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May 13, 1969

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APOLLO 10 (MISSION F) CREW CHARTS

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MSC INTERNAL NOTE NO. 69-FM-136

PROJECT APOLLO

APOLLO 10 (MISSION F) CREW CHARTS

By Data Management Group
Mission Planning Support Office

May 13, 1969

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

Approved: Richard P. Parten
Richard P. Parten, Chief
Mission Planning Support Office

Approved: John P. Mayer
John P. Mayer, Chief
Mission Planning and Analysis Division

FOREWORD

The purpose of this document is to present the crew charts for Apollo 10 (Mission F). These charts have been coordinated by the Data Management Group of Mission Planning and Analysis Division with Mr. Bill Anderson of Flight Crew Support Division and Mr. Ray Mitchell of TRW, who supports the Flight Planning Branch FCSD under TRW task 81. The charts are to be included in the onboard data file and are considered to be presented in final form as of May 5, 1969.

Should any changes be made to the crew charts prior to lift-off, the backup crew's copy of the onboard crew charts will reflect the changes and will supersede the original charts. An operational description of the crew charts will not be covered in this document because the charts have already been defined in the mission techniques documents.

The following is a list of the Apollo 10 (Mission F) crew charts, with the originator of each chart and responsible organization.

Chart 1: Launch abort curves - E. M. Henderson, FAB/MPAD

Chart 2: Listing of planned launch trajectory parameters - E. M. Henderson, FAB/MPAD

Chart 3: TLI + 10 minute abort - B. Weber, FAB/MPAD

Chart 4: TLI + 10 minute abort - B. Weber, FAB/MPAD

Chart 5: Nominal LOI 15 minute abort CSM/LM - C. Foggatt, FAB/MPAD

Chart 6: LOI mode I 15 minute and 5 hour abort curves, CSM only - C. Foggatt, FAB/MPAD

Chart 7: LOI mode III abort curves, CSM only - C. Foggatt, FAB/MPAD

Chart 8: LM PDI abort maneuver - J. Bell, OMAB/MPAD

Chart 9: ΔV_0 versus $\Delta\theta_{Long}$, K = .4 to .04 - J. Yencharis, LMAB/MPAD

Chart 10: ΔV_0 versus $\Delta\theta_{Long}$, K = .04 to .004 - J. Yencharis, LMAB/MPAD

Chart 11: P37 return to earth program - corridor control - J. Yencharis, LMAB/MPAD

Loss of communication Navigation Procedures - C. Denham, MPB/MPAD

Chart 12: Detailed sighting schedule for aborts at TLI + 4 hr for a May 18, 1969, launch (15.5-hr return) - C. Denham, MPB/MPAD

Chart 13: Detailed sighting schedule for aborts at TLI + 4 hr for a May 18, 1969, launch (greater than a 15.5-hr return) - C. Denham, MPB/MPAD

Chart 14: Detailed sighting schedule for aborts from lunar orbit after rev 17 for a May 18, 1969, launch (TEI to TEI plus 40 hr) - C. Denham, MPB/MPAD

Chart 15: Detailed sighting schedule for aborts from lunar orbit after rev 17 for a May 18, 1969, launch (EI minus 40 hr to EI) - C. Denham, MPB/MPAD

Chart 16: Planet half-unit vectors - J. Blucker, MPB/MPAD

Chart 17: Entry Corridor - J. Burton, LAB/MPAD

Chart 18: Command module computer constant - drag value - J. Burton, LAB/MPAD

Chart 19: Earth orbit BBA versus $\Delta\Delta V_X$ - J. Burton, LAB/MPAD

Chart 20: SM RCS propellant profile (total) - A. Loyd, GPB/MPAD

Chart 21: Onboard reading of LM RCS propellant remaining, percentage - S. Mayfield, GPB/MPAD

Chart 22: SPS tailoff ΔV versus spacecraft weight - O. Graf, GPB/MPAD

Chart 23: SPS versus RCS criteria, CSM alone - minimum preburn ullage - O. Graf, GPB/MPAD

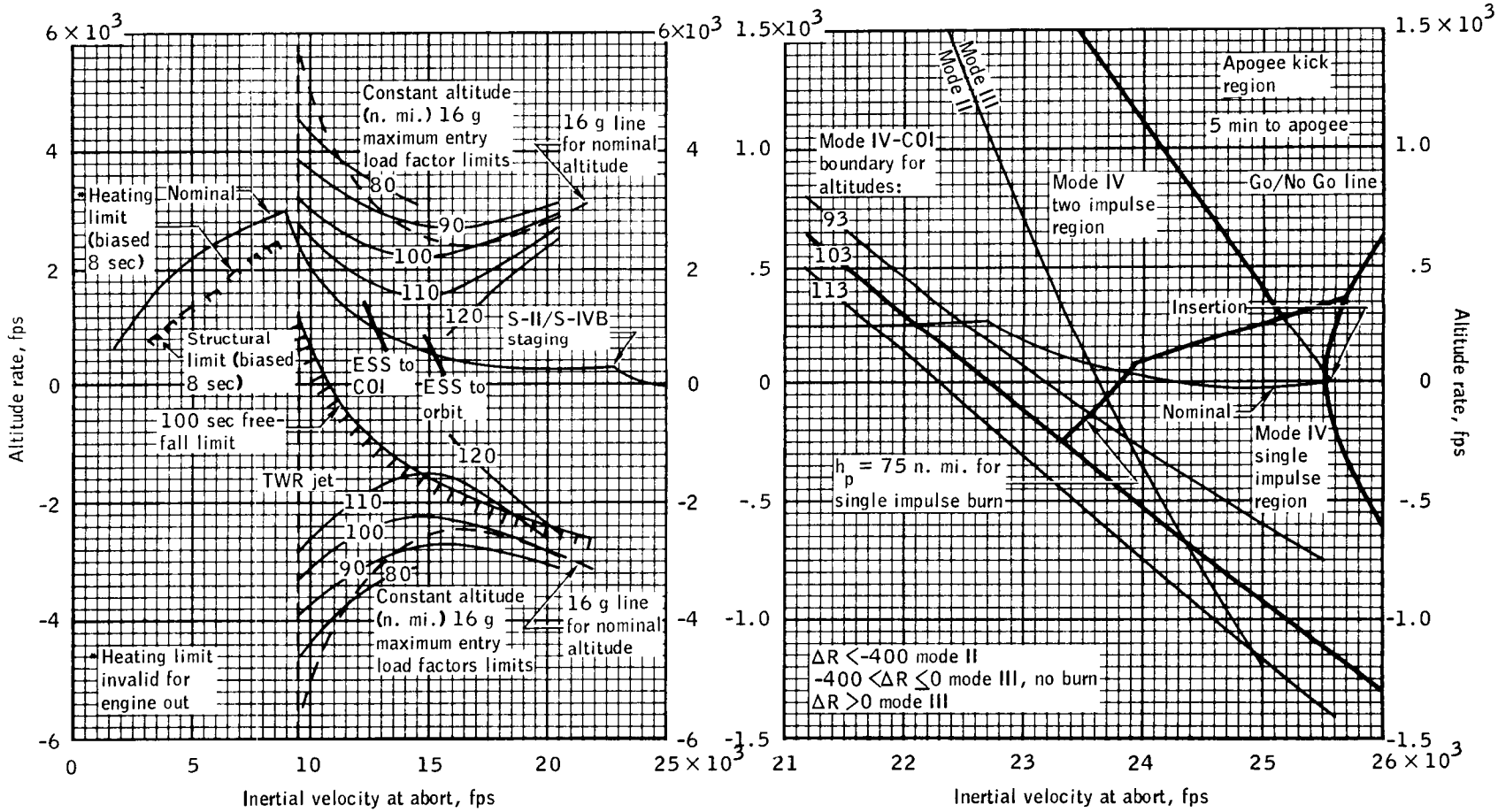
Chart 24: Hydrogen remaining in one tank - W. Scott, GPB/MPAD

Chart 25: Onboard readout of ascent oxygen remaining, percentage - W. Scott, GPB/MPAD

Detailed sighting schedules for May 20, 23, 24, and 25 launch days will be provided to Flight Crew Support Division by the Data Management Group in the form of crew charts on May 13, 1969.

Any questions concerning this document should be directed to Mike Collins, Data Management Group, Mission Planning Support Office, HU3-4908.

Henderson/FAB/MPAD
4/18/69



Crew chart 1.- Launch abort curves.

Henderson/FAB/MPAD
4/18/69

Time from first motion, g.e.t., min:sec	SC IMU pitch gimbal angle, θ, deg	DSKY displays		
		Inertial velocity, V_i, fps	Altitude rate, h, fps	Altitude, h, n. mi.
00:00.0	90	1 340	0	0.0
00:30.0	87	1 390	296	0.7
01:00.0	69	1 847	828	3.3
01:30.0	48	3 051	1486	9.0
02:00.0	33	5 127	2200	18.2
02:15.0*	27	6 567	2582	24.1
02:30.0	23	7 928	2822	30.7
02:39.9**	22	8 998	3009	35.5
03:00.0	22	9 239	2626	44.8
03:30.0	29	9 805	2153	56.6
04:00.0	26	10 449	1801	66.4
04:30.0	23	11 190	1474	74.5
05:00.0	20	12 030	1178	81.1
05:30.0	17	12 976	916	86.2

*S-IC center-engine cutoff (TB_2)

**S-IC outboard-engine cutoff (TB_3)

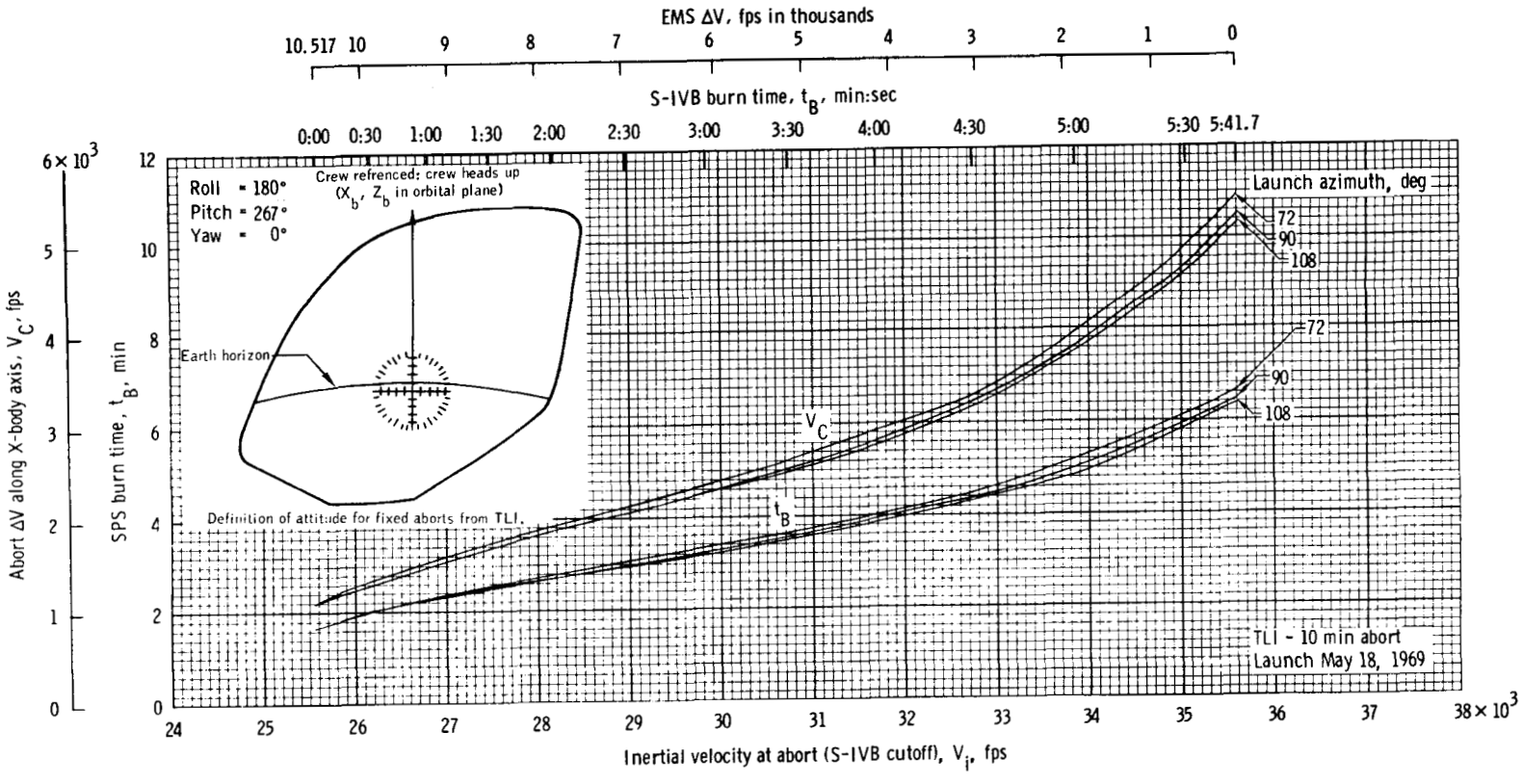
Time from first motion, g.e.t., min:sec	SC IMU pitch gimbal angle, θ, deg	DSKY displays		
		Inertial velocity, V_i, fps	Altitude rate, h, fps	Altitude, h, n. mi.
06:00.0	14	14 038	691	90.2
06:30.0	10	15 230	507	93.2
07:00.0	7	16 574	369	95.4
07:30.0	3	18 097	289	97.1
08:00.0	3	19 566	267	98.4
08:30.0	0	20 801	248	99.8
09:00.0	356	22 053	256	101.0
09:13.9***	354	22 682	280	101.7
09:30.0	350	22 872	207	102.3
10:00.0	346	23 426	103	103.1
10:30.0	343	24 011	27	103.5
11:00.0	341	24 625	-13	103.5
11:30.0	339	25 269	-19	103.4
11:43.2****	339	25 562	0	103.4

