

APOLLO 16

CSM G&C CHECKLIST

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APOLLO 16 & 17

CSM G&C CHECKLIST

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G&C CHECKLIST

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STAR LIST

<u>STAR NAME</u> (Numerical)		<u>STAR NAME</u> (Alphabetical)	
NO			NO
00	Planet	Acamar	6
1	Alpheratz	Achernar	4
2	Diphda	Acrux	25
3	Navi	Aldebaran	11
4	Achernar	Alkaid	27
5	Polaris	Alphard	21
6	Acamar	Alphecca	32
7	Menkar	Alpheratz	1
10	Mirfak	Altair	40
11	Aldebaran	Antares	33
12	Rigel	Arcturus	31
13	Capella	Atria	34
14	Canopus	Canopus	14
15	Sirius	Capella	13
16	Procyon	Dabih	41
17	Regor	Deneb	43
20	Dnoces	Denebola	23
21	Alphard	Diphda	2
22	Regulus	Dnoces	20
23	Denebola	Earth	47
24	Gienah	Enif	44
25	Acrux	Fomalhaut	45
26	Spica	Gienah	24
27	Alkaid	Menkar	7
30	Menkent	Menkent	30
31	Arcturus	Mirfak	10
32	Alphecca	Moon	50
33	Antares	Navi	3
34	Atria	Nunki	37
35	Rasalhague	Peacock	42
36	Vega	Planet	00
37	Nunki	Polaris	5
40	Altair	Procyon	16
41	Dabih	Rasalhague	35
42	Peacock	Regor	17
43	Deneb	Regulus	22
44	Enif	Rigel	12
45	Fomalhaut	Sirius	15
46	Sun	Spica	26
47	Earth	Sun	46
50	Moon	Vega	36

CMC GENERAL

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VERB LIST (Decimal)

- 01 Display Oct Compnt 1 (R1)
- 02 Display Oct Compnt 2 (R1)
- 03 Display Oct Compnt 3 (R1)
- 04 Display Oct Compnt 1, 2 (R1, R2)
- 05 Display Oct Compnt 1, 2, 3 (R1,R2,R3)
- 06 Display Decimal (R1 or R1, R2 or R1,R2,R3)
- 07 Display DP Decimal - (R1,R2)
- 11 Monitor Oct Compnt 1 (R1)
- 12 Monitor Oct Compnt 2 (R1)
- 13 Monitor Oct Compnt 3 (R1)
- 14 Monitor Oct Compnt 1, 2 (R1, R2)
- 15 Monitor Oct Compnt 1, 2, 3 (R1,R2,R3)
- 16 Monitor Decimal (R1 or R1,R2 or R1,R2,R3)
- 17 Monitor DP Decimal - (R1,R2)
- 21 Load Compnt 1 (R1)
- 22 Load Compnt 2 (R2)
- 23 Load Compnt 3 (R3)
- 24 Load Compnt 1, 2 (R1, R2)
- 25 Load Compnt 1, 2, 3 (R1, R2, R3)
- 27 Display Fixed Memory
- 30 Request Executive
- 31 Request Waitlist
- 32 Recycle Prog
- 33 Proceed Without DSKY inputs
- 34 Terminate Function
- 35 Test Lights
- 36 Request Fresh Start
- 37 Change Prog (Major Mode)
- *40 Zero ICDU
- 41 Coarse Align CDU (N20 & N91)
- 42 Fine Align IMU
- 43 Load FDAI ATT Error needles
- *44 Set Surface Flag
- *45 Reset Surface Flag
- *46 Activate DAP
- *47 Set LM State Vector into CSM State Vector
- 48 Load DAP (R03)
- 49 Start Crew Defined MNVR(R62)
- 50 Please Perform
- 51 Please Mark
- *52 Marked on offset landing site
- 53 Please Mark alternate LOS
- 54 Start REND backup sighting mark (R23)

- 55 Increment CMC Time (Decimal)
- *56 Terminate Tracking (P20)
- 57 FULTKFLG Display
- *58 Reset Stick Flag and set V50 N18 flag
- 59 Please Calibrate
- *60 Set N17 = N20
- *61 Display DAP att error
- *62 Display total att error (N22-N20)
- *63 Display total astro att error (N17-N20)
- 64 Start S-band ant routine (R05)
- *65 Verify Prelaunch Align Optics (CSM)
- *66 Set CSM State Vector into LM State Vector
- 67 W-Matrix RSS Error Display
- *69 Restart
- 70 Update Liftoff Time (P27)
- 71 Univ Update-BLOCK ADR (P27)
- 72 Univ Update-SINGLE ADR (P27)
- 73 Update CMC Time (Octal) (P27)
- *74 Initialize erasable dump via downlink
- *75 Backup Liftoff
- *78 Update prelaunch azimuth
- *80 Update LM State Vector
- *81 Update CSM State Vector
- 82 Start Orbit Param Disp (R30)
- 83 Start REND Param Display No. 1 (R31)
- 85 Start REND Param Display No.2 (R34)
- *86 Reject REND backup sighting mark
- *87 Set VHF range flag
- *88 Reset VHF range flag
- 89 Start REND Final ATT Routine (R63)
- 90 Request REND out of plane display (R36)
- 91 Compute Banksum
- *93 Enable W matrix initialization
- *94 Enable Cislunar Tracking recycle
- *96 Terminate integration and go to P00
(Select P00 by V37 after use of V96)
- 97 SPS Thrust Fail (R40)
- 99 Enable engine ignition
- *Callable with other extended verb in use
and does not lock out other extended verbs

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NOUN LIST (Decimal)

01	Specify Machine Address (Fract) (R1,R2,R3)	.XXXXX
02	Specify Machine Address (Whole) (R1,R2,R3)	XXXXX.
03	Specify Machine Address (R1,R2,R3)	.01°
05	Angular Error/Diff	.01°
06	Option Code (R1 & R2)	OCTAL
07	BIT operator: Address,BIT ID, Action	OCTAL
08	Alarm Data	OCTAL
09	Alarm Codes	OCTAL
10	Channel to be Specified (R1)	OCTAL
11	TIG (CSI)	hrs,min,.01sec
12	Option code (R1&R2)	OCTAL
13	TIG (CDH)	hrs,min,.01sec
14	VC/O (R1) (P15)	FPS
15	Increment Machine Address (R1)	OCTAL
16	Time of event	hrs,min,.01sec
17	Astronaut total att	R,P,Y .01°
18	Auto Maneuver	R,P,Y .01°
20	Present ICDU Angles	R,P,Y .01°
21	PIPA PULSES X,Y,Z	Pulses
22	New ICDU Angles	R,P,Y .01°
24	Delta CMC Clock Time	hrs,min,.01sec
25	Checklist (please perform)	OCTAL
26	Prio/Delay, ADRES, BBCON(R1,R2 & R3)	OCTAL
27	Self-Test on/off sw	OCTAL
29	X SM LAUNCH Azimuth	.01°
30	Target Code(Gyrocomp verif)	
31	Time of rdvz W-mat.init.	hrs,min,.01sec
32	Time from Perigee	hrs,min,.01sec
33	Time of Ignition (TIG)	hrs,min,.01sec
34	Time of Event	hrs,min,.01sec
35	Time from Event	hrs,min,.01sec
36	Time of CMC Clock	hrs,min,.01sec
37	TIG (TPI)	hrs,min,.01sec
38	State Vector Time	hrs,min,.01sec
39	Δ Time of Transfer	hrs,min,.01sec

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40	TF GETI/TFC	min-sec
	VG	.1 FPS
	ΔV (Accumulated)	.1 FPS
41	Target	Azimuth .01°
		Elevation .001°
		Ident 0000X
42	Apogee Alt (HA)(RLS/Pad)	.1 NM
	Perigee Alt (HP) (RLS/Pad)	.1 NM
	ΔV (Required)	.1 FPS
43	Lat	.01°
		(+ North)
	Long	.01°
		(+ East)
	Alt (RLS/Pad)	.1 NM
44	Apogee Alt (HA) (RLS/Pad)	.1 NM
	Perigee Alt (HP)(N50)(RLS/Pad)	.1 NM
	TFF	min-sec
45	Marks	XXBXX
	TF GETI	min-sec
	MGA	.01°
46	DAP Config (R1&R2)	OCTAL
47	CSM weight	LBS
	LM Weight	LBS
48	Pitch Trim	.01°
	Yaw Trim	.01°
49	ΔR	.01 NM
	ΔV	.1 FPS
	SOURCE CODE (1 optics, 2 VHF)	0000X.
50	ΔR (miss distance)	.1 NM
	Perigee Alt (HP)(RLS/Pad)	.1 NM
	TFF	min-sec
51	RHO	.01°
	GAMMA	.01°
52	CENTANG (active veh)	.01°
53	RANGE	.01 NM
	RANGE RATE	.1 FPS
	PHI (1cl horiz)	.01°
54	Range	.01 NM
	Range Rate	.1 FPS
	Theta (1cl horiz)	.01°
55	Precision offset	CODE
	E(ELEV ANGLE)	.01°
	CENTANG (passive veh)	.01°

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58	HP alt (post TPI) (RLS/Pad)	.1 NM
	ΔV (TPI)	.1 FPS
	ΔV (TPF)	.1 FPS
59	ΔV LOS 1	.1 FPS
	ΔV LOS 2	.1 FPS
	ΔV LOS 3	.1 FPS
60	G Max	.01 G
	V Pred	FPS
	Gamma EI	.01°
61	Impact Lat	.01°
		(+ North)
	Impact Long	.01°
		(+ East)
	Head Up/Down	+/-00001
		(+ Heads up)
62	VI-Inertial Vel Mag	FPS
	H Dot-Alt Rate	FPS
	H-Alt (RLS/Pad)	.1 NM
63	RTGO from 0.05 G	.1 NM
	To Splash	
	VIO, Predicted Iner Vel	FPS
	TFE, time from .05G	min-sec
64	Drag Acceleration	.01 G
	VI, Inertial Velocity	FPS
	RTGO to Target	.1 NM
65	Sampled CMC Time	hrs,min,.01 sec
	(fetched in interrupt)	
66	Beta, CMD Bank Angle	.01°
	CRSRNG Error	.1 NM
	DNRNG Error	.1 NM
67	RTGO to Target	.1 NM
	Lat, Present Position	.01°
		(+ North)
	Long, Present Position	.01°
		(+ East)
68	Beta, CMD Bank Angle	.01°
	VI, Inertial Vel.	FPS
	H Dot, Alt Rate	FPS
69	Beta	.01°
	DL	.01 G
	VL	FPS
70	Star Code(before mark)	OCTAL
	LMK Data	OCTAL
	Horiz data	OCTAL

