



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 72-FM-110

April 12, 1972

FINAL CREW CHARTS
FOR APOLLO 16 (J-2 MISSION)
FOR THE APRIL 16, 1972, LAUNCH

Systems Management Branch

MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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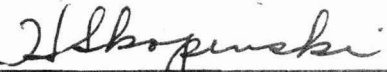
PROJECT APOLLO

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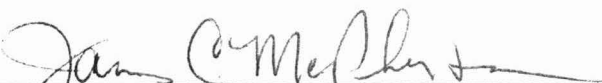
By Data Management Section
Systems Management Branch

April 12, 1972

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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FOREWORD

The purpose of this document is to present the Mission Planning and Analysis Division (MPAD) final crew charts for the Apollo 16 (J-2) mission onboard data file. The command and service module (CSM) charts are in part I, and the lunar module (LM) charts are in part II. These charts were generated by MPAD in response to a request from the Crew Procedures Division (CPD)^a and were coordinated by the Data Management Section of the Systems Management Branch with Ted Guillory of the Flight Planning Branch of CPD.

The final crew charts presented in this document reflect the Apollo 16 trajectory, consumables, and flight plan status as of April 10, 1972. The dependence of each crew chart (i.e., mission independent, profile dependent, profile dependent, flight plan dependent, etc.) is noted on each chart.

Any questions concerning the enclosed crew charts should be directed to Larry D. Davis, Data Management Section, Systems Management Branch, HU3-6361.

^aMemo CG54-71M-210 dated Sept. 9, 1971, signed by T. W. Holloway.

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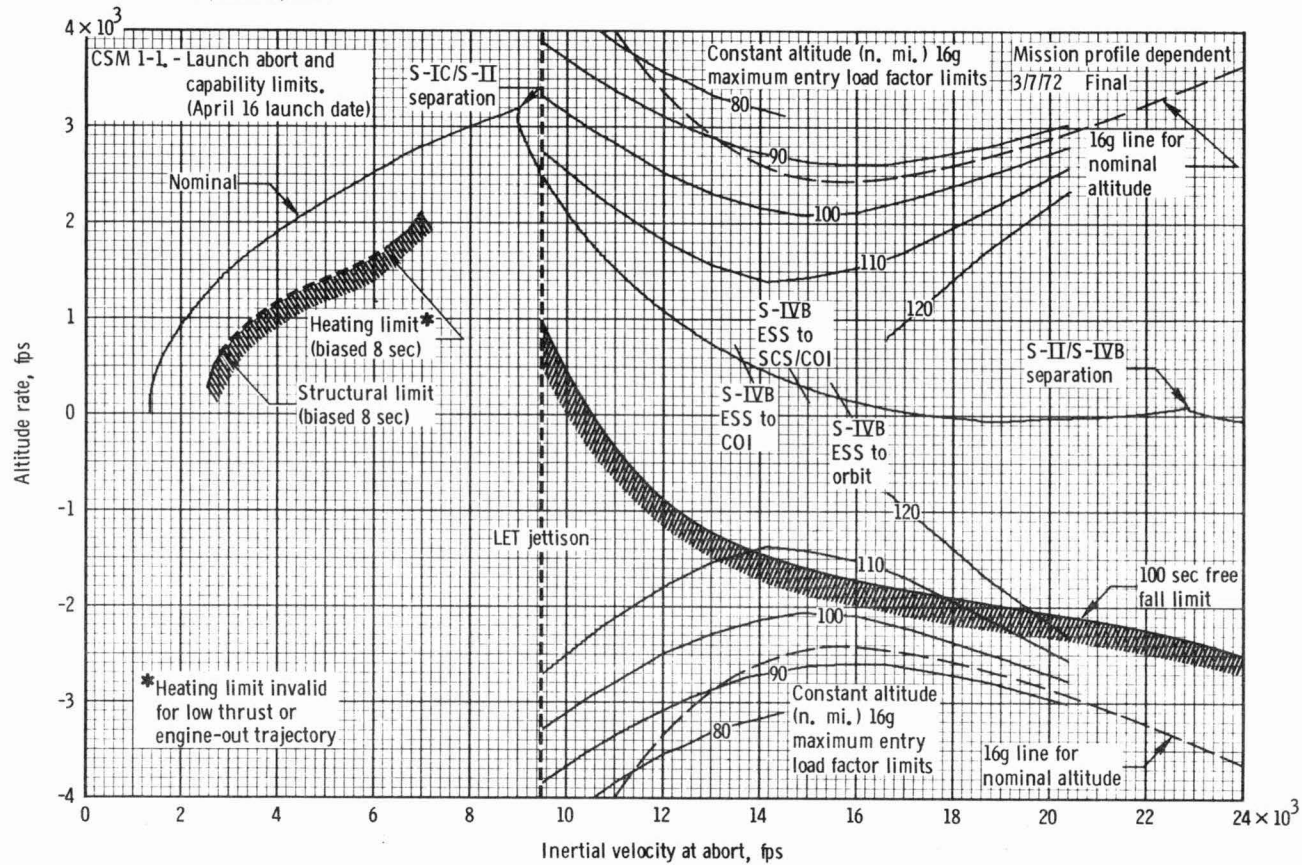
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Henderson/FPB/MPAD (for Launch Checklist)

Data source ODS Vol. I Pt. 1-90, Feb. 1972
April 16 Launch Trajectory, LAR-72-034, N50 Tape No. A14066
 Data confirmed 3/8/72 JH

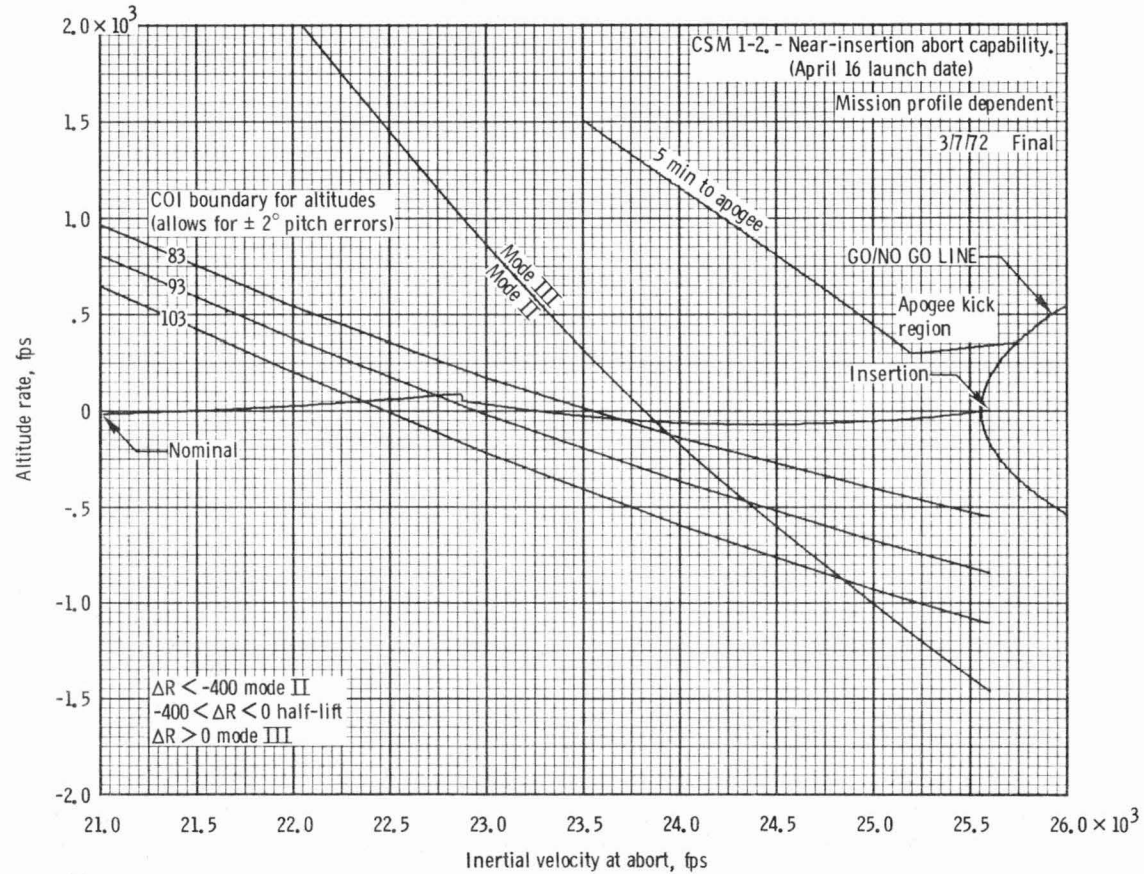


Launch abort and capability limits.

Henderson/FPB/MPAD. (for Launch Checklist)

Data source *ODS Vol I, Pt. 2-90, 14/772*
Apr 16 Launch Trajectory, L.A. = 72059 MSC Tape No. A14066

Data confirmed *3/8/72 G18*



Near-insertion abort capability.

Henderson/FAB/MPAD (for Launch Checklist, CSM Cue Cards)

Data source Apr 16 Launch Traj. L. Az = 72.039°Data confirmed EM MSC Tape No. A14066

CSM 1-3.- Launch trajectory Mission
 parameters - Saturn V boost. profile
 (April 16 launch date) dependent

3/15/72 Final

SATURN V BOOST

	DET	ϕ	V_I	$\dot{H}$	H
	00:00	90	1341	0	-.0
	:30	85	1400	299	.6
	1:00	68	1883	817	3.3
	1:30	49	3044	1504	9.0
	2:00	34	5087	2234	18.2
a	2:18	28	6783	2726	25.4
	2:30	25	7902	2961	31.1
b	2:40	22	8976	3174	36.3
	3:00	22	9164	2777	46.0
	3:30	24	9702	2290	58.4
	4:00	21	10341	1861	68.7
	4:30	19	11079	1464	76.9
	5:00	17	11914	1102	83.2
	5:30	14	12852	778	87.8
	6:00	12	13899	497	90.9
	6:30	9	15067	263	92.8
	7:00	6	16374	86	93.6
	7:30	3	17842	-23	93.7
	8:00	6	19262	-58	93.5
	8:30	0	20618	-28	93.3
	9:00	-3	22003	21	93.2
c	9:17	-5	22869	86	93.4
	9:30	-7	22998	36	93.5
	10:00	-10	23535	-30	93.5
	10:30	-13	24100	-66	93.3
	11:00	-16	24690	-69	92.9
	11:30	-18	25306	-36	92.6
d	11:44	-18	25599	-1	92.6

^aTimebase 2 (S-IC center-engine + .01 sec)^bTimebase 3 (S-IC outboard-engine cutoff + .01 sec)^cTimebase 4 (S-II engine cutoff + .01 sec)^dTimebase 5 (S-IVB guidance cutoff signal + .21 sec)

Henderson/FAB/MPAD (for Launch Checklist)

Data source Orbital Mechanics

Data confirmed SM

CSM 1-4.- Recommended manual EOI Mission independent
shutdown velocities. 4/15/71 Final

SHUTDOWN ALTITUDE, h (N. MI.)	INERTIAL VELOCITY, V_i (fps)	h_a/h_p (N. MI.)
150	25291	150/90
145	25318	145/90
140	25344	140/90
135	25371	135/90
130	25398	130/90
125	25424	125/90
120	25451	120/90
115	25478	115/90
110	25505	110/90
105	25532	105/90
100	25559	100/90
95	25586	95/90
90	25613	90/90
85	25641	90/85
80	25668	90/80
75	25695	90/75
70	25723	90/70

NOTE: Insertion altitude defines cutoff velocity assuming $h = 0$ and results in $h = 90$ n mi (h_a or h_p) $1/2$ rev. later, example: If $h = 75$, V_i @ cutoff = 25,695 results in a 75/90 orbit.

Fraley/GDB/MPAD (for Launch Checklist)

Data source April 16 SLP Procedures Doc

Data confirmed CWF

CSM 2-1.- Gimbal angles for observing
S-IVB through CSM hatch window after
CSM/LM ejection. (April 16 launch date)

Launch day dependent

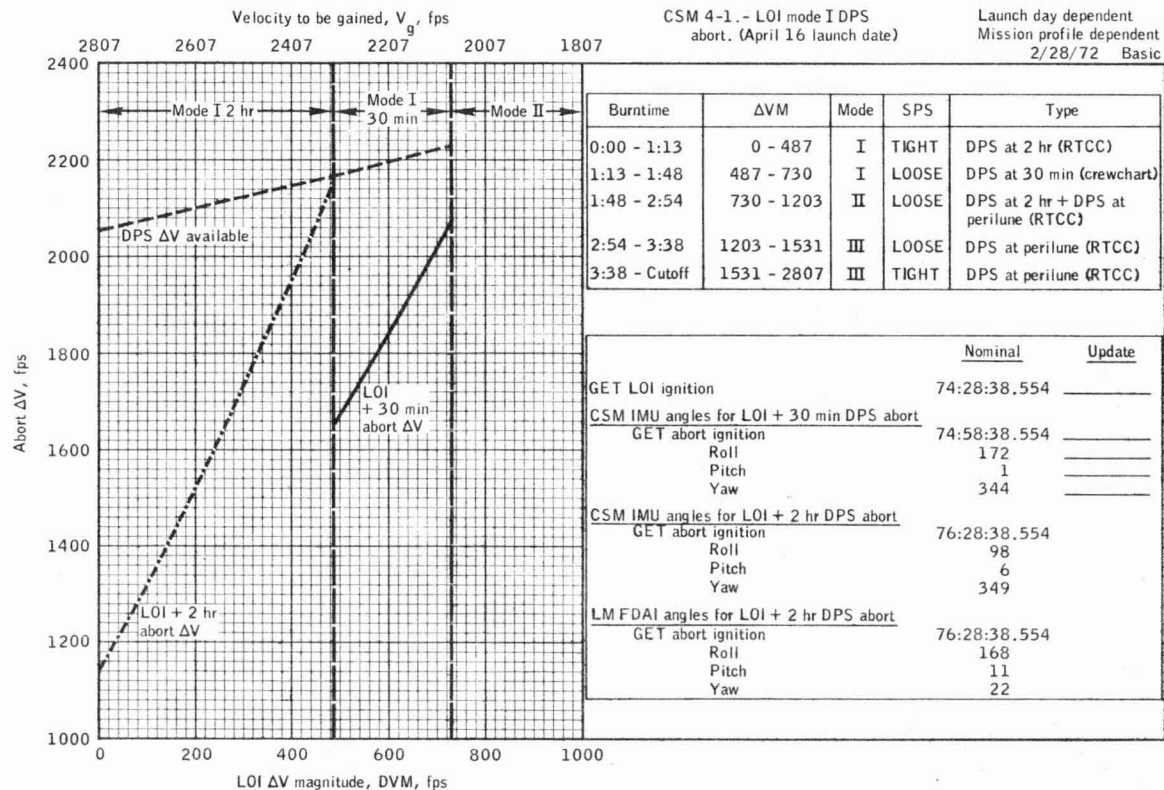
Launch month dependent

Mission profile dependent 2/9/72 Basic

Time from ejection min:sec	S-IVB APS EVASIVE MANEUVER			SM RCS BACKUP EVASIVE MANEUVER		
	SC inertial attitude, deg			SC inertial attitude, deg		
	Roll	Pitch	Yaw	Roll	Pitch	Yaw
CSM/LM ejection 00:00	301.2	325.5	40.9	301.2	325.5	40.9
S-IVB acquired in hatch window 13:00	90.0	325.5	355.9	90.0	325.5	355.9
23:00	90.0	325.5	355.9	90.0	325.5	355.9
25:00	90.0	325.4	22.3	74.3	310.3	0.0
30:00	90.0	145.6	25.3	90.0	325.4	2.1
35:00	90.0	145.5	15.2	90.0	325.4	5.4
40:00	90.0	145.5	11.1	90.0	325.3	8.1
S-IVB venting maneuver 44:20	90.0	145.7	8.6	90.0	324.2	13.4
50:00	57.8	122.1	0.0	41.5	119.2	0.0
55:00	47.5	117.1	0.0	30.9	114.6	0.0

Based on launch site refsmmat

Gonzales/MAB/MPAD (for Contingency C/L, Flight Plan)
 Data source APX-10 16 0.7.
 Data confirmed L.A.

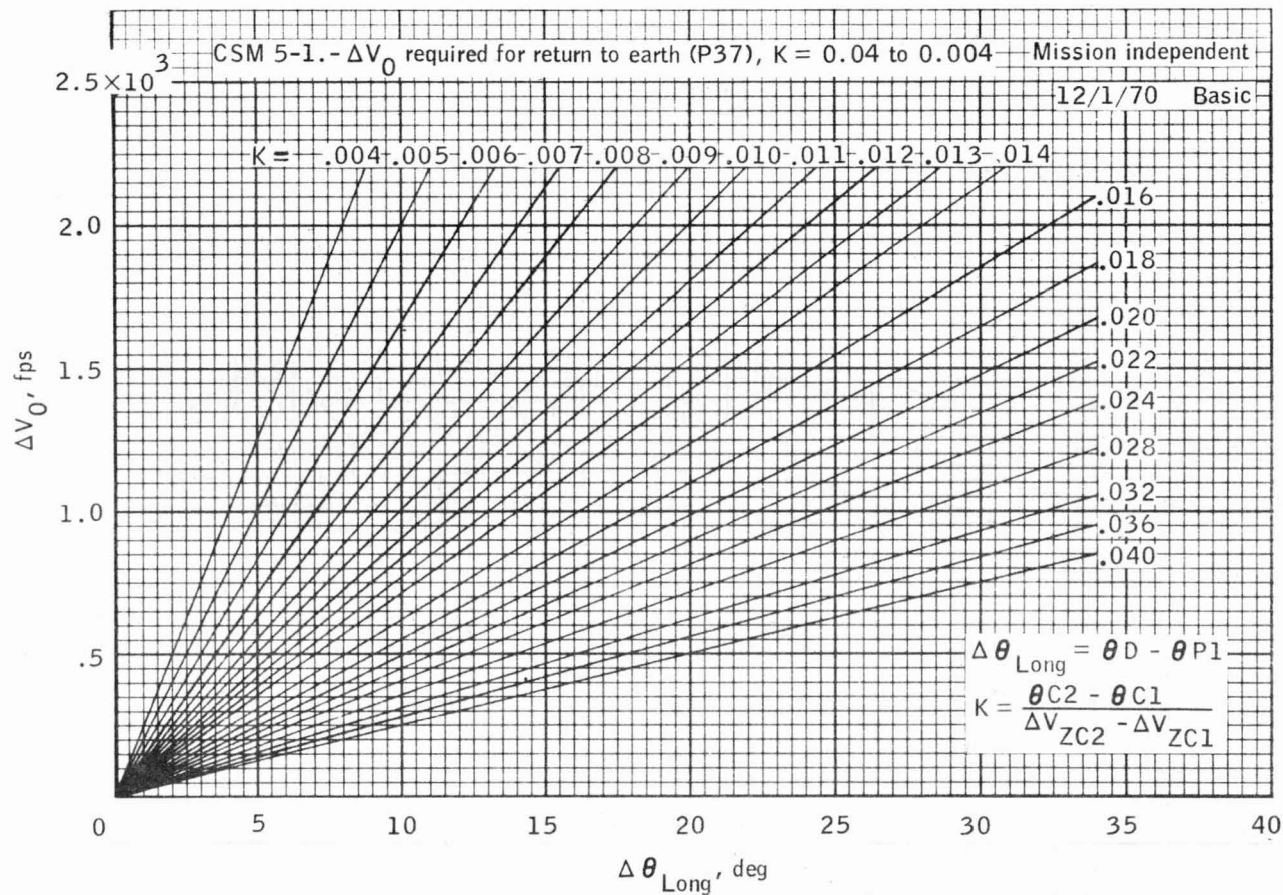


Launch day dependent
 Mission profile dependent
 2/28/72 Basic

Gonzales/LMAB/MPAD (for G and C Checklist)

Data source MIT-AG #239-69, Apollo Dec. Group Memo #5

Data confirmed L. G.

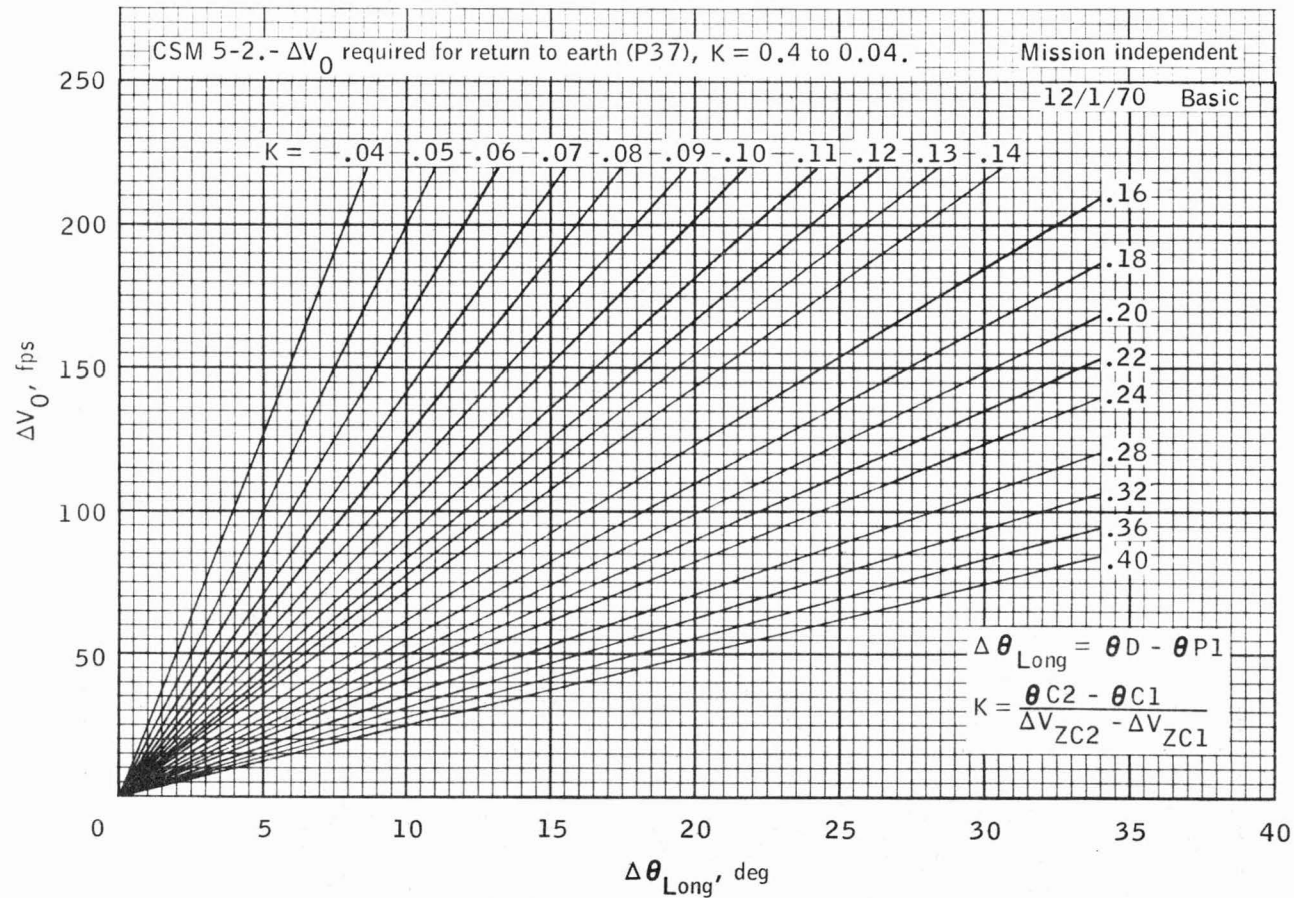


ΔV_0 required for return to earth (P37), $K = 0.04$ to 0.004 .

Gonzales/LMAB/MPAD (for G and C Checklist)

Data source MIT-AG #239-69, Apollo Doc. Group Memo #5

Data confirmed A. &



ΔV_0 required for return to earth (P37), $K = 0.4$ to 0.04 .

Blucker/MPB/MPAD (for G and C Checklist)

Data source JPL EphemerisData confirmed JASCSM 6-1.- Venus unit vectors.
(April 16 launch date)Launch day dependent
Launch month dependent
2/1/72 Basic

0 Hours GET = 4:16:17:54

Liftoff = 4:16:__:__

VENUS UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
.0	.30386	.84562	.43887
5.0	.30064	.84648	.43941
10.0	.29742	.84734	.43995
15.0	.29421	.84818	.44049
20.0	.29100	.84901	.44102
25.0	.28780	.84983	.44154
30.0	.28460	.85064	.44205
35.0	.28141	.85144	.44256
40.0	.27822	.85223	.44306
45.0	.27503	.85301	.44355
50.0	.27186	.85377	.44404
55.0	.26868	.85452	.44452
60.0	.26552	.85527	.44500
65.0	.26236	.85600	.44546
70.0	.25921	.85672	.44593
75.0	.25607	.85742	.44638
80.0	.25293	.85812	.44683
85.0	.24980	.85881	.44727
90.0	.24668	.85948	.44771
95.0	.24357	.86014	.44814
100.0	.24047	.86080	.44856
105.0	.23737	.86144	.44898
110.0	.23429	.86207	.44939
115.0	.23121	.86269	.44979
120.0	.22815	.86330	.45019
125.0	.22509	.86389	.45058
130.0	.22204	.86448	.45096
135.0	.21901	.86506	.45134
140.0	.21598	.86562	.45171
145.0	.21297	.86618	.45208
150.0	.20996	.86673	.45244

CSM 6-1.- Concluded.

Launch day dependent
 Launch month dependent
 1 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

VENUS UNIT VECTOR			
TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
155.0	.20697	.86726	.45279
160.0	.20399	.86779	.45314
165.0	.20102	.86830	.45348
170.0	.19806	.86880	.45382
175.0	.19511	.86930	.45415
180.0	.19218	.86978	.45447
185.0	.18925	.87026	.45479
190.0	.18634	.87072	.45510
195.0	.18344	.87118	.45541
200.0	.18056	.87163	.45571
205.0	.17768	.87206	.45600
210.0	.17482	.87249	.45629
215.0	.17197	.87291	.45657
220.0	.16914	.87332	.45685
225.0	.16631	.87372	.45712
230.0	.16350	.87411	.45738
235.0	.16071	.87449	.45764
240.0	.15792	.87487	.45789
245.0	.15515	.87523	.45814
250.0	.15240	.87559	.45838
255.0	.14965	.87594	.45862
260.0	.14692	.87628	.45885
265.0	.14421	.87662	.45908
270.0	.14150	.87694	.45930
275.0	.13881	.87726	.45951
280.0	.13614	.87757	.45972
285.0	.13348	.87787	.45992
290.0	.13083	.87817	.46012
295.0	.12819	.87845	.46031
300.0	.12557	.87873	.46050

Blucker/MPB/MPAD (for G and C Checklist)

Data source JPL ExpressData confirmed JTB

CSM 6-2.- Mars, Jupiter,
 Saturn unit vectors.
 (April 16 launch date)

Launch day dependent
 Launch month dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54

Liftoff = 4:16:__:__

MARS UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
.0	.28621	.87132	.39860
10.0	.28164	.87255	.39917
20.0	.27706	.87376	.39972
30.0	.27248	.87495	.40027
40.0	.26789	.87612	.40080
50.0	.26330	.87728	.40133
60.0	.25871	.87840	.40184
70.0	.25411	.87951	.40235
80.0	.24951	.88060	.40284
90.0	.24491	.88167	.40333
100.0	.24031	.88271	.40381
110.0	.23571	.88374	.40428
120.0	.23111	.88474	.40474
130.0	.22651	.88573	.40519
140.0	.22191	.88669	.40563
150.0	.21731	.88763	.40607
160.0	.21271	.88855	.40649
170.0	.20811	.88945	.40690
180.0	.20351	.89033	.40731
190.0	.19891	.89118	.40771
200.0	.19431	.89202	.40809
210.0	.18972	.89284	.40847
220.0	.18512	.89363	.40884
230.0	.18053	.89441	.40920
240.0	.17593	.89516	.40956
250.0	.17134	.89589	.40990
260.0	.16675	.89661	.41024
270.0	.16216	.89730	.41056
280.0	.15757	.89797	.41088
290.0	.15298	.89862	.41119
300.0	.14838	.89925	.41149

CSM 6-2.- Concluded.

Launch day dependent
 Launch month dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

JUPITER UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
.0	.14286	-.91015	-.38887
100.0	.14400	-.90996	-.38890
200.0	.14430	-.90988	-.38897
300.0	.14386	-.90990	-.38908

SATURN UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
.0	.43161	.83847	.33268
50.0	.42784	.84008	.33348
100.0	.42404	.84170	.33427
150.0	.42019	.84331	.33507
200.0	.41632	.84491	.33585
250.0	.41242	.84652	.33664
300.0	.40848	.84811	.33742

Mitchell/MPB/MPAD (for Contingency C/L)

Data source _____

Data confirmed PHM

CSM 7-1.- Loss of comm navigation procedures.	Mission independent
	5/27/71 Final

5/27/71 Final

Revision 2

LOSS OF COMMUNICATION NAVIGATION PROCEDURES

GENERAL RULES

- 1 A sighting or set is to consist of three marks.
- 2 Calibrate optics at the beginning of each batch and every half hour while navigation sightings in progress if the remaining sightings require more than 30 minutes to complete. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 1 bit (.003°).
- 3 All attitude control should be done using coupled RCS thruster pairs.
- 4 See loss of comm midcourse procedures for maneuver times.
- 5 While in P23 V06N49 display:
If $\Delta R > 50$ nm, Or $\Delta V > 50$ fps;
Reject mark, reselect star and horizon,
verify procedures, and repeat mark.

If large correction recurs, accept.

Large ΔR , ΔV values may be expected at the following times:

At initiation of tracking (first mark of each star of first batch).

At first switch of reference bodies.

After long periods between sightings.

Last hours before EI.

CSM 7-1.- Continued.

Mission independent
5/27/71 Final
Revision 2

- 6 Loss of W-Matrix after initiation of navigation sightings:
 - (a) Upon loss of W-Matrix, current onboard state vector is retained.
 - (b) W-Matrix Reinitialization and Navigation Procedures
 - (1) Sightings Not In Progress:

Before next batch, reinitialize W-Matrix, V67
V06N99 Load values shown in tables.

Continue Navigation
 - (2) Sightings In Progress:

Immediately reinitialize W-Matrix, V67
V06N99 Load values shown in tables.

Restart interrupted batch of navigation sightings.