***S-II engine cutoff (TB_4)

****S-IVB guidance cutoff signal

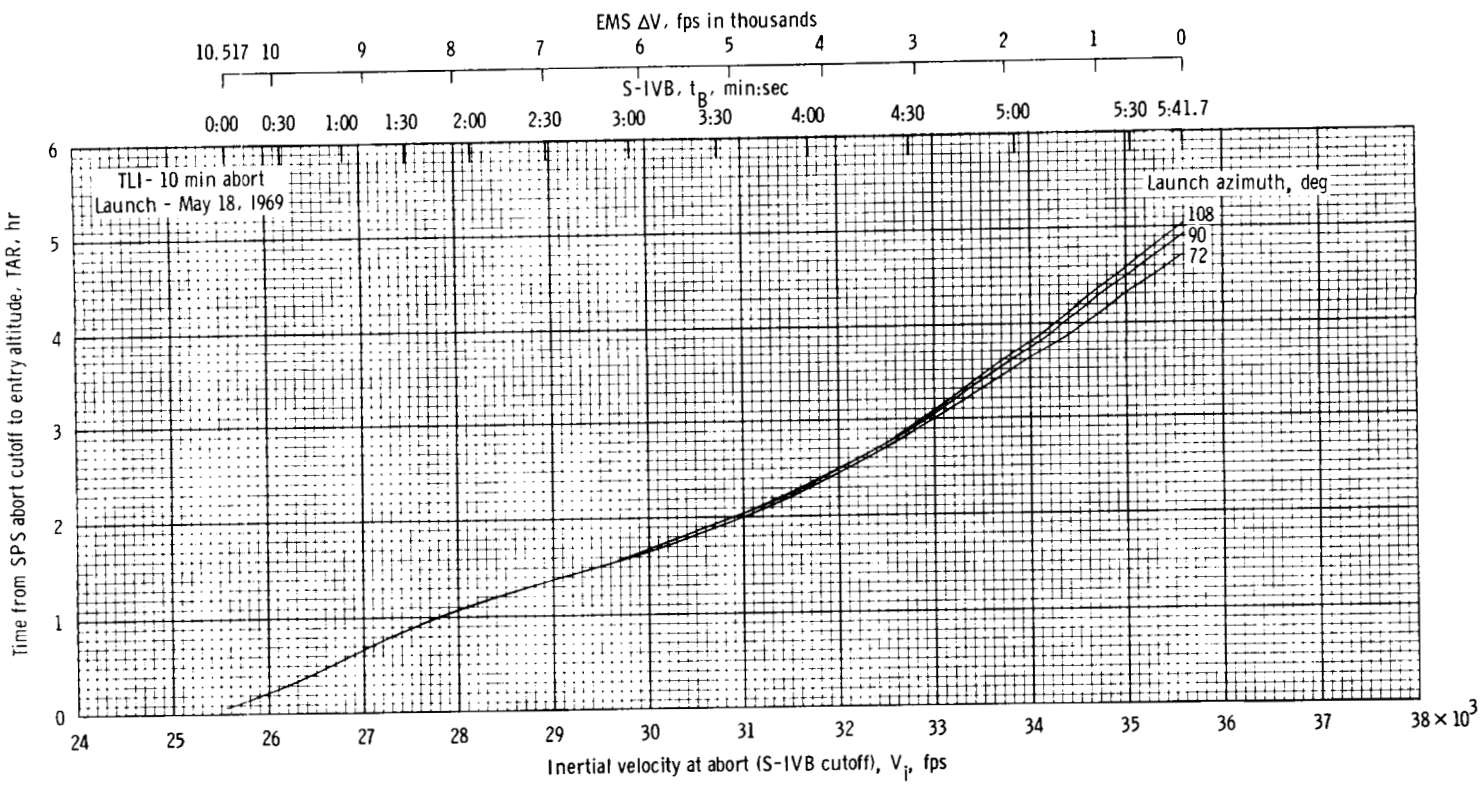
Crew chart 2.- Listing of planned launch trajectory parameters.

Weber/FAB/ MPAD
3/31/69



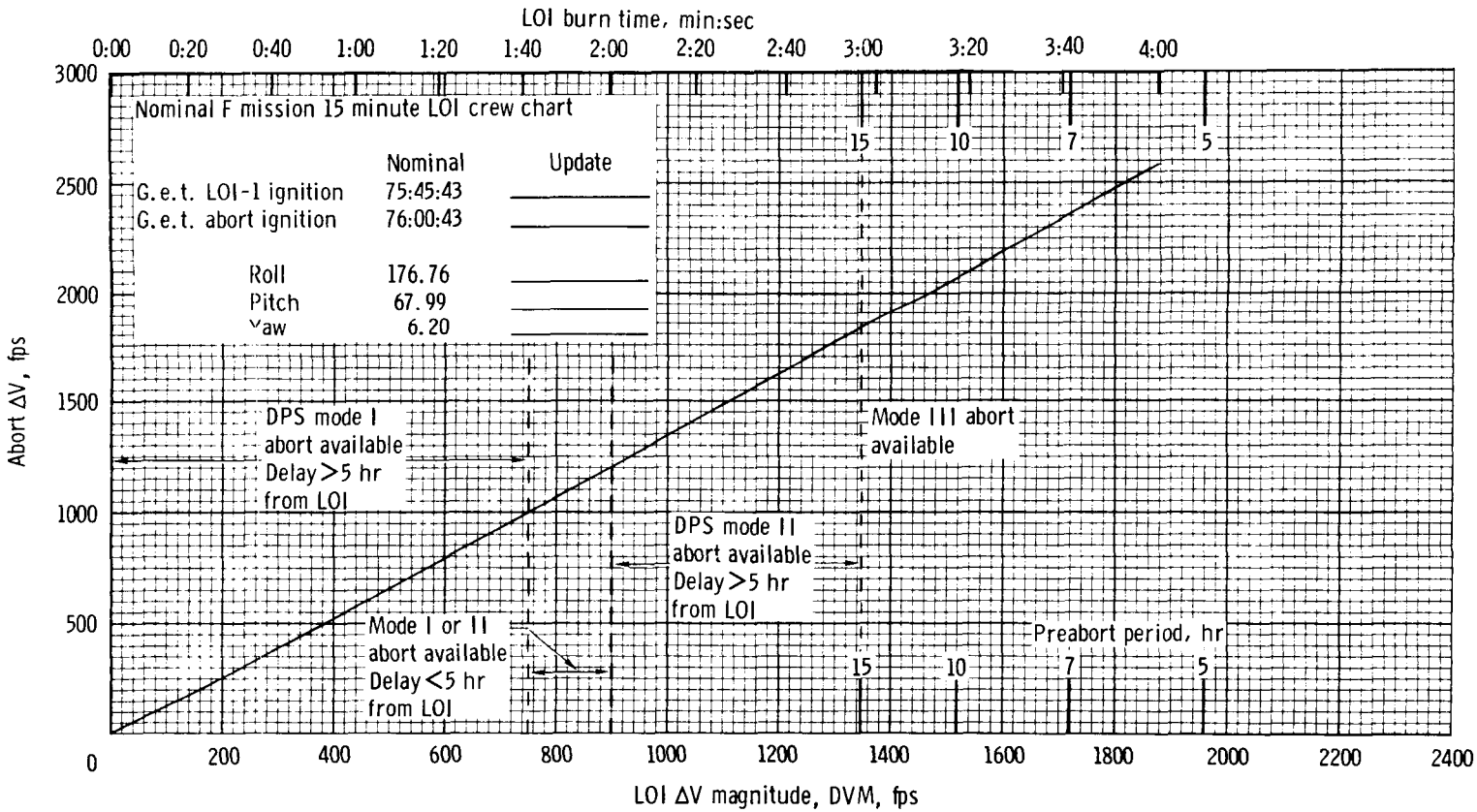
Crew chart 3.- TLI + 10 minute abort

Weber/FAB/MPAD
3/31/69



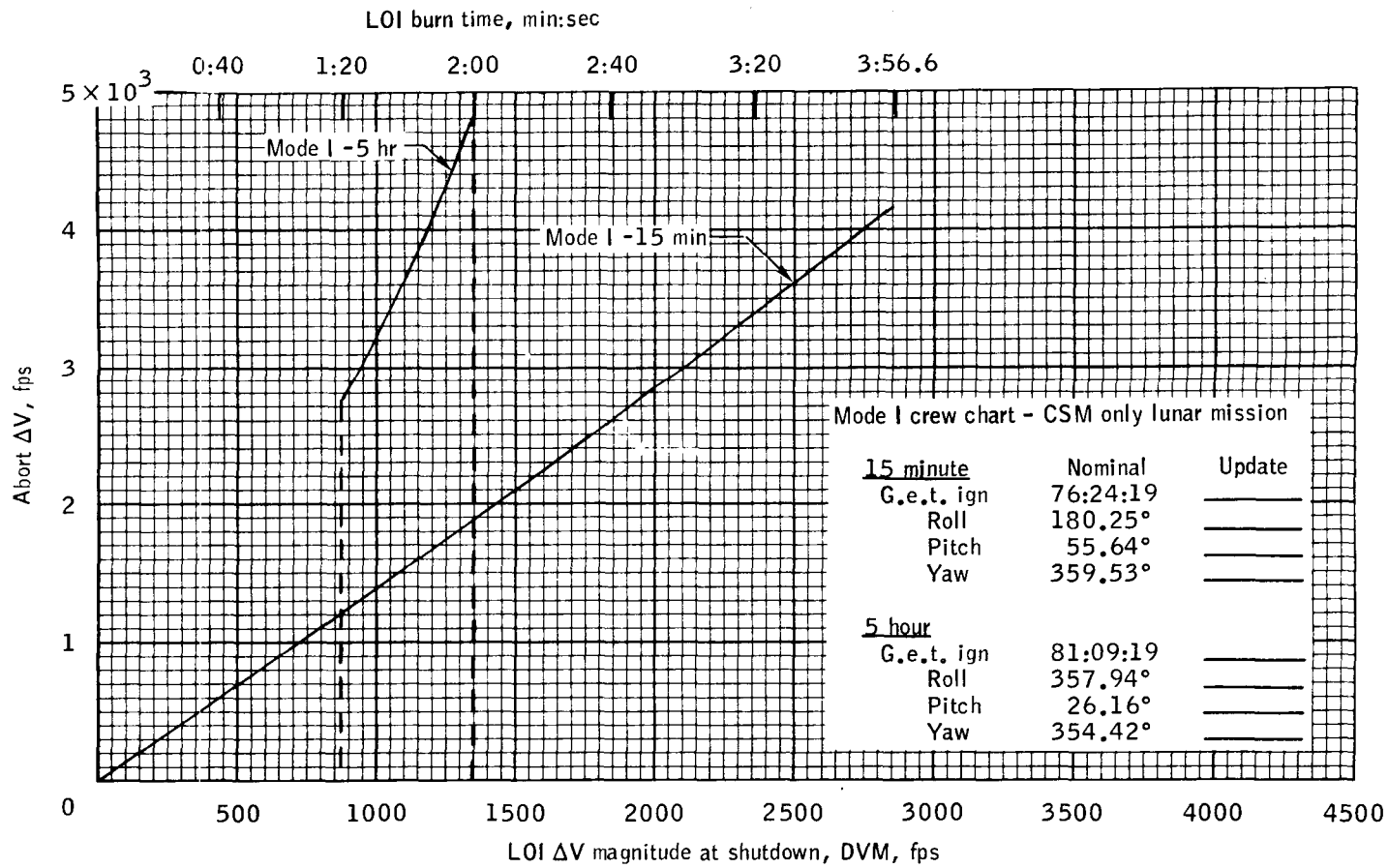
Crew chart 4. - TLI + 10 minute abort

Foggatt/FAB/MPAD
3/31/69



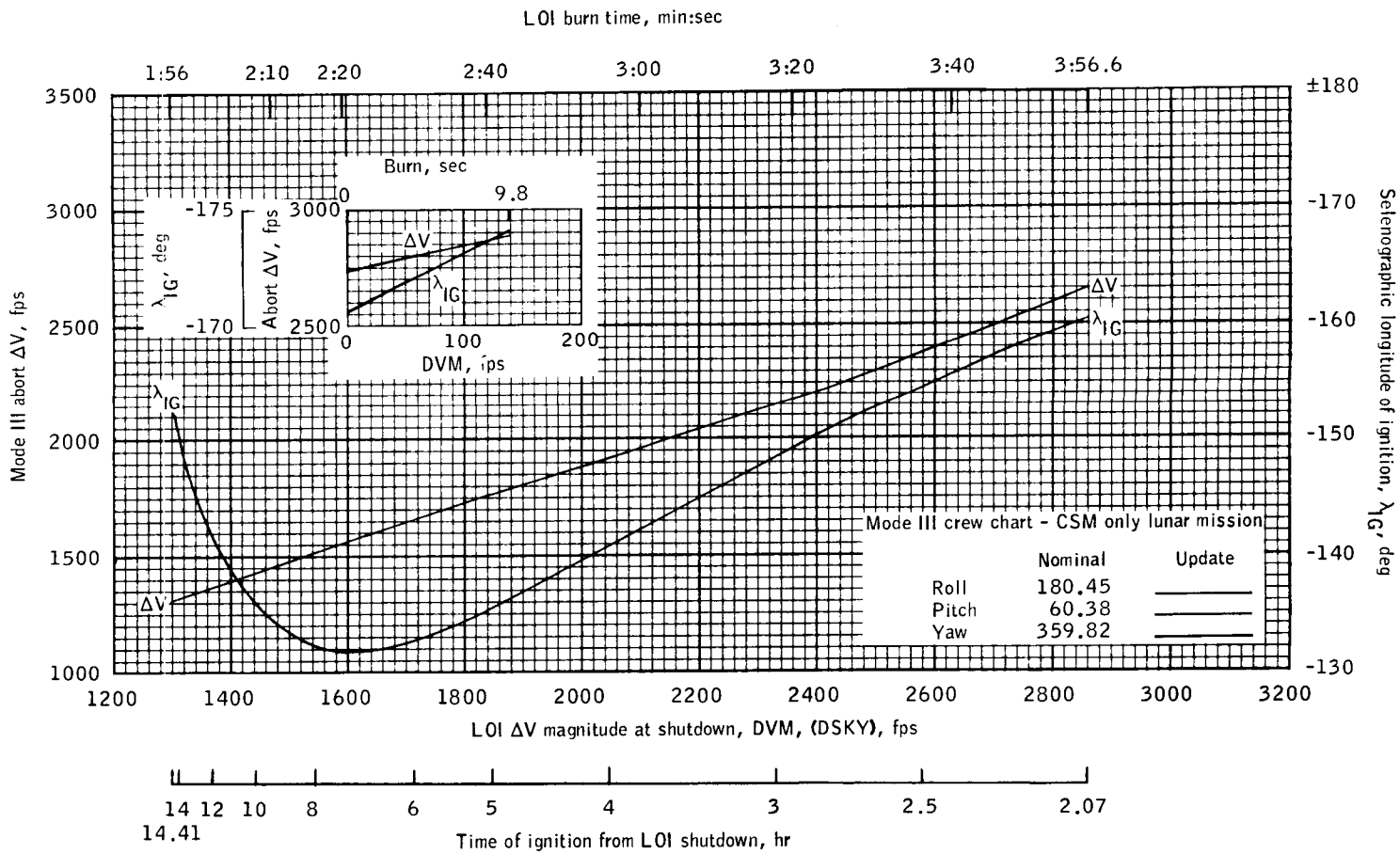
Crew chart 5. - Nominal LOI 15 minute abort CSM/LM.

