BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 08071

SUBJECT: LRV Weight and Performance Reporting - Case 320

DATE: August 31, 1970

FROM: R. D. Raymond
P. F. Sennewald
J. C. Slaybaugh

MEMORANDUM FOR FILE

On August 25, 1970, a presentation was given by the authors to Dr. R. A. Petrone on the progress made by MSC, MSFC and MA in developing an acceptable method for reporting LRV weight and performance. Figures 1-19, attached, were used as Vu-graphs during the presentation.

The MSFC proposal was described and critiqued, as shown in Figures 1 through 8. Alternative weight and performance reporting formats were then discussed, as shown in Figures 9 and 18. Figures 14 through 17 were provided to review the background of the reference mission used by MSFC to evaluate LRV performance. Figures 10 through 13 were presented to account for the twenty-six pound LRV weight increase shown as a change since the last Weight and Performance Review.

The course of action agreed upon is:

1. The proposed weight reporting matrix, Figure 9, will be adopted, with both MSC and MSFC reports to be due on the fifteenth of each month.

2. The format of the proposed performance report, Figure 18, is acceptable, but concern was expressed about the possible impact on MSFC of reporting performance on a monthly basis. The frequency of performance reporting will be reviewed with W. E. Stoney before a final decision.

3. A letter incorporating the results of (1) and (2) will be sent to the NASA Centers.

R. D. Raymond

P. F. Sennewald

J. C. Slaybaugh

RDR
2032-PFS-meh
JCS

Attachments

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(NASA-CR-86468) LRV WEIGHT AND PERFORMANCE REPORTING (Bellcomm, Inc.) 21 p
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ATTACHMENT 1

Figures 1-19

BACKGROUND

- MA LETTER OF 7/7/70
- APO REVIEW OF JULY
- MA LETTER OF 8/13/70
- MSFC LETTER OF 8/19/70

Figure 1

SUMMARY OF MSFC LETTER OF 8/19

- BOEING/HUNTSVILLE AND BOEING/MSC WILL EXCHANGE LRV RELATED WEIGHT DATA MONTHLY
- MSC REPORT LM PERFORMANCE ON FIRST OF MONTH
- MSFC REPORT LRV PERFORMANCE ON FIRST OF MONTH
- THREE PAGE REPORTING FORMAT

Figure -2

SATURN PROGRAM

LUNAR ROVER PROJECT

• LRV OPERATIONAL WEIGHTS •

SPEAKER:

DATE:

	J-1	J-2	J-3	J-4
BASIC LRV	473.76			
PAYLOAD SUPPORT ITEMS	15.00			
STOWED LRV IN QUAD I	488.76			
LESS DEPLOYMENT HARDWARE	40.10			
DEPLOYED LRV	448.66	448.66	448.66	448.66
CREW SYSTEMS	798.40	798.40	798.40	798.40
CARGO	213.00	268.00	253.50	308.50
OPERATIONAL LRV	1460.06	1515.06	1500.56	1555.56

