

SECTION III - CONSUMABLES ANALYSIS



NOTE

Acknowledgement is made to the Consumables Analysis Section (CAS) of the Mission Planning and Analysis Division (MPAD) for their work in the preparation of the RCS and cryogenics consumable analysis presented herein.

AS503/103 PROPELLANT BUDGET

The results of the SM, CM, and SPS propellant budget analysis are summarized in the following tables and figures:

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Ground Rules and Assumption

The ground rules and assumptions listed below were used in the construction of the SM-RCS budget.

1. Data Source: Data for SM-RCS engine performance and propellant requirements were obtained from Part 4, Volume I of the CSM/LM Spacecraft Operational Data Book; May 1968.
2. Maneuvers: Since it is impossible to predict in all cases what maneuvers rates or angles will be required, it was assumed that all maneuvers were 3 axis at rates from 0.2 deg/sec to 0.5 deg/sec (unless otherwise noted). Angles were varied as a function of the maneuver requirements. It was also assumed that all IMU alignments

required 3 axis orientations with allowances for minimum impulse control, which may seem conservative, but would allow for unscheduled attitude maneuvers. An increase in passive thermal control (PTC) requirements was made to allow for active control of the non spin axis. Predicted costs are 1.3 lbs/hr translunar and 1.4 lbs/hrs transearth with a total increase of 100 lbs to the budget. Navigation sightings, like the IMU alignments, were predicted at the same cost for all cases. Realizing that some navigation sightings will be easier to accomplish than others, a nominal cost of approximately 1.2 lbs to 1.4 lbs per set was predicted. Lunar orbit maneuvers were budgeted to the lunar orbit attitude timeline. Midcourse translations were budgeted as SM-RCS corrections of 3 fps and 7 fps translunar and 10 fps, 5 fps, and 2 fps transearth. The 7 fps correction could possibly be replaced by a SPS burn since it is 2 fps above the minimum SPS burn time for translunar corrections.

3. Flow Rates: A propellant flow rate of 0.361 lbs/sec/engine was assumed for steady state operation. A minimum impulse burn has been predicted at a maximum 0.005 lbs per pulse.

TABLE 3-I

SM-RCS PROPELLANT LOADING

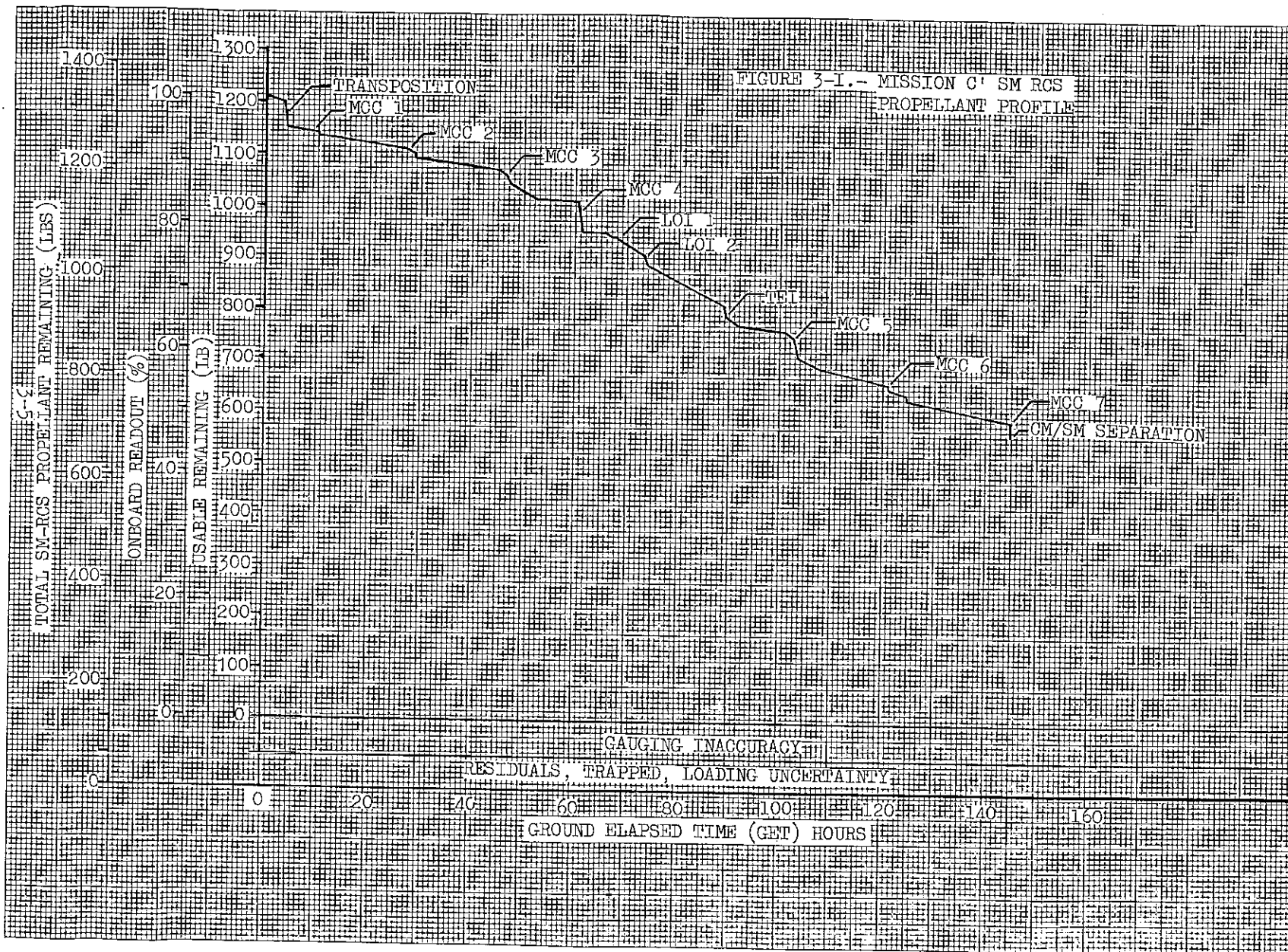
	<u>SM-RCS-LBS</u>
Nominal Loaded	1347.6
Unusable (trapped)	<u>26.8</u>
Total Deliverable	1320.8
Loading Uncertainty (temperature)	<u>36.8</u>
	1284.0
Gauging Inaccuracy	<u>72.0</u>
	1212.0
*Mixture Ratio Uncertainty	<u>82.0</u>
	1130.0
Total Used	<u>655.8</u>
Operational Margin	474.2

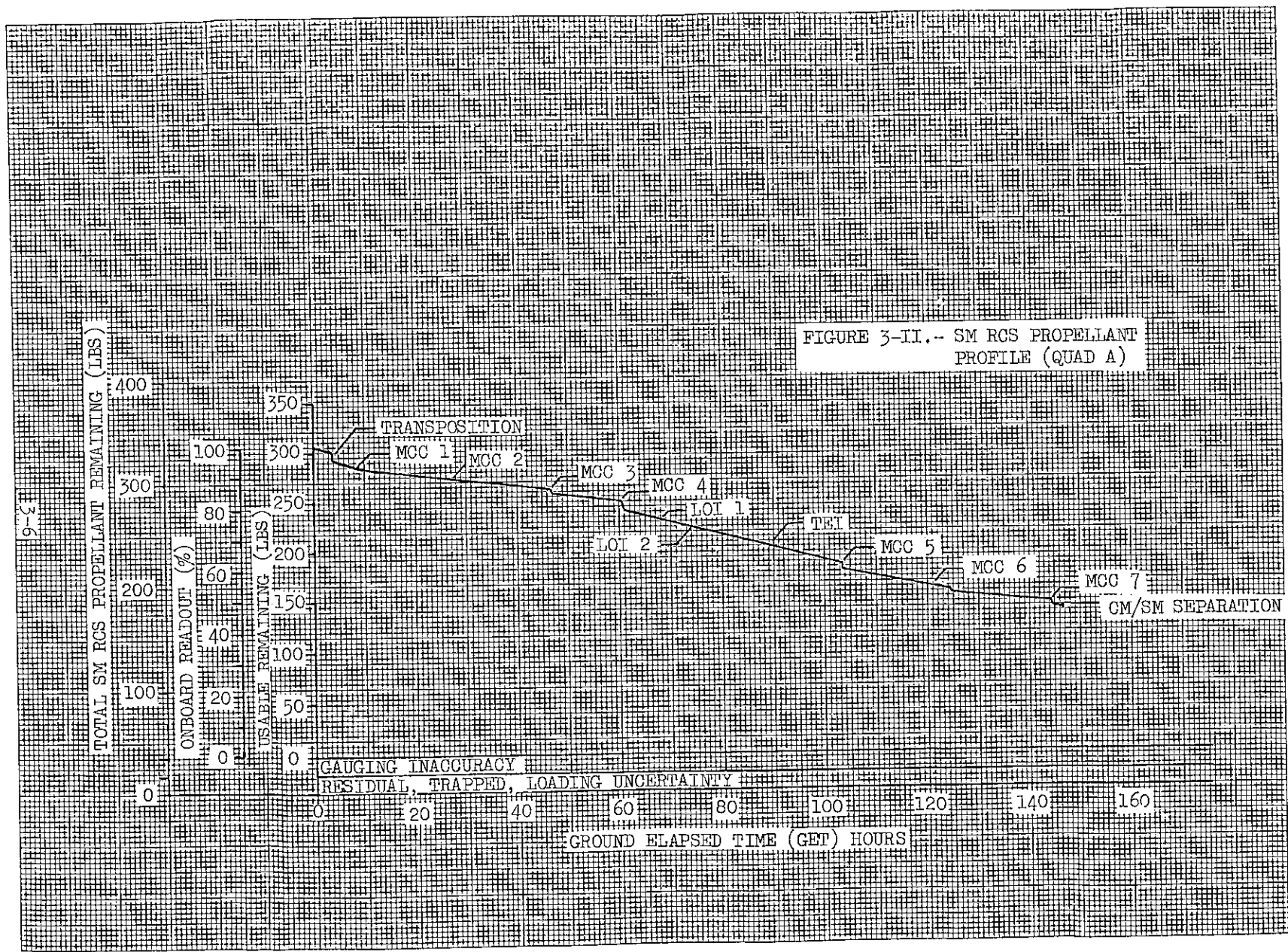
*This quantity is based on the flight plan and results from the use of approximately 460 lbs of RCS for attitude orientation and control. This is considered unusable for mission planning and represents a dispersion to the nominal profile.

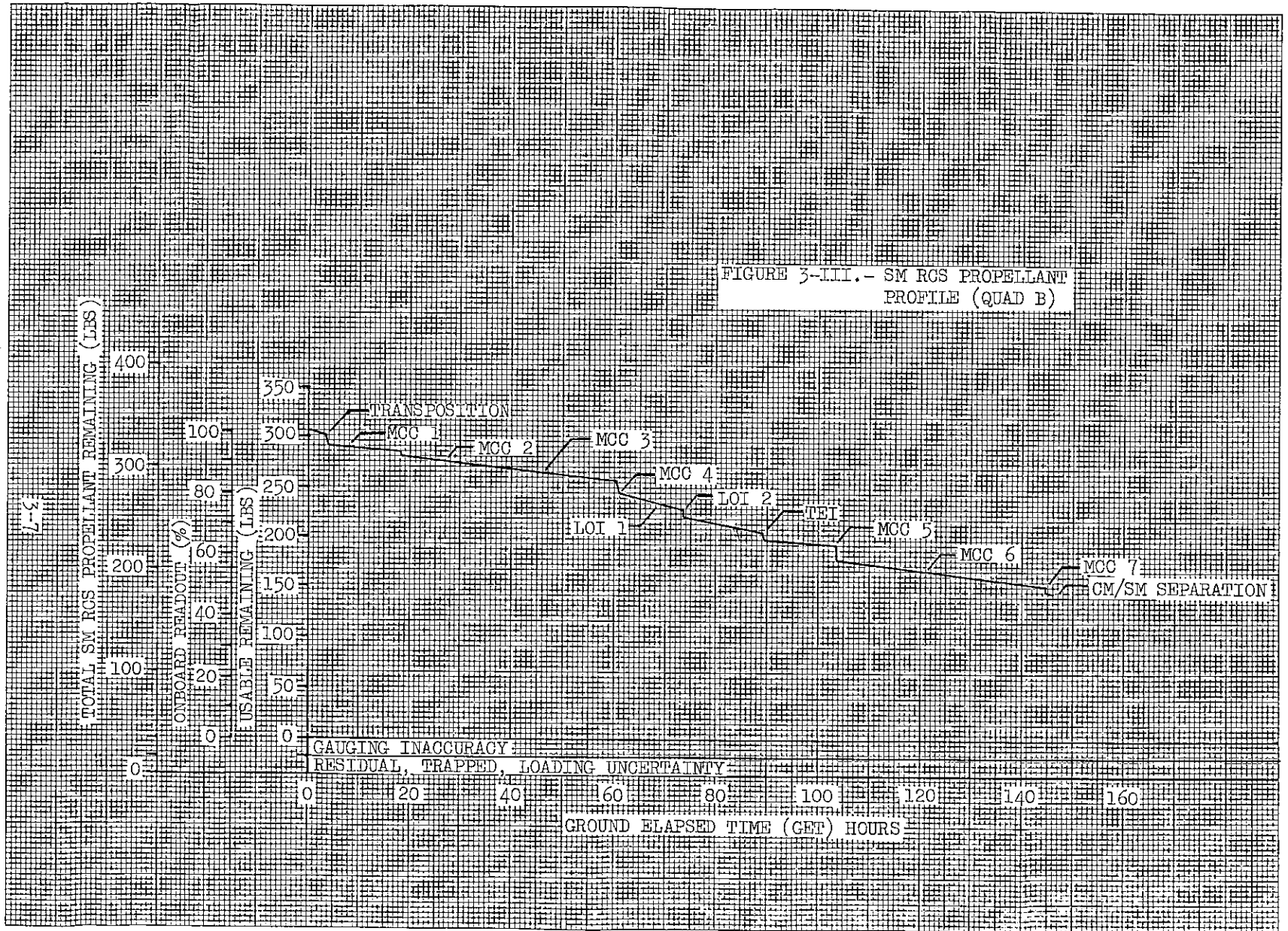
TABLE 3-II

SM RCS USAGE SUMMARY

Day (GET, HRS)	<u>PROPELLANT USED, LBS</u>		<u>PROPELLANT REMAINING, LBS</u>	
	PER DAY	ACCUMULATIVE	TOTAL	USABLE
			1347.6	1130.0
PRELAUNCH	5.8	5.8	1341.8	1124.2
1 (00:00 - 24:00)	99.6	105.4	1242.2	1024.6
2 (24:00 - 48:00)	79.9	185.3	1162.3	944.7
3 (48:00 - 72:00)	110.3	295.6	1052.0	834.4
4 (72:00 - 96:00)	147.0	442.6	905.0	687.4
5 (96:00 - 120:00)	109.1	551.7	795.9	578.3
6 (120:00 - 144:00)	89.3	641.0	706.6	489.0
7 (144:00 - 147:00)	14.8	655.8	691.8	474.2

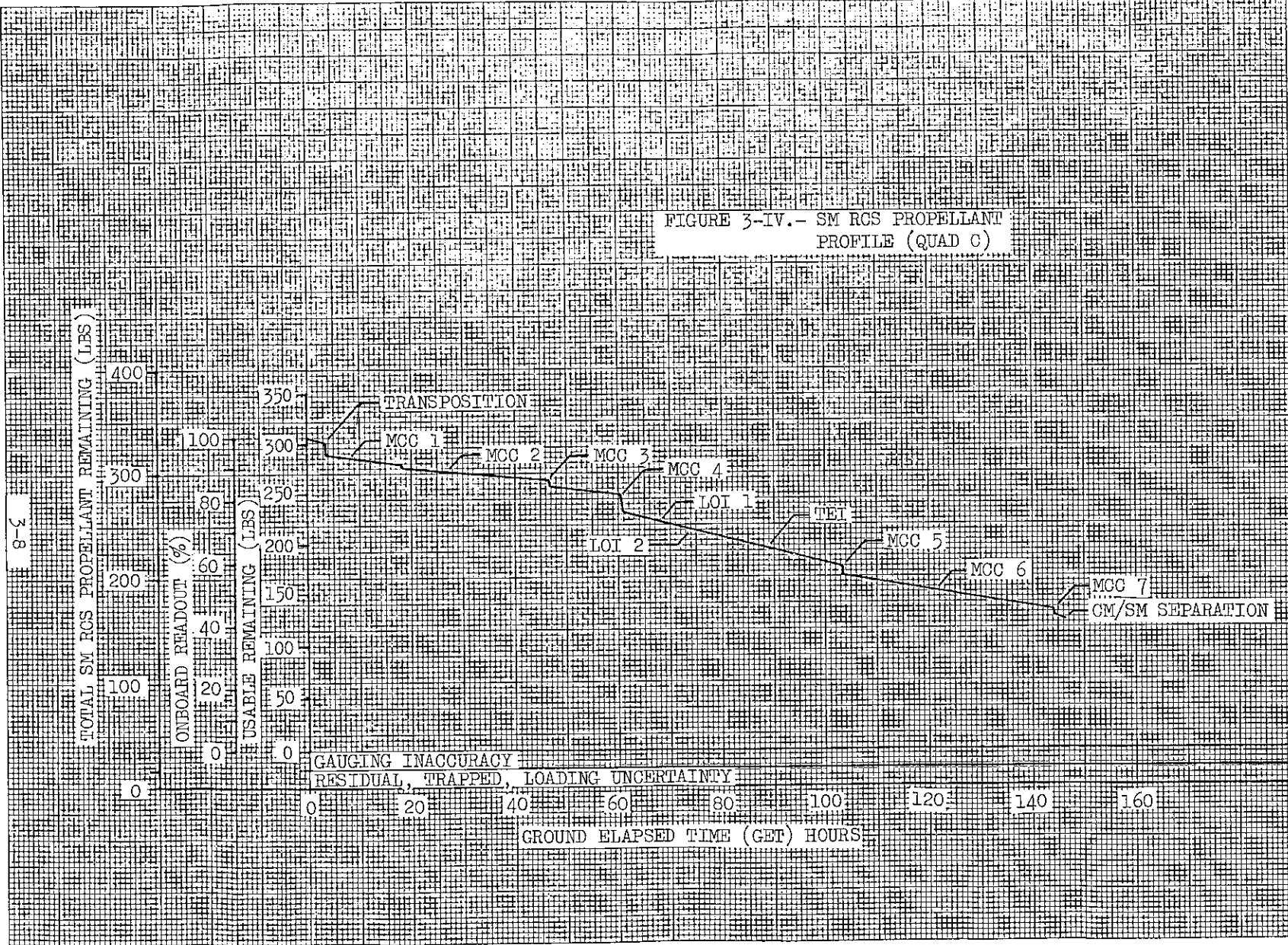






3-8

FIGURE 3-IV.- SM RCS PROPELLANT PROFILE (QUAD C)