Foggatt/FAB/MPAD
3/31/69



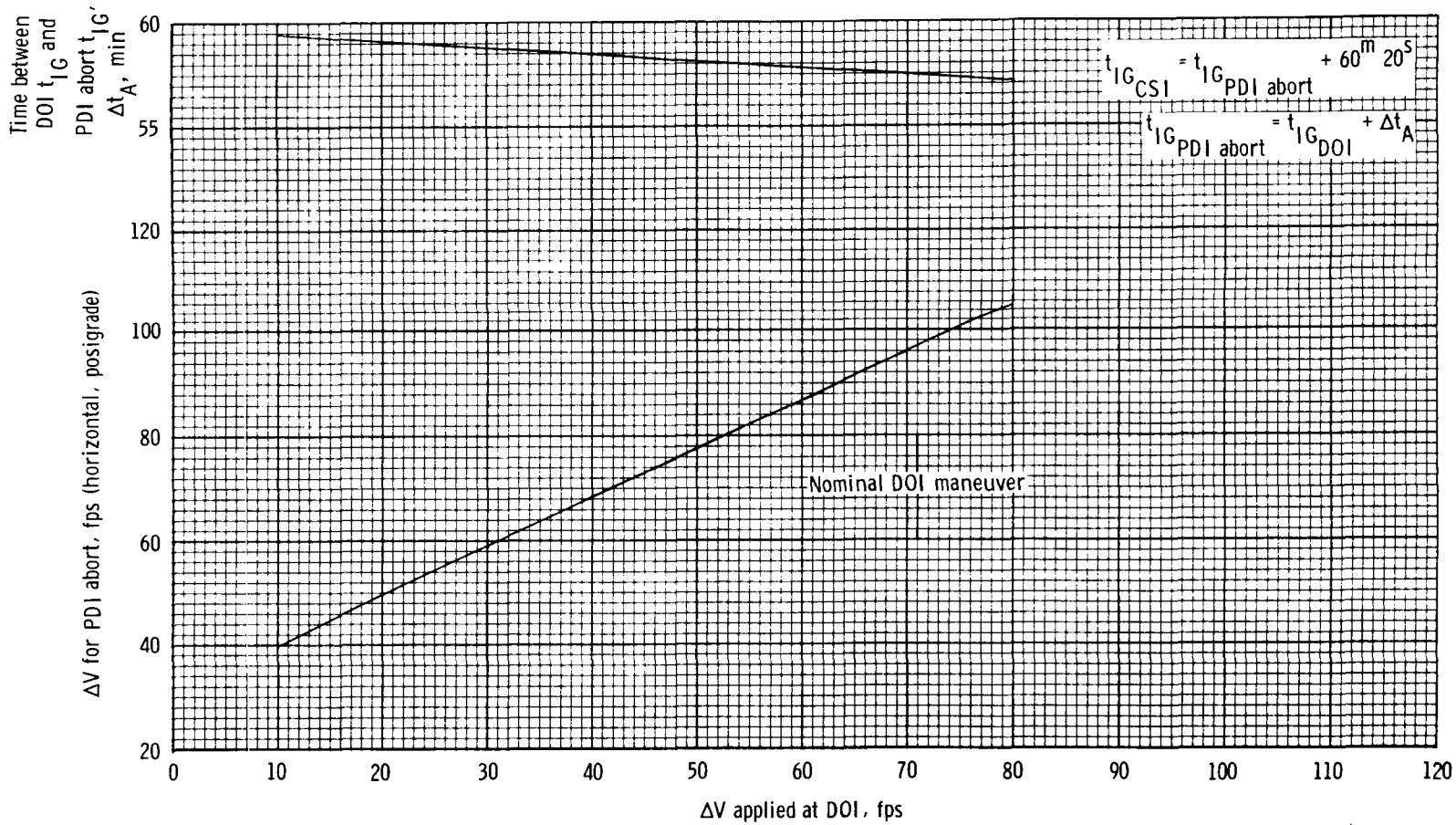
Crew chart 6.- LOI mode I 15 min and 5 hour abort curves, CSM only.

Foggatt/FAB/MPAD
3/31/69



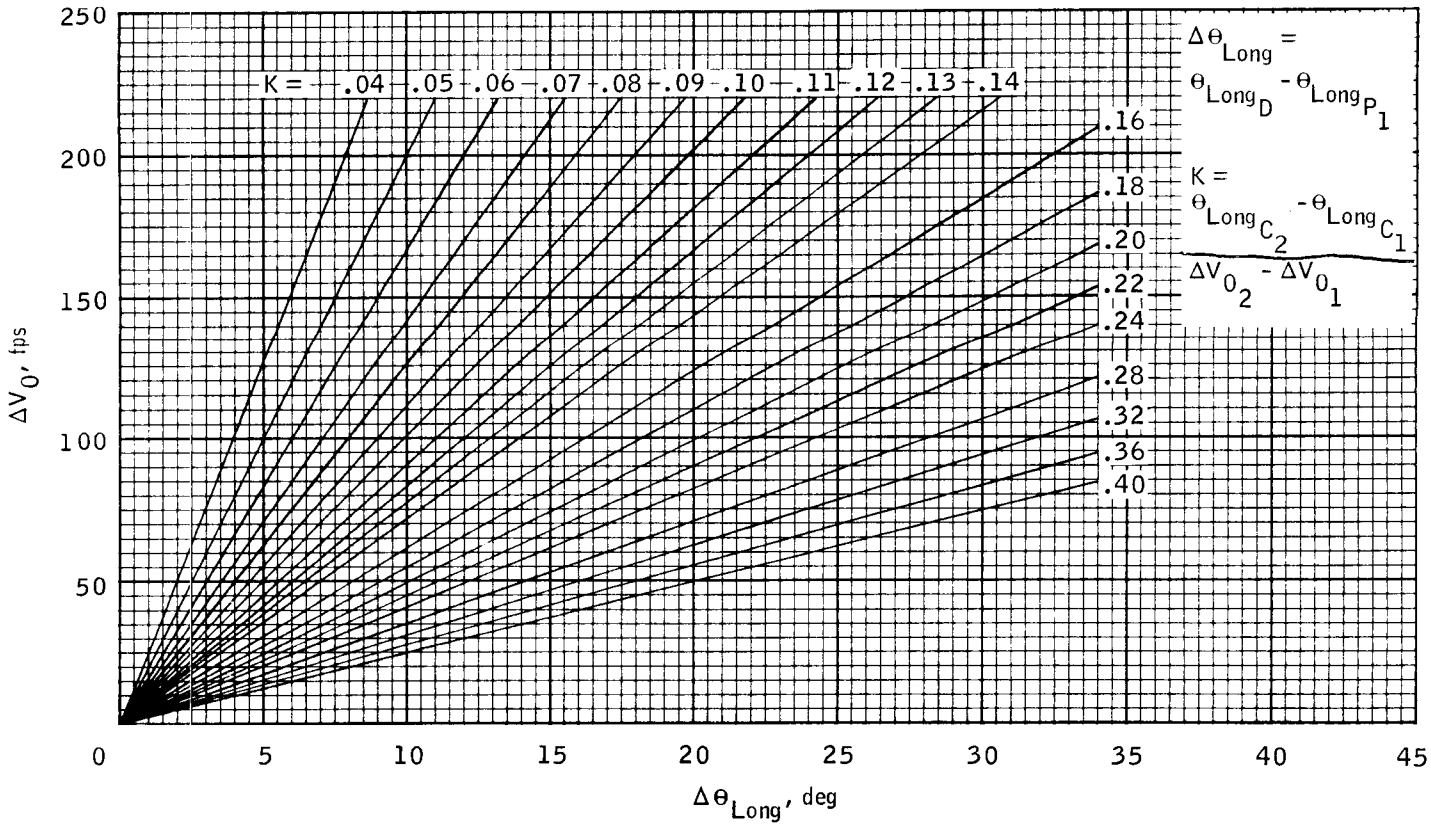
Crew chart 7.- LOI mode III abort curves, CSM only.

Bell/OMAB/MPAD
3/31/69



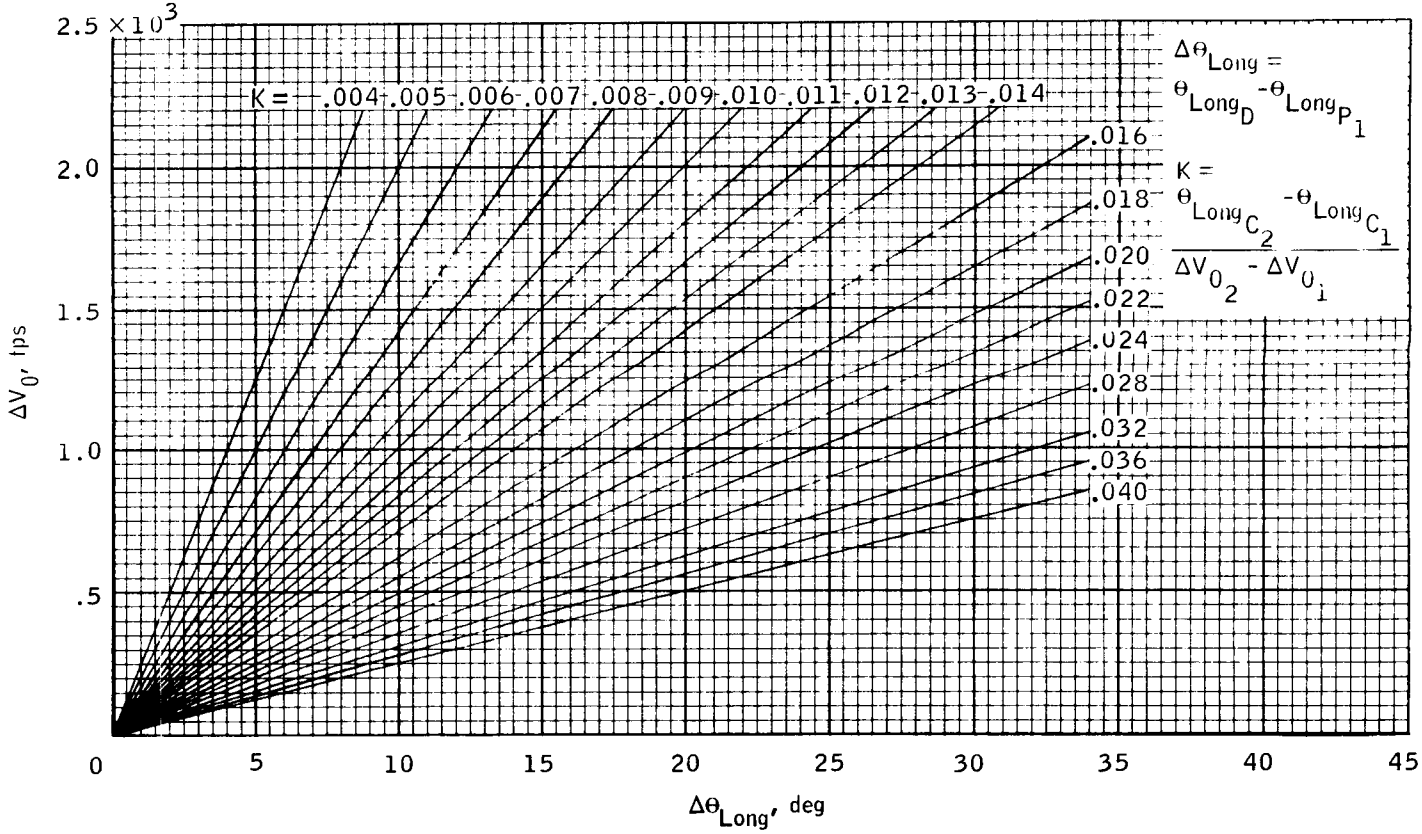
Crew chart 8. - LM PDI abort maneuver.

