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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 69-FM-190

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Internal Note No. 69-FM-190

June 27, 1969

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APOLLO 11 (MISSION G) CREW CHARTS AND CONSOLE CHARTS

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MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

(NASA-TM-X-69643) APOLLO 11 (MISSION G) CREW CHARTS AND CONSOLE CHARTS (NASA) 83 p

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Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JUN 30 1969

File No. 69-FM13-367

FROM : FM13/Mission Planning Support Office
Data Management Group

FM file

SUBJECT: Updates to Apollo 11 (Mission G) Crew Charts

Reference is made to MSC Internal Note No. 69-FM-190, "Apollo 11 (Mission G) Crew Charts and Console Charts," by the Mission Planning Support Office, Data Management Group, dated June 27, 1969.

The purpose of this memorandum is to provide the enclosed page changes to the above Internal Note. The changes are as follows:

Crew Chart 10	- Page 17
Crew Chart 11	- Page 18
Crew Chart 19	- Page 27
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Crew Chart 32	- Page 40
Crew Chart 33	- Page 41
LM Crew Chart 6	- Page 47

Any questions concerning the enclosed charts should be directed to Mike Collins or Buck Simms at HU3-4907.

Michael A. Collins, Jr.

Michael A. Collins, Jr.

APPROVED BY:

John P. Mayer
Chief, Mission Planning
and Analysis Division

RPP

Enclosure

Addressees:
See attached list

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5010-108

MSC INTERNAL NOTE NO. 69-FM-190

PROJECT APOLLO

APOLLO 11 (MISSION G) CREW CHARTS AND CONSOLE CHARTS

By Data Management Group
Mission Planning Support Office

June 27, 1969

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

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

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

FOREWORD

The purpose of this document is to present Mission Planning and Analysis Division's crew chart candidates for the Apollo 11 (G) mission onboard data file. Part I contains the crew charts that were selected by the crew to be carried onboard; the charts that were deleted from the onboard data file are presented in Part II to be used by Mission Control Center flight controllers as console charts in support of the Apollo 11 mission.

These charts have been coordinated by the Data Management Group of the Mission Planning and Analysis Division with Mr. Ted Guillory and Mr. Spencer Gardner of the Flight Planning Branch of the Flight Crew Support Division.

The charts presented are in final form as of June 27, 1969. Should any changes be made to the crew charts prior to lift-off, the backup crew's copy of the onboard charts will reflect the changes and will supercede the original charts. An operational description of the charts will not be covered in this document because the charts have previously been described in mission techniques documents.

Detailed sighting schedules for July 21 launch day will be provided to FCSD by the Data Management Group in the form of crew charts by July 6, 1969.

Questions concerning this document should be directed to Mike Collins or Buck Simms, Data Management Group, Mission Planning Support Office, HU3-4907.

The following is a list of the Apollo 11 (Mission G) crew charts and console charts with the originator of each chart and the responsible organization.

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14	Planet half-unit vectors - J. Blucker, MPB	21
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21	Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, long return for a launch on July 18, 1969 - C. Denham, MPB	29
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Crew Chart		Page
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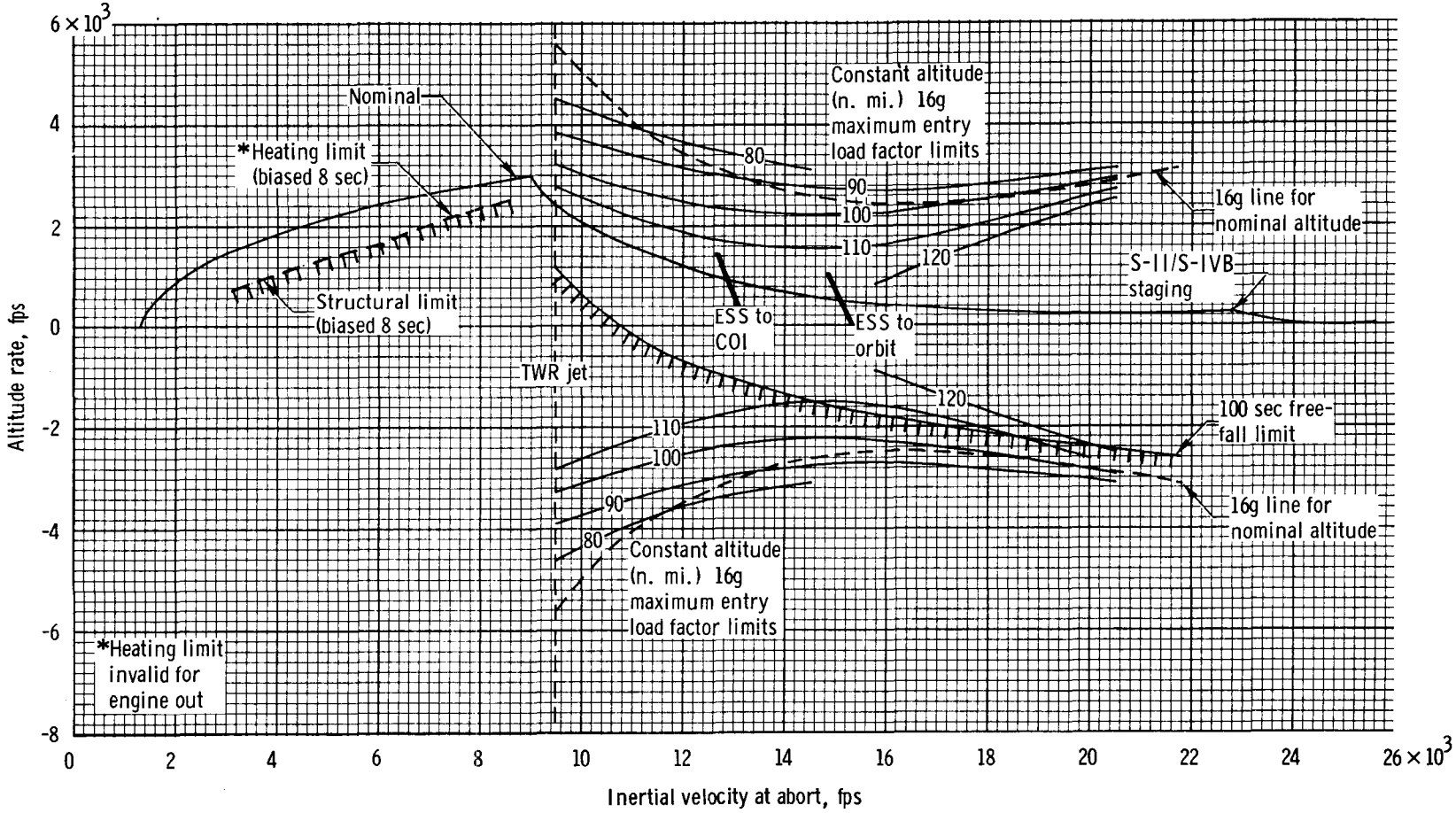
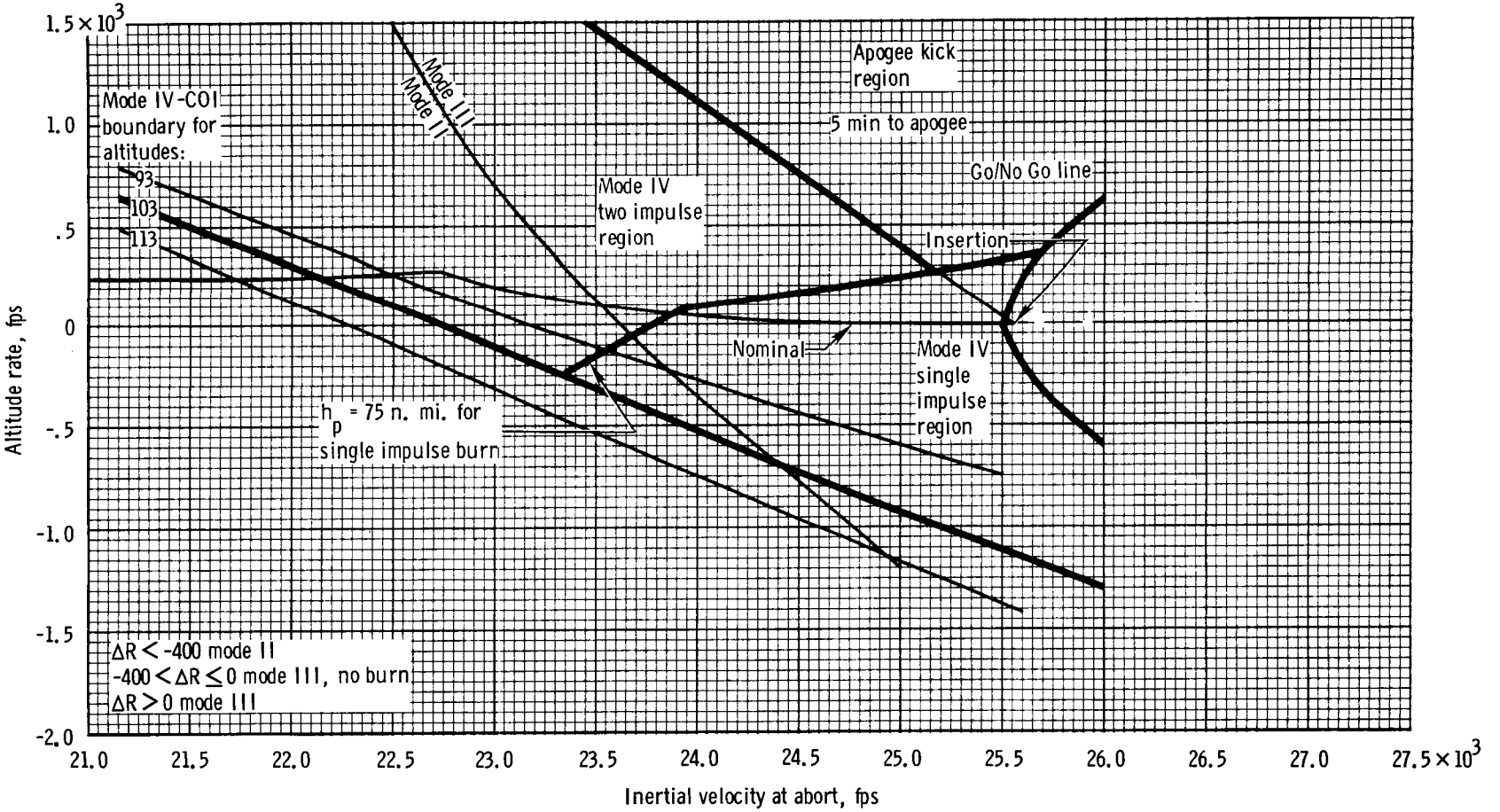
CSM CREW CHARTS AND LM CREW CHARTS

Crew chart 1. - Launch abort curves.
Henderson/FAB/MPAD
6/27/69
Final data.



Launch abort curves.

Crew chart 1. - Launch abort curves. (Concluded)
Henderson/FAB/MPAD
6/27/69
Final data.



Launch abort curves.

Crew chart 2.- Listing of planned launch trajectory parameters.
Henderson/FAB/MPAD
6/27/69
Final data.

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, $\dot{h}$, fps	Altitude, h, n. mi.
00:00	90	1 340	0	0.0
00:30	86	1 389	296	0.7
01:00	69	1 845	830	3.4
01:30	48	3 026	1486	9.1
02:00	33	5 069	2195	18.1
02:15*	28	6 505	2578	24.0
02:30	24	7 869	2824	30.7
02:40.83**	21	9 030	3028	35.9
03:00	21	9 264	2657	44.8
03:30	28	9 834	2175	56.8
04:00	25	10 484	1817	66.6
04:30	22	11 232	1482	74.8
05:00	19	12 083	1178	81.4
05:30	16	13 040	908	86.6

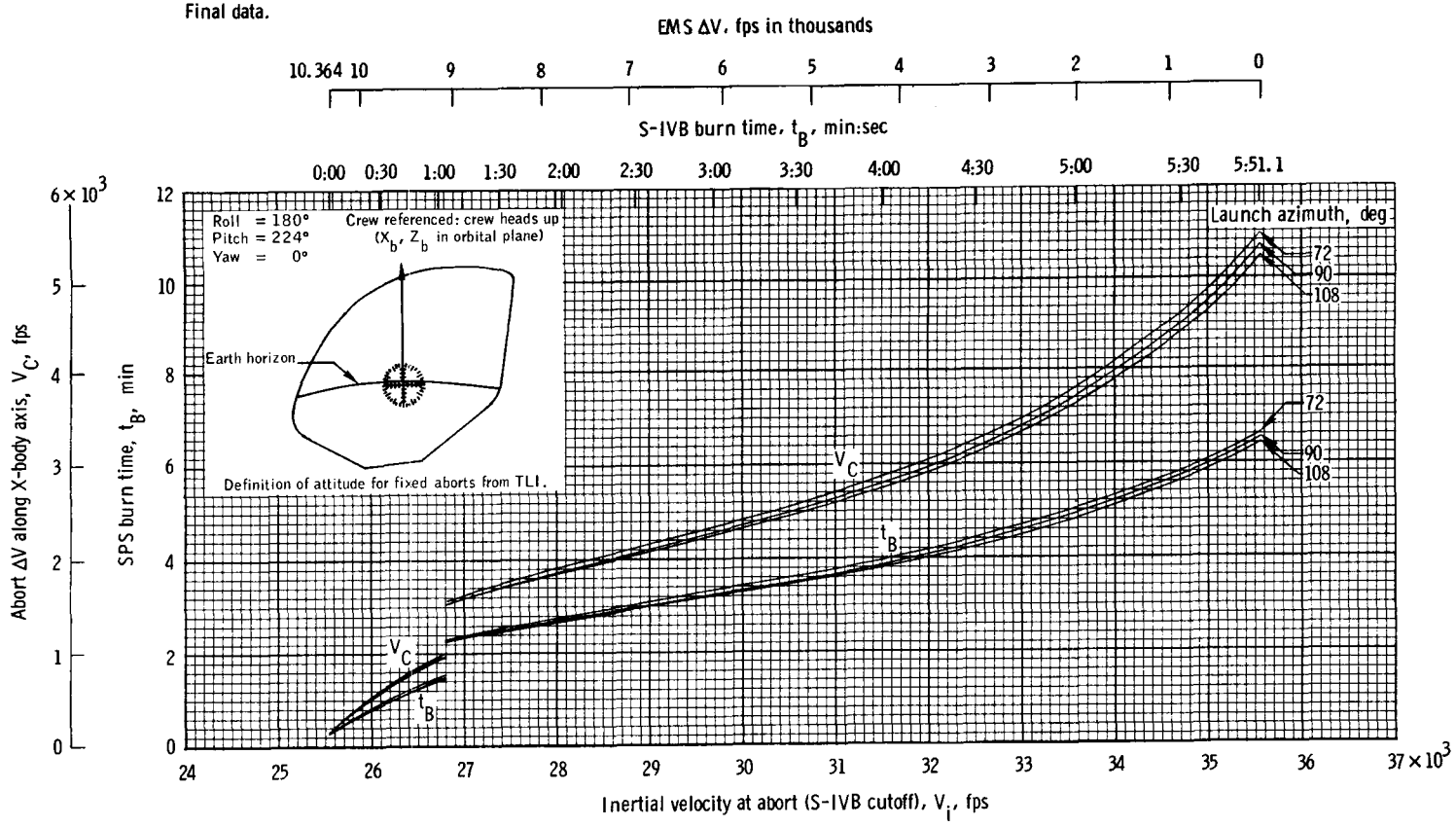
*S-IC center-engine cutoff (TB2)
**S-IC outboard-engine cutoff (TB3)

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, $\dot{h}$, fps	Altitude, h, n. mi.
06:00	13	14 114	677	90.5
06:30	10	15 320	488	93.4
07:00	6	16 677	350	95.5
07:30	3	18 214	271	97.0
08:00	3	19 714	254	98.3
08:30	359	20 966	238	99.6
09:00	355	22 233	249	100.8
09:11.38***	354	22 747	270	101.4
09:30	350	22 982	196	102.1
10:00	346	23 530	104	102.9
10:30	343	24 107	35	103.3
11:00	340	24 711	-2	103.4
11:30	338	25 343	-12	103.3
11:40.10****	338	25 562	0	103.3

***S-II outboard-engine cutoff (TB4)
****S-IVB guidance cutoff signal

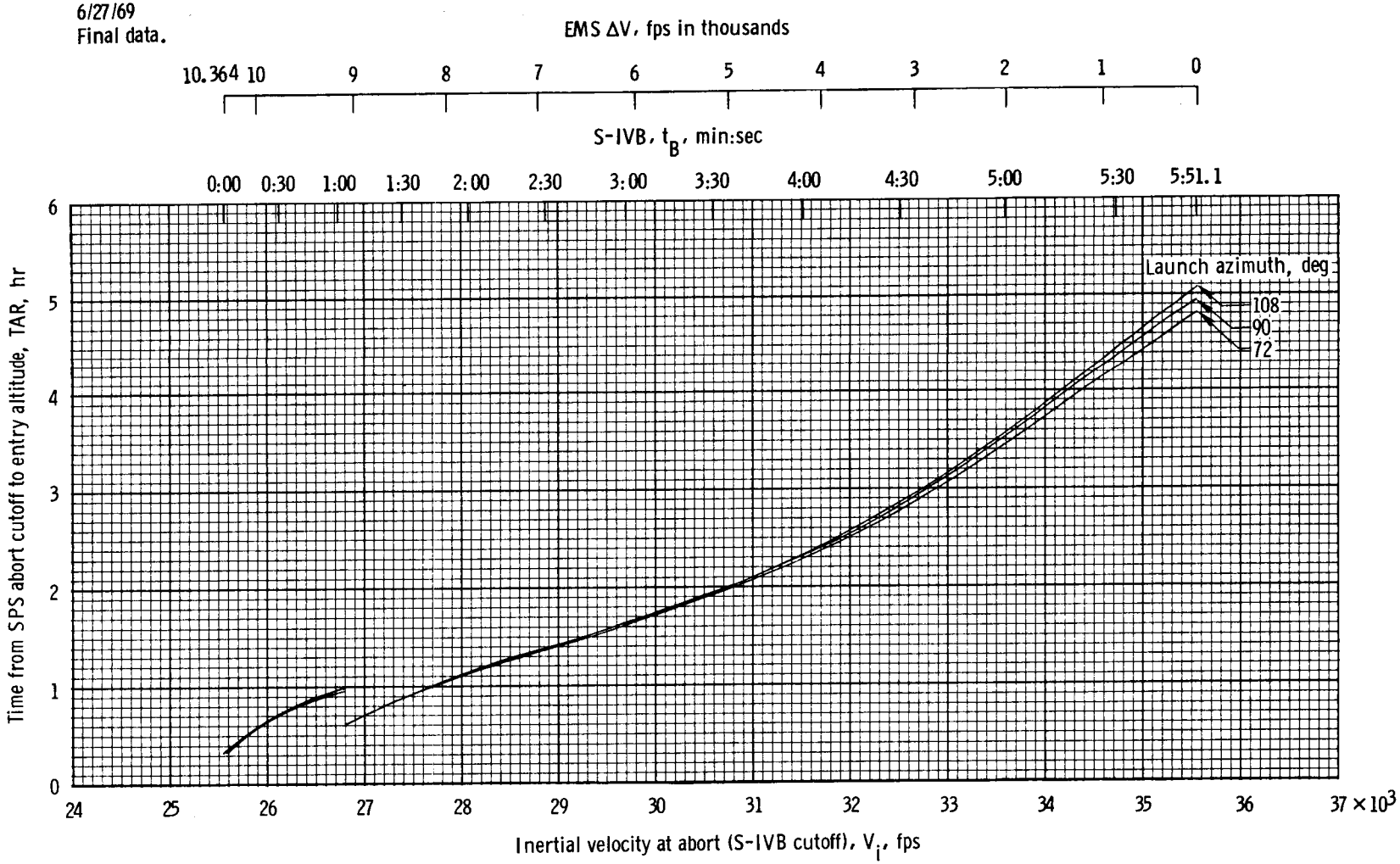
Listing of planned launch trajectory parameters.

Crew chart 3. - TLI plus 10 minute abort crew chart; abort ΔV and SPS burn time versus inertial velocity.
Laetz/FAB/MPAD
6/27/69
Final data.



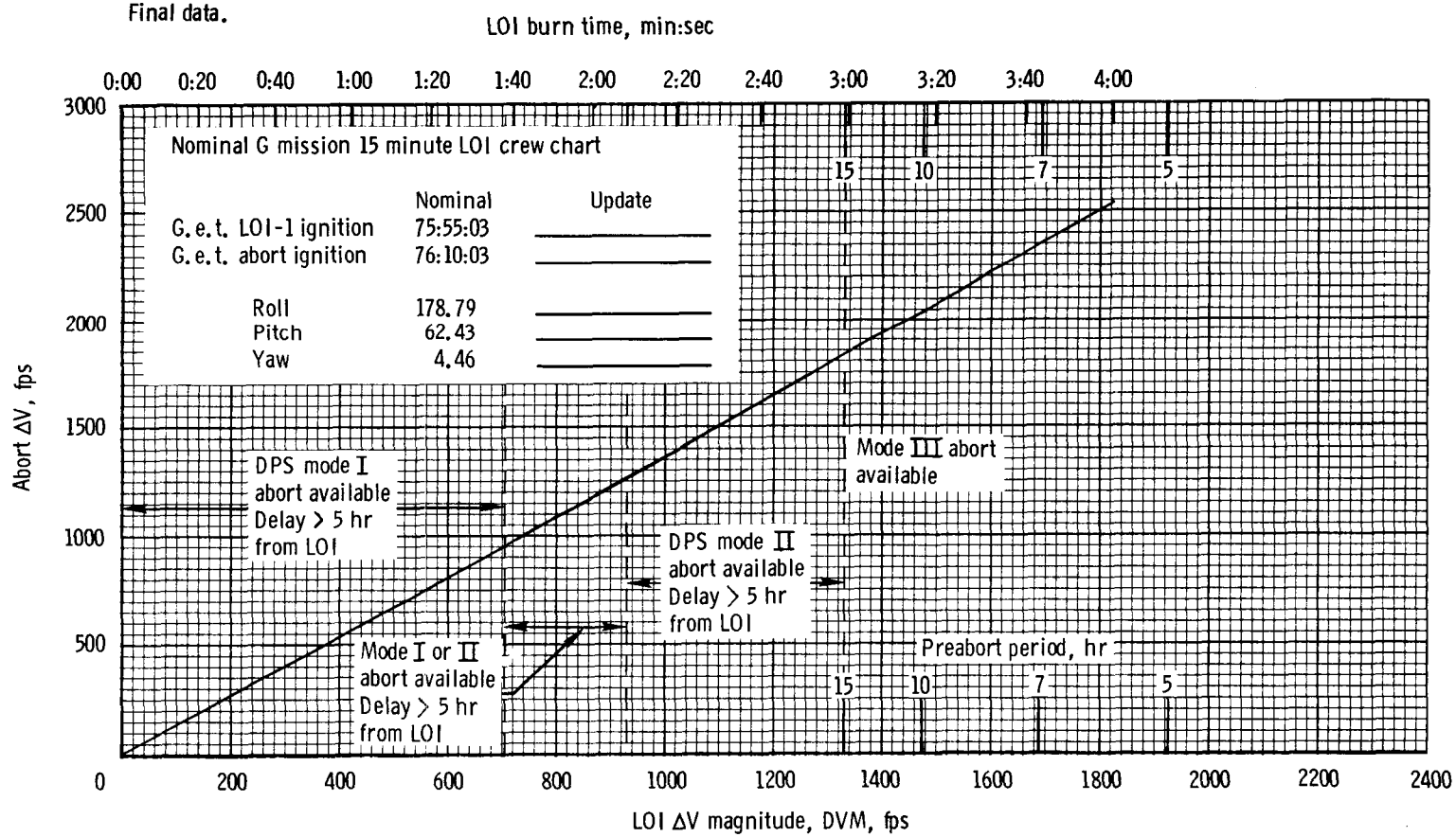
TLI plus 10 minute abort crew chart; abort ΔV and SPS burn time versus inertial velocity.

Crew chart 4. - TLI plus 10 minute abort crew chart; TAR versus inertial velocity.
Laetz/FAB/MPAD
6/27/69
Final data.



TLI plus 10 minute abort crew chart; TAR versus inertial velocity.

Crew chart 5. - Nominal LOI 15 minute abort CSM/LM.
Foggatt/FAB/MPAD
6/27/69
Final data.



Nominal LOI 15 minute abort CSM/LM.

Crew chart 6. - Check list.
Gonzales/LMAB/MPAD
6/27/69
Final data.

Basic Date - APRIL 15, 1969
CSM 107 & SUBS

P37 RETURN TO EARTH PGM - CORRIDOR CONTROL

```
Perform the following once:
  If TLI+10 min Abort performed
    V21 N1E
      3376E
        0E
If no TLI+10 min Abort
    V1N1E
    3376E
    Verify R1=01637

1                V37E 37E
    F 06 33      TIG                    (hrs,min,.01sec)
                 Load desired TIG
                 PRO

2   F 06 60      BLANK,V DESIRED,GAMMA EI    (1fps,.01°)
                 Load desired values
                 FOR MIN ΔV-LOAD +00000 IN R2 (USE PAD VALUE WHEN ON TLC)
                 For middle of corridor-load +00000 in R3
                 PRO
                          *F 05 09 00605-Solution Not   *
                          *              Convergent     *
                          *        00612-State Vector in*
                          *              Lunar Influence*
                          *V32E,RSET To 1
                          *        00607 Conic Routine  *
                          *              Failed         *
                          *        00610 State vector is*
                          *              below 400K ft  *
                          *              altitude       *
                          *F 37 37E to 1                *

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

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

5   F 06 60      BLANK,V PRED, GAMMA EI      (fps,.01°)
       (RECYCLE) V32E To 1
                 PRO

6   F 06 81      ΔVXYZ(LV) TIG                   (.1fps)
       (OPTION) N40E - VG MAG avail
                   in N40 and N80
                 KEY REL
                 PRO (To 3 on first pass)
                          *F 05 09 00605 Solution Not   *
                          *              Convergent     *
                          *        00613 Flt Path Angle *
                          *              Not Reached    *
                          *  RSET                       *
                          *  V32E To 1                  *
                          *        00607 Conic Routine  *
                          *              Failed         *
                          *F 37 37E to 1                *

7   F 04 06      THRUST OPTION
                 R1 00007
                 R2 0000X
                      X=1(SPS)
                        2(RCS)
                 Perform R03 if not performed just prior to P37 call
                 PRO

8   F 06 33      TIG                    (hrs,min,.01sec)
                 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)
```

Crew chart 6.- Check list. (Continued)
Gonzales/LMAB/MPAD
6/27/69
Final data.

Basic Date - APRIL 15, 1969
CSM 107 & SUBS

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

```
Perform the following once:
  If TLI+10 min Abort performed
    V21 N1E
      3376E
        0E
If no TLI+10 min Abort
    V1N1E
    3376E
    Verify R1=01637
```

```
1          V37E 37E
     F 06 33  TIG                    (hrs,min,.01sec)
              Load desired TIG
              PRO

2    F 06 60  BLANK,ΔV DESIRED, GAMMA EI DESIRED
              Load desired ΔV:              (1fps,.01°)
                   PAD ΔV IF ON TLC
                   0.     IF ON TEC
              Load R3 = 0
              R2   XXXXX
              PRO
                        *F 05 09  00612 State vector in  *
                        *               Lunar Influence  *
                        *         00605 Solution not     *
                        *               Convergent       *
                        *V32E, RSET TO 1                 *
                        *         00607 Conic Routine    *
                        *               Failed           *
                        *         00610 State vector is  *
                        *               below 400K ft    *
                        *               altitude         *
                        *F 37 37E to 1                   *

3    F 06 61    IMPACT LAT, IMPACT LONG          (.01°)
     If Impact LONG<12° from desired:
       Record Impact LONG as θcl ____
       PRO
     If Impact LONG>12° from desired:
       TEC:N40E Record R2 as ΔVmin___fps     TLC V32E to 1
           V32E to 1 & use |ΔV| >ΔV min      Decrease ΔV to
           ΔV neg to move LONG WEST          move LONG WEST
           ΔV pos to move LONG EAST          Increase ΔV to
                                             move LONG EAST

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

5    F 06 60    BLANK,V PRED,GAMMA EI          (fps,.01°)
                PRO

6    F 06 81    ΔVXYZ(LV) at TIG
                N40E
                Record R2 as ΔVcl = ___fps
                KEY RLSE
                PRO
                        *F 05 09  00605 Solution not     *
                        *               Convergent       *
                        *         00613 Flt Path Ang     *
                        *               not reached      *
                        *RSET V32E to 1                  *
                        *         00607 Conic Routine    *
                        *               Failed           *
                        *F 37 37E to 1                   *

7    F 06 61    IMPACT LAT,IMPACT LONG             (.01°)
                Record LONG as θpl = ___.___°
                If θpl, acceptable, PRO to step 4 of
                  CORRIDOR CONTROL (pg. F/4-7)

                PRO

8    F 06 39    ΔT TRANSFER
                PRO

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

10   F 06 81    ΔVXYZ(LV) at TIG
                N40E
                R2 XXXX.X Record as ΔVpl = ____.____fps
                V32E to 11

11   F 06 33    TIG                        (hrs,min,.01sec)
                Load same value used initially
                PRO
```

Crew chart 6.- Check list. (Concluded)
Gonzales/LMAB/MPAD
6/27/69
Final data .