3-9

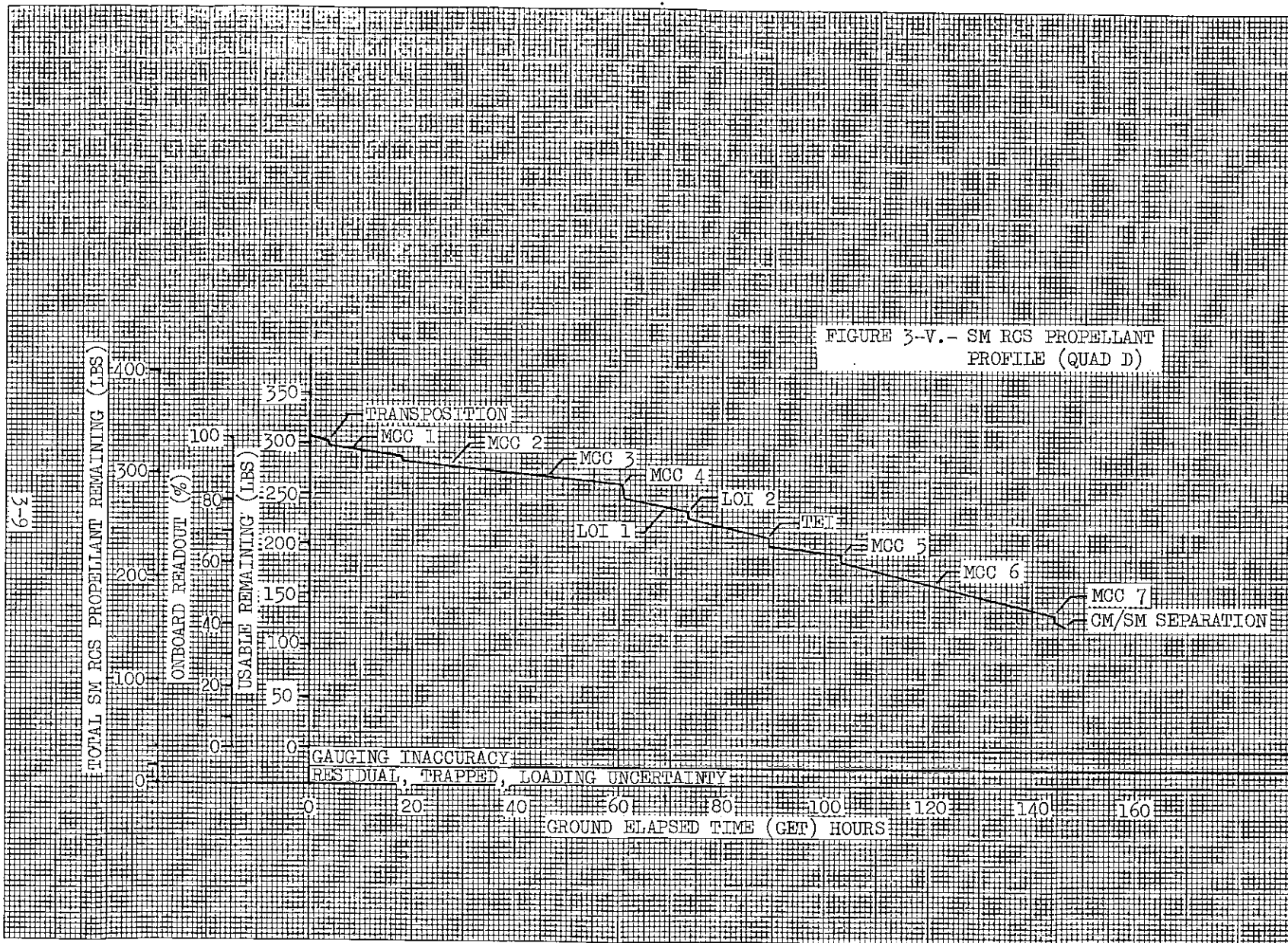


TABLE 3-III

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
.0	APOLLO 8 CSM 103	63878.	.0	1347.6	100.
.0	SM-RCS CHECKOUT FIRE EACH JET ONE SEC.	63872.	5.8	1341.8	100.
3.5	TRANSPOSITION +X TRANS 1 FPS PGNC	63865.	7.5	1334.3	99.
3.5	-X 0.5 FPS	63860.	4.8	1329.5	99.
3.5	PITCH 4 DEG/SEC	63853.	6.9	1322.7	98.
3.5	FORMATION FLYING	63833.	20.0	1302.7	97.
3.8	MANEUVER TO LOCAL VERTICAL	63830.	3.2	1299.5	96.
3.8	ATTITUDE HOLD .5 DEG DB	63830.	.3	1299.2	96.
3.9	SEPARATE FROM S-IVB -X 1.5FPS	63816.	13.7	1285.4	95.
4.0	P52 IMU ALIGN	63815.	1.1	1284.4	95.
4.3	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63814.	.8	1283.5	95.
4.3	MIN. IMPULSE MARKING	63814.	.4	1283.1	95.
4.3	NAV SIGHTING SET 2	63813.	.8	1282.3	95.
4.3	MINIMUM IMPULSE MARKING	63812.	.4	1281.9	95.
4.3	NAV SIGHTING SET 3	63812.	.8	1281.0	95.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM_RCS USED (LBS)	SM_RCS LEFT (LBS)	SM_RCS LEFT (%)
4.3	MINIMUM IMPULSE MARKING	63811.	.4	1280.4	95.
4.3	NAV SIGHTING SET 4	63810.	.9	1279.7	95.
4.3	MINIMUM IMPULSE MARKING	63810.	.4	1279.3	95.
8.0	PS2 IMU ALIGN	63809.	1.1	1278.2	95.
8.5	MIDCOURSE CORRECTION 3 AXIS ORIENT PCNCS	63808.	1.1	1277.1	95.
8.5	ATT HOLD 0.5 DEG DB	63807.	.6	1276.5	95.
9.0	DELTA VEL = NOMINALLY ZERO	63807.	.0	1276.5	95.
9.1	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63806.	.6	1275.7	95.
9.1	MIN. IMPULSE MARKING	63806.	.4	1275.3	95.
9.1	NAV SIGHTING SET 2	63805.	.8	1274.5	95.
9.1	MINIMUM IMPULSE MARKING	63805.	.4	1274.0	95.
9.1	NAV SIGHTING SET 3	63804.	.8	1273.2	94.
9.1	MINIMUM IMPULSE MARKING	63803.	.4	1272.8	94.
9.8	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	63803.	.8	1272.0	94.
9.8	ATTITUDE HOLD 0.5 DEG DB PGNCS	63802.	.8	1271.2	94.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (8)
9.8	EST. 0.3 DEG/SEC ROLL	63802.	.3	1270.9	94.
9.8	PITCH AND YAW CONTROL	63792.	9.1	1261.8	94.
16.6	PS2 IMU ALIGN	63791.	1.1	1260.8	94.
17.0	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63791.	.8	1259.9	93.
17.0	MIN. IMPULSE MARKING	63790.	.4	1259.5	93.
17.0	NAV SIGHTING SET 2	63789.	.8	1258.4	93.
17.0	MINIMUM IMPULSE MARKING	63789.	.4	1258.2	93.
17.0	NAV SIGHTING SET 3	63788.	.8	1257.4	93.
17.0	MINIMUM IMPULSE MARKING	63788.	.4	1257.0	93.
17.0	NAV SIGHTING SET 4	63787.	.8	1256.1	93.
17.0	MINIMUM IMPULSE MARKING	63786.	.4	1255.7	93.
17.0	NAV SIGHTING SET 5	63785.	.8	1254.9	93.
17.0	MINIMUM IMPULSE MARKING	63785.	.4	1254.5	93.
18.0	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	63784.	.8	1253.7	93.
18.0	ATT HOLD .5 DEG DB PGNC	63783.	.8	1252.9	93.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
18.0	EST. 0.3 DEG/SEC ROLL	63783.	.2	1252.6	93.
18.0	PITCH AND YAW CONTROL	63773.	10.4	1242.2	92.
26.0	PS2 IMU ALIGN	63772.	1.0	1241.2	92.
26.5	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63771.	.8	1240.4	92.
26.5	MIN IMPULSE MARKING	63771.	.4	1240.0	92.
26.5	NAV SIGHTING SET 2	63770.	.9	1239.1	92.
26.5	MINIMUM IMPULSE MARKING	63769.	.4	1238.7	92.
26.5	NAV SIGHTING SET 3	63768.	.8	1237.8	92.
26.5	MINIMUM IMPULSE MARKING	63768.	.4	1237.4	92.
27.5	MIDCOURSE CORRECTION - MANEUVER TO BURN ATT	63767.	1.1	1236.3	92.
27.5	ATT HOLD .5 DEG DB PGNC.	63767.	.3	1236.1	92.
28.0	DELTA VEL = NOMINALLY ZERO	63767.	.0	1236.1	92.
28.1	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63766.	.8	1235.3	92.
28.1	MIN. IMPULSE MARKING	63765.	.4	1234.8	92.
28.1	NAV SIGHTING SET 2	63765.	.8	1234.0	92.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
28.1	MINIMUM IMPULSE MARKING	63764.	.4	1233.6	92.
28.1	NAV SIGHTING SET 3	63763.	.9	1232.7	91.
28.1	MINIMUM IMPULSE MARKING	63763.	.4	1232.3	91.
28.1	NAV SIGHTING SET 4	63762.	.8	1231.5	91.
28.1	MINIMUM IMPULSE MARKING	63762.	.4	1231.0	91.
28.9	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	63761.	.8	1230.3	91.
28.9	ATTITUDE HOLD 0.5 DEG DB PG _{NCS}	63760.	.8	1229.5	91.
28.9	EST. 0.3 DEG/SEC ROLL	63760.	.3	1229.2	91.
28.9	PITCH AND YAW CONTROL	63753.	6.5	1222.7	91.
33.8	P52 IMU ALIGN	63752.	1.1	1221.7	91.
34.3	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	63751.	.8	1220.8	91.
34.3	MIN. IMPULSE MARKING	63751.	.4	1220.4	91.
34.3	NAV SIGHTING SET 2	63750.	.8	1219.6	91.
34.3	MINIMUM IMPULSE MARKING	63750.	.4	1219.2	90.
34.3	NAV SIGHTING SET 3	63749.	.8	1218.3	90.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
34.3	MINIMUM IMPULSE MARKING	63749.	.4	1217.9	90.
34.9	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	63748.	.8	1217.1	90.
34.9	ATTITUDE HOLD 0.5 DEG DB BGNCS	63747.	.8	1216.4	90.
34.9	EST. 0.3 DEG/SEC ROLL	63747.	.2	1216.1	90.
34.9	PITCH AND YAW CONTROL	63736.	11.0	1205.1	89.
44.5	P52 IMU ALIGN	63735.	1.1	1204.0	89.
45.1	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	63734.	.9	1203.1	89.
45.1	MIN. IMPULSE MARKING	63733.	.4	1202.7	89.
45.1	NAV SIGHTING SET 2	63732.	.8	1201.8	89.
45.1	MINIMUM IMPULSE MARKING	63732.	.4	1201.4	89.
45.1	NAV SIGHTING SET 3	63731.	.9	1200.4	89.
45.1	MINIMUM IMPULSE MARKING	63731.	.4	1200.1	89.
45.1	NAV SIGHTING SET 4	63730.	.8	1199.3	89.
45.1	MINIMUM IMPULSE MARKING	63730.	.4	1198.9	89.
45.1	NAV SIGHTING SET 5	63729.	.8	1198.1	89.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
45.1	MINIMUM IMPULSE MARKING	63728.	.4	1197.7	89.
46.4	P52 IMU ALIGN	63727.	1.1	1196.6	89.
46.6	MIDCOURSE CORRECTION 3 AXIS ORIENT PGNC	63726.	1.1	1195.5	89.
46.6	ATT HOLD 0.5 DEG DB PGNC	63726.	.4	1195.1	89.
47.0	RCS +X TRANS PGNC 3 FPS	63704.	22.1	1173.0	87.
47.2	CISLUNAR NAVIGATION STAR EARTH HORIZON ORIENT	63703.	.8	1172.2	87.
47.2	MINIMUM IMPULSE MARKING	63702.	.4	1171.8	87.
47.2	NAV SIGHTING SET 2	63702.	.8	1171.0	87.
47.2	MINIMUM IMPULSE MARKING	63701.	.4	1170.6	87.
47.2	NAV SIGHTING SET 3	63700.	.8	1169.8	87.
47.2	MINIMUM IMPULSE MARKING	63700.	.4	1169.3	87.
47.8	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	63699.	.8	1168.5	87.
47.8	ATTITUDE HOLD 0.5 DEG DB PGNC	63698.	.8	1167.8	87.
47.8	EST. 0.3 DEG/SEC ROLL	63698.	.3	1167.5	87.
47.8	PITCH AND YAW CONTROL	63693.	5.2	1162.3	86.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
51.5	P52 IMU ALIGN	63692.	.9	1161.4	86.
52.3	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	63691.	.8	1160.6	86.
52.3	MIN. IMPULSE MARKING	63691.	.4	1160.1	86.
52.3	NAV SIGHTING SET 2	63690.	.8	1159.3	86.
52.3	MINIMUM IMPULSE MARKING	63690.	.4	1158.9	86.
52.3	NAV SIGHTING SET 3	63689.	.8	1158.1	86.
52.3	MINIMUM IMPULSE MARKING	63688.	.4	1157.7	86.
52.3	NAV SIGHTING SET 4	63687.	.8	1156.9	86.
52.3	MINIMUM IMPULSE MARKING	63687.	.4	1156.4	86.
52.3	NAV SIGHTING SET 5	63686.	.8	1155.6	86.
52.3	MINIMUM IMPULSE MARKING	63686.	.4	1155.2	86.
53.3	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	63685.	.8	1154.4	86.
53.3	ATTITUDE HOLD 0.5 DEG DB PGNC	63684.	.8	1153.6	86.
53.3	EST. 0.3 DEG/SEC ROLL	63684.	.2	1153.4	86.
53.3	PITCH AND YAW CONTROL	63675.	8.8	1144.4	85.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
60.0	P52 IMU ALIGN	63674.	.9	1143.7	85.
60.5	MIDCOURSE CORRECTION 3 AXIS ORIENT PGNC5	63673.	.9	1142.7	85.
60.5	ATT HOLD 0.5 DEG DB PGNC5	63673.	.4	1142.4	85.
61.0	RCS →X TRANS PGNC5 7 FPS	63622.	51.2	1091.2	81.
61.2	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	63621.	.8	1090.4	81.
61.2	ATTITUDE HOLD 0.5 DEG DB PGNC5	63620.	.8	1089.6	81.
61.2	EST. 0.3 DEG/SEC ROLL	63620.	.3	1089.3	81.
61.2	PITCH AND YAW CONTROL	63612.	7.5	1081.8	80.
66.0	P52 IMU ALIGN	63612.	.9	1080.9	80.
66.5	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	63611.	.8	1080.2	80.
66.5	ATTITUDE HOLD 0.2 DEG DB	63610.	.8	1079.4	80.
66.5	EST. 0.3 DEG/SEC ROLL	63610.	.3	1079.1	80.
66.5	PITCH AND YAW CONTROL	63609.	.5	1078.6	80.
67.0	MANEUVER TO LOI ATT	63608.	.8	1077.8	80.
67.1	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	63608.	.8	1077.1	80.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
67.1	ATT HOLD .5 DEG DB PGNC5	63607.	.8	1076.3	80.
67.1	EST. 0.3 DEG/SEC ROLL	63607.	.2	1076.1	80.
67.1	PITCH AND YAW CONTROL	63605.	1.3	1074.8	80.
68.2	P52 IMU ALIGN	63604.	.9	1073.9	80.
✓68.4	LUNAR ORBIT INSERTION BURN 1 3-AXIS ORIENT PGNC5	63604.	.9	1073.0	80.
68.4	ATT HOLD .5 DEG DB PGNC5	63603.	.4	1072.6	80.
68.4	START TRANSIENT CONTROL NO ULLAGE	63602.	1.3	1071.3	79.
69.1	SPS BURN BUILDUP	63599.	.0	1071.3	79.
69.1	STEADY STATE BURN 245.8 SEC PGN CS	47037.	.3	1070.9	79.
69.1	TAILOFF	46996.	.0	1070.9	79.
69.1	DAMP SHUT DOWN TRANSIENT	46995.	1.1	1069.8	79.
69.1	ATTITUDE HOLD 5 DEG DB	46993.	2.1	1067.7	79.
69.5	ROLL 180 DEG	46992.	1.0	1066.7	79.
69.5	ATTITUDE HOLD 5 DEG DB	46990.	2.1	1064.6	79.
70.3	P52 IMU ALIGN	46989.	.8	1063.7	79.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
70.6	ORIENT TO TRACKING ATTITUDE PITCH 10 ORDEAL	46988.	1.1	1062.6	79.
70.6	EST ORBITAL RATE	46986.	1.5	1061.1	79.
71.1	MAINTAIN ORB RATE AND COAS GROUND TRACK	46986.	.7	1060.4	79.
71.3	COAS GROUND TRACK DETERMINATION	46985.	.7	1059.7	79.
71.5	YAW 45 DEG RT FOR TV ORDEAL	46982.	2.9	1056.8	78.
71.6	YAW 45 DEG LEFT	46979.	2.9	1053.9	78.
71.9	ORIENT FOR PSEUDO LANDING	46978.	1.1	1052.7	78.
72.0	MAINTAIN ORB RATE AND COAS GROUND TRACK	46977.	.7	1052.0	78.
72.4	PITCH .2 DEG/SEC TO BURN ATT	46977.	.3	1051.7	78.
72.5	ATTITUDE HOLD 5 DEG DB	46973.	4.3	1047.4	78.
72.6	PS2 IMU ALIGN	46972.	.8	1046.6	78.
73.0	ROLL LEFT 180 DEG 2DEG/SEC	46971.	1.0	1045.6	78.
73.0	ATTITUDE HOLD 0.2 DEG DB	46970.	.8	1044.8	78.
✓ 73.5	LUNAR ORBIT INSERTION BURN 2 ORIENTATION	46969.	.8	1044.0	77.
73.5	ATT HOLD .5 DEG DB PGNC5	46968.	1.1	1042.9	77.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LCFT (LBS)	SM- RCS LEFT (%)
73.5	ULLAGE 2 JET B AND D	46952.	15.7	1027.2	76.
73.5	SPS BURN BUILD UP	46949.	.0	1027.2	76.
73.5	STEADY STATE BURN 9.7 SEC PG _{NCS}	46296.	.2	1027.0	76.
73.5	TAILOFF	46255.	.0	1027.0	76.
73.5	DAMP SHUT DOWN TRANSIENT	46254.	1.1	1025.9	76.
73.7	ROLL RIGHT 180 DEG	46253.	1.1	1024.8	76.
73.8	ORIENT TO TRACKING ATTITUDE	46252.	1.1	1023.7	76.
73.8	EST ORBITAL RATE	46250.	1.5	1022.2	76.
74.1	ORIENT FOR LANDMARKS	46249.	1.1	1021.2	76.
74.3	PITCH TO ACQUIRE MSFN	46248.	1.3	1019.9	76.
74.3	ATTITUDE HOLD 5 DEG DB	46246.	2.1	1017.7	76.
74.5	P52 IMU ALIGN	46245.	.8	1016.9	75.
75.0	PITCH TO VERTICAL .2 DEG/SEC	46244.	.7	1016.2	75.
75.2	ROLL 180 DEG	46244.	.3	1015.9	75.
75.2	EST ORBITAL RATE	46243.	1.5	1014.4	75.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
75.7	ROLL RIGHT 180 DEG 2 DEG/SEC	46241.	1.1	1013.3	75.
75.8	MAINTAIN ORB RATE	46240.	1.5	1011.8	75.
76.0	ORIENT FOR LANDMARKS, PHOTOGRAPHY	46239.	1.1	1010.7	75.
76.1	EST AND STOP SIGHTING RATE	46238.	1.3	1009.4	75.
76.4	ROLL 180 DEG 2 DEG/SEC	46236.	1.1	1008.3	75.
76.5	ATTITUDE HOLD 5 DEG DB	46236.	.4	1007.9	75.
76.6	PS2 IMU ALIGN.	46235.	.8	1007.1	75.
77.1	ROLL 180 DEG 2 DEG/SEC	46234.	1.1	1006.0	75.
77.1	PITCH DOWN .2 DEG/SEC	46234.	.4	1005.6	75.
77.1	EST. ORB RATE	46232.	1.5	1004.1	75.
77.2	CONTROL POINT SIGHTING	46231.	1.1	1003.0	74.
77.3	PITCH .3 DEG/SEC AT ACQ	46231.	.5	1002.6	74.
77.7	PITCH .2 DEG/SEC AT LOSS	46230.	.7	1001.9	74.
77.7	EST. ORB RATE	46229.	1.5	1000.4	74.
78.0	ORIENT FOR PSEUDO LANDING SITE LANDMARK SIGHTING	46227.	1.1	999.3	74.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (8)
78.0	PITCH .3 DEG/SEC AT ACQ	46227.	.5	998.9	74.
78.3	ROLL 180 DEG AT LOSS	46226.	1.1	997.8	74.
78.5	ATTITUDE HOLD 5 DEG DB	46224.	2.1	995.6	74.
78.6	P52 IMU ALIGN	46223.	.8	994.8	74.
79.0	ROLL 180 DEG	46222.	1.1	993.8	74.
79.1	PITCH 2 DEG/SEC	46219.	2.4	991.3	74.
79.1	EST. DRB RATE	46218.	1.5	989.8	73.
79.1	CONTROL POINT SIGHTING	46217.	1.1	988.7	73.
79.1	MAINTAIN SIGHTING RATE	46217.	.1	988.6	73.
79.5	PITCH .3 DEG/SEC AT ACQ	46216.	.5	988.1	73.
79.5	PITCH .2 DEG/SEC AT LOSS	46216.	.3	987.8	73.
79.5	EST. DRB RATE	46214.	1.5	986.3	73.
80.0	ORIENT FOR PSEUDO LANDING SITE LANDMARK SIGHTING	46213.	1.1	985.2	73.
80.1	PITCH .3 DEG/SEC AT ACQ	46213.	.5	984.7	73.
80.2	ROLL 180 DEG AT LOSS	46212.	1.1	983.7	73.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
80.2	ATTITUDE HOLD 5 DEG DB	46210.	2.1	981.5	73.
80.6	PS2 IMU ALIGN	46209.	.8	980.7	73.
80.7	ROLL 180 DEG 2 DEG/SEC	46208.	1.1	979.6	73.
80.8	PITCH .2 DEG/SEC	46207.	.3	979.3	73.
80.8	EST. ORB RATE	46206.	1.5	977.8	73.
81.1	PITCH .3 DEG/SEC AT ACQ	46205.	.5	977.3	73.
81.3	PITCH .5 DEG/SEC AT LOSS	46205.	.7	976.6	72.
81.5	PITCH .3 DEG/SEC AT ACQ	46204.	.4	976.1	72.
81.6	PITCH .5 DEG/SEC AT LOSS	46204.	.7	975.4	72.
81.7	PITCH .3 DEG/SEC AT ACQ	46203.	.5	975.0	72.
81.8	PITCH .5 DEG/SEC AT LOSS	46202.	.7	974.3	72.
81.9	ORIENT FOR PSEUDO LANDING SITE LANDMARK SIGHTING	46201.	1.1	973.2	72.
82.1	PITCH .3 DEG/SEC AT ACQ	46201.	.5	972.7	72.
82.3	ROLL 180 DEG 2 DEG/SEC	46200.	1.1	971.6	72.
82.3	ATTITUDE HOLD 5 DEG DB	46195.	4.3	967.3	72.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
82.5	P52 IMU ALIGN	46195.	.8	966.5	72.
82.8	ROLL 180 DEG 2 DEG/SEC	46194.	1.1	965.5	72.
83.0	PITCH .2 DEG/SEC	46193.	.3	965.1	72.
83.1	PITCH .3 DEG/SEC AT ACQ	46193.	.5	964.7	72.
83.3	PITCH .5 DEG/SEC AT LOSS	46192.	.7	964.0	72.
83.4	PITCH .3DEG/SEC	46192.	.5	963.5	71.
83.6	PITCH .5 DEG/SEC	46191.	.7	962.8	71.
83.7	PITCH .3DEG/SEC	46191.	.5	962.4	71.
83.8	PITCH .5 DEG/SEC	46190.	.7	961.7	71.
83.9	ORIENT FOR PSEUDO LANDING SITE LANDMARK SIGHTING	46189.	1.1	960.5	71.
84.2	PITCH .3DEG/SEC	46188.	.5	960.1	71.
84.2	ROLL 180 DEG 2 DEG/SEC	46187.	1.0	959.0	71.
84.2	ATTITUDE HOLD 5 DEG DB	46185.	2.1	956.9	71.
84.5	P52 IMU ALIGN	46184.	.8	956.1	71.
84.7	PITCH .2 DEG/SEC	46184.	.3	955.7	71.