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71	Star code (after mark)	OCTAL
	LMK Data	OCTAL
	Horiz data	OCTAL
73	ALT (P21) (RLS/Pad)	10 NM
	VEL (P21)	FPS
	GAMMA (P21)	.01°
74	BETA, CMD Bank Angle	.01°
	VI, Inertial Velocity	FPS
	Drag Acceleration	.01 G
75	ΔH (CDH)	.1 NM
	ΔT	min-sec
	ΔT	min-sec
78	Axis YAW	.01°
	Axis PITCH	.01°
	OMICRON	.01°
79	P20 opt 2 rate	.0001°/sec
	P20 deadband	.01°
80	TF GETI/TFC	min-sec
	VG	FPS
	ΔV (Accumulated)	FPS
81	$\Delta VX, Y, Z$ (1cl vert)	.1 FPS
82	$\Delta VX, Y, Z$ (LV) CDH	.1 FPS
83	$\Delta VX, Y, Z$ (Body Control Axis)	.1 FPS
84	$\Delta VX, Y, Z$ (Other Vehicle)	.1 FPS
85	$\Delta VX, Y, Z$ (Body Control Axis)	.1 FPS
86	$\Delta VX, Y, Z$ (1cl vert)	FPS
87	Opt Calib Data - Shaft (R1)	.01°
	Trunnion (R2)	.001°
88	Planet	X Y Z .XXXXX .XXXXX .XXXXX
89	Landmark - Lat	.001°
		(+ North)
	Long/2	.001°
		(+ East)
	Alt	
	(Mean lunar radius)	.01 NM
90	REND out of Y (Active)	.01 NM
	Plane para Y DOT (Active)	.1 FPS
	Y DOT (Passive)	.1 FPS
91	OCDU Angles Shaft (R1)	.01°
	Trunnion (R2)	.001°
92	New OCDU Angles Shaft (R1)	.01°
	Trunnion (R2)	.001°

ALARM CODES

93	Delta Gyro Angles X,Y,Z	.001°
94	OCDU ANGLES (R56 & R23)	
	R1 SHAFT	.01°
	R2 TRUNNION	.001°
95	TF GETI/TFC (P15)	min-sec
	VG (P15)	FPS
	VI (P15)	FPS
96	Y (CSM)	.01 NM
	Y DOT (CSM)	.1 FPS
	Y DOT (LM)	.1 FPS
97	System Test Inputs	XXXXX.
		XXXXX.
		XXXXX.
98	System Test Results	XXXXX.
		.XXXXX
		XXXXX.
99	POS ERR	1 FT
	VEL ERR	.1 FPS
	OPTION Code	0000X.

V05 N09 ALARM CODES

00110 Mark reject has been entered but
ignored
Continue

00113 No inbits (chan 16)
Continue; if alarm recurs use MDC DSKY.

00114 More marks made than desired
Continue

00115 V41 N91 keyed with OPTICS MODE not
in CMC
OPTICS MODE - CMC and OPTICS ZERO - OFF

00116 Optics switch altered before 15 sec
zero time elapsed
OPTICS ZERO - ZERO (15 sec).

00117 V41 N91 keyed but CMC has reserved
OCDU (from start of gimbal test in
P40 until termination of TVC
functional allocation of the
"optics" CDU Driving Output)
V41 N91 not yet available

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- 00120 Optics torque has been requested
but optics have not been zeroed
since last FRESH START or RESTART
OPTICS ZERO - OFF then ZERO (15 sec).
- 00121 In 0.05 sec following mark, an ICDU
changed by more than 0.033°
Repeat MK.
- (m)00205 PIPA saturated
Use SCS control (G&N 12).
- 00206 The IMU zero routine has been
entered with both the GMBL LOCK
It and NO ATT It on
Coarse align to 0,0,0 Reselect V40E
- (m)00207 ISS turn-on request not present for
90 sec
Redo IMU turn on (G&N 12).
- (m)00210 The IMU is not operating
Redo IMU turn on. If alarm recurs,
perform fresh start (V36E).
Consult MSFN. (G&N 12).
- (m)00211 Coarse align error
If P51(3)/52(4) in progress record gyro
torquing angles and perform fine align
check in P52(4).
Otherwise, see G/1-24. (G&N 12).
- (m)00212 PIPA fail, but PIPA is not being used
PIPA BIAS check (G&N 6/8).
- (m)00213 IMU not operating with turn-on request
See 00210
- 00214 Program using IMU when turned OFF
See 00210 or exit program.
- (m)00217 IMU coarse align or pulse torque
difficulty has occurred
If code 211 also, perform
211 cure only
Reinitiate current program.
If alarm recurs, terminate use of
ISS (G&N 12).
- 00220 IMU orientation unknown
Align or if aligned set REFSMMAT flag.
- 00401 Desired middle gimbal angle is excessive
Call N22 - maneuver if MGA $< 85^\circ$ or
realign IMU.
- 00402 Second MINKEY pulse torque must be done

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- 00404 Target out of view (90 deg test)
(G/3-6,3-11,6-3,7-16)
- 00405 Acceptable star pair is not available
(G/6-3,6-6)
- 00406 Rend navigation not operating
Select P20 (opt. 0 or 4) or continue.
- 00421 W-matrix overflow
Notify MSFN but continue.
W-matrix automatically reinitialized at
next mark.
- 00600 No solution on first iteration in P31 or
P32/72
(G/4-6,4-8)
- 00601 Post CSI Perigee/lune alt <85nm/ 5.8nm
(G/4-6,4-8)
- 00602 Post CDH Perigee/lune alt <85nm/ 5.8nm
(G/4-6,4-8)
- 00603 Time from TIG (CSI) to TIG (CDH)
<10 min
(G/4-6,4-8)
- 00604 Time from TIG (CDH) to TIG (TPI)
<10 min
(G/4-6,4-8)
- 00605 Number of iterations exceeds loop
maximum
(G/4-6,4-8,4-15,4-16)
- 00606 ΔV (CSI) has been >1000 fps for last
two iterations
(G/4-6,4-8)
- 00611 No TIG for given ELEV angle
(G/4-10,4-12)
- 00612 State vector in wrong sphere of influence
at TIG
(G/4-15)
- 00613 Reentry angle out of limits
(G/4-16)
- (m)00777 ISS warning caused by PIPA fail
(G&N 6).
- 01102 CMC self test error
(G/2-3)
- (m)01105 Downlink too fast
Rset. If alarm recurs DOWNLINK FAILURE.
(G&N 12).

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- (m)01106 Uplink too fast
Rset. If alarm recurs UPLINK FAILURE.
(G&N 12).
- (m)01107 Phase table failure-assume erasable
memory is destroyed
If Comm: 1. V74 CMC DOWNLINK
2. P27 As Necessary.
3. V48 As Necessary (V46).
4. Reestablish REFSMMAT via
P51 As Necessary.
If FRESH START recurs, CMC
FAILURE (SSR-3).
If no Comm, pg G/9-1
- 01301 Arcsin or arccos input is greater than
one
Notify MSFN, continue.
- (m)01407 VG increasing
(G&N 12).
- 01426 IMU unsatisfactory
Realign or use SCS.
- 01427 IMU reversed
Note FDAI operation is inverted.
- 01520 V37 request not permitted at this time
Wait till COMP ACTY lt.
not on continuously - reselect V37 or
if P62-67, select P00 and then desired
program.
- 01600 Overflow in drift test
This is gnd test alarm only.
- 01601 Bad IMU torque abort
See 01600
- 01703 Insufficient time for integration.
TIG slipped
(G/5-3,5-16)
- (m)03777 ISS warning caused by ICDU fail
(G&N 6)
- (m)04777 ISS warning caused by ICDU & PIPA fail
(G&N 6)
- (m)07777 ISS warning caused by IMU fail
(G&N 6)
- (m)10777 ISS warning caused by IMU & PIPA
fail (G&N 6)

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- (m)13777 ISS warning caused by IMU & ICDU fail
(G&N 6)
- (m)14777 ISS warning caused by IMU,ICDU & PIPA
fail
(G&N 6)
- **20430 Orbital integration has been
terminated to avoid possible
infinite loop.
Notify MSFN.
Probable S.V. uplink required
- **20607 No solution to conic subroutine
Reselect program.
- **20610 Alt at specified TIG in P37 < 400K ft
Reselect P37 and decrease TIG.
- **21204 Negative or zero time waitlist call.
If ave-g or ext. vb. on, continue.
Otherwise reselect program.
- **21206 Second job attempts to go to sleep via
keyboard and display program
See 21204.
- **21210 Second attempt is made to stall
Reselect program
Do not attempt use of IMU while CMC is
using it.
- **21302 SQRT called with negative argument
See 21204
- **21501 Keyboard and display alarm during
internal use
See 21204
- **21502 Illegal flashing display
See 21204
- **21521 P01 selected and P11 has already been
performed
Select correct program
- *31104 Delay routine busy
Reselect extended verb or continue with
program.
Notify MSFN.
- *31201 Executive overflow - no vac area
Reselect Extended Verb and/or Continue
Program.
- *31202 Executive overflow - no core sets
See 31201

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- *31203 Waitlist overflow - too many tasks
See 31201
- *31211 Illegal interrupt of extended verb
Reselect extended verb after optics
marking is completed.
(m) - Malf procedure indicated
- ** (2xxxx) - Generates restart (no lt), F37
(POOD00)
- * (3xxxx) - Restart (no lt) and program
continues (i.e. attempted
recovery)(BAILOUT)
- NOTE - All **alarms act as *type if
they occur when Ave-g is
on or display type ex-
tended verb is active

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V50 N25 CHECKLIST CODES

<u>R1 Code</u>	<u>ACTION</u>	<u>FUNCTION</u>
00013	Key in	Gyro Torque Option (P52,54)
00014	Key in	Fine Align Option
00015	Perform	Celestial Body Acq
00016	Key in	Terminate Mark Sequence
00017	Perform	MINKEY Rendezvous
00020	Perform	MINKEY PC pulse torquing
00041	Switch	CM/SM SEP to UP
00062	Key	CMC to STBY
00202	Perform	3-axis MNVR
00204	Key in	Engine gimbal test opt