Continue navigation

GENERAL PROCEDURE

- 1 If entry pad previously received, no tracking performed
If not, proceed.
- 2 Execute abort - if required (unless comm loss during nominal TEC).
- 3 Reinitialize W-Matrix, V67 (diagonal values, V06N99, from tables)
- 4 Determine return-time
- 5 Select navigation schedule (see tables). If table I, II, or III are not applicable, refer to do-it-yourself rules.
- 6 Select starting batch
first navigation sightings to use stars
corresponding to navigation schedule
time first occurring after abort.
- 7 Alternate sightings are provided in the event the preferred sighting cannot be performed.

CSM 7-1.- Continued.

Mission independent

5/27/71 Final

Revision 2

GENERAL PROCEDURE (CONTINUED)

- 8 After each batch (or two batches if the batches are back to back), determine entry time from P37 by calling N38 after integration has been completed and before proceeding on the lat, long display.
- 9 Determine and record Hp using routine 30 V82 N44 by specifying the time load equal to entry time determined in above step.
- 10 The state vector from each previous batch of P23 sightings is retained in the LM state vector slot until the navigator has determined the current batch to be acceptable. When the state vector from the current batch has been determined to be acceptable, the state is transferred to the LM state vector slot (V66). If the batch is unacceptable, use V47 to transfer the good state vector from the LM slot to the CSM slot (do no reinitialize the W-matrix) and repeat current batch.

DO-IT-YOURSELF PECULIAR RULES

- 1 Reinitialize W-Matrix and schedule a tracking interval as soon as possible after the abort burn; or in the case of the lunar flyby, about 1 hour after perilune. If sightings are performed translunar for any reason, reinitialize the W-Matrix 1 hour after perilune for trans-earth sightings. W-Matrix values are given in tables IV-1 and 2 for each return type.
- 2 A batch is to consist of at least three star/horizon sightings, although as many as five can be advantageous, particularly following a sleep period.
- 3 All available stars should be used in the sighting schedule. No more than three marks should be taken on a star within a batch of data.
- 4 Sightings during the last 10 hours before entry interface are important. Five earth horizon sightings should be scheduled at EI-5 hours and three earth horizon sightings should be scheduled following the MCC at EI-3 hours. If no earth horizon sightings are available, lunar horizon sightings should be used.

CSM 7-1.- Concluded.

Mission independent

5/27/71 Final

Revision 2

- 5 Whenever possible, the navigation batches should be scheduled so that, immediately following a time period of length Δt (not to exceed 3 hours) in a non-PTC mode, five times Δt should be spent in a PTC mode (thermal constraints). This rule will be violated most frequently in the following situations: (1) aborts from a translunar trajectory with short return lengths, (2) time critical aborts, (3) the 10-hour period before entry interface.
- 6 If possible, both near and far horizons should be included in each batch of data.
- 7 Star availability is related to GMT not GET. Therefore, as a clue to determine star available, refer to either Table I, II or III which has a GMT for entry corresponding to your GMT for entry. In addition, the star charts should be used to select available stars.
- 8 Go to Table IV.

Lowes/MPB/MPAD (for Contingency C/L)

Data source _____

Data confirmed

CSM 7-2.- Star sighting schedule for
lift-off + 8 hr abort.
(April 16 launch date)

Launch day dependent
Launch month dependent
Mission profile dependent
2/22/72 Basic

TABLE I.- LIFT-OFF + 8 HR ABORT

W-MATRIX REINITIALIZATION

R1 + 80000

R2 + 00070

R3 + 00003

NAVIGATION SCHEDULE

 ΔT to EI < 15 hrs, TABLE I(a) ΔT to EI > 15 hrs, TABLE I(b)

TABLE I(a)

Sighting Schedule for Abort from Translunar
Coast at 8:00 Hours GET, Apollo 16
April 16, 1972 Launch Date
Short Return (Less than 15 Hours)
(GMT of EI = 17 April 1972, 14 Hours)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 11.0	42 PEACOCK	EN	00110
	124	EF	00120
	33 ANTARES	EF	00120
	201	EF	00120
	125	EF	00120
EI - 9.0	120 AL NA'IR	EN	00110
	33 ANTARES	EF	00120
	125	EF	00120
	*201	EF	00120
	*221	EN	00110
EI - 7.0	222	EN	00110
	125	EF	00120
	75 SHAULA	EF	00120
	*212	EF	00120
	*221	EN	00110
EI - 5.0	120 AL NA'IR	EN	00110
	37 NUNKI	EF	00120
	212	EF	00120
	77 KAUS AUST	EF	00120
	44 ENIF	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-2.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE I(a)

Sighting Schedule for Abort from Translunar
 Coast at 8:00 Hours GET, Apollo 16
 April 16, 1972 Launch Date
 Short Return (Less than 15 Hours)
 (GMT of EI = 17 April 1972, 14 Hours)
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 2.5	45 FOMALHAUT	EN	00110
	235	EF	00120
	44 ENIF	EN	00110
	*224 MARKAB	EN	00110

TABLE I(b)

Sighting Schedule for Abort from Translunar
 Coast at 8:00 Hours GET, Apollo 16
 April 16, 1972 Launch Date
 Long Return (Greater than 15 Hours)
 (GMT of EI = 18 April 1972, 13 Hours)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 13.0	121	EN	00110
	37 NUNKI	EF	00120
	212	EF	00120
	77 KAUS AUST	EF	00120
	44 ENIF	EN	00110
EI - 11.0	121	EN	00110
	37 NUNKI	EF	00120
	77 KAUS AUST	EF	00120
	*214	EF	00120
	*212	EF	00120
EI - 9.0 (SAME AS EI - 11.0)	121	EN	00110
	37 NUNKI	EF	00120
	77 KAUS AUST	EF	00120
	*214	EF	00120
	*212	EF	00120
EI - 7.0	45 FOMALHAUT	EN	00110
	37 NUNKI	EF	00120
	214	EF	00120
	*224 MARKAB	EN	00110
	*213	EF	00120

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-2.- Concluded.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE I(b)

Sighting Schedule for Abort from Translunar
 Coast at 8:00 Hours GET, Apollo 16
 April 16, 1972 Launch Date
 Long Return (Greater than 15 Hours)
 (GMT of EI = 18 April 1972, 13 Hours)
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 5.0	44 ENIF	EN	00110
	224 MARKAB	EN	00110
	235	EF	00120
	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
EI - 2.5	223	EN	00110
	224 MARKAB	EN	00110
	2 DIPHDA	EN	00110
	*126	EN	00110
	*1 ALPHERATZ	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

Lowes/MPB/MPAD (for Contingency C/L)

Data source _____

Data confirmed 28/5

CSM 7-3.- Star sighting schedule for
aborts from lunar orbit.
(April 16 launch date)

Launch day dependent
Launch month dependent
Mission profile dependent
2/22/72 Basic

<u>TABLE II.- ABORTS FROM LUNAR ORBIT</u>					
<u>ABORT</u>	<u>REASON</u>	<u>TIME OF DAY</u>	<u>LOCATION</u>	<u>STATUS</u>	<u>REMARKS</u>
1	Engine failure	08:00	Lunar orbit	Successful	Engine restarted after 10 minutes.
2	Oxygen depletion	12:30	Lunar orbit	Aborted	Emergency landing initiated.
3	Communication loss	15:45	Lunar orbit	In progress	Attempting re-establishment.
4	Structural damage	19:10	Lunar orbit	Critical	Assessing damage severity.
5	Navigation error	22:00	Lunar orbit	Corrected	Course adjusted successfully.

A. ABORTS BECAUSE OF LOSS OF COMM

W-MATRIX REINITIALIZATION

$$R1 + 30000$$

R2 + 00300

R3 + 00003

NAVIGATION SCHEDULE

GMT RETURN ON APRIL 23, TABLE II(a)

GMT RETURN ON APRIL 24, TABLE II(b)

GMT RETURN ON APRIL 25, TABLE II(c)

GMT RETURN ON APRIL 26, TABLE II(d)

GMT RETURN ON APRIL 27, TABLE II(e)

GMT RETURN ON APRIL 28, TABLE II(f)

B. COMM LOSS AFTER ABORT FROM LUNAR ORBIT

W-MATRIX REINITIALIZATION

a. COMM LOSS PRIOR TO TIME FOR NAV STG
BATCH 1

$$R1 + 30000$$

R2 + 00300

R3 + 00003

b. COMM LOSS AFTER TIME FOR BATCH 1
AND NO SV UPDATE AFTER TEI

$$\overline{R1} + 99000$$

R2 + 00020

R3 + 00003

c. COMM LOSS AFTER TIME FOR BATCH 1
AND AT LEAST ONE SV UPDATE AFTER TEI

$$R1 + 45000$$

R2 + 00006

R3 + 00003

NAVIGATION SCHEDULE

GMT EI APRIL 23, TABLE II(a)

GMT EI APRIL 24, TABLE II(b)

GMT EI APRIL 25, TABLE II(c)

GMT EI APRIL 26, TABLE II(d)

GMT EI APRIL 27, TABLE II(e)

GMT EI APRIL 28, TABLE II(f)

GMT NOT COVERED BY ABOVE, GO
TO "DO-IT-YOURSELF", TABLE IV.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(a)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 23 April 1972, 17 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	23 DENEbola	MN	00210
	153	MN	00210
	151	MN	00210
	22 REGULUS	MN	00210
	163	MF	00220
TEI + 14.0	21 ALPHARD	MN	00210
	22 REGULUS	MN	00210
	26 SPICA	MF	00220
	*151	MN	00210
	*156	MF	00220
TEI + 14.5	42 PEACOCK	EF	00120
	44 ENIF	EN	00110
	45 FOMALHAUT	EN	00110
	*37 NUNKI	EF	00120
	*77 KAUS AUST	EF	00120
TEI + 18.0 (SAME AS TEI + 14.5)	42 PEACOCK	EF	00120
	44 ENIF	EN	00110
	45 FOMALHAUT	EN	00110
	*37 NUNKI	EF	00120
	*77 KAUS AUST	EF	00120
TEI + 27.0	45 FOMALHAUT	EN	00110
	77 KAUS AUST	EF	00120
	44 ENIF	EN	00110
	*214	EF	00120
	*37 NUNKI	EF	00120
EI - 29.0 (SAME AS TEI + 27.0)	45 FOMALHAUT	EN	00110
	77 KAUS AUST	EF	00120
	44 ENIF	EN	00110
	*214	EF	00120
	*37 NUNKI	EF	00120
EI - 23.0	45 FOMALHAUT	EN	00110
	221	EN	00110
	77 KAUS AUST	EF	00120
	*44 ENIF	EN	00110
	*37 NUNKI	EF	00120

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(a)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 23 April 1972, 17 Hours)
 Apollo 16, April 16, 1972 Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	45 FOMALHAUT	EN	00110
(SAME AS	221	EN	00110
EI - 23.0)	77 KAUS AUST	EF	00120
	*44 ENIF	EN	00110
	*37 NUNKI	EF	00120
EI - 15.5	45 FOMALHAUT	EN	00110
	221	EN	00110
	37 NUNKI	EF	00120
	*214	EF	00120
	*44 ENIF	EN	00110
EI - 5.0	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
	126	EN	00110
	224 MARKAB	EN	00110
	223	EN	00110
EI - 2.5	40 ALTAIR	EF	00120
	1 ALPHERATZ	EN	00110
	223	EN	00110
	*224 MARKAB	EN	00110
	*126	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

Table II(b)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 24 April 1972, 17 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	24 GIENAH	MN	00210
	170 ZUBEN' UBI	MF	00220
	153	MN	00210
	23 DENEbola	MN	00210
	157	MN	00210
TEI + 14.0	31 ARCTURUS	MF	00220
	22 REGULUS	MN	00210
	26 SPICA	MF	00220
	*151	MN	00210
	*23 DENEbola	MN	00210
TEI + 14.5	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
	44 ENIF	EN	00110
	*224 MARKAB	EN	00110
	*37 NUNKI	EF	00120
TEI + 18.0 (SAME AS TEI + 14.5)	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
	44 ENIF	EN	00110
	*224 MARKAB	EN	00110
	*37 NUNKI	EF	00120
TEI + 27.0	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
	44 ENIF	EN	00110
	*224 MARKAB	EN	00110
	*214	EF	00120
EI - 29.0	45 FOMALHAUT	EN	00110
	40 ALTAIR	EF	00120
	44 ENIF	EN	00110
	*224 MARKAB	EN	00110
	*235	EF	00120
EI - 23.0	223	EN	00110
	224 MARKAB	EN	00110
	40 ALTAIR	EF	00120
	*216	EF	00120
	*235	EF	00120

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(b)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 24 April 1972, 17 Hours)
 Apollo 16, April 16, 1972 Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	223	EN	00110
(SAME AS	224 MARKAB	EN	00110
EI - 23.0)	40 ALTAIR	EF	00120
	*216	EF	00120
	*235	EF	00120
EI - 15.5	223	EN	00110
	224 MARKAB	EN	00110
	40 ALTAIR	EF	00120
	*216	EF	00120
EI - 5.0	223	EN	00110
	1 ALPHERATZ	EN	00110
	224 MARKAB	EN	00110
	126	EN	00110
	40 ALTAIR	EF	00120
EI - 2.5	1 ALPHERATZ	EN	00110
	224 MARKAB	EN	00110
	117 SADR	EF	00120
	*217	EF	00120
	*102 MIRACH	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(c)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 25 April 1972, 18 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	73 BECRUX	MN	00210
	161	MN	00210
	72 GACRUX	MN	00210
	53	MN	00210
	154	MN	00210
TEI + 14.0	161	MF	00220
	23 DENEbola	MN	00210
	153	MN	00210
	*156	MN	00210
	*170 ZUBEN'UBI	MF	00220
TEI + 14.5	223	EN	00110
	224 MARKAB	EN	00110
	40 ALTAIR	EF	00120
	*216	EF	00120
	*126	EN	00110
TEI + 18.0 (SAME AS TEI + 14.5)	223	EN	00110
	224 MARKAB	EN	00110
	40 ALTAIR	EF	00120
	*216	EF	00120
	*126	EN	00110
TEI + 27.0	223	EN	00110
	224 MARKAB	EN	00110
	40 ALTAIR	EF	00120
	*2 DIPHDA	EN	00110
	*126	EN	00110
EI - 29.0	40 ALTAIR	EF	00120
	224 MARKAB	EN	00110
	223	EN	00110
	*221	EF	00120
	*126	EN	00110
EI - 23.0	40 ALTAIR	EF	00120
	1 ALPHERATZ	EN	00110
	223	EN	00110
	*224 MARKAB	EN	00110
	*221	EF	00120

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(c)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 25 April 1972, 18 Hours)
 Apollo 16, April 16, 1972 Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	40 ALTAIR	EF	00120
(SAME AS	1 ALPHERATZ	EN	00110
EI - 23.0)	223	EN	00110
	*224 MARKAB	EN	00110
	*221	EF	00120
EI - 15.5	40 ALTAIR	EF	00120
(SAME AS	1 ALPHERATZ	EN	00110
EI - 21.0)	223	EN	00110
	*224 MARKAB	EN	00110
	*221	EF	00120
EI - 5.0	1 ALPHERATZ	EN	00110
	102 MIRACH	EN	00110
	44 ENIF	EF	00120
	217	EF	00120
	2 DIPHDA	EN	00110
EI - 2.5	1 ALPHERATZ	EN	00110
	44 ENIF	EF	00120
	217	EF	00120
	*102 MIRACH	EN	00110
	*103 ALMACH	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

Table II(d)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 26 April 1972, 18 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	26 SPICA	MF	00220
	125	MN	00210
	54 RIGIL KENT	MN	00210
	56 HADAR	MN	00210
	73 BECRUX	MN	00210
TEI + 14.0	53	MN	00210
	232	MN	00210
	163	MN	00210
	*31 ARCTURUS	MN	00210
	*167	MN	00210
TEI + 14.5	2 DIPHDA	EN	00110
	221	EF	00120
	1 ALPHERATZ	EN	00110
	*126	EN	00110
TEI + 18.0 (SAME AS TEI + 14.5)	2 DIPHDA	EN	00110
	221	EF	00120
	1 ALPHERATZ	EN	00110
	*126	EN	00110
TEI + 27.0 (SAME AS TEI + 18.0)	2 DIPHDA	EN	00110
	221	EF	00120
	1 ALPHERATZ	EN	00110
	*126	EN	00110
EI - 29.0	1 ALPHERATZ	EN	00110
	221	EF	00120
	2 DIPHDA	EN	00110
	*44 ENIF	EF	00120
	*126	EN	00110
EI - 23.0 (SAME AS EI - 29.0)	1 ALPHERATZ	EN	00110
	221	EF	00120
	2 DIPHDA	EN	00110
	*44 ENIF	EF	00120
	*126	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(d)
 Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 26 April 1972, 18 Hours)
 Apollo 16, April 16, 1972 Launch Date)
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	1 ALPHERATZ	EN	00110
(SAME AS	221	EF	00120
EI - 23.0)	2 DIPHDA	EN	00110
	*44 ENIF	EF	00120
	*126	EN	00110
EI - 15.5	2 DIPHDA	EN	00110
	221	EF	00120
	1 ALPHERATZ	EN	00110
	*102 MIRACH	EN	00110
	*126	EN	00110
EI - 5.0	174	MF	00220
	172	MF	00220
	124	MF	00220
	26 SPICA	MF	00220
	160	MN	00210
EI - 2.5	174	MF	00220
	23 DENEbola	MN	00210
	30 MENKENT	MF	00220
	*26 SPICA	MF	00220
	*172	MF	00220

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(e)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 27 April 1972, 19 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	30 MENKENT	MF	00220
	77 KAUS AUST	MN	00210
	75 SHAULA	MN	00210
	127	MN	00210
	54 RIGIL KENT	MN	00210
TEI + 14.0	173	MN	00210
	33 ANTARES	MN	00210
	26 SPICA	MF	00220
	*124	MN	00210
	*75 SHAULA	MN	00210
TEI + 14.5	44 ENIF	EF	00120
	45 FOMALHAUT	EF	00120
	1 ALPHARATZ	EN	00110
	*102 MIRACH	EN	00110
	*126	EN	00110
TEI + 18.0 (SAME AS TEI + 14.5)	44 ENIF	EF	00120
	45 FOMALHAUT	EF	00120
	1 ALPHERATZ	EN	00110
	*102 MIRACH	EN	00110
	*126	EN	00110
TEI + 27.0 (SAME AS TEI + 18.0)	44 ENIF	EF	00120
	45 FOMALHAUT	EF	00120
	1 ALPHERATZ	EN	00110
	*102 MIRACH	EN	00110
	*126	EN	00110
EI - 29.0	44 ENIF	EF	00120
	102 MIRACH	EN	00110
	1 ALPHERATZ	EN	00110
	*126	EN	00110
	*221	EF	00120
EI - 23.0	102 MIRACH	EN	00110
	221	EF	00120
	44 ENIF	EF	00120
	*226	EN	00110
	*126	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(e)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 27 April 1972, 19 Hours)
 Apollo 16, April 16, 1972 Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	102 MIRACH	EN	00110
(SAME AS	221	EF	00120
EI - 23.0)	44 ENIF	EF	00120
	*226	EN	00110
	*126	EN	00110
EI - 15.0	224 MARKAB	EF	00120
	103 ALMACH	EN	00110
	102 MIRACH	EN	00110
	*221	EF	00120
	*126	EN	00110
EI - 5.0	33 ANTARES	MF	00220
	26 SPICA	MN	00210
	202	MF	00220
	172	MF	00220
	24 GIENAH	MN	00210
EI - 2.5	23 DENEbola	MN	00210
	172	MF	00220
	24 GIENAH	MN	00210
	*202	MF	00220
	*156	MN	00210

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(f)

Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 28 April 1972, 20 Hours)
 Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	34 ATRIA	MN	00210
	176	MF	00220
	172	MF	00220
	77 KAUS AUST	MN	00210
	37 NUNKI	MN	00210
TEI + 14.0	35 RASALAGUE	MN	00210
	26 SPICA	MF	00220
	33 ANTARES	MN	00210
	*77 KAUS AUST	MN	00210
	*37 NUNKI	MN	00210
TEI + 14.5	44 ENIF	EF	00120
	102 MIRACH	EN	00110
	126	EN	00110
	*45 FOMALHAUT	EF	00120
	*221	EF	00120
TEI + 18.0 (SAME AS TEI + 14.5)	44 ENIF	EF	00120
	102 MIRACH	EN	00110
	126	EN	00110
	*45 FOMALHAUT	EF	00120
	*221	EF	00120
TEI + 27.0	45 FOMALHAUT	EF	00120
	102 MIRACH	EN	00110
	44 ENIF	EF	00120
	*226	EN	00110
	*221	EF	00120
EI - 29.0	102 MIRACH	EN	00110
	103 ALMACH	EN	00110
	224 MARKAB	EF	00120
	*226	EN	00110
	*44 ENIF	EF	00120
EI - 23.0	103 ALMACH	EN	00110
	44 ENIF	EF	00120
	224 MARKAB	EF	00120
	*226	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-3.- Concluded.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE II(f)
 Sighting Schedule for Abort from Lunar Orbit
 (GMT of EI = 28 April 1972, 20 Hours)
 Apollo 16, April 16, 1972, Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
EI - 21.0	103 ALMACH	EN	00110
(SAME AS	44 ENIF	EF	00120
EI - 23.0)	224 MARKAB	EF	00120
	*226	EN	00110
EI - 15.5	44 ENIF	EF	00120
	226	EN	00110
	223	EF	00120
	*224 MARKAB	EF	00120
EI - 5.0	160	MF	00220
	76	MN	00210
	127	MN	00210
	75 SHAULA	MN	00210
	125	MN	00210
EI - 2.5	173	MN	00210
	160	MF	00220
	33 ANTARES	MN	00210
	*26 SPICA	MF	00220
	*75 SHAULA	MN	00210

* Alternate stars - to be used if other sightings cannot be made.

Lowes/MPB/MPAD (for Contingency C/L)

Data source _____

Data confirmed BSCSM 7-4.- Comm loss during nominal TEC.
(April 16 launch date)Launch day dependent
Launch month dependent
Mission profile dependent
2/22/72 BasicTABLE III.- COMM LOSS DURING NOMINAL TEC

W-MATRIX REINITIALIZATION

a. COMM LOSS PRIOR TO TIME FOR NAV STG BATCH 1

R1 + 30000

R2 + 00300

R3 + 00003

b. COMM LOSS AFTER TIME FOR NAV STG BATCH 1
AND NO SV UPDATE AFTER TEI

R1 + 99000

R2 + 00020

R3 + 00003

c. COMM LOSS AFTER TIME FOR NAV STG BATCH 1
AND AT LEAST ONE SV UPDATE AFTER TEI

R1 + 45000

R2 + 00006

R3 + 00003

TABLE III

Sighting Schedule for Nominal Transearth Coast
(GMT of EI = 28 April 1972, 20 Hours)
Apollo 16, April 16, 1972 Launch Date

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 2.0	54 RIGIL KENT	MN	00210
	77 KAUS AUST	MN	00210
	37 NUNKI	MN	00210
	170 ZUBEN' UBI	MF	00220
	75 SHAULA	MN	00210
TEI + 14.0	30 MENKENT	MF	00220
	26 SPICA	MF	00220
	33 ANTARES	MN	00210
	*77 KAUS AUST	MN	00210
	*75 SHAULA	MN	00210
TEI + 14.5	45 FOMALHAUT	EF	00120
	103 ALMACH	EN	00110
	44 ENIF	EF	00120
	*224 MARKAB	EF	00120
	*226	EN	00110

* Alternate stars - to be used if other sightings cannot be made.

CSM 7-4.- Concluded.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/22/72 Basic

TABLE III
 Sighting Schedule for Nominal Transearth Coast
 (GMT of EI = 28 April 1972, 20 Hours)
 Apollo 16, April 16, 1972 Launch Date
 (Concluded)

<u>Time</u>	<u>Star</u>	<u>Horizon</u>	<u>R3</u>
TEI + 18.0	45 FOMALHAUT	EF	00120
(SAME AS	103 ALMACH	EN	00110
TEI + 14.5)	44 ENIF	EF	00120
	*224 MARKAB	EF	00120
	*226	EN	00110
TEI + 27.0	103 ALMACH	EN	00110
	44 ENIF	EF	00120
	224 MARKAB	EF	00120
	*226	EN	00110
EI - 29.0	227	EN	00110
	224	EF	00120
	223	EF	00120
	*126	EF	00120
	*226	EN	00110
EI - 23.0	227	EN	00110
(SAME AS	224	EF	00120
EI - 29.0)	223	EF	00120
	*126	EF	00120
	*226	EN	00110
EI - 21.0	227	EN	00110
	224 MARKAB	EF	00120
	223	EF	00120
	*226	EN	00110
	*126	EF	00120
EI - 15.5	223	EF	00120
	224 MARKAB	EF	00120
	126	EF	00120
EI - 5.0	26 SPICA	MF	00220
	33 ANTARES	MN	00210
	156	MF	00220
	75 SHAULA	MN	00210
	173	MN	00210
EI - 2.5	31 ARCTURUS	MF	00220
	125	MN	00210
	75 SHAULA	MN	00210
	*206	MN	00210
	*160	MF	00220

* Alternate stars - to be used if other sightings cannot be made.

Pixley/MPB/MPAD (for G and C Checklist)

Data source PP

Data confirmed PP

CSM 7-5.- Do-it-yourself
sighting schedule.

Mission independent
12/1/70 Basic

TABLE IV - DO-IT-YOURSELF

1. ABORTS FROM TLC

W-MATRIX INITIALIZATION

R1 + 80000
R2 + 00070
R3 + 00003

NAVIGATION SCHEDULE

ΔT TO EI <20 hrs
BATCHES OF 3 SETS EVERY 2.5 hrs
BATCH OF 5 SETS AT EI-5
(BEFORE LAST MCC AT EI-3)
BATCH OF 3 SETS AFTER LAST MCC

ΔT >20 hrs
SLEEP PERIODS OF 8 HOURS MAY BE SCHEDULED.
CREW SHOULD BE AWAKE LAST 10 HOURS PRIOR
TO EI.

WHILE AWAKE:

BATCHES OF 3 SETS EVERY 3 HRS
BATCHES OF 5 SETS AFTER
SLEEP PERIODS
BATCH OF 5 SETS PRIOR TO
LAST MCC (AT EI-3)
BATCH OF 3 SETS AFTER LAST MCC

NOTE - ONLY STAR/EARTH HORIZON MARKS WILL BE MADE.

2. FLYBY, ABORT FROM LUNAR ORBIT, TEC.

W-MATRIX INITIALIZATION

- a. COMM LOSS BEFORE BATCH 1
(at TEI + 1 or perilune +1 hr)

R1 + 30000
R2 + 00300
R3 + 00003

CSM 7-5.- Continued.

Mission independent

TABLE IV - Continued

12/1/70 Basic

- b. COMM LOS AFTER BATCH 1
(at TEI + 1 or perilune + 1 hr)
and
No SV update after TEI
R1 + 99000
R2 + 00020
R3 + 00003
- c. COMM LOSS AFTER BATCH 1
(at TEI + 1 or perilune + 1 hr)
and
At least one SV update
after TEI
R1 + 45000
R2 + 00006
R3 + 00003

NAVIGATION SCHEDULE

A. RETURN LENGTH >70 hrs

- 1 Refer to Table III for placement of batches of star/horizon sightings and relate the times given at "TEI +" and "EI-" to the specific transearth situation. For each batch scheduled, take three marks on each available star (up to 5 stars).
- 2 Schedule three earth horizon sightings for every 5 hours between TEI + 32 and EI - 40 hours, or if an additional sleep period is needed for very slow returns, schedule five earth horizon sightings before the sleep period and five earth horizon sightings upon awakening.

CSM 7-5.- Concluded.

Mission independent

TABLE IV - (Concluded)

12/1/70 Basic

B. RETURN LENGTH <70 hrs

- 1 Sleep periods of 8 hours should be provided. Astronauts should be awake the last 10 hours before entry interface.
- 2 Three sets of star horizon observations should be scheduled every three hours while awake with five sets scheduled before and after each sleep period.
 - (a) A batch of lunar horizon sightings should be taken at TEI + 1 hour or perilune + 1 hour.
 - (b) The second batch of data should consist of earth horizon sightings.
 - (c) The third batch of data should consist of lunar horizon sightings.
 - (d) The remainder of the data should be earth horizon sightings. If no earth horizon sightings are available, lunar horizon sightings should be substituted.
- 3 Five earth/horizon sets should be scheduled at EI-5 hours before the MCC at EI = 3 hours. Three sets should be taken after the midcourse. If no earth horizon sightings are available, lunar horizon sightings should be substituted.

Yencharis/MAB/MPAD (for Contingency C/L)

Data source Miss Tech.

Data confirmed JDY

CSM 7-6.- Loss of comm midcourse procedures.	Mission independent 4/5/72 Final
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4/5/72 Final

Revision 3

LOSS OF COMM MIDCOURSE PROCEDURES

TIME OF MIDCOURSE AND MIDCOURSE EXECUTION CRITERIA

- 1 For midcourses following translunar coast aborts, execute the midcourse maneuvers whenever it is felt that a good estimate of the trajectory has been obtained by P23 and the ΔV shown by P37 is greater than 0 fps. The last midcourse maneuver should be executed no later than EI - 3 hours.
- 2 For midcourses following TEI, execute midcourse maneuvers at the times specified in the flight plan. These times are:
MCC5: TEI + 17 hours
MCC6: EI - 22 hours
MCC7: EI - 3 hours
These midcourse maneuvers should be executed if the ΔV from P37 is greater than 0 fps.

MIDCOURSE MANEUVER RULES

Follow monitoring, shutdown and trim criteria as outlined in flight plan for MCC5, MCC6 and MCC7. Follow this criteria both for transearth midcourses and midcourses following TLC aborts.

Figure 7-6.- Concluded.

Mission independent

4/5/72 Final

Revision 3

GENERAL INFORMATION

It can be determined if the entry corridor is being attained by determining Hp (vacuum perigee altitude) using the procedure outlined in the General Loss-of-Comm Navigation Procedure section, (steps 8, 9, 10) and comparing that value to the Hp limits listed in the following table.

