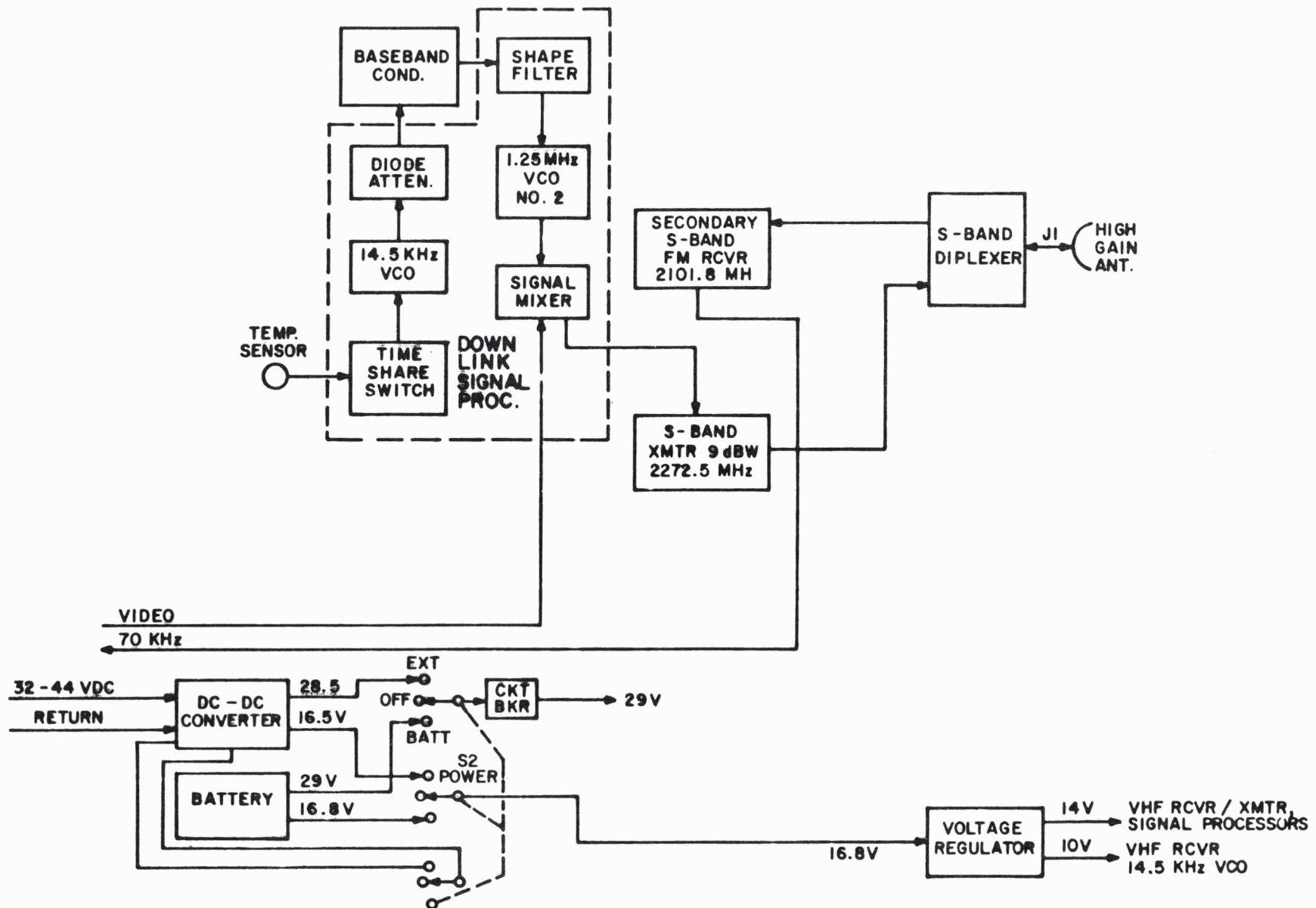
# RCA

## LCRU BLOCK DIAGRAM MODE 3 FM / TV





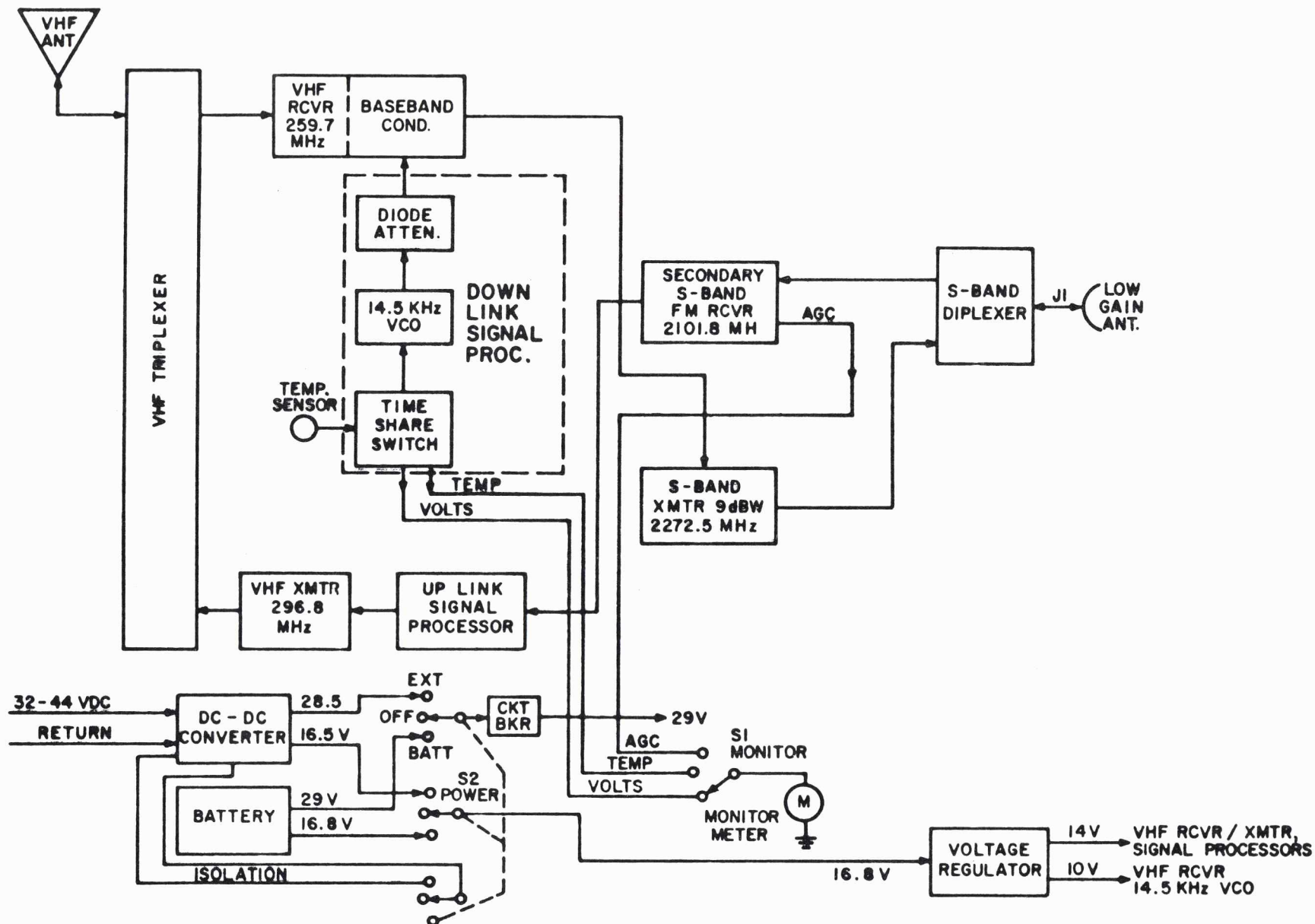
# LCRU BLOCK DIAGRAM MODE 4 TV RMT (STANDBY)





# RCA

## LCRU BLOCK DIAGRAM MODE 5 PM2/NB





# LINK MARGIN SUMMARY

<u>LINK PARAMETER</u>	<u>PMI/WB</u>	<u>PMI/NB*</u>	<u>FM/TV</u>	<u>UPLINK</u>
TRANSMITTER POWER:	6.7w	6.7w	8.3w	10kw
EFFECTIVE ANT. GAIN:	6.5db	6.5db	23.0db	50.5db
EFFECTIVE RADIATED POWER (EIRP INCL. ALL CKT LOSSES)	12.5dbw	12.5dbw	30.2dbw	90.5dbw
TOTAL RECEIVED POWER: (INCL ALL CKT. LOSSES)				
85 Ft. DISH (52.5 db)	-146.6dbw	-146.6dbw	-128.9dbw	-
210 Ft. DISH (60.0db)	-	-	-121.4dbw	-
LCRU L.G. (-5db)	-	-	-	-128.0dbw
LCRU H.G. (18.5db)	-	-	-	-101.5dbw
MARGINS (db):				
CARRIER	+15.8	+25.7	+8.8/+1.3	+27.6/+1.3
1.25 MHZ SUBCARRIER	+ 0.2	-	+2.3	-
124 KHZ SUBCARRIER	-	-	-	+39.6/+13.4
70 KHZ SUBCARRIER	-	-	-	+34.0
VOICE CHANNEL	+ 8.5	- 0.4	+10.6	>20
3.9 KHZ SUBCARRIER	+11.2	+ 0.7	+13.3	-
5.4 KHZ SUBCARRIER	+ 7.9	+ 0.2	+10.0	-
7.35 KHZ SUBCARRIER	+ 6.2	+ 1.0	+ 8.3	-
10.5 KHZ SUBCARRIER	+ 2.9	+ 0.9	+ 5.0	-
14.5 KHZ SUBCARRIER	+ 2.8	- 0.1	+ 4.9	-
VIDEO CHANNEL	-	-	+3.8/-3.7	-