V04 N06 (N12)OPTION CODES

<u>R1 Code</u>	<u>Purpose</u>	<u>Input for R2</u>
00001	Specify IMU Orientation	1=PREF, 2=NOM 3=REFS, 4=LDG SITE
00002	Specify vehicle	1=CSM, 2=LM
00004	Specify FULTKFLG setting	0=VHF and optics, 1=VHF or optics
00007	Specify Propulsion System	1=SPS, 2=RCS
00024	Specify P20 mode	0=Rndz., VECPOINT 1=Celestial body, VECPOINT 2=Rotate 4=Rndz., 3-axis 5=Celestial body, 3-axis

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MONITOR DATA IN ERASABLE MEMORY

1		V11 NO1E (OCTAL ADD) E
2	F 11 01	R1 DATA R3 OCTAL ADD
3		N15E (For next succeeding word)
4		ENTR (For each succeeding word)

FLAG WORD SET/RESET

CHANGE DATA IN ERASABLE MEMORY

1	V25N 07E F 21 07 (LOAD FLAG WORD ADDRESS) E	F 21 01	V21 NO1E (ADDRESS) E R3 ADDRESS Load New Data in R1 E N15E (For next succeeding word) ENTR (For each succeeding word)
2	F 22 07 (LOAD BIT CODE)* ENTR		
3	F 23 07 (SET BIT) Key 1E (RESET BIT) Key 0E		

110

*To determine code:

Find bit in chart

Number above bit (4,2 or 1) is code.

(Used in correct octal position)

For more than one bit, add codes.

Examples:	Bit	Code
	3	4
	6	40
	7	100
	15&13	50000

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FLAGWORD BIT ASSIGNMENTS

APOLLO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
11	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

MONITOR OF INPUT/OUTPUT CHANNELS

F 11 10 V11 N10E
(LOAD CHANNEL ADDRESS) E
R1 Octal Contents of Specified
Channel

CHANNEL SET/RESET
Note: Only channel no's <30
may be used

1 F 21 07 V25N 07E
(LOAD CHANNEL NUMBER) E
2 F 22 07 (LOAD BIT CODE)* ENTR
3 F 23 07 (SET BIT) Key 1E
(RESET BIT) Key 0E

*To determine code:
Find bit in chart
Number above bit (4,2 or 1) is code.
(Used in correct octal position)
For more than one bit, add codes.
Examples:

Bit	Code
3	4
6	40
7	100
15&13	50000

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SC CONT/MODE AND OPTICS MODE OVERRIDE

V21 N1E, 374E, A00D0 ENTR

A=0: Use switches (SC CONT and CMC MODE)
A=1: CMC FREE
A=2: CMC HOLD
A=3: CMC AUTO
A=5,6 or 7: SCS
D=0: Use switches (OPTICS)
D=1: OPT CMC
D=2: OPT ZERO
D=3: OPT MAN

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G
1-19

CMC INPUT/OUTPUT CHANNELS

CHANNEL	NAME	4	2	1	4	2	1	4	2	1	4	2	1	4	2	1
CP	1	BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9	BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1
	2			SHIFT PULSE												
	3			SHIFT PULSE												
	4			SHIFT PULSE												
OUT	5															
	6															
	7															
	8															
CP	9															
	10															
	11															
	12															
OUT	13															
	14															
	15															
	16															
IN	17															
	18															
	19															
	20															
OUT	21															
	22															
	23															
	24															
OUT	25															
	26															
	27															
	28															

* INVERTED LOGIC

VHF RNG DSKY DISPLAY

VHF RNG - on (up)

P20 - running in opt 0 or 4

V87E

V16 N02E

3703E

R1=XXX.XX nm

(max R1 = 163.83;

if R1 neg, RNG = 327.67 - |R1|)

G&N RECOVERY PROCEDURES

Recoveries:

if P06 inadvertently selected: (with F 50 25 00062)

1. a. Press PRO to STBY, press PRO
again to F 37

or b. V37E 00E

2. V37E 51E, PRO (set DRIFT flag)
V37E 00E

3. V25 N7E, 77E, 10000E, 1E (set REFSMMAT flag)

if V36 inadvertently keyed in:

1. V37E 51E, PRO (set DRIFT flag)
V37E 00E

2. V48

3. V46

4. Perform General System Checkout
as necessary

if GO JAM performed:

V74 when convenient, do procedure for
inadvertent V36

if Run-away PIPA during ave-G:

V36E before PRO on N85 or N83
to preserve CSM state vector.

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if All 8's appear spontaneously on DSKY

1. V99 N99
2. V25 N01E
3. 00000E
4. +99999E
5. +99999E
6. +99999 CLR,CLR,CLR
7. 00000E
8. 00000E
9. 00000E

If OPR ERR, begin again

General System Checkout:

Get to P00 by one of the following:

1. V37E 00E
2. V96E
3. V36E, wait 15 sec, V96E
4. Simultaneously press & hold RESET and MARK
REJECT (GO JAM), wait 15 sec, V37E 00E

OPT ZERO - OFF

OPT ZERO - ZERO

Check for Reasonableness

1. V82 with both options
2. V83
3. P21 NAV CHECK
4. P52 check auto optics positioning
If nominal, continue; if not, perform P51
5. CMC Self Test

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MNVR Completion Time

1. DURING AUTO MNVR

V4 N1 E

3316 E

RECORD R1 & R2

2. V24 N25 E

LOAD STEP 1 R1 & R2 (OCTAL)

3. V6 N34 E (hrs., min., .01 Sec.)

MNVR Completion Time - 1sec.

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V35 - DSKY CONDITION LIGHT TEST
CMC - on

Note: CMC lt. on opens PIPA suspension loop which generates alarm 212 and may cause PIPA bias shift.

- 1 Key V37E 00E (required)
DSKY - P00
 - 2 Key V35E
 - 3 Monitor the following events
 - a. All DSKY condition lts - on
 - b. ISS warning lt - on
CMC warning lt - on
 - c. All DSKY numerical windows display "8".
Sign positions in R1, R2, R3 show +,
V, N windows flash
- Wait 5 sec
- d. All DSKY warning lts - off
(except PROG if IMU on)
 - e. ISS lt - off
CMC lt - off
V, N quits Flashing
 - f. P00 will be displayed.
 - g. Key RSET
(Don't call ave. G for 15 sec)
- V40 ~~IF V37 within 10 sec, RE-KEY V40E, V46E, V50E~~
- V41 N91 COARSE ALIGN OCDU's
CMC - on
G/N PWR OPTICS - on
OPT MODE - CMC
OPT ZERO - OFF

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EXT VERBS

1 V37E00E
2 V41N 91E
3 F 21 92 SHAFT, TRUN NEW OCDU (.01°, .001°)
Load desired shaft and trun
4 41 OPTICS DRIVE TO SPECIFIED ANGLES

V41 N20 COARSE ALIGN ICDU's

CMC - on
ISS - on

1 V41N 20E
2 F 21 22 NEW ICDU ANGLES RPY (.01°)
Load desired ICDU angles

3 41 NO ATT 1t - on
*POSS PROG ALARM *
V5 N9E 211 Coarse align error
*Repeat V41 N20 *

4 V40E
NO ATT 1t - off
Wait 10 sec

5 V37E XXE

V42 GYRO TORQUING

CMC MODE - FREE

1 F 21 93 V42E
LOAD DELTA GYRO ANGLES (XYZ) (.001°)
(In flight - 90° max)

2 42 NO ATT 1t - off
Monitor Gyro Torquing on FDAI

EXT VERBS

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V48 - DAP DATA LOAD & ACTIVATE PROCEDURE

1

F 04 46 V48E
R1 ABCDE*
R2 ABCDE

	VEHICLE CONFIG	QUAD A/C FOR 2	QUAD B/D FOR 2	ERR DEADBAND	RATE SELECT
R1	0 = No DAP 1 = CSM 2 = CSM & LM 3 = CSM & SIVB 6 = CSM & LM (Ascent Stg only)	0 = Fail A/C 1 = Use A/C	0 = Fail B/D 1 = Use B/D	0 = $\pm 0.5^\circ$ 1 = $\pm 5.0^\circ$	0 = 0.05°/sec 1 = 0.2°/sec 2 = 0.5°/sec 3 = 2.0°/sec
	Roll Quad Select	Quad A	Quad B	Quad C	Quad D
R2	0 = Use B/D 1 = Use A/C	0 = Fail 1 = Use	0 = Fail 1 = Use	0 = Fail 1 = Use	0 = Fail 1 = Use

PRO

2 F 06 47 CSM WT, LM WT (lbs,lbs)
Load correct values*
PRO

3 F 06 48 TRIM ENGINE GMBL (.01°)
Load correct values
PRO

4 If activation req'd (Changing to or from
NO DAP or CSM & SIVB DAP):
CMC MODE - FREE
V46E

* For SPS burn w/Ascent Stage, A=1, & load total mass
in R1 of N47

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V49 CREW DEFINED MANEUVER

CMC - on
ISS - on
SCS - operating

- 1 V37E 00E
V62E
- 2 F 06 22 V49E
NEW ICDU ANGLES RPY (.01°)
Load desired angles
PRO
- 3 F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC
CMC MODE - AUTO
PRO
(MAN) MNVR - To 5
- 4 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)
- 5 F 50 18 REQ TRIM MNVR TO FDAI RPY ANGLES
(TRIM) PRO To 4
(BYPASS) ENTR

V54 BACKUP OPTICS MARK

P20 - running in opt. 0 or 4
and tracking

- 1 V54E

*PROG ALARM *
*V5 N9E - 00406 *
Not rend tracking
- 2 F 06 94 Backup SHAFT, TRUN (.01°, .001°)
Load angles
PRO

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3 F 53 45 PERFORM BACKUP MARK
MARKS, TFI, MGA or code
(marks,min-sec,.01°)
RHC - Align target on alt. LOS
ENTR (V86E to reject - within 7 sec)

POSS F 06 49 ΔR , ΔV , source code
* (.01NM,.1fps,0000X)*
*(REJECT) V32E *
*(ACCEPT) PRO *