Hp LIMITS FOR ENTRY CORRIDOR

	Minimum* Hp (n. mi.)	Nominal Hp (n. mi.)	Maximum** Hp (n. mi.)
TLC aborts			
Lift-off + 8 hrs			
≈15 hr trip time	4.8	19.3	34.0
≈39 hr trip time	6.1	19.8	33.6
Lift-off + 15 hrs	6.7	19.9	33.2
Lift-off + 25 hrs	7.4	20.0	33.1
Lift-off + 35 hrs	7.8	20.2	32.8
Lift-off + 45 hrs	7.7	20.1	32.8
Lift-off + 55 hrs	7.8	20.1	32.9
Nominal transearth coast	8.3	20.3	32.8

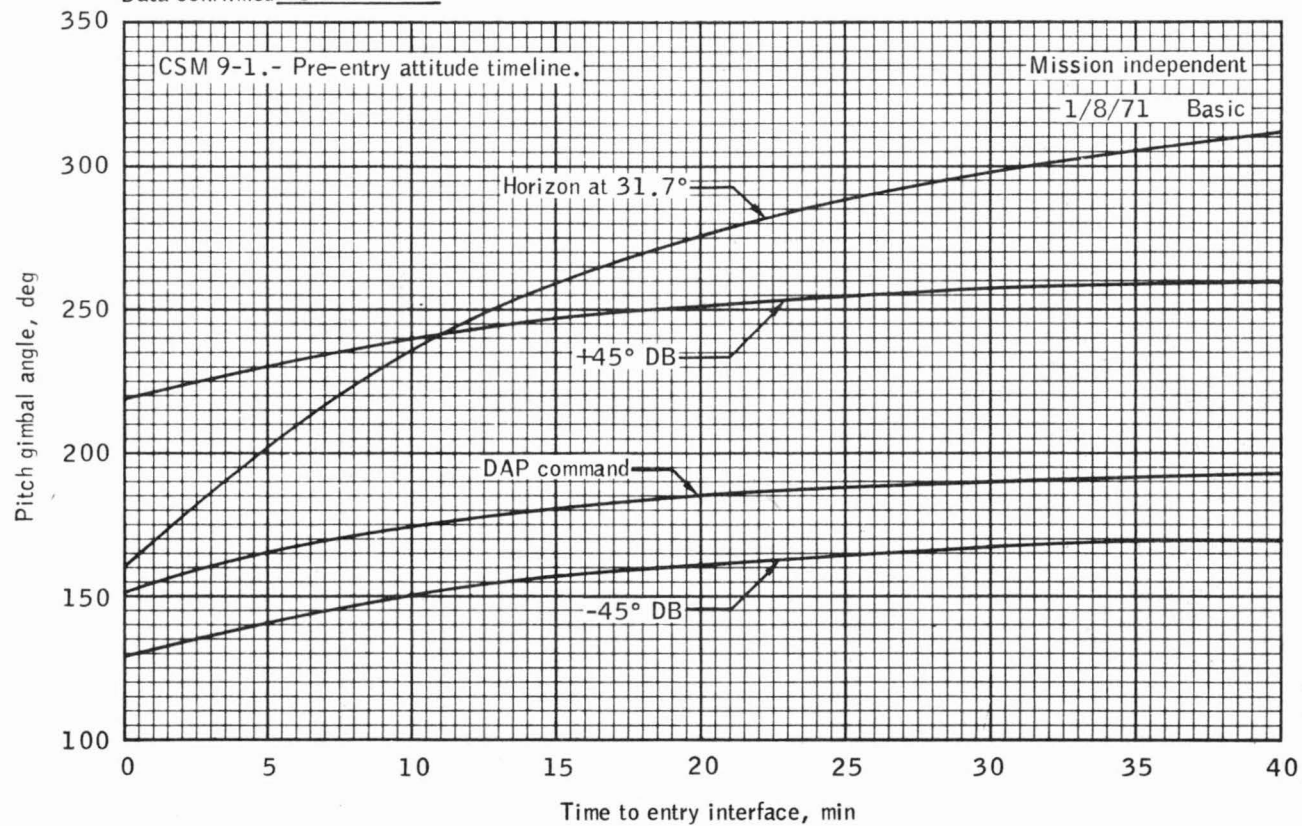
*Corresponds to entry with bank 15° 12g undershoot

**Corresponds to entry with constant g - 2500 n. mi. overshoot

Heath/LAB/MPAD (for Entry Checklist and CSM Cue Cards)

Data source MSC IN 70-FM-71

Data confirmed DWf

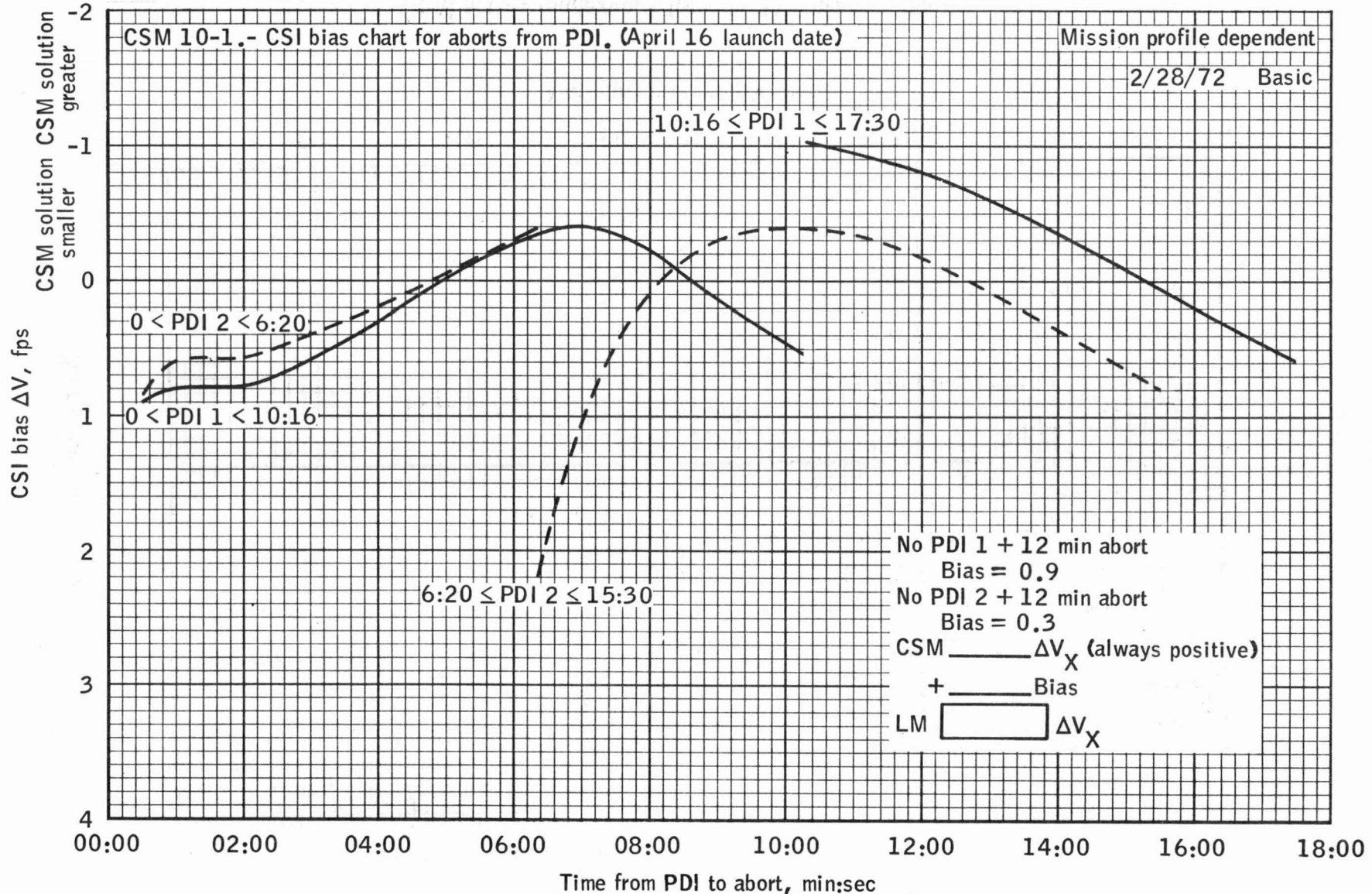


Pre-entry attitude timeline.

DuPont/MAB/MPAD (for CSM Rescue, LM Timeline)

Data source Spacecraft O.T.

Data confirmed ATD

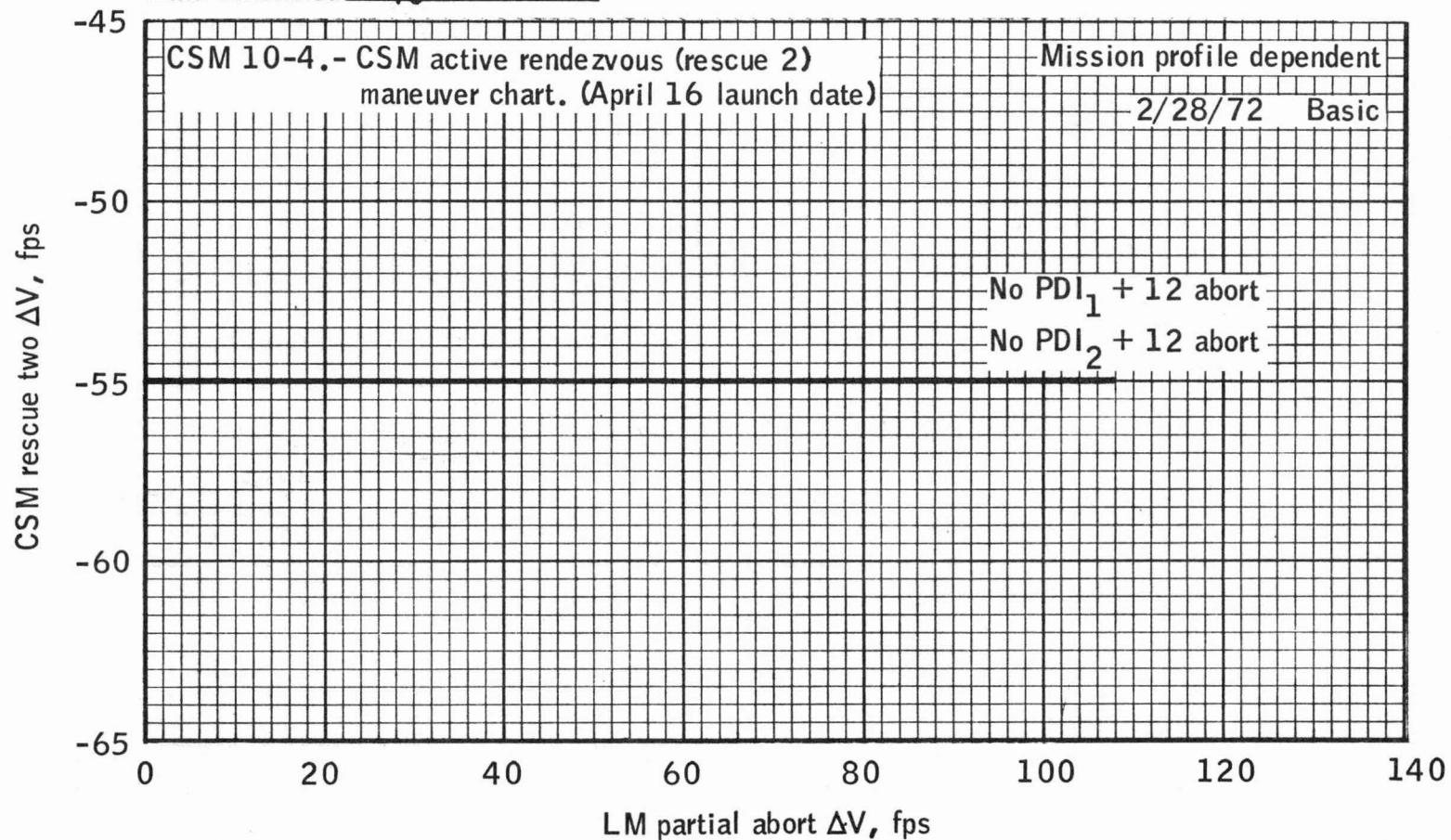


CSI bias chart for aborts from PDI.

DuPont/MAB/MPAD (for CSM Rescue)

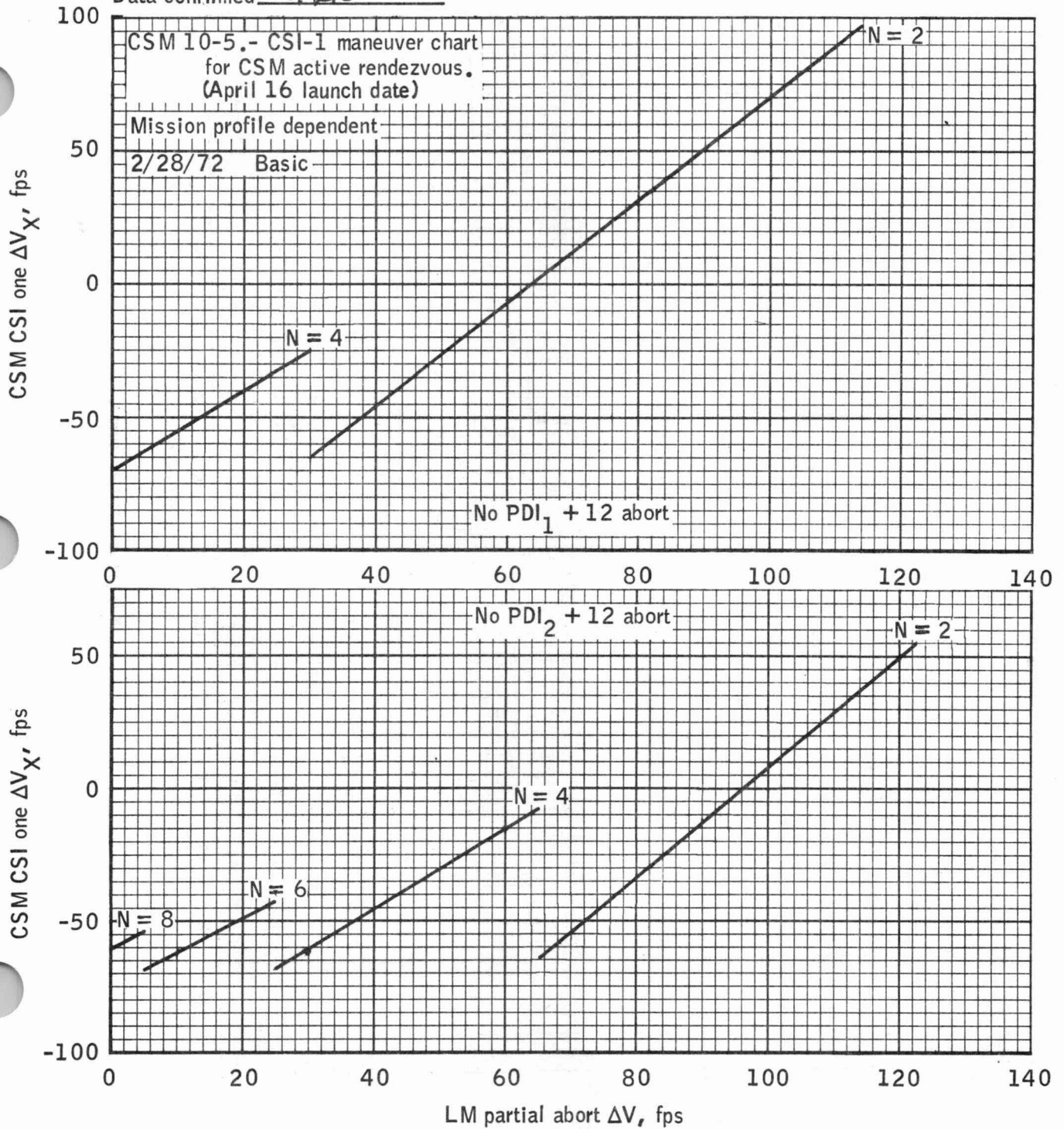
Data source Spacecraft O.T.

Data confirmed U.S.D.



CSM active rendezvous (rescue 2) maneuver chart.

DuPont/MAB/MPAD (for CSM Rescue)

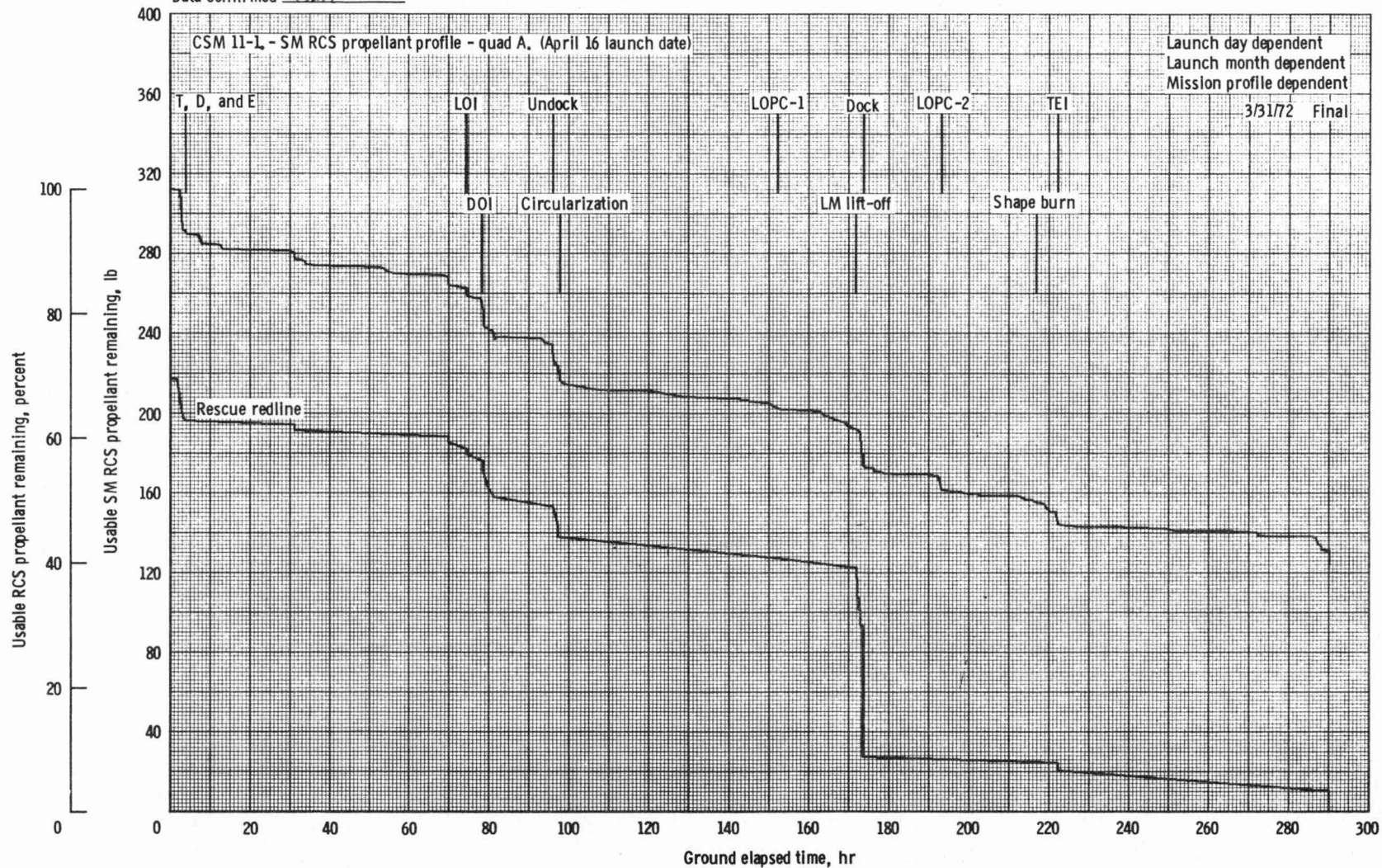
Data source Spacecraft O.T.Data confirmed 928

CSI-1 maneuver chart for CSM active rendezvous.

Mayfield/SMB/MPAD (for Flight Plan, CSM Systems Data)

Data source 2008 Flight Plan

Data confirmed 2007

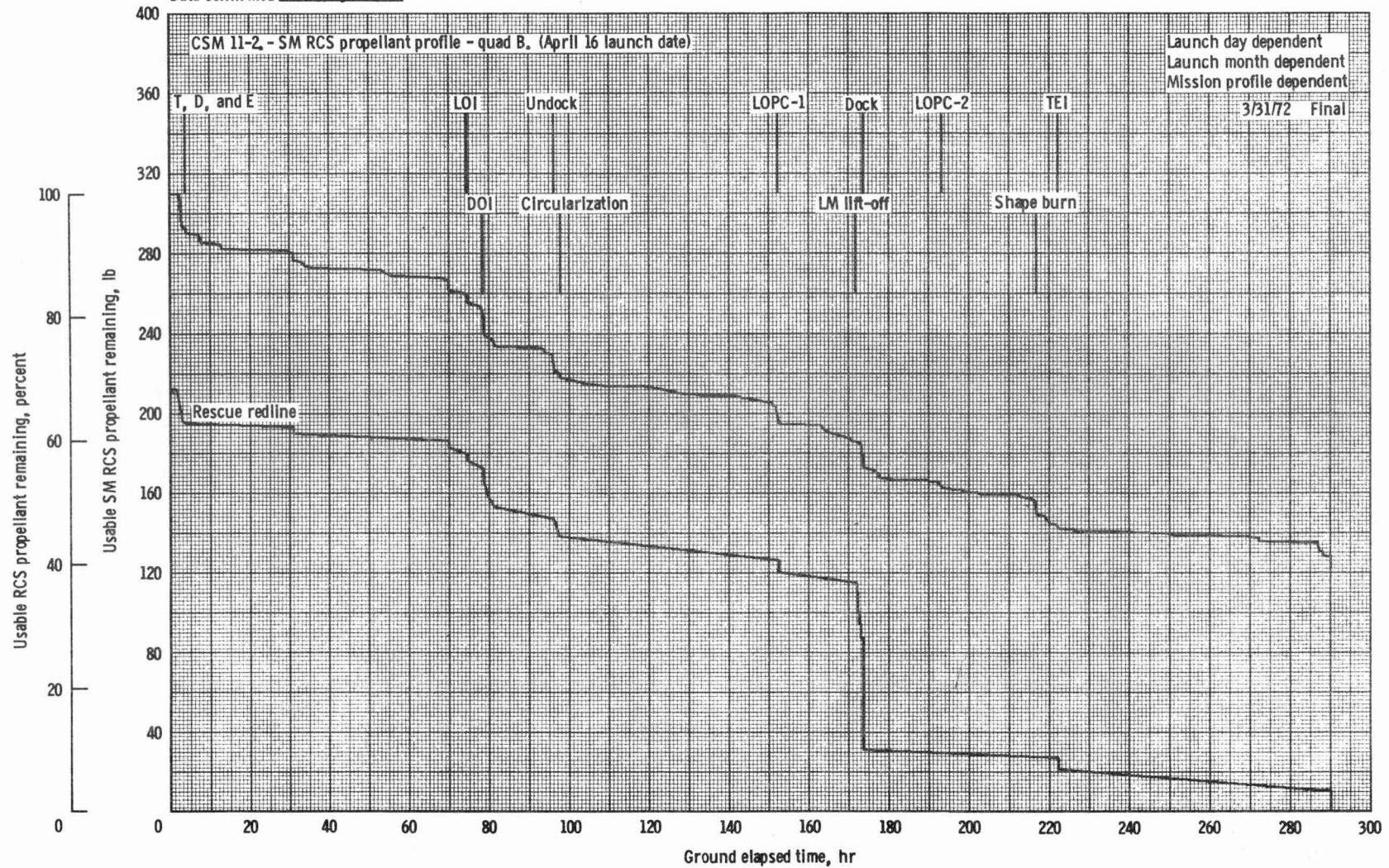


SM RCS propellant profile - quad A.

Mayfield/SMB/MPAD (for Flight Plan, CSM Systems Data)

Data source SMB E-46/14/Plan

Data confirmed AKM



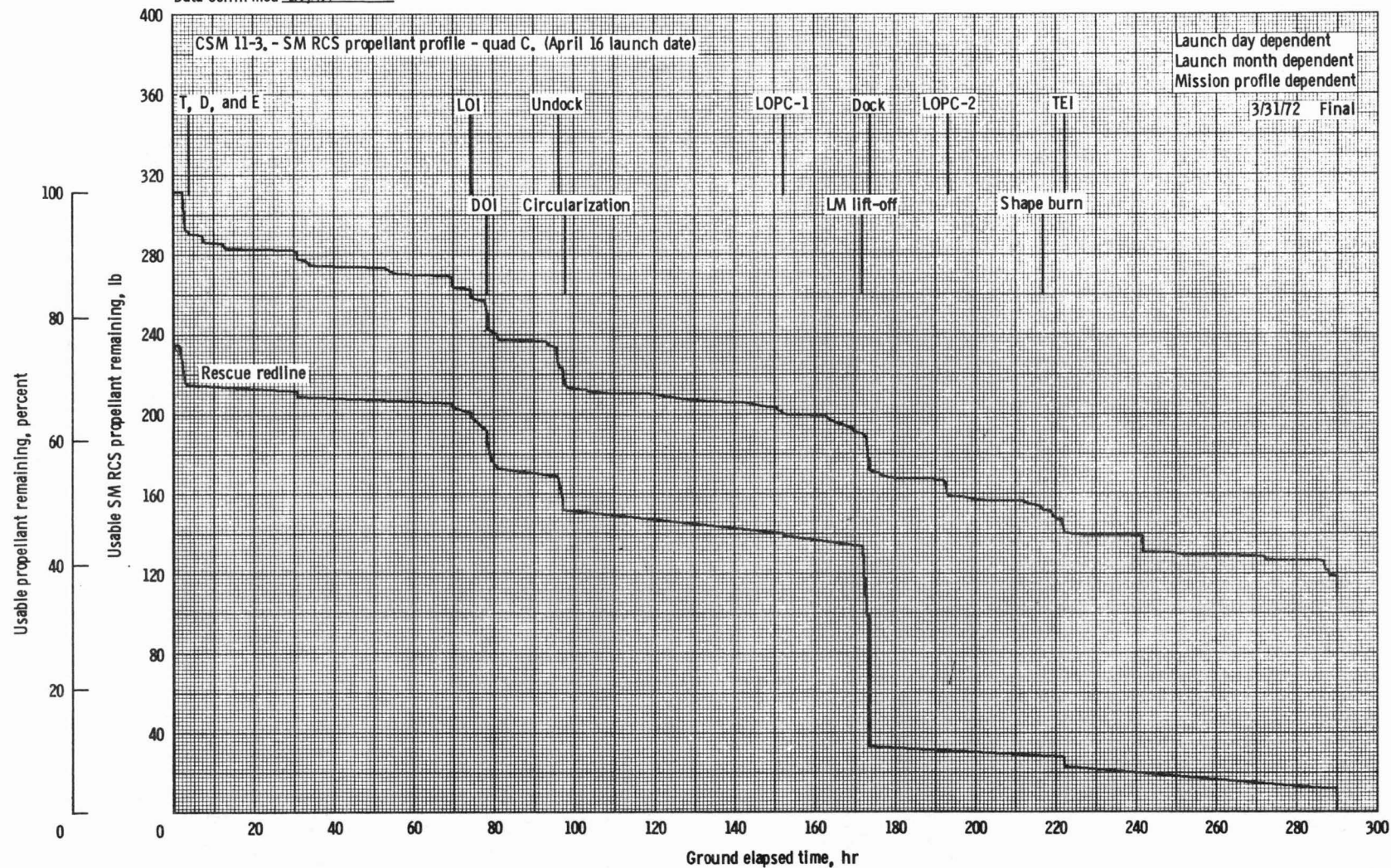
SM RCS propellant profile - quad B.

54

Mayfield/SMB/MPAD (for Flight Plan, CSM Systems Data)

Data source 5000 & Flight Plan

Data confirmed SLM

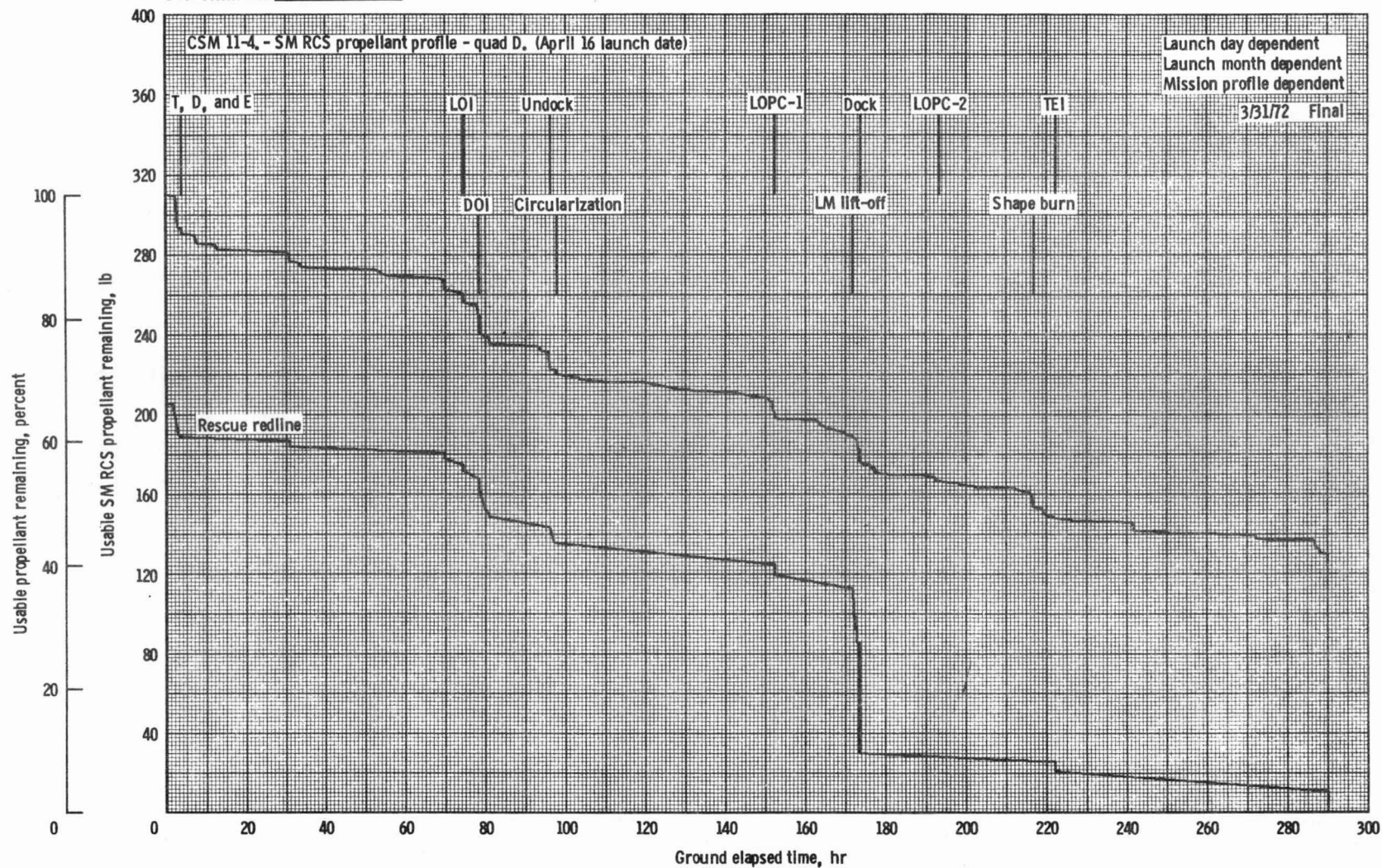


SM RCS propellant profile - quad C.