REF: (1) TBC REPORT 5-9616-H-050 DATED 8-14-70
(2) MSC REPORT DATED 8-15-70

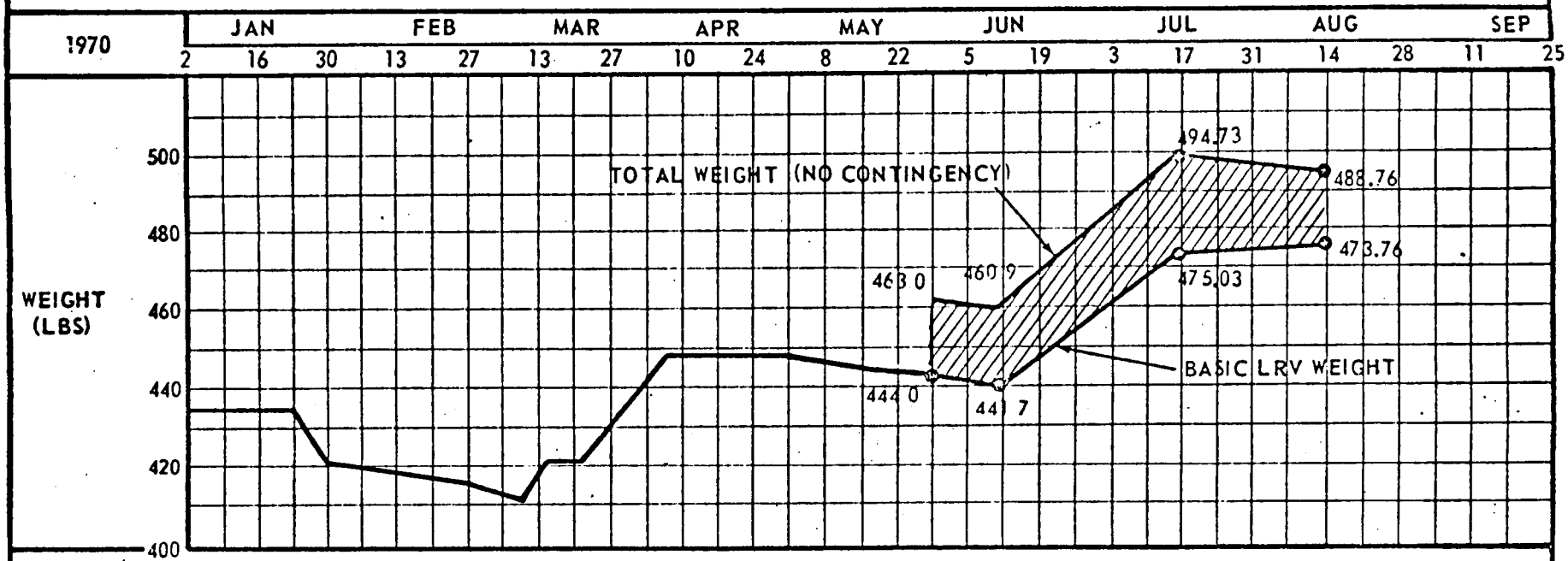
Figure -3

MSFC WEIGHT TABLE

- CONTAINS MSC/GAC WEIGHTS
  - LM
  - CARGO STOWED ON LRV BEFORE LAUNCH
- VEHICLE WEIGHT NOT SHOWN
- VEHICLE PAYLOAD WEIGHT NOT SHOWN
- MSC/MSFC WEIGHT INTERFACES NOT WELL DEFINED
- NOT AMENABLE TO EFFECTIVE CONTROL WEIGHT DEFINITION
- CONTAINS PENDING CHANGES FOR MSC CARGO

Figure -4

LUNAR ROVING VEHICLE
WEIGHT STATUS



LEVEL V SUBSYSTEM	CURRENT WEIGHT				Δ LBS FROM LAST RPT
	WEIGHT*	PERCENTAGE			
		EST	CALC	ACT	
1. CHASSIS	74.89	7.0	93		-3 58
2. SUSPENSION	19.64		100		-0-
3. STEERING	9.68		100		+0 28
4 TRACTION DRIVE	42 40		100		-0-
5. WHEELS	46.96	1.2	98.8		-0-
6 DRIVE CONTROLS	18 68	21.4	78.6		-0 30
7 CREW STATION	25.84	14.5	85.5		-0.30
8 BATTERIES	116 0	5.0	95.0		-0-
9. POWER SYSTEM	36.20	40.9	59.1		-1.63
10. NAVIGATION	18.44	1.6	98.4		+1.60
11 SPACE SUPPORT EQUIP	45.87**	27.3	72.7		+4 10
12. THERMAL PROTECTION	19 16	79.0	21.0		-1 44
BASIC LRV (TOTAL)	473.76	14.4	85.6		-1.27
PAYLOAD SUPPORT	15.00				-4.00

*ALL PAYLOAD SUPPORT WEIGHTS REMOVED FROM SUBSYSTEMS

**INCLUDES 4.7 POUNDS GRUMMAN SUPPLIED HARDWARE

Figure -5

MSFC WEIGHT HISTORY

- CONTAINS MSC WEIGHTS
- VEHICLE WEIGHT NOT SHOWN

Figure -6

SATURN PROGRAM

LUNAR ROVER PROJECT

• EFFECT OF WEIGHT ON RANGE •

SPEAKER:

DATE:

8712 WATT-HOUR BATTERIES
90% DEPTH OF DISCHARGE
LUNAR SOIL SIMULANT
REFERENCE MISSION
MID RANGE P.S.D.
TEST DATA INCORPORATED

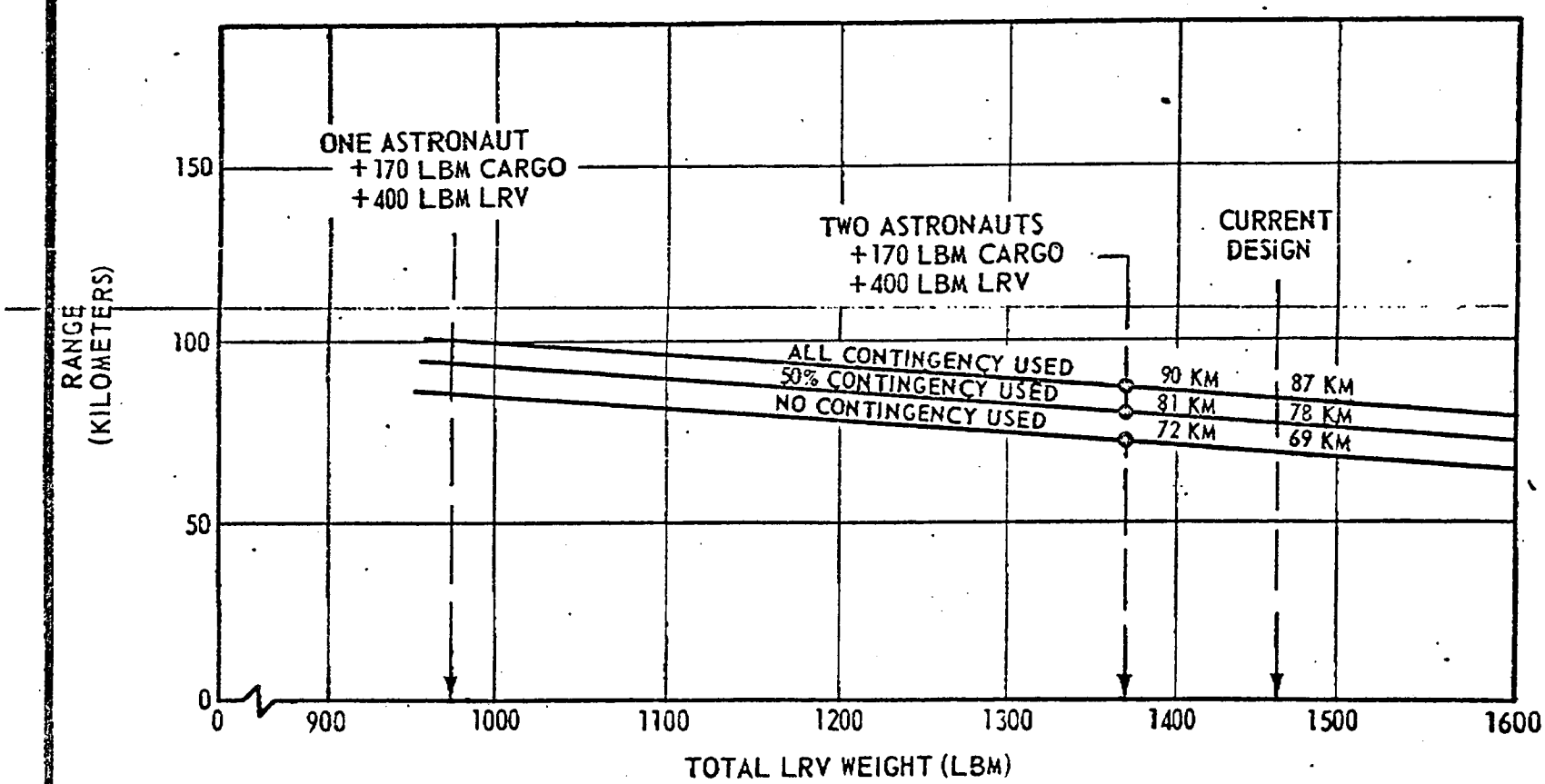


Figure-7

MSFC PERFORMANCE

- NOT AMENABLE TO MSC/MSFC INTERFACE VISIBILITY
- NOT AMENABLE TO CONTROL WEIGHT DISPLAY

Figure-8

LRV WEIGHT STATUS MATRIX*

				LRV FOLDED IN LM QUAD I			LRV ON SURFACE		
MSFC REPORT	DEPLOYMENT AND LM ATTACHMENT HARDWARE			35.4					
	VEHICLE	VEHICLE LESS PAYLOAD SUPPORT		448.66	433.66		[TBD] 448.66		
		PAYLOAD SUPPORT			15.0				
MSC REPORT	VEHICLE PAYLOAD	CARGO	EQUIP. (SCI., PHOTO., SUPP.)			X	1011.4 + X	213.0 + X	153.0 + X
			SAMPLES						60.0
		CREW SYSTEMS						798.4	
	TOTAL			484.06 + X		[TBD]	1460.1 + X		

[ ] CONTROL WEIGHTS (TBD)

*DERIVED FROM TBC 8-14-70 WEIGHT REPORT

Figure -9

LRV WEIGHT CHANGE 7-15-70 TO 8-19-70

8-19-70	1.	STOWED LRV IN QUAD I LESS 4.7 LB GAC LM HARDWARE	484.1
7-15-70	2.	LRV FOLDED IN LM QUAD I	457.8
			+26.3

1. MSFC LETTER PM-SAT-LRV-223-70 (E) DATED 8-19-70 FROM R. G. SMITH TO R. A. PETRONE.

2. APOLLO SPACECRAFT WEIGHT STATUS SUMMARY DATED 7-15-70.

Figure -10

LUNAR ROVING VEHICLE WEIGHT STATUS

JULY 15, 1970

DOCUMENT NO. LRV-TS-2-163 (6-12-70)

BATTERY ENERGY: 8,712 WATT-HRS