\* PM2/NB ALL MARGINS 1.0db greater than PMI/NB

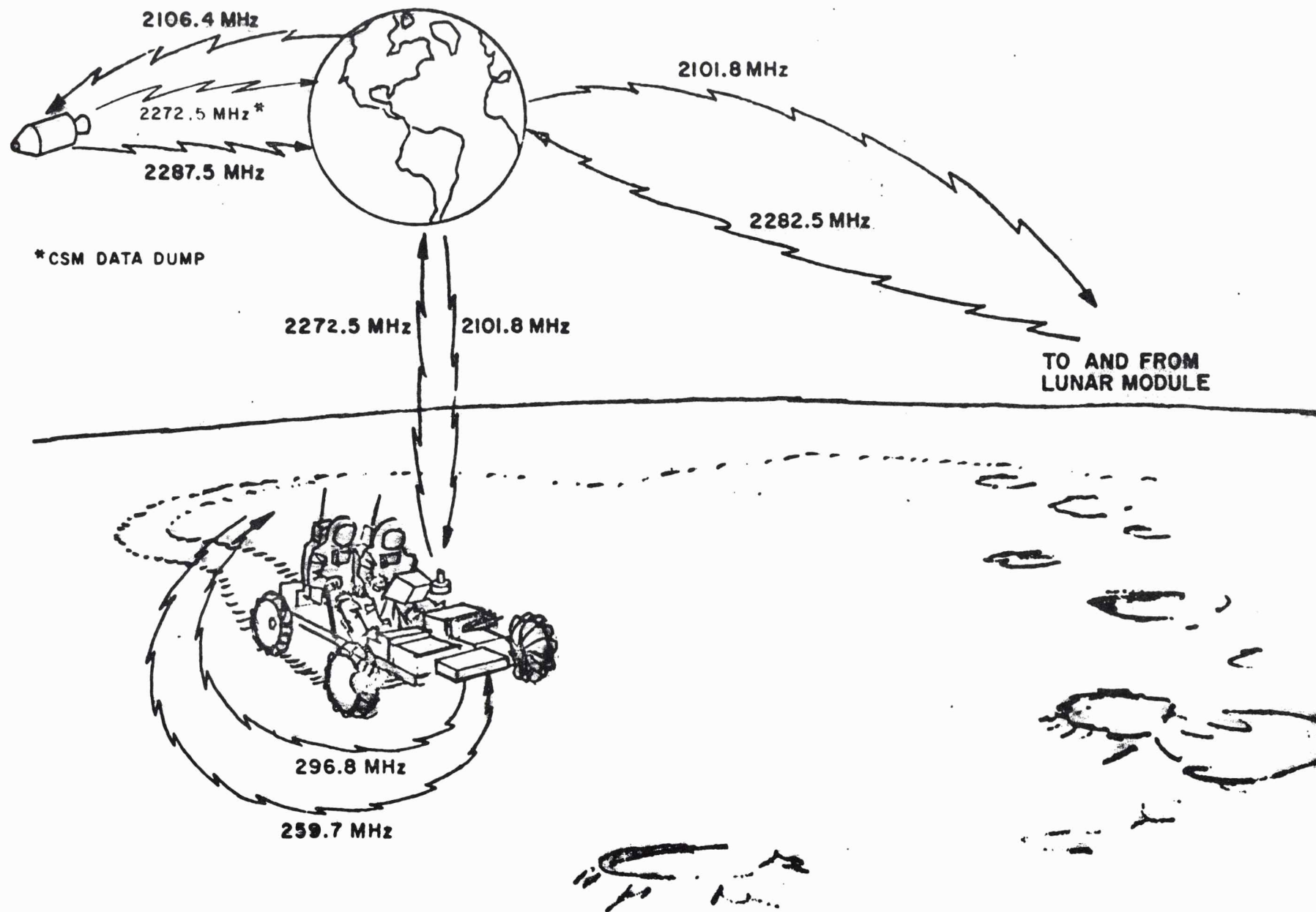
14-4

## **5.0 SYSTEM DESIGN**



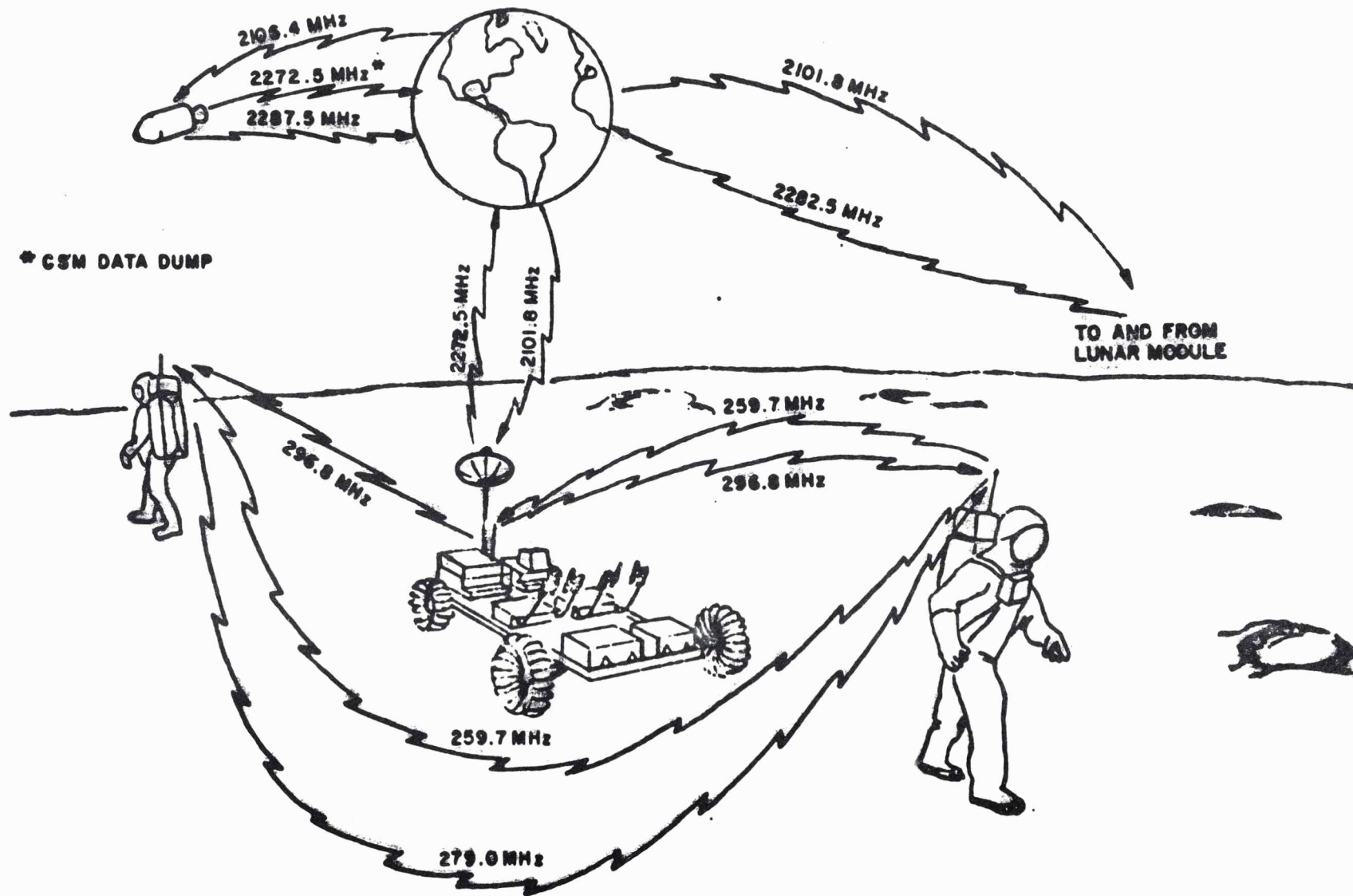
**RCA**

# LCRU IN MOBILE OPERATION ON LRV



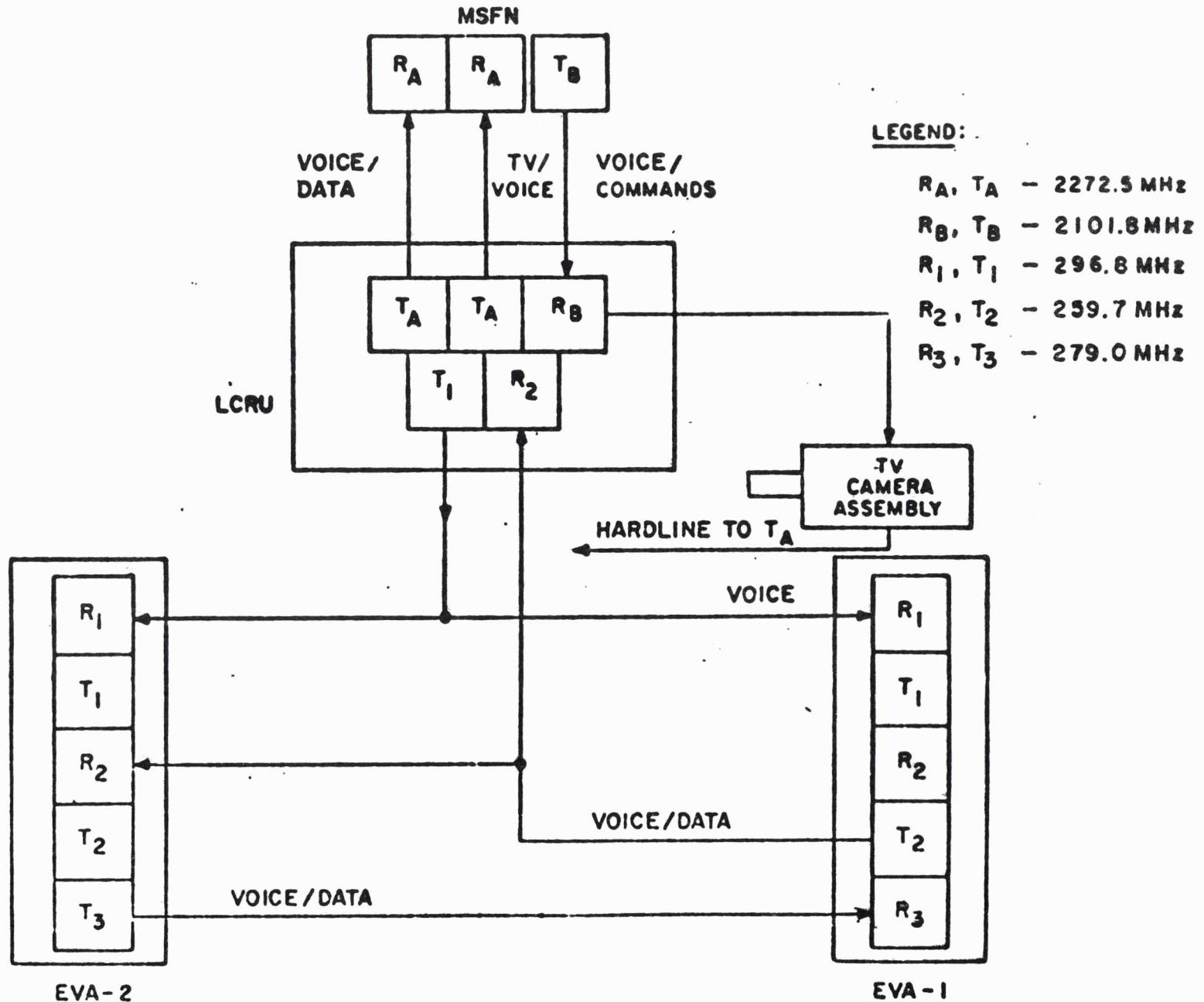
**RCA**

# LCRU IN FIXED BASE OPERATION ON LRV





# SYSTEM COMMUNICATIONS LINKS







SIGNAL DESIGN MODULATION PARAMETERS,  
DOWN LINK

A. 1.25-MHz SUBCARRIER DEVIATIONS

VOICE	6.6 kHz	}	±15% EACH CHANNEL FOR LCRU,
3.9-kHz SUBCARRIER	2.7 kHz		
5.4-kHz SUBCARRIER	3.0 kHz		±25% EACH CHANNEL FOR EVCS/LCRU OVERALL TOLERANCE
7.35-kHz SUBCARRIER	5.2 kHz		
10.5-kHz SUBCARRIER	6.1 kHz		
14.5-kHz SUBCARRIER	7.6 kHz		

B. CARRIER DEVIATIONS - PRIMARY  
PM MODE

1.25-MHz SUBCARRIER	1.85 RAD	±10%
---------------------	----------	------

C. CARRIER DEVIATIONS - SECONDARY  
PM VOICE MODE

VOICE	0.98 RAD	}	±15% EACH CHANNEL FOR LCRU,
3.9-kHz SUBCARRIER	0.23 RAD		
5.4-kHz SUBCARRIER	0.25 RAD		±25% EACH CHANNEL FOR EVCS/LCRU OVERALL TOLERANCE
7.35-kHz SUBCARRIER	0.43 RAD		
10.5-kHz SUBCARRIER	0.51 RAD		
14.5-kHz SUBCARRIER	0.40 RAD		