Yencharis/LMAB/MPAD
3/31/69



Crew chart 9.- ΔV_0 versus $\Delta\theta_{Long}$, K = .4 to .04.

Yencharis LMAB/MPAD
3/31/69



Crew chart 10.- ΔV_0 versus $\Delta\Theta_{Long}$, K = .04 to .004.

Yencharis/LMAB/MPAD
4/29/69

Crew chart 11.- P37 return to earth program - corridor control.

1A		V37E 37E	
	F 06 33	TIG	(hrs, min, .01 sec)
		Load desired TIG	
		PRO	
2	F 06 60	BLANK, ΔV DESIRED, GAMMA EI DESIRED	(1fps, .01°)
		Check desired values	
		R2 00000	(MIN ΔV)
		R3 00000	(ENTRY ON TARGET LINE)
		PRO	
		* F 05 09	00612 STATE VECTOR IN LUNAR INFLUENCE
		*	00605 SOLUTION NOT CONVERGENT
		*	00607 CONIC ROUTINE FAILED
		*	00610 STATE VECTOR IS below 400K ft ALTITUDE
		* V32 E, RSET TO 1	

PAGE 2A

3 F 06 61 IMPACT LAT, IMPACT LONG (.01°)
(RECYCLE) V32E TO 1
PRO

4 F 06 39 ΔT TRANSFER (hrs, min, .01 sec)
(RECYCLE) V32E TO 1
PRO

5 F 06 60 BLANK, VPRED, GAMMA EI (fps, .01°)
(RECYCLE) V32E TO 1
PRO

6 F 06 81 ΔVXYZ (LV) aT TIG (.1 fps)
(OPTION) V06E 40E ΔV MAG. available in N40 and N80
PRO (To 3 on first pass)
* F 05 09 00605 Solution not
* Convergent
* 00613 FLT. Path Angle
* 00607 not reached CONIC ROUTINE FAILED
* RSET
* V32E TO 1

7 F 04 06 THRUST OPTION

PAGE 3A

		R1	00007
		R2	0000X
			X= 1 (SPS)
			2 (RCS)
		PRO	(IF R03 HAS BEEN COMPLETED)
8	F 06 33	TIG	(hrs, min, .01 SEC)
		PRO	
9	F 16 45	MARK, TFI, MGA	(mark, min-sec, .01°)
		PRO	(MGA set To -00002 IF NO REFSMMAT SET)
10	F 37	(40E OR 41E)	

PAGE 1B

P37 RETURN TO EARTH PROGRAM - LONGITUDE CONTROL
(CANNOT USE WHEN TIME TO ENTRY IS < 4 HRS)

1B		V37E 37E
	F 06 33	TIG (hrs, min, .01 sec)
		Load desired TIG
		PRO
2	F 06 60	BLANK, ΔV DESIRED, GAMMA EI DESIRED (1 fps, .01°)
		Load desired ΔV [redacted]
		Load PAD ΔV [redacted] if on TLC
		Load 0. fps if on TEC
		R2 xxxxx
		PRO

*	F 05 09	00612	State vector in
*			Lunar Influence
*		00605	Solution not
*			Convergent
*		00607	Conic Routine Failed
*		00610	State vector is
*			below 400K ft
*			altitude
*	V32E, RSET TO 1B		

PAGE 2B

3 F 06 61 IMPACT LAT, IMPACT LONG (.01°)

(RECYCLE IF LONG IS NOT WITHIN 30° OF DESIRED. INCREASE ΔV DESIRED TO OBTAIN A MORE EASTERLY LONG, DECREASE TO OBTAIN MORE WESTERLY) V32 E TO 1B

PRO (AFTER RECORDING LONG AS θ_{c_1})

4 F 06 39 ΔT TRANSFER (hrs, min, .01 sec)

PRO

5 F 06 60 BLANK, VPRED, GAMMA EI (fps, .01°)

PRO

6 F 06 81 ΔVXYZ (LV) ΔT TIG

PRO

*	F 05 09	00605	Solution not
*			Convergent
*		00613	FLT. Path Angle
*			not reached
*		00607	Conic Routine
*			Failed

* RSET

* V32 E TO 1B

PAGE 3B

7	F 06 61	IMPACT LAT, IMPACT LONG Record LONG as θ_{P_1} PRO	(.01°)
8	F 06 39	ΔT TRANSFER PRO	
9	F 06 60	BLANK, VPRED, GAMMA EI PRO	(fps, .01°)
10	F 06 81	ΔVXYZ(LV) at TIG V 06 E 40E R2 xxxxx Record as ΔV_{o_1} (Check To see if θ_{P_1} is an acceptable LONG. IF IT IS V32E TO 1A OF CORRIDOR CONTROL CHECKLIST AND LOAD ΔV_{o_1} IN R2) V32 E TO 11	
11	F 06 33	TIG Load same value used initially PRO	(hrs, min, .01 sec)
12	F 06 60	BLANK, ΔV DESIRED, GAMMA EI DESIRED	(1 fps, .01°)

PAGE 48

Load a desired ΔV 100 fps greater than or less than ΔV_{o_1} recorded above and record value as ΔV_{o_2} (ΔV_{o_2} must be nonzero)

R2 XXXXX

PRO

* F 05 09 SAME AS IN 2

* V32E, RSET TO 1

13 F 06 61 IMPACT LAT, IMPACT LONG (.01°)

Record LONG as θ_{c_2}

PRO

14 F 06 39 ΔT TRANSFER

PRO

15 F 06 60 BLANK, VPRED, GAMMA EI

PRO

16 F 06 81 ΔVXYZ(LV) at TIG

V06E 40E

R2 XXXXX (ΔV MAG)

PAGE 5B

17 IF value in R2 is equal To $\Delta V_{o_2} \pm 2.$ fps use crawchart To find ΔV_o after computing K and $\Delta\theta_{LONG}$ WHERE

ΔV_{o_1}	is	from	step	10
θ_{c_1}	is	from	step	3
θ_{p_1}	"	"	"	7
ΔV_{o_2}	"	"	"	12
θ_{c_2}	"	"	"	13

θ_{LONG_D} is The desired LONG

V32E TO 1A OF CORRIDOR CONTROL CHECKLIST WITH ΔV DESIRED = $\Delta V_{o_1} \pm \Delta V_o$ LOADED INSTEAD OF 0.

(IF VALUE IN R2 IS NOT EQUAL TO ΔV_{o_2}) PRO

18 F 06 61 IMPACT LAT, IMPACT LONG (.01°)

IF LONG WAS OVERSHOT, RECYCLE WITH $|\Delta V_{o_1} - \Delta V_{o_2}| < 100$ fps V32E TO 11

PAGE 6B

IF LONG WAS NOT REACHED, P37 hiT
CONSTRAINT. LONG IS NOT ATTAINABLE
V32E TO 1B AND TRY DIFFERENT TIG.

Loss of Communications Navigation Procedures

1. TL+4 hours abort (detailed schedules provided for 72.1 and 108.2 injections)

a. Make abort burn
b. Re-initialize W-matrix
c. Initiate sighting as soon as possible after abort following the schedule given in the crew chart.

(1.) The horizontal lines represented the start of the sighting intervals.
(2.) The vertical lines represent stars which are available for use with P23.
(3.) The numbers adjacent to the vertical lines are the required sightings with the given star.
(4.) Only earth horizon marks will be made.

d. Two charts are provided for each launch day; one is for a short return time using the 72.1 injection (approximately 19 hours or less), the second for longer returns using the 108.2 injection (19 hours or greater). Targets for aborts from other injection opportunities are nearly identical to these schedules with variations in star AOS and LOS.

2. LO aborts (detailed schedules provided)

a. The first and last 17 hours of the schedule should not be changed.
b. The data in the middle of the TE leg may be moved around for rest periods and MCC's.
c. Change to EI chart at EI-40
d. The key for the detailed schedule is:
Vertical Solid Line: Star/Horizon combination available for earliest TLI (72°, 1st opportunity).
Vertical Dashed Line: Star/Horizon combinations available for latest TLI (108°, 2nd opportunity).
Horizontal Solid Line: Sighting interval.
N: N sets of 3 marks on this star/horizon or star/landmark combination.

3. General TE optical navigation rules

a. A sighting is to consist of three marks.

b. A sighting interval is to consist of at least three star/horizon sightings; although as many as five are advisable (five should be used at the end of every sleep period). Observations using stars in the orbit plane should be emphasized. One sighting using an out-of-plane star (angle $\geq$ 45 degrees to the orbit plane) in every five sets is sufficient. If only three stars are grouped together, all stars should be in plane.

3. General TE optical navigation rules, cont'd.

c. The navigation sighting intervals should be scheduled so that, immediately following a 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), provided it does not interfere with navigation sightings which are essential for a safe entry.

d. The sextant calibration routine will be exercised at least every half hour while navigation sightings are in progress. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 0.003 degree.

e. If an abort burn is performed during translunar coast, the W-matrix will be reinitialized to its launch value of 3,300 feet and 3.3 feet per second for onboard processing of the transearth sighting data. Navigation sightings intervals will be scheduled every 2.5 hours, and only star/earth horizon sightings should be made. The last sighting will be scheduled just after the last midcourse correction at EI-3 hours.

f. The transearth navigation sighting schedule in the flight plan is designed for a 54-hour return trajectory. In the event that the return time is altered (i.e., early TLI because of a communication loss, etc.) the following rules are to be followed for setting up a navigation schedule which will ensure a safe entry:

(1.) <u>TEI through TEI+17</u>

The nominal schedule is to be adhered to from TEI to TEI+17. The first two batches of sightings are to be on the moon, and the second two batches are to be on the earth. They are scheduled at TEI+1:30, TEI+12:30, TEI+13:30, and TEI+16:00 hours. The corresponding sightings are shown in the flight plan.

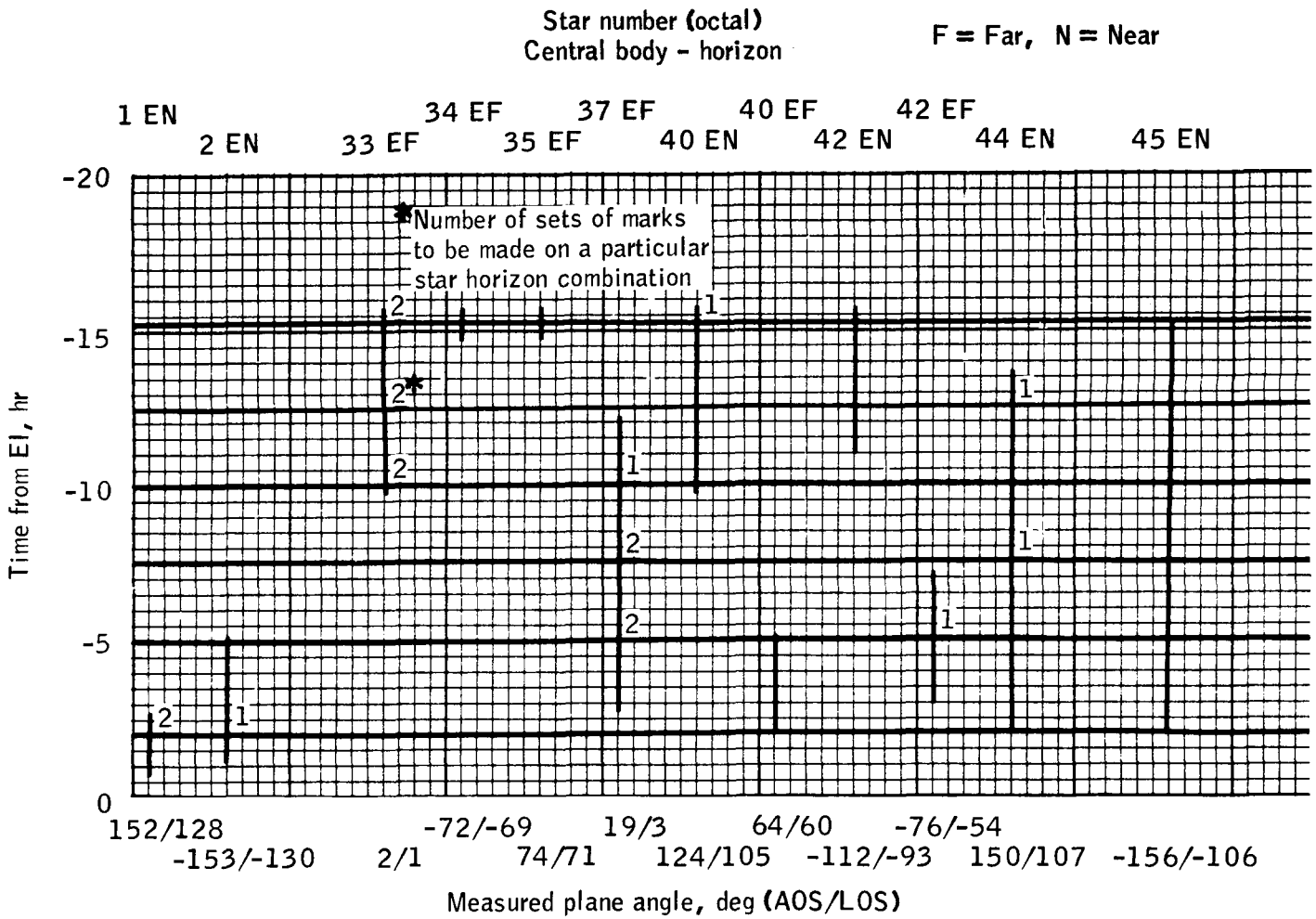
(2.) <u>EI-17 through EI</u>

The nominal schedule is also to be adhered to from EI-17 to EI. The navigation sightings are scheduled at EI-16, EI-11:20, EI-10:20, EI-7:40, EI-5, and EI-2:20. The corresponding central body for the star/horizon sightings is shown in the flight plan.

