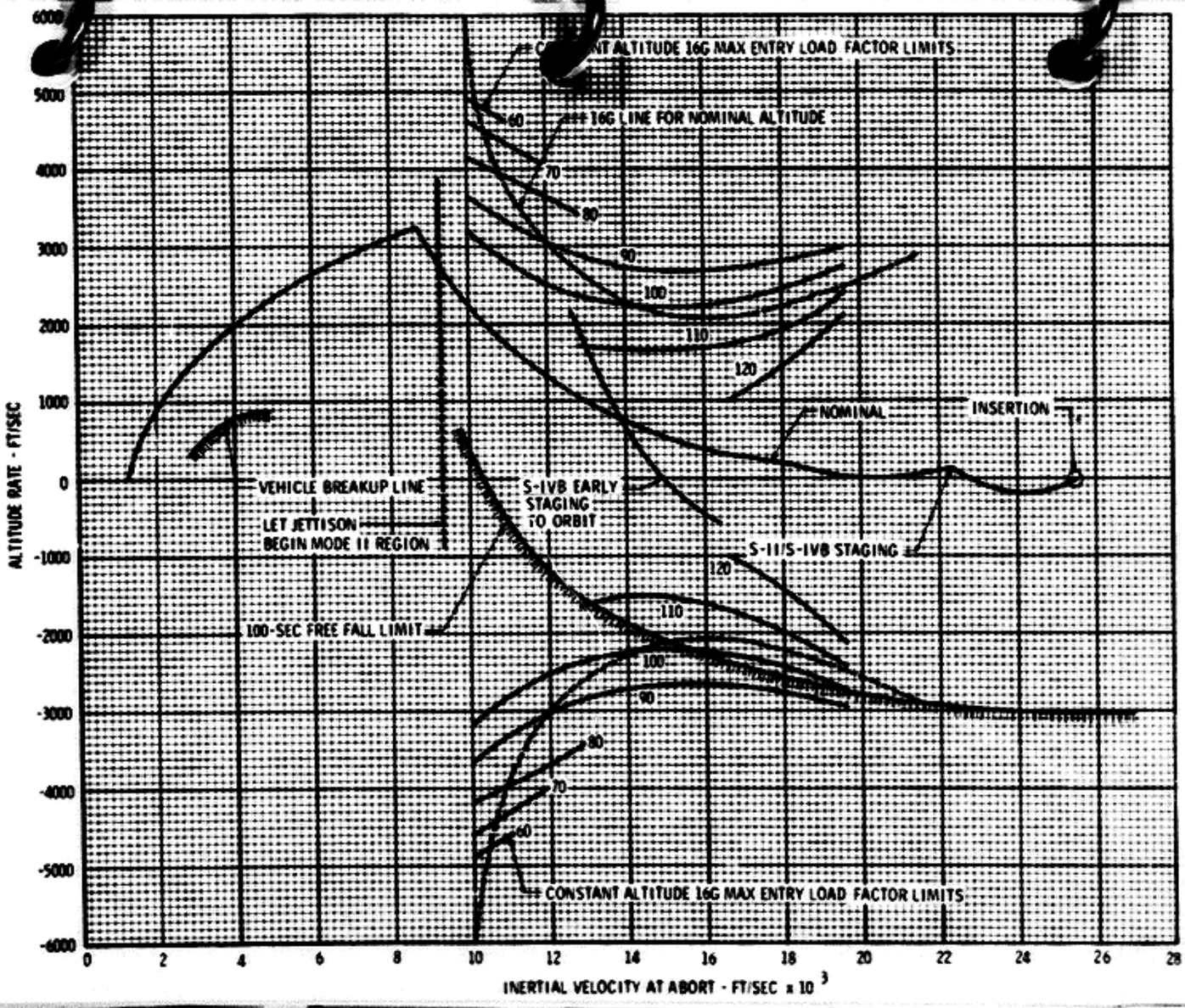
APOLLO 8

CHARTS & GRAPHS

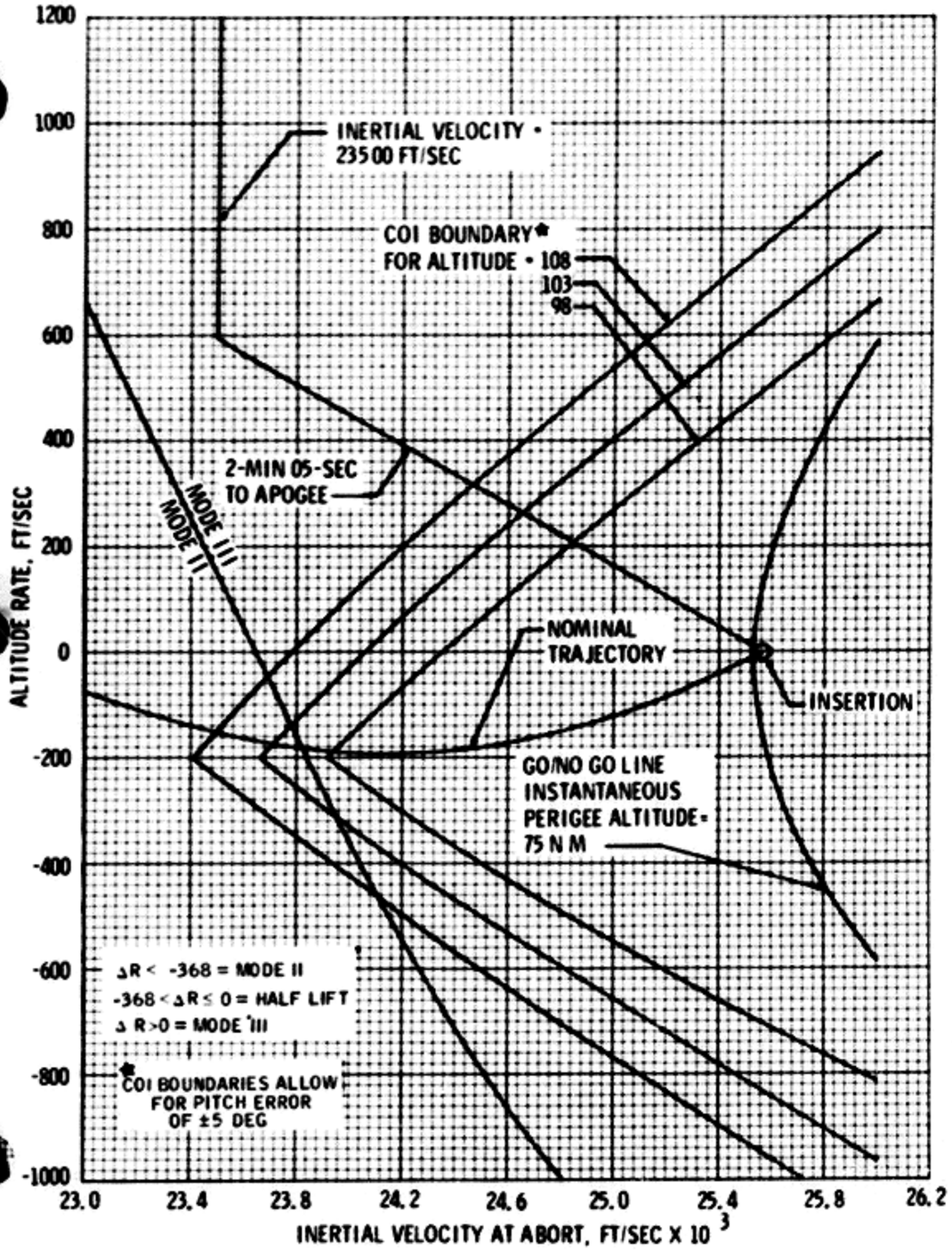
PART NO	S/N
SKB 32100038- 201	1002

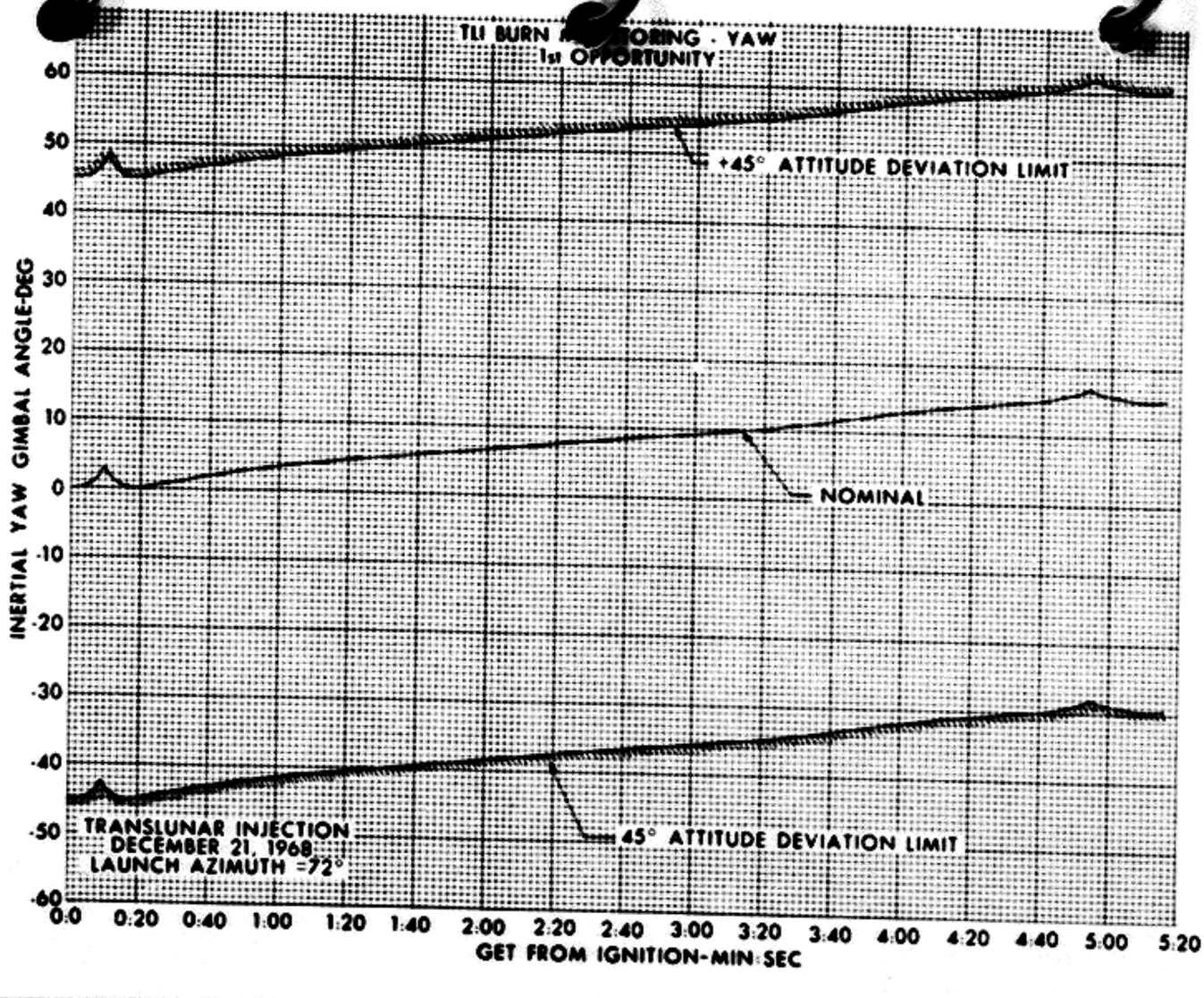
DSKY LAUNCH READOUT

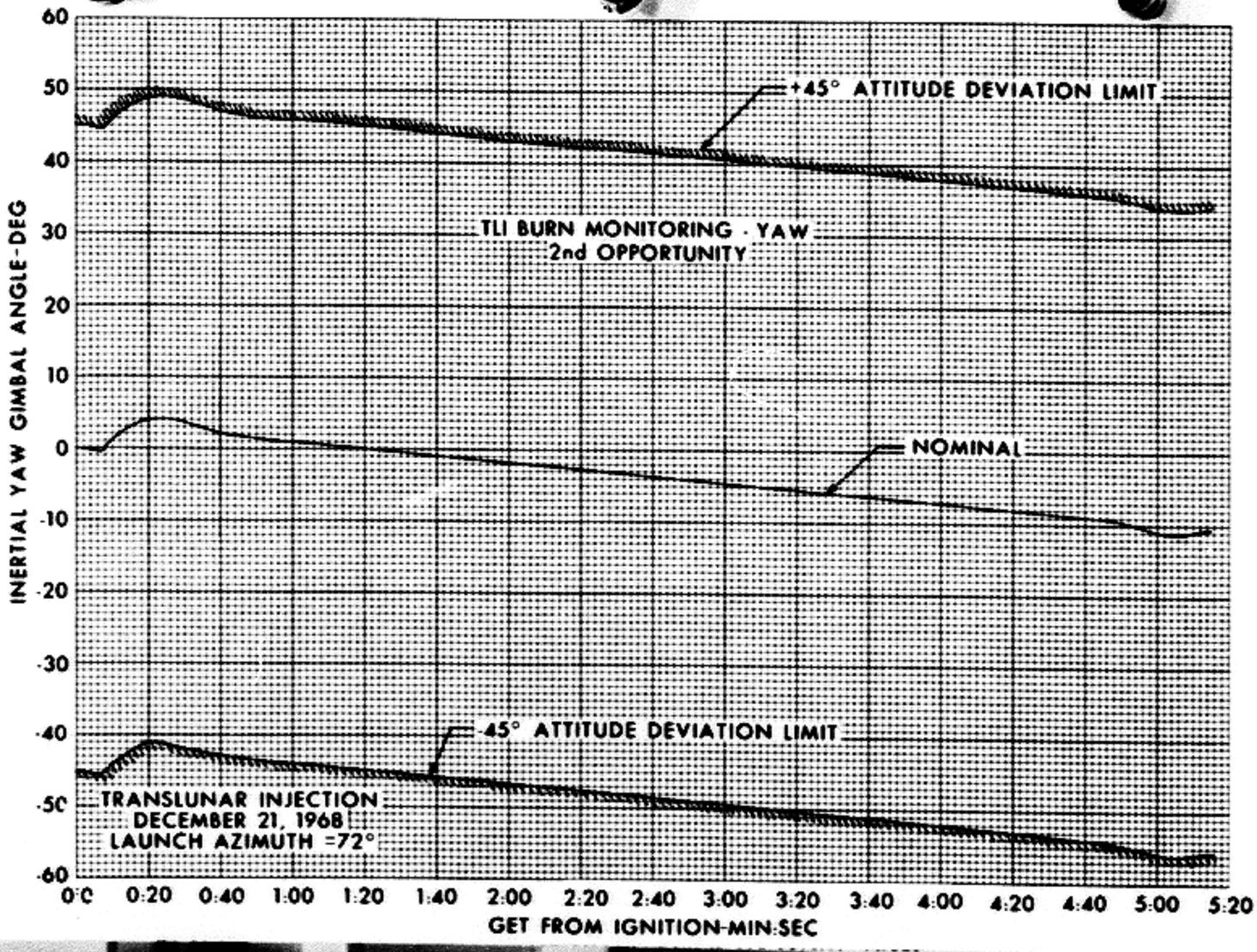
Time	VI(FPS)	H(FPS)	H,pad(NM)
00:20	1366	+ 212	0.4
00:40	1567	+ 529	1.5
01:00	2060	+ 949	3.9
01:20	2872	+1449	7.9
01:40	4103	+1991	13.5
02:00	5780	+2553	21.0
02:20	7679	+3033	30.4
02:40	8936	+3117	40.7
03:00	9262	+2795	50.5
03:20	9637	+2505	59.5
03:40	10056	+2245	67.1
04:00	10525	+1987	74.3
04:20	11042	+1737	80.0
04:40	11608	+1498	85.9
05:00	12225	+1267	90.0
05:20	12894	+1049	94.1
05:40	13618	+ 847	97.2
06:00	14401	+ 666	99.6
06:20	15248	+ 506	101.5
06:40	16164	+ 371	102.9
07:00	17158	+ 265	104.0
07:20	18211	+ 170	104.6
07:40	19137	+ 61	105.0
08:00	20130	+ 12	105.2
08:20	21197	+ 37	105.2
08:40	22356	+ 117	105.5
09:00	22637	+ 26	106.0
09:10	22825	- 26	106.0
09:20	23016	- 67	106.0
09:30	23211	- 108	105.8
09:40	23408	- 136	105.5
09:50	23608	- 158	105.2
10:00	23811	- 180	105.0
10:10	24017	- 189	104.5
10:20	24225	- 190	104.3
10:30	24436	- 185	104.0
10:40	24650	- 165	103.5
10:50	24886	- 145	103.3
11:00	25083	- 102	103.2
11:10	25304	- 59	103.2
11:20	25527	- 7	103.2