SM-RCS PROPELLANT-BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (8)
84.7	ESTABLISH ORB RATE	46182.	1.5	954.2	71.
85.1	PITCH UP 70 DEG AT .5 DEG/SEC	46182.	.7	953.5	71.
85.1	MAINTAIN ORB RATE	46182.	.1	953.4	71.
85.5	PITCH UP 40 DEG AT .2 DEG/SEC	46181.	.3	953.0	71.
85.7	ROLL 180 DEG	46180.	1.0	952.0	71.
86.2	ROLL 180 DEG 2DEG/SEC	46179.	1.1	950.9	71.
86.3	PITCH 60DEG .2DEG/SEC	46179.	.3	950.6	71.
86.2	ATTITUDE HOLD 5 DEG DB	46177.	2.1	948.5	70.
86.7	PS2 IMU ALIGN	46176.	.8	947.7	70.
86.9	PITCH .2 DEG/SEC	46175.	.3	947.3	70.
86.9	ESTABLISH ORB RATE	46174.	1.5	945.8	70.
88.3	PS2 IMU ALIGN	46173.	.8	945.1	70.
88.7	ROLL 180 DEG	46173.	.3	944.7	70.
89.1	TRANS-EARTH INJECTION ORIENTATION	46172.	.8	943.9	70.
89.1	ATT HOLD .5 DEG DB	46171.	1.1	942.9	70.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (8)
89.1	ULLAGE 2 JET B AND D QUADS 21 SEC PGNCS	46155.	15.7	927.1	69.
89.1	SPS BURN BUILD UP	46152.	.0	927.1	69.
89.1	STEADY STATE BURN 206 SEC PGNCS	32272.	.2	926.9	69.
89.1	TAILOFF	32231.	.0	926.9	69.
89.1	DAMP SHUT DOWN TRANSIENT	32230.	1.1	925.8	69.
89.2	PITCH TO VERTICAL ACQUIRE MOON	32229.	.7	925.1	69.
90.2	P52 IMU ALIGN	32229.	.7	924.4	69.
90.5	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	32228.	1.0	923.4	69.
90.5	MIN. IMPULSE MARKING	32227.	.4	923.0	68.
90.5	NAV SIGHTING SET 2	32226.	1.0	922.0	68.
90.5	MINIMUM IMPULSE MARKING	32226.	.4	921.6	68.
90.5	NAV SIGHTING SET 3	32225.	1.0	920.6	68.
90.5	MINIMUM IMPULSE MARKING	32225.	.4	920.2	68.
91.0	NAV SIGHTING SET 4	32224.	1.0	919.2	68.
91.0	MINIMUM IMPULSE MARKING	32223.	.4	918.8	68.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
91.0	NAV SIGHTING SET 5	32222.	.9	917.9	68.
91.0	MINIMUM IMPULSE MARKING	32222.	.4	917.4	68.
91.0	NAV SIGHTING SET 6	32221.	1.0	916.5	68.
91.0	MINIMUM IMPULSE MARKING	32220.	.4	916.0	68.
91.0	NAV SIGHTING SET 7	32219.	1.0	915.1	68.
91.0	MINIMUM IMPULSE MARKING	32219.	.4	914.6	68.
91.0	NAV SIGHTING SET 8	32218.	1.0	913.7	68.
91.0	MINIMUM IMPULSE MARKING	32218.	.4	913.2	68.
92.0	ORIENT FOR PTC (YAW TEST)	32217.	.7	912.5	68.
92.0	ATT HOLD .5 DEG DB PGNC	32216.	.8	911.7	68.
92.0	EST. 0.3 DEG/SEC YAW	32216.	.5	911.3	68.
92.0	PITCH AND ROLL CONTROL	32210.	5.6	905.7	67.
96.0	P52 IMU ALIGN	32209.	.7	905.0	67.
96.3	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32209.	.7	904.3	67.
96.3	ATTITUDE HOLD 0.5 DEG DB PGNC	32208.	.8	903.5	67.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
96.3	EST. 0.3 DEG/SEC ROLL	32208.	.2	903.3	67.
96.3	PITCH AND YAW CONTROL	32202.	5.2	898.1	67.
100.0	PS2 IMU ALIGN	32202.	.7	897.4	67.
100.5	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32201.	1.0	896.4	67.
100.5	MIN. IMPULSE MARKING	32200.	.4	896.0	66.
100.5	NAV SIGHTING SET 2	32199.	1.0	895.0	66.
100.5	MINIMUM IMPULSE MARKING	32199.	.4	894.6	66.
100.5	NAV SIGHTING SET 3	32198.	1.0	893.6	66.
100.5	MINIMUM IMPULSE MARKING	32198.	.4	893.2	66.
101.0	MAN TO SIGHTING ATT	32197.	1.0	892.2	66.
101.5	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32196.	.9	891.3	66.
101.5	MIN. IMPULSE MARKING	32195.	.4	890.8	66.
101.5	NAV SIGHTING SET 2	32194.	1.0	889.9	66.
101.5	MINIMUM IMPULSE MARKING	32194.	.4	889.4	66.
101.5	NAV SIGHTING SET 3	32193.	1.0	888.4	66.

SM-RCS. PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (8)
101.5	MINIMUM IMPULSE MARKING	32192.	.4	888.0	66.
101.5	NAV SIGHTING SET 4	32191.	1.0	887.1	66.
101.5	MINIMUM IMPULSE MARKING	32191.	.4	886.6	66.
102.0	NAV SIGHTING SET 5	32190.	1.0	885.7	66.
102.0	MIN. IMPULSE MARKING	32190.	.4	885.2	66.
102.0	NAV SIGHTING SET 6	32189.	1.0	884.3	66.
102.0	MINIMUM IMPULSE MARKING	32188.	.4	883.9	66.
102.8	P52 IMU ALIGN	32188.	.7	883.1	66.
103.5	MIDCOURSE CORRECTION 3 AXIS ORIENT PGCS	32187.	1.0	882.2	65.
103.5	ATTITUDE HOLD .5 DEG DB PGCS	32186.	.8	881.4	65.
103.5	RCS +X TRANS PGCS 10 FPS	32149.	37.1	844.3	63.
105.0	P52 IMU ALIGN	32148.	.7	843.6	63.
105.2	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32147.	1.0	842.6	63.
105.2	MIN. IMPULSE MARKING	32147.	.4	842.2	62.
105.2	NAV SIGHTING SET 2	32146.	1.0	841.2	62.

SM_RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM_RCS USED (LBS)	SM_RCS LEFT (LBS)	SM- RCS LEFT (#)
105.2	MINIMUM IMPULSE MARKING	32145.	.4	840.7	62.
105.2	NAV SIGHTING SET 3	32144.	1.0	839.8	62.
105.2	MINIMUM IMPULSE MARKING	32144.	.4	839.3	62.
105.2	NAV SIGHTING SET 4	32143.	1.0	838.4	62.
105.2	MINIMUM IMPULSE MARKING	32142.	.4	837.9	62.
105.2	NAV SIGHTING SET 5	32141.	1.0	837.0	62.
105.2	MINIMUM IMPULSE MARKING	32141.	.4	836.6	62.
106.1	HAN TO SIGHTING ATT	32140.	1.0	835.6	62.
106.3	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	32139.	1.0	834.6	62.
106.3	MIN. IMPULSE MARKING	32139.	.4	834.1	62.
106.3	NAV SIGHTING SET 2	32138.	1.0	833.2	62.
106.3	MINIMUM IMPULSE MARKING	32137.	.4	832.7	62.
106.3	NAV SIGHTING SET 3	32136.	1.0	831.8	62.
106.3	MINIMUM IMPULSE MARKING	32136.	.4	831.3	62.
107.6	P52 IMU ALIGN	32135.	.7	830.6	62.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
108.0	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32134.	1.0	829.7	62.
108.0	MIN. IMPULSE MARKING	32134.	.4	829.2	62.
108.0	NAV SIGHTING SET 2	32133.	1.0	828.3	61.
108.0	MINIMUM IMPULSE MARKING	32132.	.4	827.8	61.
108.0	NAV SIGHTING SET 3	32131.	1.0	826.9	61.
108.0	MINIMUM IMPULSE MARKING	32131.	.4	826.4	61.
108.0	NAV SIGHTING SET 4	32130.	1.0	825.5	61.
108.0	MINIMUM IMPULSE MARKING	32129.	.4	825.0	61.
108.0	NAV SIGHTING SET 5	32128.	1.0	824.0	61.
108.0	MINIMUM IMPULSE MARKING	32128.	.4	823.4	61.
108.8	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32127.	.7	822.9	61.
108.8	ATT HOLD .5 DEG DB PGNCS	32127.	.8	822.2	61.
108.8	EST. 0.3 DEG/SEC ROLL	32126.	.4	821.7	61.
108.8	PITCH AND YAW CONTROL	32120.	6.0	815.7	61.
113.0	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32119.	.7	815.0	60.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM_RCS USED (LBS)	SM_RCS LEFT (LBS)	SM_ RCS LEFT (%)
113.0	ATTITUDE HOLD 0.5 DEG DB PGWCS	32119.	.8	814.3	60.
113.0	EST. 0.3 DEG/SEC ROLL	32118.	.2	814.1	60.
113.0	PITCH AND YAW CONTROL	32116.	2.8	811.3	60.
115.1	P52 IMU ALIGN	32115.	.7	810.6	60.
115.3	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32114.	.7	809.9	60.
115.3	ATTITUDE HOLD 0.5 DEG DB PGWCS	32113.	.8	809.1	60.
115.3	EST. 0.3 DEG/SEC ROLL	32113.	.2	808.9	60.
115.3	PITCH AND YAW CONTROL	32108.	5.0	803.9	60.
119.0	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32108.	.7	803.2	60.
119.0	ATT HOLD .5 DEG DB PGWCS	32107.	.8	802.5	60.
119.0	EST. 0.3 DEG/SEC ROLL	32107.	.2	802.3	60.
119.0	PITCH AND YAW CONTROL	32105.	1.4	800.9	59.
120.0	P52 IMU ALIGN	32105.	.7	800.2	59.
120.0	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32104.	1.0	799.2	59.
120.0	MIN. IMPULSE MARKING	32103.	.4	798.8	59.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (%)
120.0	NAV SIGHTING SET 2	32102.	1.0	797.8	59.
120.0	MINIMUM IMPULSE MARKING	32102.	.4	797.3	59.
120.0	NAV SIGHTING SET 3	32101.	1.0	796.4	59.
120.0	MINIMUM IMPULSE MARKING	32100.	.4	795.9	59.
121.0	PS2 IMU ALIGN	32100.	.7	795.2	59.
121.5	MIDCOURSE CORRECTION 3 AXIS ORIENT PGNC5	32099.	.7	794.5	59.
121.5	ATT HOLD .5 DEG DB PGNC5	32098.	.4	794.1	59.
121.5	SM-RCS -X TRANS 2FPS	32091.	7.5	786.6	58.
122.6	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	32090.	1.0	785.6	58.
122.6	MIN. IMPULSE MARKING	32090.	.4	785.2	58.
122.6	NAV SIGHTING SET 2	32089.	1.0	784.2	58.
122.6	MINIMUM IMPULSE MARKING	32088.	.4	783.8	58.
122.6	NAV SIGHTING SET 3	32087.	1.0	782.8	58.
122.6	MINIMUM IMPULSE MARKING	32087.	.4	782.4	58.
123.1	MANEUVER TO SIGHTING ATTITUDE	32086.	.9	781.5	58.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
123.6	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32085.	1.0	780.6	58.
123.6	MIN. IMPULSE MARKING	32084.	.4	780.1	58.
123.6	NAV SIGHTING SET 2	32083.	1.0	779.1	58.
123.6	MINIMUM IMPULSE MARKING	32083.	.4	778.7	58.
123.6	NAV SIGHTING SET 3	32082.	1.0	777.7	58.
123.6	MINIMUM IMPULSE MARKING	32082.	.4	777.3	58.
123.6	NAV SIGHTING SET 4	32081.	1.0	776.3	58.
123.6	MINIMUM IMPULSE MARKING	32080.	.4	775.9	58.
123.6	NAV SIGHTING SET 5	32079.	1.0	774.9	58.
123.6	MINIMUM IMPULSE MARKING	32079.	.4	774.5	57.
124.5	ORIENT FOR PTC 3 AXIS 0.2 DEG/SEC	32078.	.7	773.8	57.
124.5	ATT HOLD .5 DEG DB PGNC5	32077.	.8	773.0	57.
124.5	EST. 0.3 DEG/SEC ROLL	32077.	.2	772.8	57.
124.5	PITCH AND YAW CONTROL	32070.	7.0	765.8	57.
129.5	PS2 IMU ALIGN	32069.	.7	765.1	57.