(3.) <u>TEI+17 through EI-17</u>

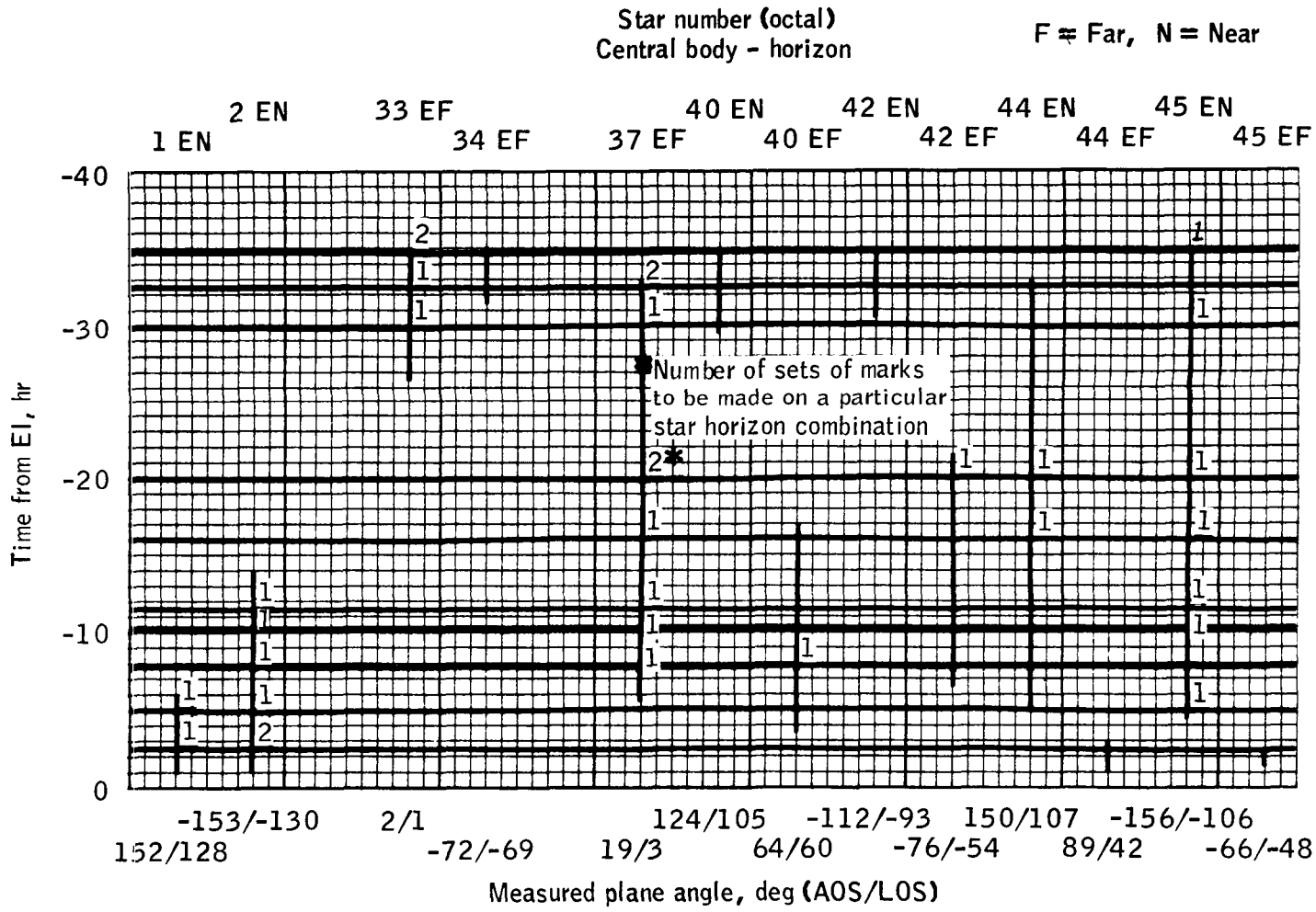
Between TEI+17 and EI-17 schedule two-thirds as many sightings as there are hours of coast during this period. Sightings should be scheduled in a ratio of 2 to 1, earth to moon, with a minimum of 17 sightings during this coast period (i.e., if the time between TEI+17 and EI-17 is less than 25.5 hours, 17 sightings will be required).

Denham/MPB/MPAD
4/30/69



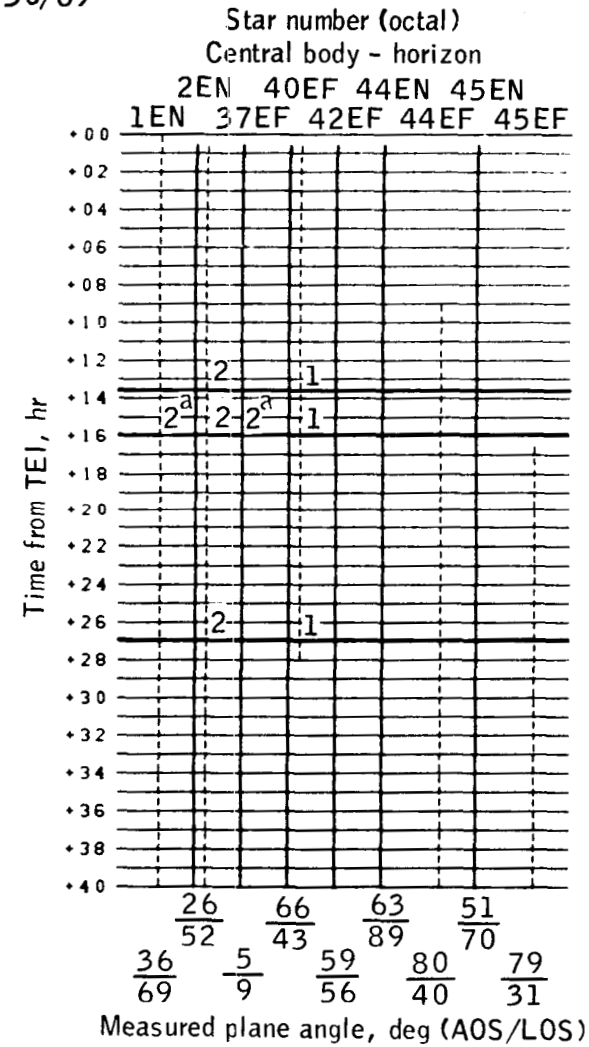
Crew chart 12.- Detailed sighting schedule for aborts at TLI + 4 hr for a May 18, 1969, launch (15.5 hr return).

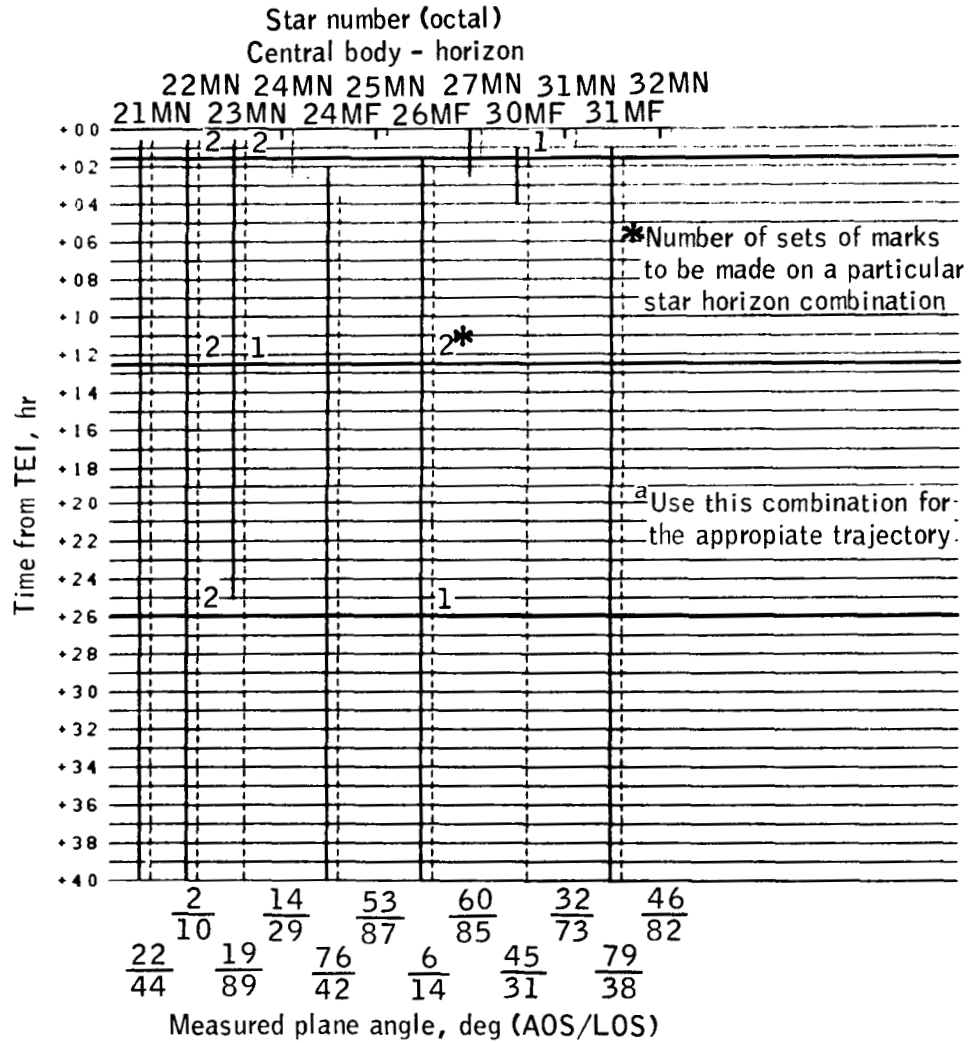
Denham/MPB/MPAD
4/30/69



Crew chart 13.- Detailed sighting schedule for aborts at TLI + 4 hr for a May 18, 1969, launch (greater than a 15.5 hr return).

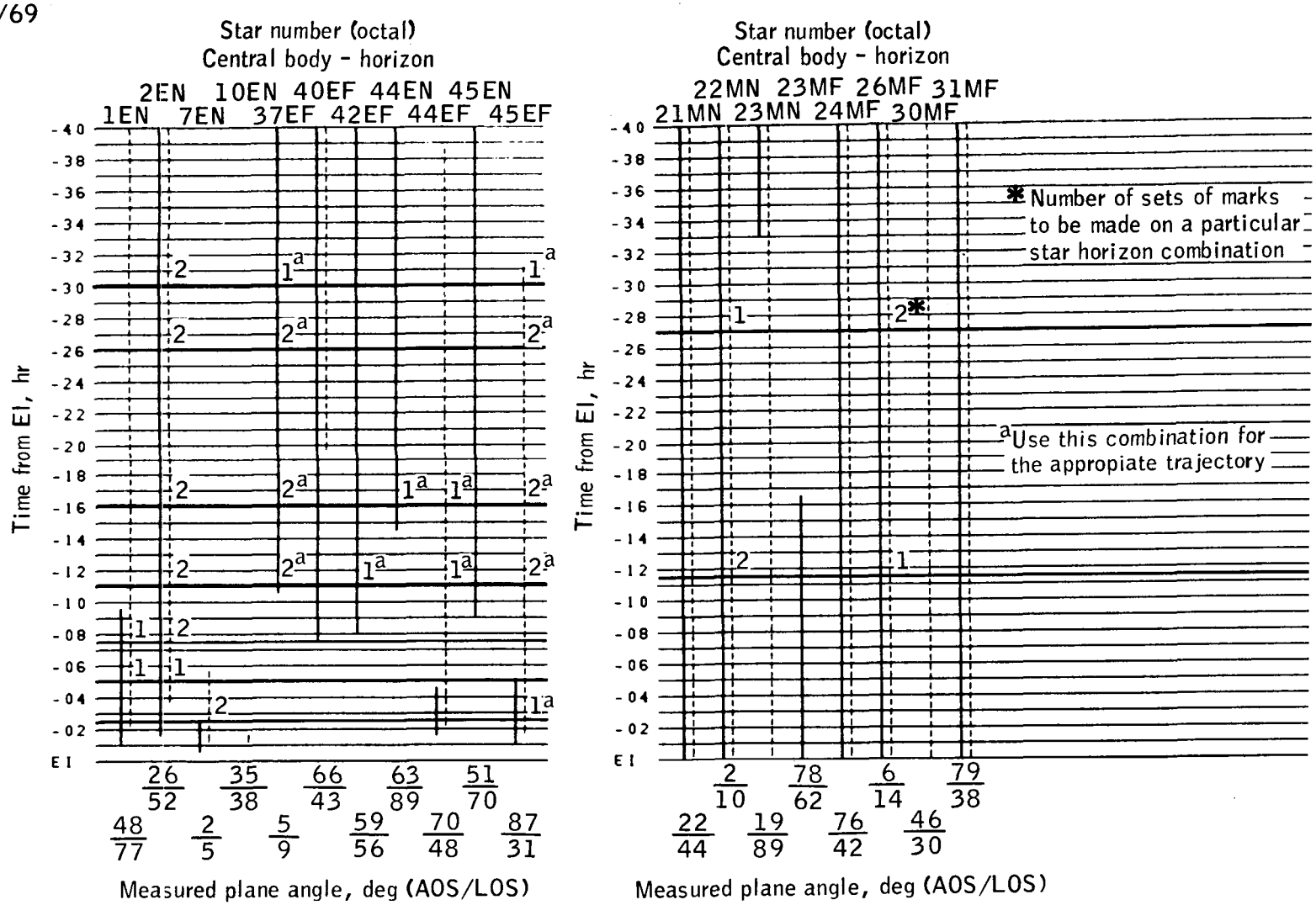
Denham/MPB/MPAD
4/30/69





Crew chart 14.- Detailed sighting schedule for aborts from lunar orbit after rev 17 for a May 18, 1969, launch (TEI to TEI plus 40 hr).