	APOLLO 16	APOLLO 17	APOLLO 18	APOLLO 19
LRV FOLDED IN LM QUAD I (INCLUDES 15.0 LB PAYLOAD ATTACH HDWR)	457.8	457.8	457.8	457.8
SPACE SUPPORT EQUIPMENT (SSE)	22.7	22.7	22.7	22.7
SSE THERMAL PROTECTION	0.6	0.6	0.6	0.6
LRV CHASSIS	2.3	2.3	2.3	2.3
LRV DEPLOYED ON LUNAR SURFACE	432.2	432.2	432.2	432.2

LRV PAYLOAD

LM S.L. ITEM NO.	CREW SYSTEMS	(798.4)	(798.4)	(798.4)	(798.4)
	CREW	340.0	340.0	340.0	340.0
B1024 & B1025	PLSS (CHARGED)	203.0	203.0	203.0	203.0
B1001	RCU-PLSS	11.2	11.2	11.2	11.2
B1012	OXYGEN PURGE SYSTEM (OPS)	69.6	69.6	69.6	69.6
B1014	LUNAR EVA VISOR ASSY. (LEVA)	9.8	9.8	9.8	9.8
B1015	EVA GLOVES	4.4	4.4	4.4	4.4
B1018	LUNAR OVERSHOES	9.0	9.0	9.0	9.0
B1030	LIQUID COOLING GARMENT (LCG)	13.8	13.8	13.8	13.8
B1048	INSUIT DRINKING DEVICE + WATER (2.1#)	2.5	2.5	2.5	2.5
B1052	BUDDY UMBILICAL (CHARGED) (7.2 UMB., 1.1 #H_2O)	8.3	8.3	8.3	8.3
B1053	BAG, BUDDY UMBILICAL	2.6	2.6	2.6	2.6
B0200	PRESSURE GARMENT ASSY. (PGA)	118.0	118.0	118.0	118.0
B0203	BIOINSTRUMENTATION	2.2	2.2	2.2	2.2
B0205	UCTA	1.0	1.0	1.0	1.0
B0207	BIOBELT ASSY.	0.4	0.4	0.4	0.4
D0200	PERSONAL DOSIMETER	0.8	0.8	0.8	0.8
B1020. 6 & .7	WAIST TETHER	1.0	1.0	1.0	1.0
AD202	CHRONOGRAPH	0.2	0.2	0.2	0.2
B0113	FECAL CONTAINMENT SUBSYSTEM	0.6	0.6	0.6	0.6