When marking complete:
PRO (return to Program in process)

V55 - CMC TIME UPDATE

1 F 21 24 V55E
LOAD Δ CMC TIME (hrs,min,.01sec)

V57 DISPLAY FULTKFLG CONDITION

1 V57E

2 F 04 12 R1 00004 Specify FULTKFLG setting
R2 00000 VHF and Optics working
00001 VHF or Optics working
Load desired value in R2
(If display erased upon ENTR,
verify by repeating V57)

PRO

V64 HI GAIN ANTENNA POINTING

1 F 06 51 V64E
RHO, GAMMA (.01°, .01°)
HGA TRACK - MAN
Set in required P&Y Angles
S BD ANT - HI GAIN
HGA TRACK - AUTO
PRO

V67 - W-MATRIX ERROR DISPLAY

1
F 06 99 V67E
POS ERR, VEL ERR, OPT CODE (ft,.1fps)
R3 00001=Rend
(must do V93E to reinit.)
00002=Orbital
00003=Cislunar
00000=No Reinitialization

Load desired data
PRO

V74 CMC DOWNLINK

1 V74E (Places erasable memory on downlink)

V82 ORBIT PARAMETER DISPLAY

Note: If high CMC activity (e.g.P4Xw.Lambert)
POSS PROG ALARM and restart (no light)
-code 31201 or 31202 stored

1 F 04 12 V82E (If AVE G On, Go To 3)
R1 00002 Specify Vehicle
R2 00001 CSM
00002 LM
PRO

2 F 06 16 GET EVENT (hrs,min,.01sec)
Load desired time (present time,
use all zeroes)
PRO

3 F 16 44 HA, HP, TFF (.1nm,.1nm,min-sec)
(RECYCLE) V32E To 2 (Not Nec If AVE G On)
(Δ R-miss dist DISP-P11 & P00) N50E To 4
(TF PER) N32E To 5
(EXIT) PRO

4 F 16 50 Δ R (miss dist), HP, TFF(.1nm,.1nm,min-sec)
KEY RLSE To 3

5 F 16 32 TIME FROM PER (Useful only if TFF=-59B59)
(hrs,min,.01sec)
KEY RLSE To 3

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V83 RNDZ PARAMETER DISPLAY #1

Note: If high CMC activity (e.g. P3X or P7X w P20), POSS PROG ALARM and restart (no light)-code 31201 or 31202 stored
If alt above earth or moon >432 nm:
P23 running - do not key V83 (or 85)
P23 not running:
Wait for no integration (COMP ACTY not on continuously)
V96E (selects P00)
V83E (or 85E) - perform routine
V37E 00E

1
F 16 54 V83E
RANGE, RANGE RATE, THETA (.01nm,.1fps,.01°)
PRO

V85 - RNDZ PARAMETER DISPLAY #2

Note: See V83 restrictions

1
F 16 53 V85E
RANGE, RANGE RATE, PHI (.01nm,.1fps,.01°)
PRO

V87 - SET VHF RNG FLAG

VHF AM B - DUPLEX

VHF RNG - on (up)

P20 - running in opt. 0 or 4

1 V87E (starts VHF range sampling)

2 V88E (TERMINATE)

or V37E XXE

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V89 - RENDEZVOUS FINAL ATTITUDE

CMC - on
ISS - on
SCS - operating

- 1 V37E 00E
V62E
- 2 F 06 78 V89E
AXIS YAW, AXIS PITCH (.01°)
Load axis to be pointed at LM
PRO
- 3 F 06 18 FINAL FDAI RPY ANGLES (.01°)
(AUTO MNVR) PRO
(UPDATE DISPLAY) V32E
- 4 F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC
CMC MODE - AUTO
PRO
(MAN) MNVR To 6
- 5 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)
- 6 F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(TRIM) ALIGN SC about pointing axis
PRO To 5
(BYPASS) ENTR

V90 - OUT-OF-PLANE DISPLAY

- 1
F 06 16 V90E
GET EVENT (hrs,min,.01sec)
Load desired time (present time,
use all zeroes)
PRO
- 2 F 06 96 Y(CSM),YDOT(CSM),YDOT(LM)
(.01nm,.1fps,.1fps)
(RECYCLE) V32E to 1
(EXIT) PRO

V91 - COMPUTE BANKSUM
CMC - on (req)

- 1 V37E 00E
- 2 F 05 01 V91E
R1 - Sum of all cells in bank
R2 - Bank number
R3 - Bugger word
Verify R1=R2 or R1+R2=77777 (If not, rcd
R2)
(NEXT BANK) PRO
(TERM) V34E

V93 - ENABLE W-MATRIX INITIALIZATION

- 1 V93E

IMU POWER UP PROCEDURE

LOGIC POWER 2/3-on
FDAI POWER - BOTH
FDAI SELECT - 1/2
CMC MODE - FREE

1

G/N IMU PWR - on (up)
NO ATT 1t - on (90 sec)
NO ATT 1t - out
Wait 15 sec (To allow PIPA inhibit
reset)

2

V37E XXE

*If CMC not available: *
* G/N IMU PWR - on(up) *
* Wait 90 sec *
* IMU CAGE - on(up) 5 sec,*
* then release *

IMU POWER DOWN PROCEDURE

CMC MODE - FREE

G/N IMU PWR - OFF
ISS warning
*RSET *

**IF IMU PWR OFF, wait 5 *
MIN PRIOR to PWR ON*

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MEASUREMENT & LOADING OF PIPA BIAS

1 DET - RESET
SC RATES <0.1°/sec
CMC MODE - FREE

2 V25N 21E, E,E,E/Start Event Timer

3 06 21 V06 N21 (do not ENTR)
XYZ PIPA COUNTS

4 Record At T + 1:04 - ENTR
(X) R1 ____ (Y) R2 ____ (Z) R3 ____ (+000AB)

5 F 21 01 V21N 01E (use same sign as above)
1452 E (CALCULATED X BIAS) E,E,(+AB000)
1454 E (CALCULATED Y BIAS) E,E
1456 E (CALCULATED Z BIAS) E

CMC POWER UP PROCEDURE

1 PRO, hold (~5 sec) until STBY lt - out
(repeat, if necessary)
CMC warning, RESTART, PROG ALARM
*RSET and continue *

2 F 37 00E

P06 - CMC POWER DOWN PROGRAM

1 F 04 46 V48E
Load 0 (NO DAP) in left digit of R1
PRO, PRO, PRO
V46E

V37E 06E
F 50 25 00062 CMC PWR DN

PRO, hold (~5 sec) until STBY lt - on
(repeat, if necessary)

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CMC SELF CHECK

- 1 F 21 01 V25 N01E, 1365E
E,E,E
- 2 15 01 V15 N01E, 1365E
R1 NUMBER OF ERRORS
R2 NUMBER OF TESTS STARTED
R3 NUMBER OF E-MEM TESTS SUCCESSFUL
- 3 V21 N27E 10E SELF TEST FIXED & ERASABLE
(4E SELF CHECKS ERASABLE
5E SELF CHECKS FIXED)
- 4 15 01 TEST SUCCESSFUL WHEN R2>3 (78 sec minimum)
* IF PROG 1t - On *
* V05 N09E 01102 SELF *
* TEST ERROR *
*N8E-Rec for MSFN *
(TERM) V21N27E 0E

OPTICS POWER UP PROCEDURE

Verify optics manual drive disengaged
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - on (up)
OHC - Drive trun <10°
OPT ZERO - ZERO (15 sec)

OPTICS POWER DOWN

- 1 G/N PWR OPTICS - OFF

SCT MANUAL DRIVE PROCEDURE

Verify G&N PWR OPTICS - OFF

- 1 Insert tool E and rotate ~1 rev CCW
to engage drive (socket backs out)
- 2 Drive optics either direction
(~1 rev/degree)
- 3 To disengage, push and rotate
~1 rev CW(button will remain flush)

SCS POWER UP

AUTO RCS SELECT (16) - OFF
 BMAG MODE (3) - RATE 2
 CMC MODE - FREE
 SC CONT - CMC
 cb SCS LOGIC PWR (4) - close
 ΔV CG - as required
 LOGIC PWR 2/3 - on (up)
 SIG COND/DRIVER BIAS PWR (2) - AC1
 SCS ELEC PWR - GDC/ECA (88 watts)
 FDAI PWR - OFF (verify)
 BMAG PWR (2) - ON (145 watts)
 FDAI PWR - BOTH (58 watts)
 AUTO RCS SELECT (16) - enable

SCS POWER DOWN

EMS FUNCTION - OFF
 EMS MODE - STBY
 FDAI SCALE - 5/1
 FDAI SELECT-1/2
 FDAI SOURCE - ATT SET
 ATT SET - GDC
 MAN ATT (3) - MIN IMP
 ATT DB - MAX
 RATE - LOW
 AUTO RCS SELECT (16) - OFF
 TRANS CONTR PWR - OFF
 RHC PWR NORMAL (2) - OFF
 RHC PWR DIRECT (2) - OFF
 CMC MODE - FREE
 BMAG MODE (3) - RATE 2
 SCS TVC (2) - RATE CMD
 .05G sw - OFF
 α/Pc sw - Pc
 TVC GMBL DRIVE (P&Y) - AUTO
 BMAG PWR (2) - WARMUP (105 watts)
 TVC SERVO PWR (2) - OFF
 FDAI PWR - OFF
 LOGIC PWR 2/3 - OFF
 SCS ELEC PWR - OFF
 SIG COND/DRIVER BIAS PWR (2) - OFF

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P20 - OPTIONS

- 0 - Rendz, VECPOINT, p. G/3-2
- 1 - Celestial body, VECPOINT, p. G/3-1
- 2 - Rotate, p. G/8-1
- 4 - Rendz, 3-axis, p. G/3-2
- 5 - Celestial body, 3-axis, p. G/3-1

P20 - UNIVERSAL TRACKING

Options 1 & 5 - Celestial Body
(1:VECPOINT; 5:3-axis)
CMC - on (req)
ISS - on and aligned (req)
BMAG MODE (3) - RATE 2