D. CARRIER DEVIATIONS - TV MODE (COLOR)

TELEVISION	1.7 MHz	±4% (±9% TV/LCRU)
1.25-MHz SUBCARRIER	275 kHz	±10%



SIGNAL DESIGN MODULATION PARAMETERS,  
UP LINK

A. CARRIER DEVIATIONS

70-kHz COMMAND SUBCARRIER .8 RAD  $\pm 10\%$

124-kHz VOICE SUBCARRIER .8 RAD  $\pm 10\%$

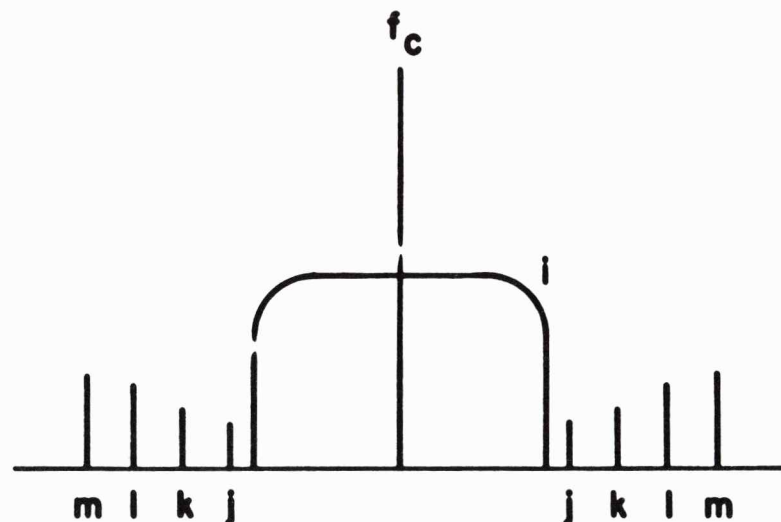
B. 124-kHz SUBCARRIER DEVIATION  $\pm 7.5$  kHz  $\pm 10\%$

C. 70-kHz SUBCARRIER DEVIATION  $\pm 5.0$  kHz  $\pm 10\%$

5-5



## DOWN LINK VHF SPECTRUM



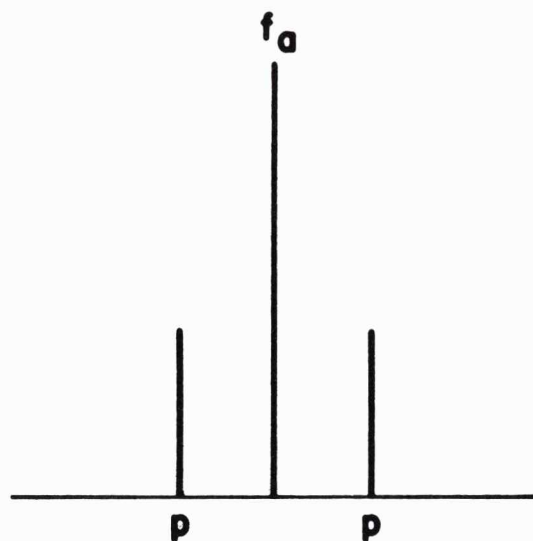
- $f_c$  = 259.7 MHz CARRIER EVC-1 TO LCRU
- i = BASEBAND VOICE, EVA-1 OR EVA-2
- j = 3.9 KHz SUBCARRIER, EVA-2 EKG DATA
- k = 5.4 KHz SUBCARRIER, EVA-1 EKG DATA
- l = 7.35 KHz SUBCARRIER, EVA-2 PLSS STATUS DATA (PAM)
- m = 10.5 KHz SUBCARRIER, EVA-1 PLSS STATUS DATA (PAM)





## DOWN LINK S-BAND SPECTRUM

### PRIMARY MODE (FM/PM)



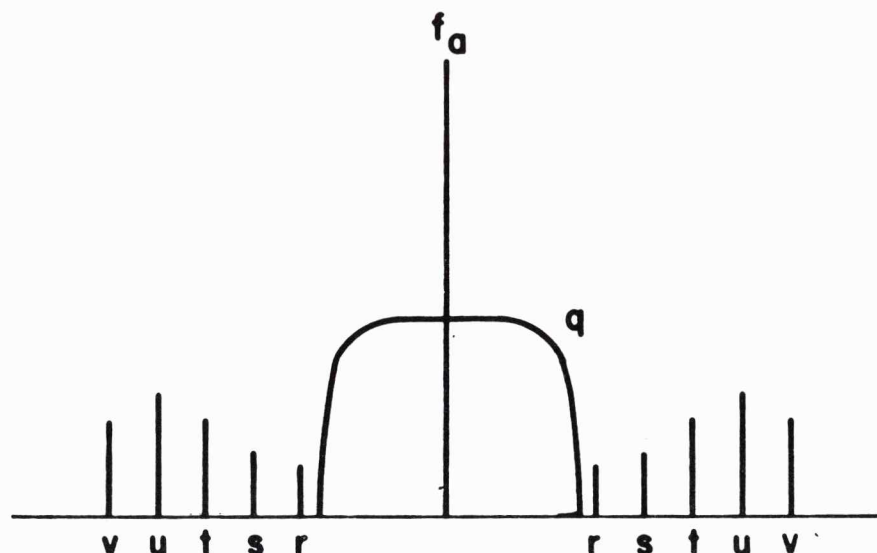
$f_a$  = 2272.5 MHz CARRIER (LCRU TO MSFN)

$p$  = 1.25 MHz SUBCARRIER  
EVA-1 OR EVA-2 VOICE, AND EMU/LCRU DATA BASEBAND,  
FREQUENCY MODULATED ONTO SUBCARRIER



## DOWN LINK S-BAND SPECTRUM

### SECONDARY MODE (PM)

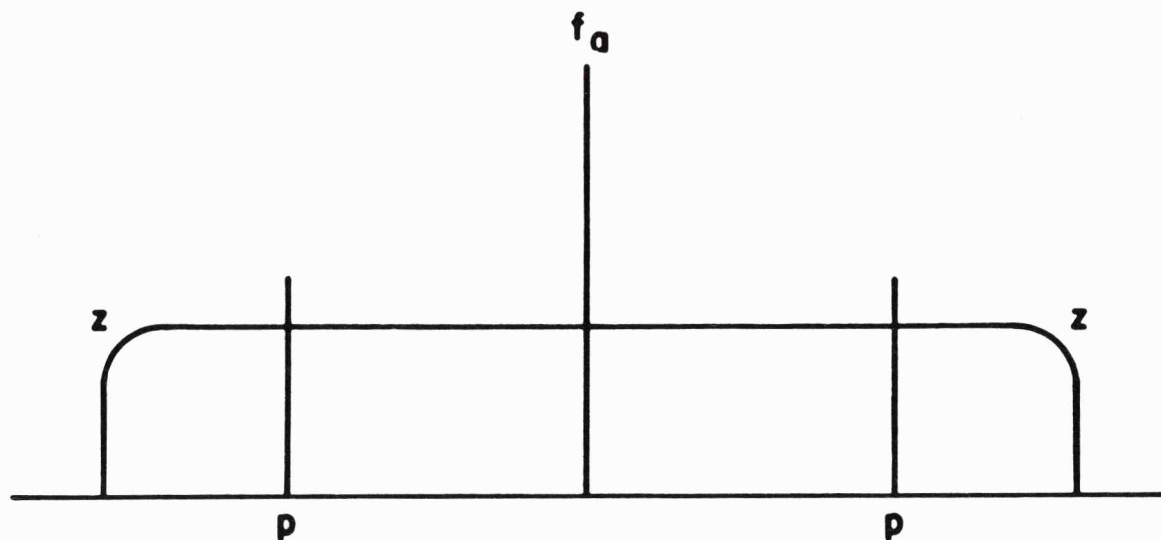


- $f_a$  = 2272.5 MHz CARRIER (LCRU TO MSFN)  
 $q$  = BASEBAND VOICE, EVA-1 OR EVA-2  
 $r$  = 3.9 KHz SUBCARRIER, EVA-2 EKG DATA  
 $s$  = 5.4 KHz SUBCARRIER, EVA-1 DKG DATA  
 $t$  = 7.35 KHz SUBCARRIER, EVA-2 PLSS STATUS DATA (PAM)  
 $u$  = 10.5 KHz SUBCARRIER, EVA-1 PLSS STATUS DATA (PAM)  
 $v$  = 14.5 KHz SUBCARRIER, LCRU STATUS DATA (TIME SHARED)



## DOWN LINK S-BAND SPECTRUM

TV/VOICE MODE (FM/FM)



$f_a$  = 2272.5 MHz CARRIER (LCRU TO MSFN)

$p$  = 1.25 MHz SUBCARRIER  
EVA-1 OR EVA-2 VOICE, AND EMU/LCRU DATA BASEBAND,  
FREQUENCY MODULATED ONTO SUBCARRIER

$z$  = COLOR TELEVISION VIDEO BASEBAND

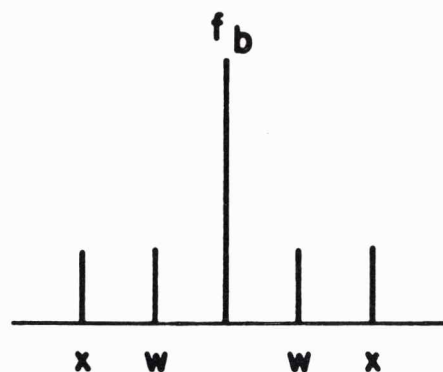




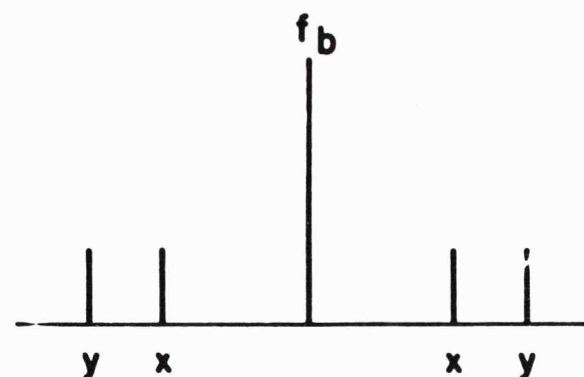
## UPLINK S-BAND SPECTRUM

(FM/PM)

LM



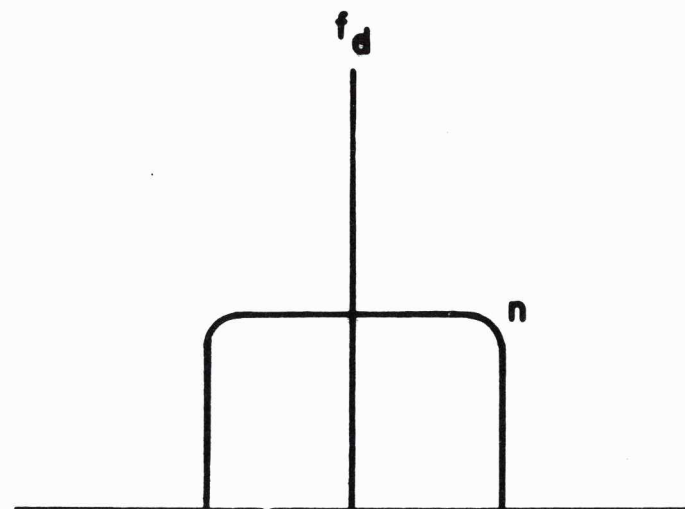
LCRU



- $f_b$  = 2101.8 MHz CARRIER, MSFN TO LCRU OR MSFN TO LM AND LCRU
- w = 30 KHz SUBCARRIER, UPLINK VOICE TO LM
- x = 70 KHz SUBCARRIER, UPLINK COMMAND DATA TO LCRU AND/OR LM
- y = 124 KHz SUBCARRIER, UPLINK VOICE TO LCRU