Mayfield/SMB/MPAD (for Flight Plan, CSM Systems Data)

Data source SODS & Flight Plan

Data confirmed ARM

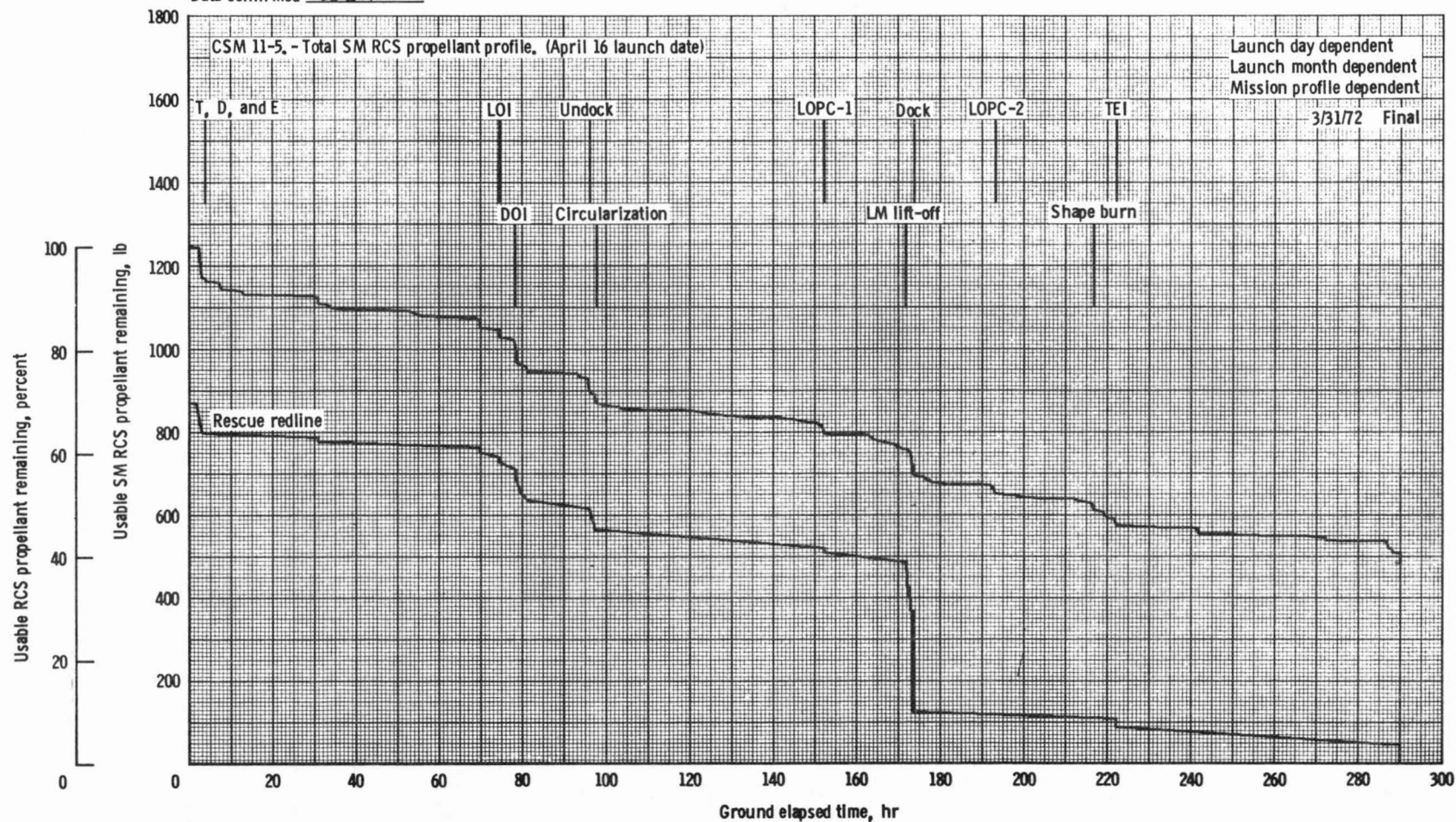


SM RCS propellant profile - quad D.

Mayfield/SMB/MPAD (for Flight Plan, CSM Systems Data)

Data source SM 11-5 Flight Plan

Data confirmed SM 11-5

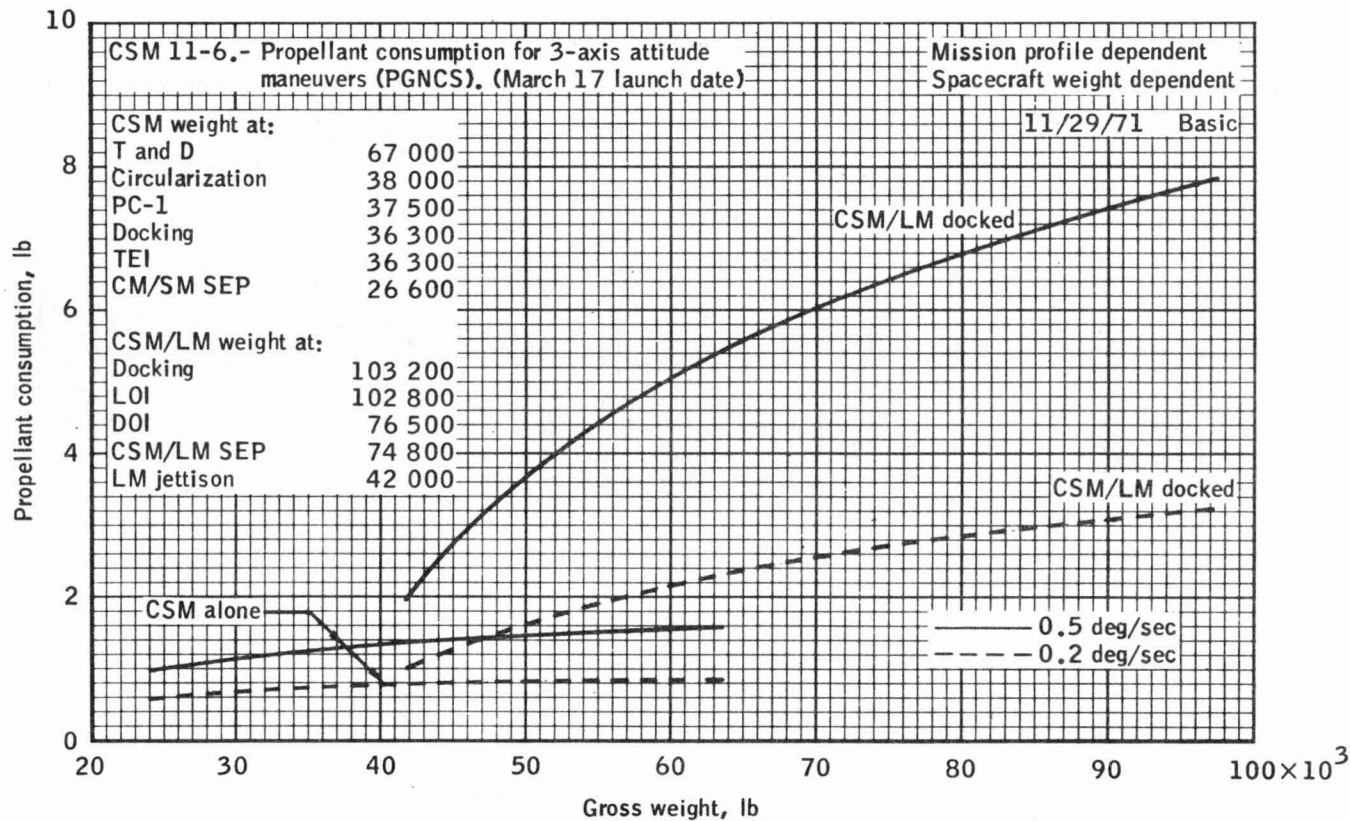


Total SM RCS propellant usage profile.

Mayfield/GPB/MPAD (for G and C Checklist)

Data source Amev 114, Vol. III

Data confirmed 2/2/71

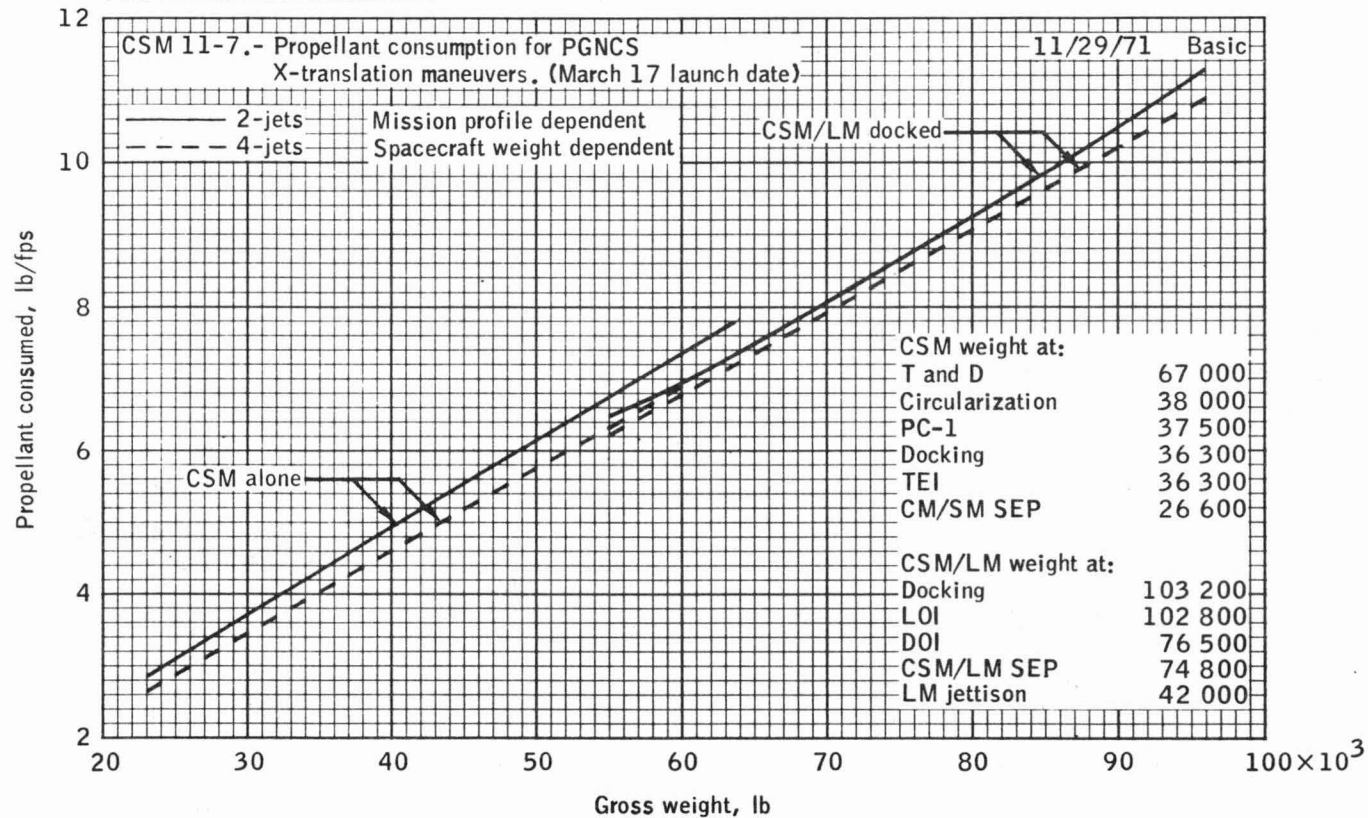


Propellant consumption 3-axis attitude maneuvers (PGNCS).

Mayfield/GPB/MPAD (for G and C Checklist)

Data source Ameva 114, Vol. III

Data confirmed APM

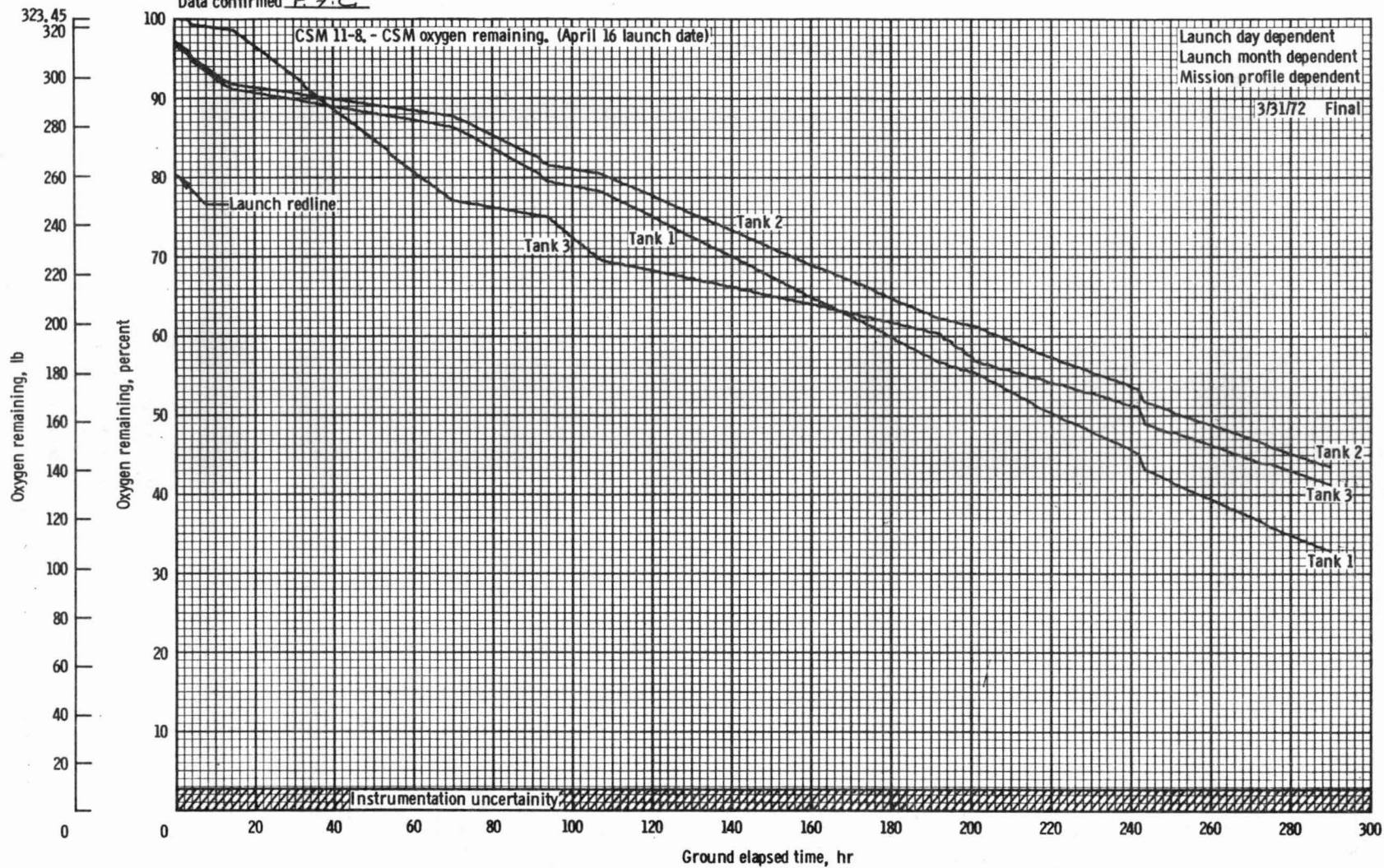


Propellant consumption for PGNCs X-translation maneuvers.

Cantin/SMB/MPAD (for Flight Plan)

Data source ELT PLW SODB

Data confirmed P.Z.C.

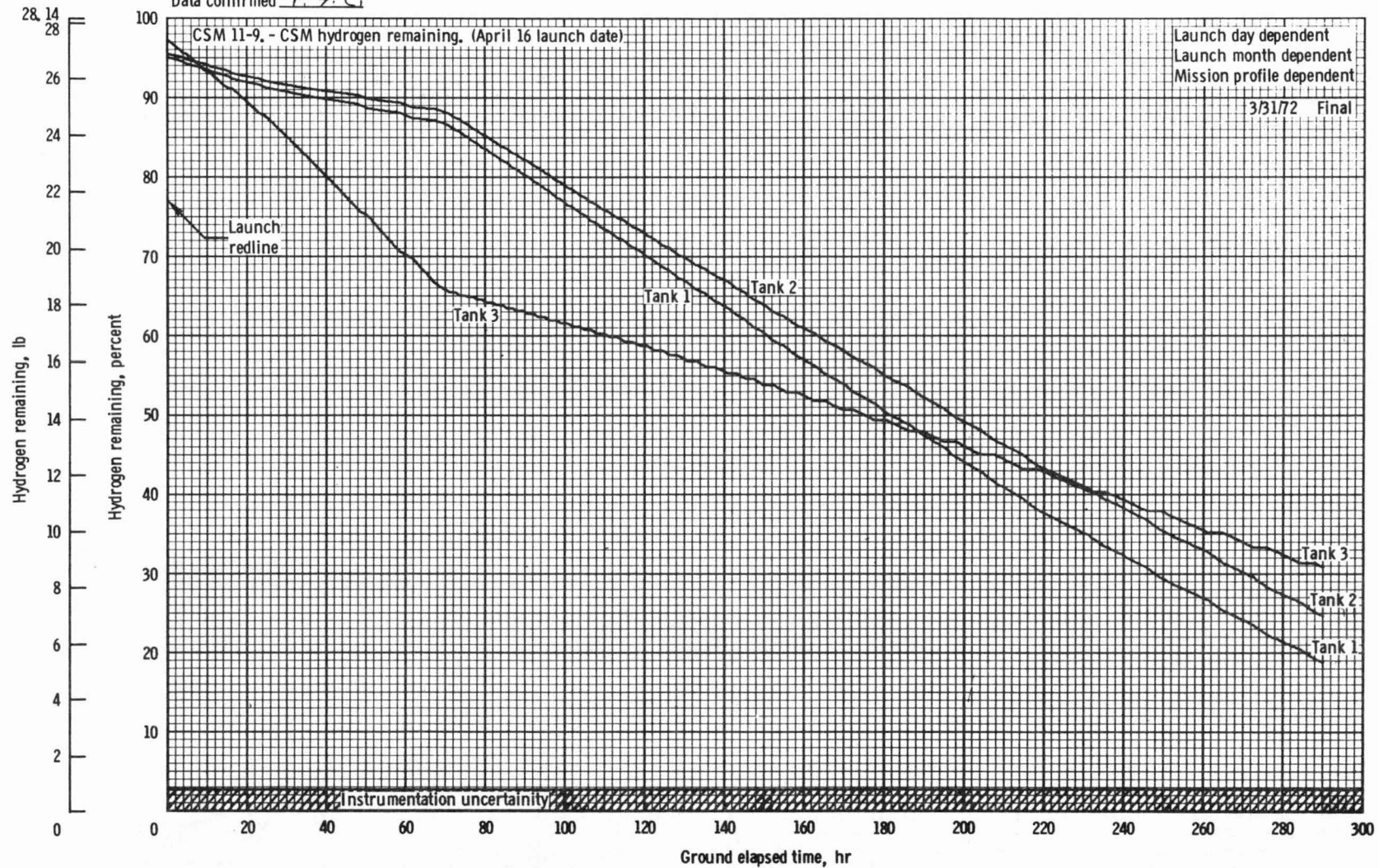


CSM oxygen remaining.

Cantin/SMB/MPAD (for Flight Plan)

Data source FLT PLN, 50573

Data confirmed P. Z. C.



CSM hydrogen remaining.

Cantin/GPB/MPAD (for Flight Plan)

Data source SOD B; 7th Plan.

Data confirmed A.E.C.

CSM 11-10.- Ground rules and assumptions Mission profile dependent
for the CSM cryogenics. (March 17 launch date) 12/13/71 Basic

GROUND RULES AND ASSUMPTIONS FOR THE CSM CRYOGENICS

1. Three O_2 and H_2 tanks are available.
2. Fuel cell purging is included in the EPS requirements.
3. No cryogenic venting was assumed in flight.
4. The EPS hydrogen consumption rate ($\dot{H}_2$) (lb/hr) = $0.00257 \times I_{fc}$
when I_{fc} is the total fuel cell current.
5. The EPS oxygen consumption rate ($\dot{O}_2$) (lb/hr) = $7.936 \times \dot{H}_2$.
6. No allowance for the SM enhancement battery is assumed.

CSM 11-10.- Concluded.

Mission profile dependent
3/1/72 Basic

7. The following tank depletion schedules are being used:

CRYO MANAGEMENT SCHEDULE

GET (hrs:min)	Tank numbers				
	Oxygen htrs ^a		H ₂ tank 1, 2 htrs, tank 3 fan		
	Auto	Off	Auto	Manual	Off
0:00	1, 2	3	1, 2	3	
3:12	1, 2, 3				
4:12	1, 2	3			
14:30	3	1, 2	1, 2, 3		
23:06			3		1, 2
31:30	1, 2, 3				
32:42	3	1, 2			
^a 70:00	1, 2	3	1, 2		3
93:48	3	1, 2			
107:24	1, 2	3			
191:30	3	1, 2			
201:30	1, 2	3			
241:54	1, 2, 3				
243:18	1, 2	3			

^aSwitch to 100-watt heaters in O₂ tanks 1, 2, and 3 at this time.

The CSM consumables summary (table 5-1) shows that a significant H₂ and O₂ margin exists at the end of the mission. This is reflected in the H₂ and O₂ usage profiles shown in figures 5-1 and 5-2. However, these curves do not include dispersions.

In summary, the nominal mission requirements can be satisfied with the existent consumables.

Cantin/SMB/MPAD (for Flight Plan)

Data source SODB → ext. PlanData confirmed P. J. C.CSM 11-11.- Cryogenic summary.
(April 16 launch date)Mission profile dependent
3/1/72 Basic

APOLLO 16 CRYOGENIC SUMMARY

	H ₂ lbs	O ₂ lbs
PLANNING ALLOWANCE		
TOTAL LOADED	87.9	990.3
LESS RESIDUAL	3.5	19.8
LESS INSTRUMENTATION ERROR	<u>2.3</u>	<u>26.0</u>
AVAILABLE FOR MISSION PLANNING	82.1	944.5
PRELAUNCH REQUIREMENT*	3.8	48.3
FLIGHT REQUIREMENT		
EPS (INCLUDING FUEL CELL PURGE)	59.3	470.9
ECS (INCLUDING CABIN PURGE + EVA)	--	83.7
LM PRESSURIZATION	<u>--</u>	<u>11.1</u>
	59.3	565.7
NOMINAL RESERVES		
EPS UNCERTAINTY (2.5%)	1.5	11.8
ECS UNCERTAINTY (.08 #/HR)	<u>--</u>	<u>23.2</u>
	1.5	35.0
TOTAL REQUIREMENT	64.6	649.0
MARGIN T = 0 (FILL/LAUNCH)	17.5	295.5

*Supplied by KSC.

Mayfield/SMB/MPAD (for Flight Plan)

Data source O.T. & SODB

Data confirmed Sam

CSM 11-12.- CM RCS propellant summary.
(April 16 launch date)

Mission profile dependent
3/8/72 Basic

CM RCS PROPELLANT SUMMARY

Item	Propellant required, lb	Propellant remaining, lb
Loaded	--	233.2
Trapped	36.4	196.8
Available for mission planning . . .	--	196.8
Nominal usage*	59.3	137.5
Nominal remaining	--	137.5

*CM RCS propellant usage is for dual ring operation
with DAP control

Mayfield/GPB/MPAD (for Flight Plan)

Data source Flight Plan, SODB & FCD

Data confirmed ASMM

CSM 11-13.- SM RCS budget
(March 17 launch date)

Mission profile dependent
12/7/71 Basic

Ground Rules and Assumptions

1. Following transposition and docking, the S-IVB performs the evasive maneuver.

2. Two midcourse corrections (translunar) are executed as SPS burns with one MCC followed by an RCS trim.

3. One midcourse correction (transearth) is executed as an RCS burn of 5 fps.

4. Quad management is to be determined during the mission.

5. Single jet RCS control during SIM exps.

6. Couple jet RCS control during SIM off periods (major burns).

7. All maneuvering at low rate ($0.2^\circ/\text{sec}$) both docked and undocked.

8. Attitude hold deadband during SIM photography and major burns - 0.5° .

9. Attitude hold deadband at other times - 3.0° (except for 2° deadband test).

10. Lunar orbit usage	SIM photography	1.0 lb/hr
	Rest periods	0.1 lb/hr
	Other	0.5 lb/hr

11. Nominal ullages.

12. Redlines have been defined by the Flight Control Division as an aid in assuring that mission rules are not violated during the mission. They are subject to review during the mission as mission phases are completed and systems capabilities are evaluated. In the event the rescue redline is violated prior to rendezvous, lunar orbit photography activities can be curtailed to conserve propellant. The lunar orbit redline includes a nominal transearth coast phase (with all navigational sightings) plus a 3 sigma G&N TEI cutoff error MCC. If a rescue is required and the lunar orbit redline is violated prior to the nominal TEI, TEI can be performed early and navigational sighting activity curtailed during the transearth phase. The rescue redline is based on the minimized activity during the transearth phase.

Mayfield/SMB/MPAD (for Flight Plan)

Data source Flight Plan & SDBData confirmed SP2

CSM 11-14.- SM RCS propellant loading Mission profile dependent
 and usage summary. (April 16 launch date) 3/31/72 Final

APOLLO 16 SM RCS ANALYSIS

Item	Required, lb	Remaining, lb
Actual Loading	- -	1342.4
Initial outage M/R	15.6	- -
Total trapped	26.4	- -
Gaging inaccuracy	56.0	- -
Deliverable		1244.4
Nominal usage		
Translunar coast	198.2	- -
Lunar orbit	469.3	- -
Transearth coast	94.1	- -
Total	761.6	- -
Nominal remaining usable		482.8

Mayfield/SMB/MPAD (for Flight Plan)

Data source C.T. & S.D.B.

Data confirmed APR 12

CSM 11-15.- Assumptions for the SPS
propellant analysis. (April 16 launch date)

Mission profile dependent
3/31/72 Final

THE SPS ANALYSIS ASSUMPTIONS

FOR THE SPS PROPELLANT ANALYSIS

1. All spacecraft weights and the sequential consumables losses were taken from the Spacecraft Operational Data Book, Amendment 119.
2. The engine I_{sp} assumed for this analysis is 314.9 seconds.
3. The 3σ dispersions are the RSS of the penalties imposed on the SPS margin by 3σ dispersions in propellant loading, mixture ratio, engine I_{sp} , maneuver ΔV , spacecraft weight, and consumable weight losses.
4. The CSM/LM weights for the J-missions have increased to an extent that, for some launch dates, the S-IVB will not have sufficient propellant reserves to compensate for a 3σ engine. Thus, in order to have a combined 3σ confidence level for the S-IVB and SPS, the S-IVB ΔV deficit is covered in the SPS propellant budget.
5. The ground rule for a contingency allowance is to budget for either an LM rescue or for a maneuver to avoid adverse weather conditions at entry, whichever produces the least SPS margin. The ΔV for the LM rescue allowance and the weather avoidance allowance is 600 ft/sec and 300 ft/sec, respectively. For this mission, the weather avoidance allowance produces the least SPS margin.

Mayfield/SMB/MPAD (for Flight Plan)

Data source C.T. & SCDBData confirmed [Signature]CSM 11-16.- SPS propellant summary.
(April 16 launch date)Mission profile dependent
3/31/72 Final

APOLLO 16 SPS PROPELLANT SUMMARY

[APRIL 16, 1972, LAUNCH DATE; 72° LAUNCH AZIMUTH]

Item	Required, lb	Remaining, lb
Actual loading		40 746.5
Trapped and unavailable	441.4	40 305.1
Outage	45.6	40 259.5
Unbalance meter	100.0	40 159.5
Available for ΔV		40 159.5
Required for ΔV		
LOI (2807.0 fps)	24 785.6	15 373.9
DOI (206.1 fps)	1 576.4	13 797.5
CIRC (99.6 fps)	397.2	13 400.3
LOPC-1 (158.7 fps)	613.7	12 786.6
LOPC-2 (282.5 fps)	1 064.7	11 721.9
SHAPE (40.0 fps)	160.5	11 561.4
TEI (3212.2 fps)	10002.2	1 559.2
Nominal remaining		1 559.2
Dispersions		
TLMC (23 fps)	262.3	1 296.9
-3 σ performance	354.3	942.6
S-IVB ΔV deficit	0.0	942.6
Margin above 3 σ		942.6
Available for contingencies*		942.6

* 942.6 lb is equivalent to 359 fps end-of-mission reserve.