Figure -11

• LRV OPERATIONAL WEIGHTS •

	J-1	J-2	J-3	J-4
BASIC LRV	473.76			
PAYLOAD SUPPORT ITEMS	15.00			
STOWED LRV IN QUAD I	488.76			
LESS DEPLOYMENT HARDWARE	40.10			
DEPLOYED LRV	448.66	448.66	448.66	448.66
CREW SYSTEMS	798.40	798.40	798.40	798.40
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REF: (1) TBC REPORT 5-9616-H-050 DATED 8-14-70
(2) MSC REPORT DATED 8-15-70

Figure -12

LRV WEIGHT CHANGES

SUBSYSTEM	6/12/70	8-14-70	Δ	Reason for Change
CHASSIS	72.5	77.9	5.4	Inc. Struct. Wt. & LCRU Mounts
SUSPENSION	19.6	19.6	-	-
STEERING	9.4	9.7	.3	Redesigned Steering Arm
TRACT. DRIVE	42.4	42.4	-	-
WHEELS	46.1	47.0	.9	Thicker tread strip required
DRIVE CONTROL	19.0	18.7	-.3	Reduced brake cable weight
CREW STATIONS	21.7	25.8	4.1	Increased fender overlap and handhold
BATTERIES	118.0	116.0	-2.0	Reduced weight based on prototype hard.
POWER SYSTEM	33.3	37.2	3.9	Inc.cable guage, add.auxiliary outlet
NAVIGATION	16.8	18.4	1.6	Inc.weight based on prototype hardware
SPACE SUPPORT EQUIPMENT	26.8	45.9	19.1	Modified Deployment Mechanism
THERMAL PROT.	16.3	19.2	2.9	Revised estimate of center chassis
MSFC ITEMS	19.0	11.0	-8.0	Removed battery monitoring & LCRU Mts.
	460.9	488.8		
GAC HARDWARE	3.1	4.7		
	457.8	484.1	+26.3	

Figure -13

MSFC LRV REFERENCE MISSION

- FOUR EVA TRAVERSES --- 120 KM TOTAL
  - EVA #1 MARIUS HILLS TRAVERSE
  - EVA #2 USGS TRAVERSE NO. 1
  - EVA #3 BELLCOMM COPERNICUS PLUS USGS TRAVERSE NO. 2
  - EVA #4 BELLCOMM HADLEY-APENNINE

- LURAIN ROUGHNESS DATA

SMOOTH MARE	MID-RANGE PSD	27%
ROUGH MARE	MID-RANGE PSD	28%
HUMMOCKY UPLAND	MID-RANGE PSD	26%
ROUGH UPLAND	MID-RANGE PSD	19%