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM-RCS LEFT (#)
130.0	CISLUNAR NAVIGATION STAR/LUNAR HORIZON ORIENT	32068.	1.0	764.1	57.
130.0	MIN. IMPULSE MARKING	32068.	.4	763.7	57.
130.0	NAV SIGHTING SET 2	32067.	1.0	762.7	57.
130.0	MINIMUM IMPULSE MARKING	32067.	.4	762.2	57.
130.0	NAV SIGHTING SET 3	32066.	1.0	761.3	56.
130.0	MINIMUM IMPULSE MARKING	32065.	.4	760.9	56.
130.5	MANEUVER TO SIGHTING ATTITUDE	32064.	1.0	759.9	56.
130.8	CISLUNAR NAVIGATION STAR EARTH HORIZON ORIENT	32063.	1.0	758.9	56.
130.8	MINIMUM IMPULSE MARKING	32063.	.4	758.5	56.
130.8	NAV SIGHTING SET 2	32062.	1.0	757.5	56.
130.8	MINIMUM IMPULSE MARKING	32061.	.4	757.1	56.
130.8	NAV SIGHTING SET 3	32060.	1.0	756.1	56.
130.8	MINIMUM IMPULSE MARKING	32060.	.4	755.7	56.
131.4	NAV SIGHTING SET 4	32059.	1.0	754.7	56.
131.4	MIN. IMPULSE MARKING	32059.	.4	754.3	56.

SM-RCS PROPELLANT BUDGET

TIME (HR)	EVENT	S/C WT (LBS)	SM_RCS USED (LBS)	SM_RCS LEFT (LBS)	SM_ RCS LEFT (#)
131.4	NAV SIGHTING SET 5	32058.	1.0	753.3	56.
131.4	MINIMUM IMPULSE MARKING	32057.	.4	752.8	56.
131.4	NAV SIGHTING SET 6	32056.	1.0	751.9	56.
131.4	MINIMUM IMPULSE MARKING	32056.	.4	751.5	56.
131.8	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	32055.	.7	750.7	56.
131.8	ATT HOLD .5 DEG DB PGNC	32054.	.8	749.9	56.
131.8	EST. 0.3 DEG/SEC ROLL	32054.	.2	749.7	56.
131.8	PITCH AND YAW CONTROL	32048.	6.4	743.3	55.
135.5	P52 IMU ALIGN	32047.	.7	742.6	55.
135.7	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	32046.	.7	741.9	55.
135.7	ATT HOLD .5 DEG DB PGNC	32046.	.8	741.1	55.
135.7	EST. 0.3 DEG/SEC ROLL	32045.	.2	741.0	55.
135.7	PITCH AND YAW CONTROL	32040.	5.0	736.0	55.
139.4	P52 IMU ALIGN	32040.	.7	735.2	55.
139.5	ORIENT FOR PTC 3AXIS 0.2 DEG/SEC	32039.	.8	734.5	55.

SM-RCS PROPELLANT BUDGET						
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)	
139.5	ATTITUDE HOLD 0.5 DEG DB PG _{MCS}	32038.	.8	733.7	54.	
139.5	EST. 0.3 DEG/SEC ROLL	32038.	.2	733.5	54.	
139.5	PITCH AND YAW CONTROL	32034.	3.9	729.6	54.	
142.2	CISLUNAR NAVIGATION STAR/EARTH HORIZON ORIENT	32033.	1.0	728.7	54.	
142.2	MIN. IMPULSE MARKING	32033.	.4	728.2	54.	
142.2	NAV SIGHTING SET 2	32032.	.9	727.3	54.	
142.2	MINIMUM IMPULSE MARKING	32031.	.4	726.9	54.	
143.7	P52 IMU ALIGN	32031.	.7	726.1	54.	
144.4	MIDCOURSE CORRECTION	32030.	.7	725.4	54.	
144.4	ATT HOLD .5 DEG DB PG _{NCS}	32030.	.3	725.2	54.	
144.4	RCS +X TRANS PG _{NCS} 5 FPS	32011.	18.6	706.6	52.	
145.0	CISLUNAR NAVIGATION STAR EARTH HORIZON ORIENT	32011.	.0	706.6	52.	
145.0	MINIMUM IMPULSE MARKING	32010.	.4	706.1	52.	
145.7	P52 IMU ALIGN	32010.	.7	705.4	52.	
146.1	MANEUVER TO REENTRY ATTITUDE	32009.	1.0	704.4	52.	

SM-RCS PROPELLANT BUDGET					
TIME (HR)	EVENT	S/C WT (LBS)	SM-RCS USED (LBS)	SM-RCS LEFT (LBS)	SM- RCS LEFT (%)
146.5	PITCH TO ACQUIRE HORIZON	32008.	.7	703.7	52.
146.5	YAW 45 DEG	32007.	.7	703.0	52.
146.5	ATT HOLD .5 DEG DB PGNC	32007.	.4	702.6	52.
146.6	CM/SM SEPARATION DELTA VEL=3 FPS	19526.	10.8	691.8	51.

TABLE 3-IV
CM RCS PROPELLANT USAGE SUMMARY

Loaded, lb.		270.0
Less		
Trapped, lb.	32.4	
Temperature variation allowance, lb.	6.4	
Available for mission planning, lb.		231.2
Nominal Usage		
Separation and attitude hold prior to 0.05 g	12.1	
Guidance commands for remainder of reentry	19.5	
Operational Reserve, lb.		199.6

TABLE 3-V
Mission C Prime SPS Propellant Budget

<u>Item</u>	Propellant (Lbs)
Loaded	40785
Trapped	-441
Outage	- 18
Unbalance Meter	<u>-100</u>
Available for ΔV	40226
Required for ΔV ¹	<u>-31253</u>
Nominal Remaining	8973

¹Includes 14.4 lbs per start for start losses

$$I_{SP} = 314.25 \pm 1.593$$

$$MR = 1.595 \pm 0.0067$$

Vehicle Wt

CSM 22955.7

<u>Burn</u>	<u>ΔV</u>	<u>Propellant Required</u>
TLMC ²	120.	780.0
LOI	2991.	16074.7
Circularization	138.5	648.5
TEI	3531.7	13537.7
TEMC	62	<u>211.9</u>
		31252.7

²2 starts

TABLE 3-VI

CRYOGENIC CONSUMPTION ANALYSIS SUMMARY

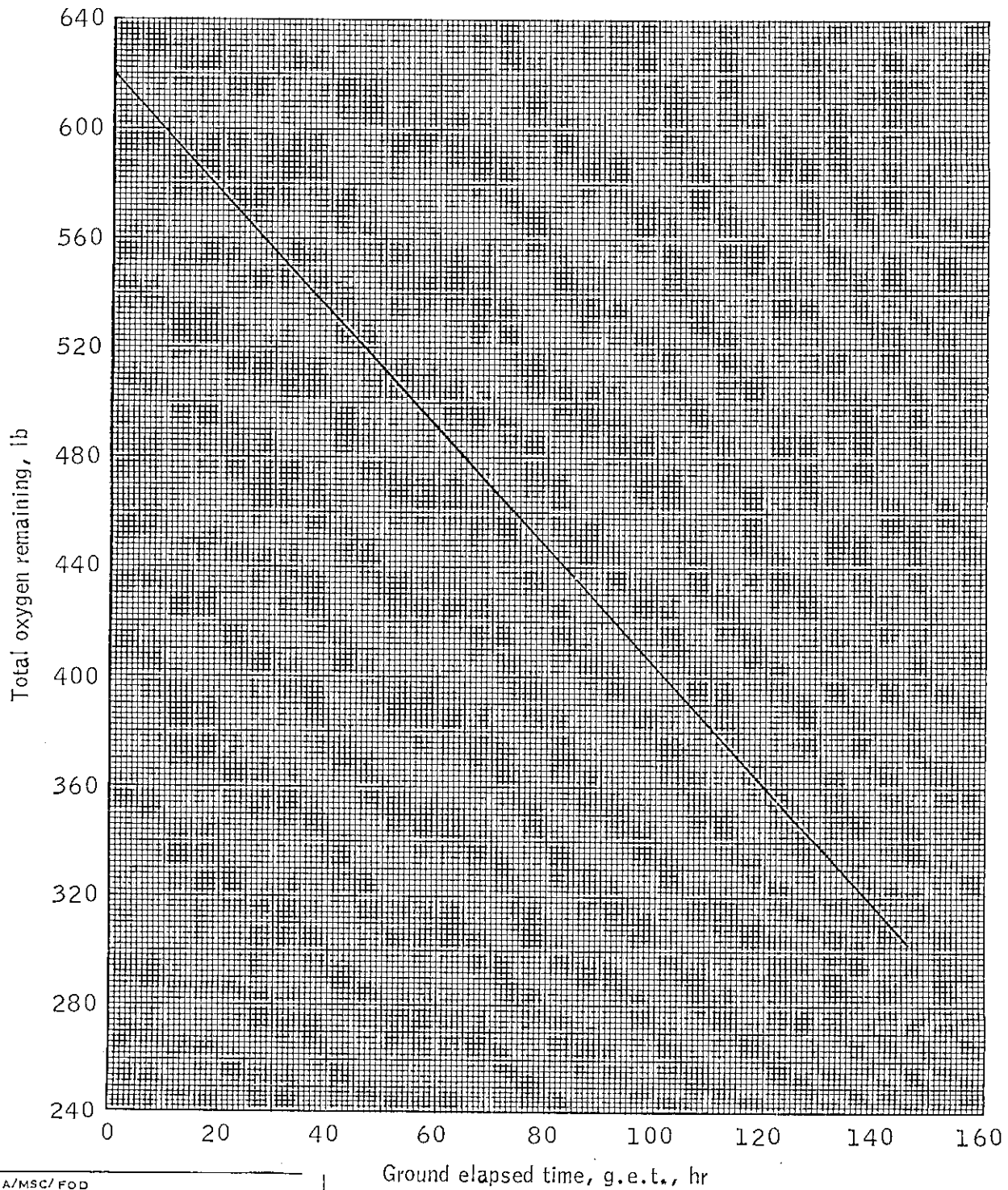
	<u>O₂ (lbs)</u>	<u>H₂ (lbs)</u>
Loaded	653.0	58.4
Residual & Instrumentation Error	30.0	3.9
Available for mission	623.0	54.5
Mission requirements	344.0	33.9
Margin	279.0	20.6

The results of the cryogenic consumption analysis are summarized in the following figures:

1. Figure - Nominal Mission O₂ Profile.
2. Figure - Nominal Mission H₂ Profile.

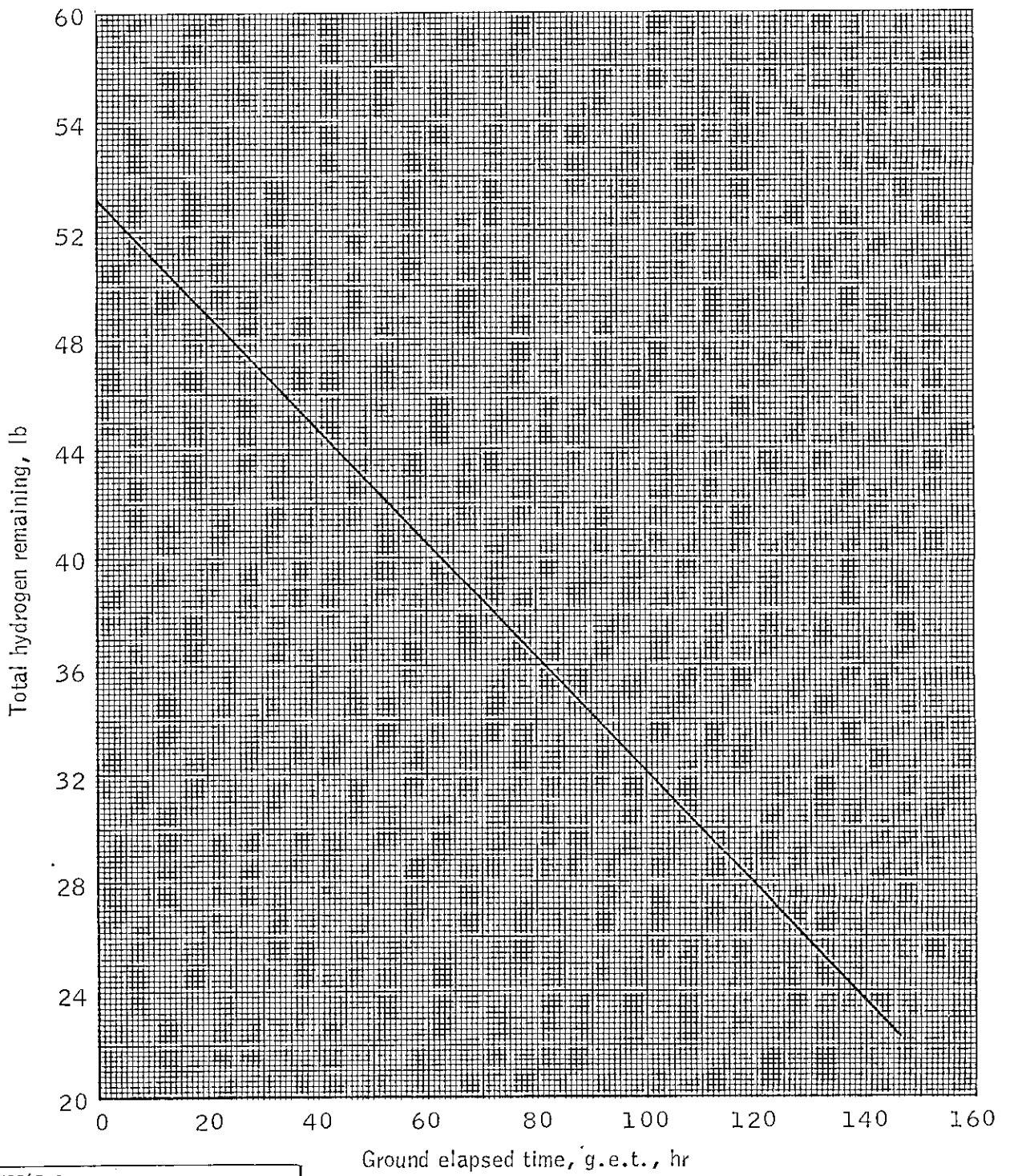
The following ground rules and assumptions were used for the construction of the mission H₂ and O₂ profiles.

1. 10 fuel cell purges.
2. Cabin O₂ leak rate of 0.2 lb/hr.
3. Metabolic O₂ rate of 0.23 lb/hr for 3 crewmen.
4. Waste management O₂ rate of 0.051 lb/hr.
5. Water tank O₂ purge rate of 0.056 lb/hr.
6. The hydrogen consumption rate is .00257 lb/amp/hr.
7. The oxygen consumption rate is 7.936 times the hydrogen consumption rate.



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Figure 3-VI.- Oxygen profile for Apollo 8.



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BRANCH GFB DATE 11-29-68
BY Scott PLOT NO. 387

Figure 3-VII.- Hydrogen profile for Apollo 8.

TABLE 3-VII

CREW CHECKLIST PROCEDURE/CONSUMABLES DATA SUMMARY
(AVERAGE ELECTRICAL POWER LOADS)

CREW CHECKLIST PROCEDURE	AVERAGE POWER		BUS VOLTAGE	BATTERY CURRENT	BATTERY POWER	FUEL CELL CURRENT	BUS POWER	CRYO CONSUMPTION		H ₂ O PRODUCTION
	AC	DC						H ₂	O ₂	
	WATTS	WATTS	VOLTS	AMPS	WATTS	AMPS	WATTS	LB/HR	LB/HR	LB/HR
Contingency Drift Flight										
1. Normal	676.6	1067.5	28.75	-	-	74.0	2130	0.189	1.50	1.69
2. Power Down	676.6	905.9	28.90	-	-	67.0	1940	0.174	1.38	1.55
Boost thru Separation and Formation Flying										
1. Lift-Off	770.0	1085.0	29.30	19.0	556.0	58.0	2260	0.149	1.18	1.34
2. 1st Stage Separation	779.1	1812.5	28.65	33.0	945.0	73.5	3060	0.189	1.50	1.69
3. Insertion (Earth Orbit)	734.9	1202.3	28.30	-	-	81.0	2290	0.208	1.65	1.86
4. TLI & Separation Preparation	744.6	1179.5	28.30	-	-	81.0	2290	0.207	1.65	1.85
5. Separation and Formation Flying	764.4	1193.6	28.25	-	-	82.0	2320	0.210	1.67	1.88
Power Up										
1. Stabilization and Control	767.0	1128.0	28.35	-	-	80.0	2270	0.206	1.64	1.84
2. G&N Optics	681.8	1156.6	28.45	-	-	77.5	2210	0.199	1.59	1.77
3. Stabilization and Control, and G&N Optics	772.2	1217.1	28.25	-	-	82.5	2330	0.213	1.68	1.90
G&N/SPS Orbit Change										
1. Initial Conditions	774.8	1156.8	28.30	-	-	81.0	2290	0.208	1.65	1.86
2. Ignition Preparation	788.2	1897.5	28.60	-	-	74.0	3080	0.192	1.52	1.71
3. Ignition	868.5	2458	28.05	45.0	1260	86.5	3690	0.224	1.78	2.00
Battery Charging	724.6	1116.5	28.5	-	-	77.0	2190	0.197	1.57	1.76
G&N SM RCS Orbit Change Thrusting (P41)										
1. Initial Conditions	774.8	1170.2	28.3	-	-	82.0	2320	0.210	1.66	1.87

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CREW CHECKLIST PROCEDURE/CONSUMABLES DATA SUMMARY
(AVERAGE ELECTRICAL POWER LOADS)

CREW CHECKLIST PROCEDURE	AVERAGE POWER		BUS VOLTAGE	BATTERY CURRENT	BATTERY POWER	FUEL CELL CURRENT	BUS POWER	CRYO CONSUMPTION		H ₂ O PRODUCTION
	AC	DC						H ₂	O ₂	
	WATTS	WATTS	VOLTS	AMPS	WATTS	AMPS	WATTS	LB/HR	LB/HR	LB/HR
2. Ignition	774.8	1602.2	27.6	-	-	97.0	2680	0.250	1.99	2.24
Entry to Landing										
1. Preparation	684.4	1089.2	29.6	23.0	680.0	52.0	2220	0.134	1.06	1.20
2. CM RCS Htrs	684.4	1659.2	29.2	34.0	993.0	62.0	2800	0.159	1.26	1.43
3. CM SM Separation	501.8	760.6	28.5	55.0	1565.0	-	1565.0	-	-	-
4. Entry	492.3	812.7	28.6	56.5	1605.0	-	1605.0	-	-	-
Post Landing	-	86.0	28.0	3.07	86.0	-	86.0	-	-	-



SECTION IV - DETAILED TEST OBJECTIVES



SECTION 4

TEST OBJECTIVE ACTIVITIES

This section contains the activity summaries which reflect the test objectives for Mission C' as described in "Mission Requirements AS 503/CSM 103 C' Type Mission (Lunar Orbit)" dated November 16, 1968. These activity summaries are presented in the approximate sequence in which they are planned to occur during the mission. In the case of activities which are repeated in the mission plan, they are described only once in this summary. Those test objectives which do not relate to specific mission activities are grouped at the end of this section as "Miscellaneous Tests" and "Telecommunications". Test objective requirements which are not scheduled in this flight plan are identified as being not implemented, "N.I."