Basic Date - APRIL 15, 1969
CSM 107 & SUBS

12 F 06 60 BLANK,ΔV DESIRED, GAMMA EI DESIRED

To move West from Θpl
TEC: Load ΔVc2 =-ΔVcl-10
TLC: Load ΔVc2 =ΔVcl-10

To move EAST from Θpl
TLC or TEC: Load ΔVc2=ΔVcl+10
Record ΔVc2_____fps

R2 XXXXX.
PRO
F 05 09 SAME AS IN 2
*V32E. RSET to 11 *

13 F 06 61 IMPACT LAT,IMPACT LONG (.01°)
Record LONG as Θc2 = _____.__°

Compute $K = \frac{|\Theta c2-\Theta cl|}{10}$ +_____

Compute ΔΘLong=Θd-Θpl= ±_____

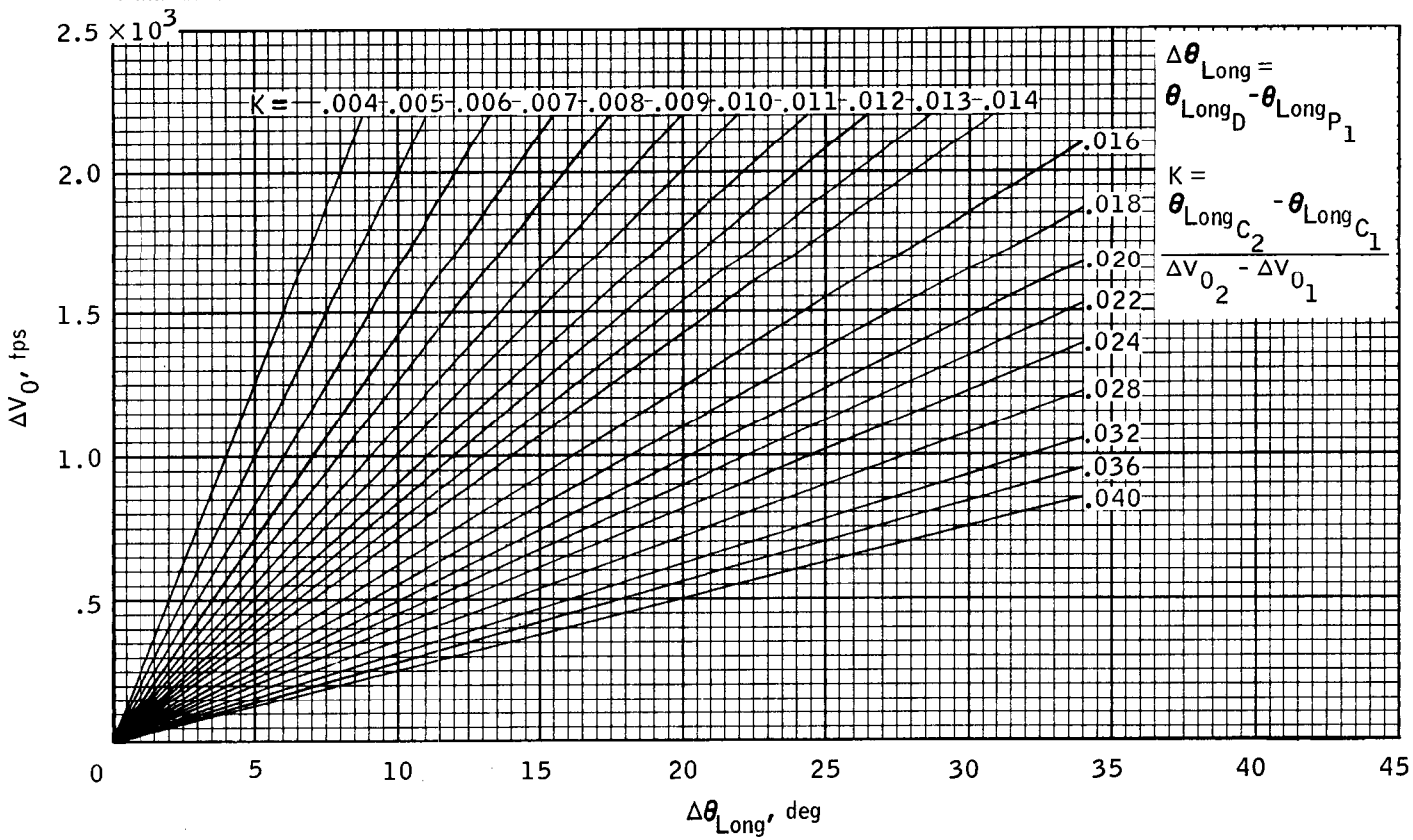
Obtain from Chart ΔVo = ±_____

Make sign of ΔVo same as ΔΘ long
If ΔVc2 pos, ΔVd = ΔVpl(step 10)+ΔVo
If ΔVc2 neg, ΔVd = -ΔVpl+ ΔVo
ΔVd=_____

V32E to step 1 of Longitude Cont
& use ΔVd in R2 of N60 (step 2)

Crew chart 7.- ΔV_0 versus $\Delta\theta_{Long}$, K = .04 to .004.

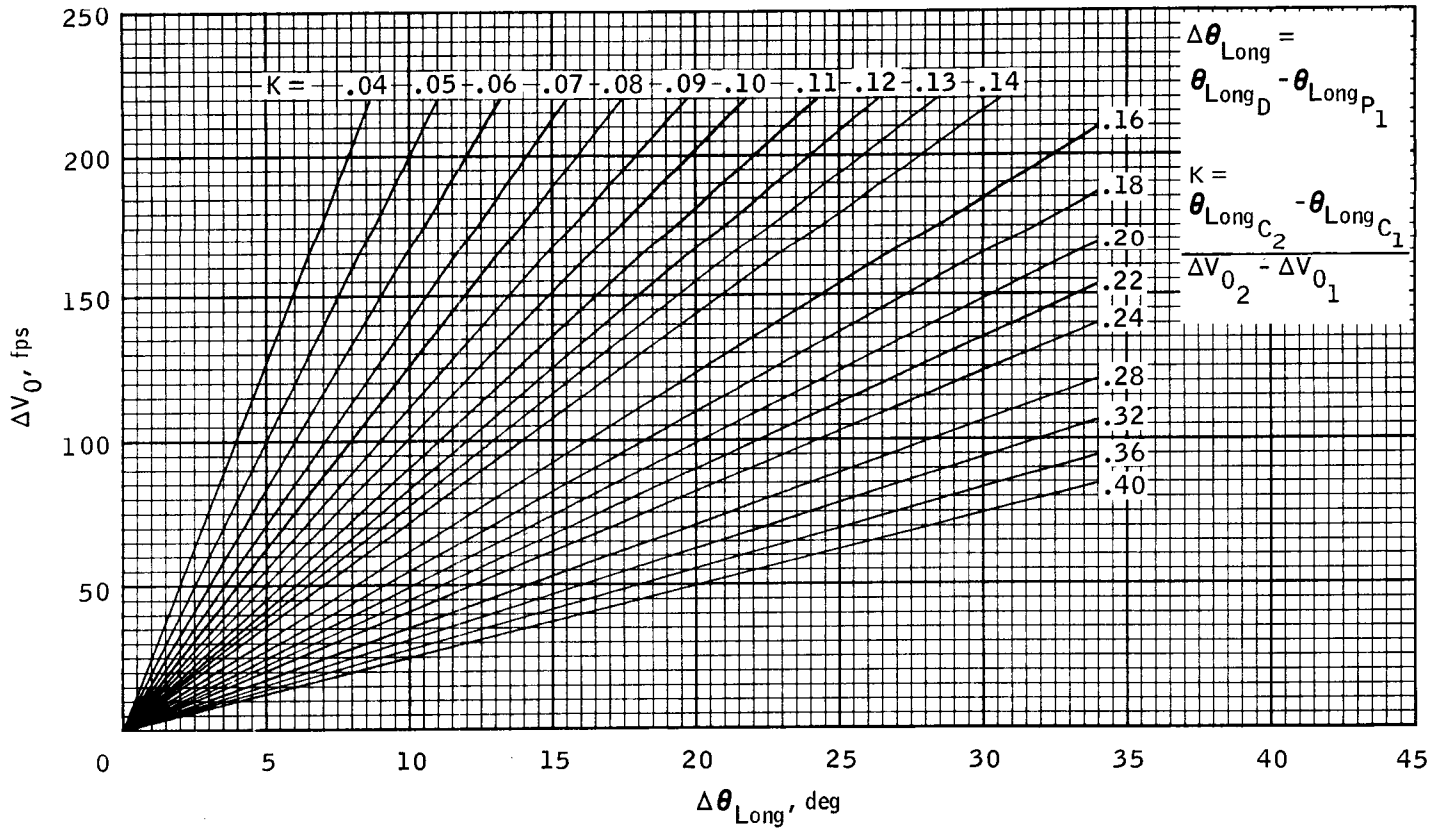
Gonzales/LMAB/MPAD
6/27/69
Final data.



ΔV_0 versus $\Delta\theta_{Long}$, K = .04 to .004.

Crew chart 8.- ΔV_0 versus $\Delta\theta_{Long}$, K = .4 to .04.

Gonzales/LMAB/MPAD
6/27/69
Final data.



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

Crew chart 9.- Loss of communications navigation procedures.
Denham/MPB/MPAD
6/27/69
Final data.

1. TLI plus 4 hrs abort (detailed schedules provided).

a. Make abort burn.

b. Initialize W-matrix at the first mark to value given on the detailed sighting schedule.

c. Initiate sighting as soon as possible after abort following the schedule given in the crew chart.

1. The horizontal lines represent 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 a given star.

4. Only earth horizon marks will be made.

d. Crew charts are provided for each day to insure coverage for the entire daily launch window. The charts provide data for a short return time (25 hours or less) and for a long return time (greater than 25 hours); targets for aborts from trajectories other than those given on the crew charts are the same, but acquisition and loss times of the stars will differ.

2. Lunar orbit aborts (detailed schedules provided).

a. The first 17 hours and the last 25 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 mid-course maneuvers.

c. Change to the EI chart at EI minus 40 hours.

Crew chart 9.- Loss of communications navigation procedures. (Continued)
Denham/MPB/MPAD
6/27/69
Final data.

d. The key for the detailed schedule is as follows.

1. Vertical solid line: star/horizon combinations available for the earliest loss of communications TEI: 28 revolutions in lunar orbit, 72 degree launch azimuth, first TLI opportunity.

2. Vertical dashed line: star/horizon combinations available for a later TEI: 35 revolutions in lunar orbit, 108 degree launch azimuth, second TLI opportunity.

3. Horizontal solid line: start of a sighting interval.

4. The numbers adjacent to the vertical lines are the required sightings with the given star.

3. Loss of communications during the nominal transearth trajectory.

The scheduled sightings and initial W-matrices provided in the flight plan should be followed.

4. General TE optical navigation rules for cases not covered by crew charts and flight plan.

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 $>45^{\circ}$ to the orbit plane) in every five sets is sufficient. If only three stars are grouped together, all stars should be inplane.

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.

Crew chart 9.- Loss of communications navigation procedures. (Continued)
Denham/MPB/MPAD
6/27/69
Final data.

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°.

e. If an abort burn is performed during translunar coast, the W-matrix will be initialized to 10,000 feet and 10 ft/sec for onboard processing of the transearth sighting data. Navigation sightings will be scheduled every 2.5 hours in the short return trajectory and only star/earth horizon marks will be made. The last sighting interval will be scheduled just after the last midcourse correction at EI minus 3 hours.

f. The transearth navigation sighting schedule in the flight plan is designed for a 60 hour return trajectory (30 revolutions in lunar orbit). If the return time is altered due to an early TEI because of communications loss or any other reason, the following rules are to be followed for setting up a navigation sighting schedule to ensure a safe entry.

1. TEI through TEI plus 17 hr

The nominal schedule is to followed from TEI to TEI plus 17 hr. The first of 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 approximately TEI plus 1 hr 30 min, TEI plus 11 hr 30 min, TEI plus 13 hr, and TEI plus 15 hr. The corresponding sightings are shown in the flight plan.

2. EI minus 25 hr though EI

The nominal schedule is also to be followed from EI minus 25 hr to EI. The navigation sightings are scheduled at approximately EI minus 25 hr, EI minus 23 hr, EI minus 19 hr, EI minus 15 hr, EI minus 10 hr, EI minus 5 hr, and EI minus 2 hr 30 min. The corresponding central body for the star horizon sightings is shown in the flight plan.

Crew chart 9.- Loss of communications navigation procedures. (Concluded)
Denham/MPB/MPAD
6/27/69
Final data.

3. TEI plus 17 hr through EI minus 25 hr

Between TEI plus 17 hr and EI minus 25 hr 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 10 sightings during this coast period (i.e., if the time between TEI plus 17 hr and EI minus 25 hr is less than 18 hr, 10 sightings will be required).

g. Large state vector corrections may be expected at the following times.

1. At initiation of tracking.

2. At the first switch of reference bodies.

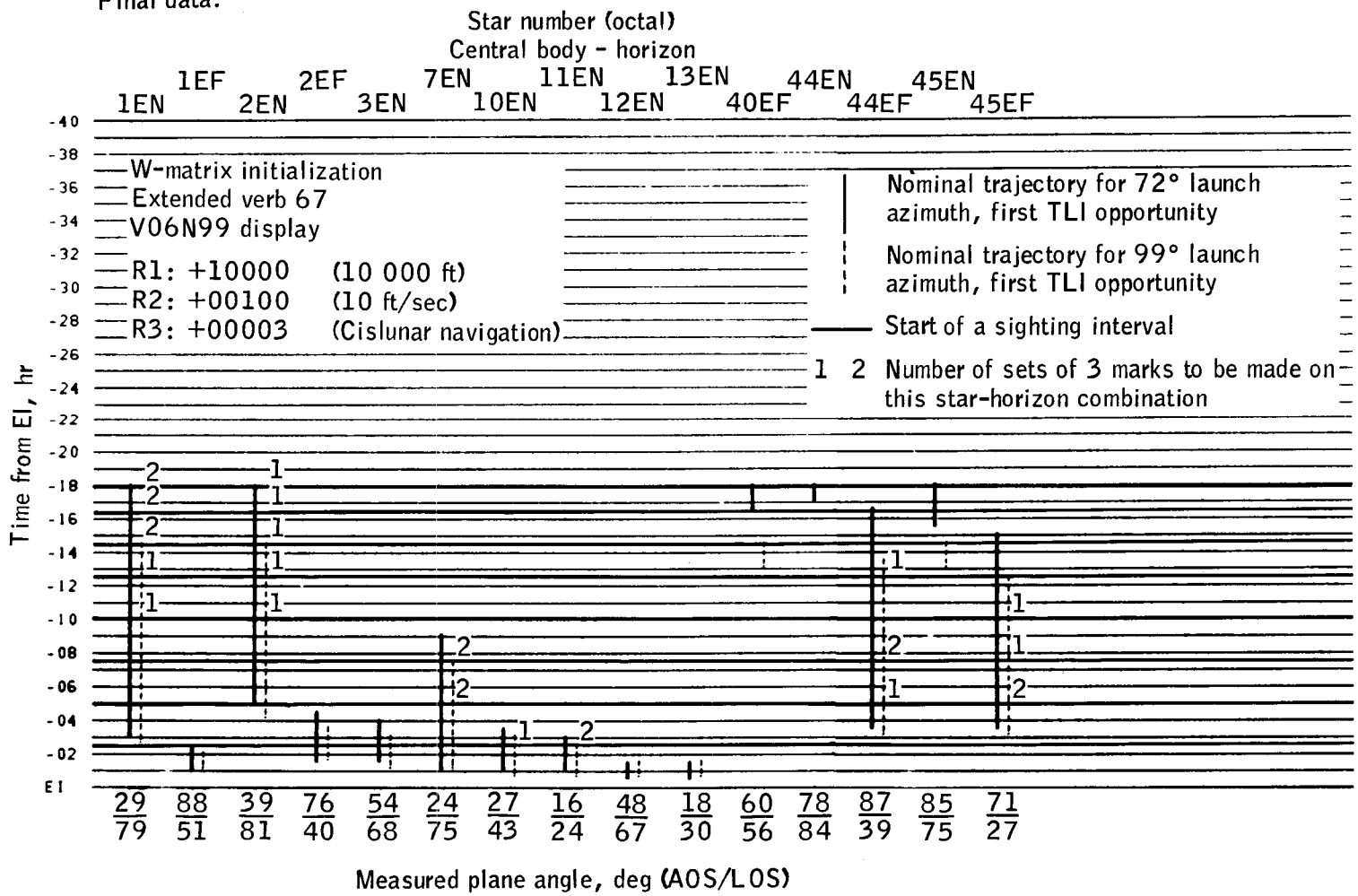
3. After a long period of no sightings.

4. During the last hours of TE coast when the vehicle is near the earth.

If a large state vector correction (greater than 50 nautical miles in position and 50 feet per second in velocity) is displayed during the V06N49 display in P23, the mark should be rejected and repeated. If the large correction occurs again, it should be accepted and incorporated.

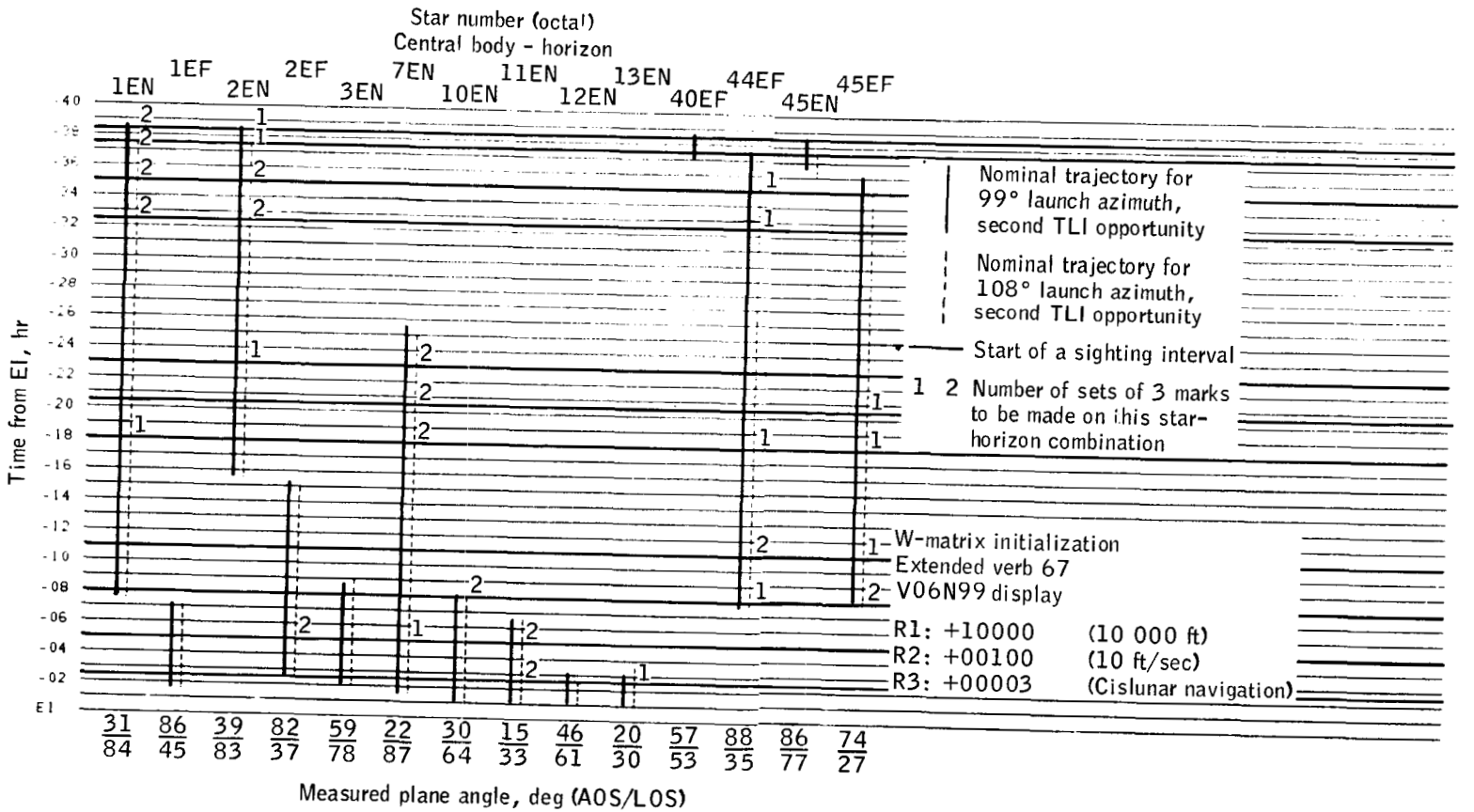
h. Star availability is directly related to the GMT of entry interface. In event of an abort not covered by a crew chart but having a GMT time of EI the same as that on a crew chart, the star availability from the crew chart may be used near the earth.

Crew chart 10.- Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, short return for a launch on July 16, 1969.
Denham/MPB/MPAD
7/1/69
Final data.



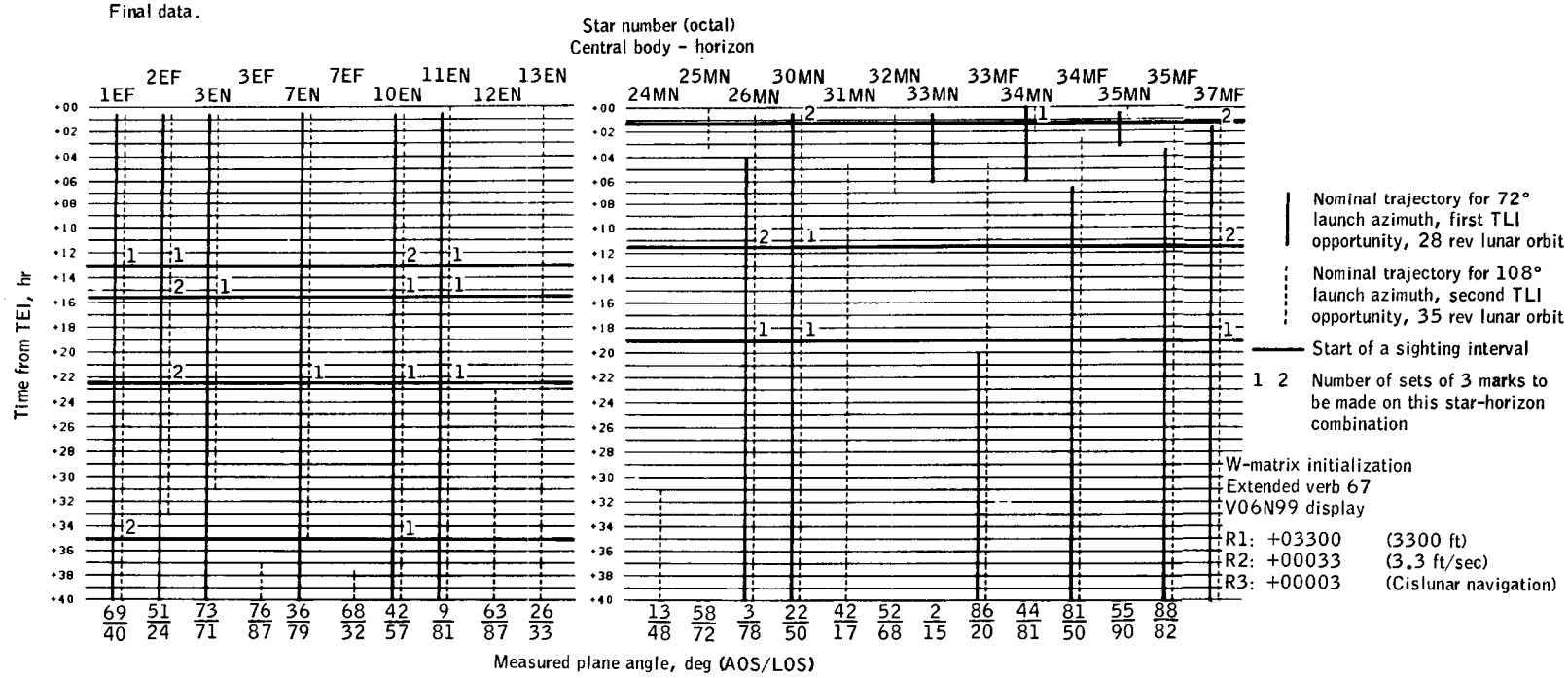
Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, short return for a launch on July 16, 1969.

Crew chart 11.- Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, long return for a launch on July 16, 1969.
Denham/MPB/MPAD
7/1/69
Final data.



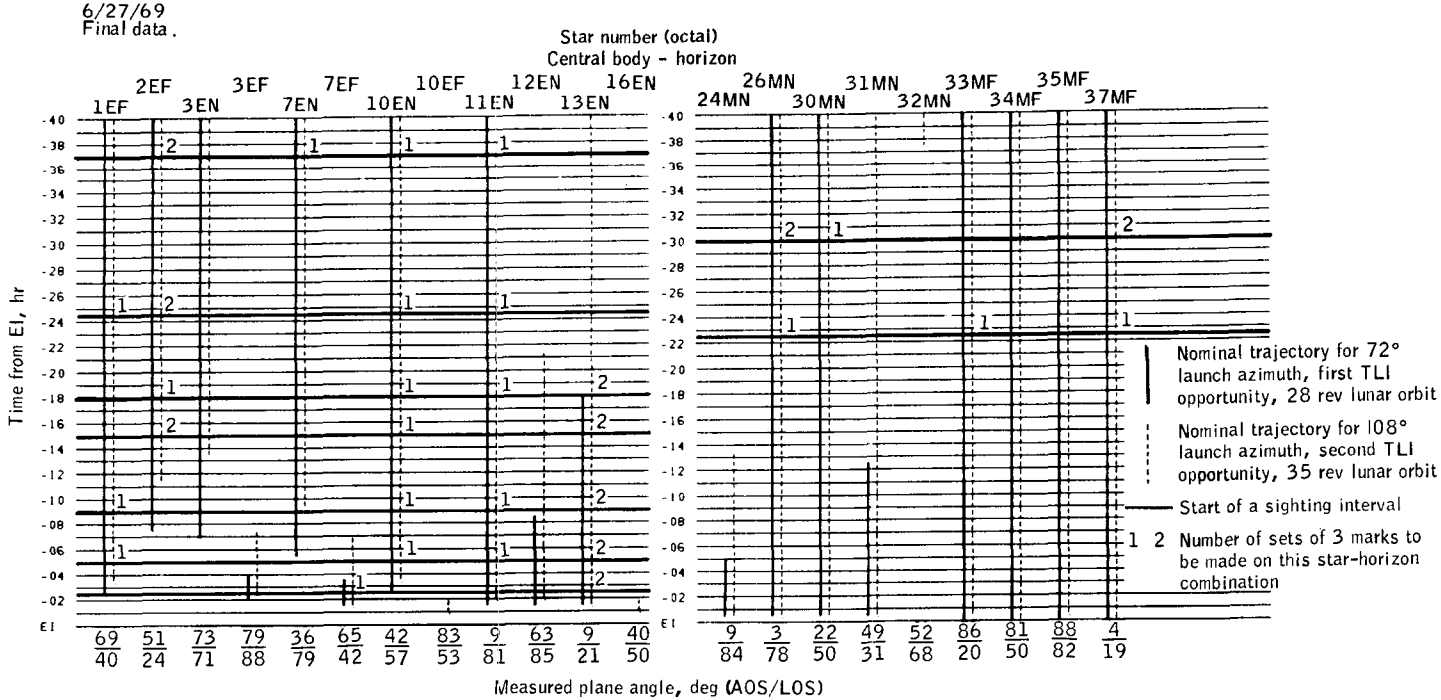
Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, long return for a launch on July 16, 1969.

Crew chart 12.- Star availability and sighting schedule for an abort from lunar orbit for a launch on July 16, 1969 (TEI to TEI plus 40 hours).
Denham/MPB/MPAD
6/27/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit for a launch on July 16, 1969 (TEI to TEI plus 40 hours).