- LURAIN SLOPE AVERAGE DISTRIBUTION SIMILAR TO SMOOTH MARE

Figure-14

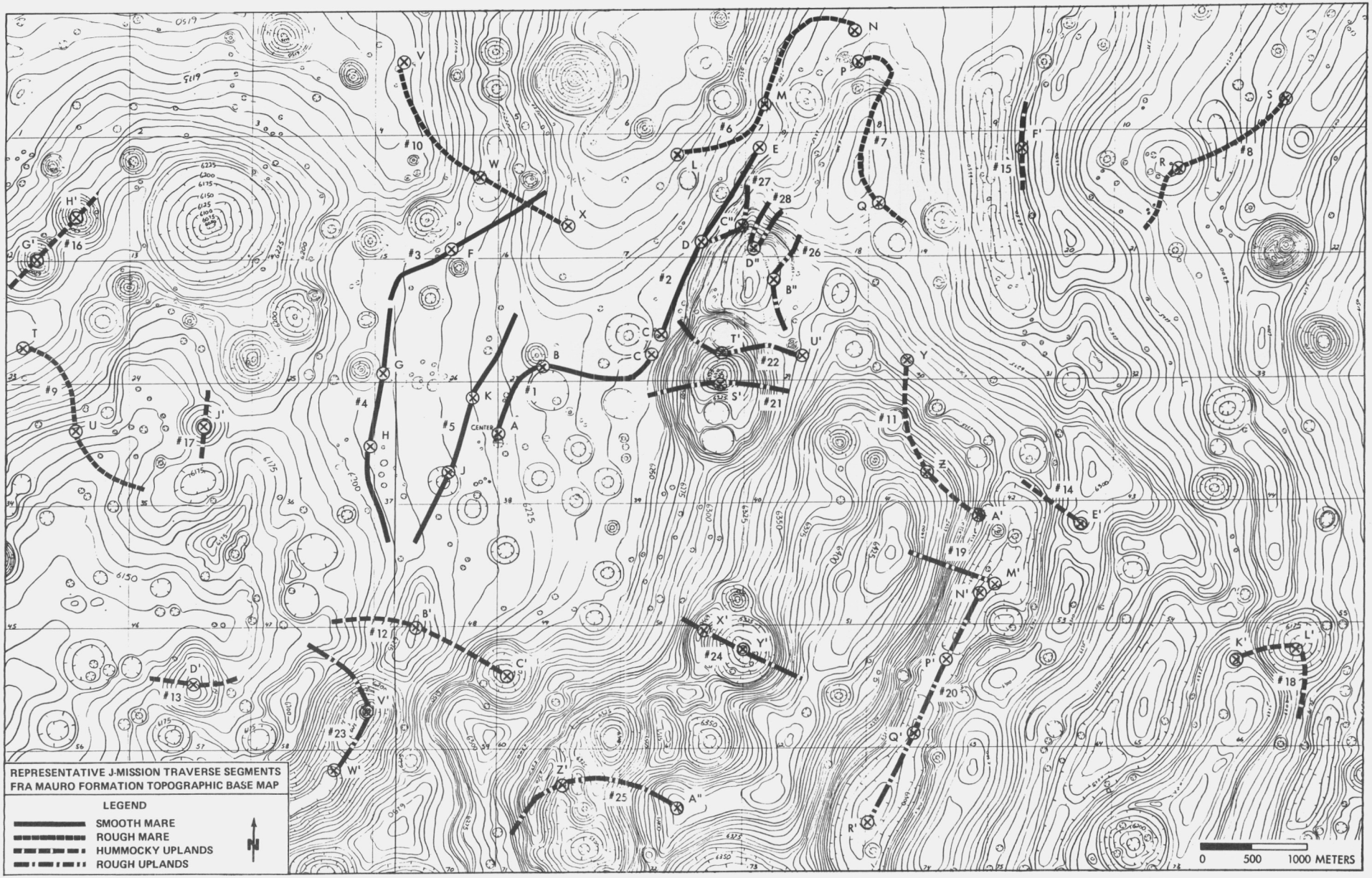


FIGURE 2

Figure 15

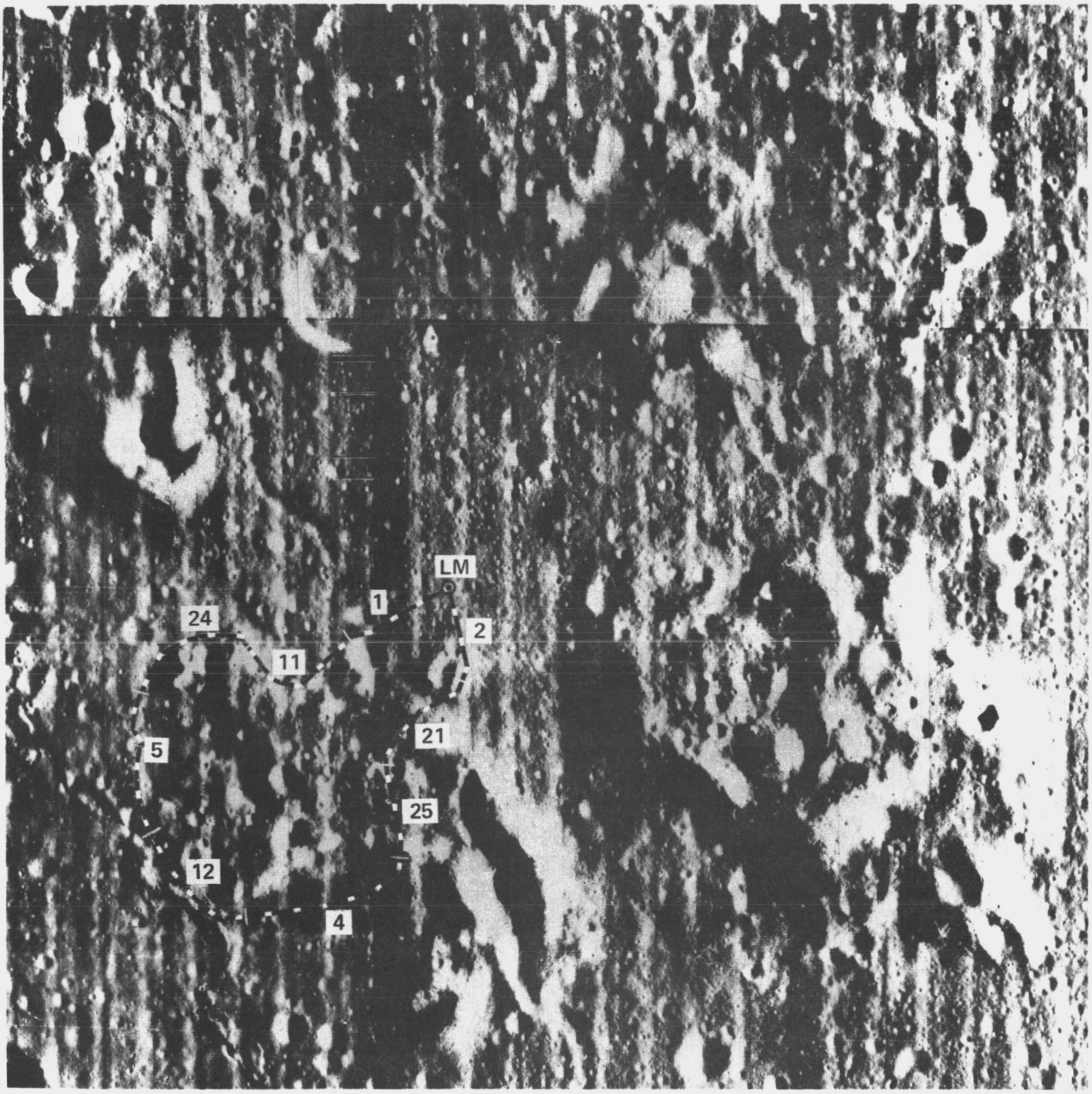


FIGURE 4 - MARIUS HILLS LRV TEST TRAVERSE

MSFC LRV REFERENCE MISSION CHARACTERISTICS

TRAVERSE	RANGE (KILOMETERS)	NUMBER OF STARTUPS	AVERAGE SPEED (KM/HR)	DRIVING TIME (HOURS)	SCIENCE TIME (HOURS)	TOTAL TIME (HOURS)
EVA # 1	19.3	18	7.84	2.46	2.62	5.1
EVA # 2	31.1	21	7.63	4.08	2.75	6.9
EVA # 3	44.2	15	8.27	5.35	3.62	9.0
EVA # 4	25.1	18	8.51	2.95	3.00	6.0
TOTAL	119.7	72	8.06	14.84	11.99	27.0