Each activity summary provides the following information:

- A. TEST OBJECTIVES. This is the listing of the Functional Test Objectives (complete or partial) which relate to the particular activity;
- B. TEST REQUIREMENTS. Here the special test prerequisites are presented in addition to brief statements of the requirements for performing the activity;
- C. TEST PROCEDURES/CHECKLISTS. These are the procedural references for the performance of the activity as far as the test objectives are concerned; and
- D. DATA REQUIREMENTS. This part of the summary identifies the gross data which are needed for evaluation of test results in terms of flight crew and ground support requirements.

A cross reference for relating Detailed and Functional Test Objectives with the activity summaries is provided as the initial part of this section.

The following ground rules are to be used in implementing data requirements:

- A. The collection of highly desirable (HD) data should not constrain the timeline or the crew procedures.
- B. CSM data storage equipment (DSE) HBR recording is needed only when MSFN coverage is not available and when mandatory data are required.
- C. Data collected by the crew which are required only for postflight analysis, need not be voiced to MSFN in real time.

TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
SL.27 SL.27-1 SL.27-2	GNCS Boost Monitor/Saturn V Boost Monitor - GNCS Performance Boost Monitor - Display Adequacy	Launch Launch	4-8 4-8
SL.30 SL.30-1 SL.30-2 SL.30-3	IMU Performance GNCS Accelerometer Biases During Coasting Flight GNCS/IRIG Drift Rates During Coasting Flight Overall GNCS Errors During Thrusting Maneuvers	PIPA Bias Check IMU Realignment Lunar Orbit Insertion	4-18 4-15 4-8,27
PL.31 PL.31-1 PL.31-2	GNCS Entry Lunar Return GNCS Performance During Entry - Lunar Return EMS Capability to Monitor Entry - Lunar Return	Entry Entry	4-12,35 4-12,35
SL.32 SL.32-1 SL.32-2 SL.32-3 SL.32-4 SL.32-5	Midcourse Navigation/Star Earth - Landmark Star/Earth Landmark Navigation Sighting Accuracy Verify and Update Landmark Lighting Constraints OSS Adequacy for Navigation Sightings in Deep Space Crew Capability to Identify Landmarks and Coordinate Optics/Maneuvers RCS Propellant Use and Time to Accomplish Onboard Navigation	Star/Earth Landmark Navigation Star/Earth Landmark Navigation Star/Earth Landmark Navigation Star/Earth Landmark Navigation Star/Earth Landmark Navigation	4-11,20 4-11,20 4-11,20 4-20 4-20
PL.33 PL.33-1 PL.33-2 PL.33-3 PL.33-4	Midcourse Navigation/Star-Lunar Horizon Star/Lunar Horizon Navigation Sighting Accuracy OSS Adequacy for Navigation Sightings in Deep Space Crew Capability to Coordinate Optics/Maneuvers RCS Propellant Use and Time to Accomplish Onboard Navigation	Star/Lunar Horizon Navigation Star/Lunar Horizon Navigation Star/Lunar Horizon Navigation Star/Lunar Horizon Navigation	4-24 4-24 4-24 4-24

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TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
Pl.34 Pl.34-1 Pl.34-2 Pl.34-3 Pl.34-4	Midcourse Navigation/Star-Earth Horizon Star/Earth Horizon Navigation Sighting Accuracy Verify and Update Horizon Lighting Constraints OSS Adequacy for Navigation Sightings in Deep Space Crew Ability to Identify Horizon Locator and Coordinate Optics/Maneuvers	Star/Earth Horizon Navigation Star/Earth Horizon Navigation Star/Earth Horizon Navigation Star/Earth Horizon Navigation	4-16 4-16 4-16 4-16
Pl.34-5	RCS Propellant Use and Time to Accomplish Onboard Navigation	Star/Earth Horizon Navigation	4-16
Sl.35 Sl.35-1 Sl.35-2 Sl.35-3	IMU Orientation Determination/Visibility IMU Realignment in Daylight Obtain Data - Star Visibility During TL and TE Coast Degradation of Navigation/IMU Align by Vented/Ejected Particles	IMU Realignment Star Visibility Star Visibility	4-31 4-15 4-26 4-26
S3.21 S3.21-1 S3.21-2 S3.21-3 S3.21-4	SPS Evaluation SPS Isp - Adequacy of Conversion - Ground to Vacuum Results SPS Performance for LOI and TEI Burns SPS PUGS in Auxiliary Mode - Relative Accuracy Aux/Pri Thermal Effects - Long SPS Burn - Heat Protection System	LOI and TEI LOI and TEI TEI LOI and TEI	4-27,33 4-27,33 4-33 4-27,33
S4.5 S4.5-1 S4.5-2	ECS Lunar Return Entry ECS Performance During Manned Lunar Return Entry Compare ECS Data with Developed Model and Unmanned Results	Entry Entry	4-35 4-35
S6.10 S6.10-1	CSM Omni Antennas Lunar Distance S-Band Performance with Omni Antennas at Lunar Distance	Telecommunications	4-38

TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
P6.11 P6.11-1 P6.11-2 P6.11-3	CSM/MSFN Communications Lunar Distance S-Band Performance with High Gain Antenna - TL Coast S-Band Performance with High Gain Antenna - Lunar Distance CSM HGA Oper. in Potential S/C Reflectivity Region	Telecommunications Telecommunications Not Implemented	4-38 4-38
S7.30 S7.30-1 S7.30-2	Heat Shield Lunar Return Block II Thermal Protection System During Manned Lunar Return TPS Surface Recession and Char Data Comparison	Entry Entry	4-35 4-35
P7.31 P7.31-1 P7.31-2	Spacecraft Environment Thermal Control Evaluate Thermal Control System During TL and TE Coast Thermal Control System During Lunar Orbit	Miscellaneous Tests Miscellaneous Tests	4-20,36 4-20,36
P7.32 P7.32-1 P7.32-2 P7.32-3	Spacecraft Dynamic Environment CSM Loads/Vibrations - Launch, TLI and Separation SLA Dynamic Response - Launch, TLI and Separation S-Band HGA Response During Deployment and SPS Burns	Launch, TLI, CSM/S-IVB Sep. Launch, TLI, CSM/S-IVB Sep. CSM/S-IVB Sep., Midcourse, LOI	4-8,11,12 4-8,11,12 4-19,12,27
P7.33 P7.33-1	SLA Panel Jettison SLA Panel Jettison Demonstration	CSM/S-IVB Separation	4-14 4-14
S20.104 S20.104-1 S20.104-2 S20.104-3	Transposition Separation and Transposition Maneuver Separation and Transposition Procedures and Timeline Adequacy S-Band Performance During Transposition	CSM/S-IVB Sep., Transposition CSM/S-IVB Sep., Transposition Telecommunications	4-12,13,14 4-12,13 4-38

4-4

TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
P20.105	LOI Maneuver	Lunar Orbit Insertion	4-27
P20.105-1	Crew/Spacecraft/MSFN Preparation and Execution of LOI Maneuver	Lunar Orbit Insertion	4-27
P20.105-2	Procedures and Timeline Adequacy for LOI Maneuver	Lunar Orbit Insertion	4-27
P20.106	TEI Maneuver	Transearch Insertion	4-33
P20.106-1	Crew/Spacecraft/MSFN Preparation and Execution of TEI Maneuver	Transearch Insertion	4-33
P20.106-2	Procedures and Timeline Adequacy for TEI Maneuver	Transearch Insertion	4-33
P20.107	Crew Activities Lunar Distance	Miscellaneous Tests	4-36
P20.107-1	Crew Procedures for Lunar Orbit Mission	Miscellaneous Tests	4-36
P20.107-2	Crew Procedures and Timeline Adequacy - Lunar Mission	Miscellaneous Tests	4-36
S20.108	CSM Consumables Lunar Mission	Miscellaneous Tests	4-36
S20.108-1	EPS Use, Performance and Fuel Cell Management	Miscellaneous Tests	4-36
S20.108-2	Water and Oxygen Requirements Data	Miscellaneous Tests	4-36
S20.108-3	LiOH Cartridge Requirements Data	Miscellaneous Tests	4-36
S20.108-4	SPS, SM/RCS and CM/RCS Propellant Requirements Data	Miscellaneous Tests	4-36
S20.108-5	Crew Food Requirements Data	Miscellaneous Tests	4-36
P20.109	Passive Thermal Control Modes	Passive Thermal Control Modes	4-22
P20.109-1	PTC Procedures and RCS Use - Roll with Attitude Hold	Passive Thermal Control Modes	4-22
P20.109-2	PTC Procedures and RCS Use - Roll without Attitude Hold	Telecommunications	4-22,38
P20.109-3	Communication Procedures Adequacy for PTC Mode	Passive Thermal Control Modes	4-22
P20.109-4	PTC Procedures and RCS Use - Yaw without Attitude Hold	Passive Thermal Control Modes	4-22
P20.110	Ground Support Lunar Distance	Miscellaneous Tests	4-36
P20.110-1	Ground Operation Support for Lunar Mission Without LM	Miscellaneous Tests	4-36

TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
P20.111	Lunar Landmark Tracking		
P20.111-1	Error Uncertainties in Lunar Landing Site Location	Lunar Landmark Tracking	4-29
P20.111-2	Obtain Data to Calibrate MSFN at Lunar Distance	Lunar Landmark Tracking	4-29
P20.111-3	Determine Minimum Sun Angle to Clearly Identify Landmarks	Lunar Landmark Tracking	4-29
P20.111-4	Lunar Landmark Tracking in Earthshine	Lunar Landmark Tracking	4-29
P20.111-5	Adequacy of CSS and OSS for Obtaining Landmark Sightings	Lunar Landmark Tracking	4-29
P20.111-6	Crew Ability to Coordinate Sightings and Vehicle Maneuvers	Lunar Landmark Tracking	4-29
P20.111-7	RCS Propellant and Time Required for Landmark Sighting	Lunar Landmark Tracking	4-29
P20.112	TLI Burn		
P20.112-1	Crew/Ground Capability for TLI at First Opportunity	Pre-TLI and TLI	4-10
P20.112-2	TLI Preparation and Execution Procedure Demonstration	Pre-TLI and TLI	4-10, 11
P20.112-3	TLI Procedures and Timeline Adequacy	Pre-TLI and TLI	4-10, 11
P20.112-4	CSM Cabin Vibration Environment during TLI Burn	Translunar Injection	4-11
P20.112-5	Crew Monitoring of GNCS and LV Displays - TLI Burn	Translunar Injection	4-11
P20.114	Midcourse Correction Capability		
P20.114-1	Procedures and Timeline Adequacy for MCC'S	Midcourse Corrections	4-19
P20.114-2	GNCS, SPS and RCS Performance on MCC'S	Midcourse Corrections	4-19
P20.114-3	Ground Capability to Update State Vector and Target for MCC	Midcourse Corrections	4-19
S20.115	Lunar Mission Photography from the CSM		
S20.115-1	Overlapping Photos from Terminator to Terminator-Lunar Orbit	Photography	4-31
S20.115-2	Photos of Earth and Lunar Landmarks	Photo, S/E Landmark Nav.	4-20
S20.115-3	Photos of Earth and Lunar Horizons	Photo, S/E Landmark Nav., S/L Landmark Nav.	4-16, 24, 31
S20.115-4	Photos of General and Scientific Interest	Photography	4-31

4-6

TEST OBJECTIVE/MISSION ACTIVITY
CROSS REFERENCE

DTO/FTO NUMBER	TEST OBJECTIVE	MISSION ACTIVITY	SECTION PAGE NO.
S20.116 S20.116-1 S20.116-2	Exhaust Effects/CSM Windows Changes in Visual Acuity Through Windows Changes in Total Transmittance of Windows	Launch Transposition Entry	4-8,13 4-35

LAUNCH

A. TEST OBJECTIVES

- S1.27-1 Boost Monitor - GNCS Performance
- S1.27-2 Boost Monitor - Display Adequacy
- S1.30-3 Overall GNCS Errors During Thrusting Maneuvers
- P7.32-1 CSM Loads/Vibrations - S-V Boost
- P7.32-2 SLA Dynamic Response - S-V Boost
- S20.116-1 Changes in Visual Acuity Through Windows

B. TEST REQUIREMENTS

1. CSM insertion into earth orbit by a Saturn V vehicle [1.27, 1.30, 7.32 & 20.116]
2. FQTR operation throughout Saturn V boost [7.32]
3. Crew observations of changes in visual acuity through the windows as the result of TJM firing & S-II retro firing [20.116]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.3.1 "Boost and Insertion"
2. FCAC L-1, L-2, & L-3 "Boost-Insertion"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. FDAI or DSKY display inadequacies [1.27] (M)
 - b. Apparent GNCS trajectory errors [1.27] (M)
 - c. Unexpected structural loads or vibrations [7.32] (M)
 - d. Log changes in visual acuity through windows ("Window Visibility" log) [20.116] (M)
2. Ground Support
 - a. CSM TM HBR [1.27, 7.32] (M)
 - b. Continuous tracking [1.27] (M)
 - c. BET [7.32] (M)
 - d. Dynamic pressure & angle of attack during S-IC operation [7.32] (M)
 - e. Wind data from 0 to 60,000 ft at launch time [7.32] (M)

f. Saturn V thrust variations vs. time-MSFC [7.32] (M)

g. Saturn V accel & IU gyro data - MSFC [7.32] (M)

A. TEST OBJECTIVES

- P20.112-1 Crew/Ground Capability for TLI at First Injection Opportunity
- P20.112-2 TLI Preparation and Execution Procedure Demonstration
- P20.112-3 TLI Procedures and Timeline Adequacy

B. TEST REQUIREMENTS

- 1. Following earth orbit insertion, flight crew accomplishment of all pre-TLI activities required for a Pacific injection on the second pass
- 2. Ground operational support personnel evaluation of all spacecraft systems and making of the go/no-go decision for the TLI burn

C. TEST PROCEDURES/CHECKLISTS

- 1. AOH paragraph 4.3.2 "Post Orbital Insertion Check"
- 2. AOH paragraph 4.4.1 "Translunar Injection"
- 3. FCAC L-4, L-5, L-1, & L-2 "Post Insertion"
- 4. FCAC L-6 & L-7 "System Verification & Monitoring"
- 5. FCAC L-8 & L-9 "TLI Preparation" to GET 02:50:38

D. DATA REQUIREMENTS

- 1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies (M)
 - b. Comments regarding feasibility of first Atlantic injection opportunity during the second revolution (M)
- 2. Ground Support
 - a. Flight Director reports of timeline and/or procedural difficulties (M)

TRANSLUNAR INJECTION

A. TEST OBJECTIVES

- P7.32-1 CSM Loads/Vibrations - TLI
- P7.32-2 SLA Dynamic Response - TLI
- P20.112-2 TLI Preparation and Execution Procedure Demo.
- P20.112-3 TLI Procedures and Timeline Adequacy
- P20.112-4 CSM Cabin Vibration Environment During TLI Burn
- P20.112-5 Crew Monitoring of GNCS & LV Displays During TLI

B. TEST REQUIREMENTS

- 1. Ground operational support and flight crew capability to execute the TLI burn [20.112]
- 2. FQTR operation throughout the S-IV burn [7.32]

C. TEST PROCEDURES/CHECKLISTS

- 1. AOH paragraph 4.4.1 "Translunar Injection"
- 2. FCAC L-9 & L-10 "TLI Preparation"

D. DATA REQUIREMENTS

- 1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies [20.112] (M)
 - b. FDAI, DSKY & LV Tank Pressure display inadequacies [20.112] (M)
 - c. Unexpected induced resonances in cabin (Visual, audible and tactile) [20.112] (M)
 - d. Comments on adequacy of TLI monitoring [20.112] (M)
- 2. Ground Support
 - a. CSM TM HBR [7.32] (M)
 - b. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.112] (M)

CSM/S-IVB SEPARATION

A. TEST OBJECTIVES

- P7.32-1 CSM Loads/Vibrations - CSM/S-IVB Separation
- P7.32-2 SLA Dynamic Response - CSM/S-IVB Separation
- P7.32-3 S-Band High Gain Antenna Dynamic Response During Deployment
- S20.104-1 Separation and Transposition Maneuver
- S20.104-2 Separation and Transposition Procedures & Timeline Adequacy

B. TEST REQUIREMENTS

- 1. CSM/S-IVB separation, SLA panel jettison and S-band high gain antenna deployment [20.104]
- 2. FOETR operation during the period of the CSM/S-IVB separation, SLA panel jettison and S-band high gain antenna deployment [7.32]

C. TEST PROCEDURES/CHECKLISTS

- 1. AOH paragraph 4.5.1.1, "CSM/SLA Separation Through Capture Latch" through step 5
- 2. FCAC Separation TBD

D. DATA REQUIREMENTS

- 1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies [20.104] (M)
- 2. Ground Support
 - a. CSM TM HBR [7.32] (M)
 - b. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.104] (M)

A. TEST OBJECTIVES

- S20.104-1 Separation and Transposition Maneuver
- S20.104-2 Transposition Procedures and Timeline Adequacy
- S20.116-1 Changes in Visual Acuity Through Windows

B. TEST REQUIREMENTS

1. After separation, a (+X) translation from the S-IVB for three seconds, a coast for one minute to approximately 70 ft., a (-X) translation for 1 1/2 seconds, and then a pitch up at 4°/sec until the spacecraft (+X) axis points at the S-IVB [20.104]
2. Determination if there are any changes in visual acuity through the windows as the result of SM RCS use [20.116]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.5.1.1, "CSM/SLA Separation Through Capture Latch" step 6
2. FCAC Transposition TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies [20.104] (M)
 - b. Inadequacies in communications with ground operational support [20.104] (M)
 - c. Log changes in visual acuity through the windows from SM RCS use ("Window Visibility" log) [20.116] (M)
2. Ground Support
 - a. CSM TM HBR [20.104] (M)
 - b. USB tracking data processor output recording [20.104] (M)
 - c. USB TM bit stream recording [20.104] (M)
 - d. MSFN tape records of S-band received signal strength [20.104] (M)
 - e. MSFN tape recordings of CSM to MSFN and MSFN to CSM voice [20.104] (M)
 - f. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.104] (M)
 - g. BET [20.104] (M)

FORMATION FLYING

A. TEST OBJECTIVES

P7.33-1 SLA Panel Jettison Demonstration
S20.104-1 Separation and Transposition Maneuver

B. TEST REQUIREMENTS

1. Formation flying with the S-IVB to acquire the following photographs:
 - a. Sequence camera photographs of the S-IVB following transposition [20.104] (HD)
 - b. Photographs of the SLA aft portion and LTA-B showing that the panels jettisoned and of any anomaly observed [7.33] (M)