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- | | |
|---------|--|
| 1 | V37E 20E |
| F 04 06 | R1 00024 TRACKING OPTION
R2 00000
Load 1 or 5 in R2
PRO |
| 2 | F 06 78* AXIS YAW, AXIS PITCH, OMICRON (.01°)
Load values (OMICRON ignored for opt 1)
Sim. Bay: 90°, 52.25°
OMICRON SEF: 180°
BEF: 0°
PRO |
| 3 | F 06 79* R2 DEADBAND (.01°)
Load d.b.
PRO |
| 4 | F 01 70 R1 000DE STARCODE
Load code
PRO (DE ≠ 00 to 6) |
| 5 | F 06 88 CELESTIAL BODY VECTOR
Load vector
PRO |

6 (Req'd Mnvr $<10^\circ$, to 7)
F 50 18 MNVR request (.01°)

(AUTO) SC CONT - CMC
CMC MODE - AUTO
PRO

06 18 RPY (.01°) to 6 when MNVR complete

(MAN) RHC - MNVR to N18 angles

When att. acceptable

SC CONT - CMC
CMC MODE - AUTO

ENTR

7 *POSS UPLINK ACTY 1t *
*(Mnvr $>10^\circ$ req'd) *
To reestablish F 50 18
* Key V58E *

CMC continues tracking center of celestial body
*CMC will react to changes in N78 and N79 (May
take 4 sec)

To terminate P20 - V56E

P20 - UNIVERSAL TRACKING

Options 0 & 4 - Rendezvous
(0:VECPPOINT; 4:3-axis)

CMC - on (req)

ISS - on and aligned (req)

SCS - on (des)

BMAG MODE (3) - RATE 2

OPT ZERO - OFF

OPT MODE - MAN

G/N OPT PWR - on

OHC - Drive trun $<10^\circ$

OPT ZERO - ZERO (15 sec)

OPT MODE - CMC

Note: For VHF RNG display
see p G/1-20

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- 1 V37E 20E
F 04 06 R1 00024 TRACKING OPTION
R2 00000
Load 0 or 4 in R2
PRO
- 2 F 06 78* AXIS YAW, AXIS PITCH, OMICRON (.01°)
Load values (OMICRON ignored for Opt. 0)
PRO
- 3 F 06 79* R2 DEADBAND (.01°)
Load d.b.
PRO
(If required mnvr <10°, go to 5)
- 4 F 50 18 MNVR request (.01°)

(AUTO) SC CONT - CMC
CMC MODE - AUTO
PRO

06 18 RPY (.01°) to 4 when MNVR complete

(MAN) RHC - MNVR to N18 angles

When att. acceptable

SC CONT - CMC
CMC MODE - AUTO

ENTR

- 5 *POSS UPLINK ACTY 1t *
*(Mnvr >10° req'd) *
To reestablish F 50 18
* Key V58E *

OPT ZERO - OFF

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CMC continues LM attitude and optics tracking
 *CMC will react to changes made to N78 and N79
 (May take 18 sec)
 To start VHF marks - V87E (V88E to stop)
 MARK at will (Reject within 7 sec)
 POSS F 06 49 ΔR , ΔV , source code
 * (.01nm,.1fps,0000X)*
 *(REJECT) V32E *
 *(ACCEPT) PRO *

For backup marks, see V54 (p G/1-26)

To terminate P20 - V56E
 OHC - Drive trun <10°
 OPT ZERO - ZERO
 G/N OPT PWR - OFF

Note: To display N49 for each measurement:

V1 N1E
 2002 E
 Rcrd: R1 _____
 V21 E
 2002 E
 77776 E

To return:
 V21 N1E
 2002 E
 Load previously recorded value
P21 GROUND TRACK DETERMINATION
 CMC - on (req)

- 1 F 04 06 V37E 21E
 R1 00002, Specify Vehicle
 R2 00001, CSM
 or 00002, LM
 PRO
- 2 F 06 34 GET LAT, LONG (hrs,min,.01sec)
 Load desired GET (for present time, use
 all zeroes)
 PRO

3 F 06 43 LAT, LONG, ALT (.01°, .01°, .1nm)
(RECYCLE) V32E to 2 (Increment GET 10 min)
(EXIT) PRO

4 F 37 XXE

NOTE: Additional Information is available
by V6 N73E
N73 Alt, VEL, GAMMA(10nm, fps, .01°)

P22 - ORBITAL NAVIGATION

CMC - on (req)
ISS - on and aligned (req)
SCS - on (req)
BMAG MODE (3) - RATE 2
OPT ZERO - OFF
OPT MODE - MAN
G&N PWR OPTICS - on
OHC - Drive trun <10°
COUPLING - RESOLVED
SPEED - MED
OPT ZERO - ZERO (15 sec)
OPT MODE - CMC
To remove rate limit: V21N1E, 1341E, E

1
F 06 45 V37E 22E
R3=MAX MGA (.01°)
(REJECT) R3>60° to P52
R3<60° IMU ALIGNED
MNVR To SIGHTING ATTITUDE
Roll to keep shaft axis >10° from
plane defined by X axis & LOS to
LMK (For 60nm alt, LMK >10nm from
gnd track requires no roll)
(MAN) OPT MODE - MAN
OPT ZERO - OFF
PRO (To 3 for earth orbit)
(AUTO) OPT ZERO - OFF
PRO (To 3 for earth orbit)

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- 2 F 05 70 (lunar orbit only)
R2 ABCDE lmk code
Load lmk code: SITE = 10001
 KNOWN = 10000
 UNKN = 20000
 A=1(known), 2(unknown)
 B=INDEX OF OFFSET designator
 C=not used
 DE=LMK ID (0,1, 5X are legal)
 IF A=2, OPT MODE - MAN
 PRO to 5
or IF A=1 & DE≠00
PRO to 4 (To 5 if OPTICS - MAN)
or IF A=1 & DE=00
PRO to 3
- 3 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
Load lmk coords
PRO (To 5 if OPTICS - MAN)
- 4 06 92 SHAFT, TRUN NEW OCDU (.01°, .001°)
 F 05 09 00404 (TRUN>90°)
 * MNVR to acquire *
 * PRO *
 * or V34E, F 37 *
Establish proper pitch rate
OPTICS MODE - MAN
- 5 F 51 MARK REQUEST (Avoid lmk near horiz)
MARK
After sufficient MARKS:
 *After 5 MARKS: *
 F 50 25 00016 TERM MARKS
PRO
- 6 F 05 71 R2 ABCDE LMK DATA
Load lmk code (if nec)
 A=1 if KNOWN LMK
 A=2 if UNKNOWN LMK
 B=INDEX OF OFFSET DESIGNATOR
 (If only 1 mark made, insure B=0)
 C=Not used in P22
 DE=LMK ID NO. (0,1 are valid)
PRO - if A=2 (or A is 1 & DE = 01) to 8

7 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
PRO

8 F 06 49 ΔR, ΔV (SV PARA) (.01nm, .1fps)
(RECYCLE) V32E to 2
(ACCEPT) Hold for 30 sec
PRO

9 F 06 89 LAT, LONG/2, ALT LMK ID (.001°, .001°, .01nm)
(DON'T STORE) PRO to 2
(STORE-CODE 01) V32E to 2
(terminate Prog) V34E

10 F 37 XXE
OHC - Drive trun <10°
OPT ZERO - ZERO
G/N PWR OPTICS - OFF
To restore rate limit (CDU transient
detection): V21N1E, 1341E, 5E

P23 - CISELUNAR MIDCOURSE NAV MEASUREMENT

CMC - on
SCS - on
ISS - on & aligned
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - on (30 min prior)
OHC - Drive trun <10°
OPT ZERO - ZERO (15 sec)
OPT MODE - CMC

1 V37E 23E

2 F 50 25 R1 00015 ACQ CALIBRATION STAR
(MAN MNVR) Mnvr veh. to point LLOS at body
ENTR to 7
(AUTO MNVR) PRO

3 F 01 70 R1 000DE STAR CODE
Load desired code
PRO (to 5 if DE≠00)

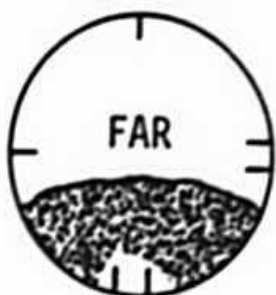
DATE 12/8/71

- 4 F 06 88 CELESTIAL BODY VECTOR
Load desired vector
PRO
- 5 F 50 18 REQUEST MNVR TO FDAI R,P,Y (.01°)
(AUTO) SC CONT-CMC
CMC MODE - AUTO
BMAG MODE (3) -RATE 2
PRO to 6
(MAN) V62E
MNVR to 5

(BYPASS) ENTR to 7
- 6 06 18 AUTO MNVR FDAI R, P, Y (.01°)
AUTO MNVR COMPLETE RETURN TO 5
- 7 F 59 REQUEST OPTICS CALIB
(BYPASS) ENTR to 9
(CALIB) OPT MODE - MAN
OPT COUPLING - DIR
SPEED - LOW
OPT ZERO - OFF
SUPERIMPOSE LLOS ON SLOS
MARK
- 8 F 06 87 R2 TRUN BIAS (.001°)
(Repeat until 2 measurements
agree within .003°)
For manual load:
V22 N94E
XXXXXE
(RECALIB) MARK to 8
(INCORP
CALIB) PRO

DATE 12/8/71

9 F 05 70



R1 000DE STAR ID
R2 00C00 LMK ID
R3 00CD0 HOR ID

STAR/ENH	STAR/LNH	STAR/EL
000DE	000DE	000DE
00000	00000	00100
00110	00210	00000

STAR/EFH	STAR/LFH	STAR/LL
000DE	000DE	000DE
00000	00000	00200
00120	00220	00000

STAR/HOR PRO TO 12 (DE=00 to 11)
STAR/LMK PRO

10 F 06 89 LAT, LONG/2, ALT (LMK)(.001° +N/E,.01nm)
PRO (DE≠00 to 12)

11 F 06 88 CELESTIAL BODY VECTOR
LOAD DESIRED VECTOR
PRO

12 F 50 25 00202 3-AXIS MNVR REQUEST
(3-AXIS) PRO
(VECPOINT)ENTR

13 F 50 18 REQUEST MNVR TO FDAI R,P,Y (.01°)
(AUTO) SC CONT - CMC
CMC MODE - AUTO
BMAG MODE (3) - RATE 2
PRO to 14
(MAN) V62E
MNVR to 13
(BYPASS) OPT MODE - CMC
OPT ZERO - OFF
ENTR to 15