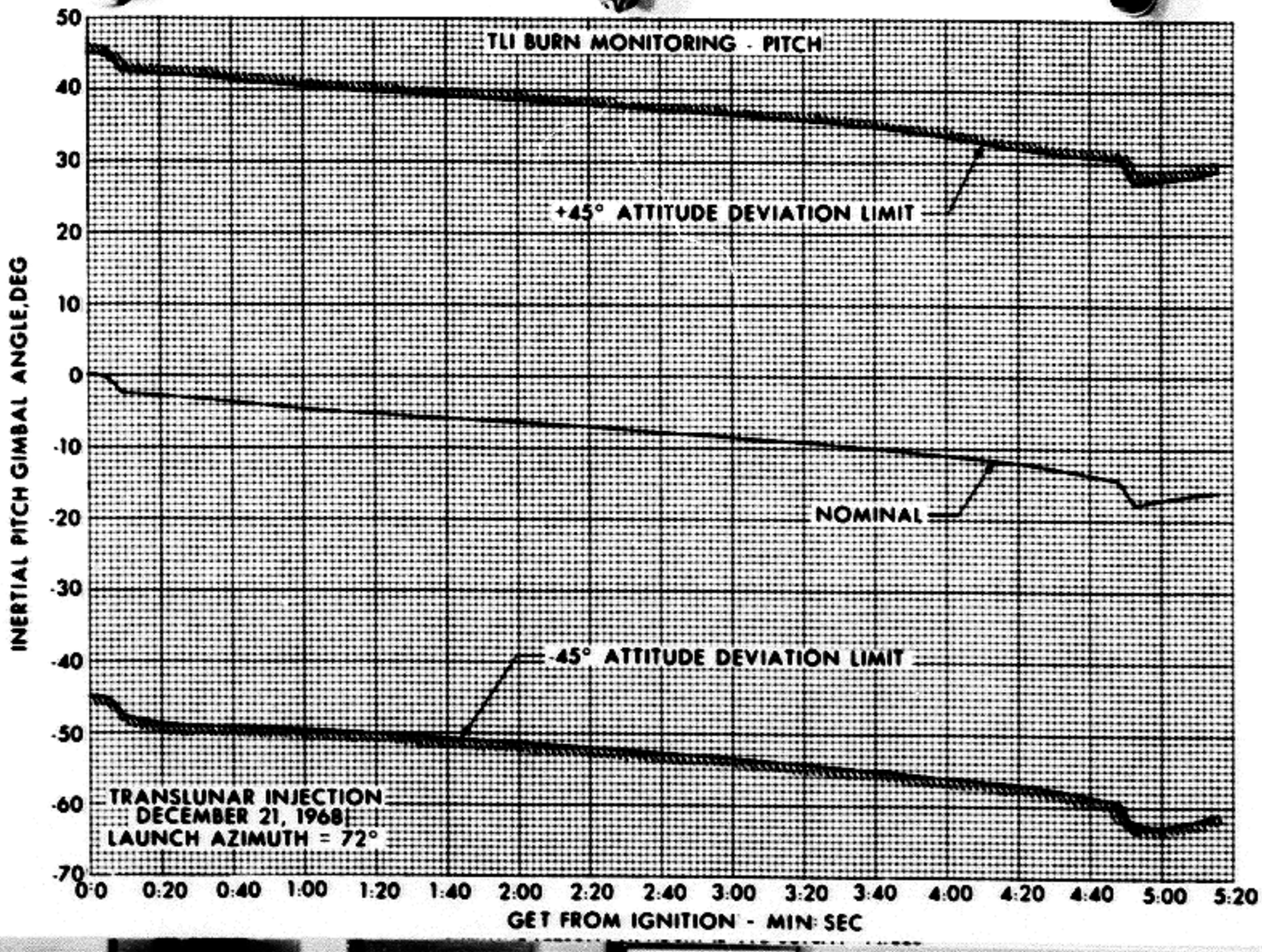


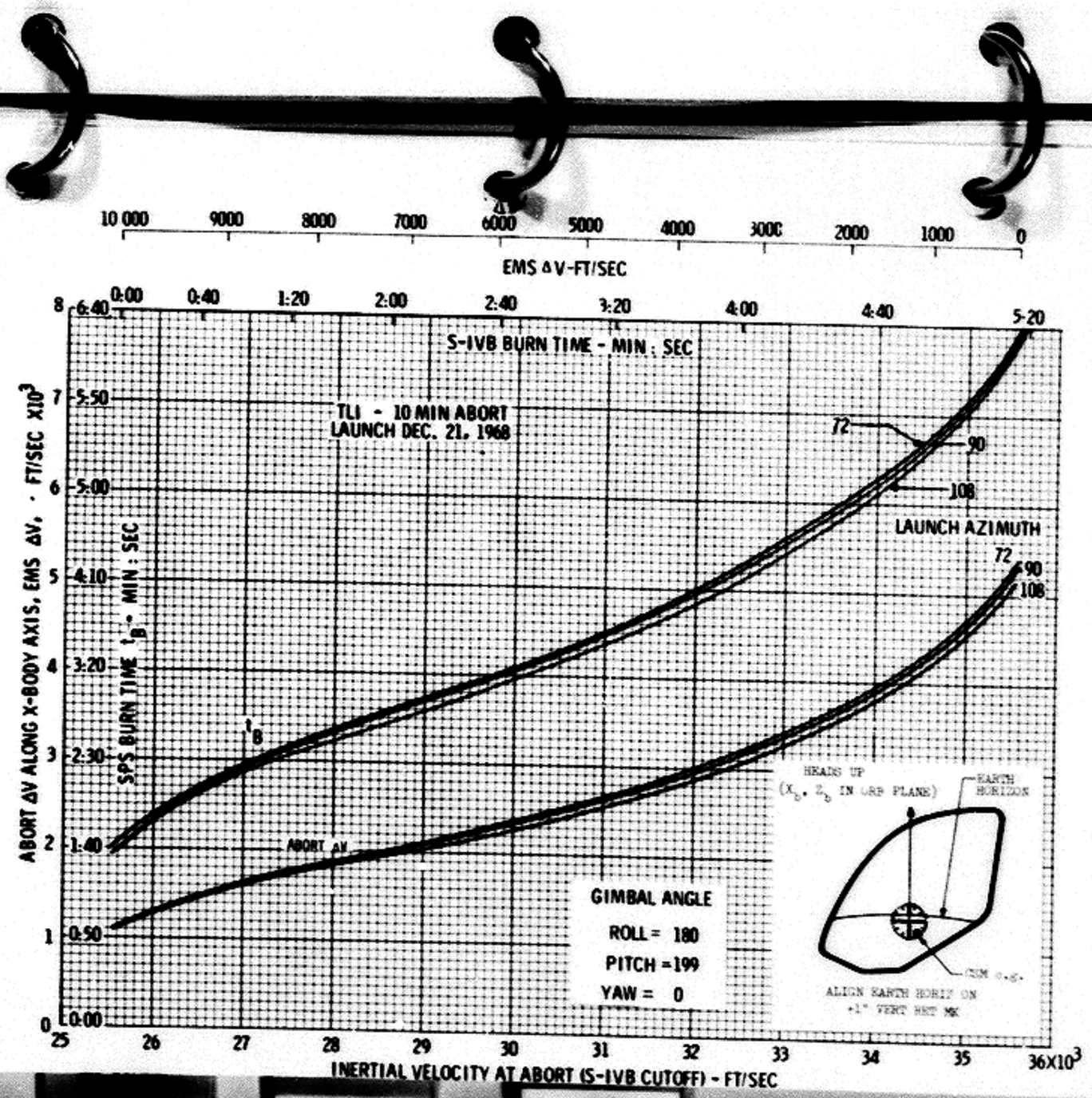
VECTORS | ENTRY | LOI | TLI | LAUNCH


INERTIAL VELOCITY • 23500 FT/SEC
COI BOUNDARY* FOR ALTITUDE • 108
103
98
2-MIN 05-SEC TO APOGEE
MODE III
MODE II
NOMINAL TRAJECTORY
INSERTION
GO/NO GO LINE INSTANTANEOUS PERIGEE ALTITUDE = 75 N M
ΔR < -368 = MODE II
-368 < ΔR ≤ 0 = HALF LIFT
Δ R>0 = MODE III
*COI BOUNDARIES ALLOW FOR PITCH ERROR OF ±5 DEG
ALTITUDE RATE, FT/SEC
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
23.0
23.4
23.8
24.2
24.6
25.0
25.4
25.8
26.2
INERTIAL VELOCITY AT ABORT, FT/SEC X 10 3

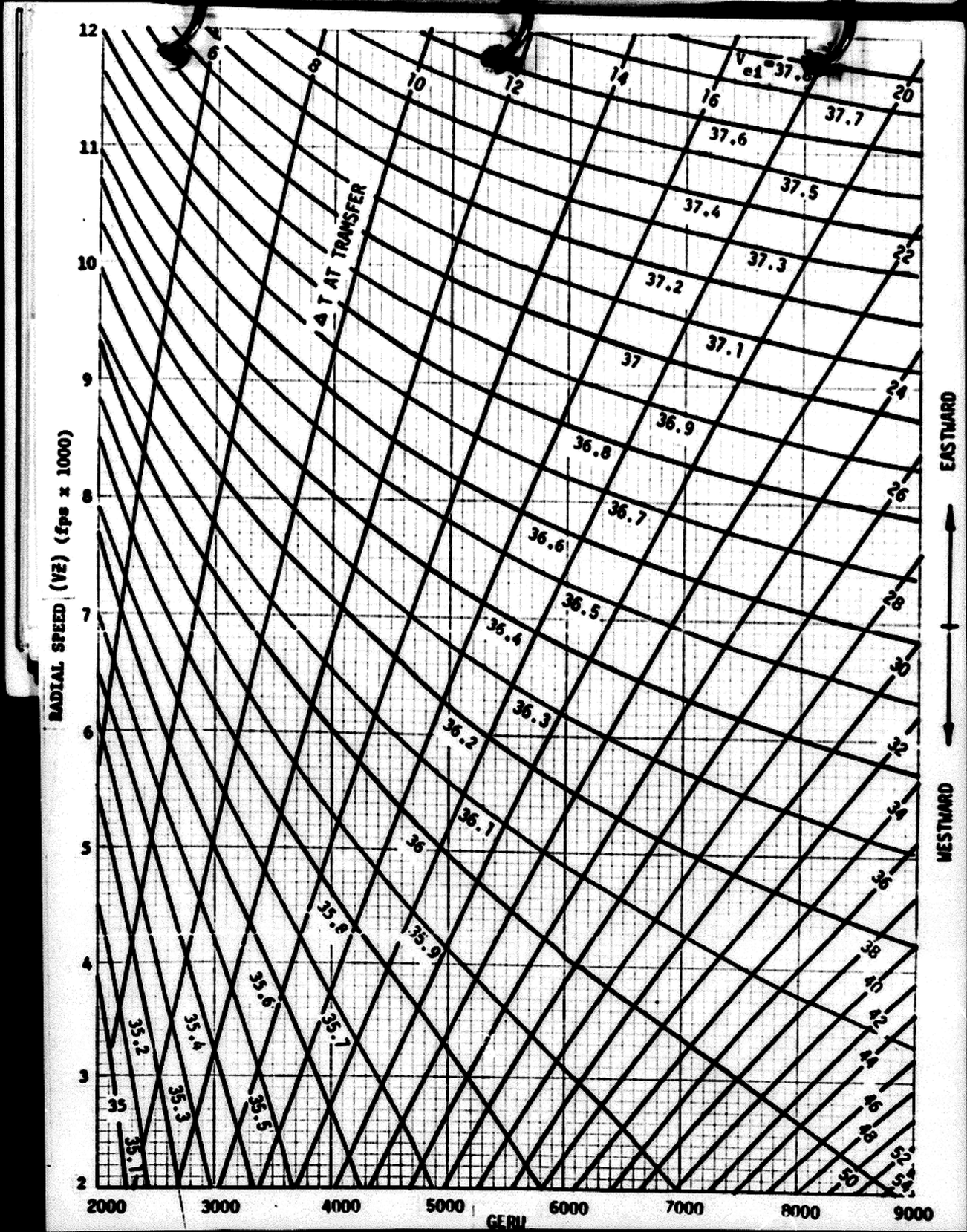

TLI BURN MONITORING - YAW
1st OPPORTUNITY
+45° ATTITUDE DEVIATION LIMIT
NOMINAL
-45° ATTITUDE DEVIATION LIMIT
TRANSLUNAR INJECTION
DECEMBER 21, 1968
LAUNCH AZIMUTH =72°
INERTIAL YAW GIMBAL ANGLE-DEG
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
0:0
0:20
0:40
1:00
1:20
1:40
2:00
2:20
2:40
3:00
3:20
3:40
4:00
4:20
4:40
5:00
5:20
GET FROM IGNITION-MIN:SEC


INERTIAL YAW GIMBAL ANGLE-DEG
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
+45° ATTITUDE DEVIATION LIMIT
TLI BURN MONITORING - YAW
2nd OPPORTUNITY
NOMINAL
-45° ATTITUDE DEVIATION LIMIT
TRANSLUNAR INJECTION
DECEMBER 21, 1968
LAUNCH AZIMUTH =72°
0:00
0:20
0:40
1:00
1:20
1:40
2:00
2:20
2:40
3:00
3:20
3:40
4:00
4:20
4:40
5:00
5:20
GET FROM IGNITION-MIN:SEC


TLI BURN MONITORING - PITCH
+45° ATTITUDE DEVIATION LIMIT
NOMINAL
-45° ATTITUDE DEVIATION LIMIT
TRANSLUNAR INJECTION
DECEMBER 21, 1968
LAUNCH AZIMUTH = 72°
INERTIAL PITCH GIMBAL ANGLE, DEG
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0:0
0:20
0:40
1:00
1:20
1:40
2:00
2:20
2:40
3:00
3:20
3:40
4:00
4:20
4:40
5:00
5:20
GET FROM IGNITION - MIN SEC