**RCA**

## UPLINK VHF SPECTRUM

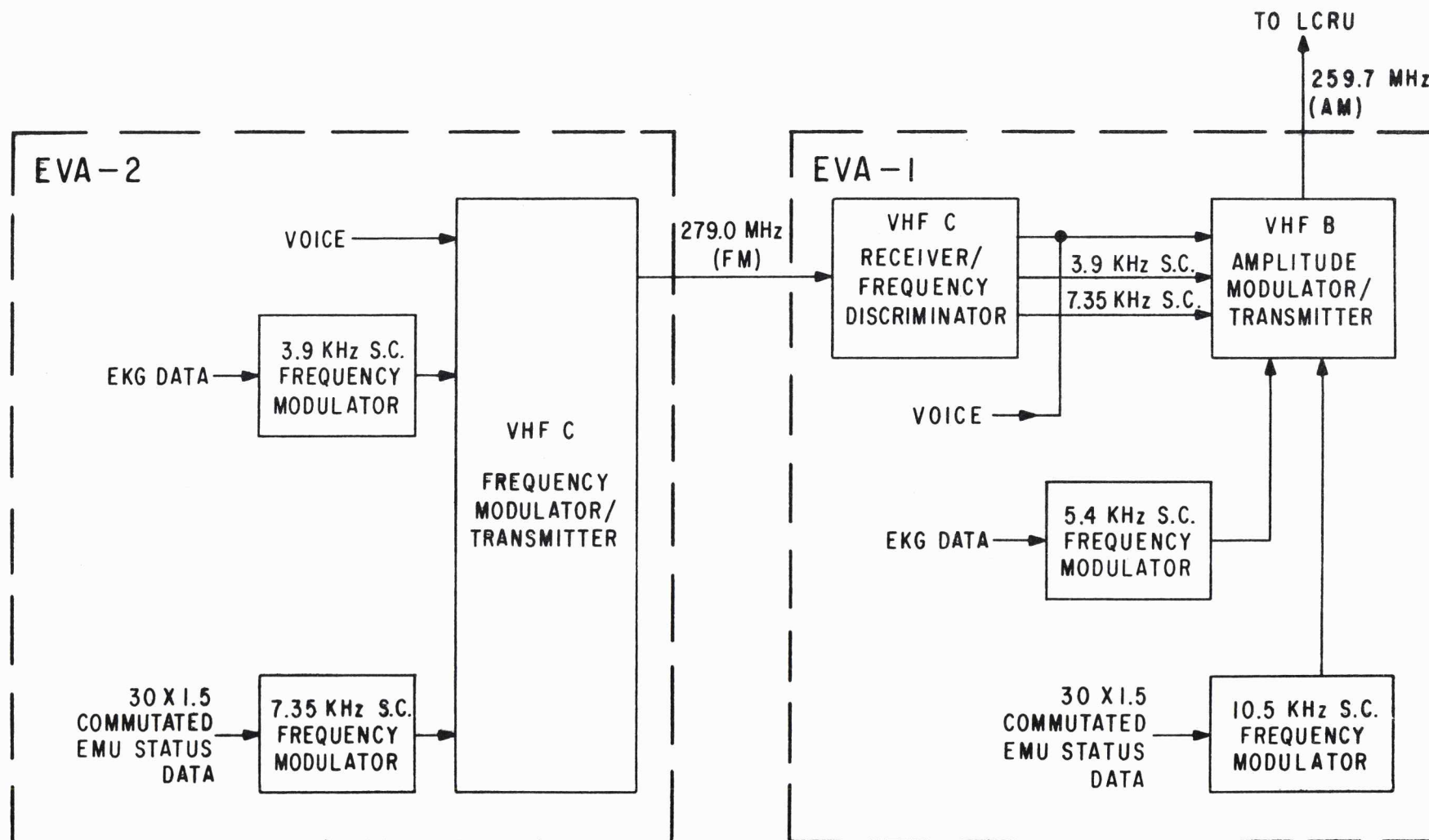


$f_d$  = 296.8 MHz CARRIER, LCRU TO EVC-1 AND EVC-2

$n$  = BASEBAND VOICE, FROM MSFN



# EVA PORTION OF DOWN-LINK EVA-2/EVA-1/LCRU/MSFN COMMUNICATIONS SYSTEMS







# SYSTEM COMMUNICATIONS LINKS (EVCS BACK UP)

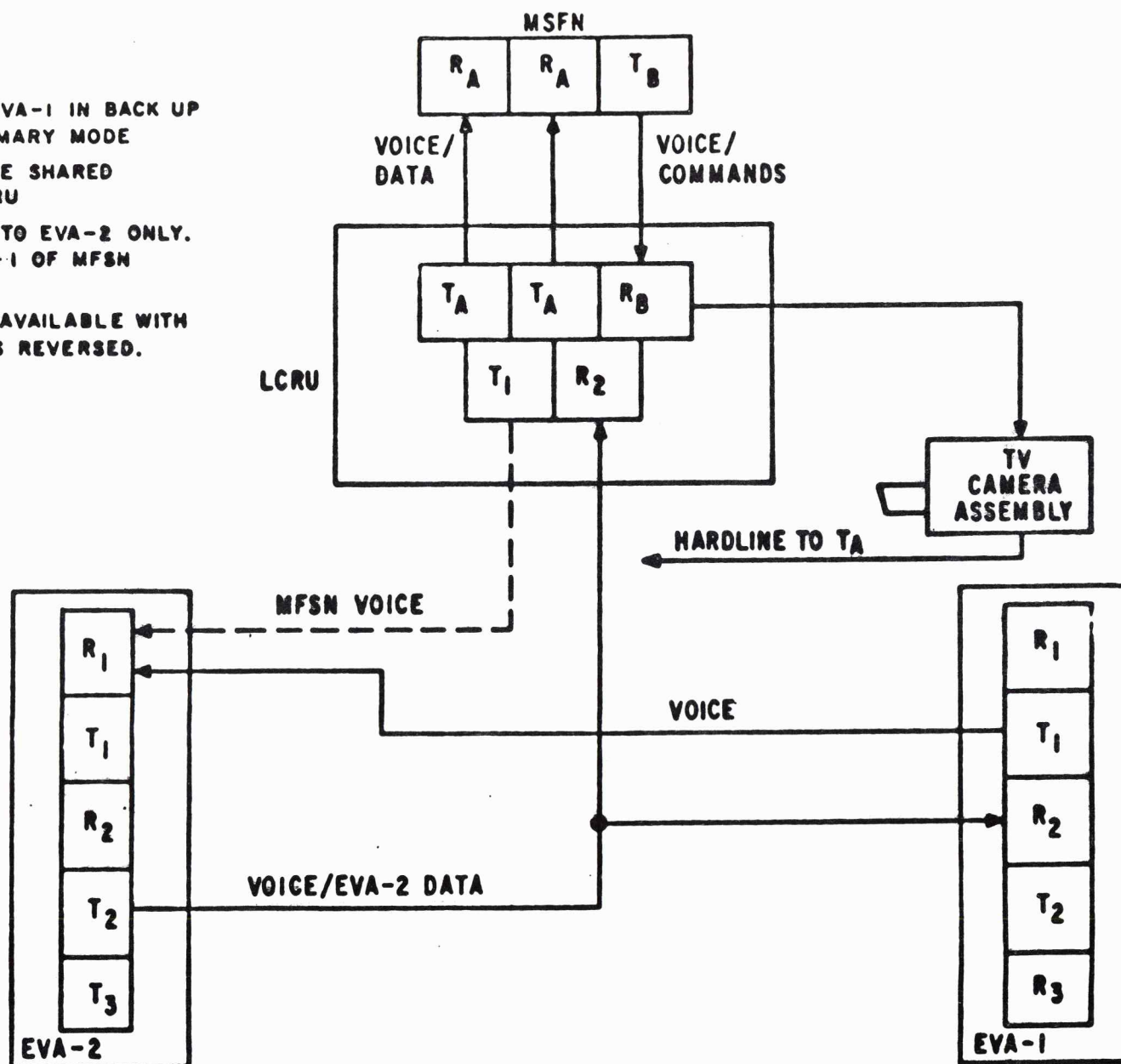
## OPERATIONAL NOTE:

- .1 CONFIGURATION SHOWS EVA-1 IN BACK UP MODE AND EVA-2 IN PRIMARY MODE
- .2 296.8 MHz CHANNEL TIME SHARED BETWEEN EVA-1 AND LCRU
- .3 MSFN VOICE AVAILABLE TO EVA-2 ONLY. EVA-2 MUST INFORM EVA-1 OF MSFN MESSAGES.
- .4 BACK UP CONFIGURATION AVAILABLE WITH EVA-2 AND EVA-1 STATUS REVERSED.

## FREQUENCY ASSIGNMENT:

5-13

$R_A, T_A$	- 2272.5 MHz
$R_B, T_B$	- 2101.8 MHz
$R_1, T_1$	- 296.8 MHz
$R_2, T_2$	- 259.7 MHz
$R_3, T_3$	- 279.0 MHz





SYSTEM CONFIGURATION DOWN LINK

EVCS/LCRU/MSFN

EVCS/LCRU VHF LINK

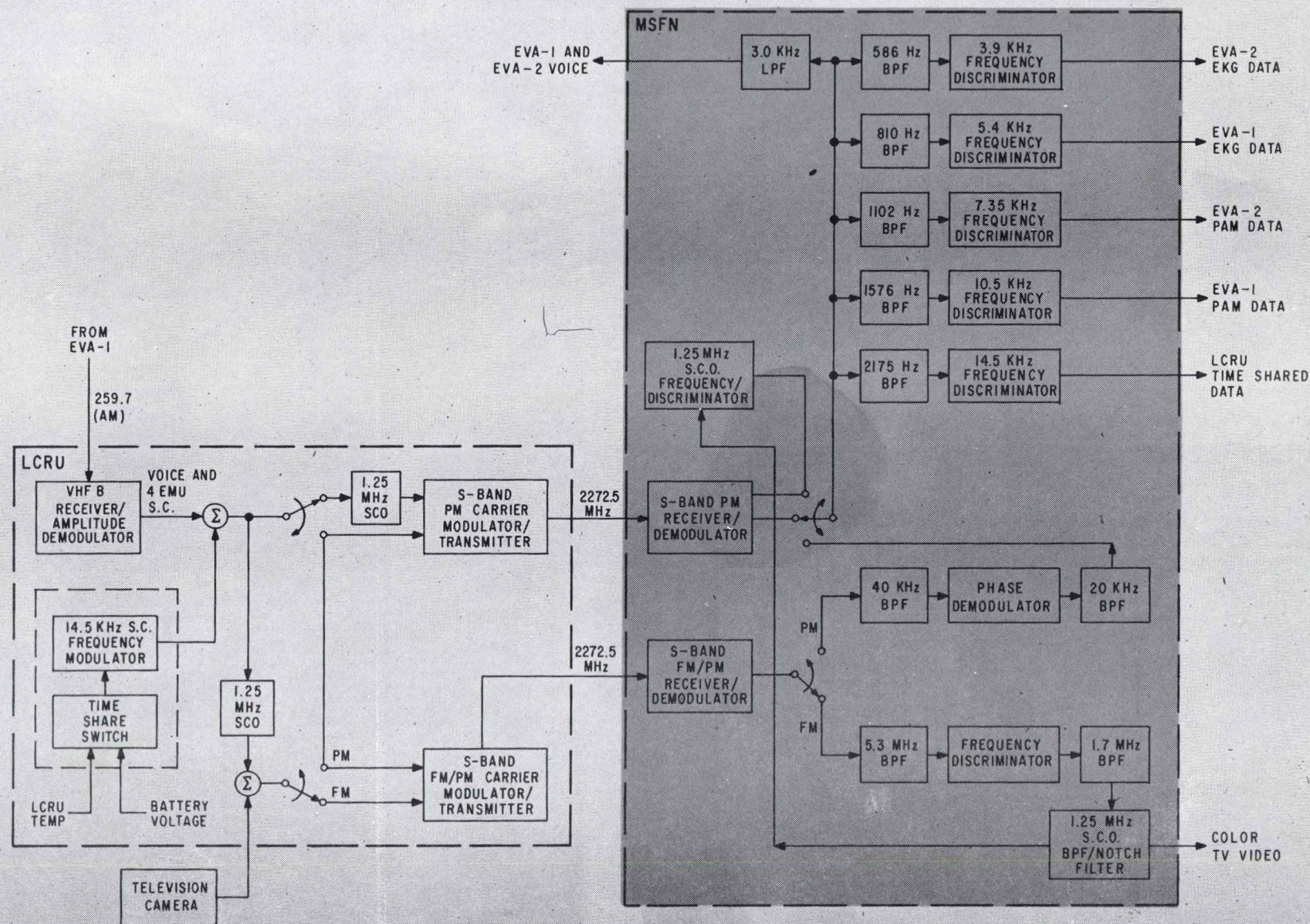
- LCRU VHF TERMINAL DESIGN BASED ON COMPATIBILITY WITH EVCS DUAL MODE DUPLEX; EVA-2 AT 279 MHz TO EVA-1; 259.7 MHz TO LCRU; AND 296.8 MHz LCRU TO EVA-1 AND EVA-2.
- LCRU VHF TERMINAL DESIGN COMPATIBLE WITH (EVCS BACKUP SIMPLEX MODE: EVC-1 TO EVC-2) TRANSMIT 296.8 MHz AND RECEIVE 259.7 MHz (OR EVC-2 TO EVC-1 SAME FREQUENCIES); IN EITHER CASE, LCRU TRANSMIT CHANNEL 296.8 MHz IS DISABLED, VOXED OFF IN ABSENCE OF MSFN VOICE.
- LINK DESIGN BASED ON EVCS/LM VHF AM LINK, BUT MODIFIED FOR PATH LOSS-EVCS/LM 119 db; EVCS/LCRU 105 db. THIS PROVIDES COMPATIBILITY WITH RF AND SNR INTERFACES SPELLED OUT FOR EVCS/LM IN ICD LID-380 11381
- BASEBAND BANDWIDTH - LCRU EMPLOYS EVCS 259.7 MHz RECEIVER (FROM EVC-2) MODIFIED FROM 3 KHz BANDWIDTH TO 20 KHz BANDWIDTH TO ACCEPT BOTH VOICE AND EMU DATA SUBCARRIERS.