Crew chart 13.- Star availability and sighting schedule for an abort from lunar orbit for a launch on July 16, 1969 (EI minus 40 hours to EI).
Denham/MPB/MPAD
6/27/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit for a launch on July 16, 1969 (EI minus 40 hours to EI).

Crew chart 14.- Planet half-unit vectors.
Blucker/MPB/MPAD
6/27/69
Final data.

VENUS HALF-UNIT VECTORS*

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	.16785	.44066	.16630
07:16:22	.16410	.44183	.16693
07:17:08	.16034	.44297	.16756
07:17:18	.15657	.44409	.16817
07:18:04	.15280	.44517	.16877
07:18:14	.14901	.44623	.16937
07:19:00	.14521	.44726	.16995
07:19:10	.14141	.44826	.17052
07:19:20	.13759	.44923	.17108
07:20:06	.13377	.45017	.17164
07:20:16	.12994	.45108	.17218
07:21:02	.12611	.45197	.17271
07:21:12	.12226	.45283	.17323
07:21:22	.11841	.45365	.17374
07:22:08	.11455	.45445	.17424
07:22:18	.11068	.45522	.17474
07:23:04	.10680	.45596	.17522

GMT M:D:H	X vector	Y vector	Z vector
07:23:14	.10292	.45667	.17569
07:24:00	.09903	.45735	.17615
07:24:10	.09513	.45801	.17660
07:24:20	.09122	.45863	.17704
07:25:06	.08730	.45923	.17747
07:25:16	.08338	.45979	.17789
07:26:02	.07945	.46033	.17830
07:26:12	.07551	.46084	.17871
07:26:22	.07155	.46132	.17910
07:27:08	.06759	.46176	.17948
07:27:18	.06362	.46218	.17985
07:28:04	.05964	.46257	.18021
07:28:14	.05565	.46294	.18056
07:29:00	.05164	.46327	.18090
07:29:10	.04763	.46357	.18122
07:29:20	.04360	.46384	.18154

*Venus is the only planet visible from the landing sites and is visible for the entire lunar stay for sites II, III, and V.

Crew chart 14.- Planet half-unit vectors. (Concluded)

Blucker/MPB/MPAD
6/27/69
Final data.

MARS HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	-.23404	-.39277	-.20239
07:18:04	-.23249	-.39349	-.20278
07:19:20	-.23053	-.39441	-.20324
07:21:12	-.22818	-.39550	-.20377
07:23:04	-.22546	-.39676	-.20434
07:24:20	-.22244	-.39815	-.20495
07:26:12	-.21915	-.39964	-.20559
07:28:04	-.21568	-.40119	-.20623
07:29:20	-.21208	-.40278	-.20687

SATURN HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	.39437	.28972	.10270
07:24:20	.39204	.29254	.10360
08:02:04	.39024	.29472	.10424

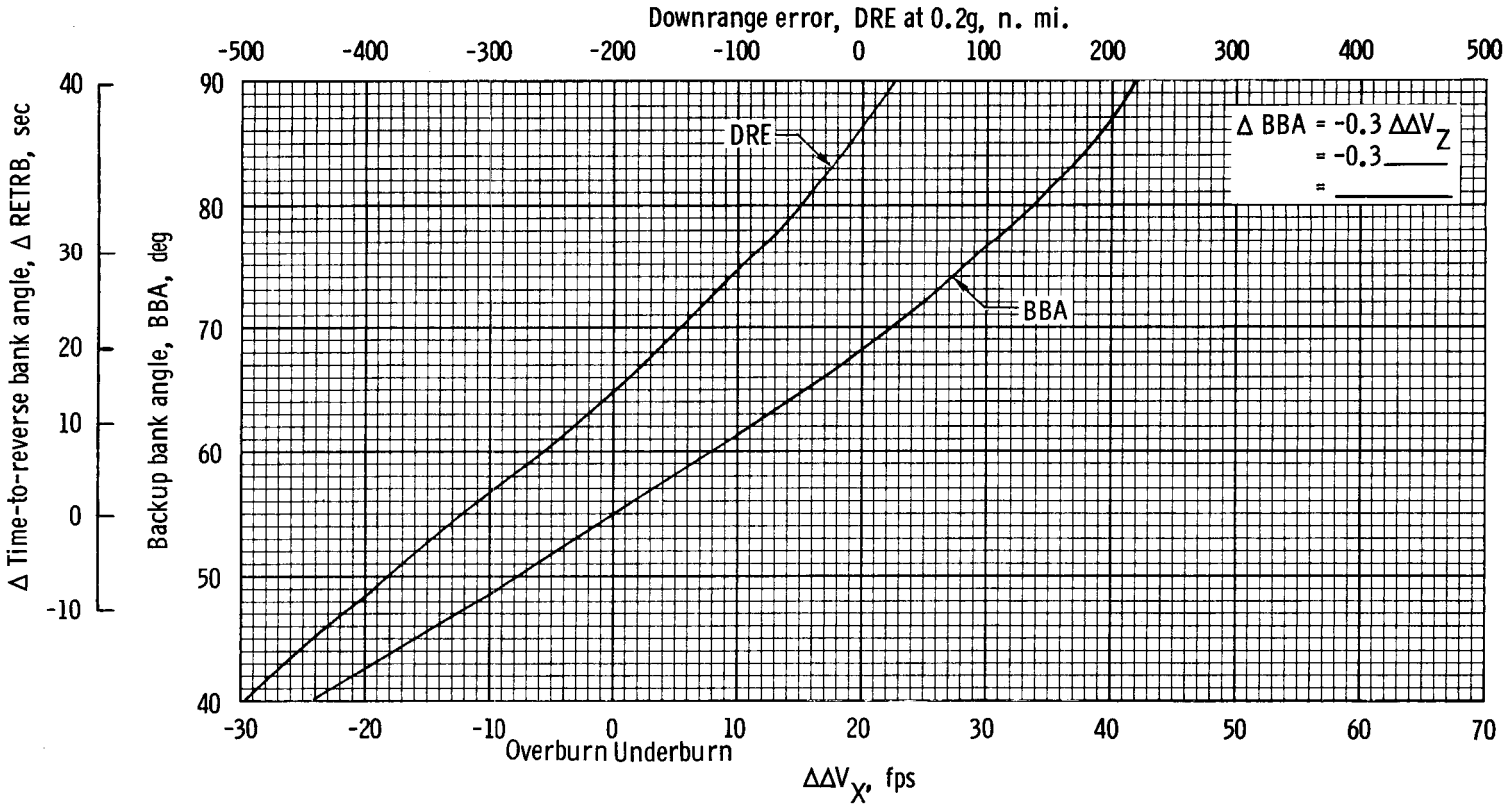
JUPITER HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	-.49989	-.00530	.00943
07:19:20	-.49986	-.00910	.00768
07:23:04	-.49980	-.01306	.00587
07:26:12	-.49970	-.01714	.00401
07:29:20	-.49955	-.02132	.00212

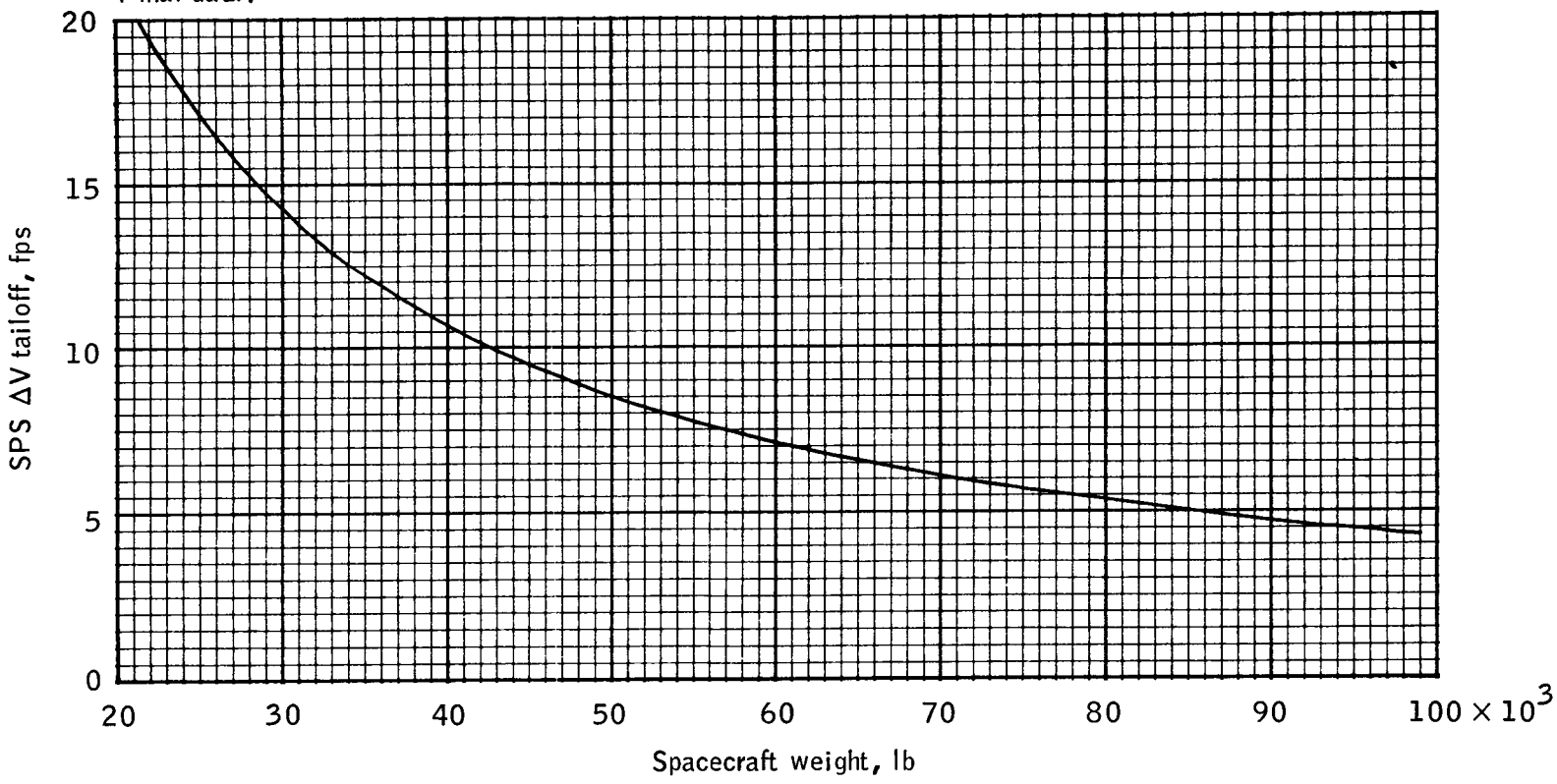
Crew chart 15. - Earth orbit BBA versus $\Delta\Delta V_X$.

Rogers/LAB/MPAD
6/27/69
Final data.



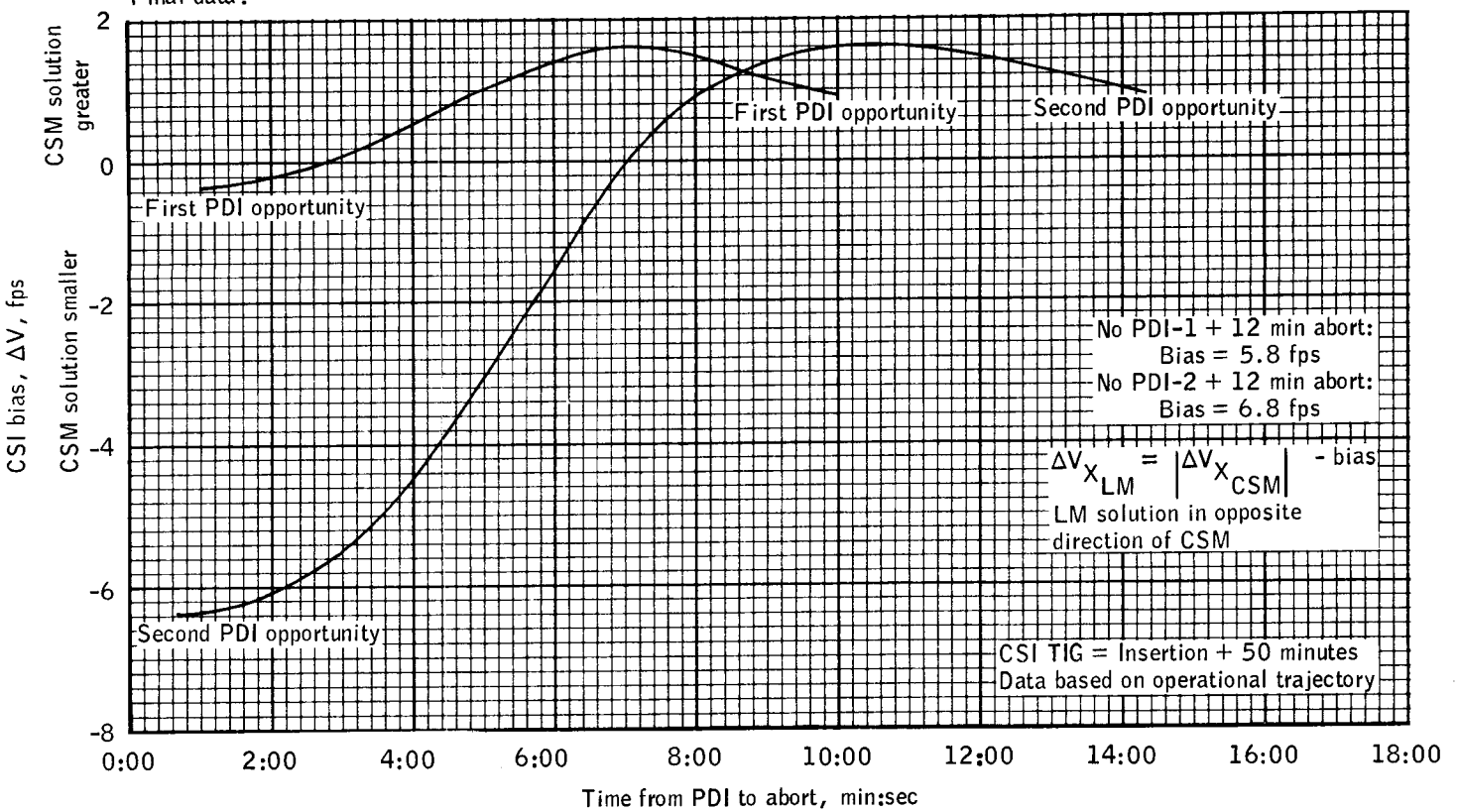
Earth orbit BBA versus $\Delta\Delta V_X$.

Crew chart 16.- SPS tailoff ΔV versus spacecraft weight.
Graf/GPB/MPAD
6/27/69
Final data.



SPS tailoff ΔV versus spacecraft weight.

Crew chart 17.- Comparison between the LM and CSM solutions for CSI maneuver as a function of abort time in powered descent.
Bell/OMAB/MPAD
6/27/69
Final data.



Comparison between the LM and CSM solutions for CSI maneuver as a function of abort time in powered descent.

Crew chart 18.- CSM hydrogen, oxygen, fuel cell and bus voltage readouts.
Scott/GPB/MPAD
6/27/69
Final data.

CSM HYDROGEN, OXYGEN, FUEL CELL AND BUS VOLTAGE READOUTS

Time, hr:min	Mission phase	H_2 tank quantity, percent	O_2 tank quantity, percent	Typical fuel cell current, amps	Typical bus voltage, volts
0:00	Lift-off	96.13	96.05	17.8	30.0
22:30	TLC	88.47	89.38	24.0	29.1
48:00	TLC	80.55	82.40	23.0	29.1
69:00	TLC	73.88	76.65	23.9	29.0
95:15	LO	64.55	68.82	25.9	28.7
123:10	LO	54.33	59.09	24.4	29.0
147:00	TEC	47.03	52.79	23.0	29.1
170:00	TEC	40.37	46.99	23.0	29.1
188:00	TEC	33.15	40.71	23.0	29.1

Assumptions:

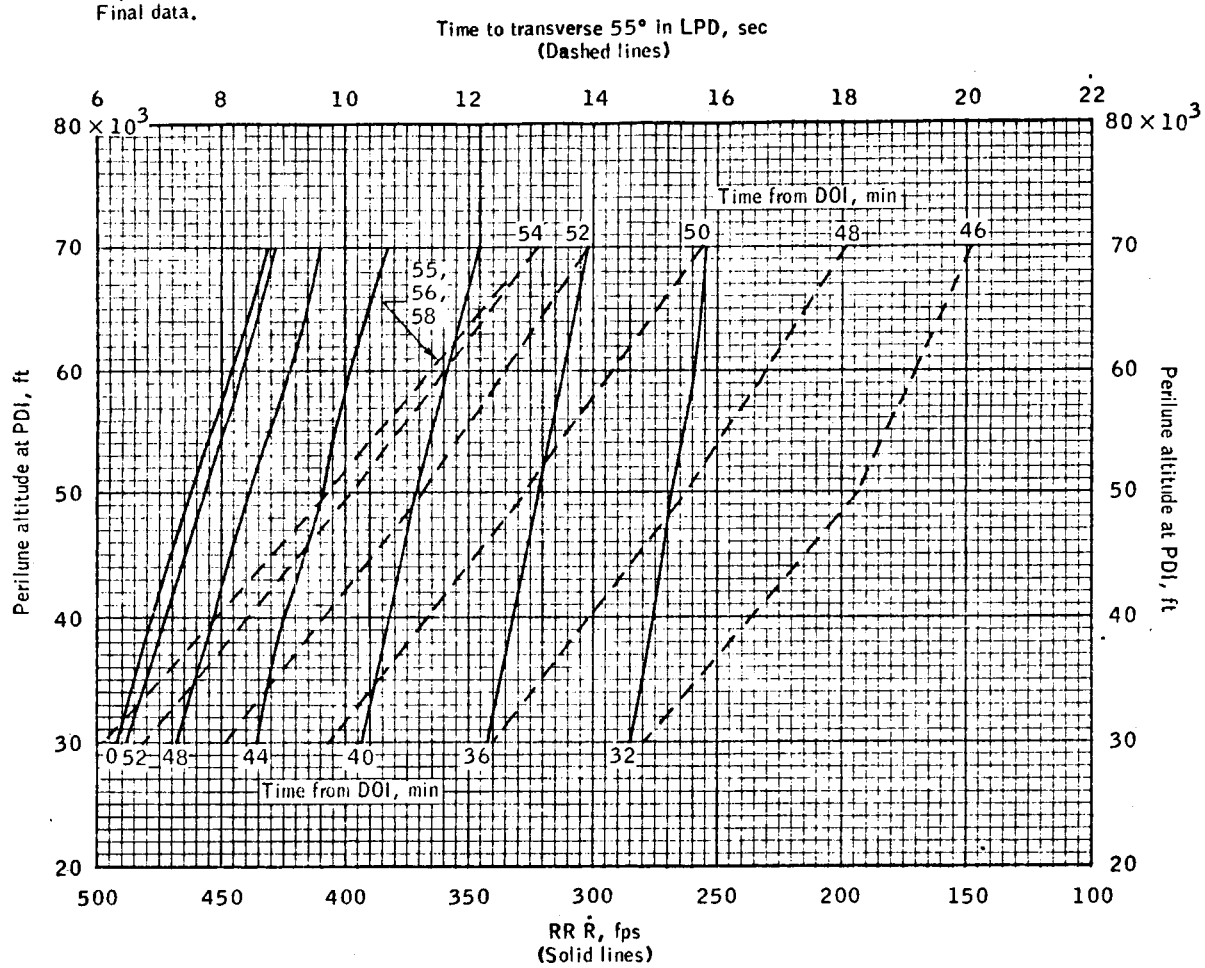
a. 100% fill H_2 and O_2

b. Average fuel cell current.

c. Tank quantities reflect KSC predicted prelaunch usage.

d. Bus loads assumed to be balanced.

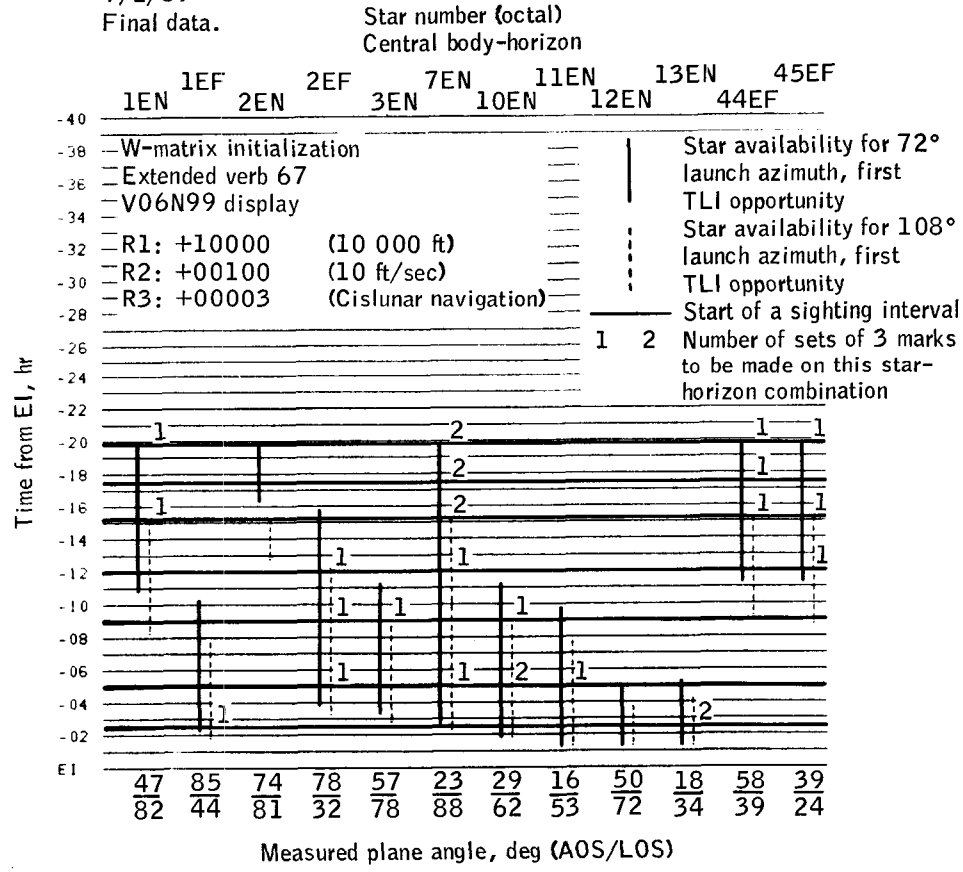
Crew chart 19.- Perilune altitude checks at PDI.
Dupnick/LAB/MPAD
7/1/69
Final data.



Perilune altitude checks at PDI.

Crew chart 20.- Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, short return for a launch on July 18, 1969.

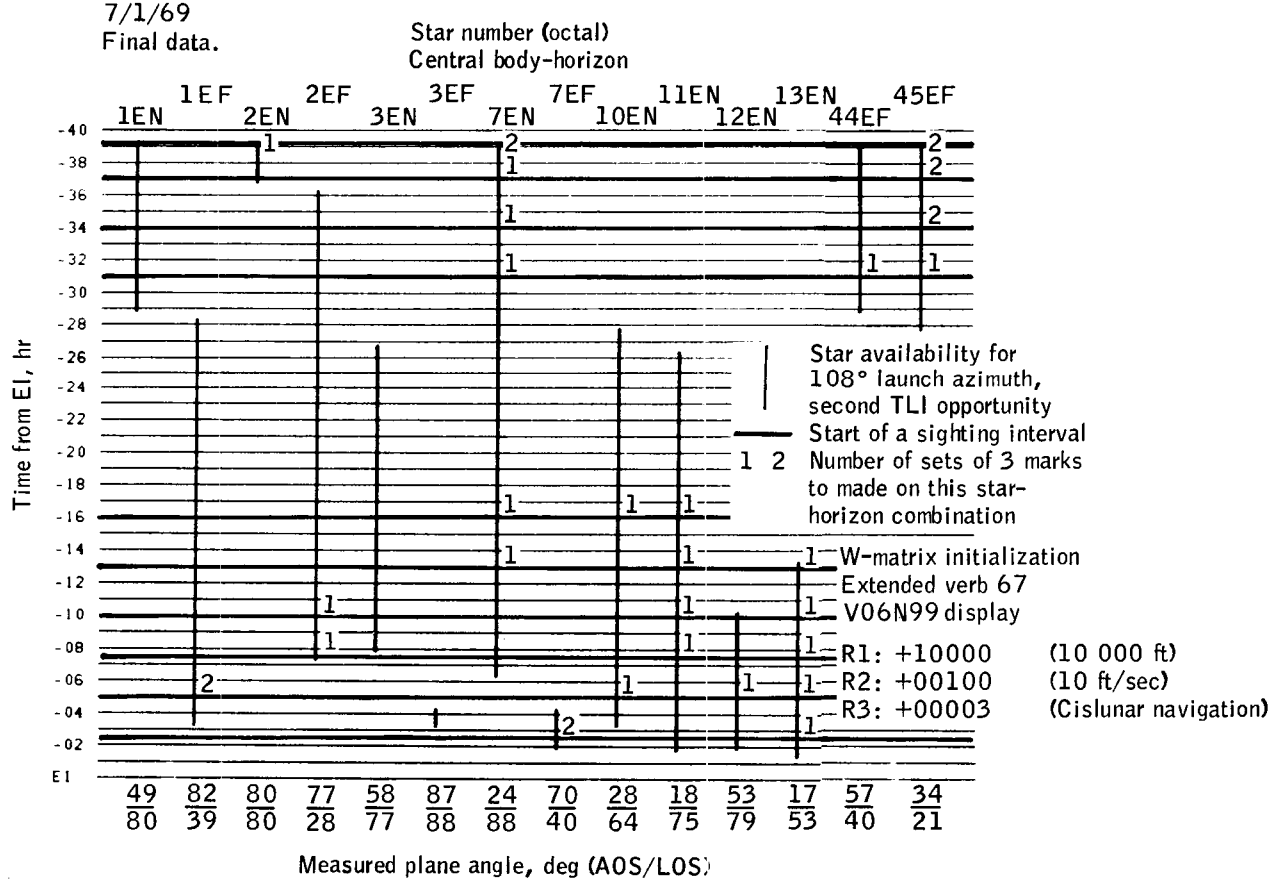
Denham/MPB/MPAD
7/1/69
Final data.



Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, short return for a launch on July 18, 1969.

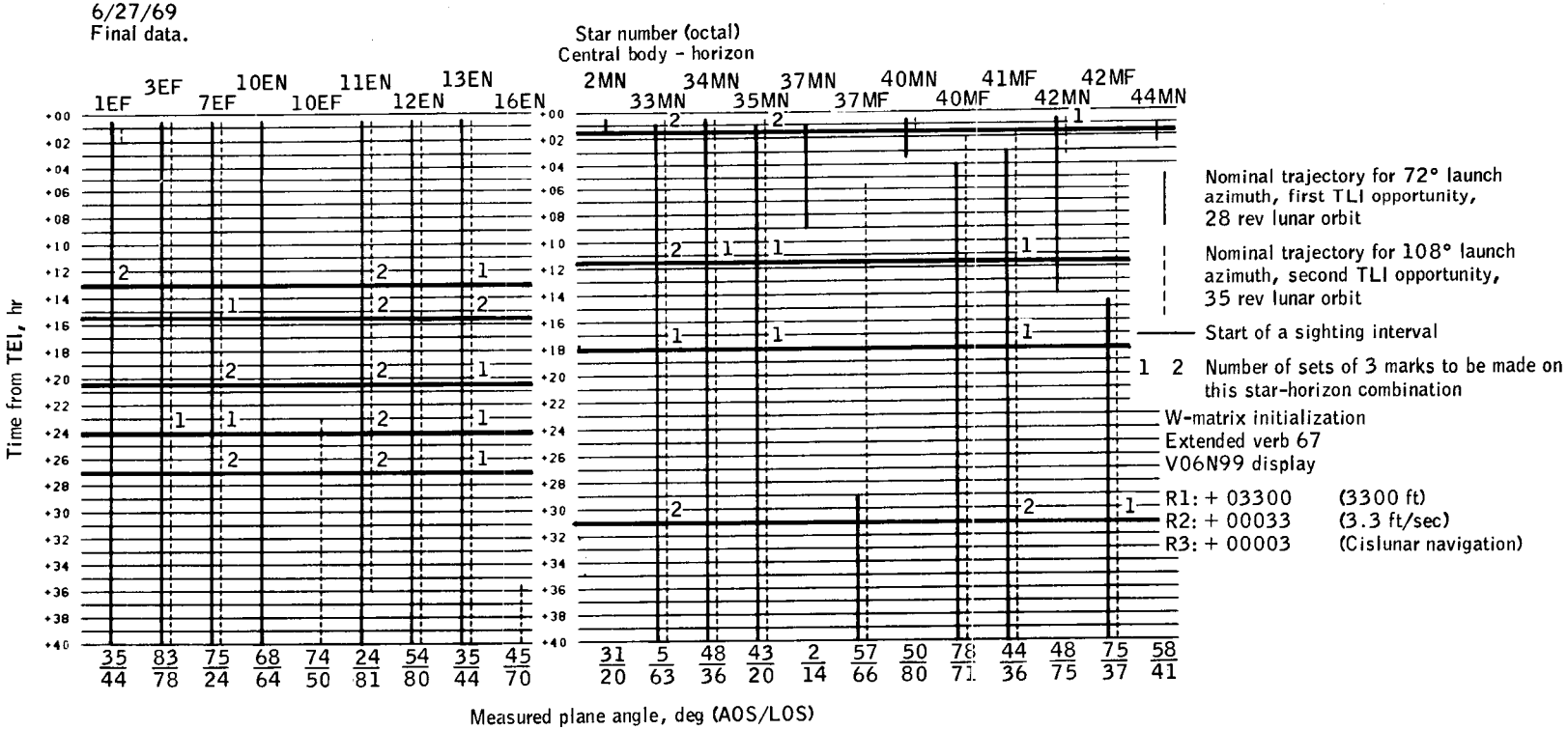
Crew chart 21.- Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, long return for a launch on July 18, 1969.