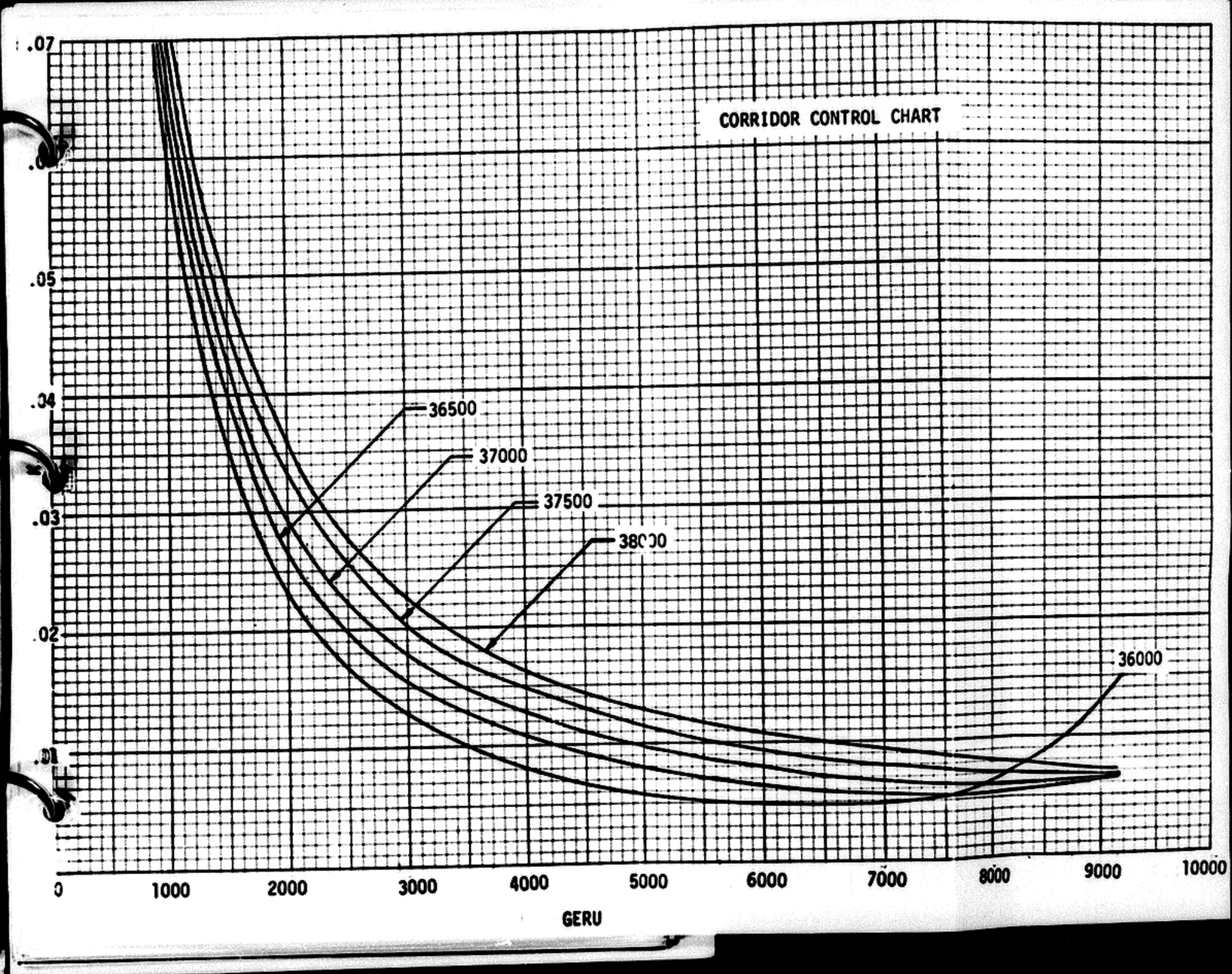

10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
EMS ΔV-FT/SEC
0:00
0:40
1:20
2:00
2:40
3:20
4:00
4:40
5:20
S-IVB BURN TIME - MIN : SEC
TLI - 10 MIN ABORT
LAUNCH DEC. 21, 1968
72
90
108
LAUNCH AZIMUTH
72
90
108
ABORT ΔV ALONG X-BODY AXIS, EMS ΔV, · FT/SEC X10³
SPS BURN TIME t_B - MIN : SEC
t_B
ABORT ΔV
6:40
5:50
5:00
4:10
3:20
2:30
1:40
0:50
0:00
8
7
6
5
4
3
2
1
0
25
26
27
28
29
30
31
32
33
34
35
36X10³
INERTIAL VELOCITY AT ABORT (S-IVB CUTOFF) - FT/SEC
GIMBAL ANGLE
ROLL = 180
PITCH = 199
YAW = 0
HEADS UP
(X_b, Z_b IN ORB PLANE)
EARTH HORIZON
CSM C.G.
ALIGN EARTH HORIZ ON
+1° VERT RET MK

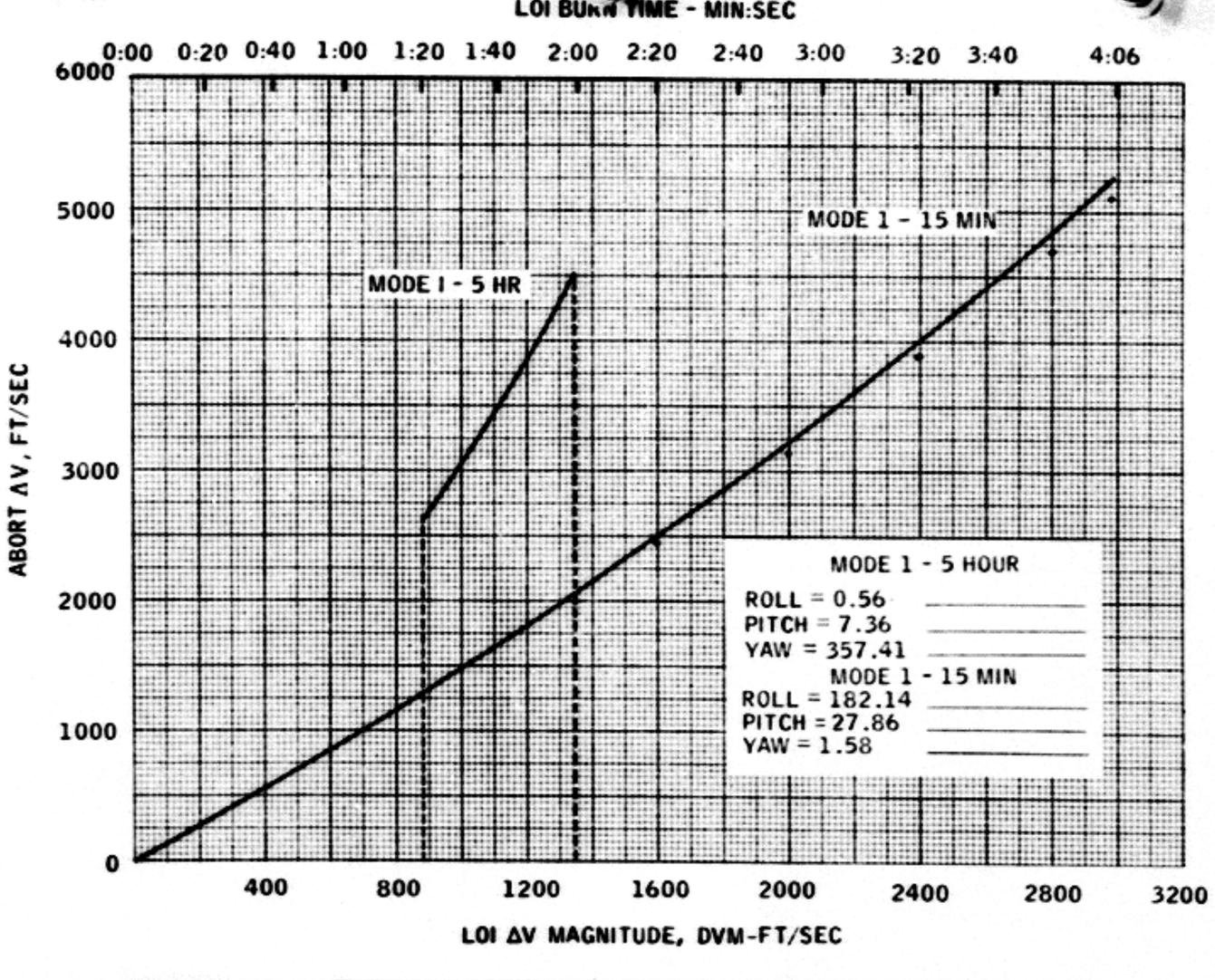
EMS ΔV - FT/SEC
10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
S-IVB BURN TIME - MIN :SEC
0:00
0:40
1:20
2:00
2:40
3:20
4:00
4:40
5:20
TIME FROM SPS ABORT CUTOFF TO REENTRY ALTITUDE , TAR. - HR
7
6
5
4
3
2
1
TLI- 10 MIN ABORT
LAUNCH - DEC. 21, 1968
LAUNCH AZIMUTH
108
90
72
25
26
27
28
29
30
31
32
33
34
35
36X10^3
INERTIAL VELOCITY AT ABORT (S -IVB CUTOFF) - FT/SEC

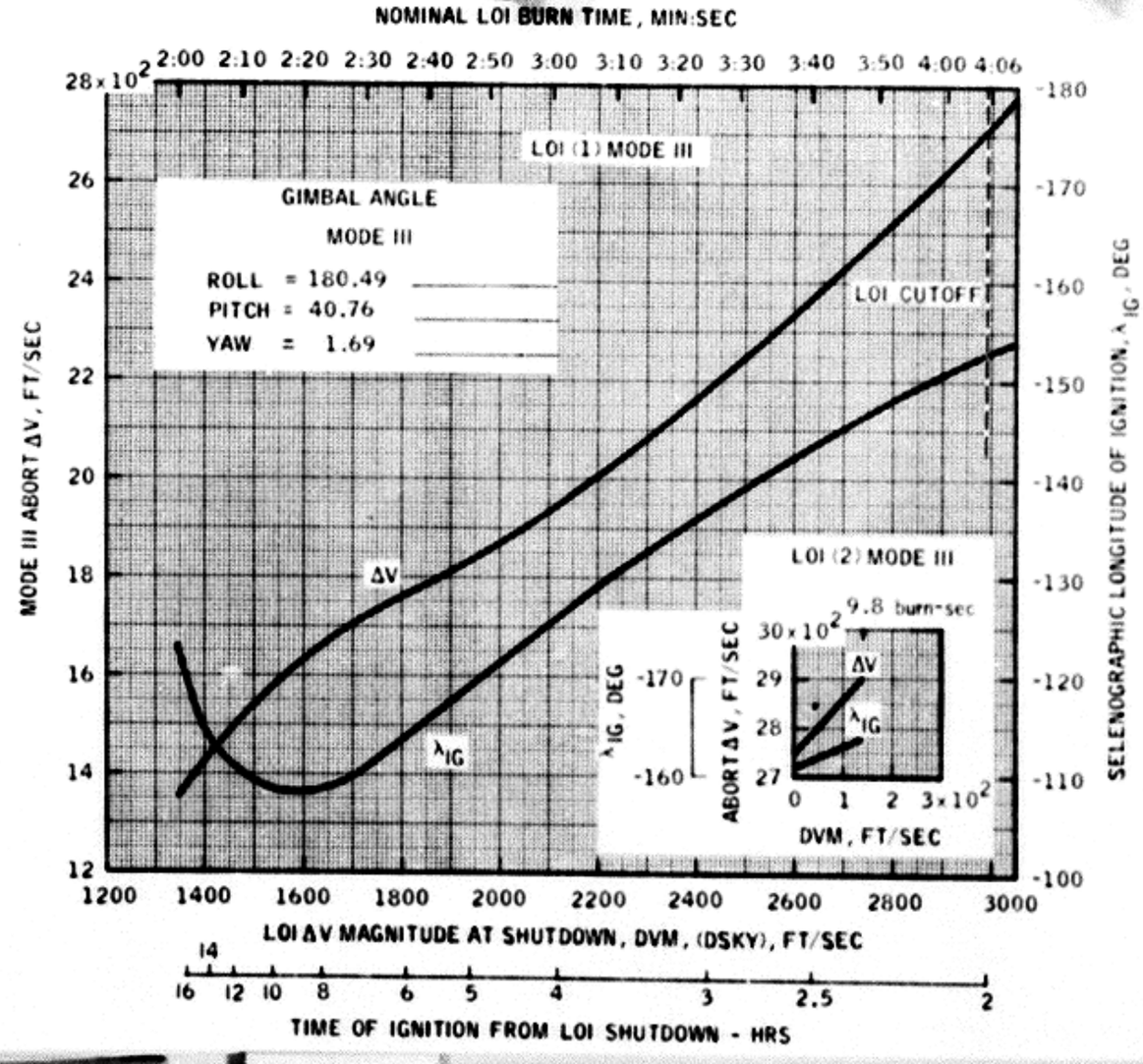

RADIAL SPEED (VE) (fps x 1000)
GERU
EASTWARD
WESTWARD
ΔT AT TRANSFER
V_{e1}=37.
12
11
10
9
8
7
6
5
4
3
2
2000
3000
4000
5000
6000
7000
8000
9000
6
8
10
12
14
16
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
37.7
37.6
37.5
37.4
37.3
37.2
37.1
37
36.9
36.8
36.7
36.6
36.5
36.4
36.3
36.2
36.1
36
35.9
35.8
35.7
35.6
35.5
35.4
35.3
35.2
35
35.1