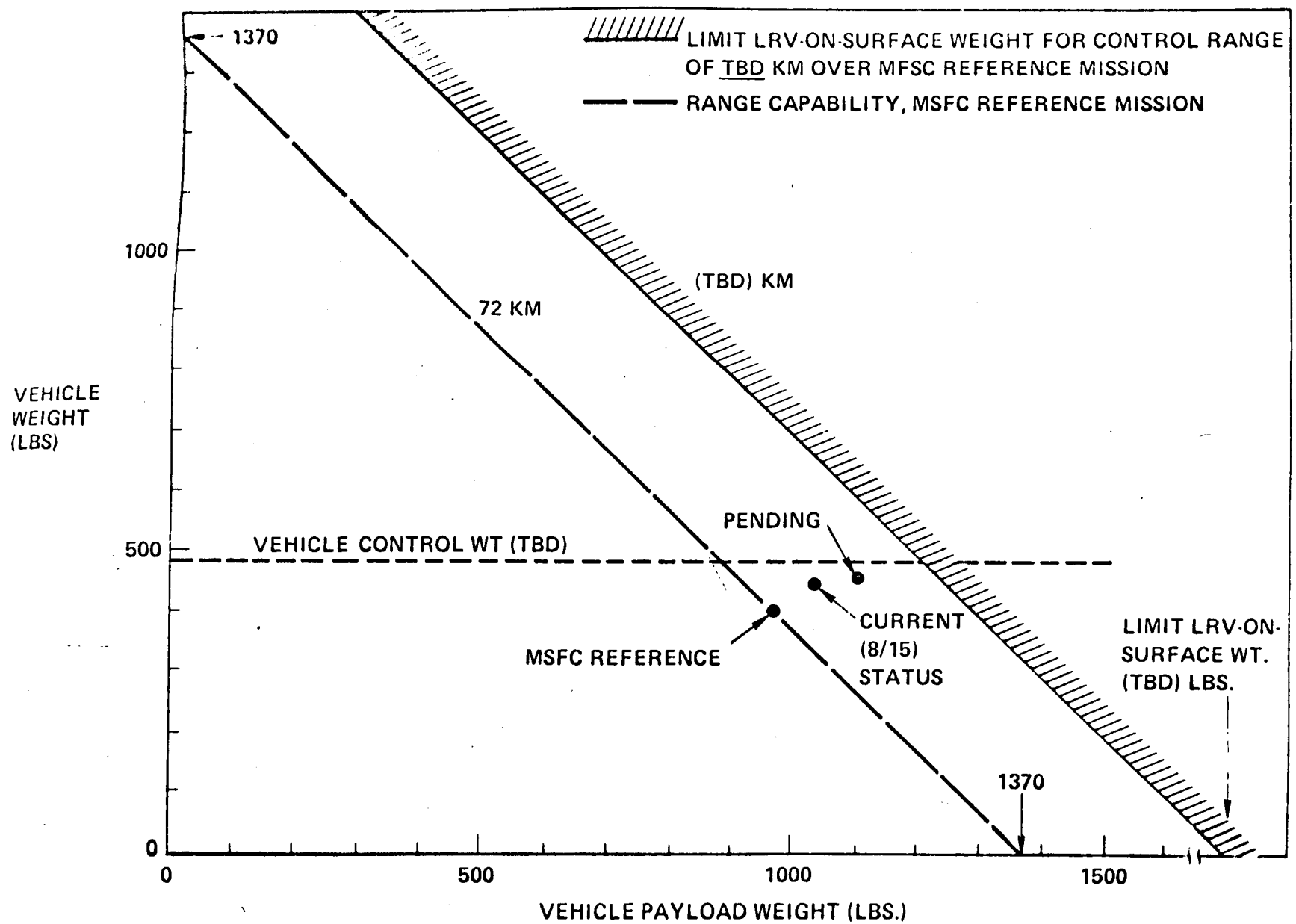
PRORATED TO LRV BATTERY SIZE

$\times \frac{6{,}241\ WH}{10{,}438\ WH}$*	72	43	SAME	8.85	7.15	16.0

*$\frac{\text{LRV BATTERIES (8,712 WH) LESS 10\% AND 1600 WH CONTINGENCY}}{\text{REFERENCE MISSION ENERGY (13,375) LESS 10\% AND 1600 WH CONTINGENCY}}$

Figure-17

LRV PERFORMANCE STATUS



~~Figure~~-18

SUMMARY

LRV WEIGHT AND PERFORMANCE REPORTING

RESPONSIBILITIES

MSFC:

- LRV WEIGHTS
- LRV-ON-SURFACE PERFORMANCE
  - MSFC REFERENCE MISSION
  - MSC NOMINAL MISSIONS

MSC:

- LRV PAYLOAD WEIGHTS
- DEFINITION OF NOMINAL SURFACE MISSIONS

MSFC/MSC:

- COORDINATED REPORTS

ACTION

- MSFC AND MSC REVIEW DRAFT MA LETTER CONTAINING
  - PROPOSED WEIGHT REPORTING MATRIX
  - PROPOSED PERFORMANCE REPORTING FORMAT
  - MID MONTH DUE DATE

Figure-19

BELLCOMM, INC.

Subject: LRV Weight and Performance Reporting - Case 320

From: R. D. Raymond
P. F. Sennewald
J. C. Slaybaugh

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