5-14





# LCRU / MSFN PORTION OF DOWNLINK EVA-2/EVA-1 LCRU / MSFN COMMUNICATION SYSTEM







## SYSTEM CONFIGURATION DOWN LINK EVCS/LCRU/MSFN

### LCRU/MSFN S-BAND LINK

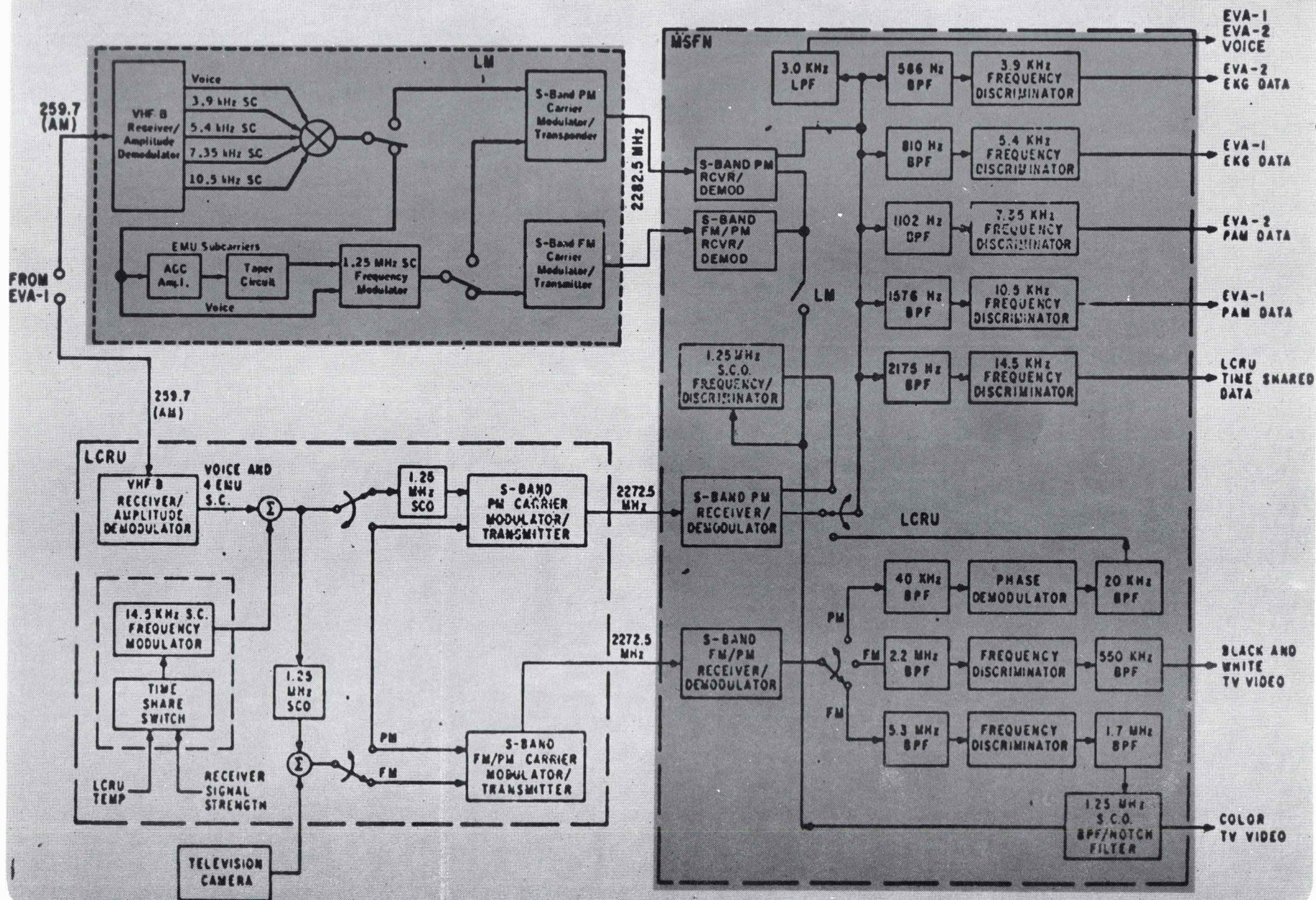
- o. SIGNAL DESIGN BASED ON COMPATIBILITY WITH MSFN BASEBAND COMPLEX FOR VOICE, THE ~~FIVE~~ **FIVE** DATA SUBCARRIERS AND COLOR TELEVISION.
- o. LINK DESIGN BASED ON COMPATIBILITY WITH TIME-SHARED USAGE OF CSM HIGH SPEED DATA CHANNEL, 2272.5 MHz.
- o. VOICE/DATA LINK EMPLOYS A HELICAL ANTENNA ADJUSTABLE FOR AZIMUTH AND ELEVATION OVER A NOMINAL 60° CONE. ANTENNA GAIN 6.5 DB MINIMUM OVER PATTERN  $\pm 30^\circ$  OFF BORESIGHT ALL VOICE/DATA LINKS VIN LCRU HELICAL ANTENNA AND MSFN 85 FOOT DISH.
- o. TV - VOICE/DATA LINK EMPLOYS 23 DB DEPLOYABLE DISH ANTENNA.
- o. THE TV LINK CAPABILITY IS PROVIDED FROM FIXED BASE OPERATIONS BETWEEN THE LCRU DISH AND THE MSFN 210 FOOT DISH.
- o. FM/PM - VOICE/DATA VIA 1.25 MHz SUBCARRIER
- o. PM - VOICE/DATA VIA BASEBAND
- o. FM/FM - TV AND VOICE/DATA FREQUENCY MULTIPLEXED (V/D ON 1.25 MHz S.C.)

5-16





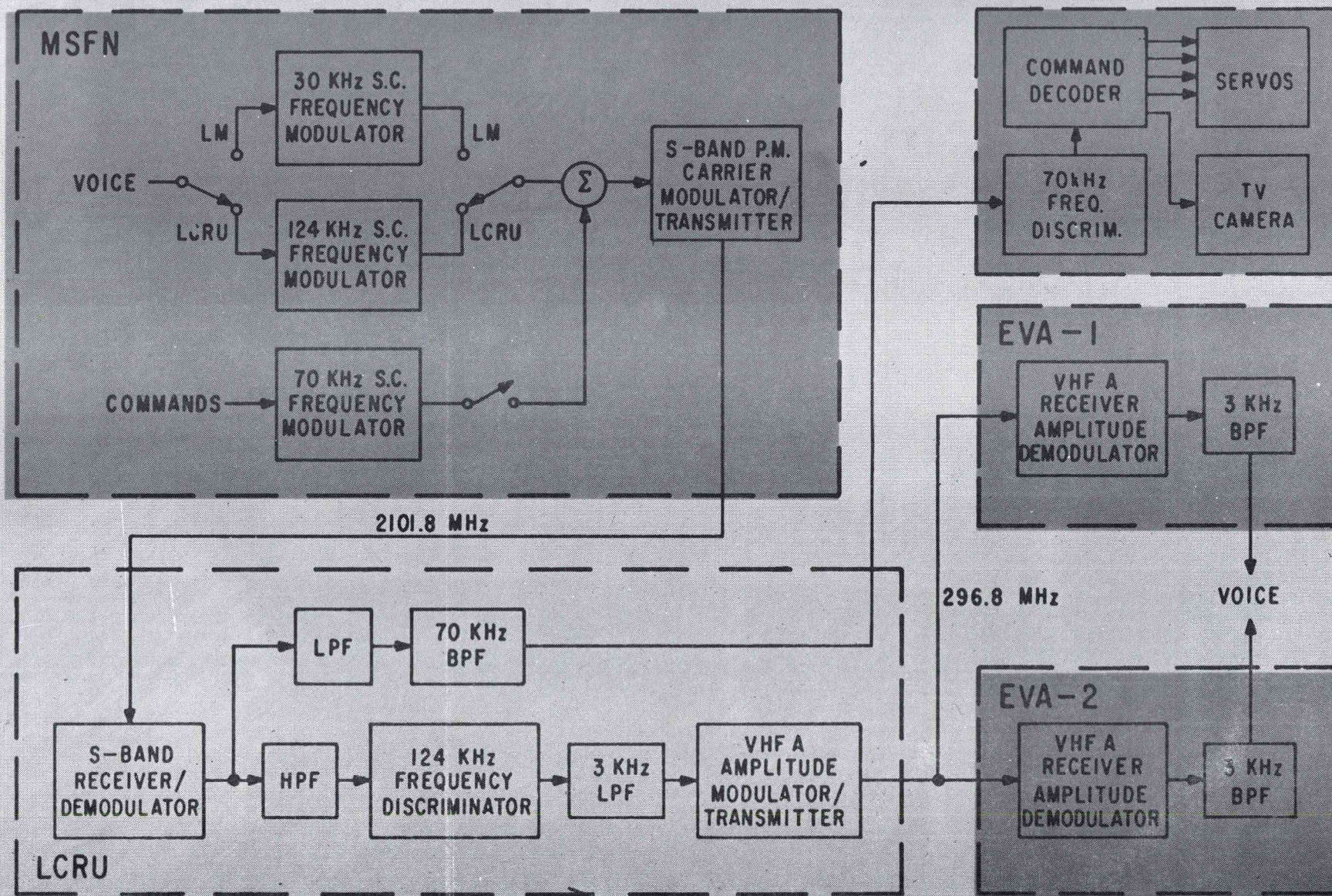
# DOWN-LINK COMMUNICATION SYSTEM EVCS/LCRU/MSFN AND LM/LCRU/MSFN







# UP-LINK MSFN/LCRU/EVA-1/EVA-2 COMMUNICATIONS SYSTEM







## SYSTEM CONFIGURATION UPLINK

### MSFN/LCRU/EVA-1, EVA-2

- SIGNAL DESIGN BASED ON COMPATIBILITY WITH MSFN BASEBAND COMPLEX AND FULL TIME SHARING OF LM UPLINK CARRIER OF 2101.8 MHz.
- LCRU VOICE/DATA LINK EMPLOYS HELICAL ANTENNA TO ACCEPT SIGNALS FROM MSFN 85 FT. DISH. LCRU HELICAL ANTENNA PROVIDES MINIMUM GAIN OF -5 db  $\pm 52^\circ$  OFF BORESIGHT AND AT LEAST -9 db  $\pm 60^\circ$  OFF BORESIGHT.
- FM/PM - LCRU UPLINK VOICE ON 124 KHz SUBCARRIER AND COMMAND DATA ON 70 KHz SUBCARRIER. 70 KHz SUBCARRIER SHARED BETWEEN LM AND LCRU.
- UPLINK VOICE FROM LCRU TO EVA-1 AND EVA-2 PROVIDED VIA VOX. TRANSMISSION OVER VHF LINK LIMITED TO MSFN VOICE "ON" AND "OFF" DUTY CYCLE.
- AUTOMATIC SQUELCH PROVISION EMPLOYED ON S-BAND LINK, 2 db BELOW THRESHOLD.
- STANDBY OPERATION - PROVISION FOR REMOTE LCRU TV OPERATION VIA UPLINK COMMAND ON 70 KHz SUBCARRIER.
- SYSTEM HANDOVER FROM LM TO LCRU OR LCRU TO LM PERFORMED BY MSFN VIA SUBCARRIER SWITCHING