14 06 18 AUTO MNVR FDAI R, P, Y (.01°)
AUTO MNVR COMPLETE RETURN TO 13

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G
3-10

```

15      06 92  AUTO OPT SHFT/TRUN      (.01°, .001°)
          (MNVR)   V94E to 12
          (MARK)   MNVR SC TO POSITION LMK/HOR
                   IN FOV
                   OPT MODE - MAN

```

```
16    F 51      MARK REQUEST
                (MNVR)      V94E to 12
                (MARK)      SUPERIMPOSE STAR ON LMK/HOR
                             MARK
```

17 F 50 25 00016 TERM MARKS
(REJECT) MARK REJECT to 16 (Noun + R1 not
(TERM) PRO blanked)

```

18      F 05 71      R1  000DE STAR ID
                        R2  00C00 LMK ID
                        R3  00CD0 HOR ID

                        (STAR/HOR) PRO to 21 (DE=00 to 20)
                        (STAR/LMK) PRO to 19

```

19 F 06 89 LAT, LONG/2, ALT(LMK) (.001°+N/E,.01nm)
PRO (DE#00 to 21)

20 F 06 88 CELESTIAL BODY VECTOR
Verify vector
PRO

```
21      F 06 49      ΔR,ΔV (SV PARA)      (.01nm,.1 fps)
                (REJECT) V37E 23E
                (UPDATE) PRO
```

(To avoid auto mnvr. and auto optics
on subsequent passes: V25N7E,77E,
10000E,E. To restore: V25N7E,77E,10000E,
1E)

22 F 37 XXE
OHC - Drive trun <10°
OPT ZERO - ZERO
G/N PWR OPTICS - OFF

DATE 3/15/72

P24 RATE-AIDED OPTICS TRACKING

CMC - on (req)
ISS - on and aligned
SCS - on
BMAG MODE (3) - RATE 2
OPT ZERO - OFF
OPT MODE - MAN
G&N PWR OPTICS - on
OHC - Drive trun $<10^\circ$
OPT ZERO - ZERO (15 sec)
OPT MODE - CMC
TVC SERVO PWR 1 & 2 - OFF (verify)
GMBL MTRS (4) - OFF (verify)

- 1 V37E 24E
- 2 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
LOAD LMK COORDS
OPT ZERO - OFF
MNVR to SIGHTING ATT
Roll to keep shaft axis $> 10^\circ$ from
plane defined by X-axis & LOS to
LMK (For 60nm alt, LMK > 10 nm from
gnd track requires no roll)
PRO
- 3 06 92 AUTO OPT SHFT/TRUN (.01°, .001°)
F 05 09 00404 (TRUN $>90^\circ$)
* MNVR to acquire *
* PRO *
* or V34E, F 37 *
OPTICS MODE - MAN

DATE 12/8/71

4 F 51 MARK REQUEST
MARK (as often as desired)
To terminate:
PRO

5 F 37 XXE
OHC - Drive trun <10°
OPT ZERO - ZERO
G/N PWR OPTICS - OFF

P27 CMC UPDATE

CMC - on (req)

Auto Update:

1 V37E 00E (Not nec. if P20 opt 1,2,5 in foreground)
UP TLM (2) - ACCEPT
UPLINK ACTY 1t - on
POSS LOS before completion
*If V33 N02 showing: *
* Key ENTR *
* UPLINK ACTY 1t - out *
* P00 or P20 displayed *
*If V21 N01 *
*or V21 N02 *
* Key V34E *
* UPLINK ACTY 1t - out *
* P00 or P20 displayed *
*UP TLM (MDC) - BLOCK *

Update complete:

UPLINK ACTY 1t - out
UP TLM (MDC) - BLOCK

Voice Transmission Update:

1 V37E 00E (Not nec. if P20 opt 1,2,5 in foreground)

2 V70E LIFT-OFF TIME UPDATE
or V71E LOAD DATA CONSEC ADD
or V72E LOAD DATA IN NON CONSEC
or V73E CMC TIME UPDATE

3 P27 Displayed

DATE 12/8/71

- 4 F 21 01 R3 UPDATE BUFFER ADD (initially 304)
R1 Data E (R3 Increments)
(If change - To 6)
Repeat Step 4 for all data
- 5 F 21 02 R3 330
(Verify Data) V1 N1E
R3 304E
R1 Verify Data
N15E (R3 305)
R1 Verify Data
Consecutive ENTR's display
remaining comps. Note
octal ident (01-24) of
comps which need change
KEY REL To 6
- 6 F 21 02 R3 330
(CHANGE) Load octal ident, XXE to 4
(ACCEPT UPDATE) Key Verb, then PRO
- 7 P00 or P20 Displayed
P29 TIME OF LONGITUDE
CMC-on (req)
- 1 V37E29E
- 2 F 04 06 R1 00002 Specify Vehicle
R2 00001, CSM
00002, LM
PRO
- 3 F 06 34 GET BASE TIME (hrs,min,.01 sec)
Load time from which
CMC will begin search (all 0's for
present time)
PRO
- 4 F 06 43 R2 DESIRED LONG (.01°)
Load long
PRO

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5 F 06 34 GET LONG (hrs,min,.01 sec)
(Change long) V32E to 4
(see lat.) PRO

6 F 06 43 LAT, LONG, ALT (.01°, .01°, .1nm)
(Recycle) V32E to 2
(Term) PRO

7 F 37

P20 with GDC REFSMMAT

CMC - on (req)
IMU - off
GDC - on and REFSMMAT Known (pg G/7-13)
SCS - operating
OPT ZERO - OFF
OPT MODE - MAN
G/N OPT PWR - on
OHC - Drive trun <10°
OPT ZERO - ZERO (15 sec)
OPT MODE - CMC

1 V25N20E
Load present GDC angles
2 Perform P20 opt 4 (p. G/3-2)
Return after PRO on N79
3 Display desired att.
V16N18E (R,P,Y) (.01°)

4 Mnvr to Roll 0° or 180°, Yaw 0°
and Pitch shown in N18
V25N20E
Load present GDC angles

5 OPT ZERO - OFF
MARK (repeat as necessary)
* POSS F 06 49 ΔR, ΔV, source code *
* (.01nm, .1fps, 0000X)*
* (REJECT) V32E *
* (ACCEPT) PRO *

(To Terminate P20 - V56E
G/N OPT PWR - OFF)

DATE 12/8/71

P24 MARK BUTTON FAILED (Low Alt.)

CMC - on (req)
ISS - on and aligned (req)
OPT ZERO - OFF
OPT MODE - MAN
G&N PWR OPTICS - on
OHC - Drive trun <10°
OPT MODE - CMC
OPT ZERO - ZERO (15 sec)
SC CONT - CMC
CMC MODE - AUTO
TVC SERVO PWR 1&2 - OFF (verify)
GMBL MTRS (4) - OFF (verify)

1 MNVR TO LMK TRK PAD ATT
V49E

2 AUTO UPDATE:
V37E00E
UP TLM (2) - ACCEPT
UPLINK ACTY 1t - on
GND will uplink routine for
failed MARK button (pg. G/3-17)

Update complete:
UPLINK ACTY 1t - out
UP TLM (MDC) - BLOCK
*DO NOT CALL: *
*P21, P22, P23, P29 *
P3X, P4X, P5X, P6X, P7X

3 V5 N26E, verify:
R1: 14000
R2: 01603
R3: 16067

4 V37E 20E

5 F 04 06 R1 00024 TRACKING OPTION
R2 00000
LOAD 2 in R2
PRO

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- 6 F 06 78 AXIS YAW, AXIS PITCH, OMICRON (.01°)
LOAD: R1 +09000
R2 XXX.XX (LMK PAD ROLL ANGLE)
R3 +00000
PRO
- 7 F 06 79 RATE, DEADBAND (.0001°/sec,.01°)
LOAD: R1 -20000
R2 +00050
PRO
- 8 F 06 34 START TIME (hrs,min,.01 sec)
LOAD LMK PAD T2 TIME
PRO
- 9 V37E 24E
OPT ZERO - OFF
OPT TEL TRUN - SLAVE TO SXT
OPT COUPLING - RSLV
OPT SPEED - HI
- 10 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
LOAD LMK COORDS
PRO
- 11 AT T2 -30 SEC: OPT MODE - MAN
V30E (Start erasable prog.)
- 12 F 53 BACKUP MARK REQUEST
PRO for MARK
ENTER for MARK REJ
- 13 TO TERMINATE PROGRAM:
V34E
F 51
PRO
- 14 F 37

FAILED MARK BUTTON MARKING ROUTINE

PURP	V 7 1					V 7 1					V 7 1				
304 01	INDEX 2 4					INDEX 2 4					INDEX 1 5				
02	0	3	6	0	3	0	3	6	2	5	0	3	6	4	7
03	3	1	6	6	1	0	0	0	0	6	0	1	6	5	2
04	0	4	6	3	6	3	0	0	2	5	4	4	7	7	4
05	2	6	0	3	6	5	2	3	5	5	6	1	7	5	3
06	2	0	5	7	6	3	4	7	7	0	5	4	1	5	4
07	0	2	0	5	2	0	5	2	2	3	0	0	0	0	6
10	0	1	6	1	2	0	2	2	0	4	5	0	1	5	4
11	0	1	6	3	4	0	1	6	0	3	4	1	5	4	0
12	0	0	0	0	4	4	0	0	7	5	5	0	1	5	4
13	3	0	0	3	6	7	4	7	6	5	5	3	5	4	0
14	5	4	3	5	7	1	0	0	0	0	0	1	6	0	3
15	3	0	0	3	5	0	1	6	0	3	1	5	2	0	0
16	5	4	3	6	1	0	5	5	6	1					
17	3	0	0	3	3	0	0	0	3	2					
20	5	4	3	5	6	0	5	5	6	1					
21	3	0	0	3	4	0	0	0	5	2					
22	5	4	3	6	0	1	1	7	5	3					
23	3	0	0	3	2	0	1	6	5	0					
24	5	4	3	6	2	3	4	1	7	2					

DUE TO ERASABLE CONFLICTS, THE FOLLOWING PROGRAMS MUST NOT BE EXERCISED BETWEEN THE TIME THAT THE ERASABLE PROGRAM IS UPLINKED AND THE TIME THAT THE ERASABLE PROGRAM IS NO LONGER NEEDED: P21, P22, P23, P29, P3X, P4X, P5X, P6X, AND P7X.