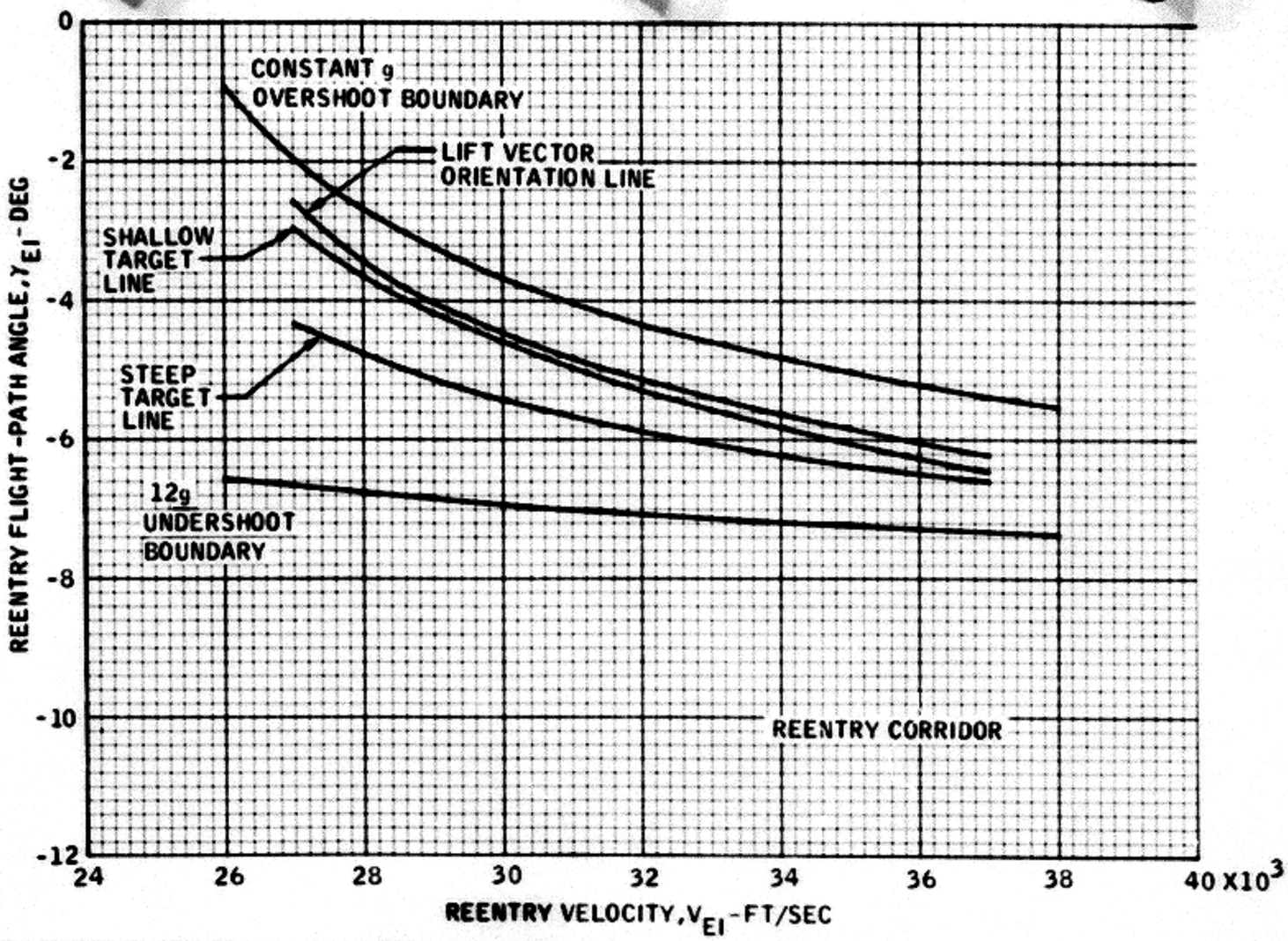
LAUNCH

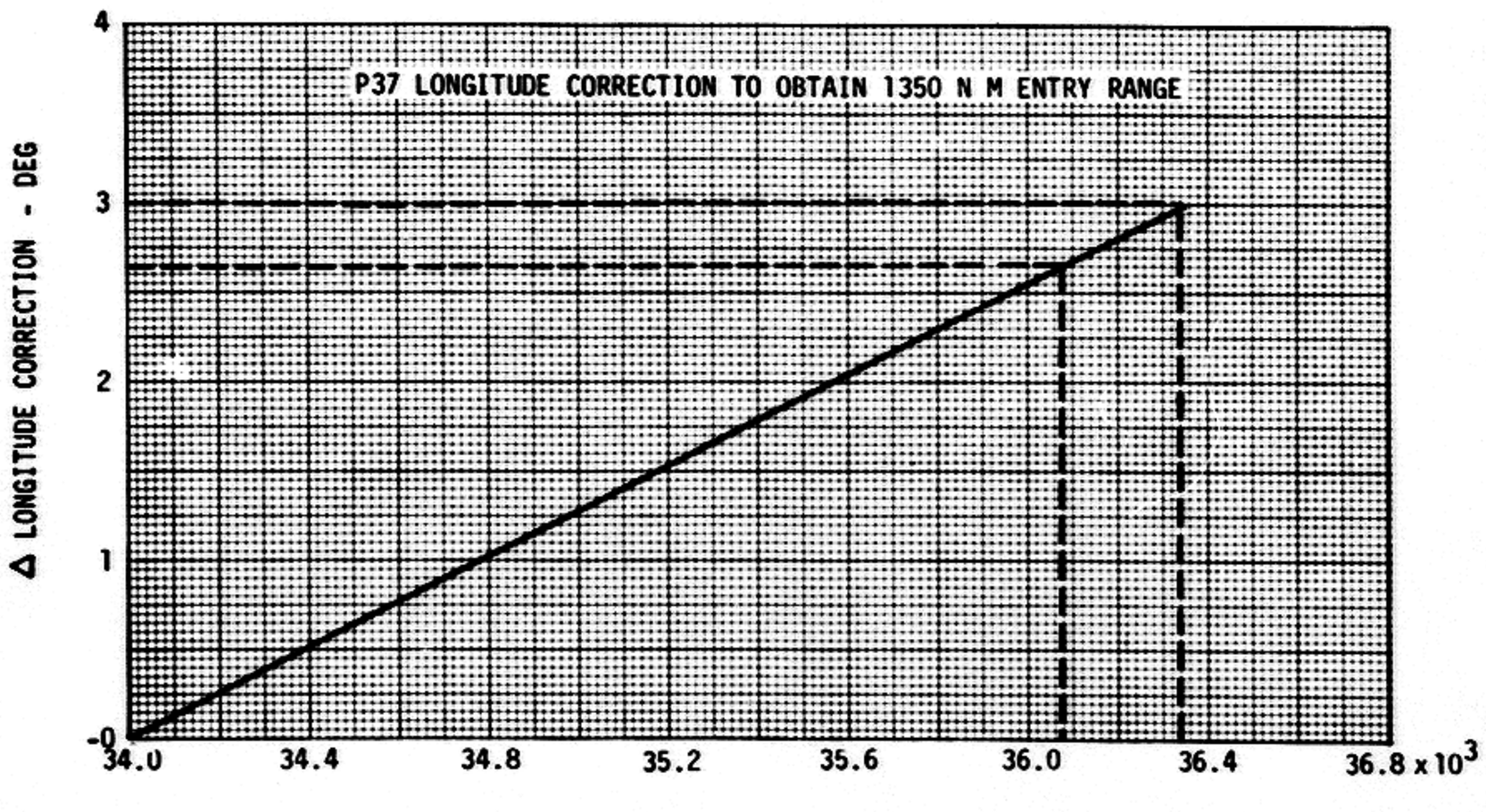
TLI

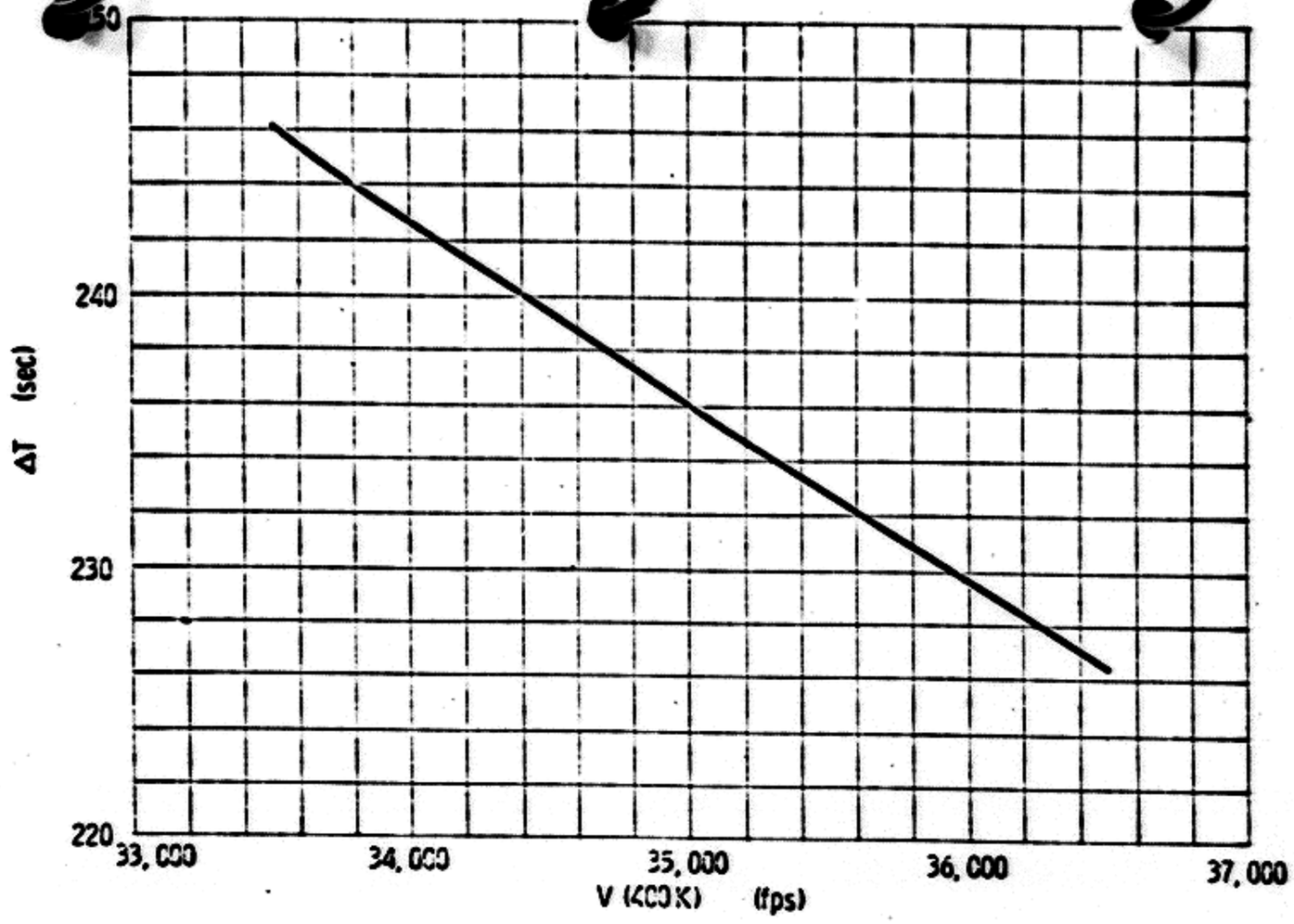

CORRIDOR CONTROL CHART
.07
.05
.04
.03
.02
36500
37000
37500
38000
36000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
GERU


LOI BURN TIME - MIN:SEC
0:00
0:20
0:40
1:00
1:20
1:40
2:00
2:20
2:40
3:00
3:20
3:40
4:06
6000
5000
4000
3000
2000
1000
0
ABORT ΔV, FT/SEC
MODE 1 - 15 MIN
MODE 1 - 5 HR
MODE 1 - 5 HOUR
ROLL = 0.56
PITCH = 7.36
YAW = 357.41
MODE 1 - 15 MIN
ROLL = 182.14
PITCH = 27.86
YAW = 1.58
400
800
1200
1600
2000
2400
2800
3200
LOI ΔV MAGNITUDE, DVM-FT/SEC