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.5.1.2 "Formation Flight With S-IVB (General)"
2. Photo checklist TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Observed anomalies in the jettison of the SLA panels or launch vehicle instability [7.33] (M)
 - b. Disposition of any observed SLA panels [7.33] (M)
 - c. Sequence photographs of the S-IVB following transposition [20.104] (HD)
 - d. Photographs of the SLA aft portion and the LTA-B showing that the panels jettisoned and of any anomalies observed [7.33] (M)
2. Ground Support
 - a. None

IMU REALIGNMENT

A. TEST OBJECTIVES

- S1.30-2 GNCS IRIG Drift Rates During Coasting Flight
- S1.35-1 IMU Realignment in Daylight

B. TEST REQUIREMENTS

1. At least two sets of back-to-back IMU realignments (at least one hour apart without an intervening ΔV maneuver) to determine IRIG drift rates [1.30]
2. One IMU realignment in daylight when at an altitude of greater than 2000 NM [1.35]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.11.1 "IMU Orientation Determination (P51)" or
2. AOH paragraph 4.11.2 "IMU Realign (P52)"
3. FCAC "P51 - IMU Orientation" or
4. FCAC "P52 - IMU Realign"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs - None
2. Ground Support - CSM TM [1.30] (M)

A. TEST OBJECTIVES

- Pl.34-1 Star/Earth Horizon Navigation Sighting Accuracy
- Pl.34-2 Verify and Update Horizon Lighting Constraints
- Pl.34-3 OSS Adequacy for Navigation Sightings in Deep Space
- Pl.34-4 Crew Ability to Identify Horizon Locator and Coordinate Optics/Maneuvers
- Pl.34-5 RCS Propellant Use and Time to Accomplish Onboard Navigation
- S20.115-3 Photographs of Earth and Lunar Horizons

B. TEST REQUIREMENTS

1. Use of the trunnion calibration option of P23 preceding a set of sightings if more than about 30 minutes has elapsed since the previous P23 trunnion calibration [1.34]
2. Translunar - Near Earth
 - a. Five sets of star/earth horizon sightings at more than 15,000 NM and less than 50,000 NM from the center of the earth [1.34]
 - b. At least 10 sequence photographs through the special sextant camera adapter while duplicating star/horizon navigation sightings when between 10,000 and 30,000 NM from the earth on TL phase. It is desirable that these photographs be taken at varying distances [20.115] - Not Implemented
 - c. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.34]
3. Translunar - Midcourse
 - a. Eighteen sets of star/earth horizon sightings at more than 50,000 NM from both the earth and the moon [1.34]
 - b. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.34]
4. Transearth
 - a. Star/earth horizon sightings under the following conditions [1.34]
 - (1) Seventeen sets at more than 50,000 NM from the earth and moon
 - (2) Three sets at less than 50,000 NM from the center of the earth
 - b. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.34]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.12.3 "Cislunar Midcourse Navigation (P23) including "Trunnion Calibration" option
2. FCAC G-20A "P23 Cislunar Midcourse Navigation Measurement"
3. Photo checklist TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Difficulties and/or inadequacies noted in handling the optics and the spacecraft [1.34] (M)
 - b. Log navigation data on Flight Plan timeline [1.34] (M)
 - c. Photo log TBD [20.115] (M)
2. Ground Support
 - a. CSM TM HBR [1.34] (M)
 - b. BET [1.34] (M)

PIPA BIAS CHECK

A. TEST OBJECTIVES

SI.30-1 GNCS Accelerometer Biases During Coasting Flight

B. TEST REQUIREMENTS

1. MSFN collection of PIPA bias data at least five times during the mission using uninterrupted TM for at least five minutes as follows:
 - a. Prior to and following an SPS burn of at least 40 seconds
 - b. As close to entry as possible
 - c. Any two other periods in the mission
2. Onboard test performed only if communications are lost

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.10.1.13 "Measurement and Loading of PIPA Bias"
2. FCAC G-51 "Measure & Load PIPA Bias"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Log PIPA bias data on Flight Plan timeline if PIPA bias tests are performed onboard
2. Ground Support
 - a. CSM TM (M)

A. TEST OBJECTIVES

- P7.32-3 S-Band High Gain Antenna Dynamic Response During SPS burns
- P20.114-1 Procedures and Timeline Adequacy for Midcourse Corrections
- P20.114-2 GNCS, SPS & RCS Performance on Midcourse Corrections
- P20.114-3 Ground Capability to Update State Vector and Target for MCC

B. TEST REQUIREMENTS

1. Ground update of the CSM state vector and of the MCC target [20.114]
2. MCC maneuver performance [20.114]
3. FQTR operation during SPS ignition, cutoff and for at least five seconds during the burn [7.32]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.10.1.5 "CSM-CMC Update P27"
2. AOH paragraph 4.14.2 "G&N/SPS Orbit Change Thrusting (P40)" or
3. AOH paragraph 4.14.3 "G&N SM RCS Orbit Change Thrusting (P41)"
4. FCAC G-21 "P27 CMC Update
5. FCAC G-30 "P40 SPS Thrust" or
6. FCAC G-37 "P41 RCS Thrust"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies [20.114] (M)
2. Ground Support
 - a. CSM TM HBR [20.114] (M)
 - b. BET [20.114] (M)
 - c. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.114] (M)

STAR/EARTH LANDMARK NAVIGATION

A. TEST OBJECTIVES

- Sl.32-1 Star/Earth Landmark Navigation Sighting Accuracy
- Sl.32-2 Verify and Update Landmark Sighting Constraints
- Sl.32-3 OSS Adequacy for Navigation Sightings in Deep Space
- Sl.32-4 Crew Capability to Identify Landmarks and Coordinate Optics/Maneuvers
- Sl.32-5 RCS Propellant Use and Time to Accomplish Onboard Navigation
- S20.115-2 Photographs of Earth and Lunar Landmarks

B. TEST REQUIREMENTS

1. Use of the trunion calibration option of P23 preceding these sets of sightings
2. Star/earth landmark sightings under the following conditions [1.32]:
 - a. Three sets after TLI while the spacecraft is less than 50,000 NM from the surface of the earth (TL or TE). These sightings may be made on the same landmark but three different stars will be used
 - b. One set at a sun elevation angle of less than ten degrees. One of the above sightings can be used to satisfy this requirement

Note - Performing sightings on one landmark and one star, then making from three to five "marks" constitutes one set of sightings
3. Approximately ten sequence photographs through the special sextant camera adapter immediately after performing each group of star/earth landmark sightings. This photography must not jeopardize any nav sightings [20.115] - Not Implemented
4. Identification of the landmark closest to sunrise or sunset that is considered acceptable for landmark tracking [1.32]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.12.3 "Cislunar Midcourse Navigation (P23)" including "trunion calibration" option
2. FCAC G-20A "P23 Cislunar Midcourse Nav Measurement"
3. Photo checklist TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Difficulties and/or inadequacies noted in handling the optics and the spacecraft [1.32] (M)

b. Log navigation data on Flight Plan timeline [1.32] (M)

c. Photo log TBD [20.115] (HD)

2. Ground Support

a. CSM TM HBR [1.32] (M)

b. BET [1.32] (M)

PASSIVE THERMAL CONTROL MODES

A. TEST OBJECTIVES

- PI09-1 PTC Procedures & RCS Use - Roll With Att. Hold
- PI09-2 PTC Procedures & RCS Use - Roll W/O Att. Hold
- PI09-3 Communications Procedures Adequacy for PTC Mode
- PI09-4 PTC Procedures & RCS Use - Yaw W/O Att. Hold

B. TEST REQUIREMENTS

1. At least six uninterrupted hours of PTC in the translunar phase with the following conditions:
 - a. CSM (X) axis oriented perpendicular to the sun-spacecraft line and with the (-X) axis approximately perpendicular to the CSM-earth line of sight
 - b. Spacecraft attitude control in maximum deadband in pitch and yaw and roll free and rolling from 0.1 to 0.5 deg/sec.
2. At least six uninterrupted hours of PTC in the transearth phase with the following conditions:
 - a. CSM (X) axis oriented perpendicular to the sun-spacecraft line and with the (-X) axis approximately perpendicular to the CSM-earth line of sight
 - b. Spacecraft attitude control free in all axes with a roll rate of from 0.1 to 0.5 deg/sec
 - c. Deviation (coning) of (-X) axis from original orientation to be maintained to less than 15 degrees
3. If the above two modes are found to be inadequate during real time, at least six uninterrupted hours of PTC in the transearth phase with the following conditions:
 - a. CSM (+X) axis toward the sun with the high gain antenna boom on the earth side in the sun-earth-moon plane.
 - b. Spacecraft attitude control free with rotation about the major inertia axis at a rate of between 0.1 and 0.5 deg/sec
 - c. Deviations of rotational axis from original orientation to be maintained less than 7.5 degrees
4. Normal communications procedures evaluation during PTC

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph TBD - meanwhile use "Special PTC Procedure"
2. "Passive Thermal Control Mode 1" (X Axis Roll, Pitch and Yaw Hold) or

3. "Passive Thermal Control Mode 2" (X Axis Roll W/O Pitch and Yaw Hold) or
4. "Passive Thermal Control Mode 3" (Yaw - Z Axis with Pitch and Roll Free)

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs

- a. Procedural difficulties in establishing, maintaining or terminating PTC (M)
- b. Narration of procedure and results when establishing or correcting the PTC Mode (M)
- c. Difficulties in establishing and maintaining S-band communications during the PTC Mode (M)
- d. Log PTC maneuver correction times & difficulties on the Flight Plan timeline where they occur (M)

2. Ground Support

- a. CSM TM HBR (M)
- b. BÉT (M)
- c. MSFN records of received S-band signal strength (M)
- d. Flight Director reports of procedural and/or timeline difficulties or inadequacies (M)

STAR/LUNAR HORIZON NAVIGATION

A. TEST OBJECTIVES

- Pl.33-1 Star/Lunar Horizon Navigation Sighting Accuracy
- Pl.33-2 OSS Adequacy for Navigation Sightings in Deep Space
- Pl.33-3 Crew Capability to Coordinate Optics/Maneuvers
- Pl.33-4 RCS Propellant Use and Time to Accomplish Onboard Navigation
- S20.115-3 Photographs of Earth and Lunar Horizons

B. TEST REQUIREMENTS

1. Use of the trunnion calibration option of P23 preceding a set of sightings if more than about 30 minutes has elapsed since the previous P23 trunnion calibration [1.33]
2. Translunar - Near Earth
 - a. Five sets of star/lunar horizon sightings at more than 15,000 NM and less than 50,000 NM from the center of the earth [1.33]
 - b. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.33]
3. Transearth - Near Moon
 - a. Fourteen sets of star/lunar horizon sightings at less than 50,000 NM from the center of the moon [1.33]
 - b. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.33]
 - c. At least 10 sequence photographs through the special sextant camera adapter while duplicating star/horizon navigation sightings when between 10,000 and 20,000 NM from the moon on the TE phase. It is desirable that these photographs be taken at varying distances [20.115] - Not Implemented
4. Transearth - Midcourse
 - a. Nineteen sets of star/lunar horizon sightings at more than 50,000 NM from the center of the moon [1.33]
 - b. Update of the onboard state vector utilizing the navigation sighting data following each set of sightings [1.33]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.12.3 "Cislunar Midcourse Navigation (P23)" including "trunnion calibration" option
2. FCAC G-20A "P23 Cislunar Midcourse Navigation Measurement"
3. Photo checklist TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Difficulties and/or inadequacies noted in handling the optics and the spacecraft [1.33] (M)
 - b. Log navigation data on Flight Plan timeline [1.33] (M)
 - c. Photo log TBD [20.115] (HD)
2. Ground Support
 - a. CSM TM HBR [1.33] (M)
 - b. BET [1.33] (M)

STAR VISIBILITY

A. TEST OBJECTIVES

- Sl.35-2 Obtain Data - Star Visibility During TL and TE Coast
- Sl.35-3 Degradation of Navigation or IMU Alignment by Vented or Ejected Materials

B. TEST REQUIREMENTS

1. Star visibility tests by observing the star field surrounding the navigation star targets of opportunity through the SCT and identifying the dimmest star in the star pattern under at least the following conditions:
 - a. Sun - SCT LOS approximately 120°
 - b. Sun - SCT LOS approximately 70°
2. Light adaptation period required prior to performing visibility tests
3. Evaluation of the effect of vented particles on the use of the optics during IMU realignments and navigation sightings

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.11.2 "IMU Realign (P52)" or
2. AOH paragraph 4.12.3 "Cislunar Midcourse Navigation (P23)"
3. FCAC G-39 "P52 IMU Realign" or
4. FCAC G-20A "P23 Cislunar Midcourse Navigation Measurement"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
Identify and record dimmest star during each visibility test
2. Ground Support
BET during star visibility tests (M)

A. TEST OBJECTIVES

- S1.30-3 Overall GNCS Errors During Thrusting Maneuvers
- S3.21-1 SPS Isp - Adequacy of Conversion of Gnd. to Vacuum Results
- S3.21-2 SPS Performance for LOI and TEI Burns
- S3.21-4 Thermal Effects - Long SPS Burn - Heat Protection System
- P7.32-3 S-Band High Gain Antenna Dynamic Response During SPS Burns
- P20.105-1 Crew/Spacecraft/MSFN Preparation and Execution of LOI Maneuver
- P20.105-2 Procedures and Timeline Adequacy for LOI Maneuver

B. TEST REQUIREMENTS

1. SPS operation to insert the CSM into lunar orbit in two stages as follows [20.105]:
 - a. The first burn of approximately 245 seconds in duration will insert the CSM into a 60 x 170 NM orbit
 - b. The second burn of approximately 10 seconds in duration will circularize the orbit to 60 NM
2. CSM fully loaded at liftoff [20.105]
3. FQTR ON for SPS thrust buildup, 5 sec at steady state and for thrust tailoff, during first LOI-1 only [7.32]
4. DSE recording immediately before, during, and after both burns [3.21]
5. DSE recording or TM for at least five seconds duration at approximately 15 minute intervals for about three hours after LOI-1 [3.21]
6. After LOI-1 it is HD to orient the CSM to an attitude that will result in a near constant external thermal environment to the SPS aft bulkhead during the subsequent 45 minute period. The aft bulkhead should be shielded from solar radiation during this period by orienting the (+X) axis toward the sun [3.21] N.I.
7. IMU realignment performed as soon prior to LOI-1 as practicable [20.105]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.14.2 "G&N SPS Orbit Change Thrusting (P40)"
2. FCAC G-32 "SPS Thrusting (P40)"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Procedural and/or timeline difficulties or inadequacies [20.105] (M)

- b. Feasibility of monitoring abort parameters on FDAI's [20.105] (M)
 - c. Adequacy of contact with ground operational support [20.105] (HD)
 - d. If the PU valve position is changed, record GET \pm 1 sec and new valve position [3.21] (M)
2. Ground Support
- a. CSM TM LBR [20.105] (M)
 - b. BET [3.21] (HD), [20.105] (M)
 - c. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.105] (M)

LUNAR LANDMARK TRACKING

A. TEST OBJECTIVES

- P20.111-1 Error Uncertainties in Lunar Landing Site Location
- P20.111-2 Obtain Data to Calibrate MSFN at Lunar Distance
- P20.111-3 Determine Minimum Sun Angle to Clearly Identify Lunar Landmarks
- P20.111-4 Lunar Landmark Tracking in Earthshine
- P20.111-5 Adequacy of CSS and OSS for Obtaining Landmark Sightings
- P20.111-6 Crew Ability to Coordinate Landmark Sightings and Vehicle Maneuvers
- P20.111-7 RCS Propellant and Time Required for Landmark Sighting

B. TEST REQUIREMENTS

1. At least 12 sets of four marks each obtained on four selected landmarks according to the following schedule:
 - a. Track a pre-selected pseudo landing site (same terrain and lighting as the lunar landing site) for four consecutive revolutions. The sun elevation angle to be five degrees on the first tracking orbit
 - b. Track three pre-selected landmarks (or others deemed acceptable by the crew). The same three landmarks to be tracked in a four orbit tracking sequence. It is highly desirable that the sun angle be greater than 60 degrees.
 - c. An attempt made to track a landmark at a sun elevation angle of three degrees
2. On one revolution, CMP verbal description of the terrain near the sunrise terminator as observed through the scanning telescope. The observation to be made from about 10° preceding the terminator to about 15° past the terminator in the earthlit portion of the dark side. The optics angle to be fixed and the spacecraft in an orbital rate mode.
3. If the observations made of the earthlit landmarks reveals that it is feasible, it is highly desirable that the crew track two landmarks (four marks each) on two successive earthlit passes.
4. IMU realigned during the dark pass preceding each tracking sequence
5. DSE Tape Recorder ON for 20 seconds following each set of marks while N49 (ΔR , ΔV) displayed
6. ORDEAL functioning

7. Photographic records of each of the four tracked landmarks using the special sextant camera adapter and D. A. camera at 12 Fps and taking the photographs at the same time as making the MARK during sighting. Take one photograph of each landmark on two consecutive passes (i.e., eight pictures)

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.12.2, "Orbital Navigation (P22)"
2. FCAC G-18 "P22 Orbital Navigation"
3. FCAC "Lunar Landmark Tracking" TBD
4. Reference Photographic Operation's Plan, Apollo 8

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Verbal description of lunar terrain during earthshine landmark lighting evaluation (M)
 - b. Comments on the effect of earthshine while tracking lunar landmarks (M)
 - c. Procedural and/or timeline difficulties or inadequacies (M)
 - d. "Landmark Tracking Log" (Flight Plan)
 - e. Photo log
 1. Film mag IP
 2. GET camera - ON
 3. Initial shutter speed
 4. Final shutter speed
 5. Estimated remaining film at beginning and end of a sequence

PHOTOGRAPHY

A. TEST OBJECTIVES

- 1.35-3 Photographs of Vented Particles Through Windows
- 20.115-1 Overlapping Photographs from Terminator to Terminator - Lunar Orbit
- 20.115-3 Photographs of Earth and Lunar Landmarks
- 20.115-4 Photographs of General and Scientific Interest

B. TEST REQUIREMENTS

1. Terminator-to-terminator photographs on at least two passes as follows:
 - a. The first pass consisting of vertical photos with 55-60% forward overlap taken at 20 sec intervals
 - b. The subsequent pass consisting of photos taken with the camera axis 20° from local vertical. From the far side terminator to 90° sun elevation at the nadir, the camera axis will be inclined 20° forward along the orbital plane. At 90° , the camera axis will be aligned 20° aft of the nadir in the orbital plane
2. Sequence camera photographs if possible of the following targets of opportunity:
 - a. Vertical zero phase (250 mm lens)
 - b. High angle zero phase: Apollo landing sites and geologic units (250 mm lens)
 - c. Vertical terminator (250 mm lens)
 - d. Oblique terminator (250 mm lens)
 - e. Specific feature near vertical and oblique (250 mm)
 - f. Specific area near vertical (80 mm)
 - g. Lunar exploration site:
 - (1) Near vertical or oblique as required (250 mm lens)
 - (2) Approach (250 mm lens)
 - h. Surveyor landing sites (250 mm lens)
 - i. Other features and phenomena as observed (250 mm lens)
 - j. Image motion compensation (250 mm lens)