Denham/MPB/MPAD
7/1/69
Final data.



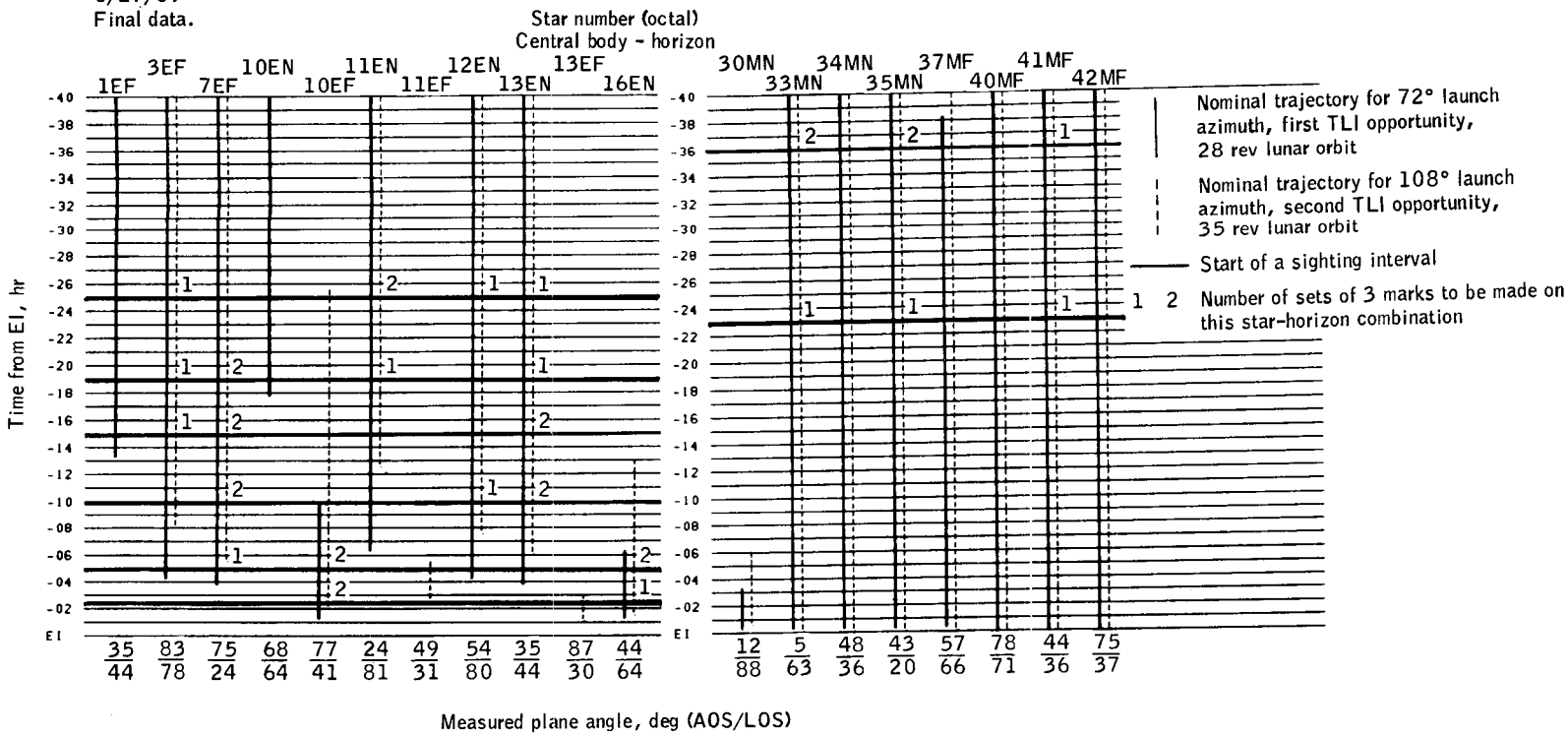
Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, long return for a launch on July 18, 1969.

Crew chart 22.- Star availability and sighting schedule for an abort from lunar orbit for a launch on July 18, 1969 (TEI to TEI plus 40 hours).
Denham/MPB/MPAD
6/27/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit for a launch on July 18, 1969 (TEI to TEI plus 40 hours).

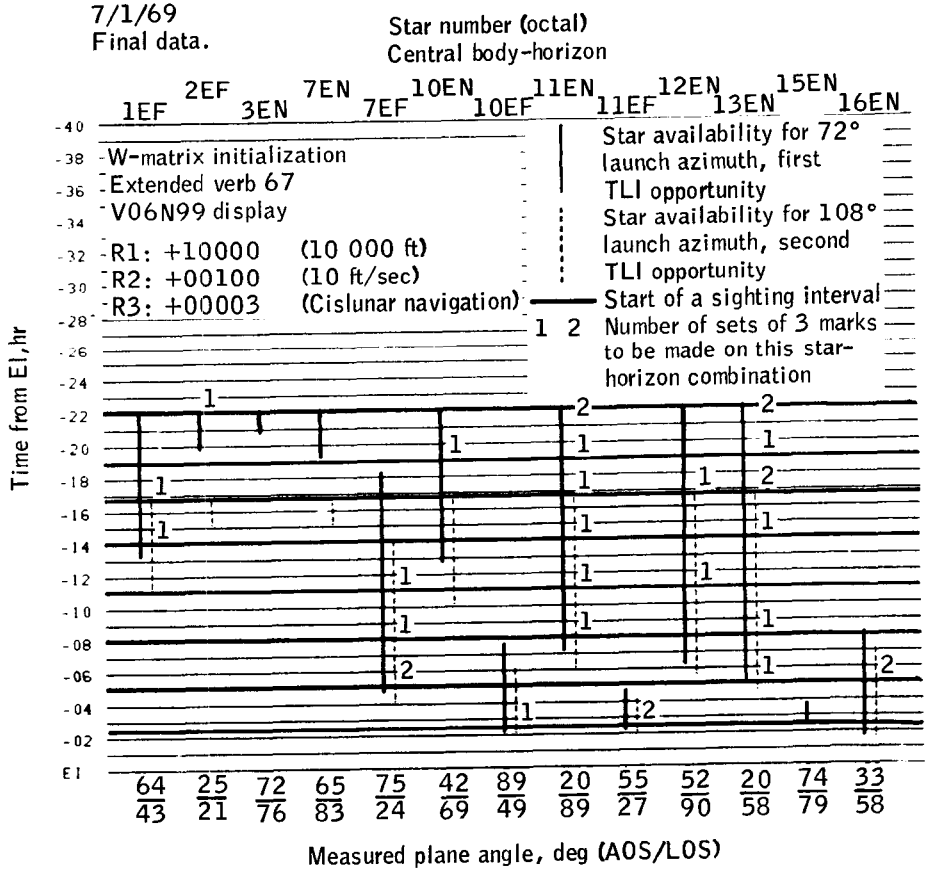
Crew chart 23.- Star availability and sighting schedule for an abort from lunar orbit for a launch on July 18, 1969 (EI minus 40 hours to EI).
Denham/MPB/MPAD
6/27/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit for a launch on July 18, 1969 (EI minus 40 hours to EI).

Crew chart 24.- Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, for a launch on July 21, 1969

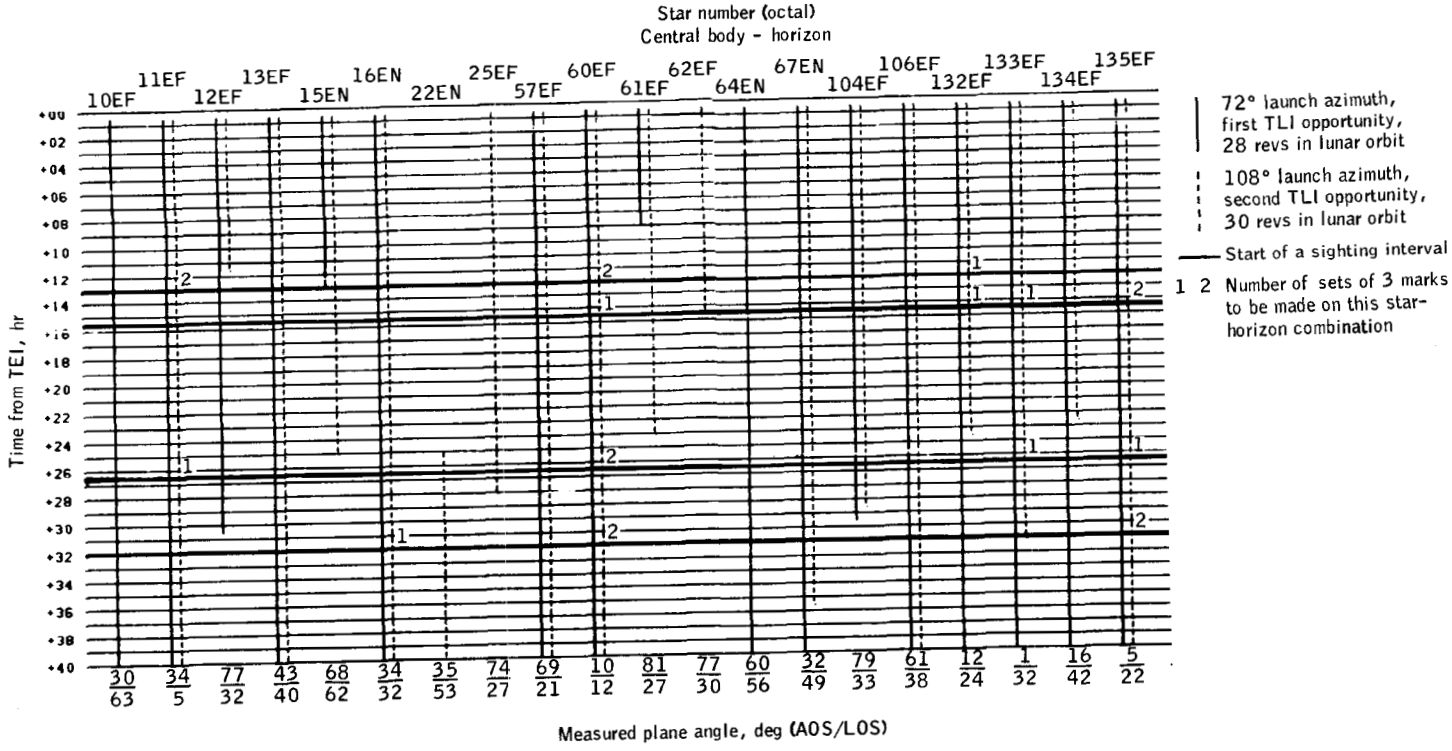
Denham/MPB/MPAD
7/1/69
Final data.



Star availability and sighting schedule for an abort from translunar coast at TLI plus 4 hours, for a launch on July 21, 1969.

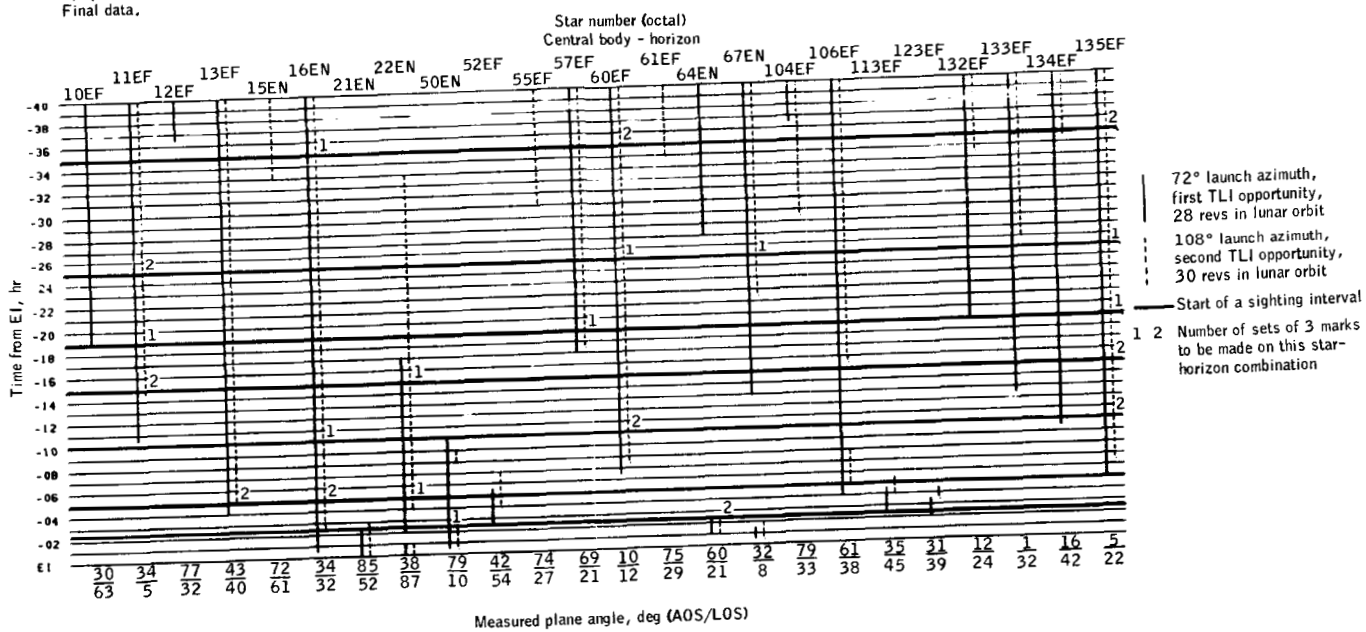
Crew chart 25.- Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; earth horizons).

Denham/MPB/MPAD
7/1/69
Final data.



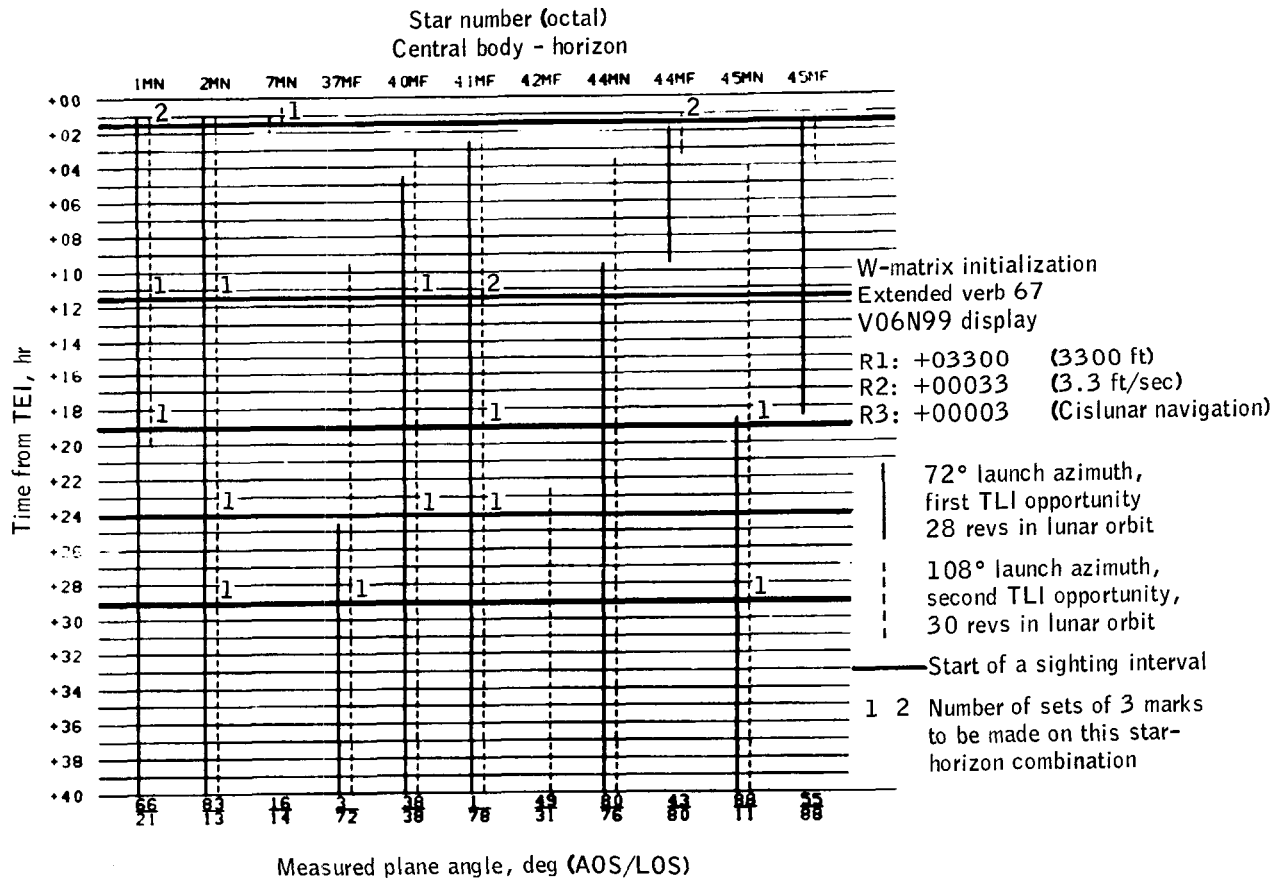
Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; earth horizons).

Crew chart 26.- Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; earth horizons).
Denham/MPB/MPAD
7/1/69
Final data.



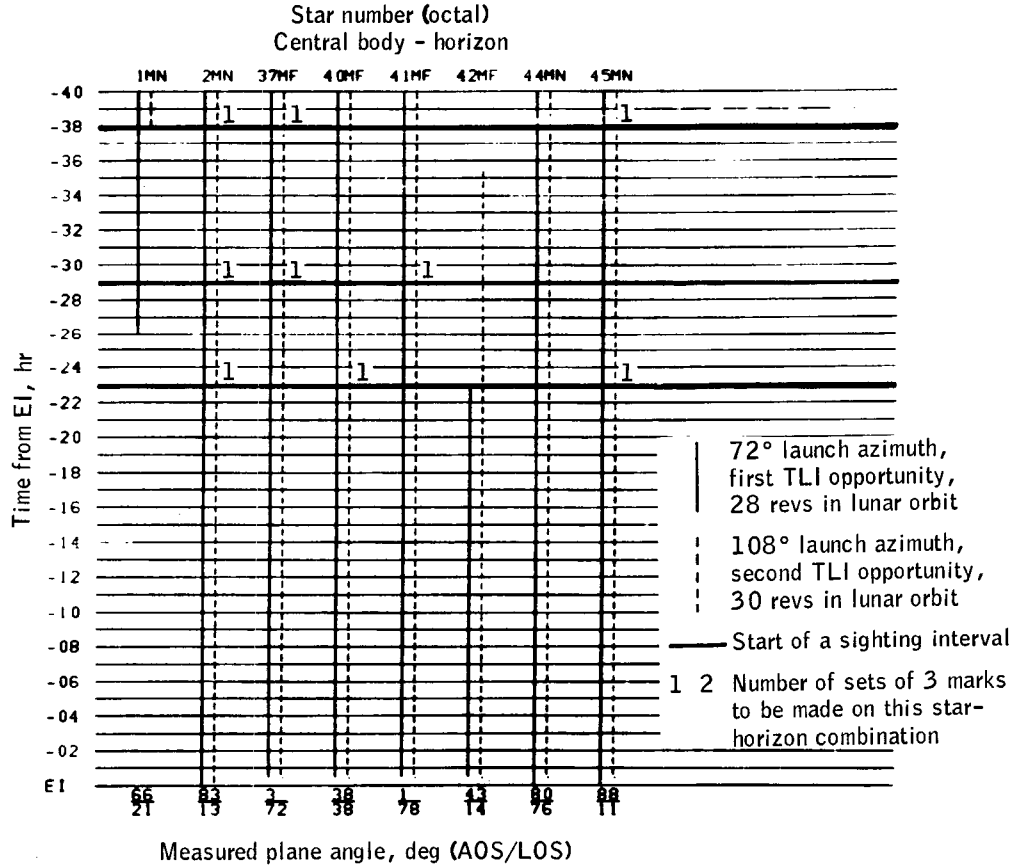
Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; earth horizons).

Crew chart 27.- Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; lunar horizons).
Denham/MPB/MPAD
7/1/69
Final data.



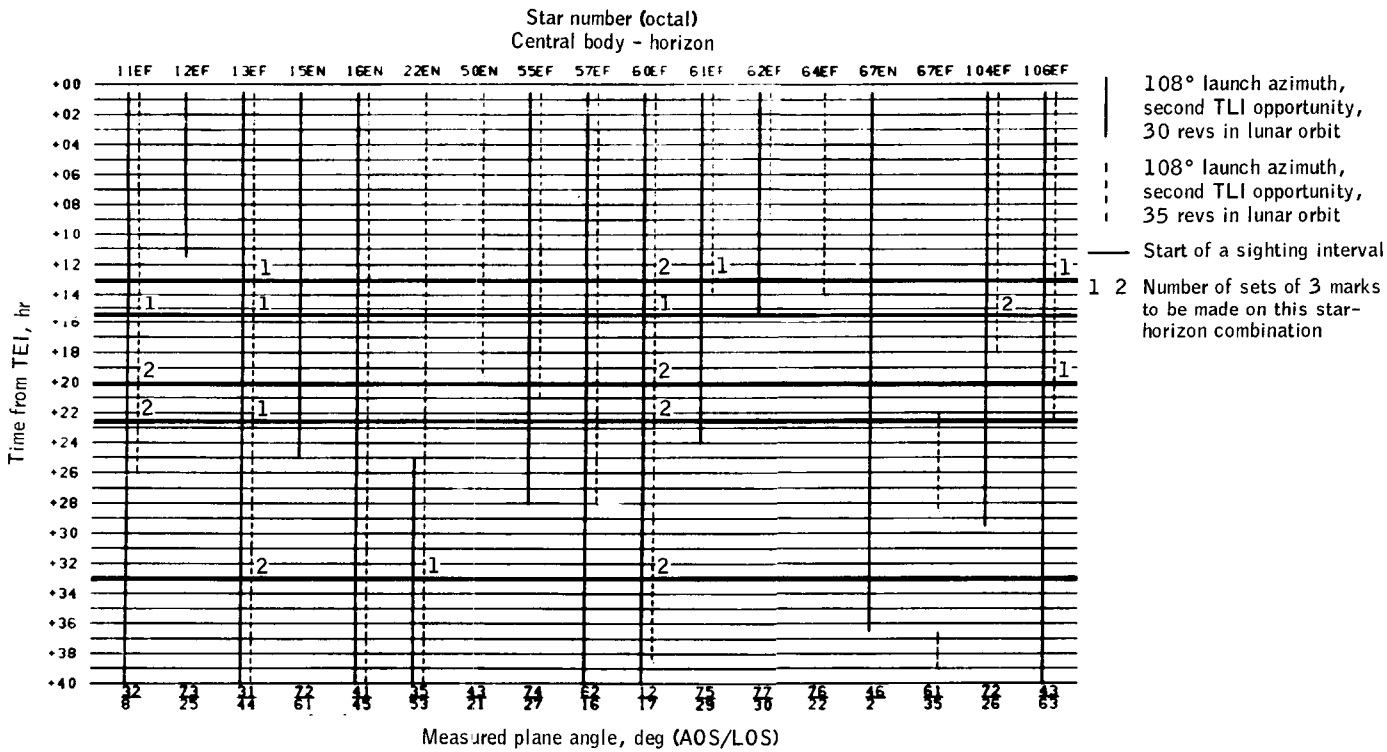
Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; lunar horizons).

Crew chart 28.- Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; lunar horizons).
Denham/MPB/MPAD
7/1/69
Final data.



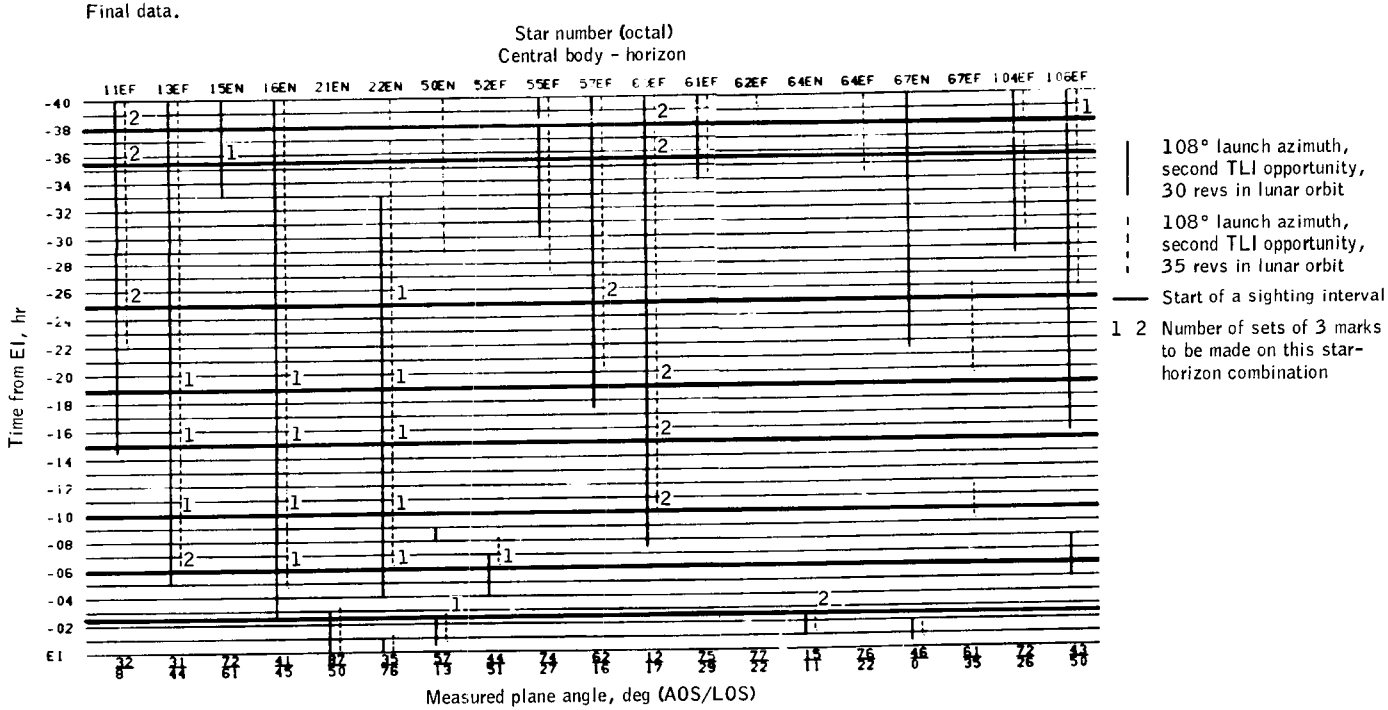
Star availability and sighting schedule for an abort from lunar orbit before noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; lunar horizons).

Crew chart 29.- Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; earth horizons).
Denham/MPB/MPAD
7/1/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; earth horizons).