Mayfield/GPB/MPAD (for Flight Plan)

Data source SCDPB

Data confirmed SCDPB

CSM 11-17.- SM RCS propellant translation cost.
(March 17 launch date)

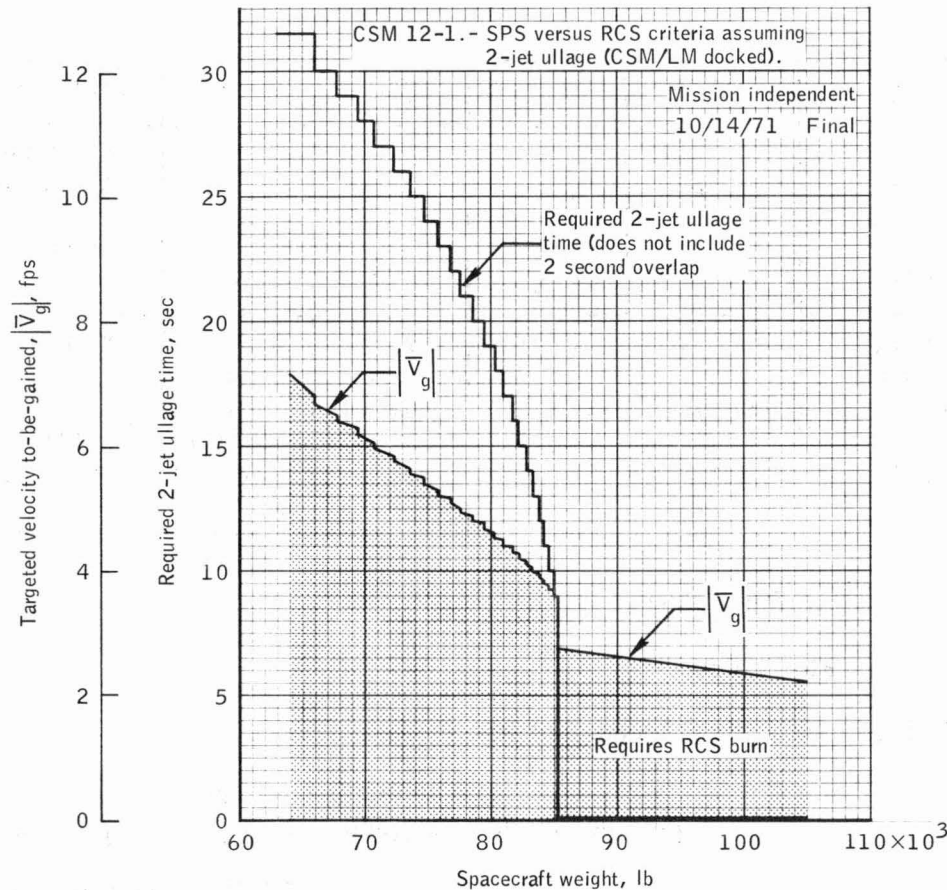
SM RCS PROPELLANT TRANSLATION COST

APOLLO 16

(CSM 113/LM-11)

Mission phase	Typical S/C weight (lb)	+X 4 jet G&C (1b/fps)	+X 4 jet SCS (1b/fps)	+X 2 jet A/C G&C (1b/fps)	+X 2 jet A/C SCS (1b/fps)	+X 2 jet B/D G&C (1b/fps)	+X 2 jet B/D SCS (1b/fps)	+Y or +Z G&C (1b/fps)
Translunar	103 000	11.7	13.3	12.0	13.3	12.4	13.3	--
Lunar orbit docked	75 000	8.6	9.3	8.7	9.3	8.8	9.3	--
Lunar orbit undocked	36 500	4.0	4.7	4.1	4.7	4.3	4.7	5.0
Transearth	26 900	3.1	3.8	3.2	3.8	3.4	3.8	3.5

Miles/GPB/MPAD (for G and C Checklist)
 Data source CSM Data Book (vol 1)
 Data confirmed H.M.



SPS versus RCS criteria assuming 2-jet ullage (CSM/LM docked).

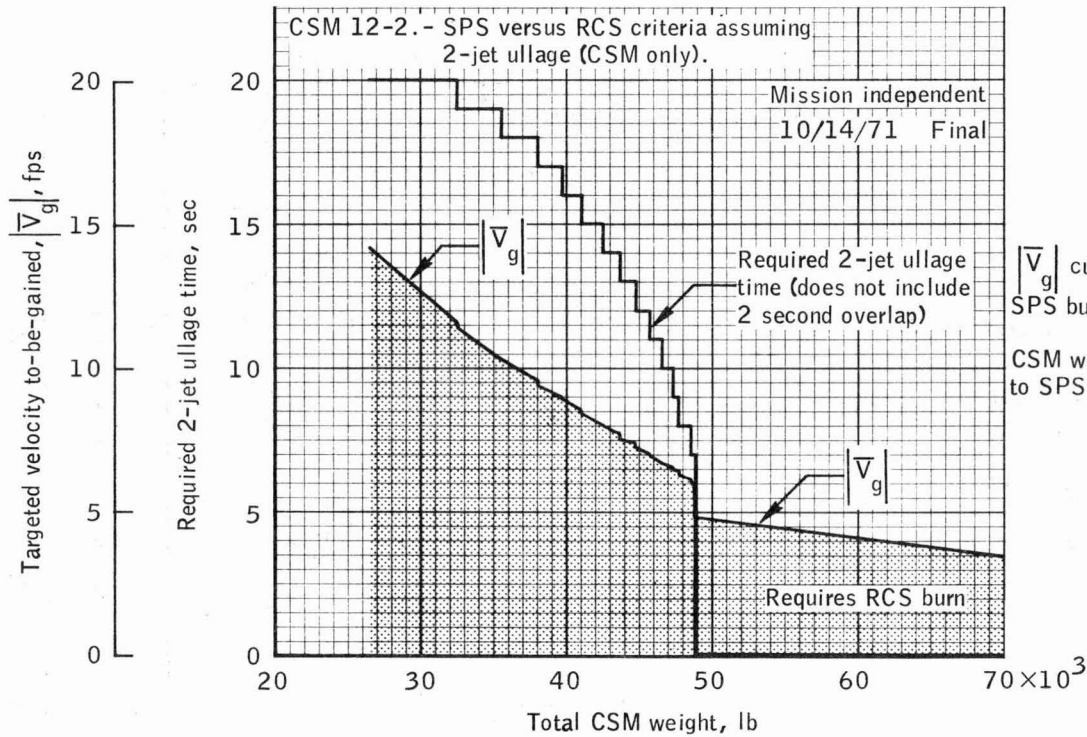
Assumptions

Spacecraft weight assumed to consist of CSM and fully loaded LM

$|\bar{V}_g|$ curve represents minimum SPS burn of 0.5 seconds.

CSM weight variations are due to SPS propellant loss only

Miles/GPB/MPAD (for G and C Checklist)
 Data source CSM Data Book (Vol 1)
 Data confirmed H.M.

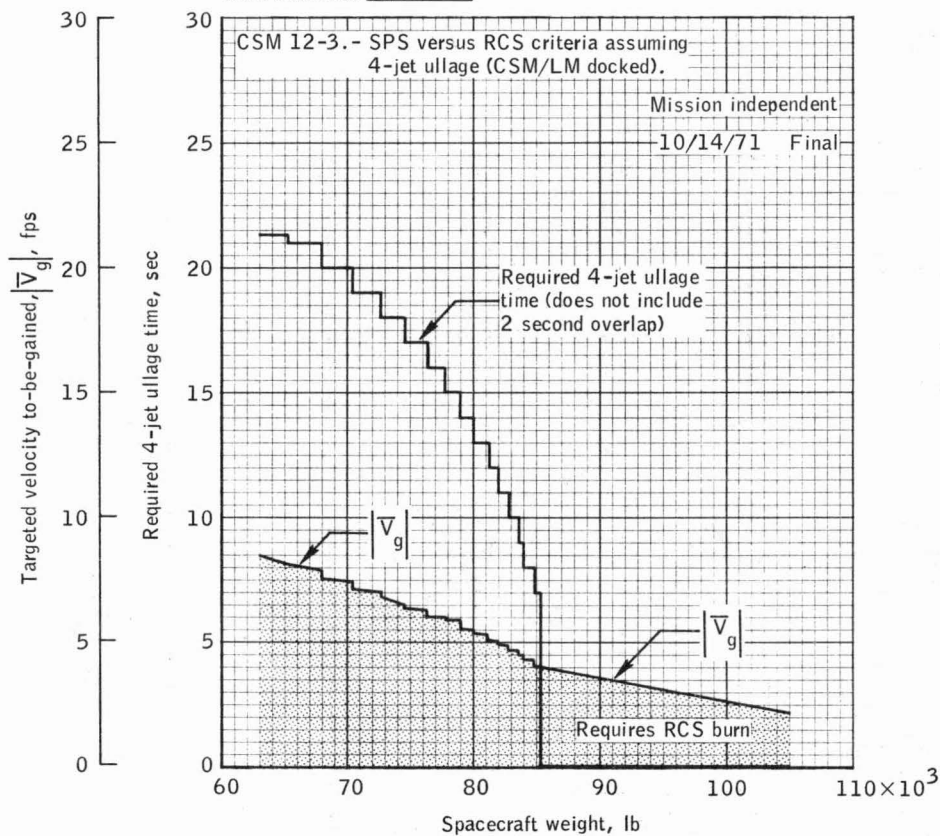


SPS versus RCS criteria assuming 2-jet ullage (CSM only).

Miles/GPB/MPAD (for G and C Checklist)

Data source CSM Data Book (Vol 1)

Data confirmed H.M.



SPS versus RCS criteria assuming 4-jet ullage (CSM/LM docked).

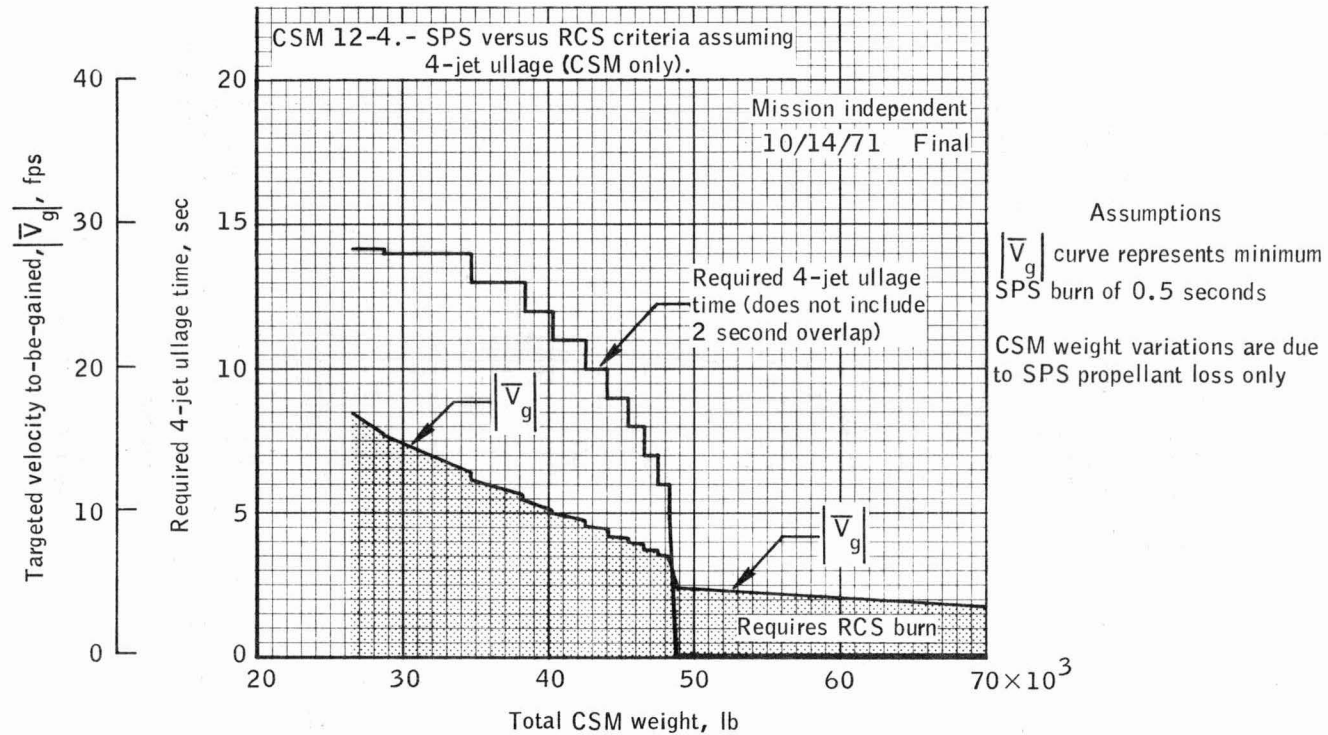
Assumptions

Spacecraft weight assumed to consist of CSM and fully loaded LM

$|\bar{V}_g|$ curve represents minimum SPS burn of 0.5 seconds

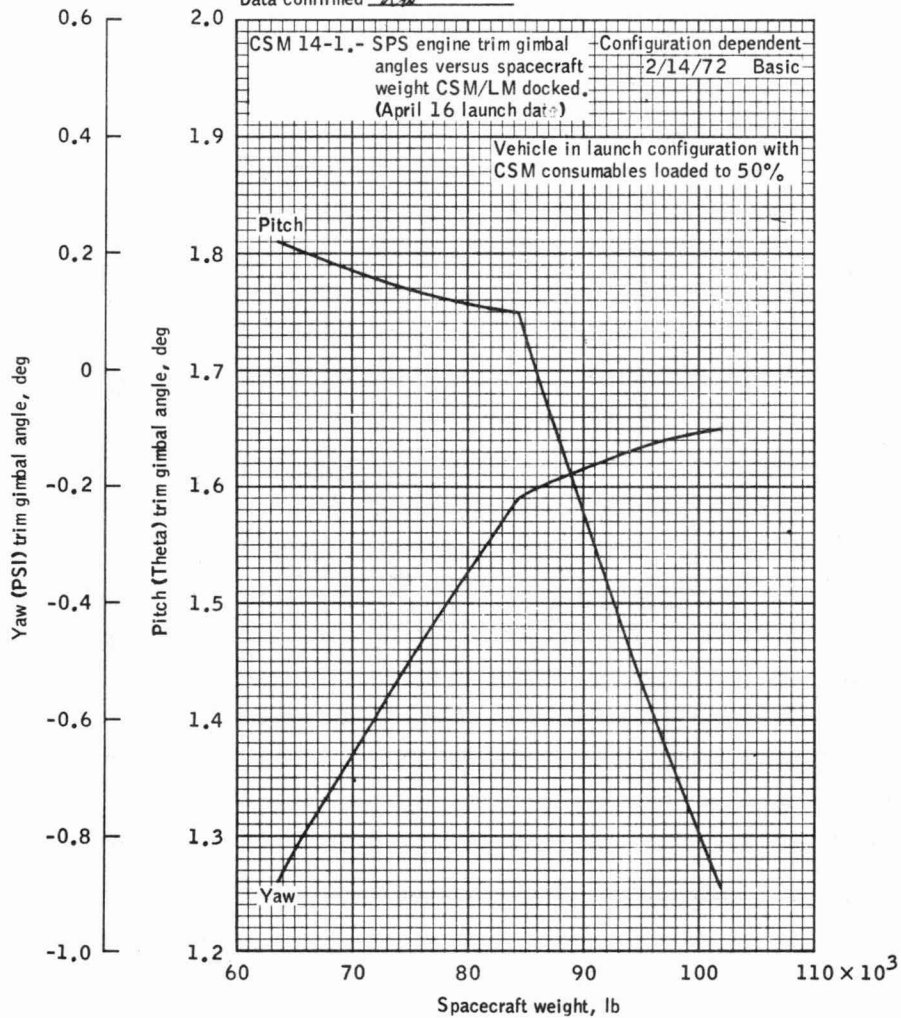
CSM weight variations are due to SPS propellant loss only

Miles/GPB/MPAD (for G and C Checklist)
 Data source CSM Data BDD (Vol 1)
 Data confirmed H. M.



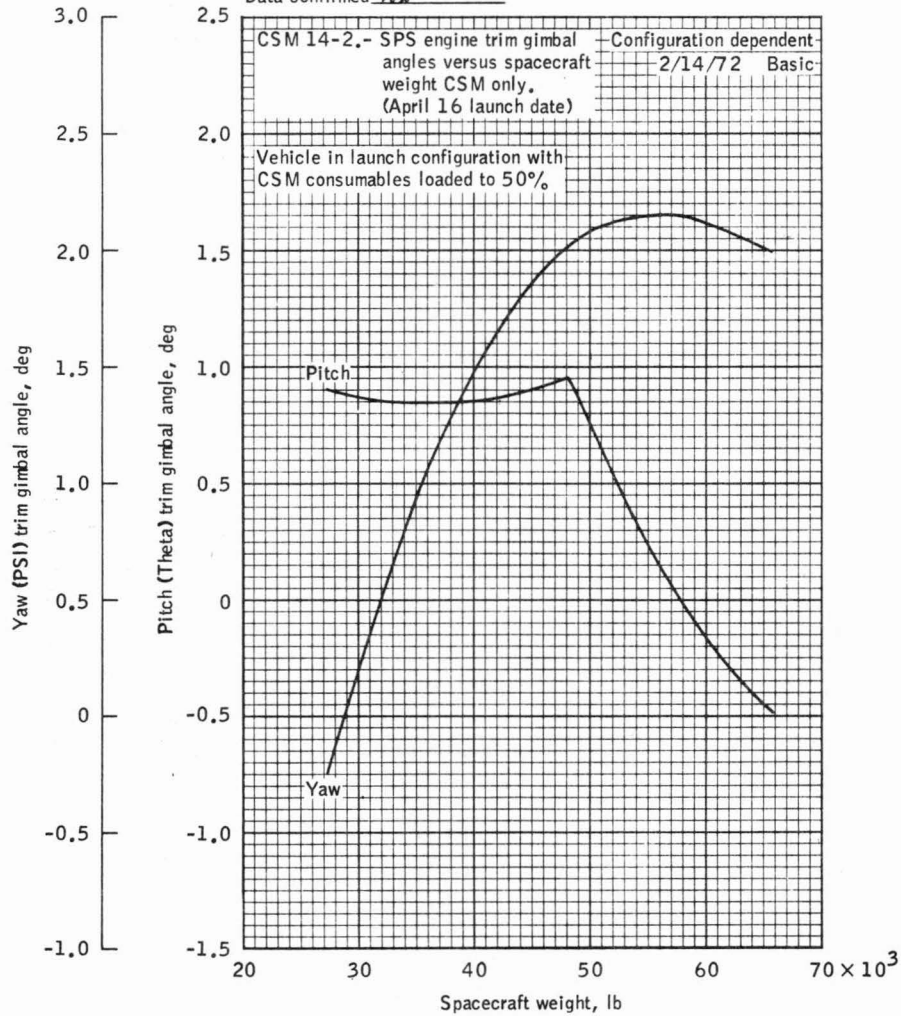
SPS versus RCS criteria assuming 4-jet ullage (CSM only).

Hischke/SMB/MPAD (for G and C Checklist)

Data source SADB Vol III A-115Data confirmed RA

SPS engine trim gimbal angles versus spacecraft weight CSM/LM docked.

Hischke/SMB/MPAD (for G and C Checklist)

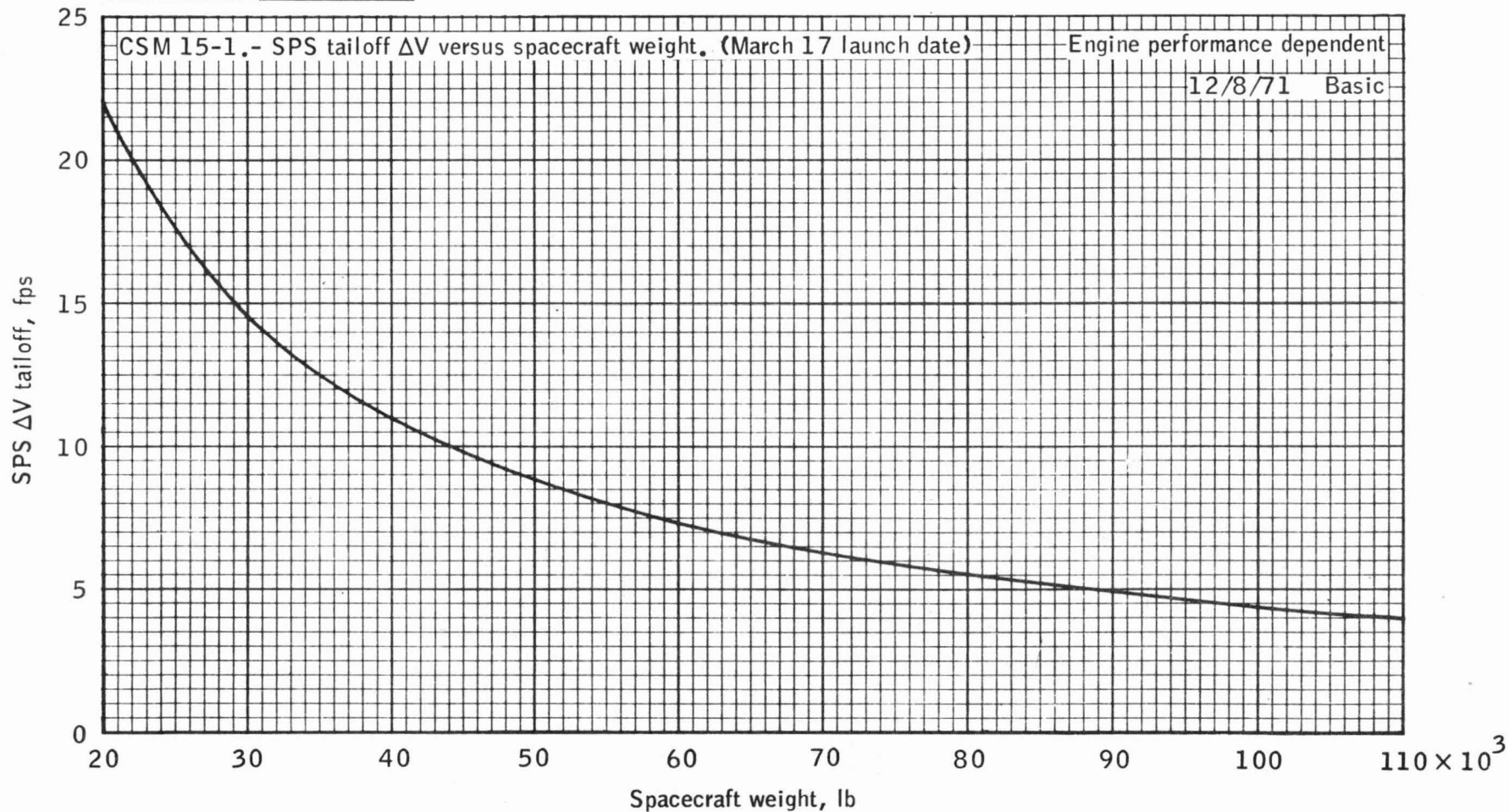
Data source SDBR Vol III A-115Data confirmed RA

SPS engine trim gimbal angles versus spacecraft weight CSM only.

Miles/GPB/MPAD (G and C Checklist)

Data source CSM Data Book

Data confirmed HJM

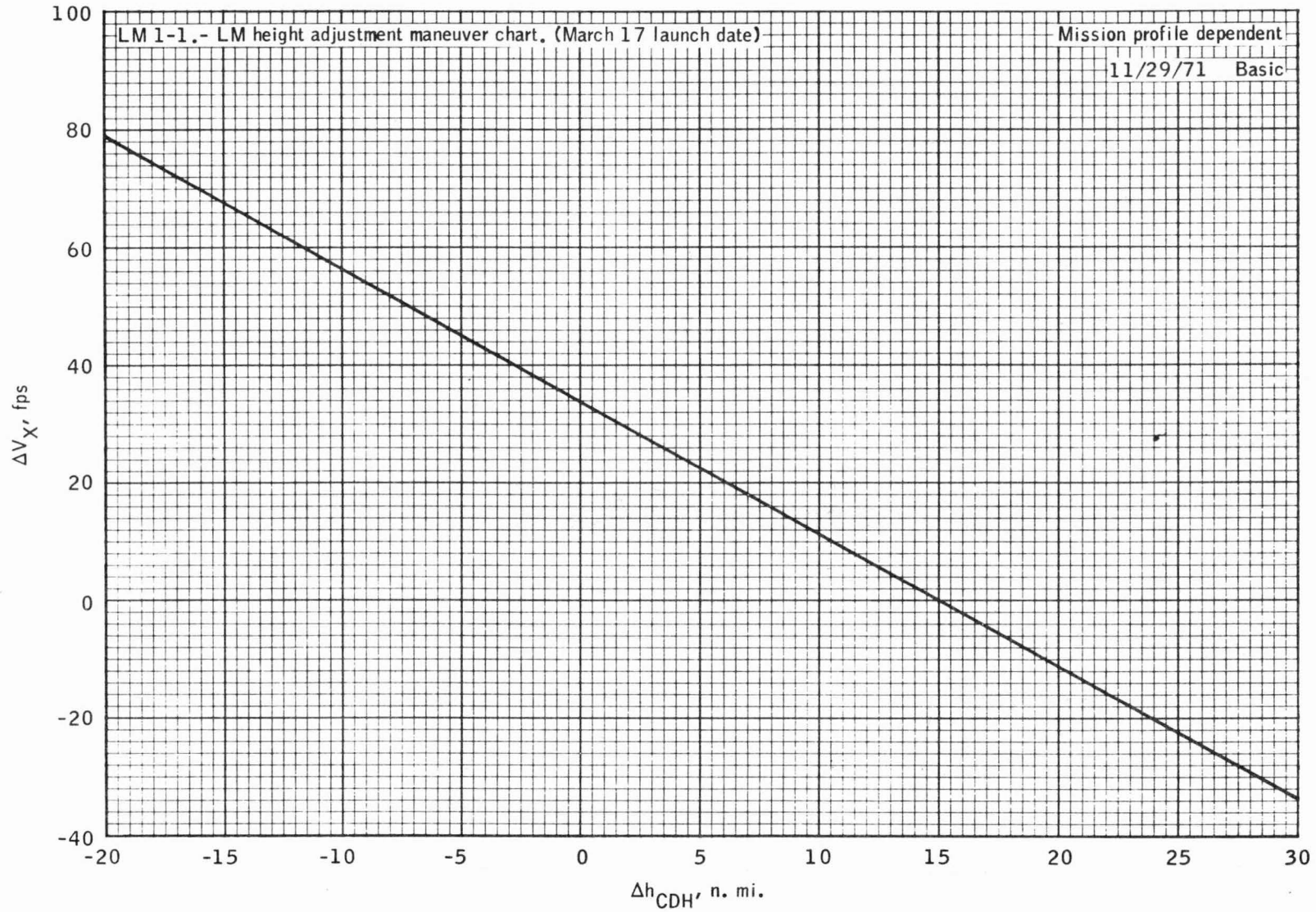


SPS tailoff ΔV versus spacecraft weight.

DuPont/OMAB/MPAD (for LM Timeline)

Data source ~~OMAB~~ Spacecraft AT.

Data confirmed ATD



LM height maneuver chart.

Moore/OMAB/MPAD (for IM Timeline)

Data source Apollo 16 07

Data confirmed KRM

IM 2-1.- Range and range rate
table (M=1).
(April 16 launch date)

Rendezvous sequence
dependent

1/27/72 Basic

M = 1

TIME min:sec	RANGE n. mi.	RANGE RATE fps
L.O.		
5:00	141.6	1652.1
6:00	153.9	801.6
7:00	157.0	-191.2
INS	156.3	-447.2
1:00	151.9	-444.1
2:00	147.5	-440.4
3:00	143.1	-436.3
4:00	138.8	-431.6
5:00	134.6	-426.4
6:00	130.4	-420.8
7:00	126.2	-414.7
8:00	122.1	-408.2
9:00	118.1	-401.3
10:00	114.2	-394.0

Moore/OMAB/MPAD (for LM Timeline)

Data source April 16 1971

Data confirmed KHDA

LM 2-2.- Range and range rate
table (M=2).
(April 16 launch date)

Rendezvous sequence
dependent

1/27/72 Basic

M = 2

TIME min:sec	RANGE n. mi.	RANGE RATE fps
INS	281.9	-453.0
1:00	277.5	-448.9
2:00	273.0	-444.2
3:00	268.6	-439.0
4:00	264.3	-433.2
5:00	260.1	-427.0
6:00	255.8	-420.2
7:00	251.7	-413.0
8:00	247.7	-405.3
9:00	243.7	-397.2
10:00	239.8	-388.7

Fridge, DuPont/SDB/MAB/MPAD (for LM Timeline)

Data source Scot
Data confirmed AGD, C.m. 7.

LM 3-1.- PDI abort summary data. (April 16 launch date)

Launch month dependent
Mission profile dependent

3/6/72 Final

PAGE	ABORT	INS			BOOST	HAM	CSI		CDH			TPI	AIM		
		TIME PDI+	N76	HA/HINS			TIME INS+	ΔVX	TIME INS+	ΔVX	ΔVZ		TIME PDI+	ΔVX	ΔVZ
	NO 1+12	NA	NA	NA	NA	NA	1+00+00*	46.4	2+02+17*	-121.0	-62.7	2+48+42	12+00	102.3	-50.0
	1+00	2+05	5655.2	137.3/55316.	NA	NA	0+55+00	50.2	1+57+17	-120.3	-42.9	2+47+19	NA	NA	NA
	2+00	3+59	5650.3	136.1/60016.				48.2	1+57+12	-117.9	-39.6				
	3+00	5+41	5646.3	132.8/60018.				47.7	1+57+02	-113.5	-33.7				
	4+00	7+18	5639.3	127.2/60023.				47.5	1+56+46	-106.2	-24.9				
	5+00	8+49	5629.8	119.6/60030.				47.3	1+56+25	-96.8	-14.2				
	6+00	10+13	5617.2	109.6/60038.				47.5	1+55+59	-84.3	-1.1				
	7+00	12+27	5597.2	97.0/65209.				46.0	1+55+24	-67.8	13.6				
	8+00	14+29	5570.9	80.0/70999.				44.5	1+54+38	-45.6	30.2				
	9+00	16+06	5546.2	63.2/74096.				43.7	1+53+52	-23.0	43.4				
	10+00	17+15	5529.7	49.9/71992.				44.0	1+53+16	-4.7	51.0				
	11+00	18+20	5554.2	65.7/67668.	50+00	1+50+00	2+40+00	35.3	3+38+59	-26.1	-37.3	4+46+08	NA	NA	NA
	12+00	19+23	5550.5	59.9/62010.				38.0	3+38+46	-19.8	-23.2				
	13+00	20+26	5541.9	52.7/60244.				39.9	3+38+29	-11.5	-6.1				
	14+00	21+26	5534.3	47.2/60242.				40.7	3+38+16	-4.8	6.2				
	15+00	22+25	5526.7	41.7/60241.				41.2	3+38+02	2.2	17.4				
	16+00	23+25	5519.1	36.2/60239.				41.6	3+37+48	9.4	27.7				
	17+00	24+24	5511.5	30.8/60238.				41.8	3+37+34	16.9	36.9				
	T2-1	7+22Ω	5510.4	29.8/60154.	50+00	3+50+00	4+40+00	36.5	5+37+20	23.0	54.4	6+44+52	NA	NA	NA
	NO 2+12	NA	NA	NA	1+07+00*	2+07+00*	3+07+00*	39.3	4+09+42*	-129.6	2.0	4+50+48	12+00	112.0	-50.0
	1+00	2+07	5666.7	146.3/54651.	1+00+00	2+00+00	3+00+00	40.9	4+02+43	-132.1	-9.3	4+50+55	NA	NA	NA
	2+00	4+00	5661.5	145.2/60017.				38.7	4+02+38	-129.9	-6.8				
	3+00	5+43	5659.5	143.6/60019.				38.1	4+02+32	-127.2	-1.4				
	4+00	7+19	5656.2	140.9/60024.				37.5	4+02+24	-123.4	6.7				
	5+00	8+50	5651.5	137.1/60031.				37.2	4+02+13	-118.2	17.3				
	6+00	10+15	5645.6	132.3/60039.				36.7	4+01+59	-112.0	29.4				
	7+00	12+32	5657.3	145.0/65451.	NA	NA	0+55+00	43.7	1+57+30	-125.5	-52.6	2+52+06	NA	NA	NA
	8+00	14+33	5632.3	128.0/71163.				43.3	1+56+46	-105.7	-26.5				
	9+00	16+10	5609.0	111.2/74179.				43.3	1+56+01	-85.4	-4.0				
	10+00	17+19	5593.7	98.0/72050.				44.2	1+55+26	-68.9	11.5				
	11+00	18+22	5581.0	85.9/67701.				45.4	1+54+54	-53.4	23.9				
	12+00	19+24	5569.4	74.0/62035.				46.8	1+54+22	-37.8	34.3				
	13+00	20+26	5551.4	59.7/60246.				47.2	1+53+43	-18.6	44.5				
	14+00	21+26	5536.6	48.8/60243.				47.1	1+53+14	-3.6	50.7				
	15+00	22+25	5521.5	37.9/60240.				46.8	1+52+44	11.7	55.1				
	T2-2	7+22Ω	5510.4	29.8/60154.	50+00	1+50+00	2+40+00	42.0	3+37+31	17.9	38.9	4+50+52	NA	NA	NA

Ω INDICATES TIME IS REFERENCED TO LIFT-OFF.