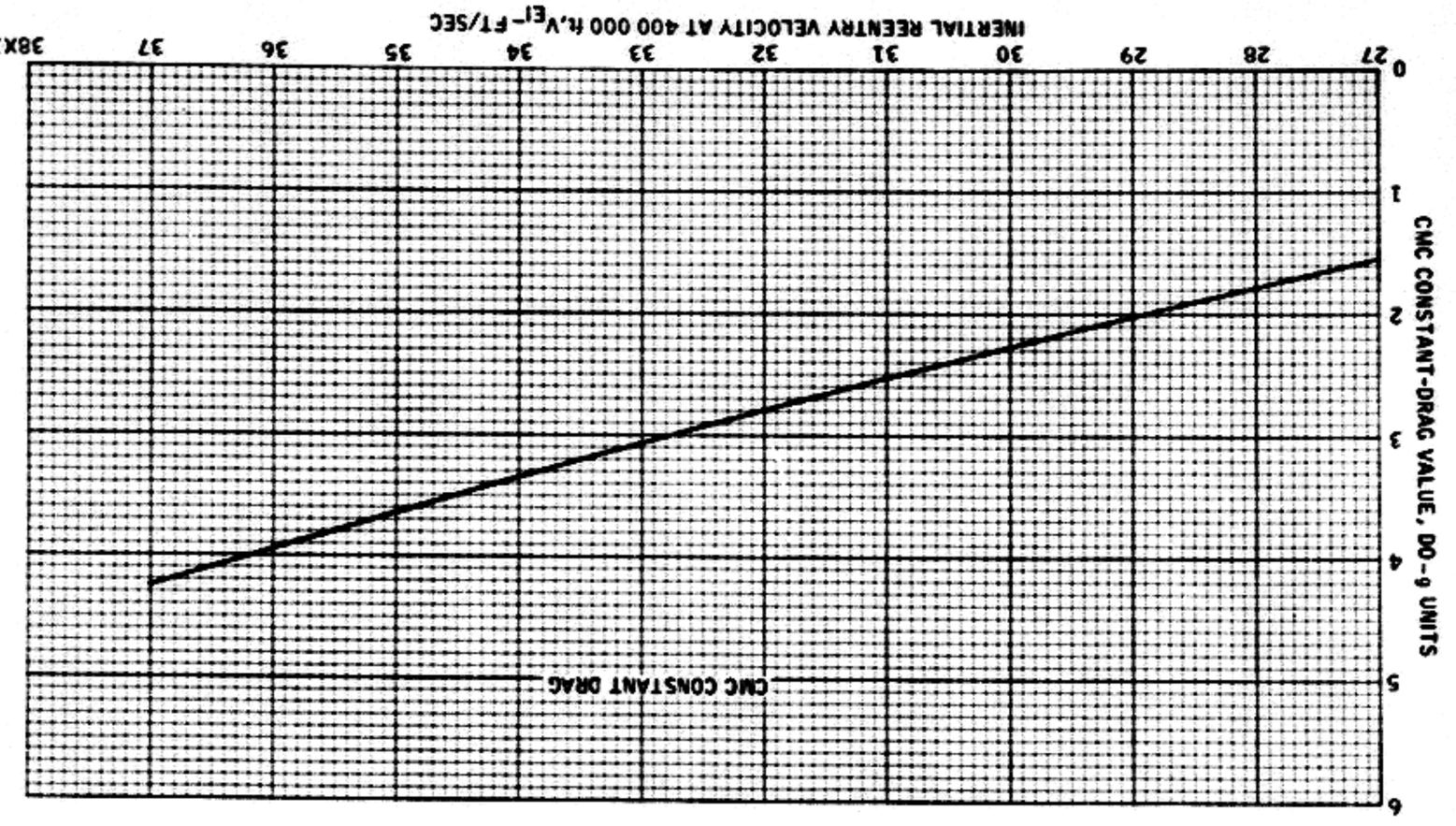

NOMINAL LOI BURN TIME, MIN:SEC
2:00 2:10 2:20 2:30 2:40 2:50 3:00 3:10 3:20 3:30 3:40 3:50 4:00 4:06
LOI (1) MODE III
GIMBAL ANGLE
MODE III
ROLL = 180.49
PITCH = 40.76
YAW = 1.69
LOI CUTOFF
ΔV
λIG
LOI (2) MODE III
9.8 burn-sec
MODE III ABORT ΔV, FT/SEC
SELENOGRAPHIC LONGITUDE OF IGNITION, λIG, DEG
LOI ΔV MAGNITUDE AT SHUTDOWN, DVM, (DSKY), FT/SEC
TIME OF IGNITION FROM LOI SHUTDOWN - HRS
DVM, FT/SEC

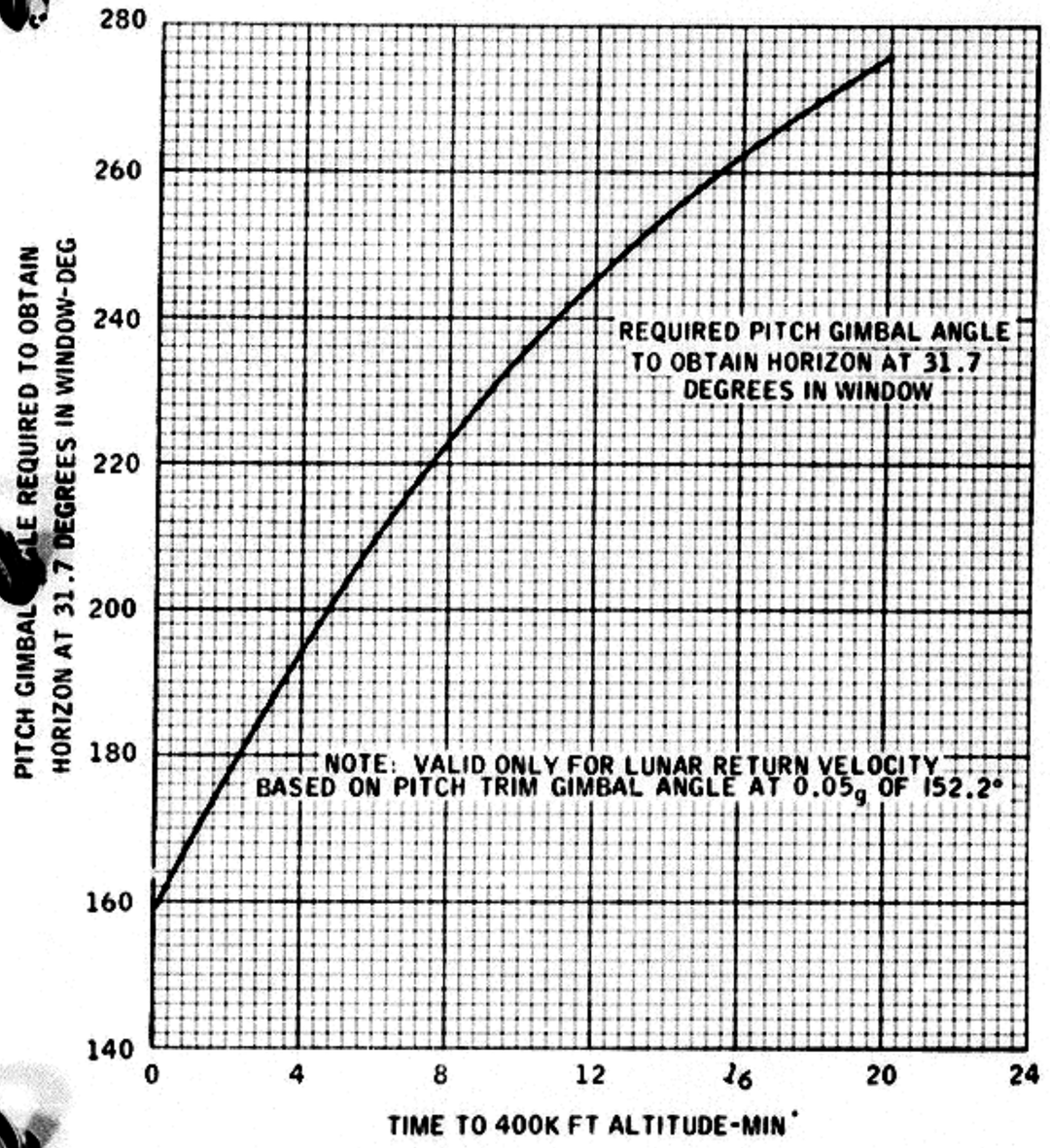

CONSTANT g
OVERSHOOT BOUNDARY
LIFT VECTOR
ORIENTATION LINE
SHALLOW
TARGET
LINE
STEEP
TARGET
LINE
12g
UNDERSHOOT
BOUNDARY
REENTRY CORRIDOR
REENTRY FLIGHT-PATH ANGLE, γ_{EI} - DEG
0
-2
-4
-6
-8
-10
-12
24
26
28
30
32
34
36
38
40 X10^3
REENTRY VELOCITY, V_{EI} - FT/SEC


P37 LONGITUDE CORRECTION TO OBTAIN 1350 N M ENTRY RANGE
Δ LONGITUDE CORRECTION - DEG
4
3
2
1
-0
34.0
34.4
34.8
35.2
35.6
36.0
36.4
36.8 x 10^3
CMC INERTIAL VELOCITY AT 400K ALTITUDE - FT/SEC