Denham/MPB/MPAD
4/30/69



Crew chart 15.- Detailed sighting schedule for aborts from lunar orbit after rev 17 for a May 18, 1969, launch (EI minus 40 hr to EI).

Planet half-unit vectors.
Blucker/MPB
3/31/69

Crew chart 16.- Planet half-unit vectors.

PLANET = VENUS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	18	16	.0	.48[illegible]49	.12044	.05178	MEAN	0	59	22.[illegible]31	5	52	37.721
								APP.	0	59	22.850	5	52	41.212
69	5	18	2	10.0	.47986	.13048	.05212	MEAN	1	0	20.093	5	54	46.639
								APP.	1	0	20.221	5	54	50.226
69	5	18	12	20.0	.47926	.13255	.05246	MEAN	1	1	18.228	5	57	3.136
								APP.	1	1	18.363	5	57	6.820
69	5	18	22	30.0	.47864	.13462	.05282	MEAN	1	2	17.121	5	59	27.087
								APP.	1	2	17.265	5	59	30.870
69	5	19	8	40.0	.47800	.13671	.05320	MEAN	1	3	16.761	6	1	58.371
								APP.	1	3	16.913	6	2	2.253
69	5	19	18	50.0	.47735	.13882	.05358	MEAN	1	4	17.136	6	4	36.863
								APP.	1	4	17.296	6	4	40.846
69	5	20	4	60.0	.47669	.14093	.05398	MEAN	1	5	18.234	6	7	22.445
								APP.	1	5	18.402	6	7	26.528
69	5	20	14	70.0	.47601	.14306	.05439	MEAN	1	6	20.044	6	10	14.993
								APP.	1	6	20.220	6	10	19.176
69	5	21	0	80.0	.47531	.14520	.05481	MEAN	1	7	22.554	6	13	14.390
								APP.	1	7	22.737	6	13	18.672
69	5	21	10	90.0	.47460	.14736	.05525	MEAN	1	8	25.753	6	16	20.516
								APP.	1	8	25.944	6	16	24.897
69	5	21	20	100.0	.47387	.14952	.05569	MEAN	1	9	29.631	6	19	33.255
								APP.	1	9	29.829	6	19	37.732
69	5	22	6	110.0	.47312	.15170	.05615	MEAN	1	10	34.177	6	22	52.489
								APP.	1	10	34.381	6	22	57.061

PLANET = VENUS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	22	16	120.0	.47235	.15388	.05661	MEAN	1	11	39.382	6	26	18.102
								APP.	1	11	39.591	6	26	22.767
69	5	23	2	130.0	.47158	.15608	.05709	MEAN	1	12	45.234	6	29	49.980
								APP.	1	12	45.449	6	29	54.736
69	5	23	12	140.0	.47078	.15829	.05758	MEAN	1	13	51.724	6	33	28.009
								APP.	1	13	51.945	6	33	32.853
69	5	23	22	150.0	.46997	.16051	.05808	MEAN	1	14	58.843	6	37	12.077
								APP.	1	14	59.068	6	37	17.007
69	5	24	8	160.0	.46914	.16274	.05860	MEAN	1	16	6.582	6	41	2.072
								APP.	1	16	6.811	6	41	7.084
69	5	24	18	170.0	.46829	.16498	.05912	MEAN	1	17	14.931	6	44	57.883
								APP.	1	17	15.164	6	45	2.975
69	5	25	4	180.0	.46742	.16723	.05966	MEAN	1	18	23.881	6	48	59.400
								APP.	1	18	24.118	6	49	4.570
69	5	25	14	190.0	.46654	.16949	.06020	MEAN	1	19	33.425	6	53	6.516
								APP.	1	19	33.665	6	53	11.760
69	5	26	0	200.0	.46563	.17176	.06076	MEAN	1	20	43.553	6	57	19.122
								APP.	1	20	43.796	6	57	24.437
69	5	26	10	210.0	.46471	.17404	.06133	MEAN	1	21	54.258	7	1	37.112
								APP.	1	21	54.504	7	1	42.497
69	5	26	20	220.0	.46377	.17633	.06192	MEAN	1	23	5.532	7	6	.380
								APP.	1	23	5.780	7	6	5.833
69	5	27	6	230.0	.46281	.17863	.06251	MEAN	1	24	17.366	7	10	28.822
								APP.	1	24	17.618	7	10	34.341

PLANET = VENUS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	[illegible]	[illegible]	16	240.0	[illegible]	.18[illegible]	.06312	MEAN	[illegible]	25	29.755	7	15	2.334
								APP.	1	25	30.009	7	15	7.919
69	5	28	2	250.0	.46082	.18327	.06374	MEAN	1	26	42.689	7	19	40.814
								APP.	1	26	42.947	7	19	46.464
69	5	28	12	260.0	.45980	.18561	.06437	MEAN	1	27	56.164	7	24	24.160
								APP.	1	27	56.425	7	24	29.876
69	5	28	22	270.0	.45875	.18796	.06502	MEAN	1	29	10.170	7	29	12.271
								APP.	1	29	10.436	7	29	18.054
69	5	29	8	280.0	.45768	.19032	.06568	MEAN	1	30	24.703	7	34	5.047
								APP.	1	30	24.973	7	34	10.899
69	5	29	18	290.0	.45659	.19270	.06635	MEAN	1	31	39.755	7	39	2.389
								APP.	1	31	40.031	7	39	8.313
69	5	30	4	300.0	.45547	.19509	.06703	MEAN	1	32	55.320	7	44	4.197
								APP.	1	32	55.602	7	44	10.197
69	5	30	14	310.0	.45433	.19749	.06773	MEAN	1	34	11.392	7	49	10.375
								APP.	1	34	11.682	7	49	16.454
69	5	31	0	320.0	.45317	.19990	.06844	MEAN	1	35	27.966	7	54	20.824
								APP.	1	35	28.263	7	54	26.987
69	5	31	10	330.0	.45198	.20233	.06917	MEAN	1	36	45.034	7	59	35.447
								APP.	1	36	45.340	7	59	41.698
69	5	31	20	340.0	.45076	.20477	.06991	MEAN	1	38	2.592	8	4	54.147
								APP.	1	38	2.906	8	5	.490
69	6	1	6	350.0	.44952	.20723	.07067	MEAN	1	39	20.634	8	10	16.828
								APP.	1	39	20.957	8	10	23.266

PLANET = VENUS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	6	1	16	360.0	.44825	.20970	.07143	[illegible]	1	40	39.154	8	15	43.392
								APP.	1	40	39.487	8	15	49.929
69	6	2	2	370.0	.44696	.21218	.07221	MEAN	1	41	58.147	8	21	13.745
								APP.	1	41	58.489	8	21	20.383
69	6	2	12	380.0	.44563	.21468	.07301	MEAN	1	43	17.607	8	26	47.788
								APP.	1	43	17.959	8	26	54.528
69	6	2	22	390.0	.44428	.21719	.07382	MEAN	1	44	37.530	8	32	25.427
								APP.	1	44	37.891	8	32	32.269
69	6	3	8	400.0	.44290	.21971	.07464	MEAN	1	45	57.910	8	38	6.566
								APP.	1	45	58.279	8	38	13.509
69	6	3	18	410.0	.44149	.22225	.07547	MEAN	1	47	18.741	8	43	51.108
								APP.	1	47	19.118	8	43	58.150
69	6	4	4	420.0	.44006	.22480	.07632	MEAN	1	48	40.019	8	49	38.957
								APP.	1	48	40.403	8	49	46.096
69	6	4	14	430.0	.43859	.22736	.07717	MEAN	1	50	1.738	8	55	30.020
								APP.	1	50	2.129	8	55	37.252

PLANET = MARS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	17	16	.0	-.13593	-.43711	-.20117	MEAN	16	50	51.949	-23	43	53.707
								APP.	16	50	54.600	-23	44	6.459
69	5	18	12	20.0	-.13790	-.43642	-.20131	MEAN	16	49	56.107	-23	45	11.128
								APP.	16	49	58.779	-23	45	23.938
69	5	19	8	40.0	-.13993	-.43572	-.20145	MEAN	16	48	58.429	-23	46	25.068
								APP.	16	49	1.122	-23	46	37.949
69	5	20	4	60.0	-.14199	-.43498	-.20158	MEAN	16	47	58.988	-23	47	35.408
								APP.	16	48	1.701	-23	47	48.376
69	5	21	0	80.0	-.14410	-.43423	-.20170	MEAN	16	46	57.859	-23	48	42.039
								APP.	16	47	.591	-23	48	55.104
69	5	21	20	100.0	-.14622	-.43347	-.20183	MEAN	16	45	55.119	-23	49	44.854
								APP.	16	45	57.869	-23	49	58.026
69	5	22	16	120.0	-.14837	-.43268	-.20195	MEAN	16	44	50.855	-23	50	43.756
								APP.	16	44	53.619	-23	50	57.039
69	5	23	12	140.0	-.15052	-.43188	-.20206	MEAN	16	43	45.150	-23	51	38.654
								APP.	16	43	47.928	-23	51	52.047
69	5	24	8	160.0	-.15267	-.43107	-.20218	MEAN	16	42	38.098	-23	52	29.465
								APP.	16	42	40.886	-23	52	42.967
69	5	25	4	180.0	-.15481	-.43026	-.20229	MEAN	16	41	29.791	-23	53	16.120
								APP.	16	41	32.587	-23	53	29.724
69	5	26	0	200.0	-.15694	-.42943	-.20240	MEAN	16	40	20.326	-23	53	58.557
								APP.	16	40	23.128	-23	54	12.250
69	5	26	20	220.0	-.15905	-.42861	-.20250	MEAN	16	39	9.801	-23	54	36.725
								APP.	16	39	12.609	-23	54	50.495

PLANET = MARS

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	27	16	240.0	-.16115	-.42778	-.20260	MEAN	16	37	58.316	-23	55	10.586
								APP.	16	38	1.130	-23	55	24.419
69	5	28	12	260.0	-.16322	-.42694	-.20270	MEAN	16	36	45.977	-23	55	40.112
								APP.	16	36	48.797	-23	55	53.997
69	5	29	8	280.0	-.16528	-.42610	-.20279	MEAN	16	35	32.886	-23	56	5.289
								APP.	16	35	35.714	-23	56	19.219
69	5	30	4	300.0	-.16733	-.42526	-.20288	MEAN	16	34	19.146	-23	56	26.115
								APP.	16	34	21.985	-23	56	40.093
69	5	31	0	320.0	-.16936	-.42442	-.20296	MEAN	16	33	4.864	-23	56	42.601
								APP.	16	33	7.718	-23	56	56.636
69	5	31	20	340.0	-.17140	-.42357	-.20303	MEAN	16	31	50.146	-23	56	54.773
								APP.	16	31	53.015	-23	57	8.883
69	6	1	16	360.0	-.17345	-.42270	-.20309	MEAN	16	30	35.098	-23	57	2.675
								APP.	16	30	37.984	-23	57	16.881
69	6	2	12	380.0	-.17552	-.42183	-.20314	MEAN	16	29	19.827	-23	57	6.366
								APP.	16	29	22.732	-23	57	20.691
69	6	3	8	400.0	-.17761	-.42093	-.20317	MEAN	16	28	4.443	-23	57	5.929
								APP.	16	28	7.364	-23	57	20.388
69	6	4	4	420.0	-.17974	-.42002	-.20318	MEAN	16	26	49.059	-23	57	1.463
								APP.	16	26	51.991	-23	57	16.064

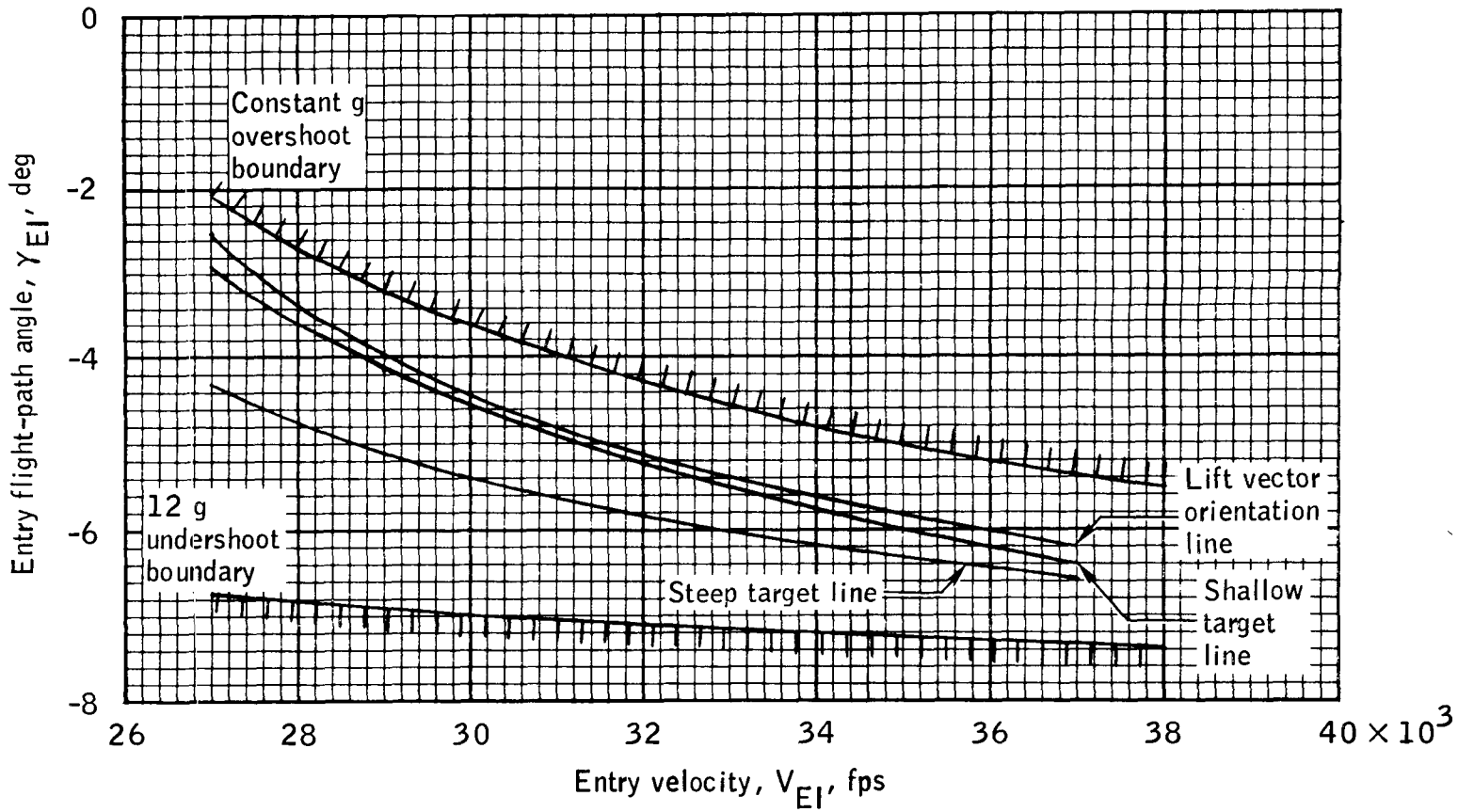
PLANET = JUPITER

TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	17	16	0	-.49870	.02591	.02508	MEAN	11	48	9.519	2	52	2.001
								APP.	11	48	11.316	2	51	51.449
69	5	26	0	200.0	-.49870	.02622	.02489	MEAN	11	47	57.987	2	51	7.900
								APP.	11	47	59.718	2	50	57.809
69	6	3	8	400.0	-.49881	.02487	.02398	MEAN	11	48	32.376	2	45	14.026
								APP.	11	48	34.051	2	45	4.257