P24 COAS MARKING (Hi Alt)

CMC - on (req)
ISS - on and aligned
G&N PWR OPTICS - OFF
OPT ZERO - ZERO
SC CONT - CMC
CMC MODE - AUTO
BMAG MODE (3) - RATE 2
MAN ATT (3) - MIN IMP

1 MNVR TO LMK TRK PAD ATT
V49E

2 AUTO UPDATE:
V37E 00E

UP TLM (2) - ACCEPT
UPLINK ACTY 1t - on
GROUND UPLINKS:
LMK POSITION IN RLS IF LMK NOT PRIME
BACKUP MARK ROUTINE (pg G/3-20)

UPDATE COMPLETE:
UPLINK ACTY 1t - out
UP TLM (MDC) - BLOCK
*DO NOT CALL: P21, P22, *
P23, P29, P3X, P4X, P5X, P6X, P7X

3 V5 N26E VERIFY N26:
R1 14000
R2 01603
R3 16067

4 V24 N94E ALT LOS OPT ANG SHAFT, TRUN
(.01°, .001°)
LOAD ANGLES
(Nom: +0E, +57470E)

5 V25 N78E AXIS YAW, AXIS PITCH, OMICRON
(.01°)
+0E, +0E, +0E

6 V22 N79E DEADBAND (.01°)
+50E

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7		V37E 24E	
8	F 06 89	LAT, LONG/2, ALT LOAD LMK COORDS PRO	(.001°, .001°, .01nm)
9	F 51	MARK REQUEST V21 N1E 3374E 0E ZERO R61CNTR V44E SET SURFFLAG V25 N7E 75E 1020E SET TRACKFLG AND LMTRG 1E	
10	F 50 18	<i>MANUALLY FLY ROLL TO ZERO FIRST</i> If MNVR < 10°, to 11 MNVR REQUEST PRO When mnvr complete - ENTR	(.01°)
11	F 51	MARK REQUEST V30E CALL ERASABLE PROG	
12	F 53	BACKUP MARK REQUEST	
13		AFTER ACQUISITION: CMC MODE - FREE TRACK LMK WITH RHC PRO for MARK ENTER for MARK REJ	
14		TO TERMINATE PROG: V34E	
	F 51	V37E 00E V45E (RESET SURFFLAG)	

NOTE:
PREFER SCS
P in MIN IMPULSE
REY RATE cmd ē
ATT 2/RATE 2

DATE 12/8/71

COAS MARKING ROUTINE

PURP		V 7 1				V 7 1				V 7 1						
304	01	INDEX		2	4	INDEX		2	4	INDEX		1	5			
	02	0	3	6	0	3	0	3	6	2	5	0	3	6	4	7
	03	3	1	6	6	1	0	0	0	0	6	0	1	6	5	2
	04	0	4	6	3	6	3	0	0	2	5	4	4	7	7	4
	05	2	6	0	3	6	5	2	3	5	5	6	1	7	5	3
	06	2	0	5	7	6	3	4	7	7	0	5	4	1	5	4
	07	0	2	0	5	2	0	5	2	2	3	0	0	0	0	6
	10	0	1	6	1	2	0	2	2	0	4	5	0	1	5	4
	11	0	1	6	3	4	0	1	6	0	3	4	1	5	4	0
	12	0	0	0	0	4	4	0	0	7	5	5	0	1	5	4
	13	3	1	7	2	5	7	4	7	6	5	5	3	5	4	0
	14	5	4	3	5	7	1	0	0	0	0	0	1	6	0	3
	15	3	1	7	2	7	0	1	6	0	3	1	5	2	0	0
	16	5	4	3	6	1	0	5	5	6	1					
	17	3	0	0	3	3	0	0	0	3	2					
	20	5	4	3	5	6	0	5	5	6	1					
	21	3	0	0	3	4	0	0	0	5	2					
	22	5	4	3	6	0	1	1	7	5	3					
	23	3	0	0	3	2	0	1	6	5	0					
	24	5	4	3	6	2	3	4	1	7	2					

DUE TO ERASABLE CONFLICTS, THE FOLLOWING PROGRAMS MUST NOT BE EXERCISED BETWEEN THE TIME THAT THE ERASABLE PROGRAM IS UPLINKED AND THE TIME THAT THE ERASABLE PROGRAM IS NO LONGER NEEDED: P21, P22, P23, P29, P3X, P4X, P5X, P6X, and P7X.

DATE 12/8/71

P24 FROZEN OPTICS (Hi Alt)

1

Record frozen shaft and trun
TPACS and voice to ground:

SHAFT

TRUN

CMC - on (req)
ISS - on and aligned
G&N PWR OPTICS - ON
OPT ZERO - OFF
OPT MODE - MAN
SC CONT - CMC
CMC MODE - AUTO
BMAG MODE (3) - RATE 2

2

MNVR TO LMK TRK PAD ATT
V49E

3

AUTO UPDATE:

V37E 00E

UP TLM (2) - ACCEPT
UPLINK ACTY 1t - on
GROUND UPLINKS RLS
UPDATE COMPLETE:
UPLINK ACTY 1t - off
UP TLM (MDC) - BLOCK

4

GROUND VOICES N78 PAD:

YAW

PITCH

5

V25 N78E AXIS YAW, AXIS PITCH, OMICRON
(.01°)

XXX.XXE
XXX.XXE
+0E

6

V22 N79E DEADBAND
+50E

DATE 12/8/71

7 V37E 24E

8 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
LOAD LMK COORDS
PRO

9 F 51 MARK REQUEST
V21 N1E
3374E
0E ZERO R61CNTR
V44E SET SURFFLAG
V25 N7E
75E
1020E SET TRACKFLG AND LMTRG
1E

10 F 50 18 If MNVR <10°, to 11
MNVR REQUEST (.01°)
PRO
When mnvr complete - ENTR

11 F 51 MARK REQUEST

12 AFTER ACQUISITION:
CMC MODE - FREE
TRACK LMK WITH MIC
MARK as desired

13 TO TERMINATE PROG:
V37E 00E
V45E (RESET SURFFLAG)

MK BUTTON FAILED OPEN

May be used with P20,22,23,24,51 & 52

1

V25 N26E
1E
2165E
16067E

2

When ready to mark (F 51):

Key V31

Use ENTR to mark (must be LEB DSKY)

Use MK REJ to reject

Notes: As long as 31 remains in verb window,
ENTR may be used to mark. This will
be true in e.g. P24 unless MK REJ.
In general MK REJ will place 51 in
verb windows. V31 must then be rekeyed.

DATE 3/15/72

P30 EXTERNAL ΔV

If uplinked REFSMMAT, do P52 (OPT 1) before P30

1	F 06 33	V37E 30E TIG Load desired TIG PRO	(hrs,min,.01sec)
2	F 06 81	ΔV XYZ(LV) Load desired ΔV 's PRO	(.1fps) (Do not use all 0's)
3	F 06 42	HA,HP, ΔV (REQ) Set ΔV Counter PRO	(.1nm,.1nm,.1fps)
4	F 16 45	MARKS,TFI,MGA (MGA Set to -00002 IF REFSMMAT FLAG NOT SET) Set DET PRO	(marks,min-sec,.01°)
5	F 37		

DATE 12/8/71

PRETHRUST
(P30's & 70's)

MINKEY SEQUENCER

- 31.1 ΔV mag. < 7 fps, perform P41 (CMC begins at step 4)
 ΔV mag. > 7 fps, perform P40 (CMC begins at step 4)
- 31.2 Perform P76
- 31.3 Go to P32, step 2
- 32.1 ΔV mag. < 7 fps, perform P41 (CMC begins at step 4)
 ΔV mag. > 7 fps, perform P40 (CMC begins at step 4)
- 32.2 Perform P76
- 32.3 R1 of N55 (P32) < 4 , Go to P36, step 2
 $= 4$, Go to P31, step 2
 > 4 , Go to P32, step 2
- 36.1 If ΔV mag. $= 0$, go to 36.2

52 in MM lights
 F 06 22 New ICDU angles (.01°)
 (RECOMP) MNVR; V32E
 (ACCEPT) PRO

F 50 25 00020 MINKEY PULSE TORQUE
 Align GDC to Roll: 90 or 270
 Pitch: 0 or 180
 Yaw: 0

(TORQUE) CMC MODE - FREE
 PRO
 (16 20 during torque)
 Torque complete:
 CMC MODE - AUTO
 $\Delta V < 7$ fps - P41 (step 4)
 $\Delta V \geq 7$ fps - P40 (step 4)

(BYPASS) ENTR
 Perform P41 (step 4)

PRETHRUST
(P30's & 70's)

DATE 12/8/71

- 36.2 Perform P76
- 36.3 If pulse torque not done, go to P33 step 2.
- 36.4 If desired: Manually MNVR back to original GDC att.
If all gimbal angle changes for mnvr back to rend. att $< 10^\circ$, go to 36.5

F 50 18 Request MNVR to RPY angles (.01°)
(ACCEPT) SC CONT - CMC
CMC MODE - AUTO
PRO
(REJECT) ENTR to 36.5

06 18 MNVR in progress (.01°)
MNVR complete, to 36.5

36.5 52 in MM lights

F 06 22 New ICDU angles (.01°)
(RECOMP) MNVR; V32E
(ACCEPT) PRO

F 50 25 00020 MINKEY PULSE TORQUE
CMC MODE - FREE
PRO
(16 20 during torque)

Torque complete: CMC MODE - AUTO
Go to P33, Step 2

- 33.1 ΔV mag. < 7 fps, perform P41 (CMC begins at step 4)
 ΔV mag ≥ 7 fps, perform P40 (CMC begins at step 4)

33.2 Perform P76

33.3 Go to P34, step 2

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- 34.1 ΔV mag. < 7 fps, perform P41 (CMC begins at step 4)
 ΔV mag. ≥ 7 fps, perform P40 (CMC begins at step 4)
- 34.2 Perform P76
- 34.3 Go to P35, step 2
- 35.1 ΔV mag < 7 fps, perform P41 (CMC begins at step 4)
 ΔV mag. ≥ 7 fps, perform P40 (CMC begins at step 4)
- 35.2 Perform P76
- 35.3 MCC2 complete, go to P79 step 2
MCC2 not complete, go to P35, step 2