* INDICATES TIME IS REFERENCED TO PDI.

LM Pont/MAB/MPAD (for LM Timeline)

Data source Spacecraft O.T.

Data confirmed AGD

LM 4-1.- Range and range rate data at insertion and 10 minutes prior to subsequent maneuvers. (April 16 launch date)

Mission profile dependent

3/1/72 Basic

PAGE	ABORT	INS		BOOST		HAM		CSI		CDH	
	TIME PDI+	RANGE	RANGE RATE	RANGE	RANGE RATE	RANGE	RANGE RATE	RANGE	RANGE RATE	RANGE	RANGE RATE
	NO 1+12	NA	NA	NA	NA	NA	NA	193.3	-526.5	104.3	-109.6
	01+00	160.9	559.5	NA	NA	NA	NA	178.2	-526.3	105.3	-123.0
	02+00	157.5	545.2	↓	↓	↓	↓	173.2	-514.9	101.2	-123.1
	03+00	143.7	526.8	↓	↓	↓	↓	159.1	-491.3	100.4	-129.1
	04+00	119.0	493.6	↓	↓	↓	↓	135.5	-447.3	101.5	-112.0
	05+00	84.1	414.6	↓	↓	↓	↓	101.6	-373.1	98.5	-136.3
	06+00	49.9	85.5	↓	↓	↓	↓	58.4	-224.1	96.7	-149.7
	07+00	74.4	-428.8	↓	↓	↓	↓	33.2	243.6	96.4	-157.6
	08+00	149.9	-468.5	↓	↓	↓	↓	86.2	196.7	96.1	-168.7
	09+00	224.5	-446.9	↓	↓	↓	↓	145.0	60.2	94.1	-176.6
	10+00	283.6	-424.8	↓	↓	↓	↓	190.7	-46.0	94.4	-182.2
	11+00	335.5	-443.0	263.0	75.6	212.3	-378.0	81.5	24.3	99.3	-88.2
	12+00	387.7	-429.2	311.8	32.1	236.2	-385.3	106.5	-6.0	98.7	-101.2
	13+00	437.3	-415.9	357.9	-9.7	258.9	-390.0	131.1	-57.9	97.5	-111.8
	14+00	487.5	-402.0	404.2	-52.8	282.0	-392.2	153.0	-68.3	96.0	-121.2
	15+00	537.5	-388.0	450.1	-96.4	305.0	-392.3	175.9	-102.6	95.4	-130.6
	16+00	587.1	-374.0	495.3	-140.6	328.1	-390.4	198.2	-139.0	93.4	-138.2
	17+00	636.3	-359.8	540.0	-185.3	351.2	-386.7	220.1	-177.4	92.3	-149.4
	T2-1	983.5	-305.9	895.9	-197.7	362.6	-350.9	245.2	-206.3	84.5	-154.7
	NO 2+12	NA	NA	381.6	-726.1	158.0	468.2	195.2	-618.9	95.9	-160.2
	01+00	381.1	618.1	373.0	-718.7	143.8	479.3	193.2	-611.4	103.9	-165.2
	02+00	378.2	604.0	368.1	-707.7	144.6	468.7	190.2	-603.0	99.1	-163.7
	03+00	364.3	594.8	352.8	-695.9	137.3	465.8	180.2	-588.6	101.1	-158.2
	04+00	338.8	583.8	327.3	-674.3	126.0	464.8	166.2	-565.8	99.2	-165.6
	05+00	300.2	570.2	289.8	-642.7	108.7	463.4	146.2	-530.3	97.3	-175.8
	06+00	247.0	551.9	238.9	-597.2	85.8	455.0	120.4	-475.0	96.4	-178.8
	07+00	178.7	544.3	NA	NA	NA	NA	188.6	-540.8	102.7	-123.9
	08+00	99.5	455.1	↓	↓	↓	↓	115.8	-406.9	101.2	-135.0
	09+00	48.7	40.3	↓	↓	↓	↓	55.2	-203.7	98.1	-152.8
	10+00	69.8	-414.7	↓	↓	↓	↓	32.1	211.8	97.1	-156.9
	11+00	114.4	-470.5	↓	↓	↓	↓	58.2	260.1	94.6	-164.5
	12+00	164.5	-466.4	↓	↓	↓	↓	97.0	166.5	92.1	-168.9
	13+00	213.5	-451.3	↓	↓	↓	↓	135.3	74.9	91.6	-171.7
	14+00	264.0	-432.4	↓	↓	↓	↓	174.2	-18.6	90.7	-175.7
	15+00	314.6	-412.2	↓	↓	↓	↓	212.5	-112.5	88.3	-175.1
	T2-2	654.0	-356.5	556.8	-194.8	363.0	-386.3	231.6	-185.9	93.2	-141.3

Moore/OMAB/MPAD (for LM Timeline)

Data source April 16 JT

Data confirmed 2/21/72

LM 7-1.- Lift-off table.
(April 16 launch date)

Launch day dependent

Launch month dependent

Mission profile dependent

1/27/72 Basic

REV	NEW TIG	NOM TIG
14		100:42:48
15		102:41:24
16		104:39:51
17		106:38:19
18		108:36:47
19		110:35:15
20		112:33:43
21		114:32:11
22		116:30:39
23		118:29:06
24		120:27:34
25		122:26:02
26		124:24:30
27		126:22:58
28		128:21:26
29		130:19:53
30		132:18:21
31		134:16:49
32		136:15:17
33		138:13:45
34		140:12:12
35		142:10:40
36		144:09:08
37		146:07:36
38		148:06:03
39		150:04:31
40		152:02:59
41		154:01:28
42		155:59:55
43		157:58:22
44		159:56:49
45		161:55:16
46		163:53:43
47		165:52:10
48		167:50:37
49		169:49:04
50		171:45:09

Blucker/MPB/MPAD (for G and C Checklist)

Data source 17th EditionData confirmed MS

LM 8-1.- Planet unit vectors (lunar referenced)

Venus, Mars, Jupiter, Saturn.

(April 16 launch date)

Launch day dependent

Launch month dependent

2/1/72 Basic

0 Hours GET = 4:16:17:54

Liftoff = 4:16:__:__

VENUS UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
90.0	.24526	.85986	.44776
95.0	.24208	.86054	.44819
100.0	.23890	.86120	.44862
105.0	.23574	.86186	.44903
110.0	.23259	.86250	.44944
115.0	.22946	.86313	.44985
120.0	.22633	.86374	.45024
125.0	.22322	.86435	.45063
130.0	.22012	.86494	.45102
135.0	.21704	.86553	.45140
140.0	.21397	.86610	.45177
145.0	.21091	.86666	.45213
150.0	.20787	.86720	.45249
155.0	.20485	.86774	.45284
160.0	.20183	.86826	.45319
165.0	.19884	.86878	.45353
170.0	.19585	.86928	.45386
175.0	.19289	.86977	.45419
180.0	.18994	.87025	.45451
185.0	.18700	.87072	.45483
190.0	.18409	.87118	.45514
195.0	.18118	.87163	.45544
200.0	.17830	.87207	.45574

LM 8-1.- Continued.

Launch day dependent
 Launch month dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

<u>MARS UNIT VECTOR</u>			
<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
90.0	.24451	.88177	.40337
95.0	.24219	.88230	.40361
100.0	.23987	.88282	.40384
105.0	.23755	.88334	.40408
110.0	.23523	.88385	.40431
115.0	.23292	.88436	.40454
120.0	.23060	.88486	.40477
125.0	.22829	.88536	.40500
130.0	.22597	.88585	.40522
135.0	.22366	.88634	.40544
140.0	.22135	.88682	.40566
145.0	.21904	.88729	.40588
150.0	.21673	.88776	.40609
155.0	.21442	.88822	.40630
160.0	.21212	.88868	.40651
165.0	.20981	.88913	.40672
170.0	.20751	.88958	.40692
175.0	.20521	.89002	.40712
180.0	.20291	.89046	.40732
185.0	.20061	.89089	.40752
190.0	.19831	.89131	.40772
195.0	.19601	.89173	.40791
200.0	.19371	.89215	.40810

LM 8-1.- Concluded.

Launch day dependent
 Launch month dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

JUPITER UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
100.0	.14388	-.90997	-.38890
200.0	.14402	-.90991	-.38901

SATURN UNIT VECTOR

<u>TIME (GET)</u> <u>HOURS</u>	<u>X(R1)</u>	<u>Y(R2)</u>	<u>Z(R3)</u>
100.0	.42393	.84174	.33429
150.0	.42007	.84336	.33508
200.0	.41620	.84497	.33586

Blucker/MPB/MPAD (for G and C Checklist)

Data source MPB/MPADData confirmed LR3LM 8-2.- Earth unit vectors.
(April 16 launch date)Launch day dependent
Launch month dependent
Mission profile dependent
2/1/72 Basic

0 Hours GET = 4:16:17:54

Liftoff = 4:16:__:__

TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
90.00	.50038	-.79424	-.34470
90.50	.50450	-.79221	-.34336
91.00	.50861	-.79017	-.34201
91.50	.51270	-.78810	-.34066
92.00	.51678	-.78602	-.33930
92.50	.52084	-.78393	-.33793
93.00	.52489	-.78182	-.33656
93.50	.52892	-.77969	-.33518
94.00	.53294	-.77754	-.33379
94.50	.53695	-.77538	-.33239
95.00	.54094	-.77321	-.33099
95.50	.54491	-.77101	-.32958
96.00	.54887	-.76880	-.32817
96.50	.55282	-.76658	-.32675
97.00	.55675	-.76434	-.32532
97.50	.56067	-.76208	-.32389
98.00	.56457	-.75981	-.32245
98.50	.56846	-.75752	-.32100
99.00	.57233	-.75521	-.31955
99.50	.57618	-.75289	-.31809
100.00	.58003	-.75056	-.31662
100.50	.58385	-.74821	-.31515
101.00	.58766	-.74584	-.31367
101.50	.59146	-.74346	-.31219
102.00	.59524	-.74106	-.31069
102.50	.59900	-.73865	-.30920
103.00	.60275	-.73623	-.30770
103.50	.60649	-.73378	-.30619
104.00	.61020	-.73133	-.30467
104.50	.61391	-.72886	-.30315
105.00	.61759	-.72637	-.30163
105.50	.62127	-.72387	-.30009
106.00	.62492	-.72136	-.29856
106.50	.62856	-.71883	-.29701
107.00	.63218	-.71628	-.29546
107.50	.63579	-.71373	-.29391
108.00	.63938	-.71115	-.29235
108.50	.64296	-.70857	-.29078
109.00	.64652	-.70597	-.28921
109.50	.65006	-.70335	-.28763
110.00	.65359	-.70072	-.28605
110.50	.65710	-.69808	-.28446
111.00	.66059	-.69543	-.28287
111.50	.66407	-.69276	-.28127

LM 8-2.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54

Liftoff = 4:16:__:__

TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
112.00	.66753	-.69007	-.27967
112.50	.67098	-.68738	-.27806
113.00	.67441	-.68467	-.27645
113.50	.67782	-.68194	-.27483
114.00	.68122	-.67921	-.27320
114.50	.68460	-.67646	-.27157
115.00	.68796	-.67369	-.26994
115.50	.69130	-.67092	-.26830
116.00	.69463	-.66813	-.26666
116.50	.69795	-.66532	-.26501
117.00	.70124	-.66251	-.26335
117.50	.70452	-.65968	-.26170
118.00	.70778	-.65684	-.26003
118.50	.71103	-.65399	-.25836
119.00	.71426	-.65112	-.25669
119.50	.71747	-.64825	-.25501
120.00	.72066	-.64535	-.25333
120.50	.72384	-.64245	-.25165
121.00	.72700	-.63954	-.24995
121.50	.73014	-.63661	-.24826
122.00	.73327	-.63367	-.24656
122.50	.73638	-.63072	-.24485
123.00	.73947	-.62776	-.24315
123.50	.74254	-.62478	-.24143
124.00	.74560	-.62180	-.23972
124.50	.74864	-.61880	-.23799
125.00	.75166	-.61579	-.23627
125.50	.75467	-.61277	-.23454
126.00	.75766	-.60973	-.23281
126.50	.76063	-.60669	-.23107
127.00	.76358	-.60363	-.22933
127.50	.76651	-.60057	-.22758
128.00	.76943	-.59749	-.22583
128.50	.77233	-.59440	-.22408
129.00	.77521	-.59130	-.22232
129.50	.77808	-.58819	-.22056
130.00	.78092	-.58507	-.21879
130.50	.78375	-.58194	-.21702
131.00	.78656	-.57879	-.21525
131.50	.78936	-.57564	-.21347
132.00	.79213	-.57247	-.21169
132.50	.79489	-.56930	-.20991
133.00	.79763	-.56611	-.20812
133.50	.80035	-.56292	-.20633

LM 8-2.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
134.00	.80306	-.55971	-.20454
134.50	.80574	-.55650	-.20274
135.00	.80841	-.55327	-.20094
135.50	.81106	-.55004	-.19914
136.00	.81369	-.54679	-.19733
136.50	.81631	-.54353	-.19552
137.00	.81890	-.54027	-.19370
137.50	.82148	-.53699	-.19189
138.00	.82404	-.53371	-.19007
138.50	.82658	-.53041	-.18824
139.00	.82911	-.52711	-.18642
139.50	.83161	-.52380	-.18459
140.00	.83410	-.52048	-.18275
140.50	.83657	-.51714	-.18092
141.00	.83902	-.51380	-.17908
141.50	.84145	-.51045	-.17724
142.00	.84387	-.50709	-.17539
142.50	.84626	-.50373	-.17355
143.00	.84864	-.50035	-.17170
143.50	.85100	-.49696	-.16984
144.00	.85334	-.49357	-.16799
144.50	.85566	-.49016	-.16613
145.00	.85796	-.48675	-.16427
145.50	.86025	-.48333	-.16241
146.00	.86252	-.47990	-.16054
146.50	.86476	-.47647	-.15867
147.00	.86699	-.47302	-.15680
147.50	.86920	-.46957	-.15493
148.00	.87140	-.46611	-.15306
148.50	.87357	-.46264	-.15118
149.00	.87573	-.45916	-.14930
149.50	.87786	-.45567	-.14742
150.00	.87998	-.45218	-.14553
150.50	.88208	-.44868	-.14364
151.00	.88416	-.44517	-.14176
151.50	.88622	-.44165	-.13986
152.00	.88827	-.43813	-.13797
152.50	.89029	-.43460	-.13608
153.00	.89230	-.43106	-.13418
153.50	.89429	-.42751	-.13228
154.00	.89626	-.42396	-.13038
154.50	.89821	-.42040	-.12848
155.00	.90014	-.41683	-.12657
155.50	.90205	-.41326	-.12466

LM 8-2.- Continued.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
156.00	.90394	-.40967	-.12276
156.50	.90582	-.40609	-.12085
157.00	.90767	-.40249	-.11893
157.50	.90951	-.39889	-.11702
158.00	.91133	-.39528	-.11511
158.50	.91313	-.39166	-.11319
159.00	.91491	-.38804	-.11127
159.50	.91667	-.38441	-.10935
160.00	.91841	-.38078	-.10743
160.50	.92014	-.37714	-.10551
161.00	.92184	-.37349	-.10358
161.50	.92353	-.36984	-.10166
162.00	.92519	-.36618	-.09973
162.50	.92684	-.36251	-.09780
163.00	.92847	-.35884	-.09587
163.50	.93008	-.35516	-.09394
164.00	.93167	-.35148	-.09201
164.50	.93324	-.34779	-.09008
165.00	.93480	-.34410	-.08814
165.50	.93633	-.34040	-.08621
166.00	.93784	-.33669	-.08427
166.50	.93934	-.33298	-.08233
167.00	.94082	-.32926	-.08039
167.50	.94227	-.32554	-.07846
168.00	.94371	-.32182	-.07652
168.50	.94513	-.31808	-.07457
169.00	.94653	-.31435	-.07263
169.50	.94791	-.31061	-.07069
170.00	.94928	-.30686	-.06875
170.50	.95062	-.30311	-.06680
171.00	.95194	-.29935	-.06486
171.50	.95325	-.29559	-.06291
172.00	.95453	-.29182	-.06097
172.50	.95580	-.28805	-.05902
173.00	.95705	-.28428	-.05707
173.50	.95828	-.28050	-.05512
174.00	.95949	-.27671	-.05318
174.50	.96068	-.27293	-.05123
175.00	.96185	-.26913	-.04928
175.50	.96300	-.26534	-.04733
176.00	.96413	-.26154	-.04538
176.50	.96525	-.25773	-.04343
177.00	.96634	-.25392	-.04148
177.50	.96742	-.25011	-.03953

LM 8-2.- Concluded.

Launch day dependent
 Launch month dependent
 Mission profile dependent
 2/1/72 Basic

0 Hours GET = 4:16:17:54
 Liftoff = 4:16:__:__

TIME (GET) HOURS	X(R1)	Y(R2)	Z(R3)
178.00	.96847	-.24630	-.03758
178.50	.96951	-.24248	-.03562
179.00	.97053	-.23865	-.03367
179.50	.97153	-.23483	-.03172
180.00	.97251	-.23100	-.02977
180.50	.97347	-.22716	-.02782
181.00	.97441	-.22333	-.02587
181.50	.97533	-.21948	-.02392
182.00	.97623	-.21564	-.02197
182.50	.97712	-.21179	-.02001
183.00	.97798	-.20794	-.01806
183.50	.97883	-.20409	-.01611
184.00	.97965	-.20024	-.01416
184.50	.98046	-.19638	-.01221
185.00	.98125	-.19252	-.01026
185.50	.98201	-.18865	-.00831
186.00	.98276	-.18478	-.00636
186.50	.98349	-.18092	-.00441
187.00	.98421	-.17704	-.00246
187.50	.98490	-.17317	-.00052
188.00	.98557	-.16929	.00144
188.50	.98622	-.16541	.00339
189.00	.98686	-.16153	.00534
189.50	.98747	-.15765	.00728
190.00	.98807	-.15376	.00923

Cockrell/MPB/MPAD (for Star Charts)

Data source USNOData confirmed BAC

LM 8-3.- Star unit vectors. (July 26 launch date)

Nearst mean Besselian year

4/7/71 Basic

DATA VALID FROM 1 JULY 71 TO 30 JUNE 72

STAR NO. (OCTAL)	UNIT VECTORS			ECLIPTIC COORDINATES		COMMON NAME	STAR IDENTIFICATION GREEK IDENTIFIER AND CONSTELLATION
	X (R1)	Y (R2)	Z (R3)	LONGITUDE (DEG.)	LATITUDE (DEG.)		
046	.78378	.47837	.39604	37.3	10.0	HAMAL	ALPHA ARIETIS
047	.58785	.64650	-.48628	34.2	-44.7		ALPHA FORNACIS
050	-.38535	.79355	.47094	112.8	6.7	POLLUX	BETA GEMINORUM
051	-.25993	.23220	-.93729	211.6	-72.2	MIAPLACIDUS	BETA CARINAE
052	-.45598	.11790	.88215	134.8	49.7	DUBHE	ALPHA URSAE MAJORIS
053	-.64862	-.11426	-.75249	211.9	-40.2		GAMMA CENTAURI
054	-.37780	-.31056	-.87225	239.1	-42.6	RIGIL KENT	ALPHA CENTAURI
055	.02745	.99128	.12885	88.4	-16.0	BETELGEUSE	ALPHA ORIONIS
056	-.42788	-.25162	-.86810	233.4	-44.1	HADAR	BETA CENTAURI
057	.15707	.98142	.11018	80.6	-16.8	BELLATRIX	GAMMA ORIONIS
060	.13540	.86760	.47847	82.2	5.4	EL NATH	BETA TAURI
061	.10975	.99373	-.02127	83.1	-24.5	ALNI LAM	EPSILON ORIONIS
062	.08995	.99536	-.03413	84.3	-25.3	ALNITAK	ZETA ORIONIS
063	-.08898	.94720	-.30804	96.8	-41.3	MURZIM	BETA CANIS MAJORIS
064	-.15044	.94732	.28275	98.7	-6.7	ALHENA	GAMMA GEMINORUM
065	-.21737	.84776	-.48379	110.4	-51.4	ADHERA	EPSILON CANIS MAJORIS
066	-.25920	.85781	-.44382	113.0	-48.5	AL WAZOR	DELTA CANIS MAJORIS
067	-.33431	.77987	.52919	109.9	10.1	CASTOR	ALPHA GEMINORUM
070	-.29533	.41426	-.86091	172.8	-72.7	AVIOR	EPSILON CARINAE
071	-.37986	.43725	-.81518	168.6	-67.2		DELTA VELORUM
072	-.54073	-.07023	-.83826	216.3	-47.8	GACRUX	GAMMA CRUCIS
073	-.49678	-.10124	-.86195	221.3	-48.6	BECRUX	BETA CRUCIS
074	-.54285	-.12733	.83012	158.5	54.3	ALIOH	EPSILON URSAE MAJORIS
075	-.09824	.79167	-.60300	264.2	-13.8	SHAULA	LAMBDA SCORPII
076	-.07868	.72733	-.68176	265.2	-19.6		THETA SCORPII
077	.08021	-.82121	-.56496	274.7	-11.0	KAUS AUST	EPSILON SAGITTARI
100	.51482	.01724	.85712	34.7	51.2	CAPH	BETA CASSIOPEIAE
101	.73342	.08001	-.67505	345.1	-40.6	ANKAA	ALPHA PHOENICIS
102	.77864	.23864	.58031	30.0	25.9	MIRACH	BETA ANDROMEDAE
103	.63806	.37649	.67167	43.8	27.8	ALMACH	GAMMA-PRIME ANDROMEDAE
104	.12804	.99175	-.00556	82.0	-23.6	MINTAKA	DELTA ORIONIS
105	.05834	.98404	-.16812	86.0	-33.1	SAIPH	KAPPA ORIONIS
106	.00780	.70773	.70644	89.5	21.5	MENKALINAN	BETA AURIGAE
107	-.30908	.81594	-.48858	119.1	-50.6	ALUDRA	ETA CANIS MAJORIS
110	-.39096	.65976	-.64177	138.2	-58.3		ZETA PUPPIS
111	-.52985	.49858	-.68606	160.8	-55.9	SUHAIL	LAMBDA VELORUM
112	-.38743	.33577	-.85858	184.9	-67.1		IOTA CARINAE
113	-.53277	.14235	.83420	139.0	45.1	MERAK	BETA URSAE MAJORIS
114	-.53560	-.20239	.81986	165.3	56.4	MIZAR	ZETA URSAE MAJORIS
115	-.19927	-.18383	.96255	132.9	73.0	KOCHAB	BETA URSAE MINORIS
116	-.01099	-.62254	.78251	267.6	74.9	ELTANIN	GAMMA DRACONIS
117	.44164	-.62363	.64501	324.5	57.1	SADR	GAMMA CYGNI
120	.59893	-.32359	-.73251	315.5	-32.9	AL NA'IR	ALPHA GRUIS
121	.64150	-.23032	-.73173	321.9	-35.4		BETA GRUIS
122	.54566	.09353	.83277	37.4	46.6	SCHEDAR	ALPHA CASSIOPEIAE
123	-.58957	.01965	.80748	150.1	47.1	PHECDA	GAMMA URSAE MAJORIS
124	-.46642	-.79717	-.38338	242.2	-2.0		DELTA SCORPII
125	-.25426	-.78658	-.56272	254.9	-11.7		EPSILON SCORPII
126	.96452	.04966	.25929	8.8	12.6		GAMMA PEGASI
127	-.06586	-.77416	-.62955	266.1	-15.6		KAPPA SCORPII
130	.46554	.17863	.86681	47.5	46.4		DELTA CASSIOPEIAE
131	.82401	.44316	.35301	33.6	8.5		BETA ARIETIS
132	.50475	.76127	.40705	59.6	4.0		ETA TAURI
133	.44921	.72146	.52698	62.7	11.3		ZETA PERSEI
134	.39503	.65724	.64186	65.3	19.1		EPSILON PERSEI
135	.23377	.80421	.54644	76.2	10.5		IOTA AURIGAE
136	.23052	.96896	-.08927	74.9	-27.9		BETA ERIDANI
137	.13398	.92530	-.35479	79.3	-43.9		BETA LEOPORIS

LM 8-3.- Concluded.

DATA VALID FROM 1 JULY 71 TO 30 JUNE 72

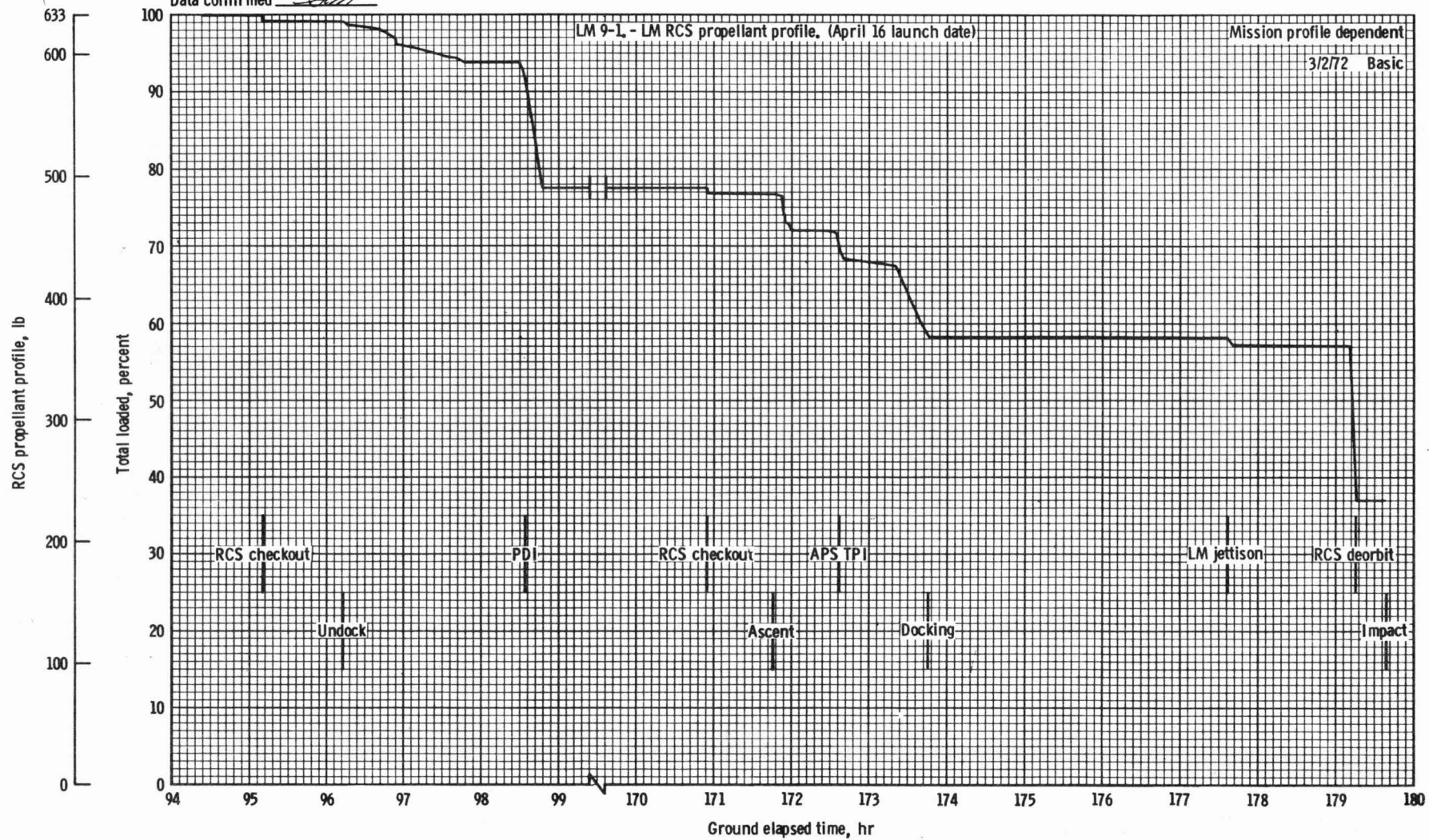
Nearst mean Besselian year
4/7/71 Basic

STAR NO. (OCTAL)	UNIT VECTORS			ECLIPTIC COORDINATES		COMMON NAME	STAR IDENTIFICATION GREEK IDENTIFIER AND CONSTELLATION
	X (R1)	Y (R2)	Z (R3)	LONGITUDE (DEG.)	LATITUDE (DEG.)		
140	.11809	.94456	-.30638	81.0	-41.1		ALPHA LEPORIS
141	.11233	.98829	-.10326	82.6	-29.2		IOTA ORIONIS
142	.09762	.92766	-.36044	84.4	-2.2		ZETA TAURI
143	.07710	.82458	-.56047	81.8	-57.4		ALPHA COLUMBAE
144	.00760	.79636	.60477	89.6	13.8		THETA AURIGAE
145	-.13538	.62039	-.77252	117.3	-72.9		TAU PUPPIS
146	-.26036	.75449	-.60246	119.9	-58.5		PI PUPPIS
147	-.47769	.77684	-.41029	131.0	-43.3		RHO PUPPIS
150	-.44258	.36729	-.81806	178.5	-63.7		KAPPA VELORUM
151	-.84900	.40299	.34176	149.2	8.8		GAMMA-PRIME LEONIS
152	-.61835	.20822	-.75781	190.1	-51.1		MU VELORUM
153	-.91566	.19204	.35310	160.9	14.3		DELTA LEONIS
154	-.90939	-.13150	-.39462	197.0	-18.0		BETA CORVI
155	-.35438	-.05533	-.93346	230.0	-56.6		ALPHA MUSCAE
156	-.98437	-.17463	-.02262	189.8	2.8		GAMMA VIRGINIS
157	-.76073	-.18517	.62209	174.2	40.1		ALPHA-SQUARED CANES VENATICI
160	-.94695	-.25720	.19268	189.6	16.2		EPSILON VIRGINIS
161	-.75591	-.27146	-.59574	212.7	-26.0		IOTA CENTAURI
162	-.54339	-.24793	-.80203	225.2	-39.6		EPSILON CENTAURI
163	-.83450	-.45004	.31792	198.9	28.1		ETA BOOTIS
164	-.61951	-.47946	.62156	197.3	49.6		GAMMA BOOTIS
165	-.58182	-.46165	-.66960	229.9	-25.5		ETA CENTAURI
166	-.51969	-.43630	-.73455	233.1	-30.0		ALPHA LUPORIS
167	-.67191	-.58286	.45696	207.7	40.6		EPSILON BOOTIS
170	-.71089	-.64757	-.27440	224.7	.3	ZUBEN'UBI	ALPHA-SQUARED LIBRAE
171	-.52437	-.50943	-.68229	234.6	-25.0		BETA LUPI
172	-.64911	-.74341	-.16127	229.0	8.5		BETA LIBRAE
173	-.45035	-.60456	-.65703	241.1	-21.2		GAMMA LUPI
174	-.55958	-.82098	.11342	231.7	25.5		ALPHA SERPENTIS
175	-.45889	-.77251	-.43892	242.5	-5.5		PI SCORPII
176	-.45705	-.82288	-.33759	242.8	1.0		BETA-PRIME SCORPII
177	-.19434	-.43449	.87946	194.1	78.4		ETA DRACONIS
200	-.35962	-.85776	.36730	240.7	42.7		BETA HERCULIS
201	-.32264	-.82048	-.47193	251.1	-6.1		TAU SCORPII
202	-.35390	-.91732	-.18244	248.8	11.4		ZETA OPHIUCHI
203	-.29034	-.80020	.52477	241.1	53.1		ZETA HERCULIS
204	-.21341	-.93878	-.27046	257.6	7.2	SABIK	ETA OPHIUCHI
205	-.09111	-.55895	-.82418	263.8	-32.3		BETA ARAE
206	-.10780	-.78840	-.60565	263.6	-14.0		NU SCORPII
207	-.08506	-.63908	-.76442	264.5	-26.6		ALPHA ARAE
210	-.08031	-.60593	.79145	251.6	75.3		BETA DRACONIS
211	-.07783	-.99377	.07981	264.9	27.9		BETA OPHIUCHI
212	.07258	-.86436	-.49760	274.2	-6.5		DELTA SAGITTARII
213	.10317	-.89713	-.42955	275.9	-2.1		LAMBDA SAGITTARII
214	.22735	-.83636	-.49882	283.2	-7.2		ZETA SAGITTARII
215	.30991	-.63473	.70787	315.9	64.4		DELTA CYGNI
216	.43454	-.88187	.18299	300.5	31.2		GAMMA AQUILAE
217	.54770	-.62411	.55723	327.4	49.4		EPSILON CYGNI
220	.35139	-.30035	.88674	12.4	68.9		ALPHA CEPHI
221	.79939	-.53163	-.27991	323.1	-2.6		DELTA CAPRICORNI
222	.44451	-.21537	-.86949	309.3	-45.4		ALPHA TUCANAE
223	.85577	-.21967	.46840	359.0	31.1		BETA PEGASI
224	.93634	-.23622	.25973	353.1	19.4	MARKAB	ALPHA PEGASI
225	.41267	.23321	-.88052	341.7	-64.2		ALPHA HYDRI
226	.82309	.56532	-.05415	31.1	-15.9		OMICRON CETI
227	.51988	.54947	.65407	55.8	22.4		BETA PERSEI
230	-.43367	.33165	-.83782	183.8	-64.2		N VELORUM
231	-.40953	.14512	-.90068	208.8	-62.1		THETA CARINAE
232	-.63489	-.01912	-.77236	207.1	-44.5		DELTA CENTAURI
233	-.23663	-.38112	-.89373	251.5	-41.9		BETA TRIANGULI AUSTRALIS
234	.26815	-.93329	.23888	289.4	36.2		ZETA AQUILAE
235	.27321	-.89225	-.35950	285.9	1.4		PI SAGITTARII
236	-.44968	-.89095	-.06320	241.9	17.2		DELTA OPHIUCHI