PLANET = SATURN

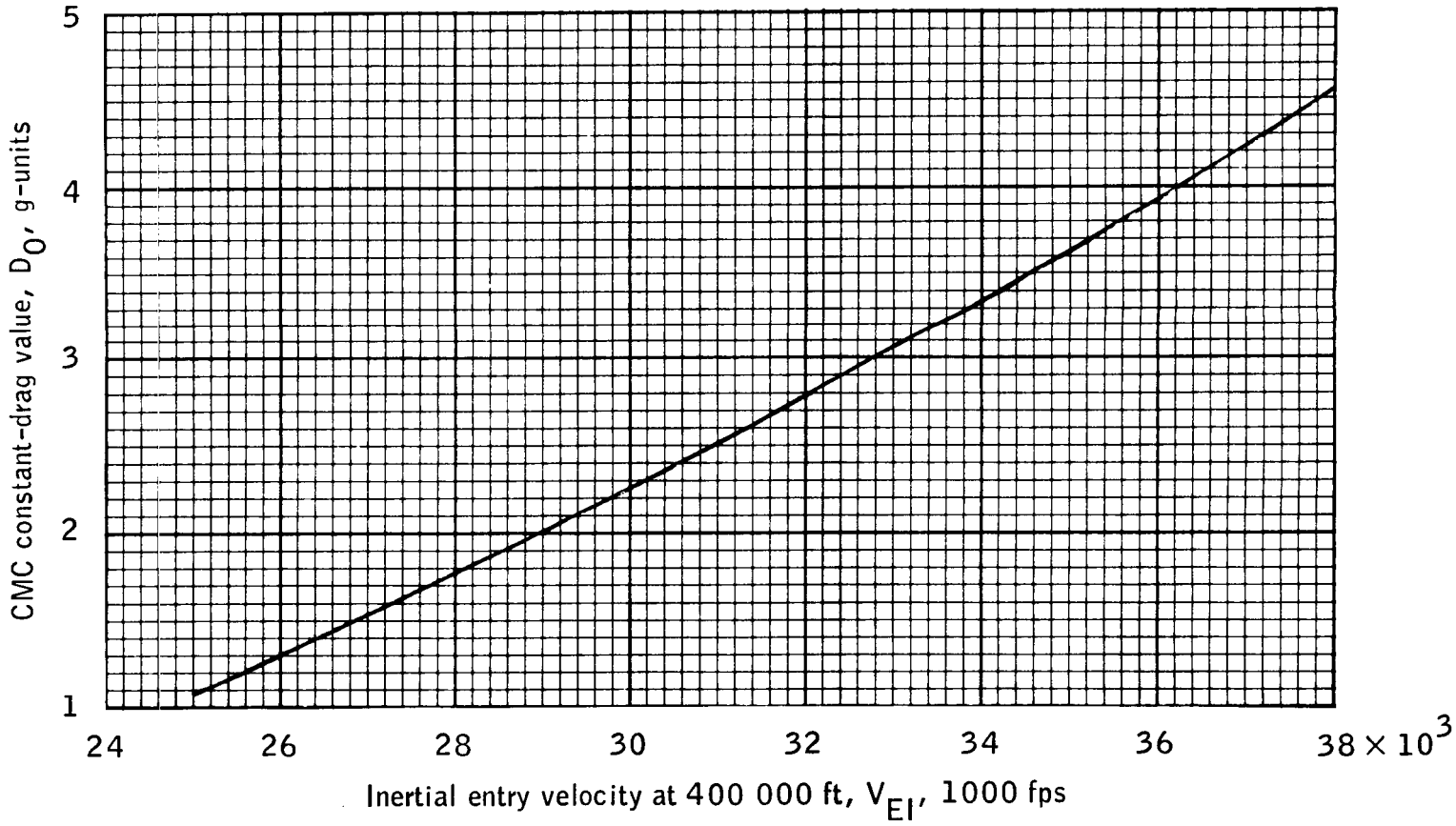
TIME (GMT) YR	MO	DA	HR	HOURS FROM FIRST RECORD	VECTOR FROM POINT K = .50 X	Y	Z		RT. ASC. HR	MN	SECOND	DECL. DG	MN	SECOND
69	5	17	16	.0	.42279	.25205	.08789	MEAN	2	3	11.271	10	7	14.526
								APP.	2	3	11.166	10	7	19.322
69	5	19	18	50.0	.42162	.25375	.08860	MEAN	2	4	8.452	10	12	10.594
								APP.	2	4	8.396	10	12	15.681
69	5	21	20	100.0	.42046	.25543	.08930	MEAN	2	5	5.134	10	17	2.214
								APP.	2	5	5.126	10	17	7.623
69	5	23	22	150.0	.41931	.25708	.08997	MEAN	2	6	1.279	10	21	49.213
								APP.	2	6	1.311	10	21	54.922
69	5	26	0	200.0	.41818	.25869	.09064	MEAN	2	6	56.851	10	26	31.431
								APP.	2	6	56.915	10	26	37.384
69	5	28	2	250.0	.41705	.26028	.09129	MEAN	2	7	51.814	10	31	8.719
								APP.	2	7	51.910	10	31	14.862
69	5	30	4	300.0	.41593	.26183	.09192	MEAN	2	8	46.135	10	35	40.942
								APP.	2	8	46.274	10	35	47.289
69	6	1	6	350.0	.41482	.26337	.09255	MEAN	2	9	39.783	10	40	7.972
								APP.	2	9	39.984	10	40	14.626
69	6	3	8	400.0	.41372	.26489	.09317	MEAN	2	10	32.724	10	44	29.678
								APP.	2	10	32.993	10	44	36.736

Burton/LAB/MPAD
3/31/69



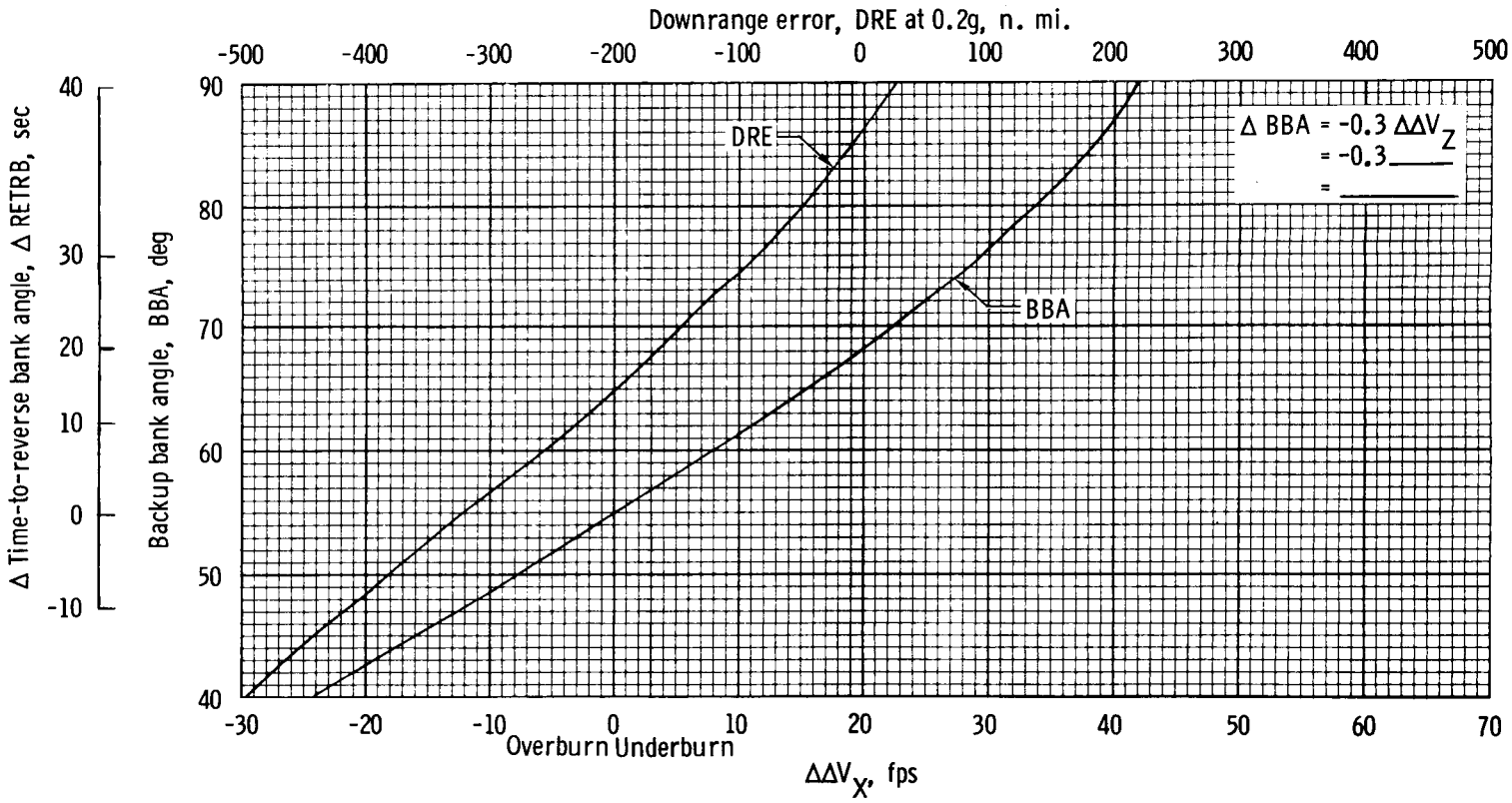
Crew chart 17.- Entry corridor.

Burton/LAB/MPAD
3/31/69



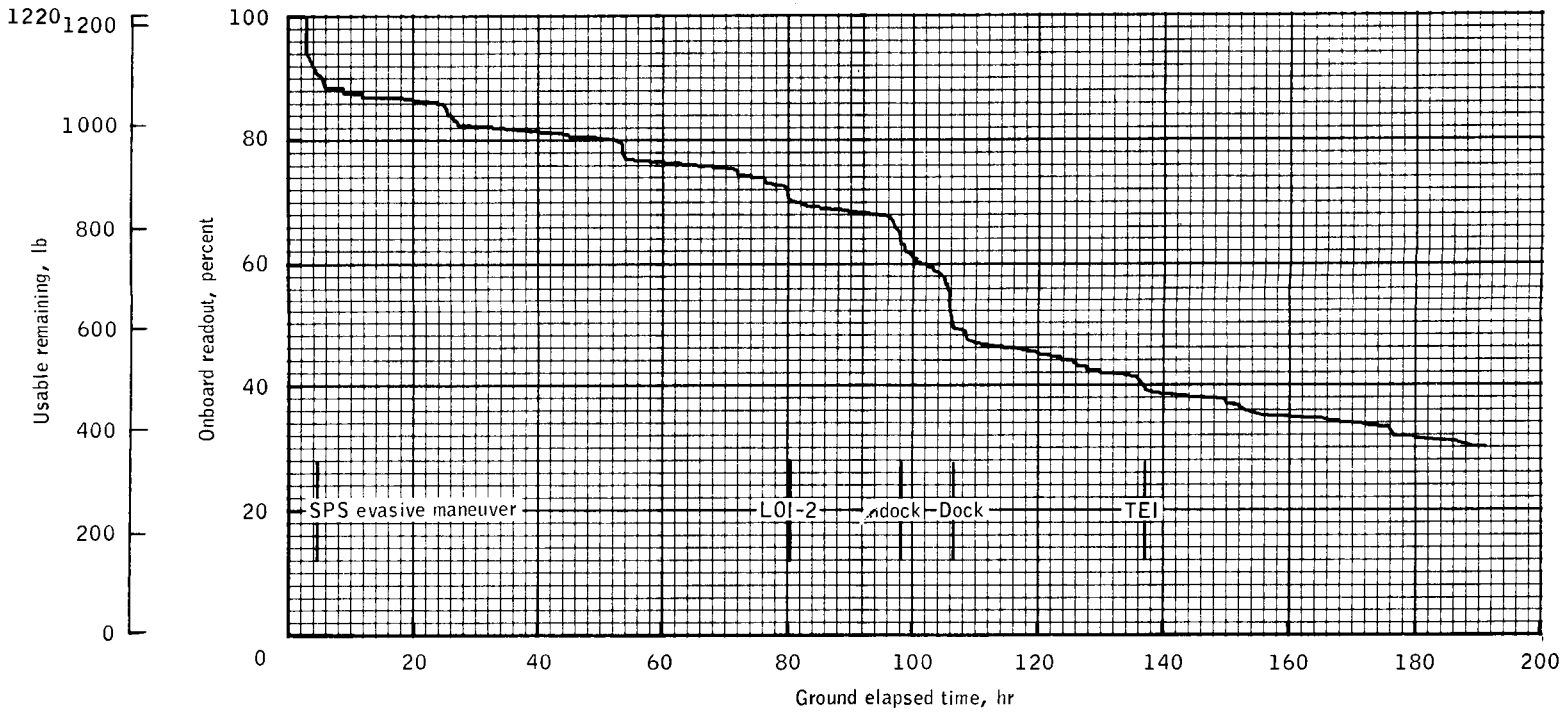
Crew chart 18.- Command module computer constant-drag value.