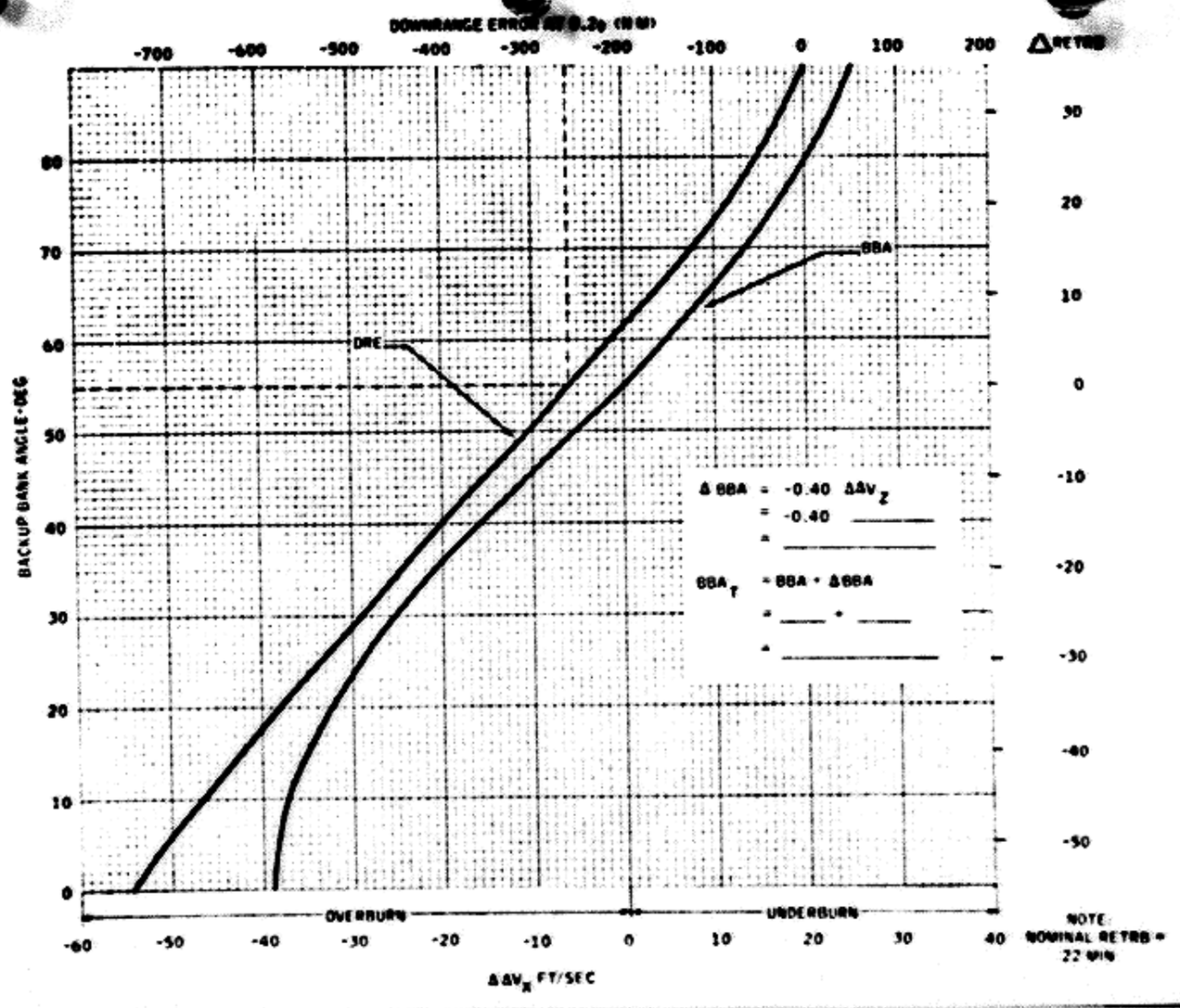


ΔT FOR P21 REQUIRED FOR 1350 N. M. ENTRY RANGE SPLASH PREDICTION

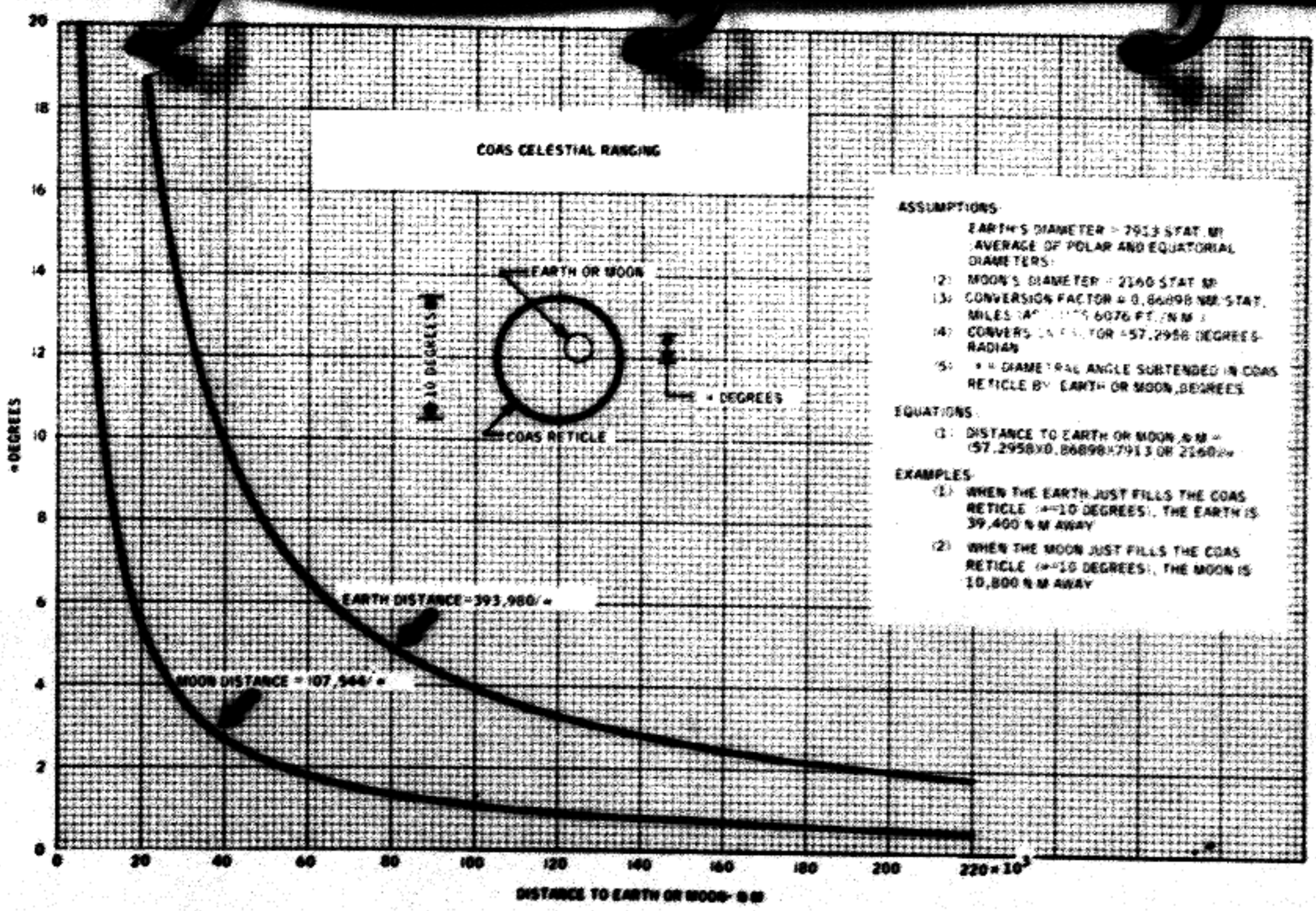

INERTIAL REENTRY VELOCITY AT 400 000 ft, V_{EI}– FT/SEC
27
28
29
30
31
32
33
34
35
36
37
38X10^3
CMC CONSTANT DRAG
0
1
2
3
4
5
6
CMC CONSTANT-DRAG VALUE, DO-g UNITS


REQUIRED PITCH GIMBAL ANGLE TO OBTAIN HORIZON AT 31.7 DEGREES IN WINDOW-DEG
280
260
240
220
200
180
160
140
REQUIRED PITCH GIMBAL ANGLE
TO OBTAIN HORIZON AT 31.7
DEGREES IN WINDOW
NOTE: VALID ONLY FOR LUNAR RETURN VELOCITY
BASED ON PITCH TRIM GIMBAL ANGLE AT 0.05g OF 152.2°
0
4
8
12
16
20
24
TIME TO 400K FT ALTITUDE-MIN

160
120
80
40
0
-40
-80
-120
-160
±180
HOLD .05g TRIM
LU/HD
LU/HD
HOLD PRESENT TRIM
LU/HD
LU/HD
TOP OF WINDOW
31.7° SCRIBE
BOTTOM OF WINDOW
LD/HU
HOLD PRESENT TRIM
LD/HU
HOLD .05g TRIM
LD/HU
LD/HU
FIELD OF VISION
LD/HU LIFT-DOWN/HEADS-UP
LU/HD LIFT-UP/HEADS-DOWN
P63 LIMIT
NOTE: VALID ONLY FOR
LUNAR RETURN VELOCITY
ANGULAR DISPLACEMENT, ◆,OF LOS TO HORIZON FROM X-BODY AXIS - DEG
4
8
12
16
20
24
TIME TO 400K FT ALTITUDE-MIN


DOWNRANGE ERROR
-700
-600
-500
-400
-300
-200
-100
0
100
200
BACKUP BANK ANGLE-DEG
80
70
60
50
40
30
20
10
0
DRE
BBA
Δ BBA = -0.40 ΔV_Z
= -0.40
=
BBA_T = BBA + ΔBBA
=
=
OVERBURN
UNDERBURN
-60
-50
-40
-30
-20
-10
0
10
20
30
40
ΔV_R FT/SEC
30
20
10
0
-10
-20
-30
-40
-50
NOTE:
NOMINAL RETRB =
22 MIN

COAS CELESTIAL RANGING



ASSUMPTIONS:

(1) EARTH'S DIAMETER = 7913 STAT MI (AVERAGE OF POLAR AND EQUATORIAL DIAMETERS)

(2) MOON'S DIAMETER = 2160 STAT MI

(3) CONVERSION FACTOR = 0.86898 NM/STAT MILES (ASSUMES 6076 FT./N M.)

(4) CONVERSION FACTOR = 57.2958 DEGREES/RADIAN

(5) α = DIAMETRAL ANGLE SUBTENDED IN COAS RETICLE BY EARTH OR MOON, DEGREES

EQUATIONS:

(1) DISTANCE TO EARTH OR MOON, ℓ M = (57.2958)(0.86898)(7913 OR 2160)/α

EXAMPLES:

(1) WHEN THE EARTH JUST FILLS THE COAS RETICLE (α=10 DEGREES), THE EARTH IS 39,400 ℓ M AWAY

(2) WHEN THE MOON JUST FILLS THE COAS RETICLE (α=10 DEGREES), THE MOON IS 10,800 ℓ M AWAY

VENUS
UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:21:13	.34475	-.32474	-.16028
12:21:18	.34628	-.32343	-.15965
12:21:23	.34780	-.32210	-.15902
12:22:04	.34931	-.32077	-.15838
12:22:09	.35082	-.31944	-.15774
12:22:14	.35232	-.31810	-.15710
12:22:19	.35382	-.31676	-.15645
12:23:00	.35531	-.31541	-.15581
12:23:05	.35679	-.31405	-.15516
12:23:10	.35826	-.31270	-.15450
12:23:15	.35973	-.31133	-.15385
12:23:20	.36119	-.30996	-.15319
12:24:01	.36264	-.30859	-.15252
12:24:06	.36409	-.30721	-.15186
12:24:11	.36553	-.30583	-.15119
12:24:16	.36696	-.30444	-.15052
12:24:21	.36838	-.30305	-.14984
12:25:02	.36980	-.30166	-.14917
12:25:07	.37121	-.30026	-.14849
12:25:12	.37261	-.29885	-.14781

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:25:17	.37401	-.29744	-.14712
12:25:22	.37540	-.29603	-.14643
12:26:03	.37678	-.29461	-.14574
12:26:08	.37816	-.29319	-.14505
12:26:13	.37952	-.29176	-.14435
12:26:18	.38088	-.29033	-.14365
12:26:23	.38224	-.28889	-.14295
12:27:04	.38358	-.28745	-.14225
12:27:09	.38492	-.28601	-.14154
12:27:14	.38625	-.28456	-.14083
12:27:19	.38757	-.28311	-.14012
12:28:00	.38889	-.28166	-.13941
12:28:05	.39020	-.28020	-.13869
12:28:10	.39150	-.27873	-.13797
12:28:15	.39279	-.27726	-.13725
12:28:20	.39408	-.27579	-.13652
12:29:01	.39536	-.27432	-.13580
12:29:06	.39663	-.27284	-.13507
12:29:11	.39790	-.27136	-.13433
12:29:16	.39915	-.26987	-.13360
12:29:21	.40040	-.26838	-.13286
12:30:02	.40164	-.26688	-.13212