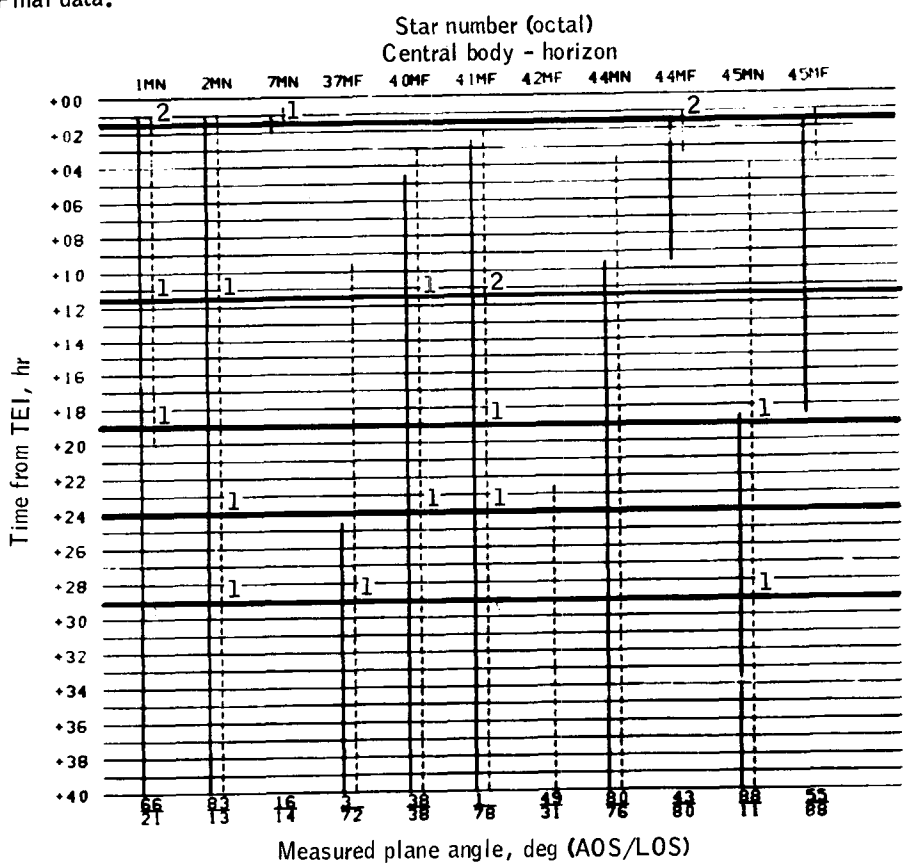
Crew chart 30.- Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; earth horizons).
Denham/MPB/MPAD
7/1/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI, earth horizons).

Crew chart 31.- Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; lunar horizons).

Denham/MPB/MPAD
7/1/69
Final data.



108° launch azimuth, second TLI opportunity, 30 revs in lunar orbit

108° launch azimuth, second TLI opportunity, 35 revs in lunar orbit

Start of a sighting interval

1 2 Number of sets of 3 marks to be made on this star-horizon combination

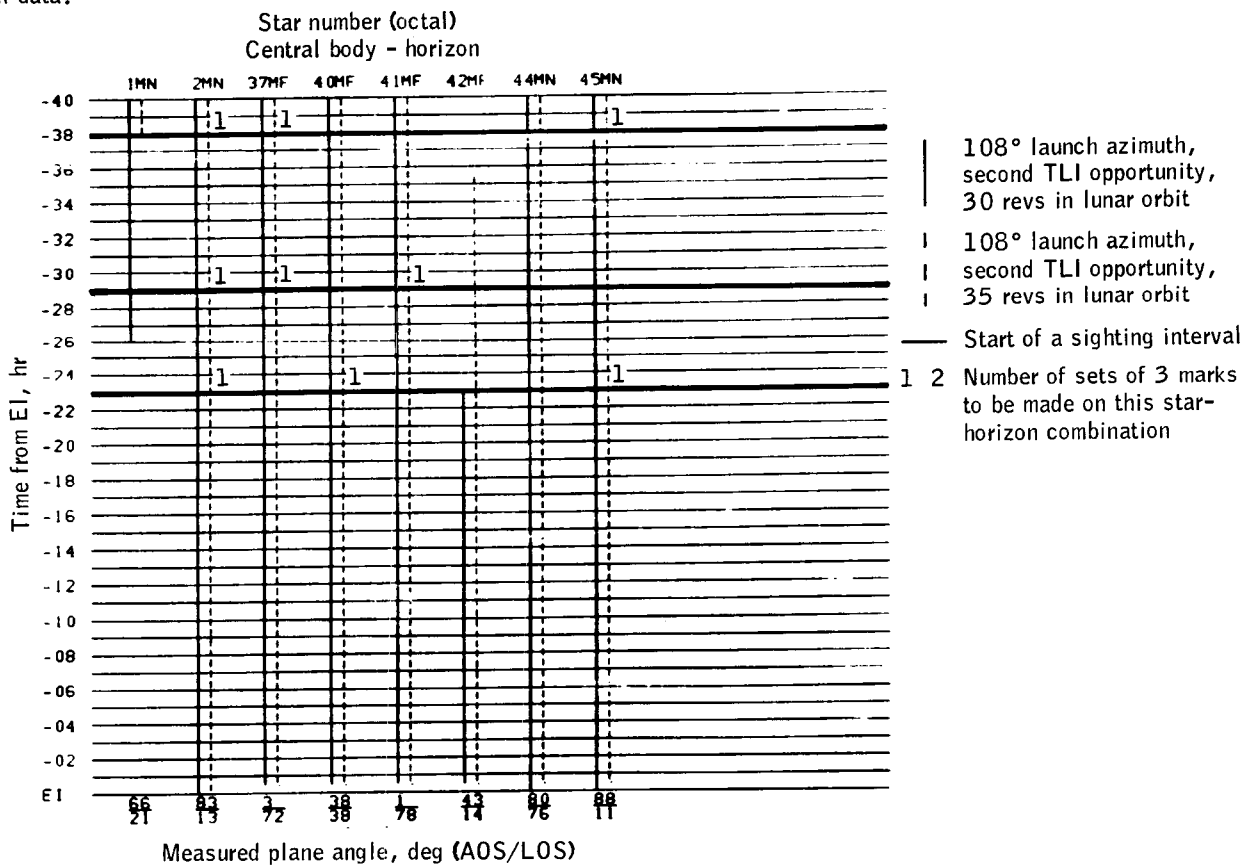
W-matrix initialization
Extended verb 67
V06N99 display

R1: +03300 (3300 ft)
R2: +00033 (3.3 ft/sec)
R3: +00003 (Cislunar navigation)

Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (TEI to TEI plus 40 hours; lunar horizons).

Crew chart 32.- Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; lunar horizons).

Denham/MPB/MPAD
7/1/69
Final data.



Star availability and sighting schedule for an abort from lunar orbit after noon, G.m.t., July 27, for a launch on July 21, 1969 (EI minus 40 hours to EI; lunar horizons).

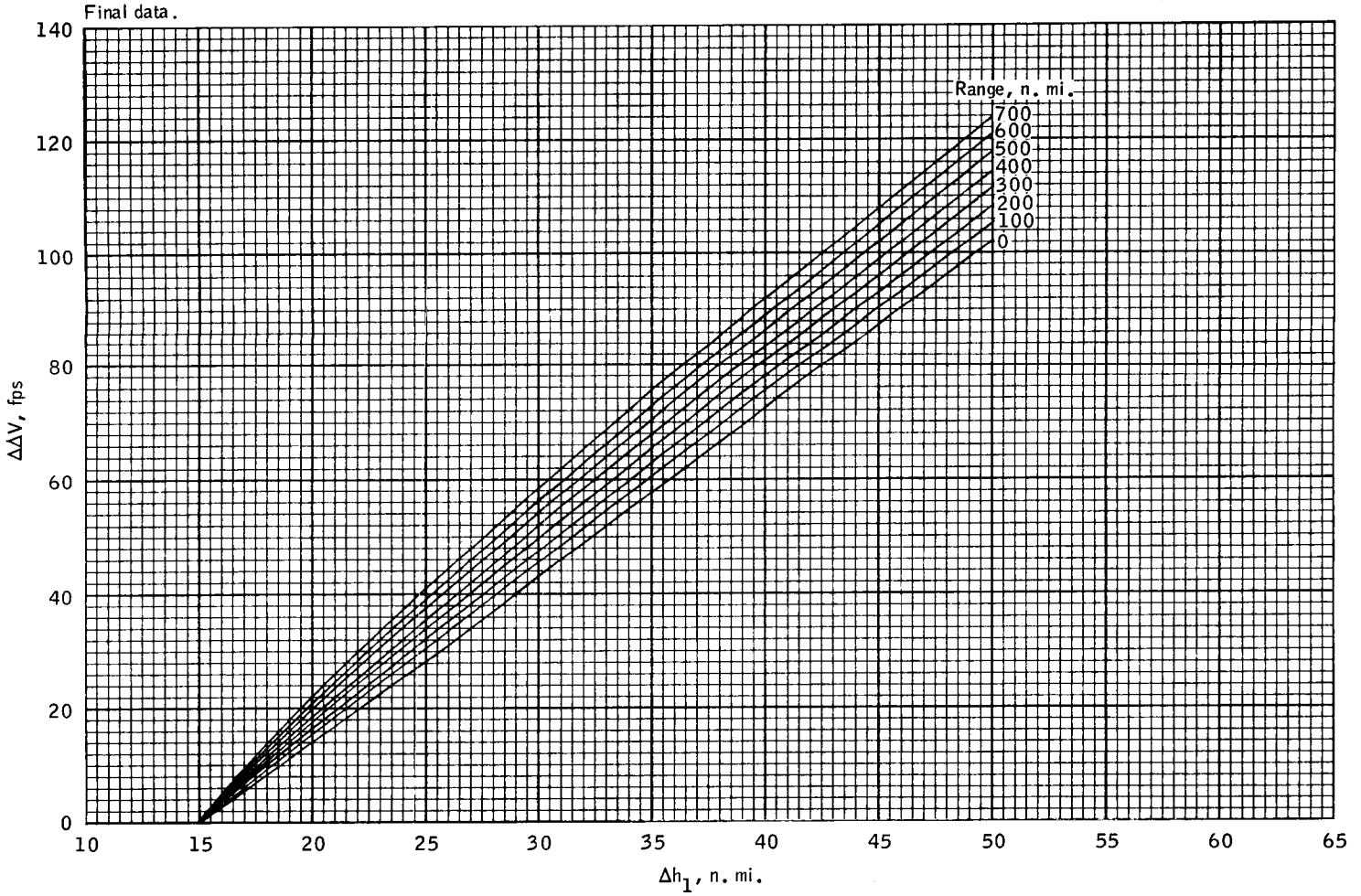
Crew chart 33.- Star unit vector.
Denham/MPB/MPAD
7/1/69
Final data.

STAR NUMBER (OCTAL)	Star unit vector X (R1)	Y (R2)	Z (R3)
46	0.73407	0.47802	0.39589
47	0.53405	0.64623	-0.48640
50	-0.38431	0.79372	0.47101
51	-0.73001	0.23231	-0.93724
52	-0.45575	0.11810	0.88224
53	-0.64582	-0.11398	-0.75236
54	-0.37808	-0.31042	-0.87218
55	0.02742	0.98127	0.17884
56	-0.40417	-0.25143	-0.86802
57	0.15754	0.98135	0.11015
60	0.13588	0.86754	0.47844
61	0.11019	0.98363	-0.02129
62	0.08039	0.99532	-0.03415
63	-0.08862	0.94724	-0.30802
64	-0.14497	0.94739	0.28278
65	-0.21709	0.84786	-0.48374
66	-0.25691	0.85793	-0.44377
67	-0.33386	0.78002	0.52926
70	-0.29531	0.41439	-0.86085
71	-0.37982	0.43742	-0.81511
72	-0.54023	-0.06999	-0.83815
73	-0.49700	-0.10101	-0.86185
74	-0.54274	-0.12708	0.83023
75	-0.09271	-0.79163	-0.60298
76	-0.07914	-0.72729	-0.68175
77	0.07973	-0.82125	-0.56498
100	0.51439	0.01701	0.85703
101	0.73333	0.07963	-0.67519
102	0.77836	0.23829	0.58016
103	0.53835	0.37621	0.67155
104	0.12348	0.99170	0.00559
105	0.05875	0.93401	-0.16813
106	0.00825	0.70772	0.70644
107	-0.30881	0.81608	-0.48852
110	-0.38073	0.65984	-0.64169
111	-0.52976	0.49832	-0.63596
112	-0.38744	0.32564	-0.85851
113	-0.53254	0.14259	0.83431
114	-0.53553	-0.20215	0.81997
115	-0.19916	-0.18374	0.96259

STAR NUMBER (OCTAL)	Star unit vector X (R1)	Y (R2)	Z (R3)
116	-0.01112	-0.62253	0.78252
117	0.44149	-0.62383	0.64492
120	0.58364	-0.32366	-0.73263
121	0.64125	-0.23061	-0.73186
122	0.54587	0.09329	0.83256
123	-0.58340	0.01991	0.80759
124	-0.46685	-0.79695	-0.38329
125	-0.25472	-0.78647	-0.56266
126	0.26459	0.04924	0.25310
127	-0.08634	-0.77413	-0.62954
130	0.46579	0.17842	0.86672
131	0.82427	0.44280	0.35285
132	0.50517	0.76104	0.40695
133	0.44053	0.72126	0.52689
134	0.39545	0.65706	0.64178
135	0.23424	0.80410	0.54640
136	0.23033	0.96886	-0.08931
137	0.13432	0.92524	-0.35482
140	0.11345	0.94450	-0.30640
141	0.11275	0.93824	-0.10328
142	0.09811	0.93762	0.36042
143	0.07736	0.82455	-0.56048
144	0.00808	0.79836	0.60477
145	-0.13525	0.62045	-0.77249
146	-0.26014	0.75451	-0.60241
147	-0.47742	0.77706	-0.41019
150	-0.44258	0.36749	-0.81727
151	-0.84875	0.40337	0.34192
152	-0.61841	0.20849	-0.75769
153	-0.91551	0.19245	0.35328
154	-0.90952	-0.13109	-0.39444
155	-0.35458	-0.05517	-0.93340
156	-0.96446	-0.17420	-0.02243
157	-0.76069	-0.18493	0.62224
160	-0.94703	-0.25679	0.19286
161	-0.75615	-0.27113	-0.59559
162	-0.54366	-0.24769	-0.80193
163	-0.83454	-0.44966	0.31809
164	-0.61960	-0.47918	0.62168
165	-0.58216	-0.46139	-0.66948

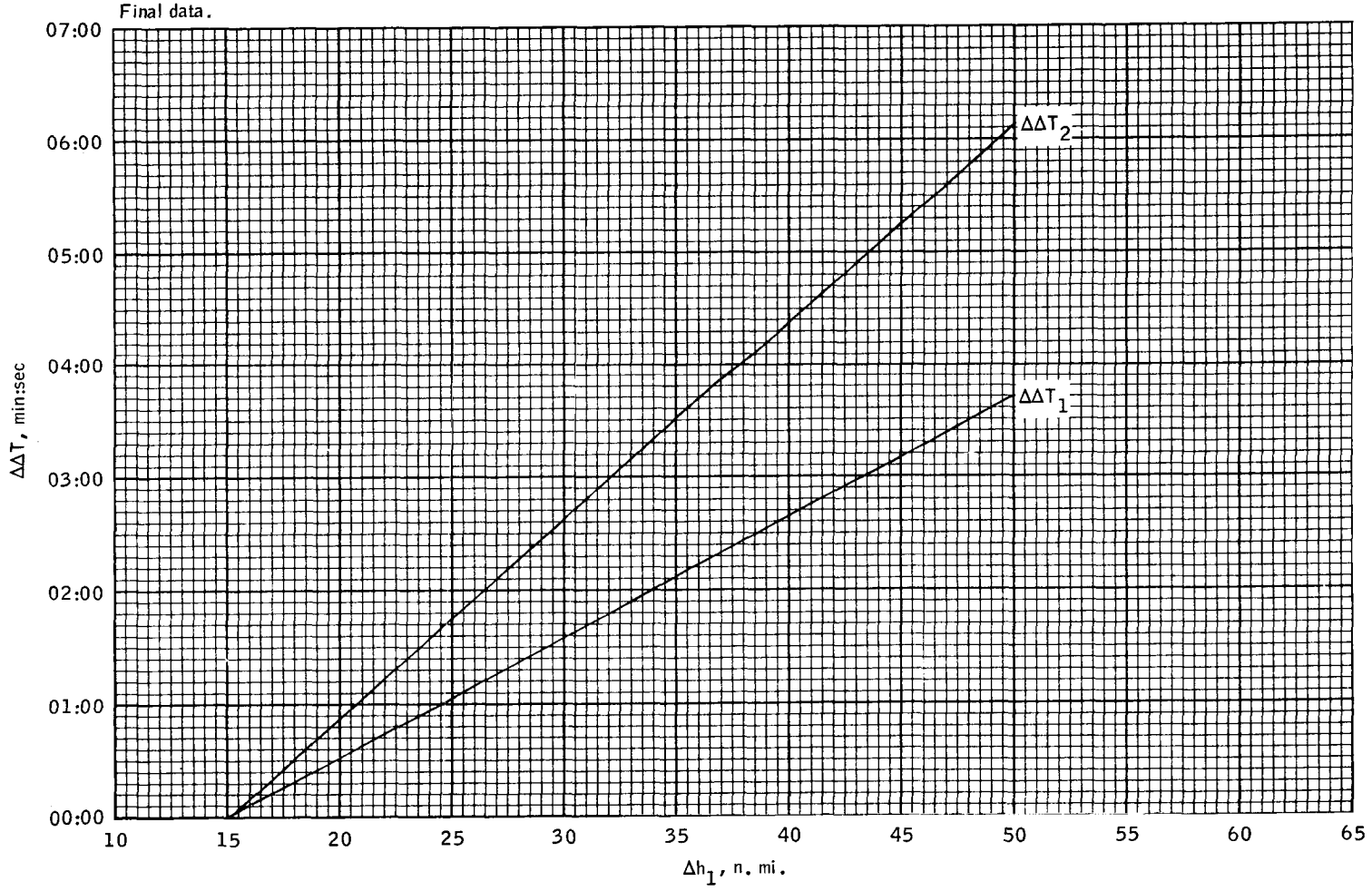
STAR NUMBER (OCTAL)	Star unit vector X (R1)	Y (R2)	Z (R3)
166	-0.52003	-0.43607	-0.73445
167	-0.67208	-0.53256	0.45709
170	-0.71123	-0.64725	-0.27426
171	-0.52473	-0.50920	-0.68218
172	-0.64947	-0.74312	-0.16114
173	-0.45075	-0.60436	-0.65694
174	-0.55992	-0.82073	0.11353
175	-0.45933	-0.77230	-0.43883
176	-0.45748	-0.80268	-0.33750
177	-0.19436	-0.43441	0.87950
200	-0.35994	-0.85760	0.36738
201	-0.32310	-0.82034	-0.47186
202	-0.35435	-0.91716	-0.18237
203	-0.29059	-0.80008	0.52482
204	-0.21389	-0.93868	-0.27042
205	-0.09153	-0.55891	-0.82416
206	-0.10827	-0.78835	-0.60562
207	-0.08550	-0.63904	-0.76441
210	-0.08043	-0.60590	0.79147
211	-0.07826	-0.99373	0.07982
212	0.07210	-0.86439	-0.49762
213	0.10269	-0.89718	-0.42957
214	0.22688	-0.83646	-0.49886
215	0.30977	-0.63437	0.70781
216	0.43418	-0.38206	0.18290
217	0.54753	-0.62435	0.55712
220	0.35143	-0.30051	0.88667
221	0.79409	-0.53199	-0.28007
222	0.44425	-0.21557	-0.86958
223	0.85576	-0.22005	0.46823
224	0.93629	-0.23664	0.25955
225	0.41260	0.23302	-0.88060
226	0.82333	0.56495	-0.05431
227	0.52025	0.54924	0.65397
230	-0.43368	0.33184	-0.83773
231	-0.40965	0.14530	-0.90060
232	-0.63505	-0.01883	-0.77224
233	-0.23697	-0.38101	-0.89363
234	0.26778	-0.93341	0.23883
235	0.27274	-0.89238	-0.35955
236	-0.45010	-0.89075	-0.06311

LM crew chart 1.- Phasing maneuver chart.
Lineberry/OMAB/MPAD
6/27/69
Final data.



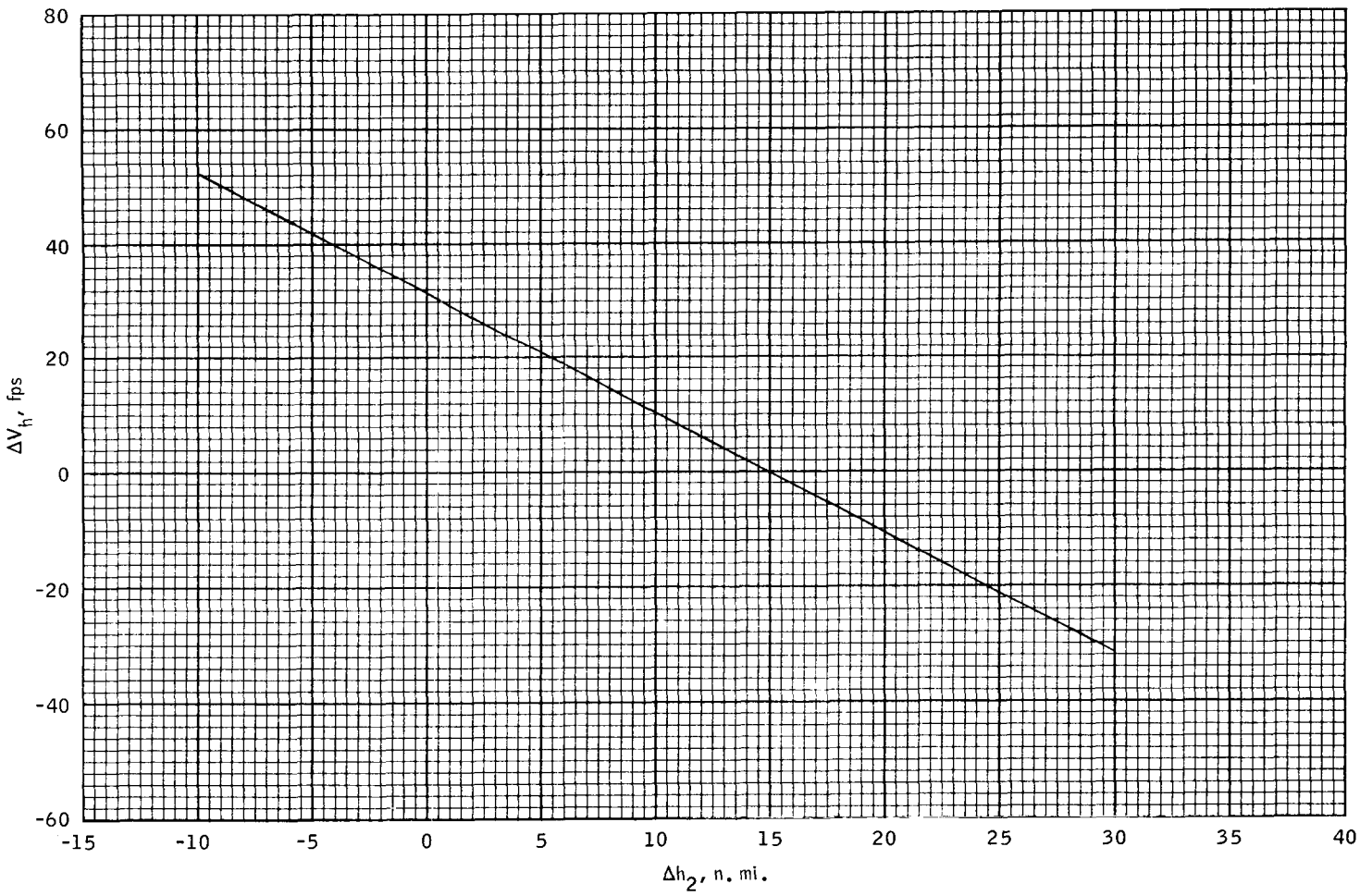
Phasing maneuver chart.

LM crew chart 2.- Maneuver ignition time chart.
Lineberry/OMAB/MPAD
6/27/69
Final data.



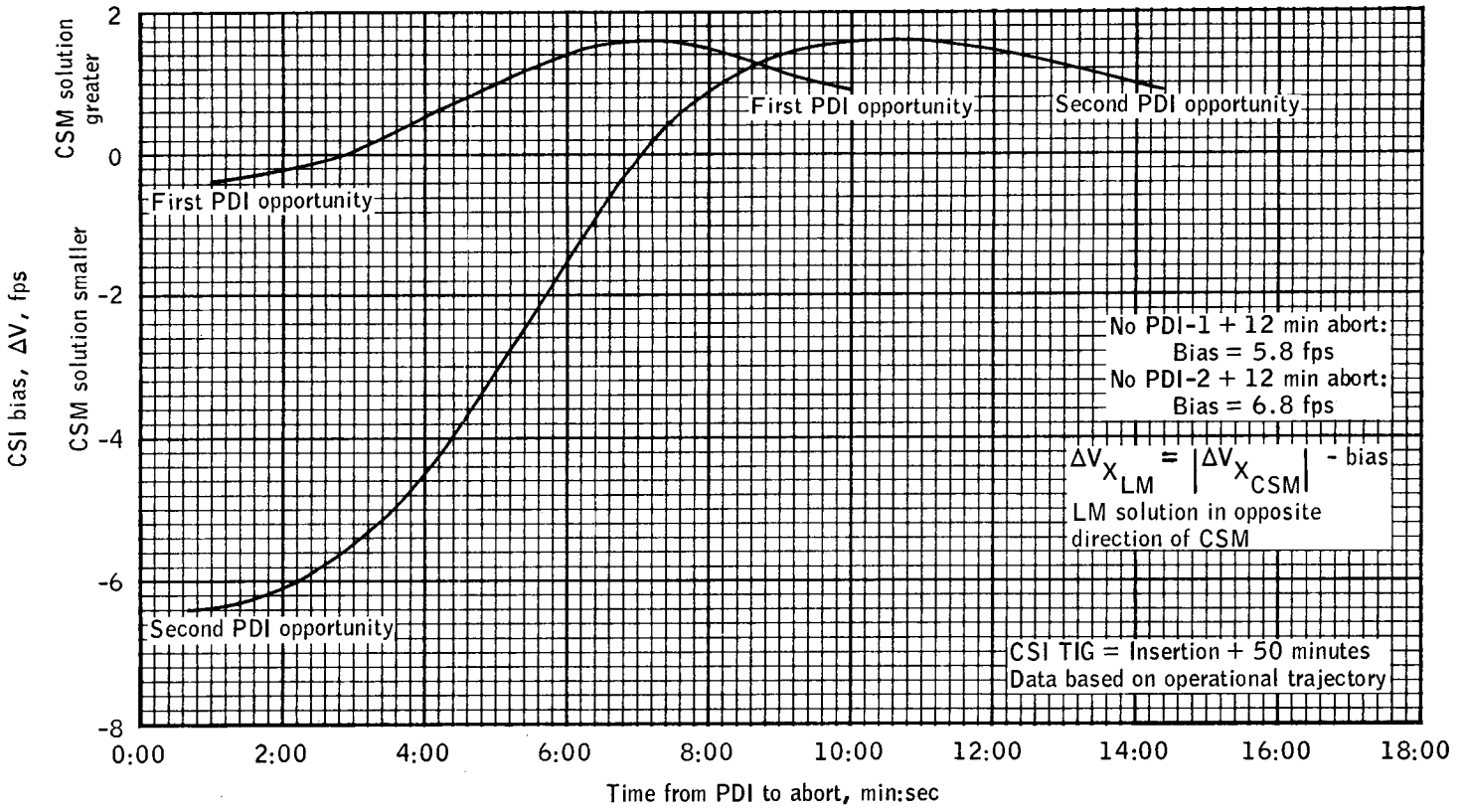
Maneuver ignition time chart.

LM crew chart 3.- Height adjust maneuver chart.
Lineberry/OMAB/MPAD
6/27/69
Final data.