Burton/LAB/ MPAD
3/31/69



Crew chart 19. - Earth orbit BBA versus $\Delta\Delta V_X$.

Loyd/GPB/MPAD
5/5/69



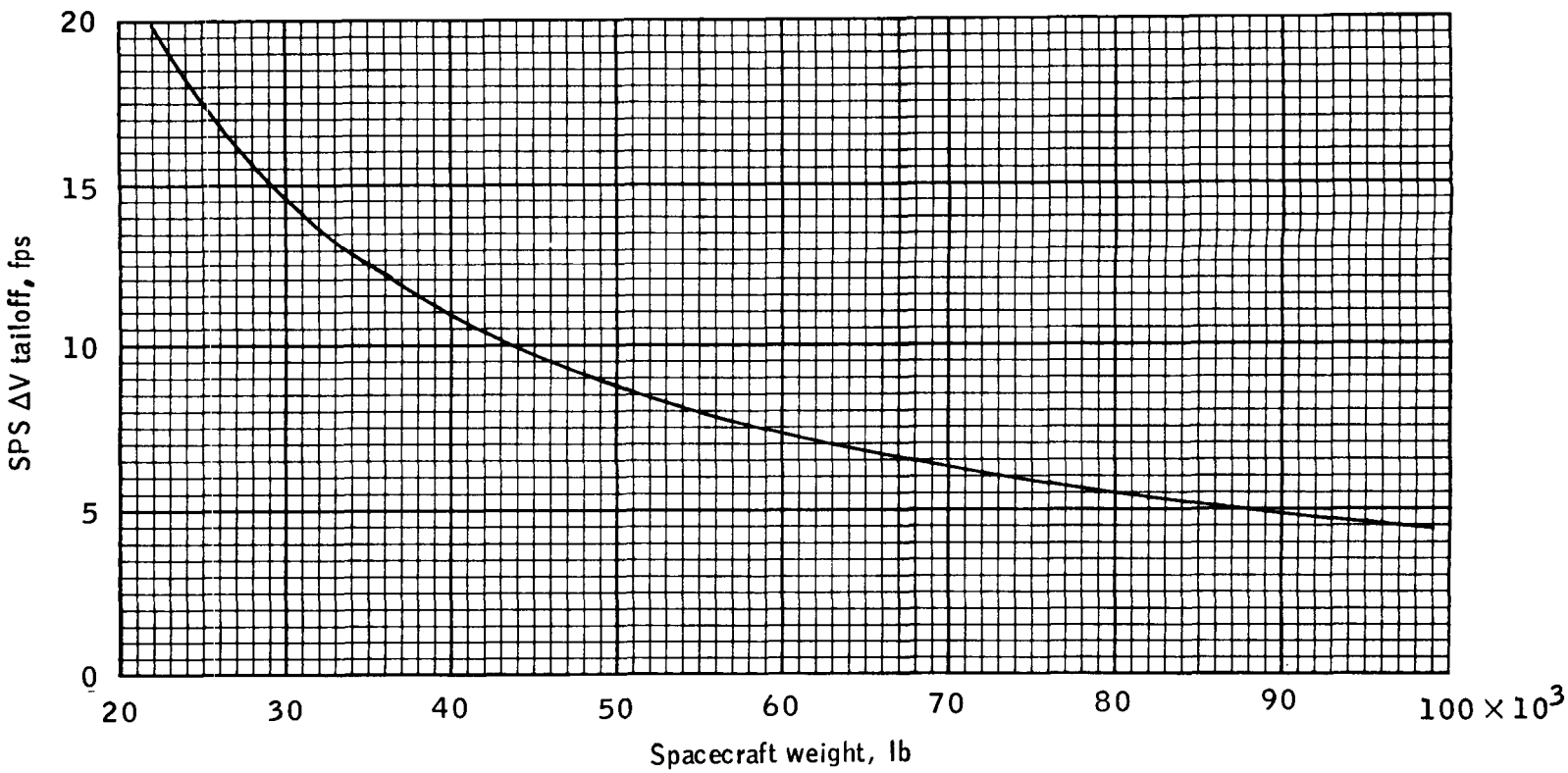
Crew chart 20.- SM RCS propellant profile (Total).

Mayfield/GPB/MPAD
4/28/69

EVENT	SYSTEM A	SYSTEM B
Post DOI	96 %	94 %
Post phasing	93	89
Post insertion	85	82
Post CSI	79	75
Post CDH	75	71
Post TPI	69	65
Post braking	54	51
Post docking	51	47

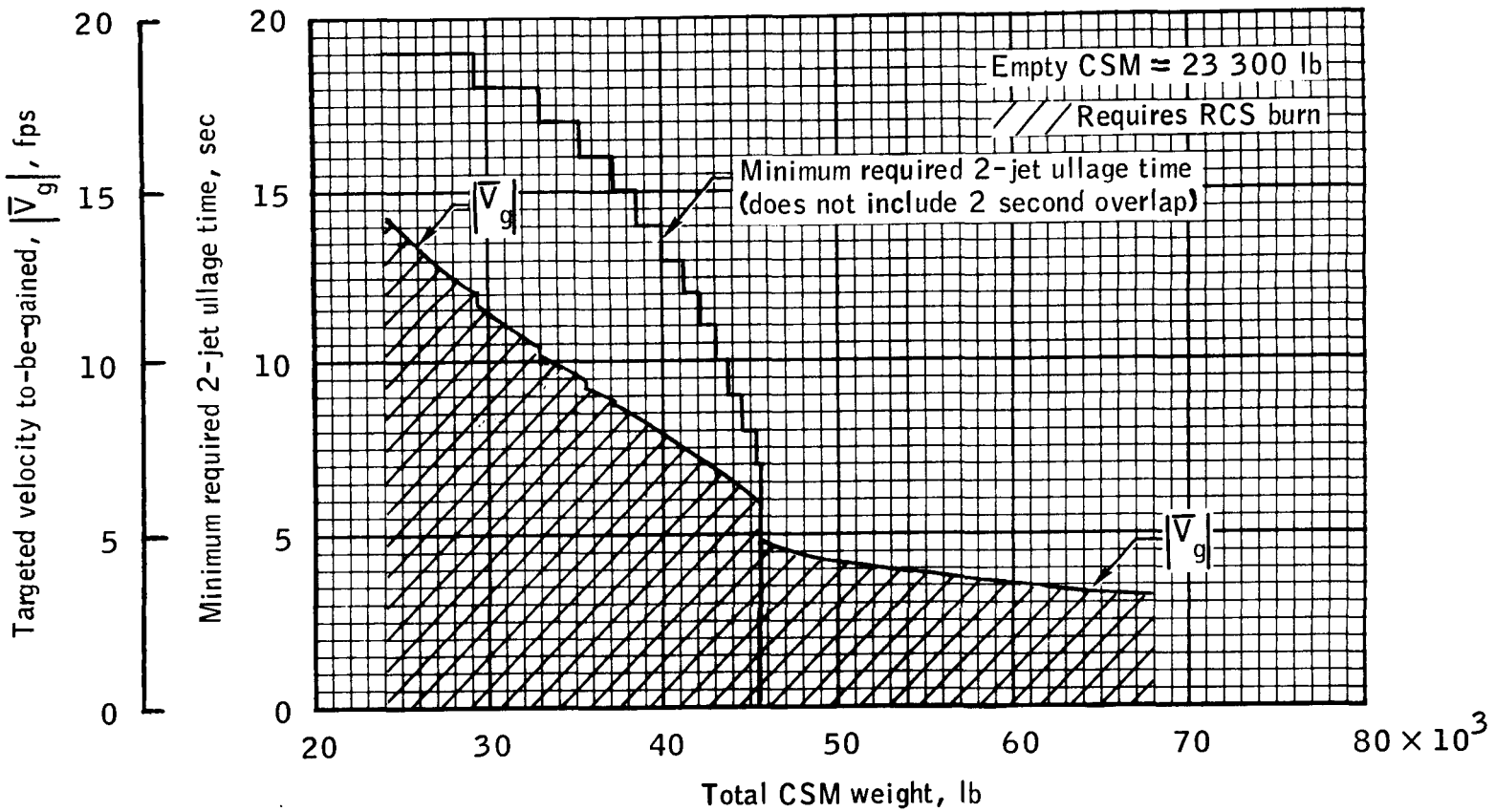
Crew chart 21.- Onboard reading of LM RCS propellant remaining, percentage.

Graf/GPB/MPAD
3/31/69



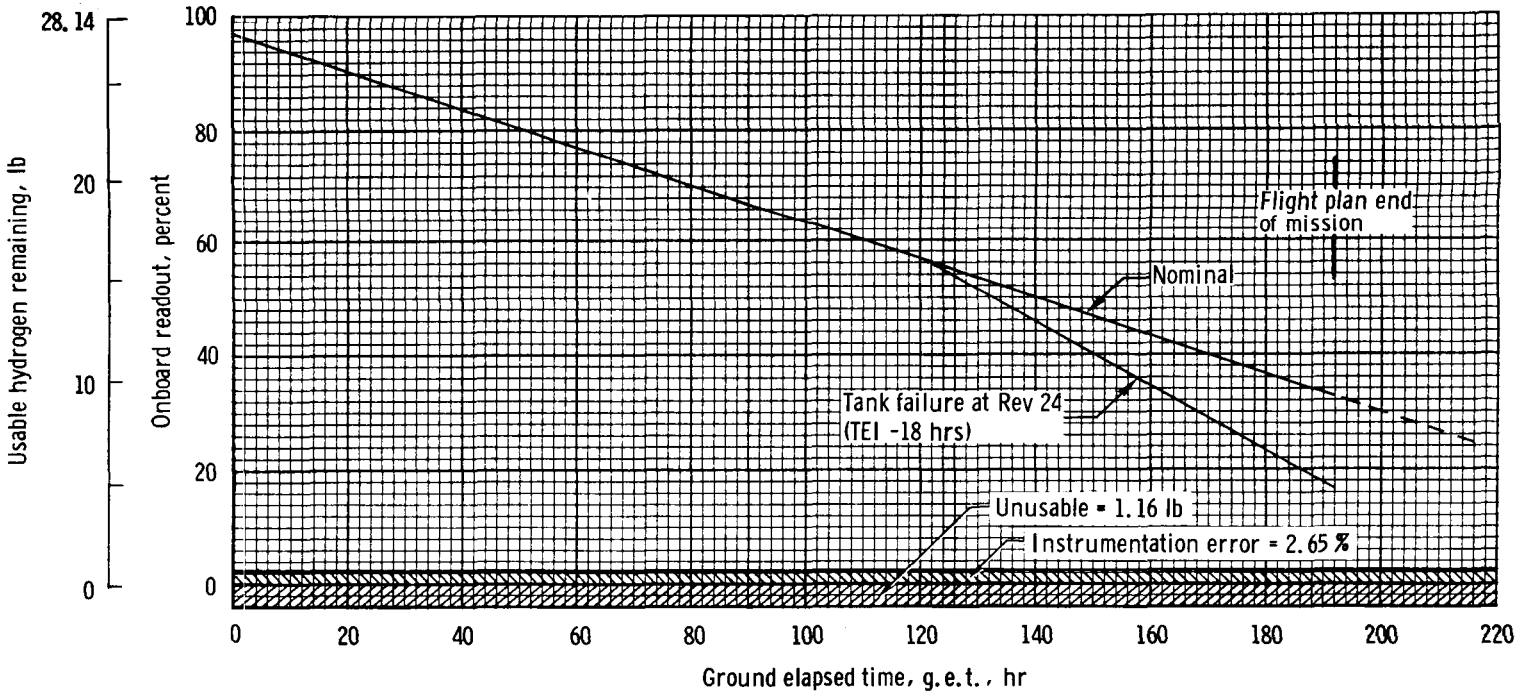
Crew chart 22.- SPS tailoff ΔV versus spacecraft weight.

Graf/GPB/MPAD
3/31/69
This chart assumes that the minimum desired SPS burn time is 0.5 sec. and that the ullage time is the minimum time shown on the chart.



Crew chart 23.- SPS versus RCS criteria, CSM alone - minimum pre-burn ullage.

Scott/GPB/MPAD
4/30/69



Crew chart 24.- Hydrogen remaining in one tank.

Swalin/GPB/MPAD
4/28/69

Event	Ascent oxygen Tank 1
Switch to ascent 1 O_2	100 %
Post staging	97
Post insertion	95
Post CSI	86
Post CDH	74
Post TPI	67
Post braking	61
Post docking	53

Crew chart 25.- Onboard readout of ascent oxygen remaining, percentage