VENUS
UNIT VECTORS (concluded)

GMT LO ___:___:___

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:30:07	.40288	-.26539	-.13138
12:30:12	.40410	-.26389	-.13064
12:30:17	.40532	-.26238	-.12989
12:30:22	.40653	-.26087	-.12914
12:31:03	.40773	-.25936	-.12839
12:31:08	.40893	-.25785	-.12764
12:31:13	.41012	-.25633	-.12688
12:31:18	.41130	-.25481	-.12612
12:31:23	.41247	-.25328	-.12536
01:01:04	.41364	-.25175	-.12460
01:01:09	.41479	-.25022	-.12383
01:01:14	.41594	-.24869	-.12307
01:01:19	.41709	-.24715	-.12230
01:02:00	.41822	-.24561	-.12153
01:02:05	.41935	-.24406	-.12075
01:02:10	.42047	-.24252	-.11998
01:02:15	.42158	-.24097	-.11920
01:02:20	.42268	-.23941	-.11842
01:03:01	.42377	-.23786	-.11763

JUPITER
UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:21:13	-.49822	-.04169	-.00612
12:23:15	-.49809	-.04317	-.00668
12:25:17	-.49796	-.04455	-.00719
12:27:19	-.49784	-.04583	-.00766
12:29:21	-.49772	-.04702	-.00809
12:31:23	-.49761	-.04810	-.00847
01:03:01	-.49751	-.04909	-.00881

SATURN
UNIT VECTORS

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:21:13	.47314	.15587	.04296
12:25:17	.47310	.15593	.04317
12:29:21	.47297	.15623	.04349
01:03:01	.47275	.15678	.04392

MARS
UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:21:13	-.45233	-.20002	-.07338
12:21:23	-.45143	-.20177	-.07414
12:22:09	-.45053	-.20351	-.07489
12:22:19	-.44961	-.20524	-.07565
12:23:05	-.44869	-.20697	-.07640
12:23:15	-.44776	-.20870	-.07715
12:24:01	-.44683	-.21042	-.07790
12:24:11	-.44588	-.21214	-.07864
12:24:21	-.44493	-.21385	-.07939
12:25:07	-.44398	-.21555	-.08013
12:25:17	-.44301	-.21726	-.08087
12:26:03	-.44204	-.21895	-.08161
12:26:13	-.44106	-.22064	-.08234
12:26:23	-.44008	-.22233	-.08308
12:27:09	-.43908	-.22401	-.08381
12:27:19	-.43809	-.22569	-.08454

LAUNCH

TLI

LOI

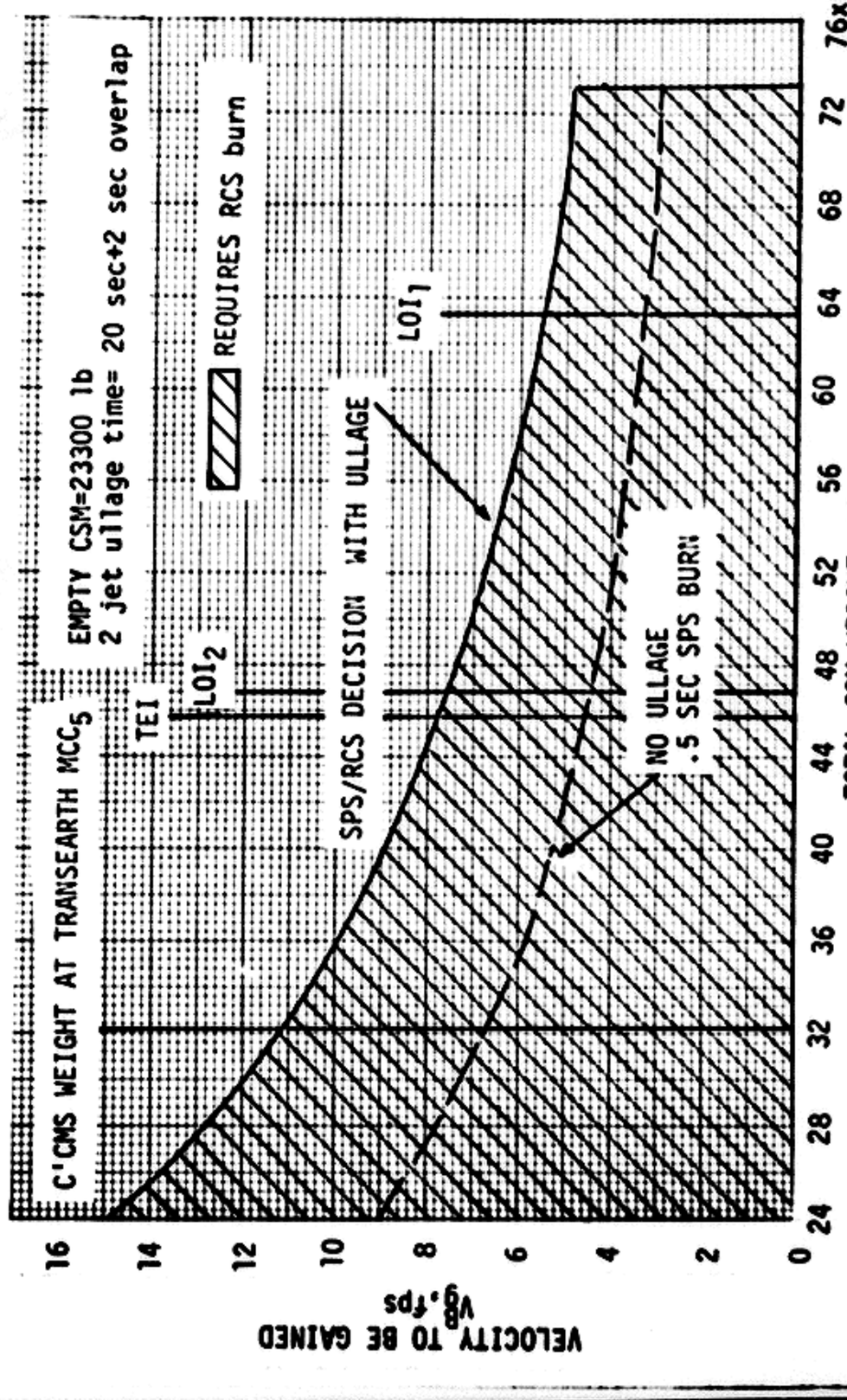
ENTRY

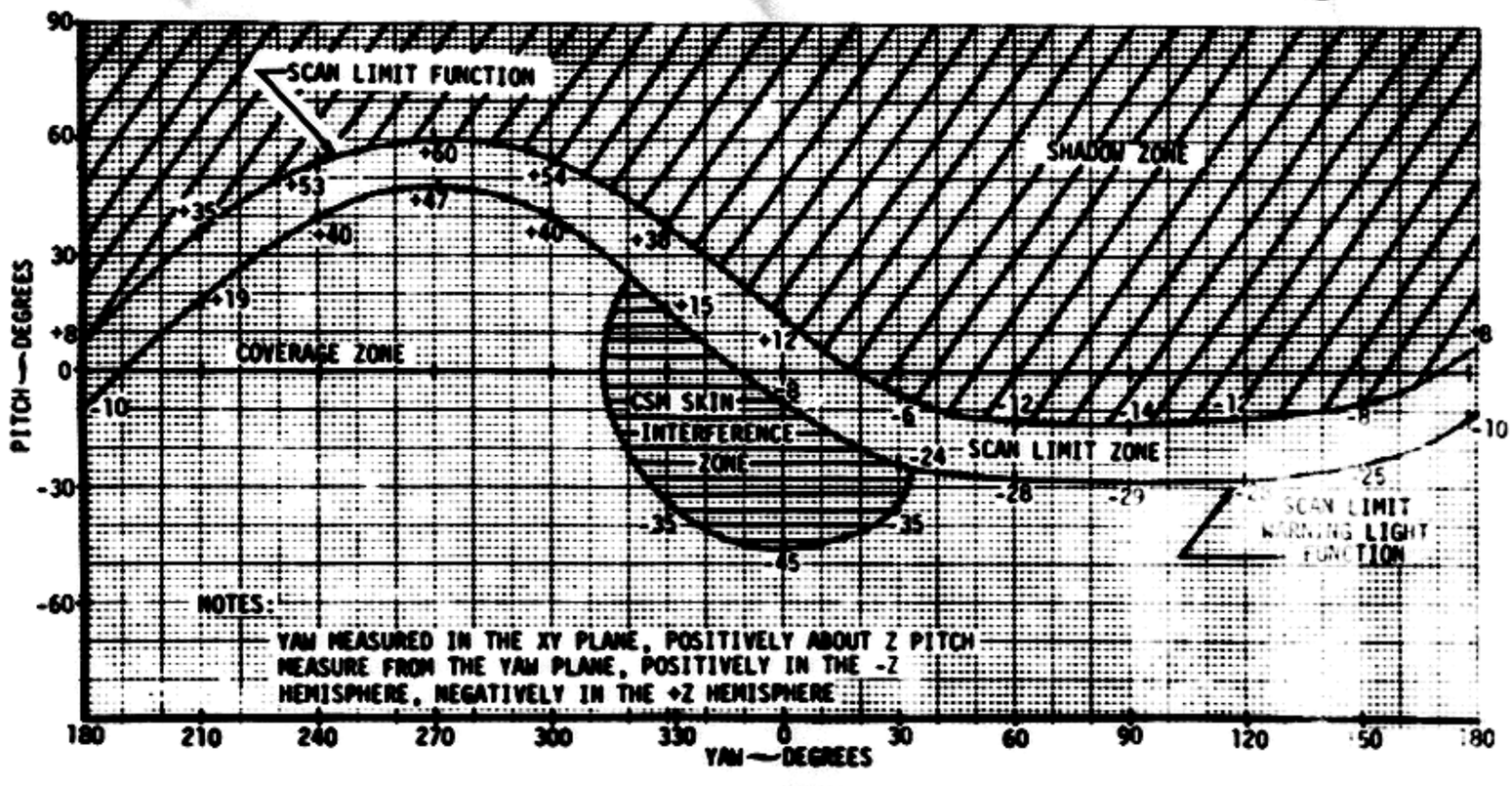
PLANET VECTORS

MARS
UNIT VECTORS

GMT LO ___:___:___

GMT M:D:H	X UNIT VECTOR	Y UNIT VECTOR	Z UNIT VECTOR
12:28:05	-.43708	-.22736	-.08527
12:28:15	-.43607	-.22902	-.08599
12:29:01	-.43505	-.23068	-.08671
12:29:11	-.43402	-.23234	-.08743
12:29:21	-.43299	-.23399	-.08815
12:30:07	-.43195	-.23563	-.08887
12:30:17	-.43090	-.23727	-.08958
12:31:03	-.42985	-.23890	-.09030
12:31:13	-.42879	-.24053	-.09101
12:31:23	-.42773	-.24215	-.09171
01:01:09	-.42666	-.24377	-.09242
01:01:19	-.42558	-.24538	-.09312
01:02:05	-.42449	-.24699	-.09382
01:02:15	-.42340	-.24859	-.09452
01:03:01	-.42231	-.25018	-.09522





HIGH-GAIN ANTENNA SCAN AND WARNING LIMIT, YAW-PITCH COORDINATES (CSM)