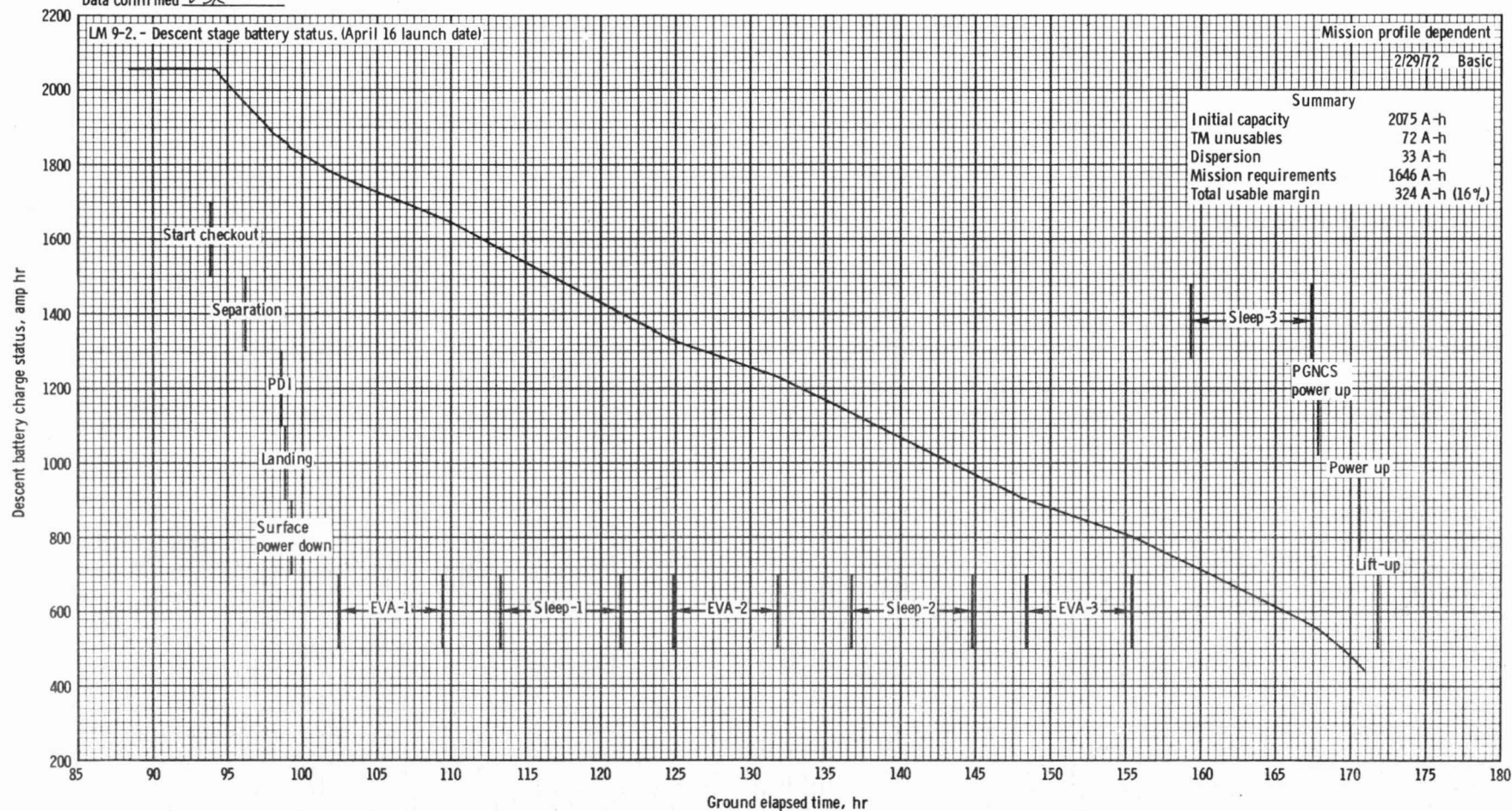
Mayfield/SMB/MPAD (for LM Systems)

Data source Flight Plan E SDB

Data confirmed SLM



Ritchey/SMB/MPAD (for LM Systems)
 Data source Lunar Flight Plan
 Data confirmed VSR

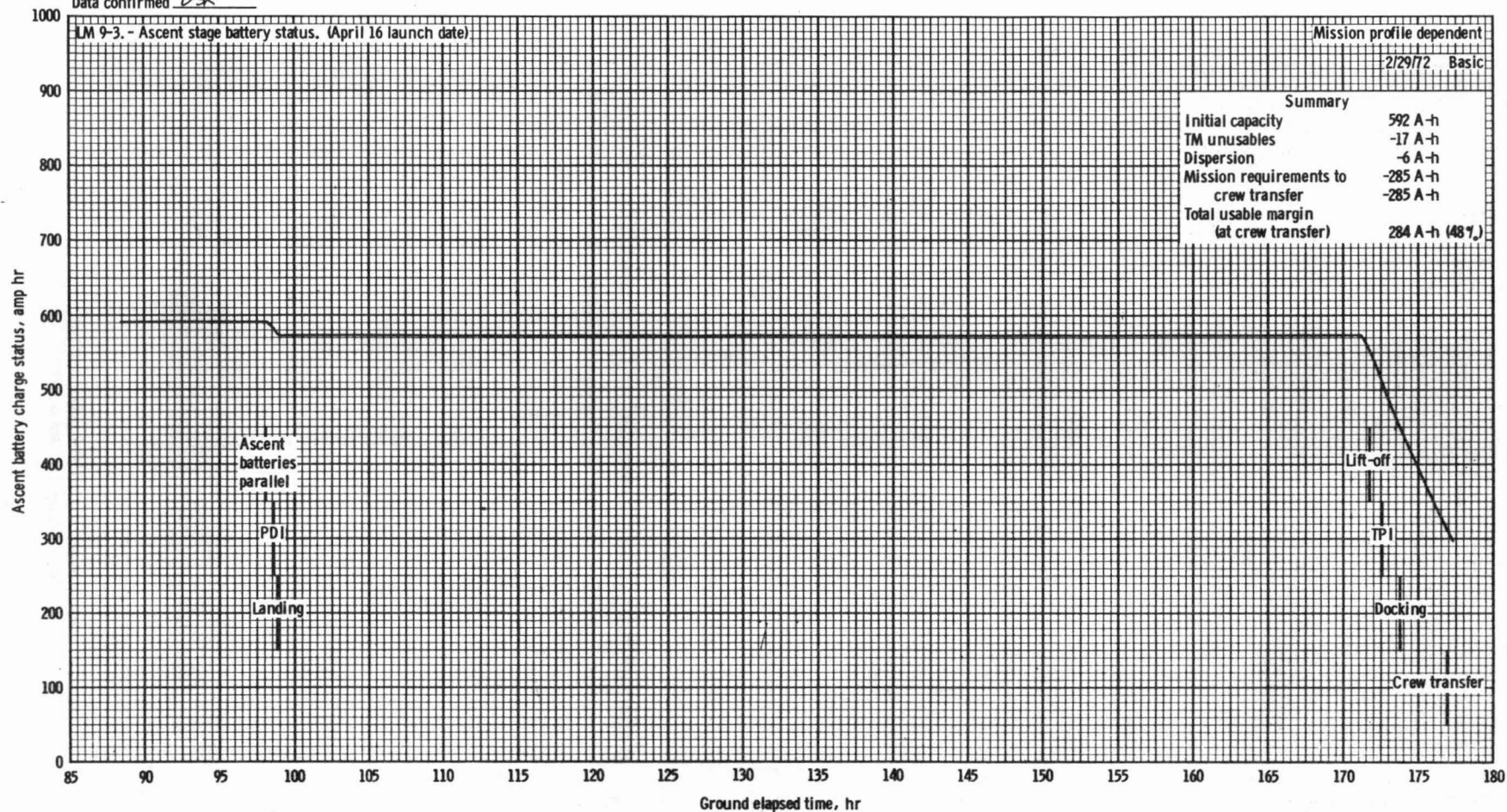


Apollo 16 descent electrical energy remaining.

Ritchey/SMB/MPAD (for LM Systems)

Data source *Lunar Flight Plan*

Data confirmed *USR*

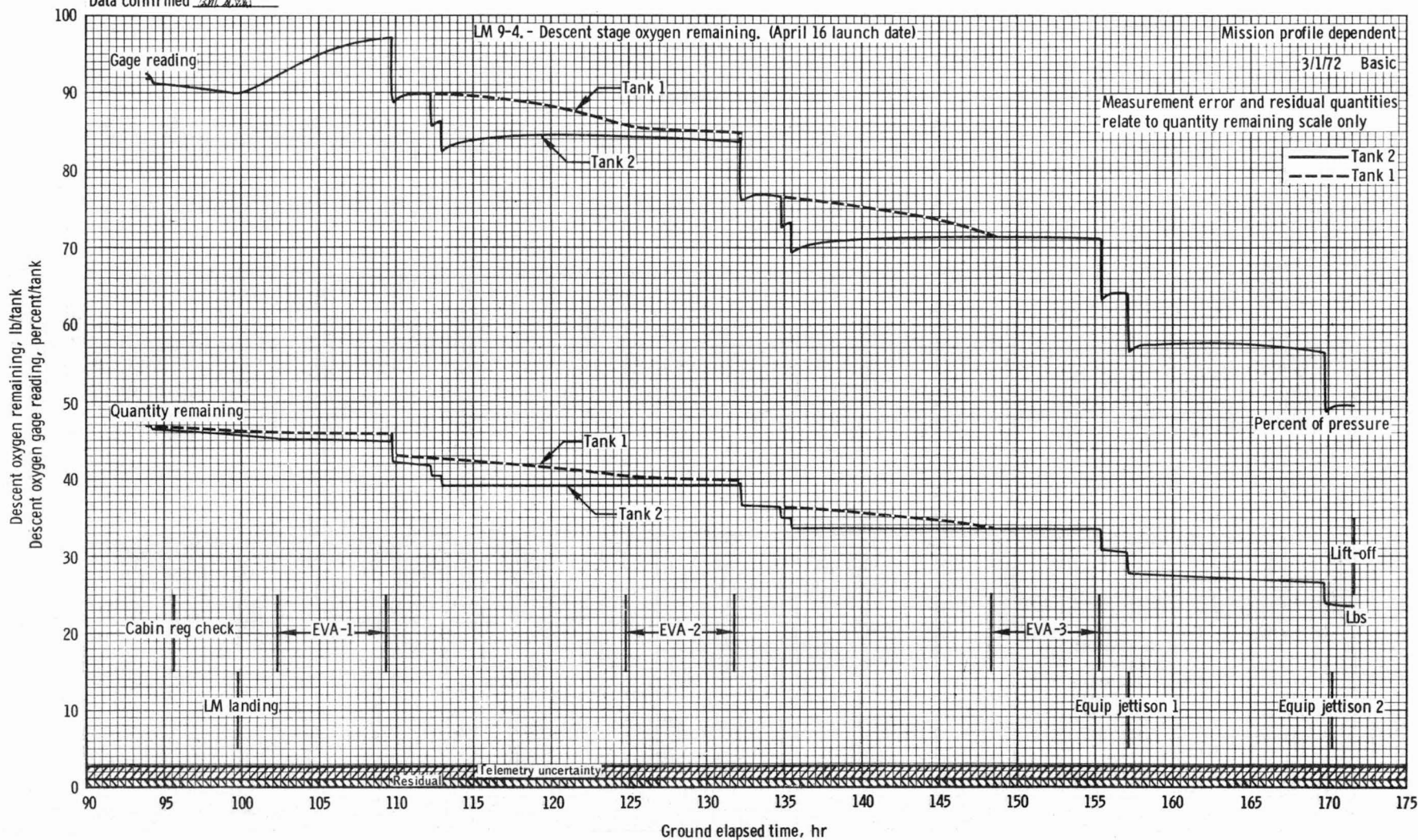


Apollo 16 ascent electrical energy remaining.

Swalin/SMB/MPAD (for LM Systems)

Data source FLIGHT PLAN 5 SUBA

Data confirmed Bob & Vicki

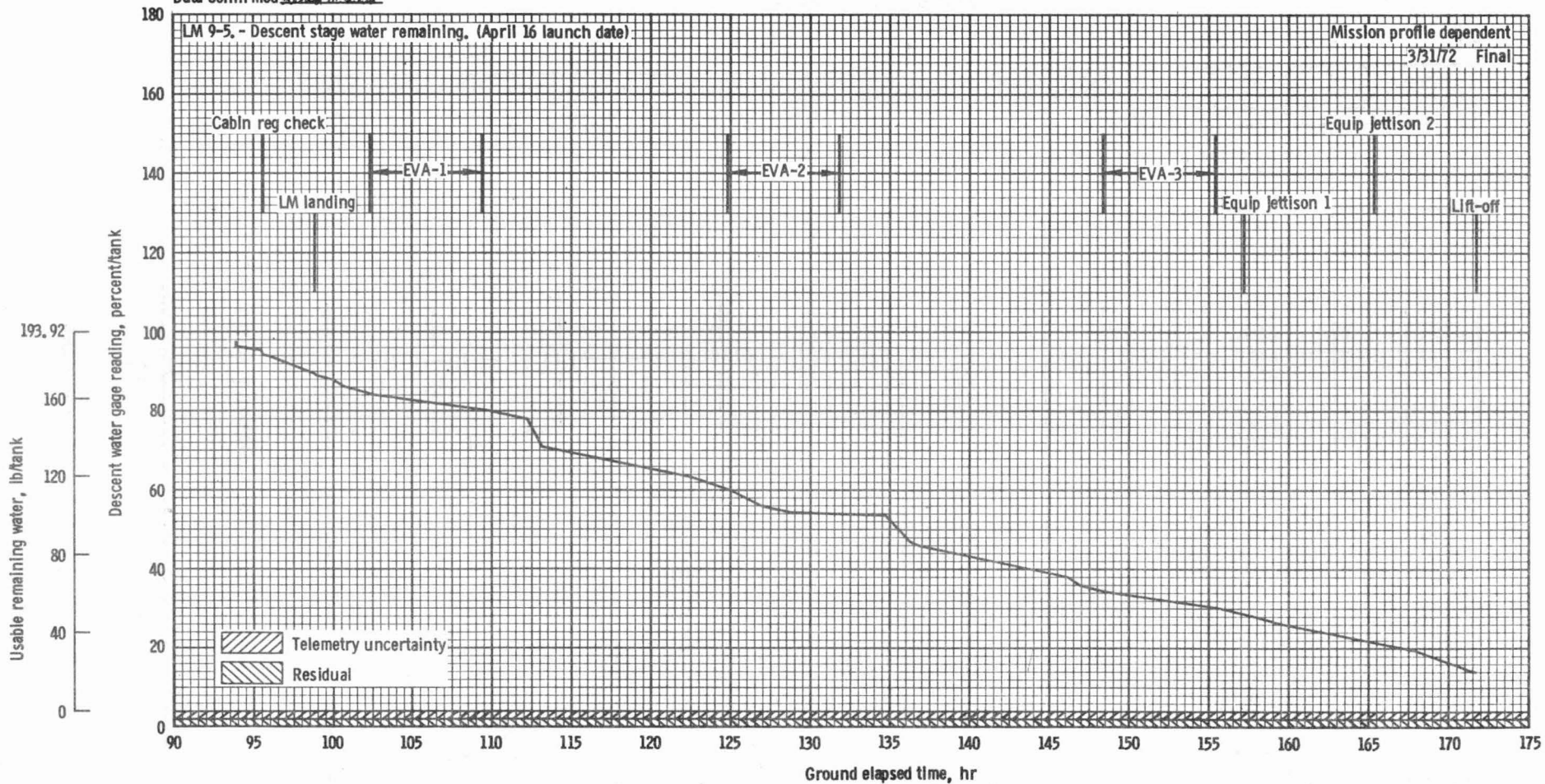


Descent stage oxygen remaining.

Swain/SMB/MPAD (for LM Systems)

Data source FIGHT PLAN 500

Data confirmed Richard S. Smith

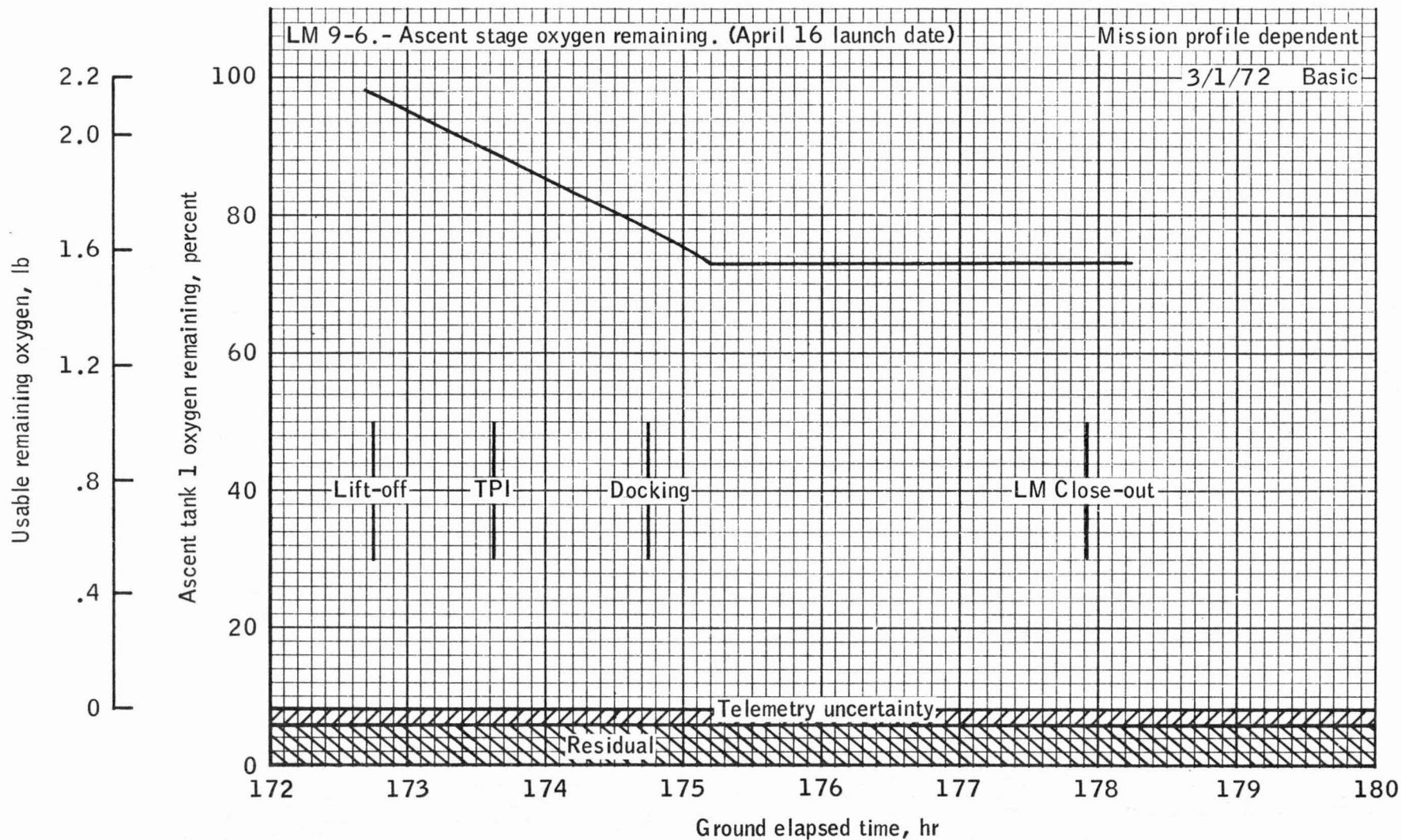


Descent stage water remaining.

Swalin/SMB/MPAD (for LM Systems)

Data source LIGHT FLIGHT SCDS

Data confirmed Swalin

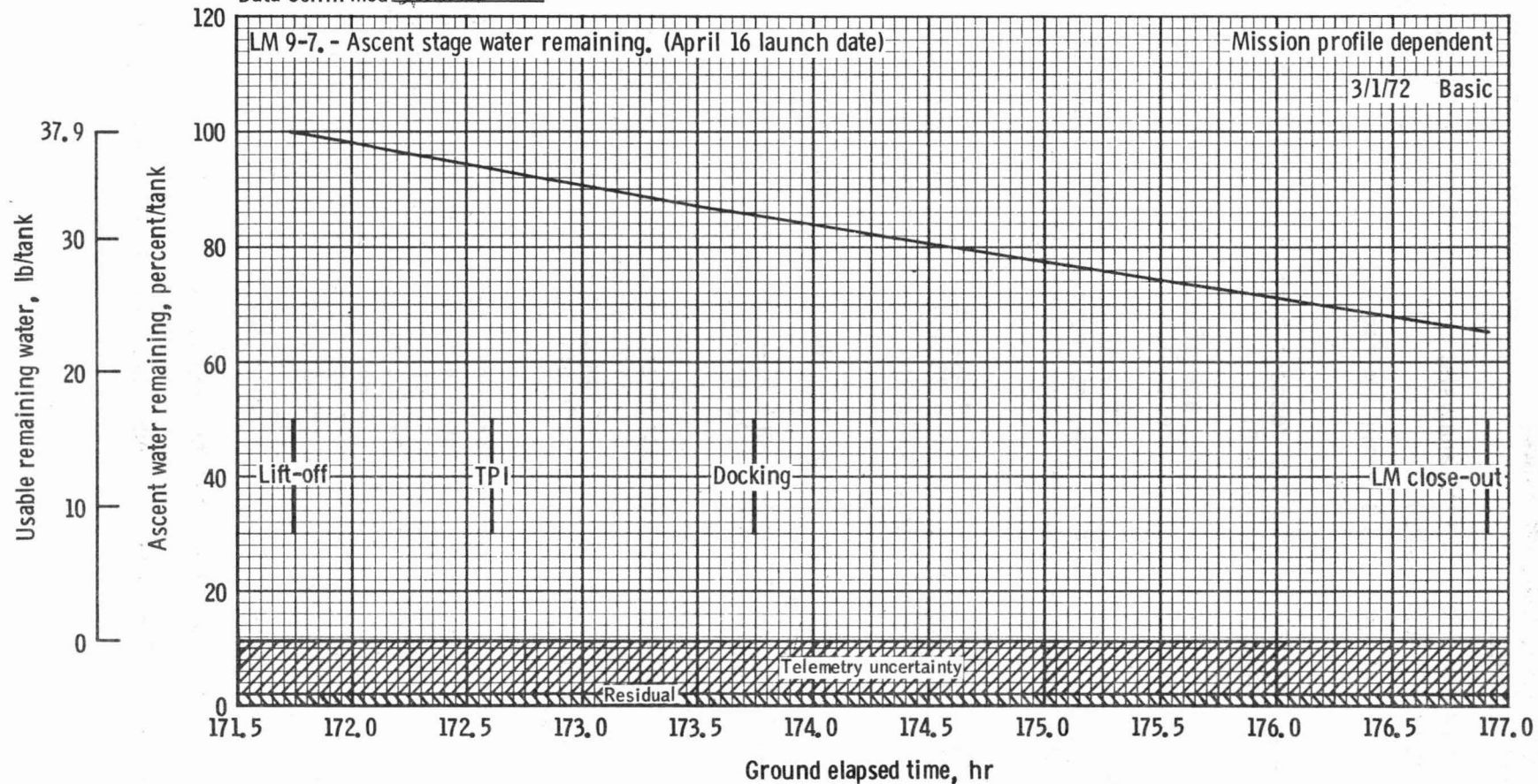


Ascent tank 1 oxygen remaining.

Swalin/SMB/MPAD (for LM Systems)

Data source FLIGHT PLAN & SOPS

Data confirmed JM. Nicks



Ascent stage water remaining.

Ritchey/GPB/MPAD (for Flight Plan)
 Data source Prelim Flight Plan
 Data confirmed USR

LM 9-8.- Assumptions for LM EPS analysis. Mission profile dependent
 (March 17 launch date) 11/24/71 Basic

ASSUMPTIONS FOR THE LM EPS ANALYSIS

- a. Energy available from the descent batteries is 2075 A-h and from the ascent batteries is 592 A-h.
- b. Energy unusables caused by lack of continuous MSFN coverage for the descent and ascent stages are zero.
- c. Energy unusables caused by TM inaccuracies for the descent and ascent stages were 72 and 17 A-h, respectively. The new descent battery current measurement uncertainty of 0.5 amperes per battery was used.
- d. Energy unusables caused by checklist deviations (dispersion) for the descent and ascent stages were 33 and 6 A-h, respectively. This dispersion is obtained by calculating 2 percent of the energy used.
- e. No energy was budgeted for the PGNCs power uncertainty.
- f. In accordance with the Flight Plan, the PGNCs was in standby mode from surface powerdown until 2.83 hours before powerup.
- g. The RCS heaters were assumed to have a 100 percent duty cycle for 15 minutes after initial activation and then to decrease to a 7 percent duty cycle until undocking. From undocking until lunar surface powerdown, the heaters were assumed to cycle at 0 percent, but, from surface powerdown until lunar lift-off, the duty cycle was assumed to be 4.5 percent.
- h. The MESA heater power requirements were established by GAEC thermal analysis. From circuit breaker activation to touchdown the heater was assumed to be on 35 percent of the time in the low mode (two 25 watt heaters). From touchdown to the start of the open thermal blanket period of EVA-1 the duty cycle was 20 percent in the high mode (six 25 watt heaters). The duty cycle was 55 percent (high mode) during the open blanket period. At the end of the open blanket period the duty cycle decreased to 29 percent. At the start of EVA-2 the MESA heaters were turned off for the remainder of the mission.
- i. The inverter was operated throughout the mission.
- j. The CDR and LMP forward window heaters were assumed not to be needed.

LM 9-8.- Concluded.

Mission profile dependent

11/24/71 Basic

ASSUMPTIONS FOR THE LM EPS ANALYSIS - Concluded

k. TV power is supplied by the LM during the first hour of EVA-1. For the remainder of EVA-1 and the other EVA's, the TV will be powered by the lunar communications relay unit (LCRU).

l. The liquid cooled garment pump was operated before each EVA for 17 minutes.

m. The S-band power amplifier was cycled as dictated by the time line.

n. The portable utility lights were assumed to be off throughout the mission.

o. In accordance with the Flight Plan, the floodlights were turned off at surface power down, and on again at power up. The overhead and forward floodlights were not used.

p. The short (M=1) rendezvous was considered nominal.

q. At the beginning of the analysis, it was assumed that a total of 10 A-h had been used from the descent batteries between the period starting 30 minutes before launch and ending at the conclusion of transposition and docking.