5-19



## LINK ANALYSIS

### PRIMARY VOICE MODE (FM/PM)

	VALUE	SOURCE
A. RF POWER		
TRANSMITTER POWER OUTPUT	8.2 dbW	RCA SPEC
TRANSMIT CIRCUIT LOSSES (CABLE LOSS, VSWR, DIPLEXER, CONNECTORS)	2.2 db	CALCULATED
TRANSMIT ANTENNA GAIN (BORESIGHT)	9.5 db	VENDOR DATA
ANTENNA POINTING LOSS ( $\pm 30^\circ$ OFF AXIS)	3.0 db	VENDOR DATA
EFFECTIVE ANTENNA GAIN	6.5 db	RCA SPEC
EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) (REQUIRED MINIMUM = 12.0 dbW)	12.5 dbW	CALCULATED
SPACE LOSS (215,000 N.ML AND $f = 2272.5$ MHz)	211.6 db	CALCULATED
MSFN 85-FT ANTENNA GAIN (INCLUDES CIRCUIT AND POLARIZATION LOSSES)	52.5 db	P&I SPEC
TOTAL RECEIVED POWER	-146.6 dbW	CALCULATED
B. CARRIER PERFORMANCE:		
MODULATION LOSS (2.04 RADIANS PEAK)	14.0 db	CALCULATED
CARRIER POWER	-160.6 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (50 Hz)	+17.0 db Hz	P&I SPEC
NOISE POWER	-188.4 dbW	CALCULATED
ACTUAL CNR	+27.8 db	CALCULATED
REQUIRED CNR	12.0 db	P&I SPEC
CARRIER MARGIN	+15.8 db	CALCULATED



## LINK ANALYSIS

### PRIMARY VOICE MODE (FM/PM) (CONT'd.)

	VALUE	SOURCE
C. 1.25 MHz SUBCARRIER PERFORMANCE:		
MODULATION LOSS (1.67 RAD)	1.8 db	CALCULATED
SUBCARRIER POWER	-148.4 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (48 kHz)	46.8 db Hz	P&I SPEC
NOISE POWER	-158.6 dbW	CALCULATED
ACTUAL SNR	+10.2 db	CALCULATED
REQUIRED SNR	+10.0 db	P&I SPEC
SUBCARRIER MARGIN	+0.2 db	CALCULATED
D. VOICE CHANNEL PERFORMANCE (DEVIATION 4.95 kHz)		
1.25 MHz SUBCARRIER POWER	-148.4 dbW	CALCULATED
FM IMPROVEMENT ( $3\beta^2$ )	9.1 db	CALCULATED
PEAK/RMS CORRECTION ( $1/2 \rho^2$ )	-8.8 db	CALCULATED
VOICE POWER	-148.1 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (3 kHz)	34.8 db Hz	P&I SPEC
NOISE POWER	-170.6 dbW	CALCULATED
ACTUAL VOICE SNR	22.5 db	CALCULATED
REQUIRED SNR	14.0 db	P&I SPEC
VOICE MARGIN	+8.5 db	CALCULATED





## LINK ANALYSIS

## PRIMARY VOICE MODE (FM/PM) (CONT'D.)

E. 3.9 kHz SUBCARRIER CHANNEL PERFORMANCE (DEVIATION 2.02 kHz)	VALUE	SOURCE
1.25 MHz SUBCARRIER POWER	-148.4 dBW	CALCULATED
FM IMPROVEMENT ( $\beta^2$ )	-5.7 dB	CALCULATED
PEAK/RMS CORRECTION (1/2)	-3.0 dB	CALCULATED
3.9 kHz SUBCARRIER POWER	-157.1 dBW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dBW/Hz	P&I SPEC
NOISE BANDWIDTH (720 Hz)	28.6 dB Hz	P&I SPEC
NOISE POWER	-176.8 dBW	CALCULATED
ACTUAL SNR	19.7 dB	CALCULATED
REQUIRED SNR	8.5 dB	P&I SPEC
3.9 kHz SUBCARRIER MARGIN	+11.2 dB	CALCULATED
F. 5.4 kHz SUBCARRIER CHANNEL PERFORMANCE (DEVIATION 2.25 kHz)		
1.25 MHz SUBCARRIER POWER	-148.4 dBW	CALCULATED
FM IMPROVEMENT ( $\beta^2$ )	-7.6 dB	CALCULATED
PEAK/RMS CORRECTION (1/2)	-3.0 dB	CALCULATED
5.4 kHz SUBCARRIER POWER	-159.0 dBW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dBW/Hz	P&I SPEC
NOISE BANDWIDTH (995 Hz)	30 dB Hz	P&I SPEC
NOISE POWER	-175.4 dBW	CALCULATED
ACTUAL SNR	16.4 dB	CALCULATED
REQUIRED SNR	8.5 dB	P&I SPEC
5.4 kHz SUBCARRIER MARGIN	+7.9 dB	CALCULATED



## LINK ANALYSIS

## PRIMARY VOICE MODE (FM/PM) (CONT'D.)

G. 7.35 kHz SUBCARRIER CHANNEL PERFORMANCE (DEVIATION = 3.9 kHz)	VALUE	SOURCE
1.25 MHz SUBCARRIER POWER	-148.4 dBW	CALCULATED
FM IMPROVEMENT ( $\beta^2$ )	-5.5 db	CALCULATED
PEAK/RMS CORRECTION (1/2)	-3.0 db	CALCULATED
7.35 kHz SUBCARRIER POWER	-156.9 dBW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dBW/Hz	P&I SPEC
NOISE BANDWIDTH (1355 Hz)	31.3 db Hz	P&I SPEC
NOISE POWER	174.1 dBW	CALCULATED
ACTUAL SNR	17.2 db	CALCULATED
REQUIRED SNR	11.0 db	P&I SPEC
7.35 kHz SUBCARRIER MARGIN	+6.2 db	CALCULATED
H. 10.5 kHz SUBCARRIER CHANNEL PERFORMANCE (DEVIATION = 4.57 kHz)		
1.25 MHz SUBCARRIER POWER	-148.4 dBW	CALCULATED
FM IMPROVEMENT ( $\beta^2$ )	-7.2 db	CALCULATED
PEAK/RMS CORRECTION (1/2)	-3.0 db	CALCULATED
10.5 kHz SUBCARRIER POWER	-158.6 dBW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dBW/Hz	P&I SPEC
NOISE BANDWIDTH (1939 Hz)	32.9 db Hz	P&I SPEC
NOISE POWER	-172.5 dBW	CALCULATED
ACTUAL SNR	13.9 db	CALCULATED
REQUIRED SNR	11.0 db	P&I SPEC
10.5 kHz SUBCARRIER MARGIN	+2.9 db	CALCULATED



## LINK ANALYSIS

### PRIMARY VOICE MODE (FM/PM) (CONT'D.)

	VALUE	SOURCE
L 14.5 SUBCARRIER CHANNEL PERFORMANCE (DEVIATION = 5.7 kHz)		
1.25 MHz SUBCARRIER POWER	-148.4 dBW	CALCULATED
FM IMPROVEMENT ( $\beta^2$ )	-8.4 dB	CALCULATED
PEAK/RMS CORRECTION (1/2)	-3.0 dB	CALCULATED
14.5 SUBCARRIER POWER	-159.8 dBW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dBW/Hz	P&I SPEC
NOISE BANDWIDTH (2680 Hz)	34.3 dB Hz	P&I SPEC
NOISE POWER	-171.1 dBW	CALCULATED
ACTUAL SNR	11.3 dB	CALCULATED
REQUIRED SNR	8.5 dB	P&I SPEC
14.5 SUBCARRIER MARGIN	+2.8 dB	CALCULATED

5-24





## LINK ANALYSIS

### SECONDARY VOICE MODE (BASEBAND PM)

A. R. F. POWER	VALUE	SOURCE
TRANSMITTER POWER OUTPUT	8.2 dbW	RCA SPEC.
TRANSMIT CIRCUIT LOSSES (CABLE LOSS, VSWR, DIPLEXER, CONNECTORS)	2.2 db	CALCULATED
TRANSMIT ANTENNA GAIN (BORESIGHT)	9.5 db	VENDOR DATA
ANTENNA POINTING LOSS ( $\pm 30^\circ$ OFF AXIS)	3.0 db	VENDOR DATA
EFFECTIVE ANTENNA GAIN	6.5 db	RCA SPEC
EFFECTIVE ISOTROPIC RADIATED POWER (EIRP) (REQUIRED MINIMUM 12.0 dbW)	12.5 dbW	CALCULATED
SPACE LOSS (215,000 N. MI AND $f = 2272.5$ MHz)	211.6 db	CALCULATED
MSFN 85 FT. ANTENNA GAIN (INCLUDES CIRCUIT AND POLARIZATION LOSSES)	52.5 db	P&I SPEC
TOTAL RECEIVED POWER	-146.6 dbW	CALCULATED
B. CARRIER PERFORMANCE		
MODULATION LOSS (WORST CASE)	-4.1 db	CALCULATED
CARRIER POWER	-150.7 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (50 Hz)	17.0 db Hz	P&I SPEC
NOISE POWER	-188.4 dbW	CALCULATED
ACTUAL CNR	37.7 db	CALCULATED
REQUIRED CNR	12.0 db	P&I SPEC
CARRIER MARGIN	25.7 db	CALCULATED

5-25



## LINK ANALYSIS

## SECONDARY VOICE MODE (BASEBAND PM) (CONT'D.)

C. VOICE PERFORMANCE	VALUE	SOURCE
MODULATION LOSS $\rho = 1.95$ and $\beta = .73$ RAD)	-10.4 db	CALCULATED
VOICE POWER	-157.0 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (3 kHz)	34.8 db Hz	P&I SPEC
NOISE POWER	-170.6 dbW	CALCULATED
ACTUAL SNR	13.6 db	CALCULATED
REQUIRED SNR	14.0 db	P&I SPEC
VOICE MARGIN	-0.4 db	CALCULATED
D. 3.9-kHz SUBCARRIER PERFORMANCE		
MODULATION LOSS (0.17 RAD)	-21.0 db	CALCULATED
3.9-kHz SUBCARRIER POWER	-167.6 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 db/Hz	P&I SPEC
NOISE BANDWIDTH (720 Hz)	28.6 db Hz	P&I SPEC
NOISE POWER	-176.8 dbW	CALCULATED
ACTUAL SNR	9.2 db	CALCULATED
REQUIRED SNR	8.5 db	P&I SPEC
3.9-kHz SUBCARRIER MARGIN	+0.7 db	CALCULATED