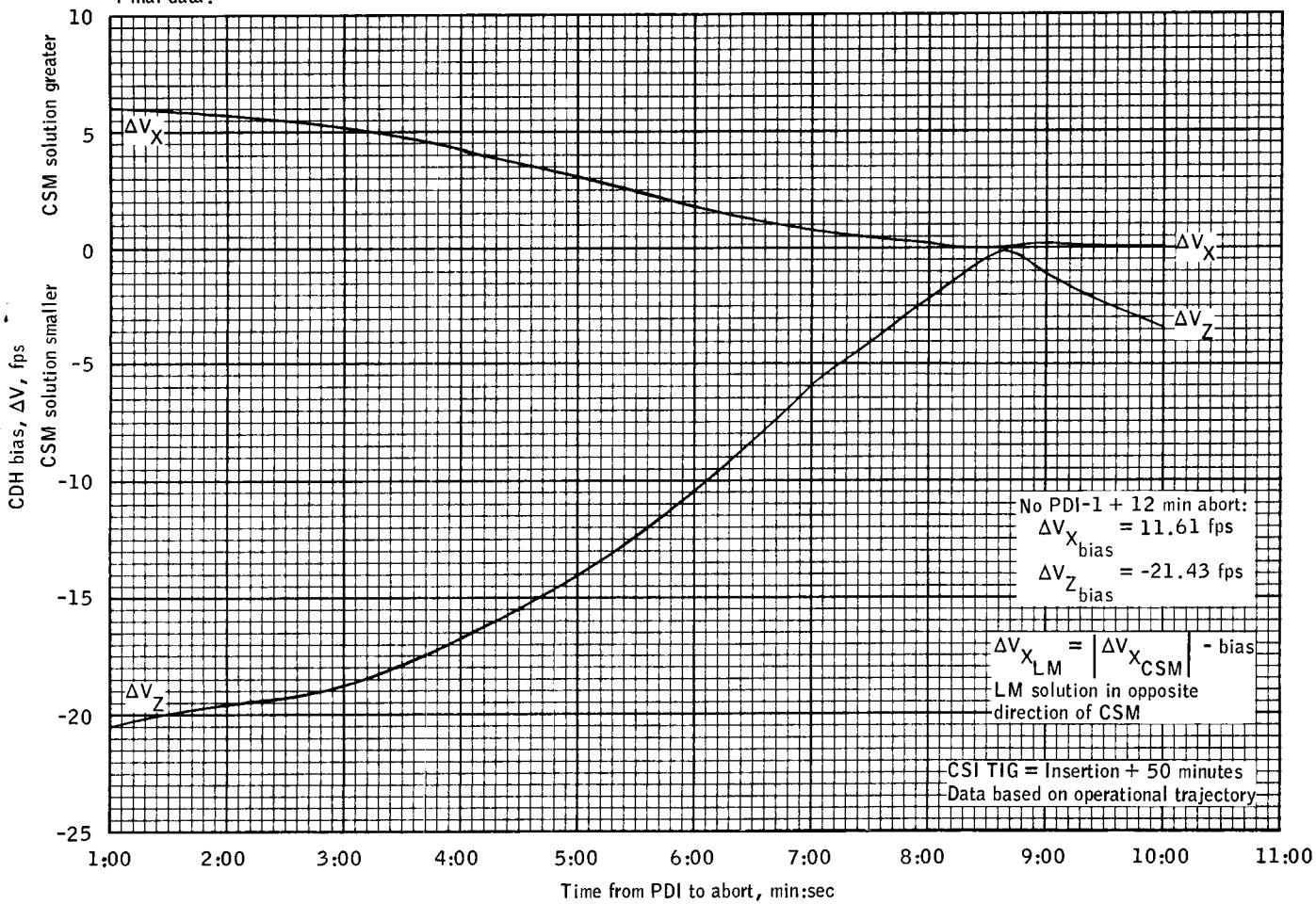
Height adjust maneuver chart.

LM crew chart 4.- Comparison between the LM and CSM solutions for CSI maneuver as a function of abort time in powered descent.
Bell/OMAB/MPAD
6/27/69
Final data.



Comparison between the LM and CSM solutions for CSI maneuver as a function of abort time in powered descent.

LM crew chart 5.- Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - first PDI opportunity (assuming CSM performs CSI).
Bell/OMAB/MPAD
6/27/69
Final data.



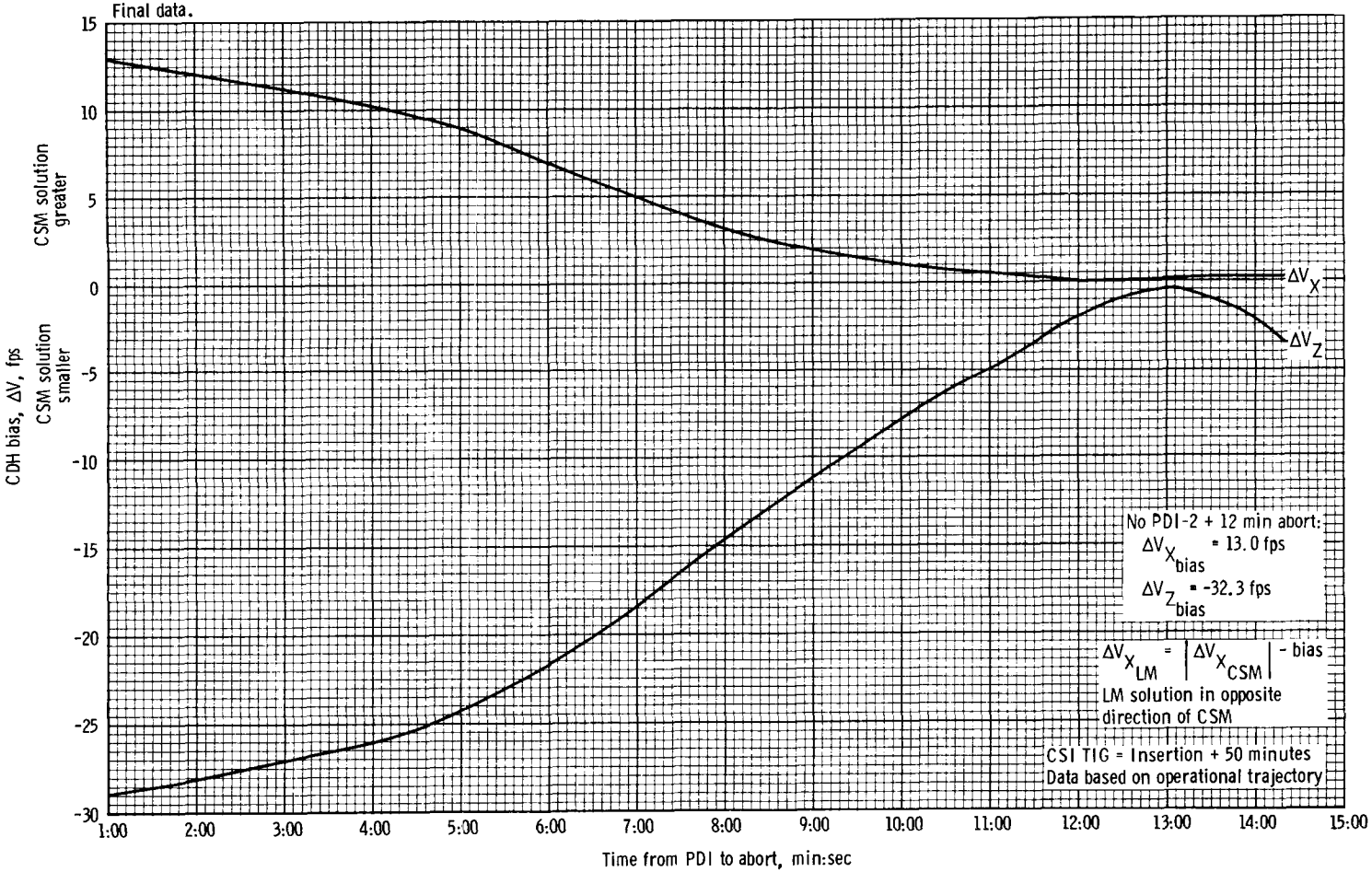
Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - first PDI opportunity (assuming CSM performs CSI).

Crew chart 6.- Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - second PDI opportunity (assuming CSM performs CSI).

Bell/OMAB/MPAD

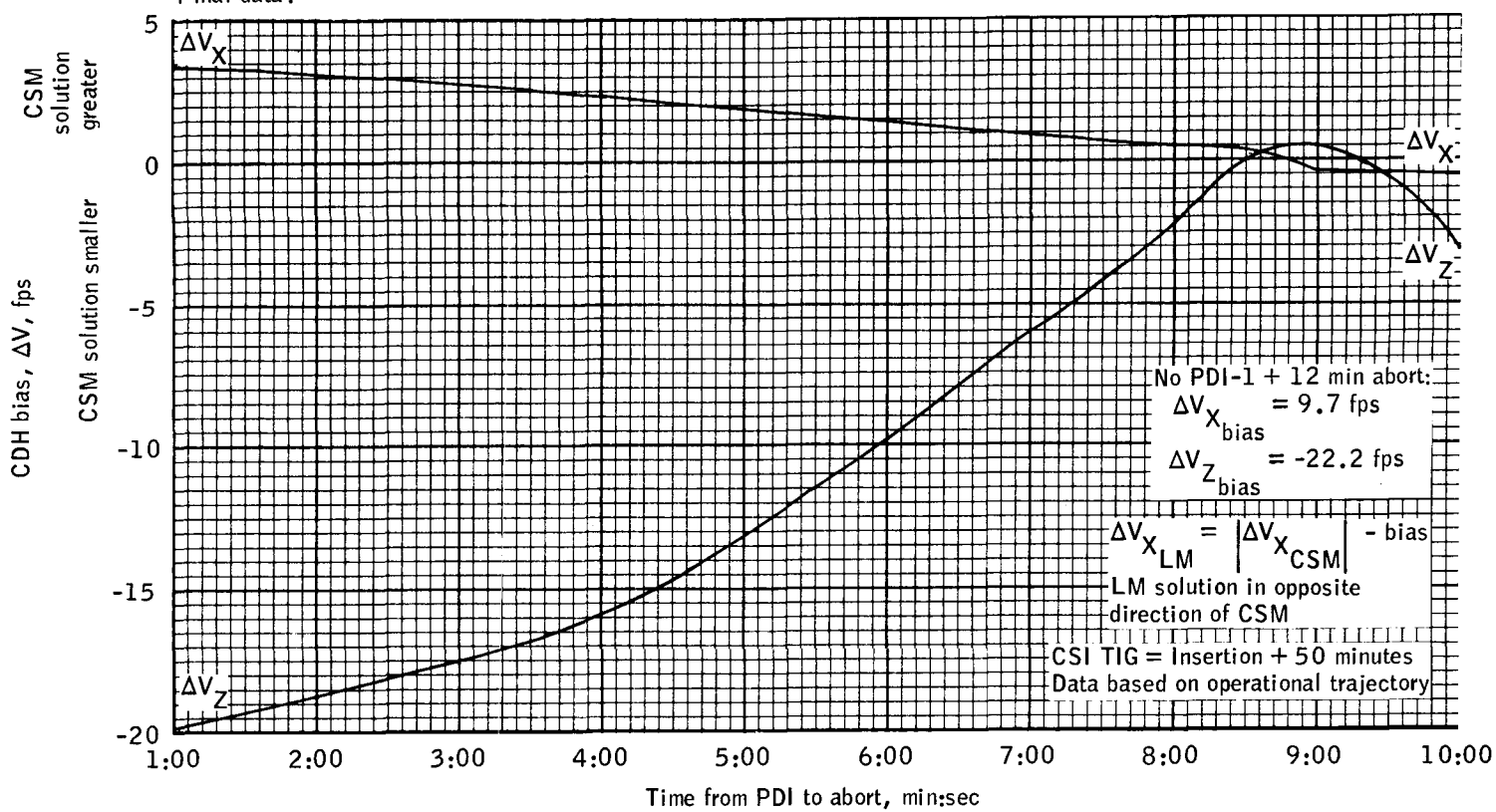
7/1/69

Final data.



Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - second PDI opportunity (assuming CSM performs CSI).

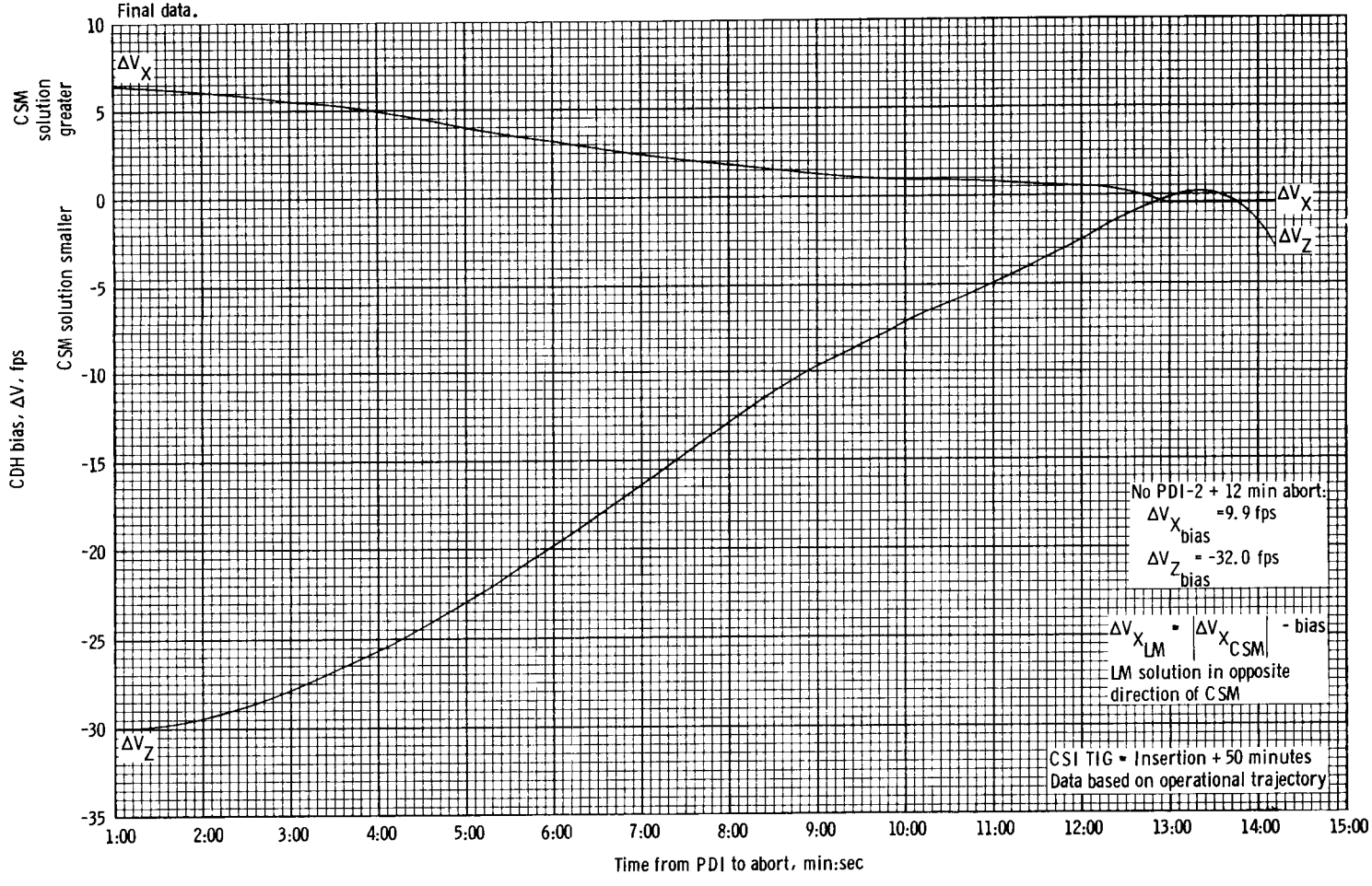
LM crew chart 7.- Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - first PDI opportunity (assuming LM performs CSI).
Bell/OMAB/MPAD
6/27/69
Final data.



Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - first PDI opportunity.
(assuming LM performs CSI).

Crew chart 8.- Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - second PDI opportunity (assuming LM performs CSI).

Bell/OMAB/MPAD
6/27/69
Final data.



Comparison between the LM and CSM solutions for CDH maneuver as a function of abort time in powered descent - second PDI opportunity.
(assuming LM performs CSI).

LM crew chart 9.- Powered descent maneuver crew chart.
Dupnick/LAB/MPAD
6/27/69
Final data.

PDI THRU TD + 3 MIN

	(OHW) θ	TFI	VI	HDOT	(ΔH) H	DPS
	(7) 286	00:00	5560	-4	(17 500) 48 800	95
ENG IGNITION DES ENG CMD OVRD - ON	(6) 285	00:30	5490	-5	48 700	94
	(10) 279	01:00	5200	-14.0	48 400	89
	(13) 275	01:30	4900	-21.0	47 900	84
LPD ALT CHECK	(16) 271	02:00	4600	-30.0	47 100	79
TM - H/HDOT	(18) 268	02:30	4280	-40.0	(17 500) 46 100	74
YAW RT 180° S-BD P = -11, Y = +14	267	03:00	3950	-53.0	44 700	68
	84	03:30	3620	-67.0	42 900	63
√ ED BATTS	82	04:00	3280	-80.0	40 700	58
V16N68E	80	04:30	2920	-95	38 000	53
V57 - ENABLE LR UPDATE	78	05:00	2550	-109	34 300	47
	76	05:30	2170	-122	31 200	42
THROTTLE DOWN	72	06:00	1780	-123	(17 500) 27 500	37
EVALUATE MAN CONT	68	06:30	1400	-114	(14 000) 24 000	32
	63	07:00	1180	-143	(10 500) 20 200	29
V16N68E	60	07:30	950	-157	(8 750) 16 200	26

	θ	TFI	VI		(ḢMAX) HDOT	H	HOR	DPS
	57	08:00	713		-157	11 450	60	22
	47	08:30	475		-139	6 950	49	19
P64			TR	LPD				
LDG ANT - HOVER	43	08:44	99	60	(-186) -112	5 000	45	18
	40	08:54	99	56	(-163) -95	4 000	42	17
S-BD P = +18, Y = -14	36	09:06	98	52	(-136) -76	3 000	38	16
223 + 00020 at 2000 FT	31	09:22	82	47	(-104) -55	2 000	33	15
	24	09:44	61	39	(-63) -32	1 000	25	13
	18	10:06	40	33	(-35) -16	500	18	12
PGNCS MODE CONT- ATT HOLD	16	10:14	32	31	(-29) -12	400	16	11
	13	10:26	20	31	(-21) -7	300	13	10
P65	9	10:48	0	43	(-12) -3	200	9	9
P66	2	11:26	-	-	(-2) -3	100	2	7
X-POINTER - LO MULT	2	11:42	-	-	-3	50	2	6
TOUCHDOWN	2	11:54	-	-	-3	13	2	6

ENG STOP - PUSH
ACA - OUT OF DETENT
MODE CONTROL (BOTH) AUTO
DES ENG CMD OVRD - OFF
ENG ARM - OFF
ASC FEED 2 (2) - CLOSE
223 + 00001
413 + 1

NO STAY

ABORT STAGE - PUSH
ENG ARM - ASC
ENG STOP - RESET
ENG START - PUSH

LM crew chart 10.- Onboard gaging LM descent and ascent oxygen quantity readout.
Swalin/GPB/MPAD
6/27/69
Final data.

ONBOARD GAGING LM DESCENT
OXYGEN QUANTITY READOUT

Time, g.e.t., hr:min	Mission phase	Tank quantity, percent
98:30	Cabin reg check	91.3
103:00	Post touchdown	87.5
110:30	EVA prep	82.0
116:36	Post equip. jettison	50.8
124:00	Switch to asc	45.5

ONBOARD GAGING
LM ASCENT OXYGEN QUANTITY READOUT

Time, g.e.t., hr:min	Mission phase	Tank 1 quantity, percent	Tank 2 quantity, percent
124:00	Switch to asc	91.1	91.1
124:27	Post lift-off	83.7	91.1
128:18	Post docking	19.7	91.1

LM crew chart 11.- Typical LM descent and ascent battery current.
Alexander/GPB/MPAD
6/27/69
Final data.

TYPICAL LM DESCENT
BATTERY CURRENT, AMPERES

Time, g.e.t., hr:min	Mission phase	Typical descent battery current, amps
98:00	Checkout	12
100:10	Undocking	14
101:42	DOI	18
102:00	Post DOI	16
102:40	Powered des	22
103:30	Sim countdown	12
111.00	Pre EVA	9
116:00	Post EVA	9
124:00	Power up	10

TYPICAL LM ASCENT
BATTERY CURRENT, AMPERES

Time, g.e.t., hr:min	Mission phase	Typical ascent battery current, amps
124:30	Powered ascent	30
125:00	Pre CSI	28
126:00	Pre CDH	26
126:45	Pre TPI	26
127:30	Pre dock	26

LM crew chart 12.- Onboard gaging LM RCS propellant quantity readout.
Mayfield/GPB/MPAD
6/27/69
Final data.

ONBOARD GAGING
LM RCS PROPELLANT QUANTITY READOUT

Mission phase	System A, percent	System B, percent
Post DOI	97	94
Post touchdown	87	83
Post insertion	87	83
Post CSI	79	75
Post CDH	77	71
Post TPI	73	67
Post docking	63	60

LM crew chart 13.- Onboard gaging LM descent and ascent water quantity readout.
Swalin/GPB/MPAD
6/27/69
Final data.

ONBOARD GAGING LM DESCENT
WATER QUANTITY READOUT

Time, g.e.t., hr:min	Mission phase	Tank quantity, percent
100:18	Undocking	90.6
103:00	Post touchdown	81.9
110:30	EVA prep	64.7
116:36	Post equip. jettison	50.8
124:23	Lift-off	32.4

ONBOARD GAGING LM ASCENT
WATER QUANTITY READOUT

Time, g.e.t., hr:min	Mission phase	Tank 1 quantity, percent	Tank 2 quantity, percent
124:23	Lift-off	100	100
128:00	Docking	72.5	72.5
131:54	LM jettison	46.5	46.5

LM crew chart 14.- Planet half-unit vectors.
Blucker/MPB/MPAD
6/27/69
Final data.

VENUS HALF-UNIT VECTORS*

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	.16785	.44066	.16630
07:16:22	.16410	.44183	.16693
07:17:08	.16034	.44297	.16756
07:17:18	.15657	.44409	.16817
07:18:04	.15280	.44517	.16877
07:18:14	.14901	.44623	.16937
07:19:00	.14521	.44726	.16995
07:19:10	.14141	.44826	.17052
07:19:20	.13759	.44923	.17108
07:20:06	.13377	.45017	.17164
07:20:16	.12994	.45108	.17218
07:21:02	.12611	.45197	.17271
07:21:12	.12226	.45283	.17323
07:21:22	.11841	.45365	.17374
07:22:08	.11455	.45445	.17424
07:22:18	.11068	.45522	.17474
07:23:04	.10680	.45596	.17522

GMT M:D:H	X vector	Y vector	Z vector
07:23:14	.10292	.45667	.17569
07:24:00	.09903	.45735	.17615
07:24:10	.09513	.45801	.17660
07:24:20	.09122	.45863	.17704
07:25:06	.08730	.45923	.17747
07:25:16	.08338	.45979	.17789
07:26:02	.07945	.46033	.17830
07:26:12	.07551	.46084	.17871
07:26:22	.07155	.46132	.17910
07:27:08	.06759	.46176	.17948
07:27:18	.06362	.46218	.17985
07:28:04	.05964	.46257	.18021
07:28:14	.05565	.46294	.18056
07:29:00	.05164	.46327	.18090
07:29:10	.04763	.46357	.18122
07:29:20	.04360	.46384	.18154

*Venus is the only planet visible from the landing sites and is visible for the entire lunar stay for sites II, III, and V.

LM crew chart 14.- Planet half-unit vectors (Concluded).
Blucker/MPB/MPAD
6/27/69
Final data.

MARS HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	-.23404	-.39277	-.20239
07:18:04	-.23249	-.39349	-.20278
07:19:20	-.23053	-.39441	-.20324
07:21:12	-.22818	-.39550	-.20377
07:23:04	-.22546	-.39676	-.20434
07:24:20	-.22244	-.39815	-.20495
07:26:12	-.21915	-.39964	-.20559
07:28:04	-.21568	-.40119	-.20623
07:29:20	-.21208	-.40278	-.20687

SATURN HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	.39437	.28972	.10270
07:24:20	.39204	.29254	.10360
08:02:04	.39024	.29472	.10424

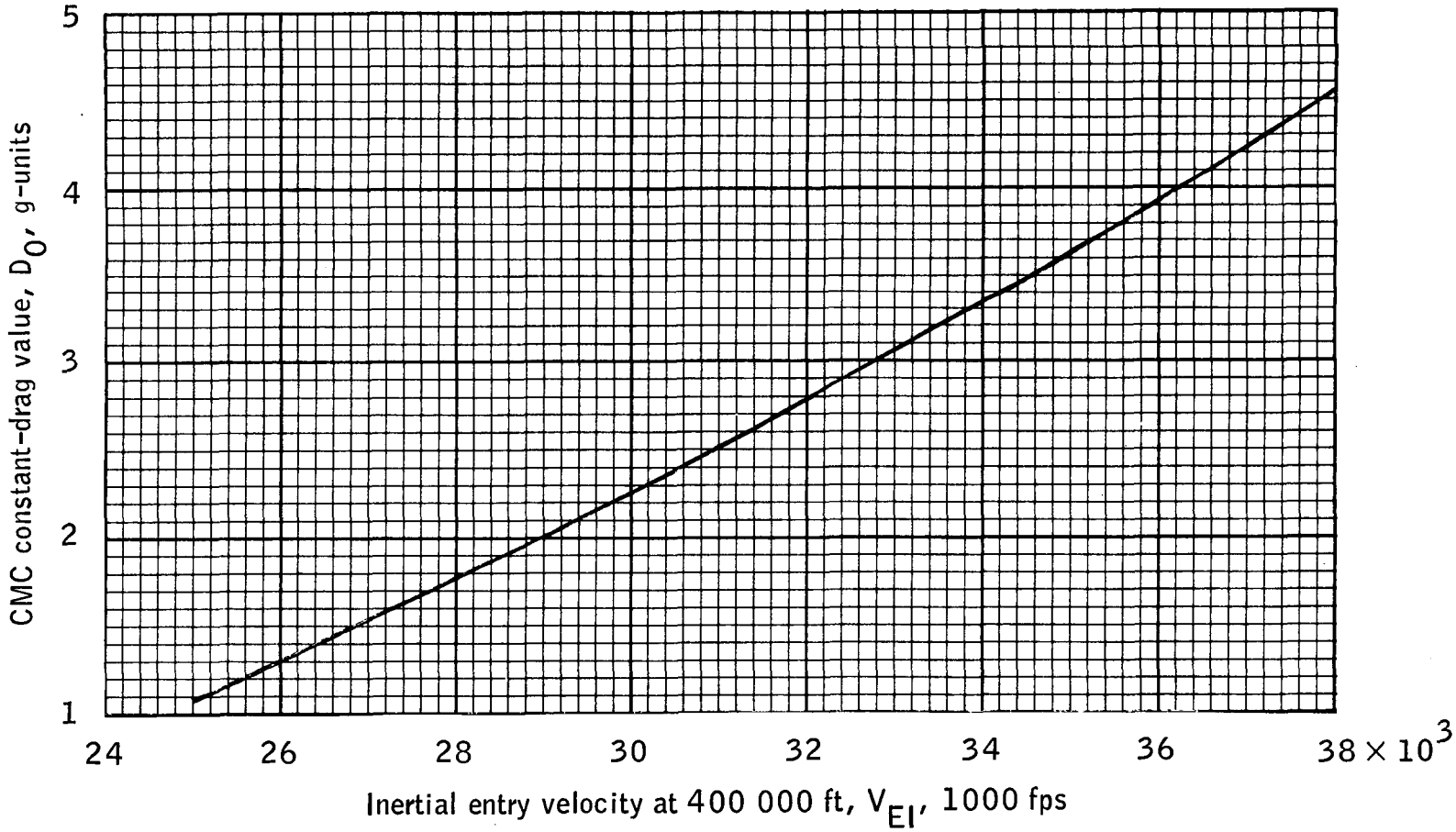
JUPITER HALF-UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X vector	Y vector	Z vector
07:16:12	-.49989	-.00530	.00943
07:19:20	-.49986	-.00910	.00768
07:23:04	-.49980	-.01306	.00587
07:26:12	-.49970	-.01714	.00401
07:29:20	-.49955	-.02132	.00212

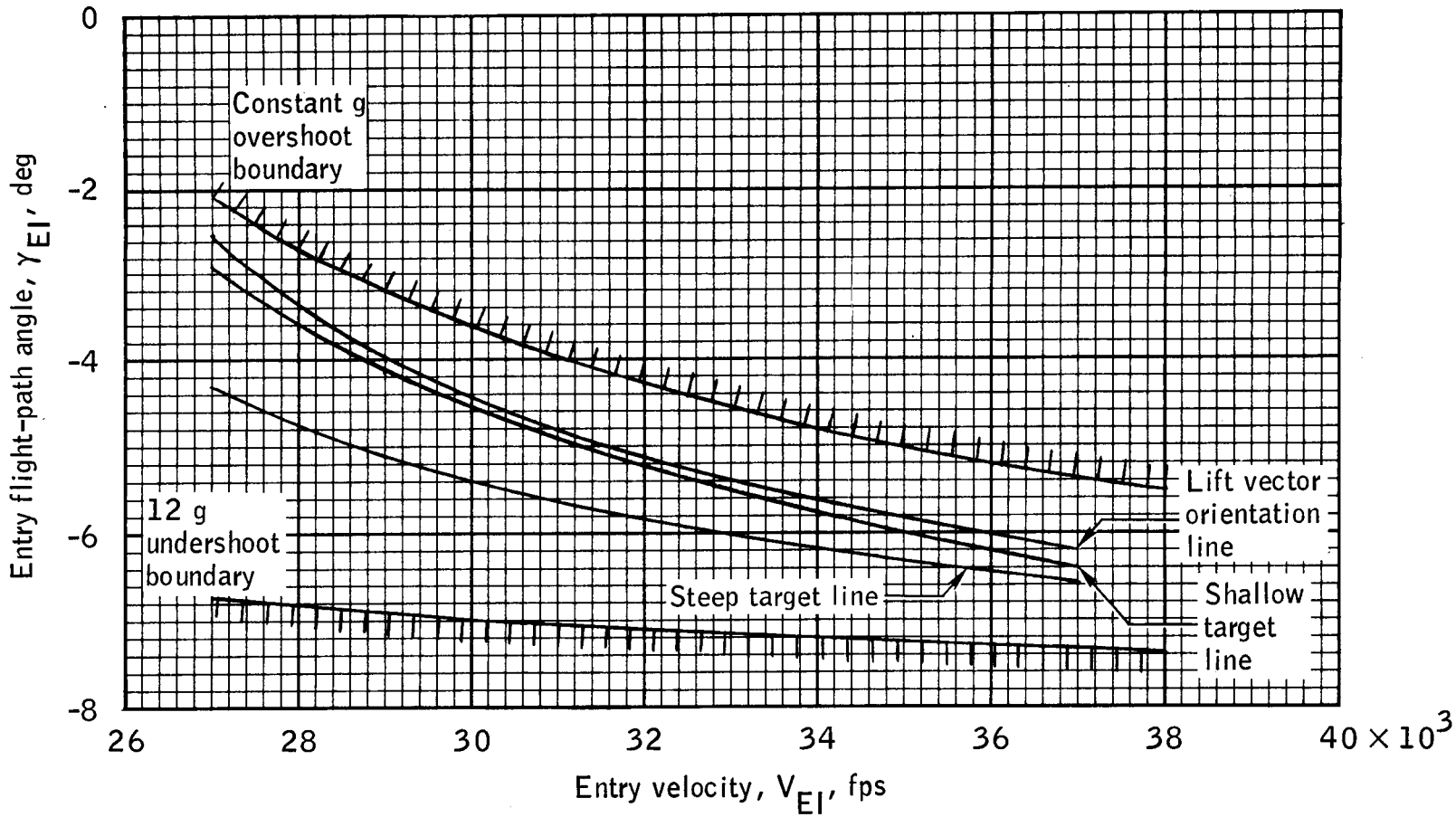
CONSOLE CHARTS

Console chart 1(CSM).- Command module computer constant-drag value.
Rogers/LAB/MPAD
6/27/69
Final data.