3. Dim light and astronomical photos attempted either during TL or TE coast or during dark portion of lunar orbits
 - a. Total darkness preferred -- S/C lighting also as low as possible
 - b. Specific star fields should be taken during TL and TE coast and in lunar orbit during earthshine
 4. Photos taken of the lunar surface during earthshine
 5. Solar corona photos taken at sunrise or sunset in lunar orbit using the moon as an occultating disc
 6. Earth photos during TL coast when the S/C is within 40,000 NM of the earth. The S/C shall be oriented with the (+X) axis toward earth for approximately 10 minutes for these photos
 7. Sequence camera photographs of the lunar terrain as viewed through the rendezvous window while duplicating the Post LOI-2 approach attitude of missions F and G.
 8. Photographs of vented particles through windows when observed
- C. TEST PROCEDURES/CHECKLISTS
1. Photographic Operation Plan for Apollo Mission C'
- D. DATA REQUIREMENTS
1. Flight Crew Reports/Logs
 - a. Photos of lunar surface per Test Requirement No. 1 above (M)
 - b. Photos of scientific and general interest subjects as defined by photo plan (HD)
 2. Ground Support
BET (M)

A. TEST OBJECTIVES

- S3.21-1 SPS Isp - Adequacy of Conversion of Ground to Vacuum Results
- S3.21-2 SPS Performance for LOI and TEI Burns
- S3.21-3 SPS PUGS in Auxiliary Mode - Relative Accuracy of Aux and Pri
- S3.21-4 Thermal Effects - Long SPS Burn - Heat Protection System
- P20.106-1 Crew/Spacecraft/MSFN Preparation and Execution of TEI Maneuver
- P20.106-2 Procedures and Timeline Adequacy for TEI Maneuver

B. TEST REQUIREMENTS

1. SPS use for injection of the CSM into transearth coast [3.21]
2. DSE recording of TM for the period 40 seconds prior to, during, and two minutes after the TEI burn [3.21, 20.116]
3. DSE recording or TM of at least five seconds duration at approximately 15 minute intervals for about three hours after TEI [3.21]
4. PUGS mode switch in the AUX position during the SPS burn [3.21]
5. After the burn it is HD to orient the CSM to an attitude that will result in a near constant external thermal environment to the SPS during the subsequent 45 minute period. The aft bulkhead should be shielded from solar radiation during this period by orienting the (+X) axis toward the sun [3.21] - N.I.
6. IMU realignment performed as soon before TEI as practicable [20.106]
7. CMC update provided on a timeline similar to the LLM such that errors at T_{ig} can be determined and compared with predicted estimates [20.106]

C. TEST PROCEDURES/CHECKLISTS

1. AOH paragraph 4.14-2 "G&N SPS Orbit Change Thrusting (P40)"
2. FCAC G-32 "SPS Thrusting (P40)"

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
 - a. Adequacy of contact with ground operational support [20.106] (HD)
 - b. If the PU valve position is changed, record GET ± 1 sec and new valve position [3.21] (M)

2. Ground Support

1. CSM TM LBR [3.21, 20.106] (M)
2. BET [3.21] (HD), [20.106] (M)
3. Flight Director reports of procedural and/or timeline difficulties or inadequacies [20.106] (M)
4. Flight Operations Plan [20.106] (M)

ENTRY

A. TEST OBJECTIVES

- 1.31-1 GNCS Performance During Entry - Lunar Return
- 1.31-2 EMS Capability to Monitor Entry - Lunar Return
- 4.5-1 ECS Performance During Manned Lunar Return Entry
- 4.5-2 Compare ECS Data With Development Model & Unmanned Results
- 7.30-1 Block II Thermal Protection System - Manned Lunar Return Entry
- 7.30-2 TPS Surface Recession and Char Data Comparison With Models
- 20.116-2 Changes in Total Transmittance of Windows

B. TEST REQUIREMENTS

- 1. Entry velocity at 400,000 ft. altitude at least 36,000 feet per second [7.30]
- 2. Automatic lunar return entry - nominal range 1350 NM and 2500 NM maximum for inclement weather [1.31]
- 3. DSE ON during entry "blackout" - recorder fully rewound and on HBR starting at CSM/SM separation [1.31]
- 4. Crew monitor the EMS and record voice on the DSE during entry [1.31]

C. TEST PROCEDURES/CHECKLISTS

- 1. AOH paragraph 4.17.7, "G and N Entry"
- 2. FCAC "Entry"

D. DATA REQUIREMENTS

- 1. Flight Crew Reports/Logs
 - a. Comments on adequacy of DSKY, FDAI and EMS displays to evaluate entry conditions [1.31] (HD)
 - b. Comments on crew comfort [4.5] (HD)
- 2. Ground Support
 - a. CSM TM HBR [1.31, 4.5] (M)
 - b. BET [1.31, 7.30] (M)
 - c. EMS Scroll Recovery [1.31] (M)
 - d. CM Recovery [7.30] (M)
 - e. Heat Shield core sample after recovery [7.30] (M)
 - f. All S/C window outer panes after recovery [20.116] (M)

MISCELLANEOUS TESTS

A. TEST OBJECTIVES

- P7.31-1 Thermal Control System During PTC
- P7.31-2 Thermal Control System During Lunar Orbit
- P20.107-1 Crew Procedures for Lunar Orbit Mission
- P20.107-2 Crew Procedures Timeline Adequacy - Lunar Mission
- S20.108-1 EPS Use, Performance and Fuel Cell Management
- S20.108-2 Water and Oxygen Requirements Data
- S20.108-3 LiOH Cartridge Requirements Data
- S20.108-4 SPS, SM/RCS & CM/RCS Propellant Requirements Data -
Translation and Attitude Maneuvers
- S20.108-5 Crew Food Requirements Data
- 20.110-1 Ground Operational Support for Lunar Mission Without LM

B. TEST REQUIREMENTS

1. Operation of the CSM in lunar orbit, undocked to determine the thermal properties of the spacecraft insulation [7.31]
2. Determination of the effectiveness of the thermal control system to provide a safe environment for operation of spacecraft equipment and consumables [7.31]
3. Accomplishment of all CM procedures peculiar to the lunar orbit mission in the same manner, where possible, as required for the LLM [20.107]
4. Management of the EPS during the lunar mission per the flight plan [20.108]
5. Utilization of the potable water produced during EPS operation as necessary [20.108]
6. Utilization of the oxygen supply system during the lunar mission as required [20.108]
7. Management of the replacement of LiOH cartridges during the mission per the flight plan [20.108]
8. Management of the consumption of the SPS and RCS propellants during the lunar mission as required [20.108]
9. Utilization of the food supply per the flight plan [20.108]
10. Performance of operational ground support of the spacecraft throughout the mission with emphasis on those phases being accomplished for the first time as part of a lunar orbit mission [20.110]

C. TEST PROCEDURES/CHECKLISTS

1. AOH CSM 103 SM2A-03-SC103-2

2. FCAC CSM 103

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs

a. Narrative describing any recommended changes in procedures and/or equipment required to accomplish the procedures [20.107] (M)

b. Comments on any procedure requiring repeating or any procedure not completed [20.107] (M)

c. Water Count Log [20.108] (M)

d. LiOH Log [20.108] (M)

e. Astronaut Menus [20.108] (HD)

f. Comments on ECS environment comfort level [20.108] (HD)

2. Ground Support

a. CSM TM HBR [7.31, 20.108] (M)

b. BET [7.31, 20.108] (M)

c. MSFN voice recording of CSM/MSFN communications [20.107] (HD)

d. Chemical analysis of recovered LiOH cartridges [20.108] (M)

e. Measurement of recovered water quantity [20.108] (M)

f. Measurement of energy remaining in recovered Entry and Post-Landing Batteries [20.108] (M)

g. Flight Director reports of mission support activities [20.110] (M)

TELECOMMUNICATIONS

A. TEST OBJECTIVES

- S6.10-1 S-Band Performance with Omni Antennas at Lunar Distance (85' MSFN)
- P6.11-1 S-Band Performance with High Gain Antenna During TL Coast
- P6.11-2 S-Band Performance with High Gain Antenna at Lunar Distance
- S20.104-3 S-Band Communications Performance During Transposition
- S20.109-3 Communications Procedures During PTC

B. TEST REQUIREMENTS

1. Continuous CSM/MSFN S-band communication during transposition using CSM omni and 85' ground antennas [20.104]

<u>Signal Combination</u>	<u>Communications Mode</u>	
	<u>Uplink</u>	<u>Downlink</u>
4.2	Carrier, PRN, Voice	Carrier, PRN, Voice, HBR

2. MSFN performance of various designated S-band communication mode tests of at least two minutes each as soon as practical after high gain antenna deployment (near earth) using the 85' ground antenna and the CSM high gain antenna as follows: [6.11]

<u>Signal Combination</u>	<u>Communications Mode</u>	
	<u>Uplink</u>	<u>Downlink</u>
4.2	Carrier, PRN; Voice	Carrier, PRN, Voice, HBR
6.2	Carrier, PRN, Voice, Updata	Carrier, PRN, Voice, HBR
.2		Recorded voice, LBR
4.3	Carrier, PRN, Voice	Carrier, PRN, Voice, LBR
6.3	Carrier, PRN, Voice, Updata	Carrier, PRN, Voice, LBR
5.2	Carrier, PRN, Updata	Carrier, PRN, Voice, HBR
8.1	Carrier, BU Voice	Carrier, Voice, LBR
.4		CSM television

3. MSFN performance of various designated S-band communication mode tests at lunar distance using 85' ground antenna or equivalent lunar distance using 30' ground antenna* and the CSM omni antennas [6.10]

*NOTE: The test can be accomplished under any one of the three following conditions which represent lunar distance or equivalent:

- a. Greater than 200 K NM with 85-foot dish (preferred)
- b. At 100 K \pm 10% NM with cooled 30-foot dish (HAW, CWM, ASC, CRO)
- c. At 70 K \pm 10% NM with uncooled 30-foot dish (others)

<u>Signal Combination</u>	<u>Communications Mode</u>	
	<u>Uplink</u>	<u>Downlink</u>
.5		Carrier, LBR
.6		Carrier, Key Subcarrier
1.7	Carrier, PRN	- Carrier, PRN
.8		Carrier, BU Voice, LBR
.10		Carrier, BU Voice

4. MSFN performance of various designated S-band communication mode tests at lunar distance using 85' ground antenna or equivalent lunar distance using 30' ground antenna* and CSM Hi gain antenna [6.11]

<u>Signal Combination</u>	<u>Communications Mode</u>	
	<u>Uplink</u>	<u>Downlink</u>
4.2	Carrier, PRN, Voice	- Carrier, PRN, Voice, HBR
5.2	Carrier, PRN, Updata	- Carrier, PRN, Voice, HBR
4.3	Carrier, PRN, Voice	- Carrier, PRN, Voice, LBR
8.1	Carrier, BU Voice	- Carrier, Voice, LBR

5. During steerable S-band antenna tests, demonstration of manual acquisition and automatic tracking using wide, medium and narrow beamwidths

C. TEST PROCEDURES/CHECKLISTS

1. AOH Section 4.7.6, "Telecommunications", paragraphs 4.7.6.1 through 4.7.6.10
2. FCAC communications checklist TBD

D. DATA REQUIREMENTS

1. Flight Crew Reports/Logs
Comments on voice quality in flight plan [6.10, 6.11 & 20.104] (M)
2. Ground Support
 - a. CSM TM HBR [6.10, 6.11] (M)
 - b. CSM MSFN Voice records [6.10, 6.11, 20.104]

*NOTE: The test can be accomplished under any one of the three following conditions which represent lunar distance or equivalent:

- a. Greater than 200 K NM with 85-foot dish (preferred)
- b. At 100 K \pm 10% NM with cooled 30-foot dish (HAW,CWM,ASC,CRO)
- c. At 70 K \pm 10% NM with uncooled 30-foot dish (others)

- c. Flight Director reports of procedural and/or timeline difficulties or inadequacies in implementing all required communication tests [6.10, 6.11, 20.104] (HD)
- d. USB TM bit stream [6.10, 6.11, 20.104] (M)
- e. USB tracking data processor output [6.10, 6.11] (HD), [20.104] (M)
- f. MSFN records of received S-band carrier strength [6.10, 6.11, 20.104] (M)
- g. MSFN tape recordings of GSM to MSFN emergency key mode [6.10] (M)

APOLLO 8 CREW STATUS REPORTS

Purpose:

1. To enhance crew safety.
2. To acquire data on food, water, sleep and exercise requirements for future mission planning.
3. To obtain medical data required for analysis and correlation with the inflight bioenvironmental data and the pre- and postflight physical examination results.

Requirements:

To obtain food, water, sleep and radiation data during the Apollo 8 mission and exercise data postflight.

Procedures:

During the Apollo 8 mission, two crew status reports via air-to-ground communications will be made by the flight crew during each 24-hours ground elapsed time (GET). The first report will be given after the first meal of the work day and will concern the sleep obtained during the previous sleep period. The second report will be given following the final meal of the work day and will concern the food and water consumed, and the radiation dose received during the previous 24 hours GET. The following information should be transmitted:

1. Food - a daily record of each crew member reflecting the meal identification code together with the description or serial number(s) of only those items not consumed from a scheduled meal.
2. Water - a daily log containing the number of aliquots from the water gun each astronaut drank. Water used for food rehydration will not be recorded.
3. Sleep - a daily notation of each crewman's best estimate as to sleep quantity and quality.
4. Radiation - a daily record of the integrated dose each crewman receives.
5. Exercise (postflight analysis only) - a daily record of the time of exercise, the type, and the duration of exercise performed by each astronaut.