## LINK ANALYSIS

### SECONDARY VOICE MODE (BASEBAND PM) (CONT'D.)

	VALUE	SOURCE
E. 5.4-kHz SUBCARRIER PERFORMANCE		
MODULATION LOSS (0.19 RAD)	-20.1 db	CALCULATED
5.4-kHz SUBCARRIER POWER	-166.7 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (995 Hz)	30.0 db Hz	P&I SPEC
NOISE POWER	-175.4 dbW	CALCULATED
ACTUAL SNR	8.7 db	CALCULATED
REQUIRED SNR	8.5 db	P&I SPEC
5.4-kHz SUBCARRIER MARGIN	+0.2 db	CALCULATED
F. 7.35-kHz SUBCARRIER PERFORMANCE		
MODULATION LOSS (0.32 RAD)	-15.5 db	CALCULATED
7.35-kHz SUBCARRIER POWER	-162.1 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (1355 Hz)	31.3 db Hz	P&I SPEC
NOISE POWER	-174.1 dbW	CALCULATED
ACTUAL SNR	12.0 db	CALCULATED
REQUIRED SNR	11.0 db	P&I SPEC
7.35-kHz SUBCARRIER MARGIN	+1.0 db	CALCULATED





## LINK ANALYSIS

## SECONDARY VOICE MODE (BASEBAND PM) (CONT'D.)

	VALUE	SOURCE
G. 10.5-kHz SUBCARRIER PERFORMANCE		
MODULATION LOSS (0.38 RAD)	-14.0 db	CALCULATED
10.5-kHz SUBCARRIER POWER	-160.6 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (1939 Hz)	32.9 db Hz	P&I SPEC
NOISE POWER	-172.5 dbW	CALCULATED
ACTUAL SNR	11.9 db	CALCULATED
REQUIRED SNR	11.0 db	P&I SPEC
10.5-kHz SUBCARRIER MARGIN	+0.9 db	CALCULATED
H. 14.5-kHz SUBCARRIER PERFORMANCE		
MODULATION LOSS (0.30 RAD)	-16.1 db	CALCULATED
14.5-kHz SUBCARRIER POWER	-162.7 dbW	CALCULATED
NOISE SPECTRAL DENSITY	-205.4 dbW/Hz	P&I SPEC
NOISE BANDWIDTH (2680 Hz)	34.3 db Hz	P&I SPEC
NOISE POWER	-171.1 dbW	CALCULATED
ACTUAL SNR	8.4 db	CALCULATED
REQUIRED SNR	8.5 db	P&I SPEC
14.5-kHz SUBCARRIER MARGIN	-0.1 db	CALCULATED



## LINK ANALYSIS TV/VOICE MODE (TV FM; VOICE FM/FM)

A. RF Power

	<u>Value</u>	<u>Source</u>
Transmitter Power Output	9.2 dBw	RCA Spec
Transmit Circuit Losses (Cable loss, VSWR, diplexer, connectors)	2.0 dB	Calculated
Transmit Antenna Gain (Boresight)	23.5 dB	Vendor data
Antenna Pointing Loss ( $\pm 2.2^\circ$ off axis)	0.5 dB	Vendor data
Effective Antenna Gain	23.0 dB	RCA Spec
Effective Isotropic Radiated Power (EIRP) (Required minimum = 30.0 dBw)	30.2 dBw ✓	Calculated
Space Loss (215,000 n.mi. and $f = 2272.5$ MHz)	211.6 dB	Calculated
MSFN Antenna Gain (Includes Circuit and Polarization Losses):		
85-ft	52.5 dB	P&I Spec.
210-ft	60.0 dB	EB69-2004(U)
Total Received Power:		
85-ft	-128.9 dBw ✓	Calculated
210-ft	-121.4 dBw ✓	Calculated
Noise Spectral Density	-205.4 dBw/Hz	P&I Spec.
Predetection Noise Bandwidth (5.3 MHz)	67.2 dB Hz	P&I Spec.
Noise Power	-138.2 dBw ✓	Calculated.
Received Predetection CNR:		
85-ft (required 8.0 dB)	9.3 dB	Calculated
210-ft (required 8.0 dB)	16.8 dB	Calculated

-211.6  
30.2  
-181.4  
52.5  
-128.9

5-29



# LINK ANALYSIS TV/VOICE MODE

(TV FM; VOICE FM/FM) (Continued)

	<u>Value</u>	<u>Source</u>
<b>B. <u>Color TV Performance (210-ft):</u></b>		
Received Predetection S/N	16.8 dB	Calculated
Required Predetection (Threshold) S/N	8.0 dB	LCRU Spec.
Predetection Circuit Margin	8.8 dB	Calculated
FM Improvement ( $\Delta f = 1.6$ MHz)	6.0 dB	Calculated
Received Postdetection S/N (1.7 MHz NBW)	25.8 dB (P/R)	Calculated
Required Postdetection S/N (peak/rms)	22.0 dB	LCRU Spec.
Postdetection Circuit Margin	+ 3.8 dB	Calculated
<b>C. <u>Color TV Performance (85-ft):</u></b>		
Received Predetection S/N	9.3 dB	Calculated
Required Predetection (Threshold) S/N	8.0 dB	LCRU Spec.
Predetection Circuit Margin	1.3 dB	Calculated
FM Improvement ( $\Delta f = 1.6$ MHz)	6.0 dB	Calculated
Received Postdetection SNR (1.7 MHz NPW)	18.3 dB (P/R)	Calculated
Required Postdetection SNR (peak/rms)	22.0 dB	NASA Desired
Postdetection Circuit Margin	- 3.7 dB	Calculated

Note: Video baseband SNR based on pre-emphasis supplied in camera such that LCRU sees flat video out to 2.0 MHz. MSFN to provide de-emphasis for video reconstitution.

P/R denotes peak/rms

16.  
9.3  
6.7





## LINK ANALYSIS

TV/VOICE MODE (TV FM; VOICE FM/FM) (Continued)

	Value	Source
<b>D. <u>1.25 MHz Subcarrier Performance (85 Ft).</u></b>		
Received Predetection CNR	9.3 dB	Calculated
Required Predetection (Threshold) CNR	8.0 dB	LCRU Spec.
Predetection Circuit Margin	+1.3 dB	Calculated
FM Improvement	3.0 dB	Calculated
Received Postdetection SNR (48 kHz)	12.3 dB	Calculated
Required Postdetection SNR	10.0 dB	P&I Spec.
Postdetection Circuit Margin	+2.3 dB	Calculated
<b>E. <u>Baseband Performance*</u></b>		
Voice Channel Margin	+ 10.6 dB	Calculated
3.9 kHz Subcarrier Margin	+ 13.3 dB	Calculated
5.4 kHz Subcarrier Margin	+ 10.0 dB	Calculated
7.35 kHz Subcarrier Margin	+ 8.3 dB	Calculated
10.5 kHz Subcarrier Margin	+ 5.0 dB	Calculated
14.5 kHz Subcarrier Margin	+ 4.9 dB	Calculated

\*Note: Since the 1.25 MHz subcarrier postdetection circuit margin in this mode is 2.1 dB better than for the primary voice mode the baseband margins result as shown.



LINK ANALYSIS  
UPLINK VOICE MODE (FM/PM)

	<u>Value</u>	<u>Source</u>
A. <u>RF Power</u>		
Transmitter Power (10 KW)	40 dBw	P&I Spec.
Transmit Antenna Gain (Includes Circuit Losses)	50.5 dB	P&I Spec.
Effective Radiated Power	+90.5 dBw	Calculated
Space Loss (215,000 n. mi. and $f = 2101.8$ MHz)	211.0 dB	Calculated

	<u>High-Gain</u>	<u>Low-Gain</u>	
Received Antenna Gain (Boresight)	21.5 dB	9.5 dB	RCA
Antenna Pointing Loss	3.0 dB	14.5 dB	RCA
Resultant Antenna Gain	18.5 dB	-5.0 dB ( $+52^\circ$ )	RCA Spec.
Receive Circuit Loss	-2.3	-2.5 dB	Calculated
Total Received Power	-101.5	-128.0 dBw	Calculated
Receiver Noise Temp. (incl. ant noise)	1602°K	1537°K	RCA
Noise Spectral Density	-196.4 dBw/Hz	-196.6 dBw/Hz	RCA
Carrier Prediction Signal-to-Noise:			
Predetection Noise Bandwidth (530 kHz)	57.3	57.3 dB Hz	RCA Spec.
Noise Power	-139.1	-139.3 dBw	Calculated
Predetection SNR	37.6	11.3 dB	Calculated
Required Predetection SNR	10.0	10.0 dB	RCA
Circuit Margin	27.6	+1.3 dB	Calculated



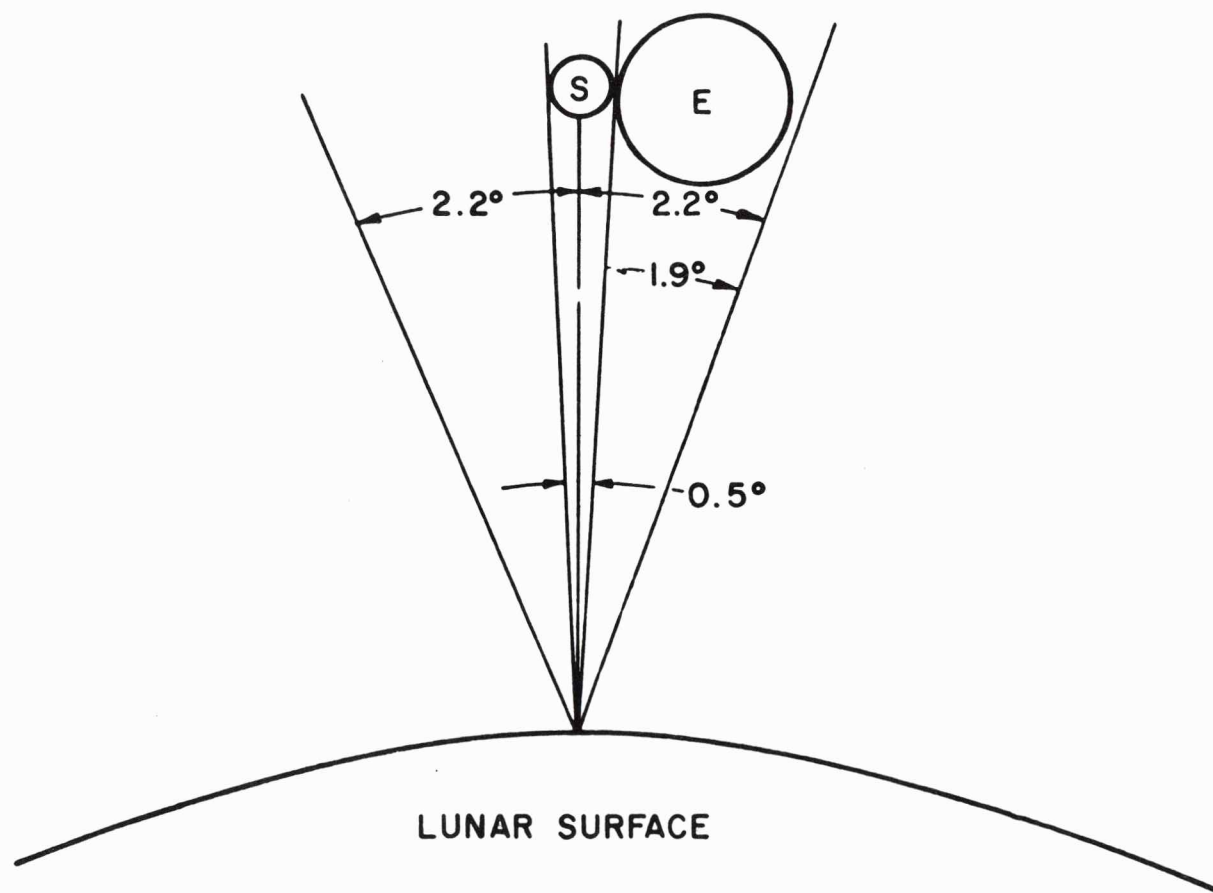
LINK ANALYSIS  
UPLINK VOICE MODE (FM/PM) (Continued)