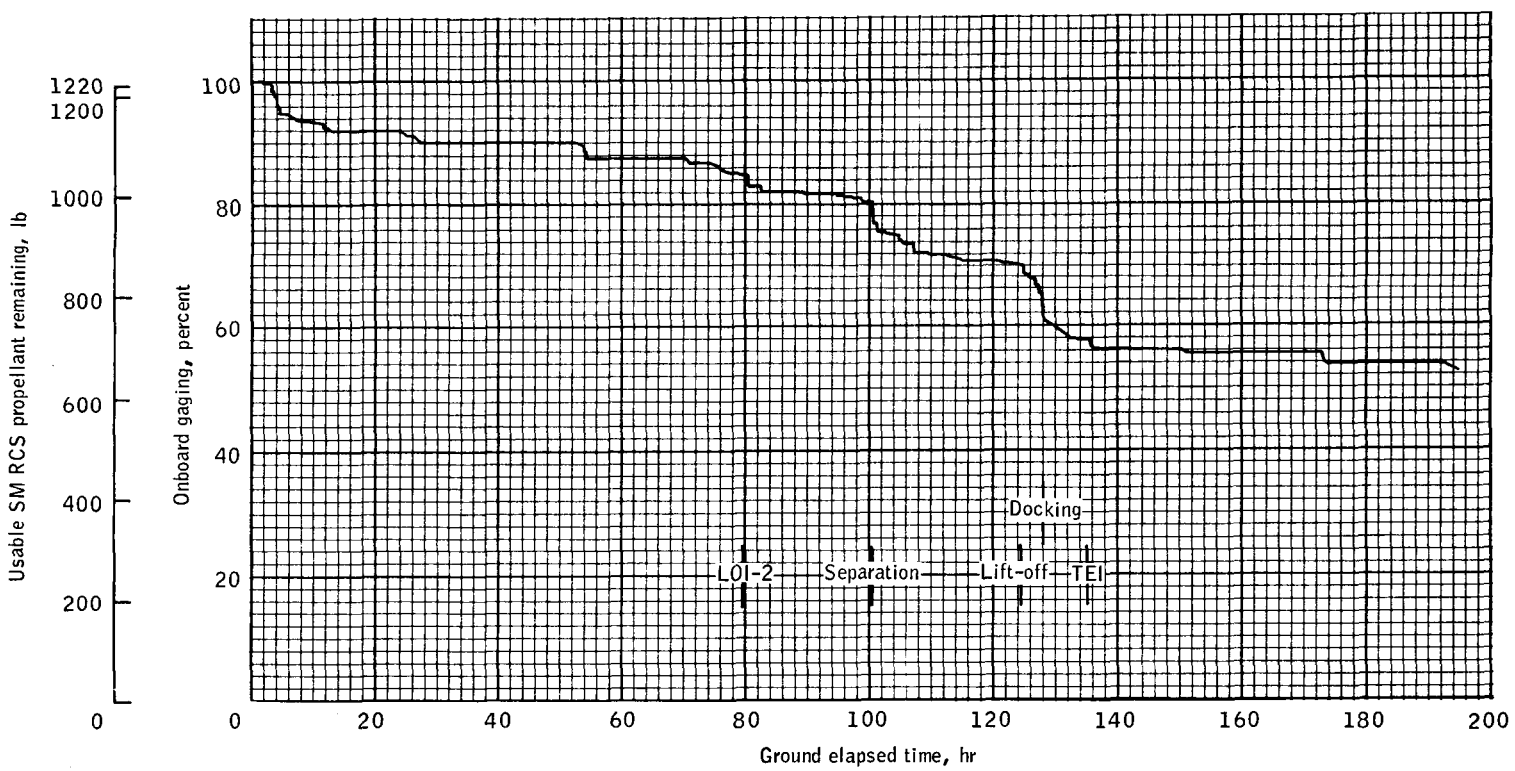
Command module computer constant-drag value.

Console chart 2(CSM). - Entry corridor.
Rogers/LAB/MPAD
6/27/69
Final data.



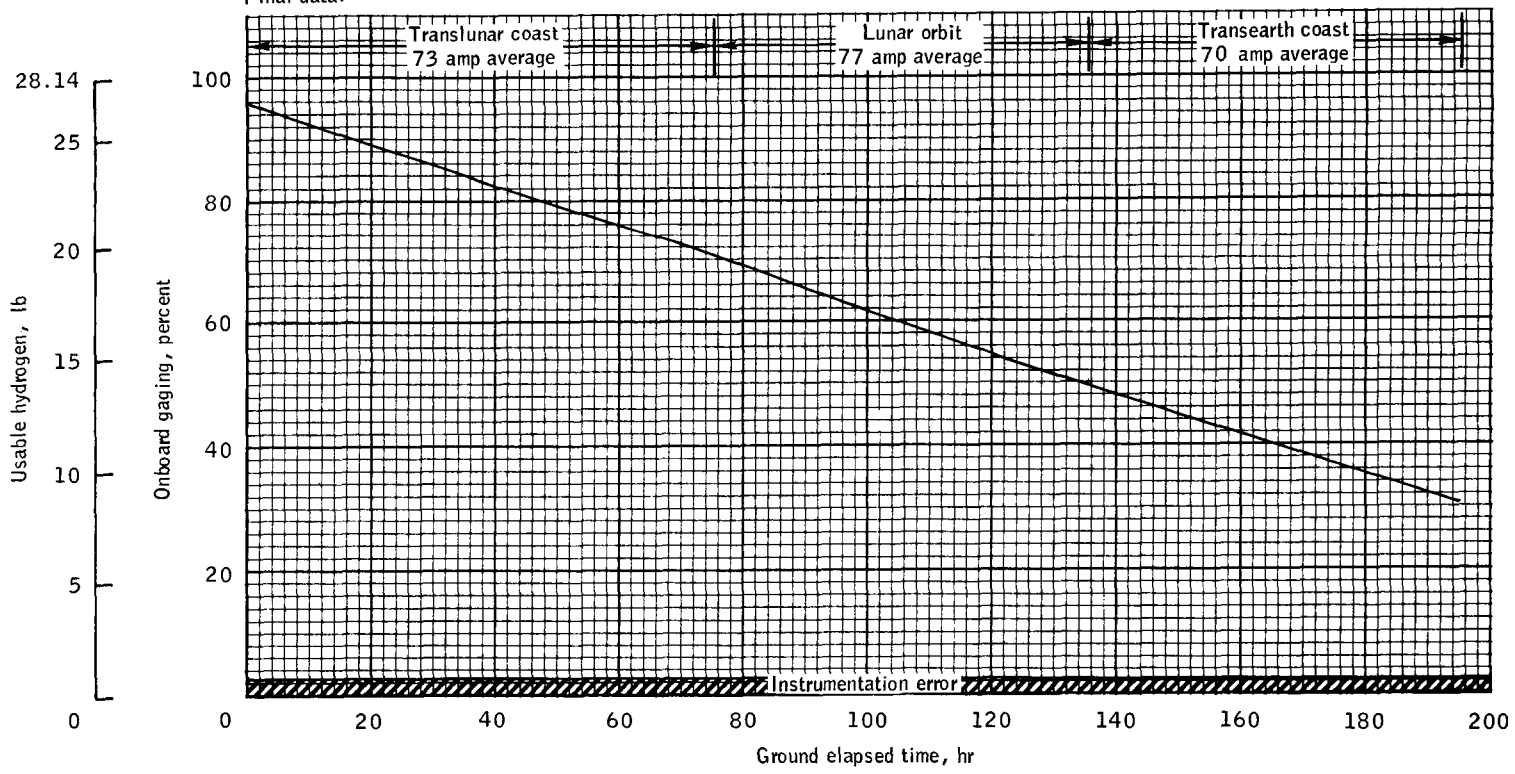
Entry corridor.

Console chart 3(CSM). - Total SM RCS propellant profile.
Loyd/GPB/MPAD
6/27/69
Final data.



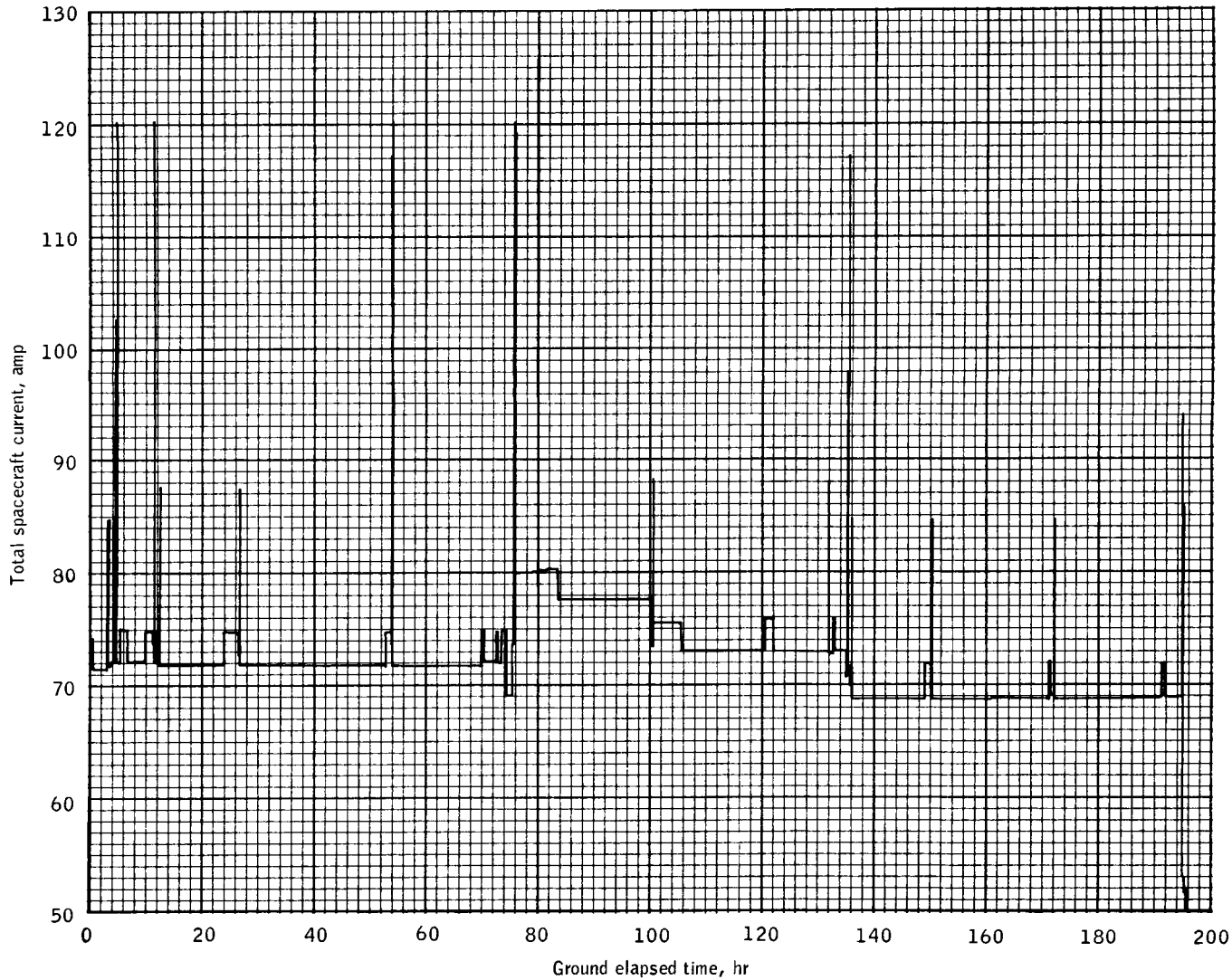
Total SM RCS propellant profile.

Console chart 4(CSM). - Hydrogen remaining in one tank.
Scott/GPB/MPAD
6/27/69
Final data.



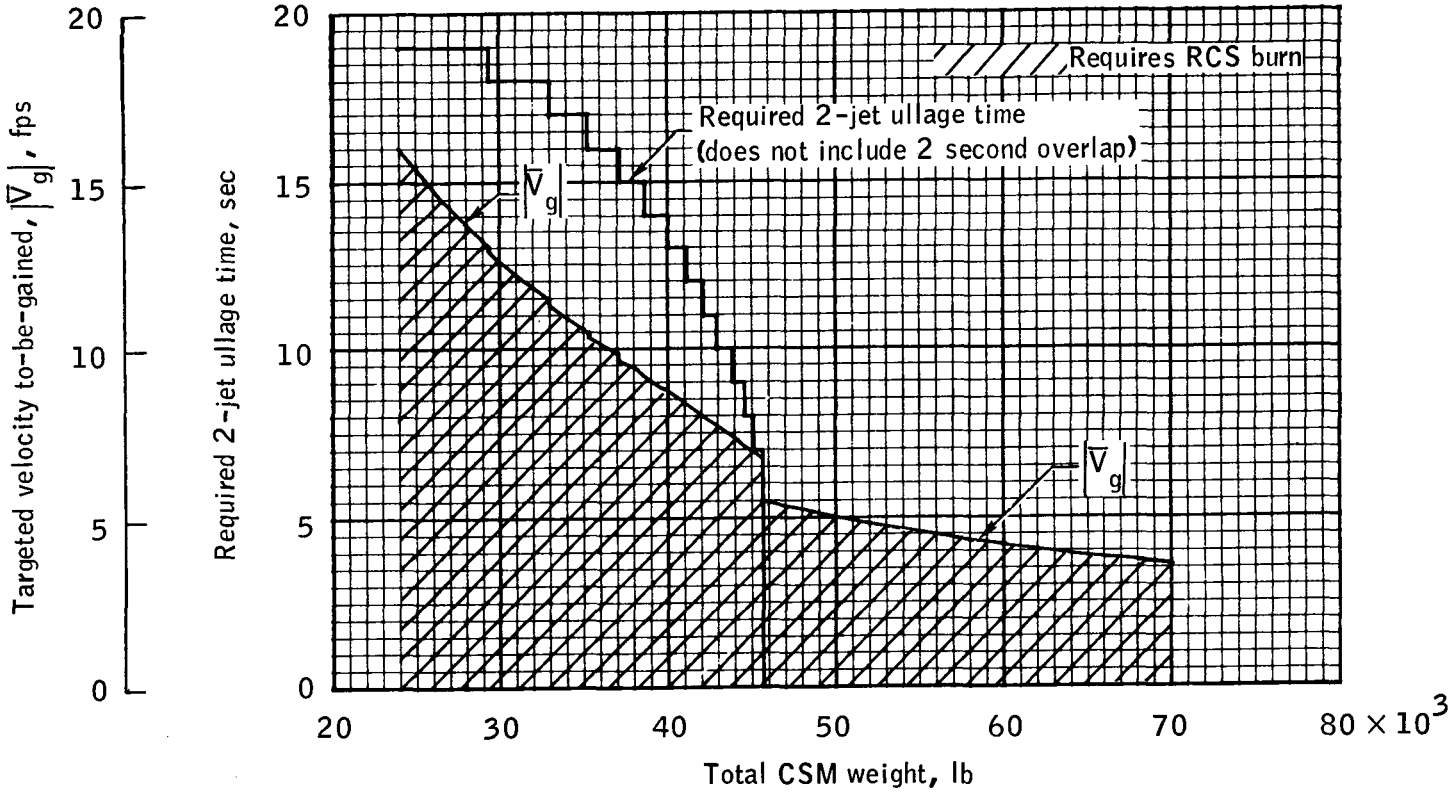
Hydrogen remaining in one tank.

Console chart 5(CSM). - CSM battery/fuel cell current.
Scott/GPB/MPAD
6/27/69
Final data.



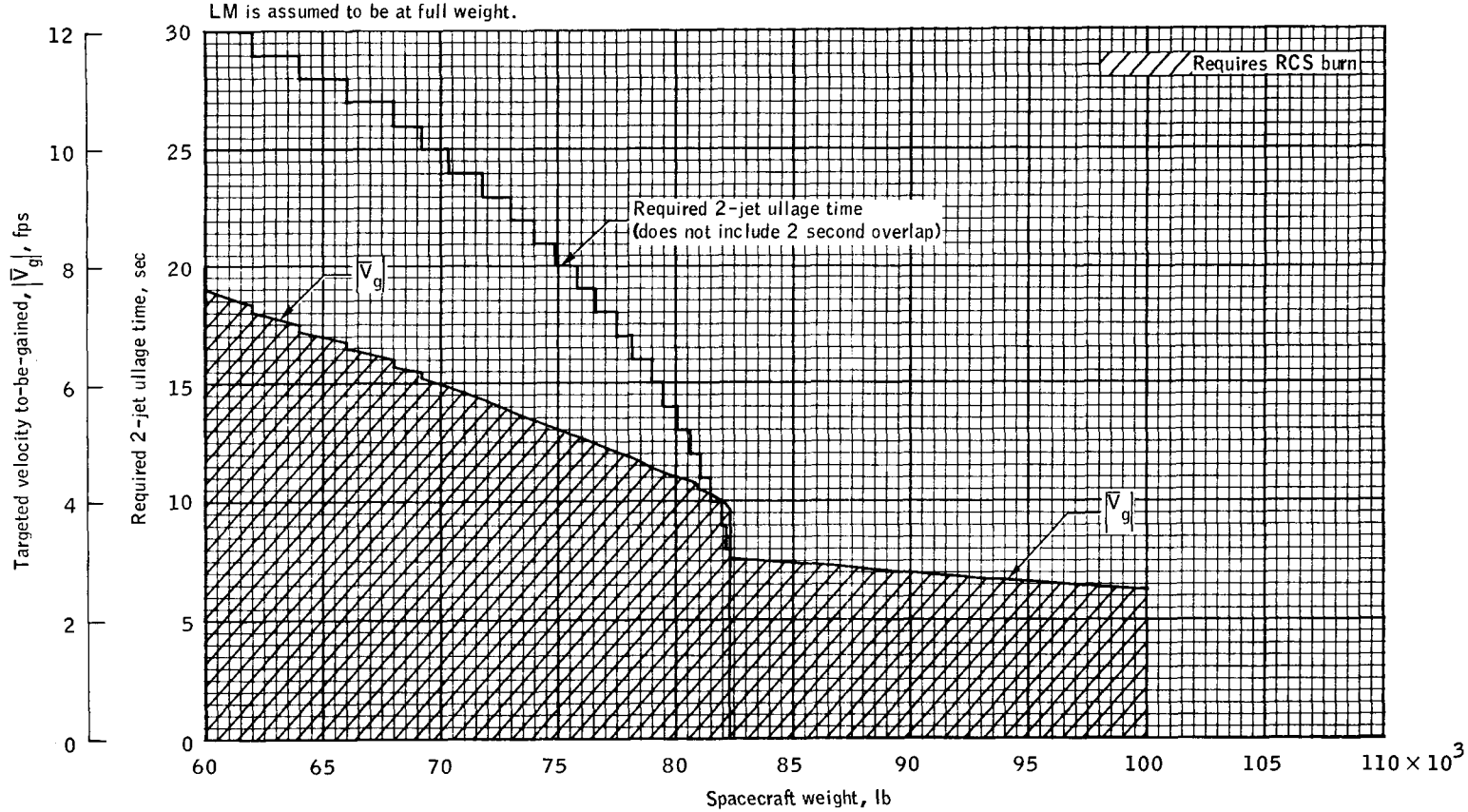
CSM battery/fuel cell current.

Console chart 6(CSM). - SPS versus RCS criteria (CSM alone).
Graf/GPB/MPAD
6/27/69
Final data.
This chart assumes that the minimum desired SPS burn time is 0.5 seconds and that the ullage time is the required time shown on the chart.



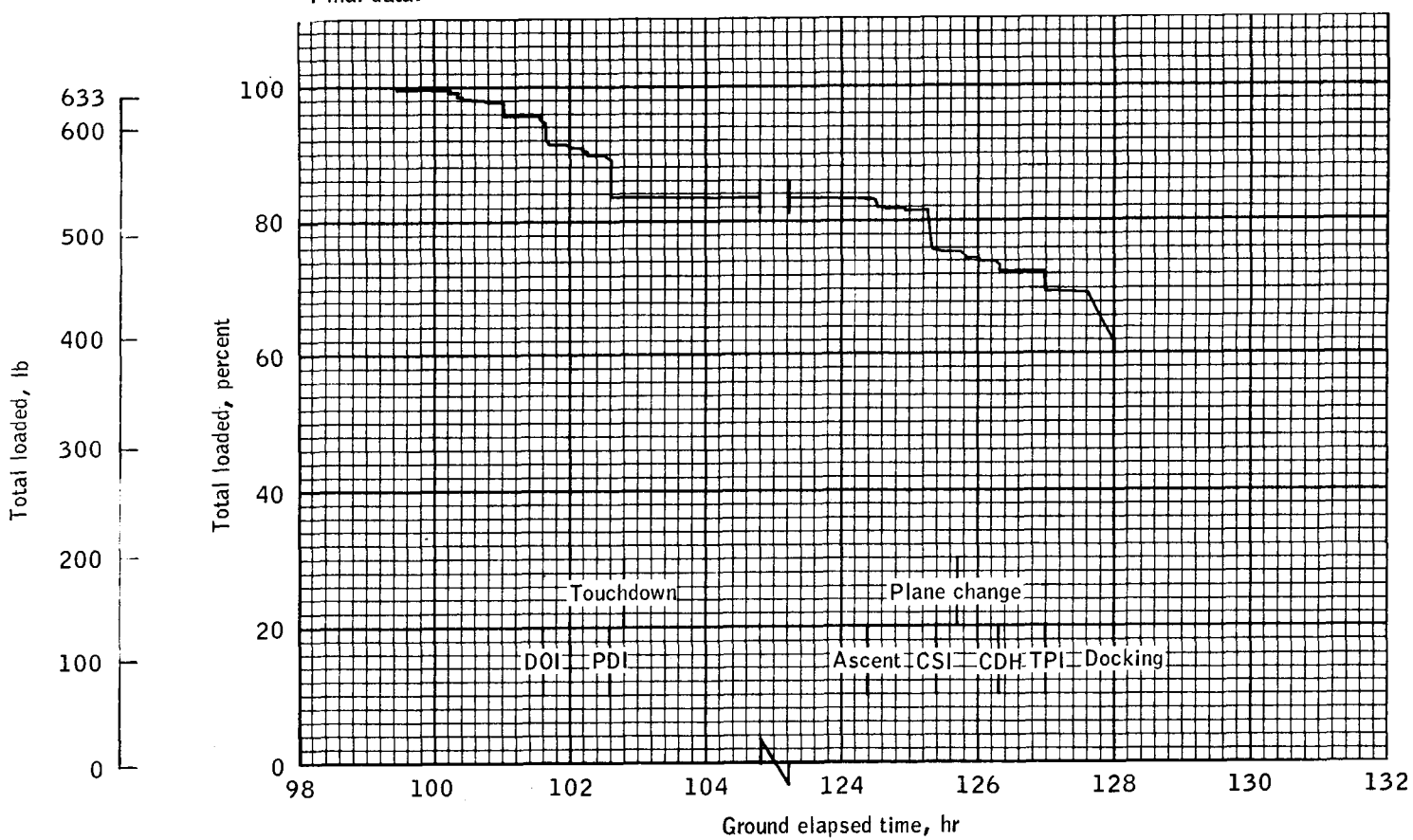
SPS versus RCS criteria (CSM alone).

Console chart 7(CSM). - SPS versus RCS criteria (CSM/LM docked).
Graf/GPB/MPAD
6/27/69
Final data.
This chart assumes that the minimum desired SPS burn time is 0.5 seconds and that the ullage time is the required time shown on the chart.
LM is assumed to be at full weight.



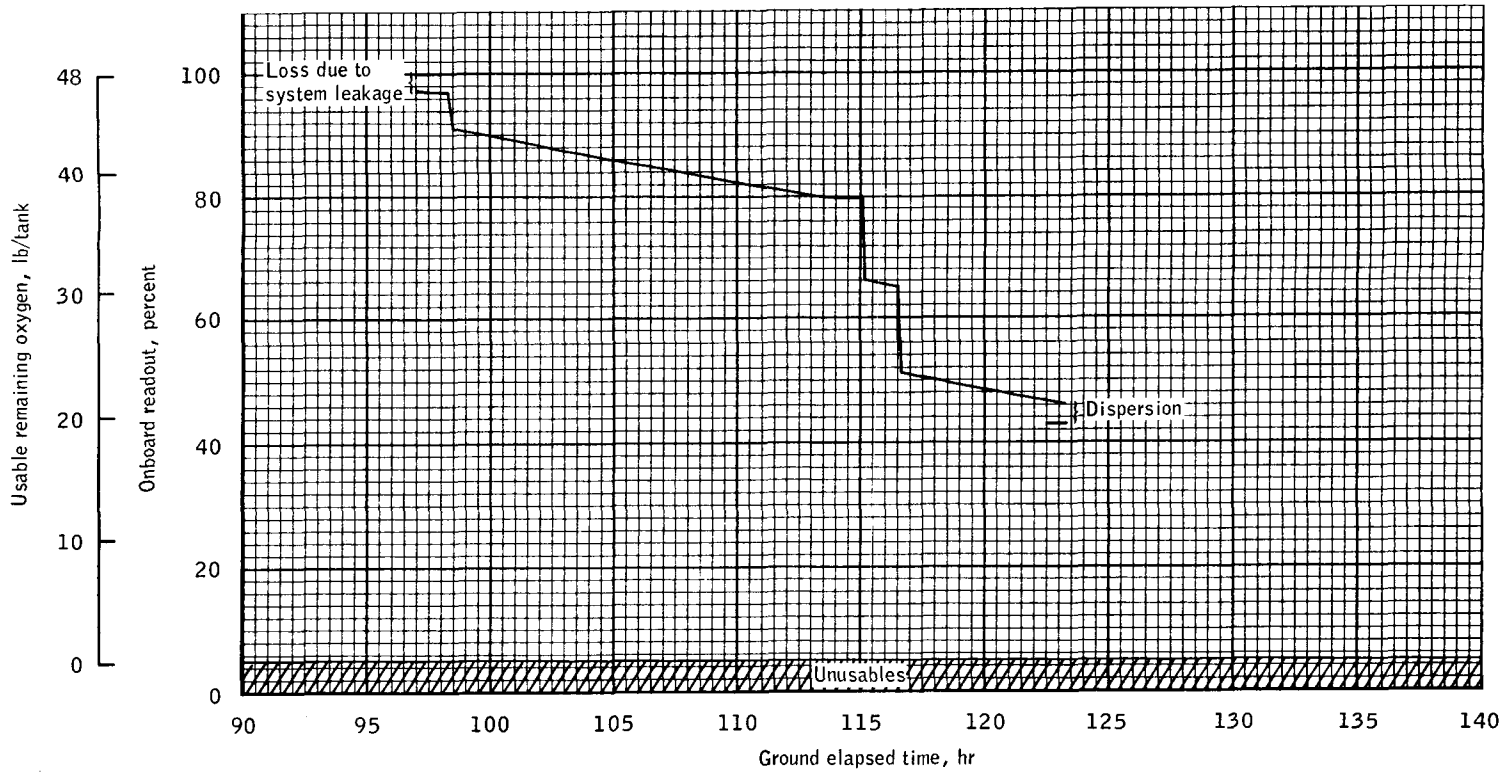
SPS versus RCS criteria (CSM/LM docked).