Ritchey/GPB/MPAD (for LM Systems)

Data source Prelim Flight PlanData confirmed VSRLM 9-9.- Descent and ascent stage EPS summary.
(March 17 launch date)Mission profile dependent
11/24/71 Basic

DESCENT STAGE EPS SUMMARY

Item	A-h required	A-h remaining
Initial capacity	--	2075
Total unusables	105	1970
Required through touchdown	214	1756
Required for surface stay	1432	324
Total usable margin	--	324

ASCENT STAGE EPS SUMMARY

Item	A-h required	A-h remaining
Initial capacity	--	592
Total unusables	23	569
Required through docking	145	424
Required from docking through crew transfer	140	284
Total usable margin	387	284

Swalin/GPB/MPAD (for Flight Plan)

Data source F. Swain

Data confirmed SWA

LM 9-10.- LM ECS assumptions.
(March 17 launch date)

Mission profile dependent
12/7/71 Basic

LM ECS Assumptions

- a. The oxygen analyses were calculated using a cabin leak rate of 0.06 lb/hr based on previous Apollo postflight analyses.
- b. Metabolic rates were varied using the final flight plan and table 4.3-II of SODB Vol. II.
- c. Metabolic oxygen consumed was calculated by $(1.643 \times 10^{-4} \times \text{lb/Btu})$ (metabolic rate, Btu/hr).
- d. The cabin regulator check and the suit integrity check were assumed to require 0.5 pound of oxygen.
- e. The cabin was pressurized five times with 5.5 pounds required for each pressurization except the last one which required 5.8 pounds.
- f. The dispersion in the oxygen profile was calculated as 5 percent of the nominal oxygen requirement.
- g. The PLSS refills required 47.2 pounds of water and 5.4 pounds of oxygen.
- h. The sublimator fill required 2.23 pounds.
- i. The drink bags required 12.0 pounds of water.
- j. Water lost through crew micturition was 0.11 lb/hr per man.
- k. Water required for thermal control was calculated by dividing the total spacecraft heat load by 1040 Btu/lb.
- l. The dispersion in the water profile was calculated as 5 percent of the nominal usage.
- m. The descent oxygen tanks were loaded to 2610.0 psi at 70.0°F.

Swalin/GPB/MPAD (for Flight Plan)

Data source FLIGHT PLAN & SCOBData confirmed SYMLM 9-11.- LM ECS summary.
(March 17 launch date)Mission profile dependent
12/7/71 Basic

LM ECS SUMMARY

(a) Water

Description	Descent, 1b	Ascent, 1b
Loaded	406.0	85.0
Sampling	11.0	0
Residual	13.3	1.7
Telemetry uncertainty	8.9	7.5
Loading uncertainty	3.0	1.8
Available for mission	369.8	74.0
Required to lunar landing	32.2	0
Required to lunar lift-off	298.6	0
Required to LM/CSM docking	0	16.4
Required to LM close-out	0	16.2
Required to lunar impact	0	9.6
Remaining in tanks	39.0	31.8
Dispersion	16.5	2.1
Margin	22.5	29.7

(b) Oxygen

Description	Descent, 1b	Ascent 1, 1b	Ascent 2, 1b
Loaded	93.8	2.4	2.4
Residual	1.6	0.1	0.1
Loading uncertainty	1.7	0.1	0.1
Available for mission	90.5	2.2	2.2
Required to lunar landing	1.7	0	0
Required to lunar lift-off	45.1	0	0
Required to LM/CSM docking	0	0.5	0
Required to LM close-out	0	0.1	0
Remaining in tank	43.7	1.6	2.2
Dispersion	2.3	0.1	0
Margin	41.4	1.5	2.2

Mayfield/GPB/MPAD (for Flight Plan)

Data source Flight Plan & SODB

Data confirmed 10/21/71

LM 9-12.- Assumptions and ground rules for the
LM RCS analysis. (March 17 launch date)

Mission profile dependent
12/7/71 Basic

ASSUMPTIONS AND GROUND RULES FOR THE LM RCS ANALYSIS

1. Data for the LM RCS engine performance and propellant requirements were obtained from the SODB, Volume II, and from postflight analyses of Apollo 9-15 missions.
2. The analysis assumes an insertion trim or RCS tweak burn (nominally zero) of 30 fps.
3. It is assumed there will be a 10-fps RCS trim following the APS TPI maneuver.

Mayfield/SMB/MPAD (for Flight Plan)

Data source Flight Plan & SODPData confirmed LCNLM 9-13.- LM RCS propellant loading and
usage summary. (April 16 launch date)Mission profile dependent
3/31/72 Final

LM RCS PROPELLANT LOADING AND USAGE SUMMARY

Item	Required, lb	Remaining, lb
Loaded		631.2
Trapped	38.0	593.2
Gaging inaccuracy and loading tolerance	43.5	549.7
Mixture ratio uncertainty	17.0	532.7
Usable		532.7
Nominal usage through lunar landing	141.6	391.1
Nominal usage from landing through docking	125.2	265.9
Nominal usage from docking through impact	136.5	129.4
Usable propellant remaining		129.4

Mayfield/SMB/MPAD (for Flight Plan)

Data source OTESTDA

Data confirmed APM

LM 9-14.- Assumptions for the APS analysis.
(April 16 launch date)

Mission profile dependent
3/31/72 Final

ASSUMPTIONS FOR THE APS ANALYSIS

The propellant loading is based on the optimization of the fuel and oxidizer balance that was computed from the LM-11 engine data. The ΔV requirements were coordinated with the Landing Analysis Branch. The ΔV requirement for the lunar ascent differs from that in the Operational Trajectory because of differences in the inert vehicle weight.

The APS analysis accounts for an APS TPI, engine valve-pair malfunction, and balanced couples. The following data were used in determining the APS propellant requirements for Apollo 16.

- a. $I_{sp} = 309.5 \pm 3.5$ seconds.
- b. Mixture ratio = $1.597 \pm .027$.
- c. Lift-off weight = $10\,862.8 \pm 38.7$ pounds.

Mayfield/SMB/MPAD (for Flight Plan)

Data source C. T. & SCUBData confirmed SPLM 9-15.- APS propellant summary.
(April 16 launch date)Mission profile dependent
3/31/72 Final

APS PROPELLANT SUMMARY

Item	Total propellant, lb
Loaded	5242.5
Trapped and unavailable	-51.9
Outage	-12.1
Available for ΔV	5178.5
Required for Ascent (6046.7 fps)	-4952.2
Remaining	226.3
Required for APS TPI ^a (52.8 fps)	-31.4
Remaining	194.9
Dispersions (-3σ)	-67.6
Pad	127.4
Operational allowances	
Engine valve-pair malfunction ($\Delta MR = +.0097$ or $-.0183$)	-20.7
Balanced couples on	-40.3
Half-degree out of plane (18 fps)	-10.7
Margin	55.8

^aThe total TPI ΔV is 74.8 fps. It is assumed that 22 fps is obtained by a 10-sec, 4-jet ullage.

Mayfield/SMB/MPAD (for Flight Plan)

Data source O.T.E. SODB

Data confirmed SPM

LM 9-16.- Assumptions for the DPS analysis.
(April 16 launch date)

Mission profile dependent
3/31/72 Final

ASSUMPTIONS FOR THE DPS ANALYSIS

The propellant loading is based on the optimization of the fuel and oxidizer balance that was computed from the LM-11 engine data. The ΔV requirements were coordinated with the Landing Analysis Branch. The ΔV requirement for lunar descent differs from that in the operational trajectory because of differences in the inert vehicle weight.

The 3σ dispersions represent total propellant cost based on 3σ uncertainties in propellant loading, trapped propellant, specific impulse, ΔV , separation weight, non- ΔV consumables weight, mixture ratio, and physical location of the low level sensor.

A flying time of 2 minutes and 30 seconds below low gate will be called a nominal requirement.

The following data were used:

- a. The separation weight is $36\,624.4 \pm 39.3$ pounds.
- b. Integrated average I_{sp} is 305.8 ± 1.8 seconds.
- c. Mixture ratio is $1.593 \pm .012$.
- d. Non- ΔV consumables from separation to PDI are 90.5 pounds.

Mayfield/SMB/MPAD (for Flight Plan)

Data source D. T. E. SODAData confirmed SPMLM 9-17.- DPS propellant summary.
(April 16 launch date)Mission profile dependent
3/31/72 Final

DPS PROPELLANT SUMMARY

Item	Total propellant, lb	Hover time, sec
Loaded	19 559.3	--
Trapped and unavailable	-104.1	--
Outage	-16.2	--
Available for ΔV	19 439.0	--
Required for ΔV (150-sec flying time from low gate, $\Delta V = 7068.7$ fps).	-18 725.5	--
Remaining	713.5	77
Dispersion (-3σ)	-286.3	--
Pad	427.3	46
Operational allowances		
Low-level (5 sec, 26.5 fps)	-47.3	--
Abort reserve (20 sec, 106 fps)	-188.0	--
Margin (hover time before abort decision point)	194.9	21

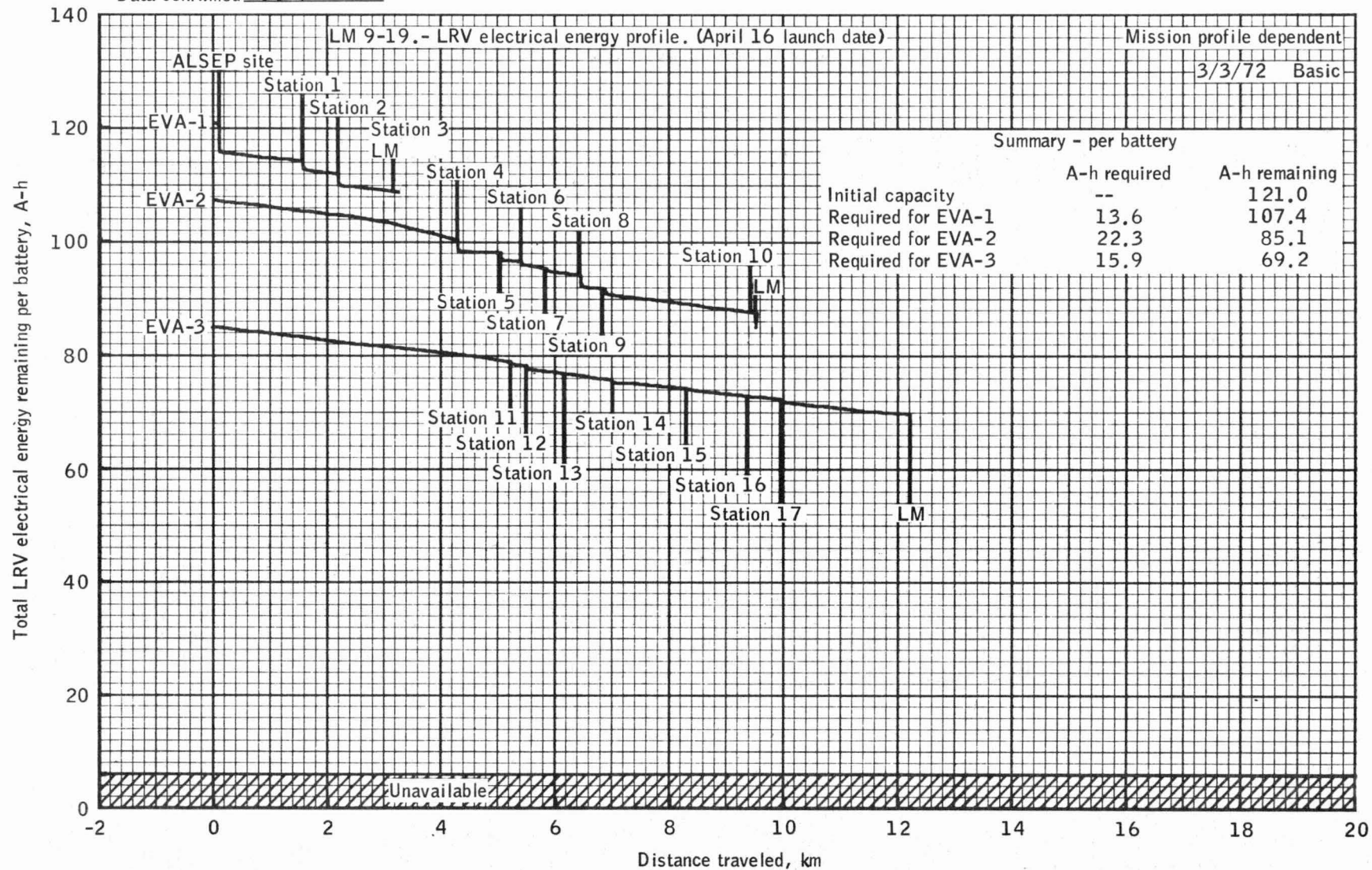
Ritchey/SMB/MPAD (for LM Systems)

Data source Ascent Flight Plan

Data confirmed USR



Apollo 16 total LM spacecraft current.



LRV electrical energy profile.

Ritchey/SMB/MPAD (for LM Systems)

Data source Traverse Plan 17 FEB 72

Data confirmed USC

LM 9-20.- Assumptions for the LRV EPS
analysis. (April 16 launch date)

Mission profile dependent
3/3/72 Basic

ASSUMPTIONS FOR THE LRV EPS ANALYSIS

- a. The energy available from each of the two batteries is 121 A-h.
- b. No unusables or uncertainties are considered in the budget.
There is no way to establish a prediction uncertainty at this time.
- c. Slopes were derived from the Apollo 16 landing site form line map.
- d. Terrain types and stop times were derived from the traverse data package.
- e. The MSFC soil model L-3 was used.
- f. The vehicle speed was 8 km/hr except where mobility conditions dictated lower speeds.
- g. The traction drive system was off during stops longer than 5 minutes.
- h. The navigation and caution systems were operated throughout each traverse.
- i. Electrical power required by the LCRU during EVA-1 and EVA-2 was supplied by LRV batteries. While driving, the LCRU was in the PM1/WB mode. During all station stops (EVA-1 and -2), except station 3, the LCRU mode of operation was FM/TV.
- j. The vehicle weight was 1470 pounds.
- k. A wander factor of 1.1 is included in the analysis.
- l. The distance traveled is the map or straight line distance between points.
- m. Clean battery radiators were assumed for all cool-down periods.

Scheffman/MIB/MPAD (for IM Cue Cards)

Data source TCWData confirmed D.S.C.

IM 11-1.- S-band 2/22/72

antenna angles. Final

(April 16

launch date)

Launch day dependent

Launch month dependent

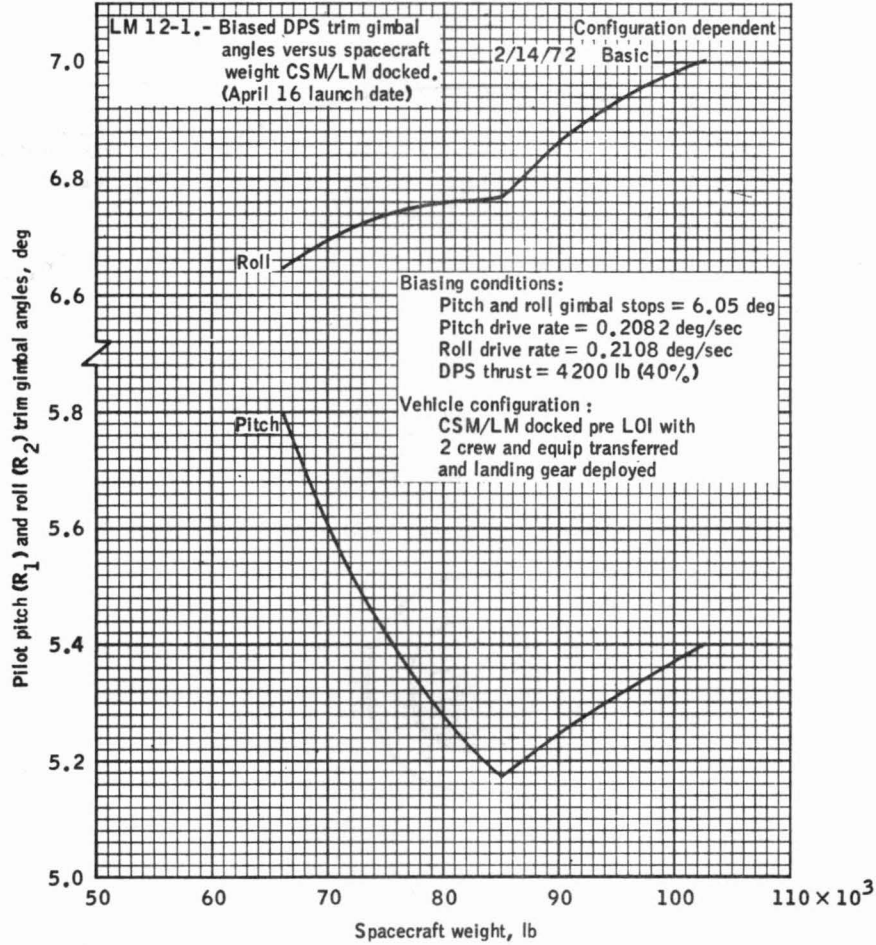
Mission profile dependent

S-BAND

ANTENNA ANGLES
DESCENT REFSMMAT

YAW=0°		IGA (PITCH)	YAW=180°	
ANTENNA			ANTENNA	
P	Y		P	Y
80	-35	0	104	-54
68	-33	10	120	-51
57	-30	20	133	-47
47	-26	30	145	-42
38	-20	40	155	-35
30	-15	50	163	-29
22	-8	60	171	-22
15	-1	70	179	-15
8	6	80	186	-8
-1	13	90	193	-1
-6	20	100	200	6
-14	27	110	207	12
-22	33	120	215	18
-32	40	130	224	24
-43	45	140	234	29
-56	50	150	245	32
-71	53	160	256	35
273	54	170	268	36
256	54	180	280	35
240	51	190	-68	33
227	47	200	-57	30
215	42	210	-47	26
205	35	220	-38	20
197	29	230	-30	15
189	22	240	-22	8
182	15	250	-15	1
174	8	260	-8	-6
167	1	270	-1	-13
160	-6	280	6	-20
153	-12	290	14	-27
145	-18	300	22	-33
136	-24	310	32	-40
126	-29	320	43	-45
116	-32	330	56	-50
104	-35	340	71	-53
92	-36	350	87	-54

Hirschke/SMB/MPAD (for LM Contingency)

Data source SMB Vc-III A-115Data confirmed RM

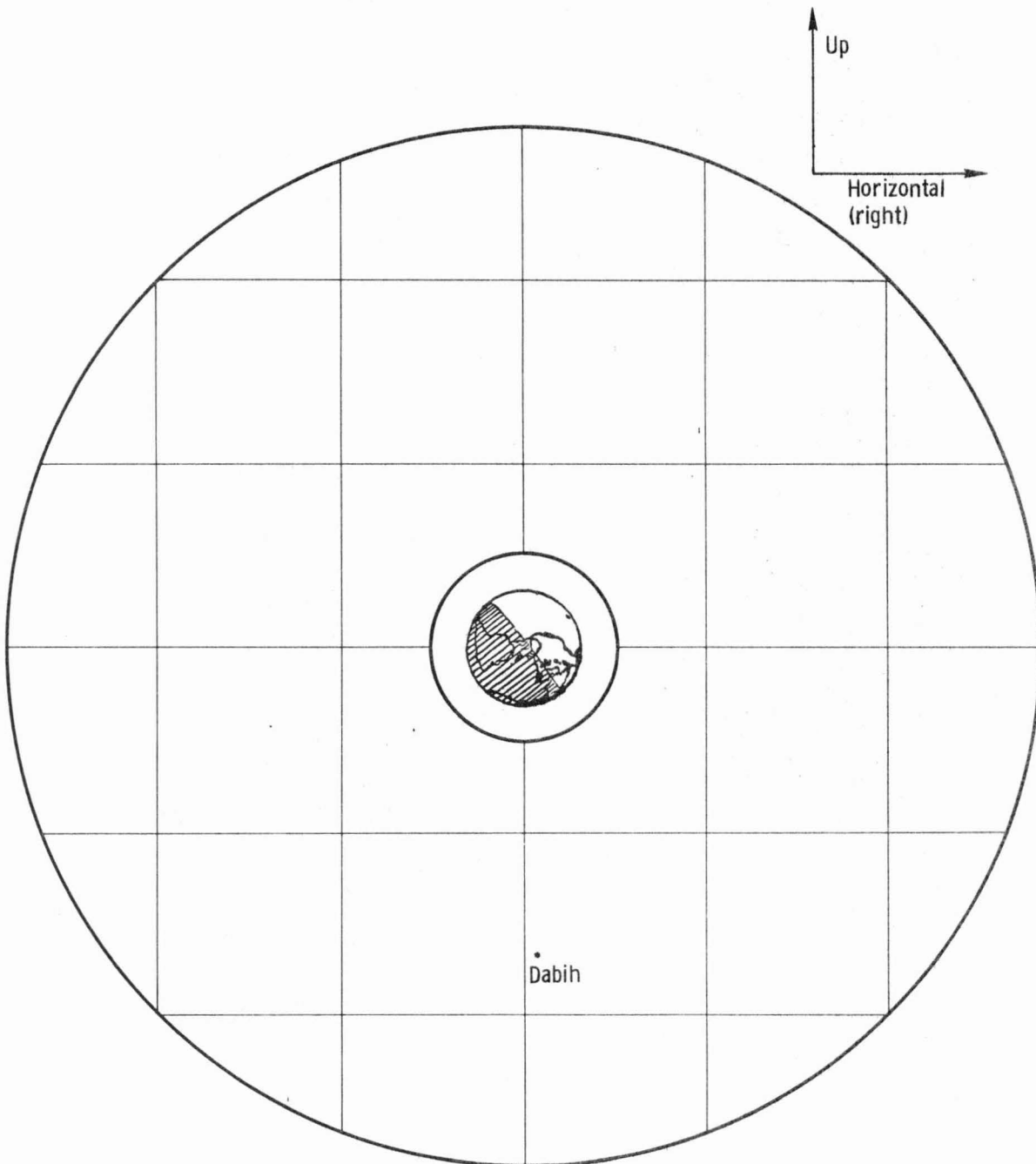
Biased DPS trim gimbal angles versus spacecraft weight CSM/LM docked.

Jenness/MIB/MPAD

Data source Flight Model, 2nd rev.Data confirmed MPAD

LM 13-1.- LCRU high gain antenna/optical sight reticle
showing earth crescent for EVA-1. (April 16 launch date)

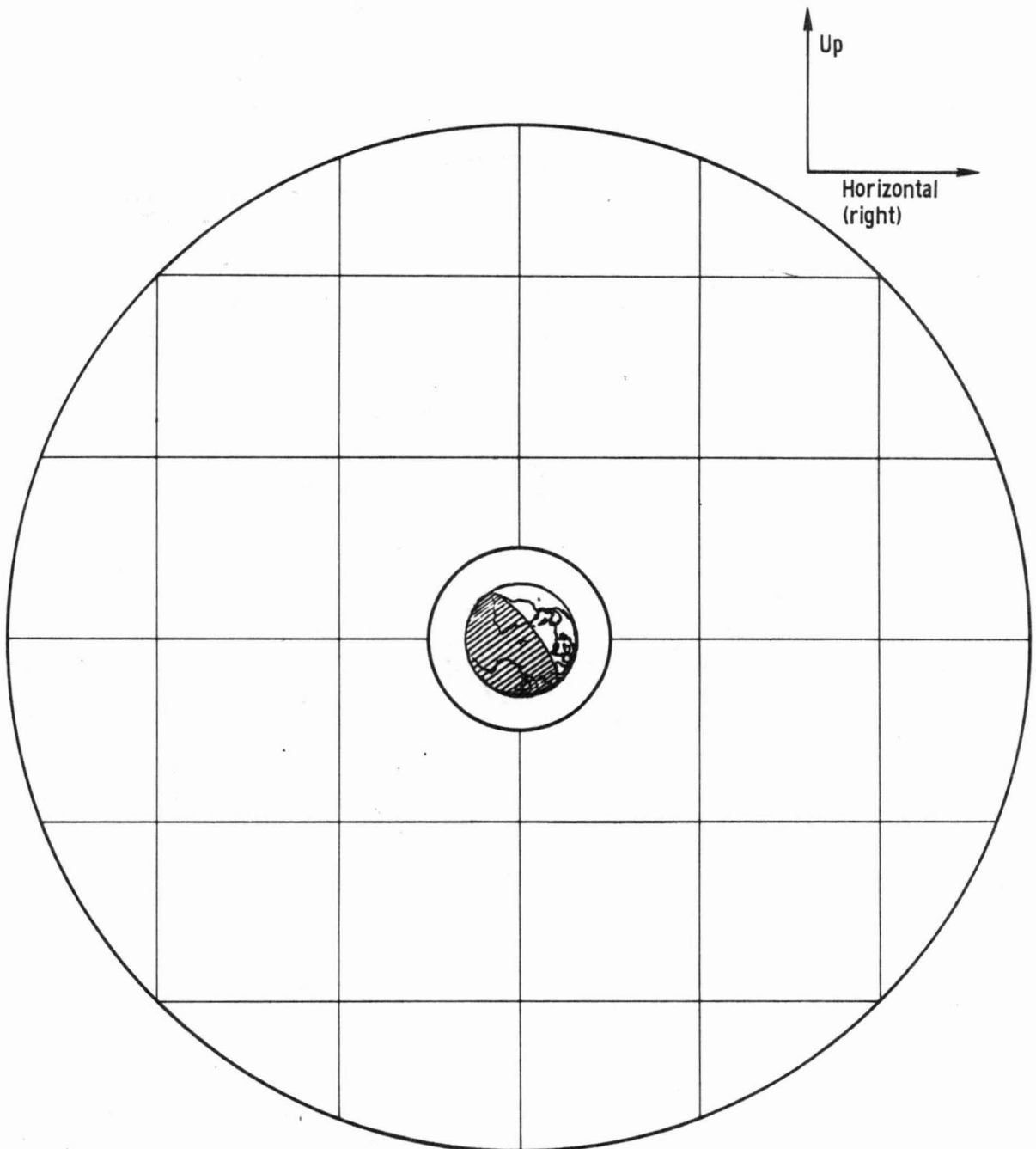
1/14/72 Basic



Jenness/MIB/MPAD
Data source Flight Manual, CT, vol. II.
Data confirmed MPD

LM 13-2.- LCRU high gain antenna/optical sight reticle
showing earth crescent for EVA-2. (April 16 launch date)

1/14/72 Basic

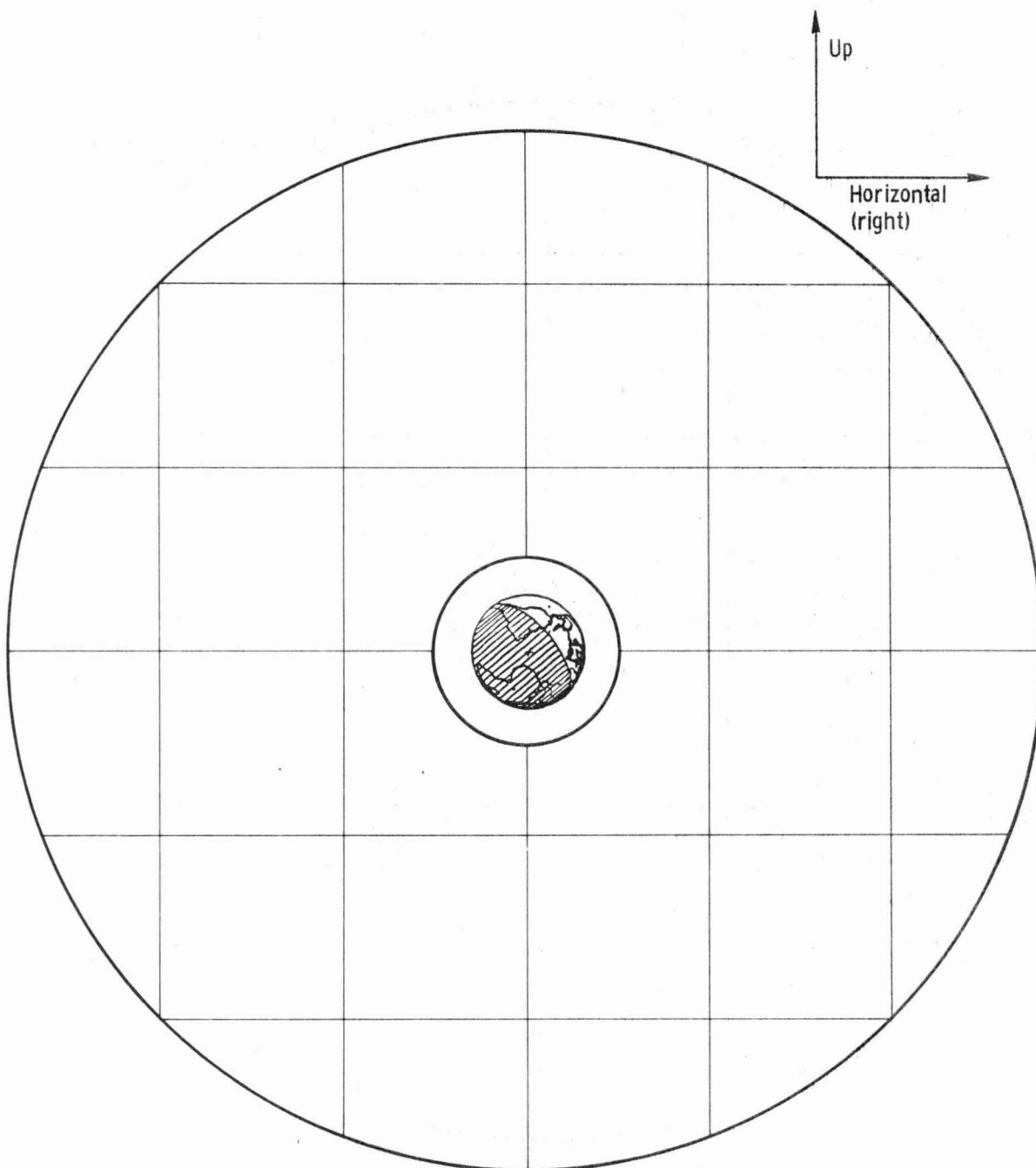


Jenness/MIB/MPAD

Data source Flight Model, vol II OT,Data confirmed WOF

LM 13-3.- LCRU high gain antenna/optical sight reticle
showing earth crescent for EVA-3. (April 16 launch date)

1/14/72 Basic



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(Revised April 7, 1972)

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ADDITIONS: See attached page