	Value		
	<u>High-Gain</u>	<u>Low-Gain</u>	<u>Source</u>
<b>B. <u>124 kHz Subcarrier Performance</u></b>			
<b>124-kHz Subcarrier Predetection Signal-to-Noise</b>			
FM Improvement ( $\Delta f = 87$ kHz)	5.7	5.7 dB	Calculated
Predetection SNR	43.2	17.0 dB	Calculated
Required Predetection SNR (35 kHz)	10.0	10.0 dB	RCA
Predetection Circuit Margin	33.2	+7.0 dB	Calculated
<b>124-kHz Subcarrier Postdetection SNR</b>			
FM Improvement ( $\Delta f = 7.5$ kHz)	10.4 dB	10.4 dB	Calculated
Postdetection SNR (3 kHz)	53.6	27.4 dB	Calculated
Required Postdetection SNR (3 kHz)	14.0	14.0 dB	P&I Spec.
Postdetection Circuit Margin	39.6	13.4 dB	Calculated
	Value		Source
<b>C. <u>70 kHz Subcarrier Performance</u></b>			
<b>70-kHz Subcarrier Predetection SNR</b>			
FM Improvement ( $\Delta f = 50$ kHz)	6.4 dB		Calculated
Predetection SNR (24 kHz)	44.0 dB		Calculated
Required Predetection SNR	10.0 dB		LCRU Spec.
Predetection Circuit Margin	+34.0 dB		Calculated



**RCA**

# LCRU HIGH GAIN ANTENNA EARTH/SUN VIEW ANGLES



**NOTE:**

1. CASE SHOWN IS PRE EARTH/SOLAR ECLIPSE WITH MAXIMUM SOLAR ENERGY VIEWED BY ANTENNA.
2. VIEW ANGLES DENOTE CONES



LCRU SYSTEM NOISE TEMPERATURES (SUN CASE)

	<u>ANTENNA GAIN</u>		
	20 dB	34 dB	23 dB
	(1)	(2)	(3)
<u>NOISE SOURCE CONTRIBUTIONS</u>			
Sun ( $100,000^{\circ}\text{K}$ at S-Band)	54	1340	112
Earth ( $290^{\circ}\text{K}$ at S-Band)	4	120	11
Moon (Back Spillover, $24^{\circ}\text{K}$ )	35	35	35
Space ( $4^{\circ}\text{K}$ )	<u>4</u>	<u>4</u>	<u>4</u>
$T_e$ , total effective noise temperature:	97	1499	162

- (1) No change to system temperature; negligible
- (2) Adds  $1150^{\circ}\text{K}$  to system temperature of  $1537^{\circ}\text{K}$ ; reduces margin by approximately 2.5 dB
- (3) No change to system temperature; negligible



## SUN CASE $T_e$

For  $h/R \geq 3$ , and  $G \geq 3$ ,

$$T_e = \frac{GT}{4 [(h/R) + 1]^2}$$

$h$  = Distance from antenna to the surface of the planet ( $1.50 \times 10^8$  km to sun)

$R$  = planet radius ( $6.96 \times 10^5$  km, sun)

$G$  = Antenna Gain

$T$  = Planetary temperature

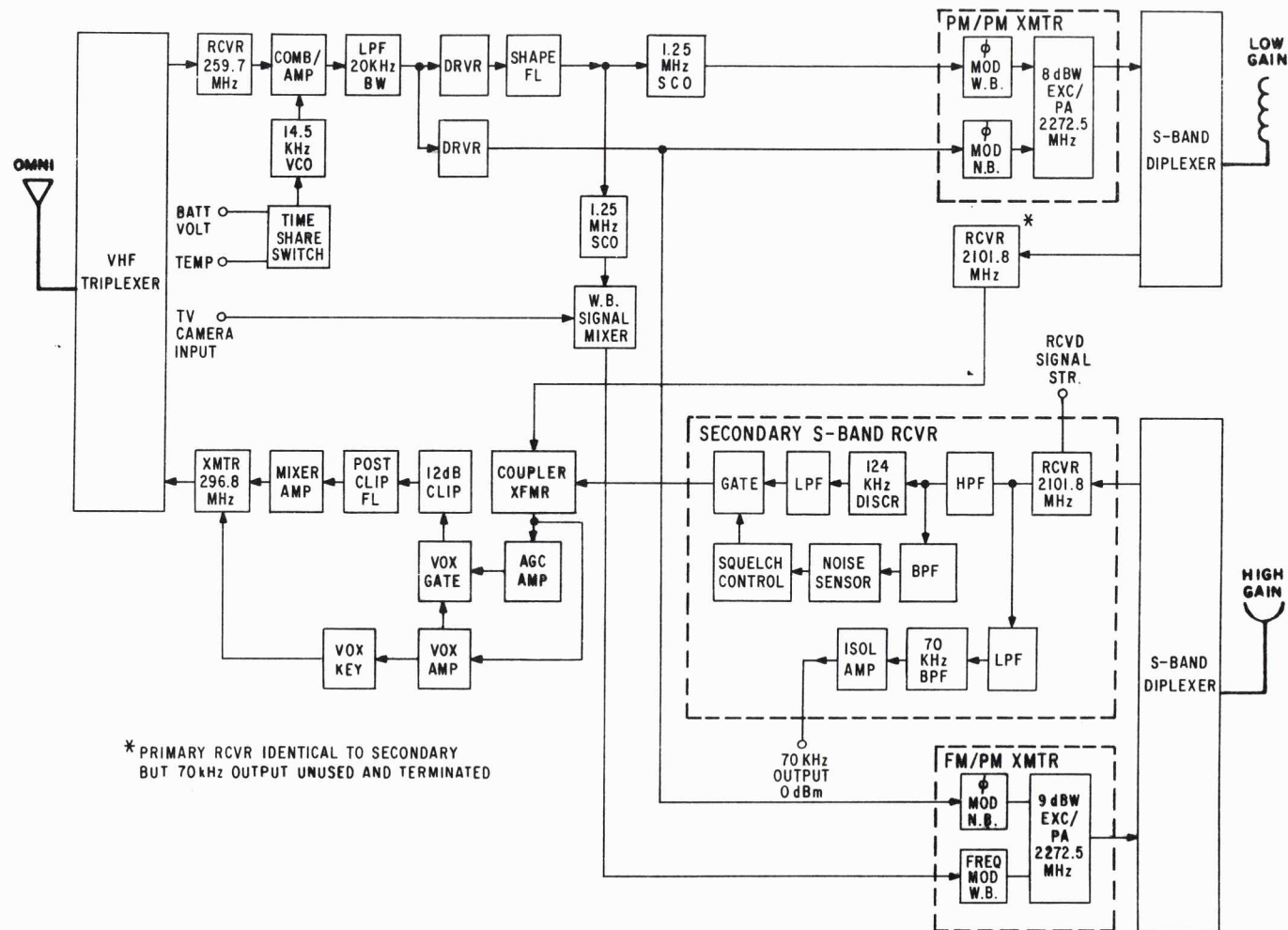
$T_e$  = Effective Noise Temperature

Reference: "Reference Data for Radio Engineers", ITT, Fifth Edition; p. 34-2, equ. (5).





## LCRU SUBSYSTEM BASELINE





## LCRU SUBSYSTEM BASELINE DESIGN

### Primary Down-Link FM/PM

- VHF signal from EVC-1 received over Omni Antenna
- VHF Receiver EVCS output combined with LCRU status data
- LCRU status data baseplate temperature and battery voltage time shares 14.5 KHz VCO
- Baseband signal levels from EVCS dependent on VHF AM receiver AGC. Voice and data channel ratios maintain track
- Baseband filtered to 20 KHz bandwidth
- FM Mode Voice and data baseband shaped to required FM indices, voice channel level reduced 5 db relative to 700 Hz.
- Baseband - voice and data signals frequency modulated on 1.25 MHz sub-carrier. Baseband level set to indices requirements of subcarrier oscillator.
- 1.25 MHz subcarrier phase modulated on S-Band 2272.5 MHz carrier
- Separate 1.25 MHz subcarrier oscillators employed to simplify signal switching and minimize single point failure
- Signal switching provided via DC lines to individual modulators and to 1.25 MHz subcarrier oscillators
- S-Band modules and antennas hardlined to separate diplexers to avoid coaxial switching.
- VHF modules and VHF omni antenna hardlined to VHF diplexer to avoid coaxial switching



## LCRU SUBSYSTEM BASELINE DESIGN

### Secondary Down-Link PM Baseband

- VHF signal from EVC-1 received over omni antenna
- VHF Receiver EVCS output combined with LCRU status data
- LCRU status data baseplate temperature and battery voltage time shares 14.5 KHz VCO
- Baseband signal levels from EVCS dependent on VHF AM receiver AGC. Voice and data channel ratios maintain track
- Baseband filtered to 20 KHz bandwidth
- Baseband (voice-data) signal level set to required indices for PM modulation sensitivity for S-Band Carrier
- Baseband phase modulated on S-Band 2272.5 MHz carrier
- Back-up mode (PM modulator of FM/PM transmitter, same modulation configuration as secondary mode)





## LCRU SUBSYSTEM BASELINE DESIGN

### TV/Data Down-Link FM/FM

- VHF signal from EVC-1 received over omni antenna
- VHF receiver EVCS output combined with LCRU status data
- LCRU status data baseplate temperature and battery voltage time shares 14.5 KHz VCO
- Baseband signal levels from EVCS dependent on VHF AM receiver AGC. Voice and data channel ratios maintain track
- Baseband filtered to 20 KHz bandwidth
- FM mode voice and data baseband shaped to required FM indices, voice channel level reduced 5 db relative to 700 Hz
- Baseband - voice and data signals frequency modulated on 1.25 MHz sub-carrier. Baseband level set to indices requirement of 1.25 MHz subcarrier oscillator
- Baseband frequency modulated on second 1.25 MHz subcarrier oscillator
- Television baseband and 1.25 MHz subcarrier combined in premodulation mixer
- Composite TV and subcarrier frequency modulated on 2272.5 MHz carrier
- FM/FM mode transmission hardlined to high gain antenna



## LCRU SUBSYSTEM BASELINE DESIGN

### UPLINK

- S-Band 2101.8 MHz carrier from MSFN received via low gain or high gain antenna
- S-Band receiver output divided into two subcarriers, 124 KHz and 70 KHz via high pass and low pass filters
- 124 KHz subcarrier demodulated by second discriminator
- Baseband voice filtered to 3 KHz, output signal gated
- Squelch controls baseband signal gate, as a function of out of band sub-carrier noise
- 70 KHz subcarrier hardlined to ground controlled television assembly
- Voice baseband shares voice coupling transformer with other S-Band receiver
- Voice baseband is AGC'd and level gated by VOX
- Voice clipped 12 db
- Clipping noise filtered
- VHF transmission operation controlled by VOX key
- Voice amplitude modulated 70% AM for compatibility with EVCS
- VHF transmitter hardlined to triplexer to avoid coaxial switching
- Received signal strength hardlined to LCRU control panel indicator
- Transmitted to EVA-1 and EVA-2 to via VHF Antenna

14-5