Console chart 8(LM). - LM RCS propellant profile.
Mayfield/GPB/MPAD
6/27/69
Final data.



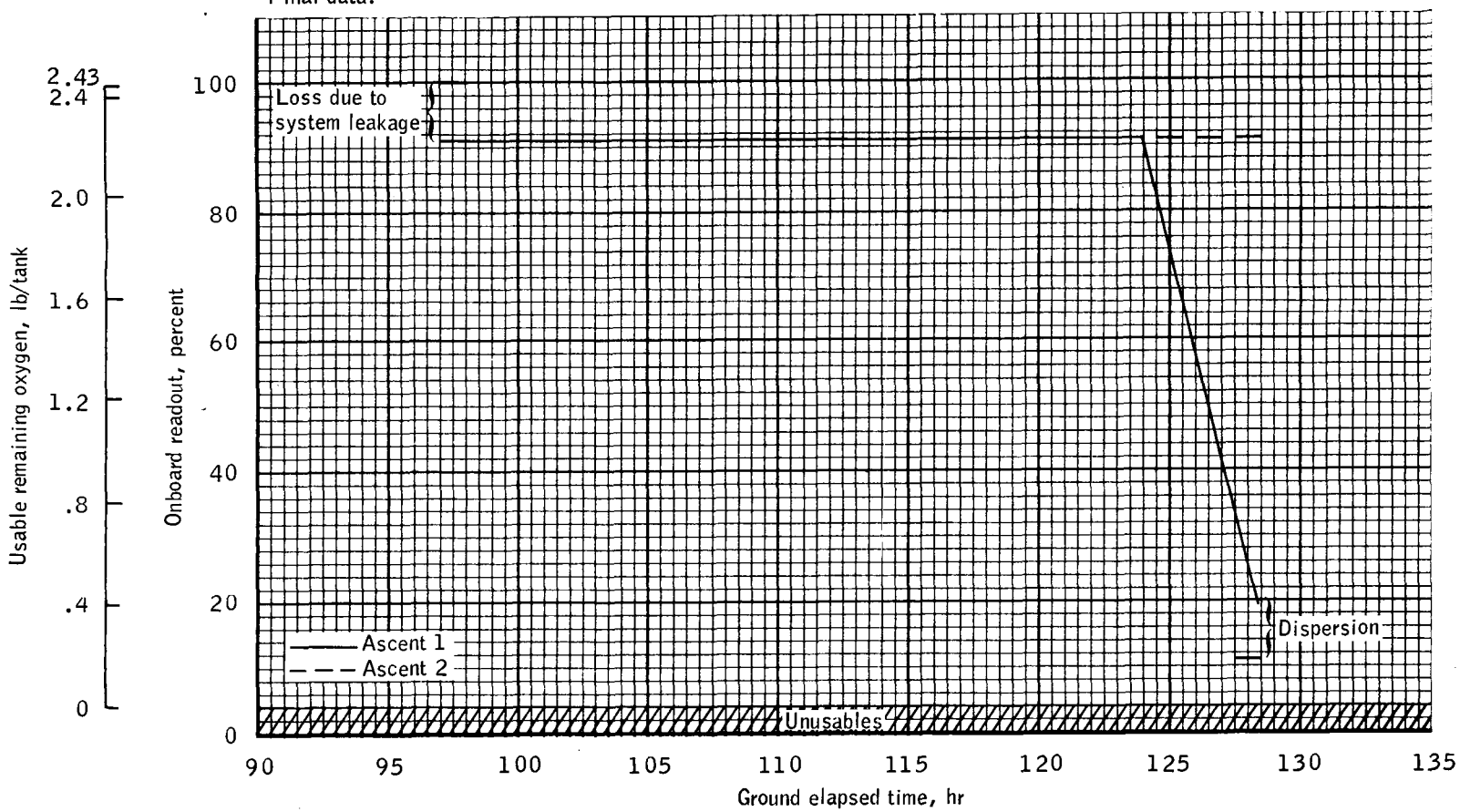
LM RCS propellant profile.

Console chart 9(LM). - Descent oxygen tank quantities as a function of mission time.
Swalin/GPB/MPAD
6/27/69
Final data.



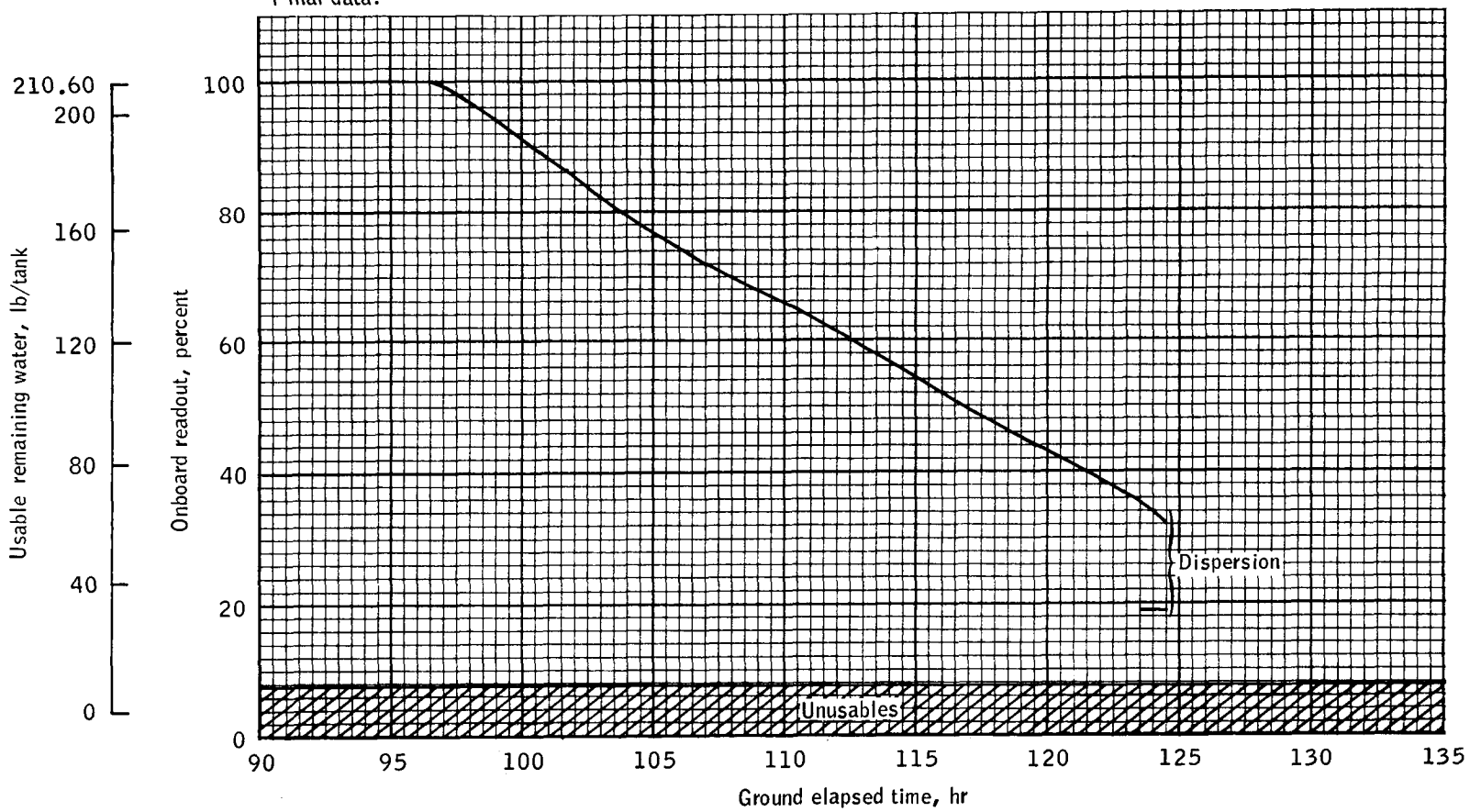
Descent oxygen tank quantities as a function of mission time.

Console chart 10(LM). - Ascent oxygen tank quantities as a function of mission time.
Swalin/GPB/MPAD
6/27/69
Final data.



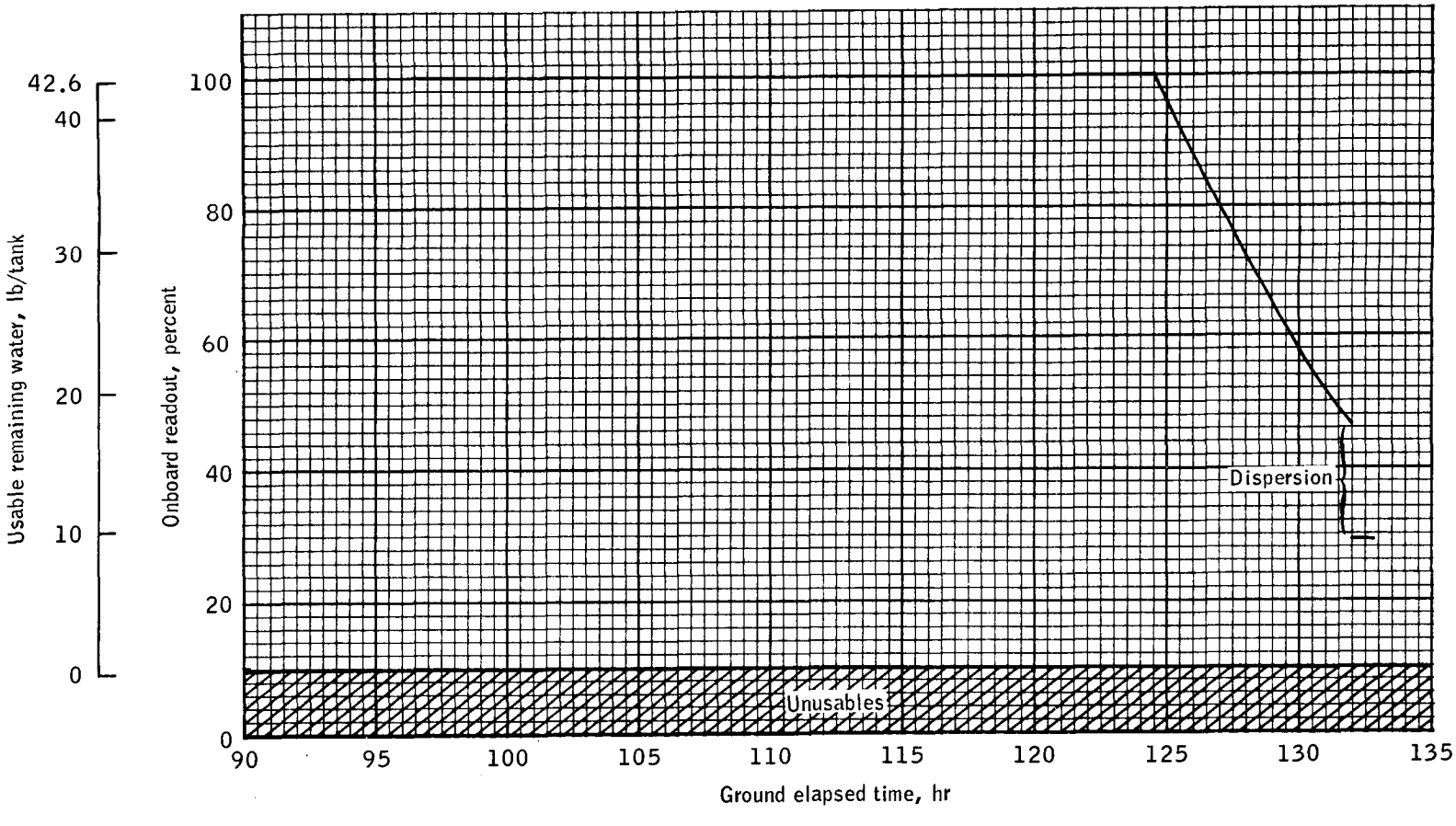
Ascent oxygen tank quantities as a function of mission time.

Console chart 11(LM). - Descent water tank quantities as a function of mission time.
Swalin/GPB/MPAD
6/27/69
Final data.



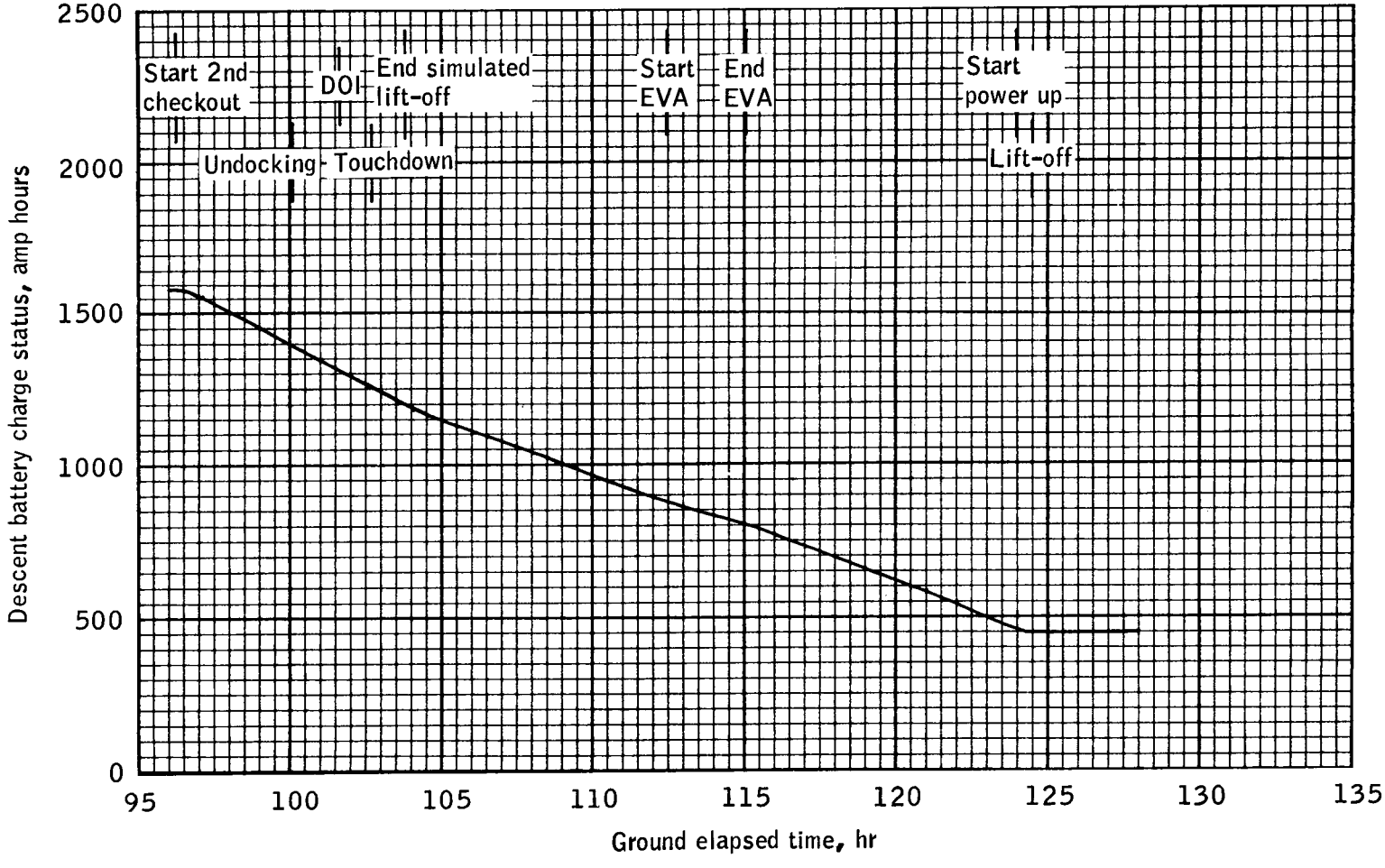
Descent water tank quantities as a function of mission time.

Console chart 12(LM). - Ascent water tank quantities as a function of mission time.
Swalin/GPB/MPAD
6/27/69
Final data.



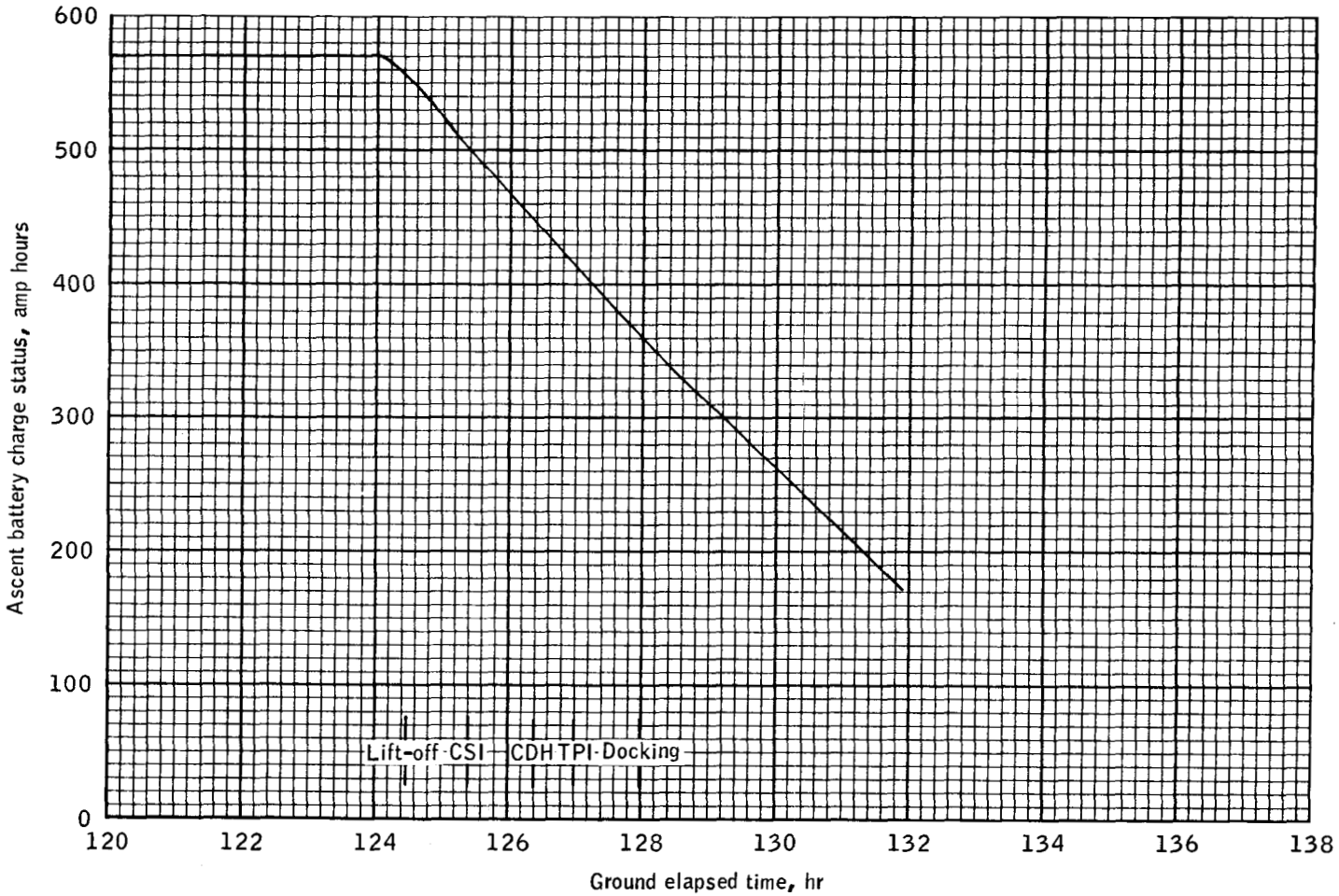
Ascent water tank quantities as a function of mission time.

Console chart 13(LM). - LM-5 descent amp hours remaining.
Alexander/GPB/MPAD
6/27/69
Final data.



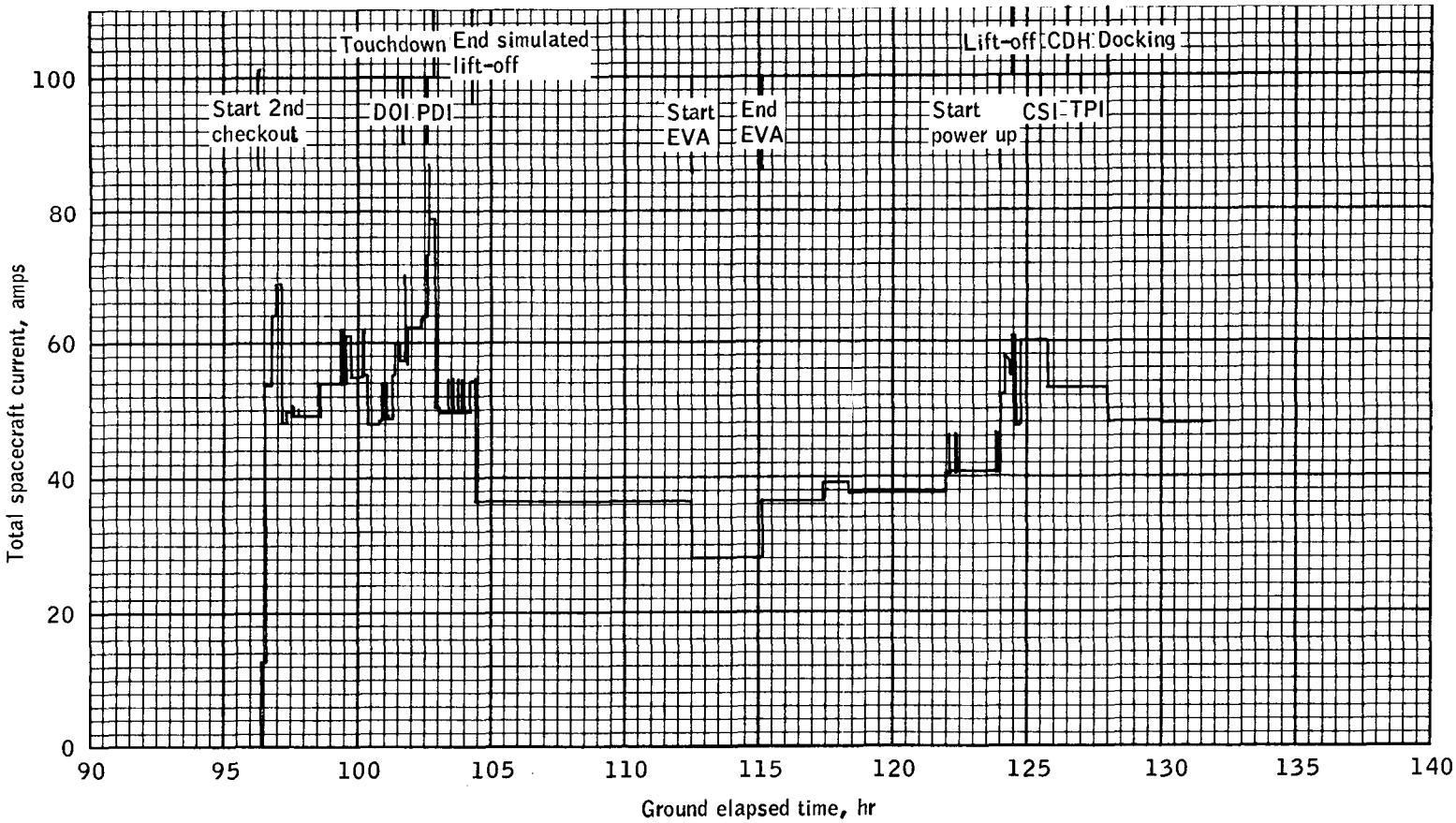
LM-5 descent amp hours remaining.

Console chart 14(LM). - LM-5 ascent amp hours remaining.
Alexander/GPB/MPAD
6/27/69
Final data.



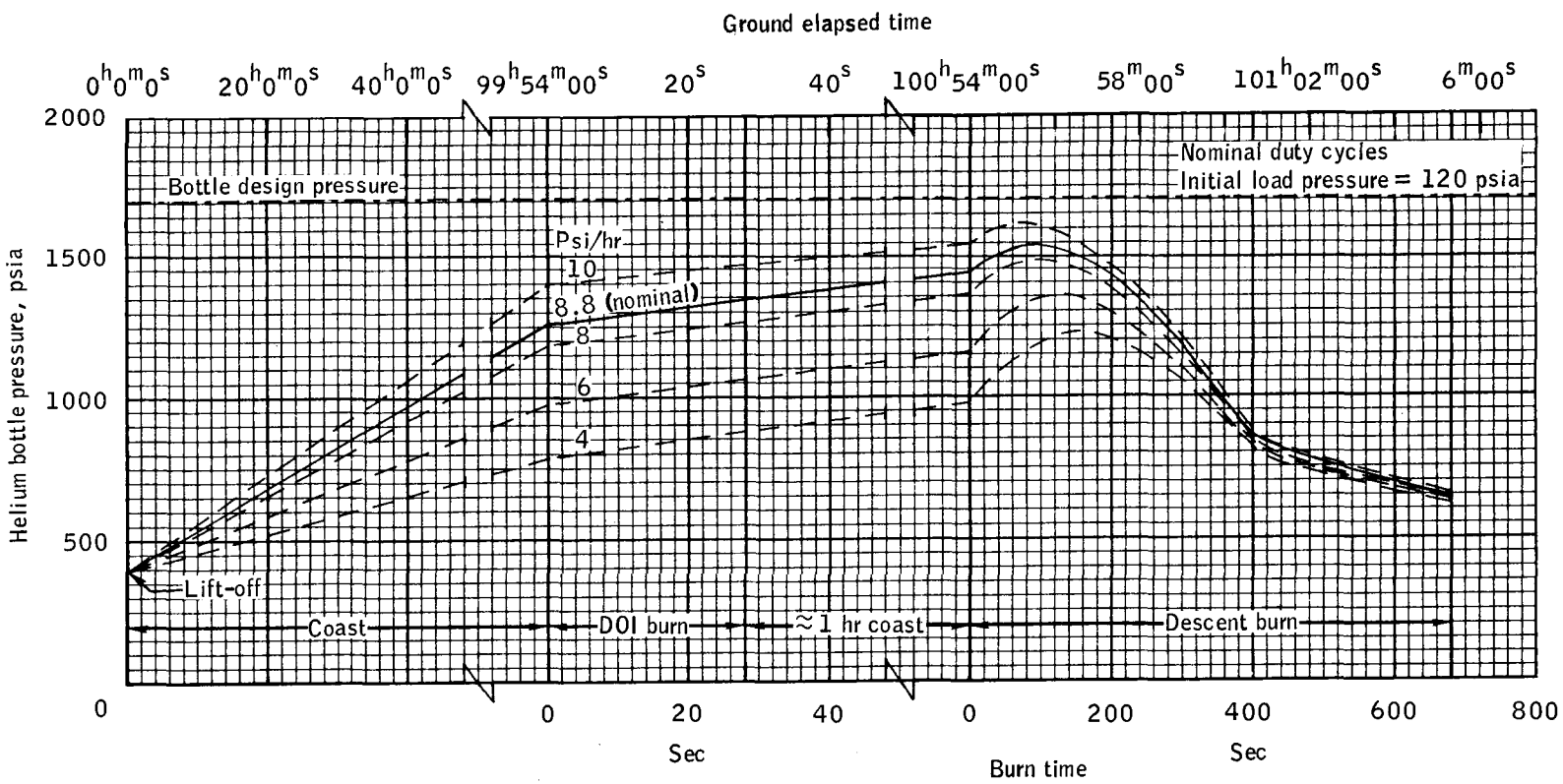
LM-5 ascent amp hours remaining.

Console chart 15(LM). - LM-5 total spacecraft current.
Alexander/GPB/MPAD
6/27/69
Final data.



LM-5 total spacecraft current.

Console chart 16(LM). - Super-critical helium.
Beal/GPB/MPAD
6/27/69
Final data.



Super-critical helium.