GA

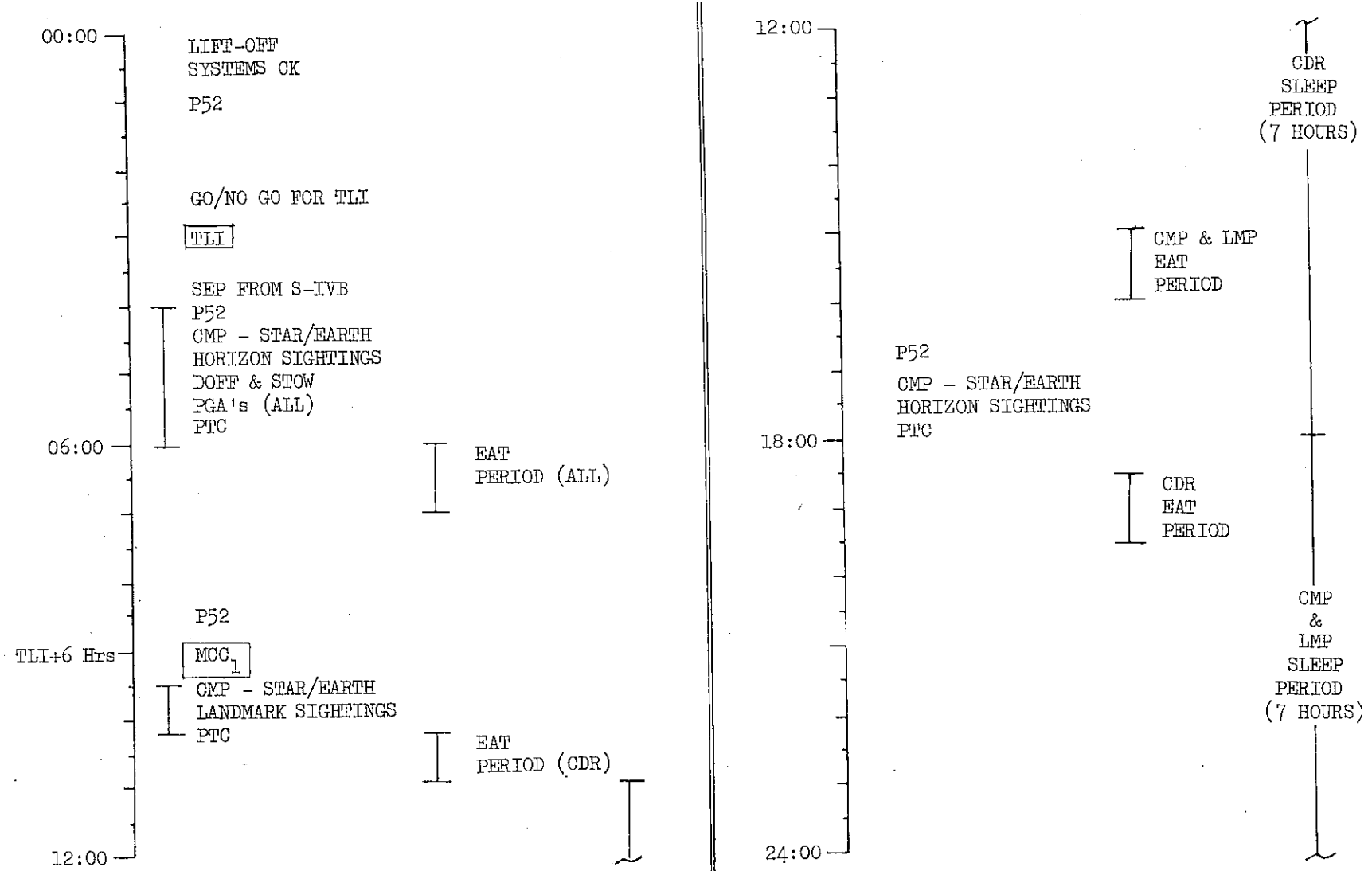
W



SECTION V - SUMMARY FLIGHT PLAN

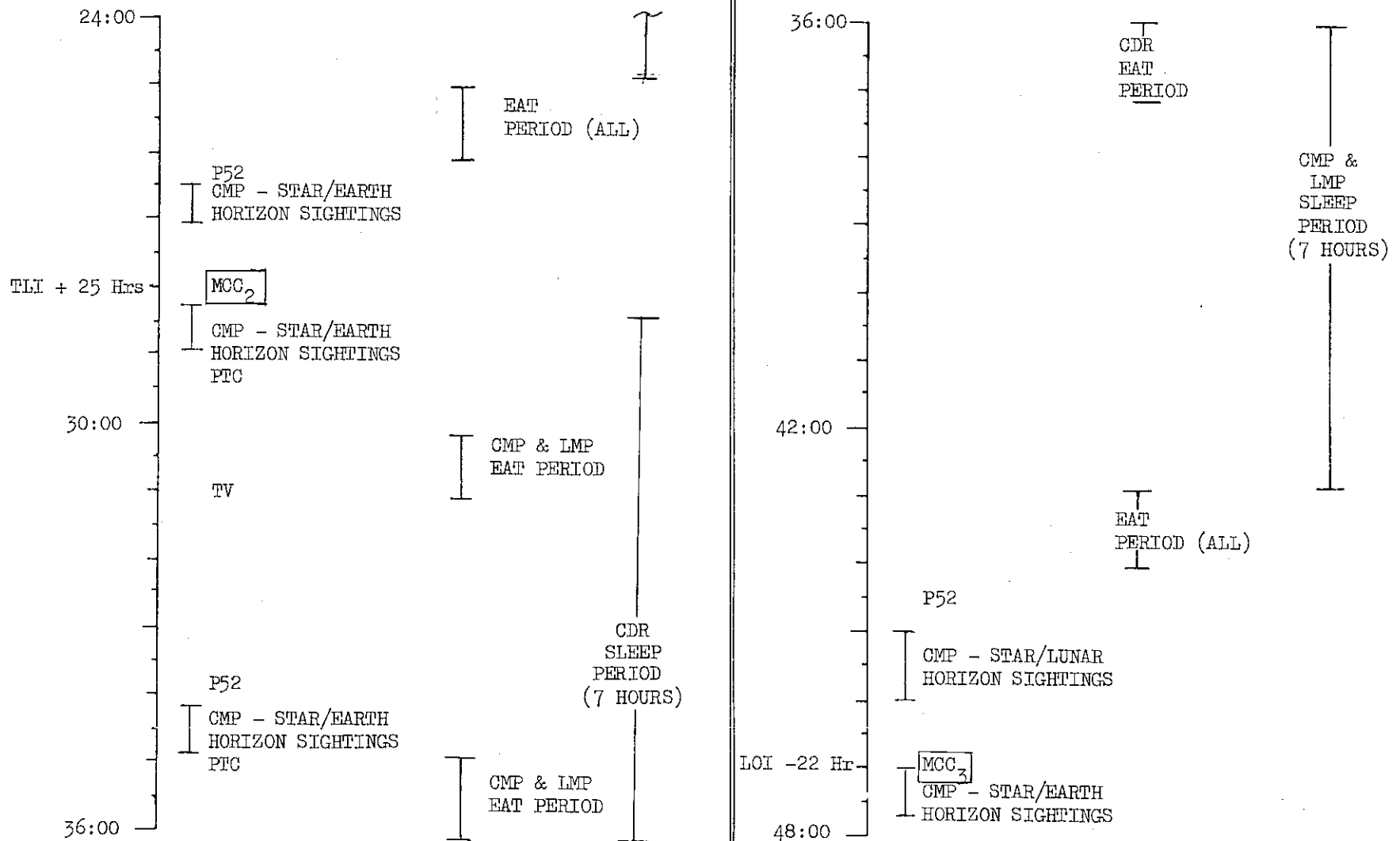


FLIGHT PLAN



MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	00:00 -24:00	1	5-1

FLIGHT PLAN

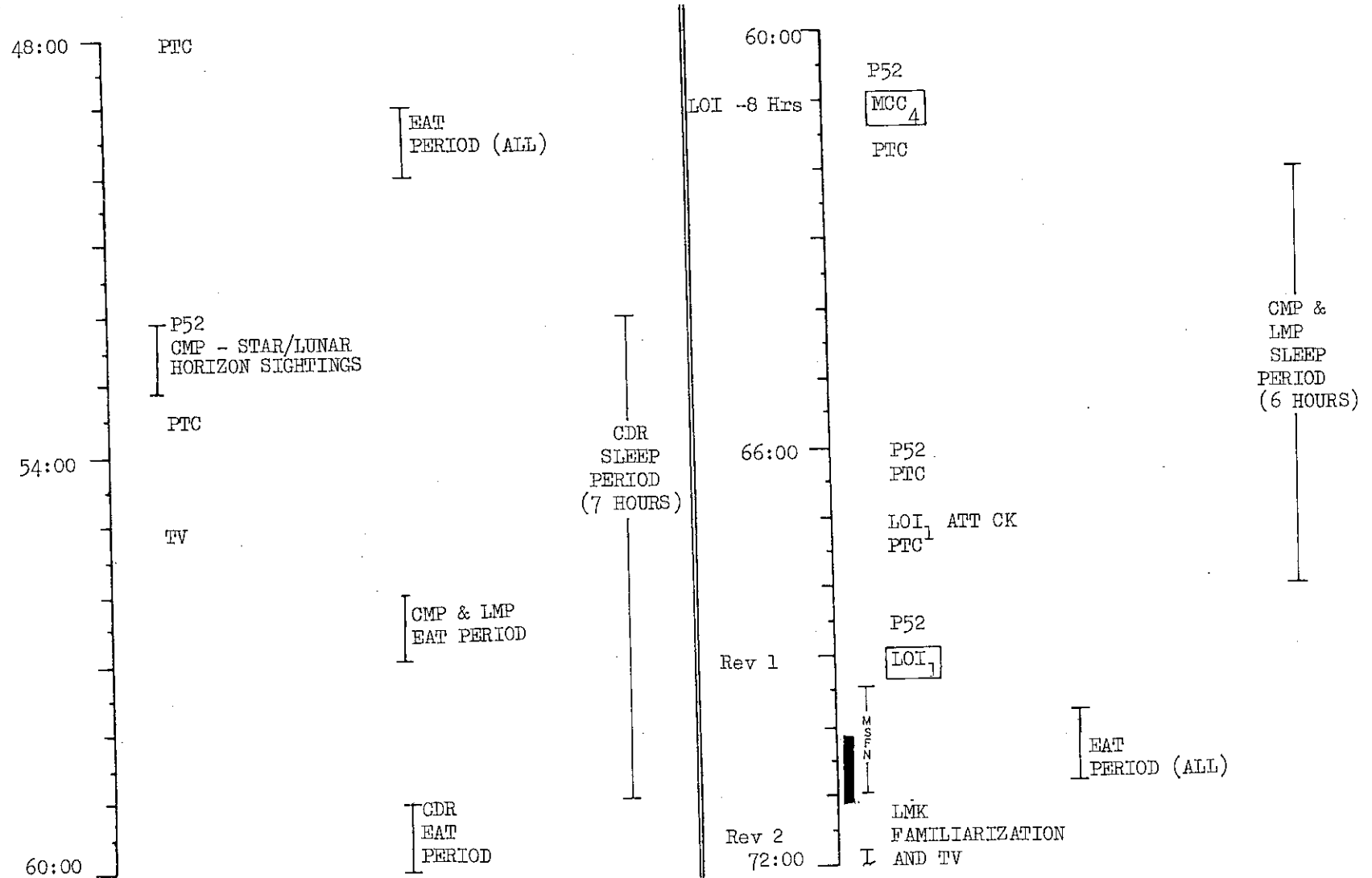


MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	24:00 - 48:00	2	5-2

MSC FORM 1186 (SEP 67)

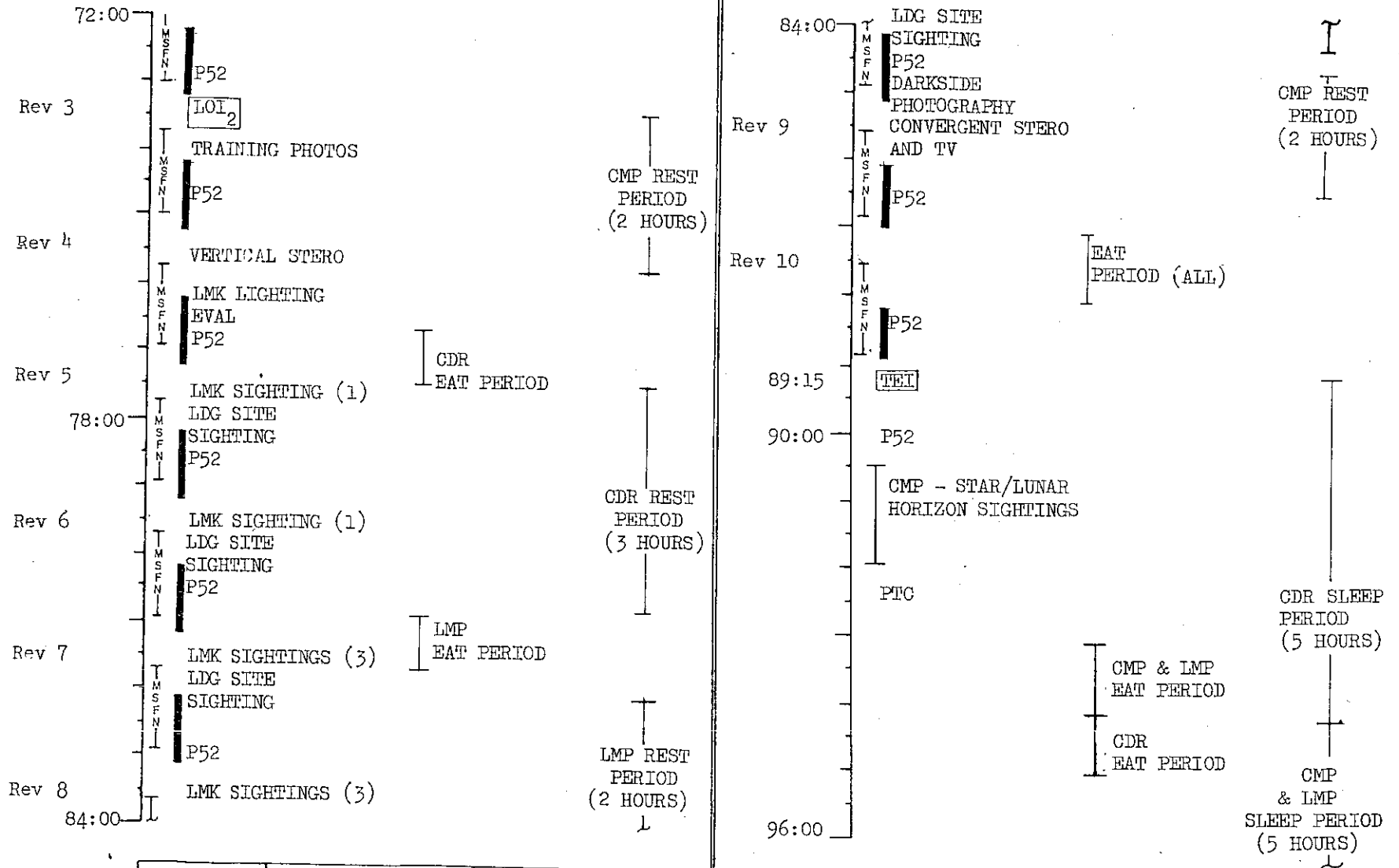
FLIGHT PLANNING BRANCH

FLIGHT PLAN



MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	48:00 - 72:00	3	5-3

FLIGHT PLAN

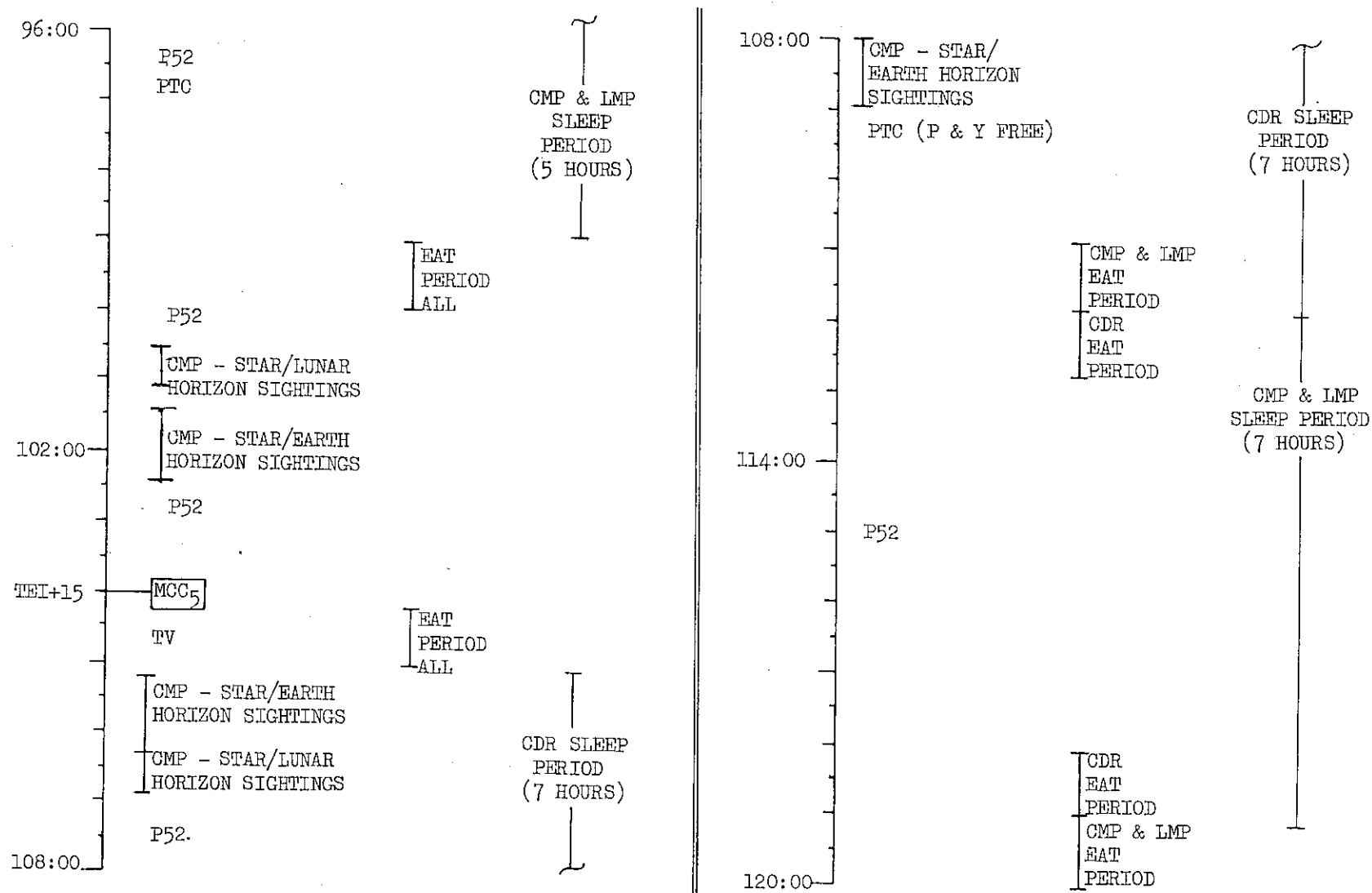


MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	72:00 - 96:00	4	5-4

MSC FORM 1186 (SEP 67)

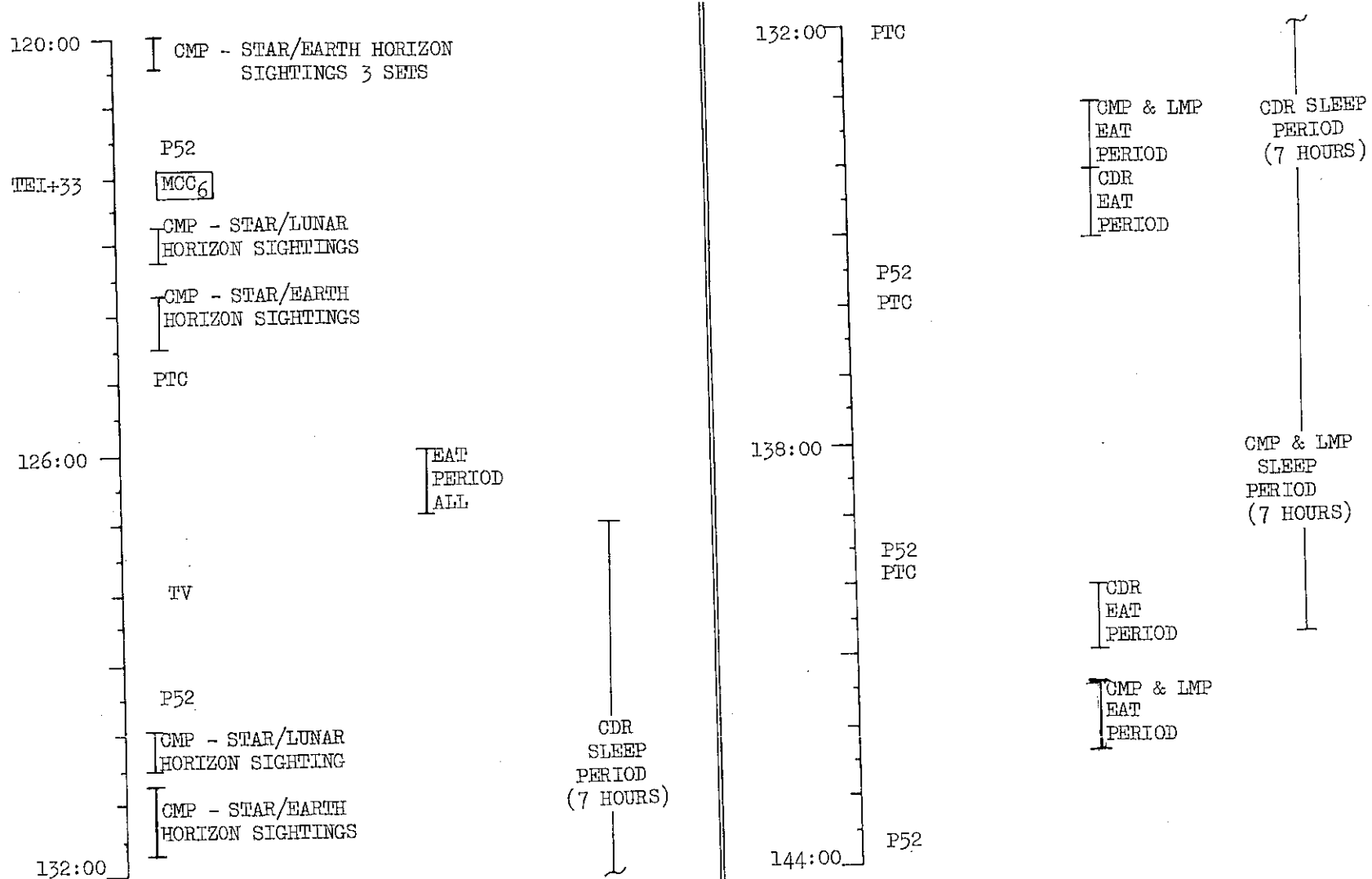
FLIGHT PLANNING BRANCH

FLIGHT PLAN



MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	96:00 - 120:00	5	5-5

FLIGHT PLAN



MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	120:00 - 144:00	6	5-6

FLIGHT PLAN

144:00
 EI -2 HRS
 147:10
 148:00

MCC₇
 P52

CM/SM SEP

EI = 400K

SPLASHDOWN

MISSION	EDITION	DATE	TIME	DAY/REV	PAGE
AS503/103	FINAL	November 22, 1968	144:00 to 146:50	6	5-7