P31 HAM PRETHRUST

1

V37E 31E
(If no REFSMFLG, To 3)F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR

2

F 50 18 (Req'd Mnvr <10°, To 3)
Request MNVR To RPY angles (.01°)(ACCEPT) SC CONT - CMC
CMC MODE - AUTO
PRO

(REJECT) ENTR To 3

06 18 MNVR in progress (.01°)
When MNVR complete: MINKEY To 3
Non - MINKEY To 2

3

F 06 11 TIG (CSI) (hrs,min,.01sec)
Load if needed
PRO

4

F 06 55 APSIS CDH,TPI ELEVATION ANGLE(+0000N,.01°)
CENTRAL ANGLE, Passive Vehicle (ωt)
(For CDH N_π from CSI, load non-zero
in R3)
Load data
PRO

5

F 06 37 TIG (TPI) (hrs,min,.01sec)
Load data
PRO

6

F 06 33 TIG (HAM) (hrs,min,.01sec)
PRO

DATE 12/8/71

- 7 F 16 45 MARKS, TFI, -00001 (marks,min-sec)
(RECYCLE) V32E
(FINAL COMP) TERM MARKS
PRO
- *F 05 09 *
- * 00600 No Intersection on *
- * First Iteration *
- * 00601 Post CSI hp<85/5.8nm*
- * 00602 Post CDH hp<85/5.8nm*
- * 00603 TIG(CDH) - TIG(CSI) *
- * <10 min *
- * 00604 TIG(TPI) - TIG(CDH) *
- * <10 min *
- * 00605 NO SOL IN 15 TRIES *
- * 00606 $\Delta V(\text{CSI}) > 1000\text{fps}$ in 2*
- * Iterations *
- * V32E To 3: Adjust *
- * Inputs *
- 8 F 06 90 Y(Active),YDOT(Active),YDOT(Passive)
(.01nm,.1fps,.1fps)
PRO
- 9 F 06 81 ΔV XYZ (LV) HAM (.1fps)
PRO (If recycle - To 7)
- 10 F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)
(MGA = -00002 if no REFSMFLG)
SET EVENT TIMER
PRO (If MINKEY, to Sequencer 31.1)
- 11 F 37

P32 CSI PRETHRUST (P72 LM)

1 V37E (32E or 72E)
(If no REFSMFLG or P72, to 3)

F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR

2 (If req'd. mnvr < 10°, to 3)
F 50 18 Request MNVR to RPY angles (.01°)
(ACCEPT) SC CONT - CMC
CMC MODE - AUTO
PRO
(REJECT) ENTR to 3

06 18 MNVR in progress (.01°)
When MNVR complete: MINKEY to 3
Non - MINKEY to 2

3 F 06 11 TIG (CSI) (hrs,min,.01sec)
Load if needed
PRO

4 F 06 55 APSIS CDH,TPI ELEVATION ANGLE,(+0000N,.01°)
CENTRAL ANGLE,Passive Vehicle (ωt)
(For CDH N π from CSI, load non-zero
in R3)
Load data
PRO

5 F 06 37 TIG (TPI) (hrs,min,.01sec)
Load data
PRO

6 F 16 45 MARKS,TFI,-00001 (marks,min-sec)
(RECYCLE) V32E (MINKEY to 8)
(FINAL PASS) TERM MARKS
PRO (MINKEY to 8)

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```

*F 05 09
* 00600 No Intersection on
*      First Iteration
* 00601 hp+CSI <85nm/5.8nm
* 00602 hp+CDH <85nm/5.8nm
* 00603 TIG(CDH)-TIG(CSI)
*      <10 min
* 00604 TIG(TPI)-TIG(CDH)
*      <10 min
* 00605 NO SOL IN 15 Tries
* 00606 ΔV(CSI)>1000fps in 2
*      Iterations
*      V32E to 3 Adjust
*      Inputs

```

- 7 F 06 75 ΔH(CDH),ΔT(CDH-CSI),ΔT(TPI-CDH)
PRO (.1nm,min-sec)
- 8 F 06 90 Y(Active), YDOT(Active), YDOT (Passive)
PRO (.01nm,.1fps,.1fps)
- 9 F 06 81 ΔV XYZ(LV)CSI (.1fps)
Change if desired
PRO (If MINKEY: recycle, to 6
final pass, to 11)
- 10 F 06 82 ΔV XYZ(LV)CDH (.1fps)
PRO (If Recycling to 6)
- 11 F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)
(MGA Set to -00002 If No
REFSMFLG or If P72)
SET EVENT TIMER TO TFI
PRO (If MINKEY, to Sequencer 32.1)
- 12 F 37

P72 - Transmit mnvr Parameters to LM

DATE 12/8/71

P36 - PLANE CHANGE PRETHRUST

- 1 V37E 36E
(If no REFSMFLG, to 3)
- F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR
- 2 (Req'd Mnvr <10°, to 3)
F 50 18 Request MNVR to RPY angles (.01°)
- (ACCEPT) SC CONT - CMC
CMC MODE - AUTO
PRO
- (REJECT) ENTR to 3
- 06 18 MNVR in progress (.01°)
When MNVR complete: MINKEY to 3
non-MINKEY to 2
- 3 F 06 33 TIG (PC) (hrs,min,.01sec)
PRO
- 4 F 16 45 MARKS,TFI,-00001 (marks,min-sec)
(RECYCLE) V32E
(FINAL COMP) TERM MARKS
PRO
- 5 F 06 90 Y(Active),YDOT (Active),YDOT (Passive)
(.01nm,.1fps,.1fps)
PRO
- 6 F 06 81 ΔV XYZ (LV) PC (.1fps)
PRO (If recycle - to 4)
- 7 F 16 45 MARKS, TFI, MGA (marks,min-sec,.01°)
(MGA = -00002 if no REFSMFLG)
SET EVENT TIMER
PRO (If MINKEY, to sequencer 36.1)

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~~P33 CDH PRETHRUST (P73 LM)~~

~~P32(72) COMPLETE~~

V37E (33E or 73E)

(If no REFSMFLG or P73, to 3)

F 50 25 00017 MINKEY OPTION

(ACCEPT) PRO

(REJECT) ENTR

2

(If req'd. mnvr <10°, to 3)

F 50 18 Request MNVR to RPY angles (.01°)

(ACCEPT) SC CONT - CMC

CMC MODE - AUTO

PRO

(REJECT) ENTR to 3

06 18 MNVR in progress (.01°)

When MNVR complete: MINKEY to 3

Non - MINKEY to 2

3

F 06 13 TIG(CDH) (hrs,min,.01sec)

PRO

4

F 16 45 MARKS,TFI,-00001 (marks,min-sec)

(RECYCLE) V32E (MINKEY to 6)

(FINAL PASS) TERM MARKS

PRO (MINKEY to 6)

F 05 09 00611 NO TIG FOR

* SPECIFIED ANGLE *

* (REDO)V32E to 3 *

* PRO to 5 *

* (6 if MINKEY) *

*CMC will use last *

* calculated value of *

* TIG (TPI) *

5

F 06 75 $\Delta H(CDH), \Delta T(TPI-CDH), \Delta T(TPI-NOMTPI)$
PRO (.1nm,min-sec)

6

F 06 90 Y(Active), YDOT(Active), YDOT(Passive)
PRO (.01nm,.1fps,.1fps)

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7 F 06 81 ΔV XYZ(LV)CDH (.1fps)
PRO (If Recycling to 4)

8 F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)
(MGA Set to -00002 If No
REFSMFLG or If P73)
SET EVENT TIMER TO TFI
PRO (If MINKEY, to Sequencer 33.1)

9 F 37

P73 - Transmit mnvr Parameters to LM

P34 TPI PRETHRUST (P74 LM)

1 V37E (34E or 74E)
(If no REFSMFLG or P74, to 3)
F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR

2 (If req'd. mnvr <10°, to 3)
F 50 18 Request MNVR to RPY angles (.01°)
(ACCEPT) SC CONT - CMC
CMC MODE - AUTO
PRO
(REJECT) ENTR to 3

06 18 MNVR in progress (.01°)
When MNVR complete: MINKEY to 3
Non - MINKEY to 2

3 F 06 37 TIG (TPI) (hrs,min,.01sec)
Load desired TIG
PRO

4 F 06 55 PRECISION OFFSETS, ELEV ANGLE, ωt
(0000X,.01°, .01°)
Load desired values
(+00000 in R2 to CALC ELEV
ANGLE AT TIG TIME)
PRO

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5 F 16 45 MARKS,TFI,-00001 (marks,min-sec)
(RECYCLE) V32E (TIG option, to 7)
(FINAL PASS) TERM MARKS
PRO (TIG option, to 7)

F 05 09 (00611 NO SOL)
*PRO To 3 *

6 F 06 37 TIG (TPI) (hrs,min,.01sec)
PRO (If not MINKEY final pass, to 8)

7 F 06 55 PRECISION OFFSETS, ELEV ANGLE, ωt
(0000X,.01°, .01°)
PRO

8 F 06 58 HP, ΔV (TPI), ΔV (TPF) (.1nm,.1fps,.1fps)
PRO

9 F 06 81 ΔV XYZ(LV)TPI (.1fps)
PRO (recycle, to 5)

10 F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)
(MGA SET To -00002 IF NO
REFSMFLG or If P74)
SET EVENT TIMER TO TFI
PRO (If MINKEY, to Sequencer 34.1)

11 F 37
P74 - Transmit Mnvr Parameters To LM

P35 TPM PRETHRUST (P75 LM)

P34(74) COMPLETE

V37E (35E or 75E)

(If no REFSMFLG or P75, to 3)

F 50 25 00017 MINKEY OPTION

(ACCEPT) PRO

(REJECT) ENTR

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- 2

(If req'd. mnvr <10°, to 3)

F 50 18 Request MNVR to RPY angles (.01°)

(ACCEPT) SC CONT - CMC

CMC MODE - AUTO

PRO

(REJECT) ENTR to 3

06 18 MNVR in progress (.01°)

When MNVR complete: MINKEY to 3

Non - MINKEY to 2
- 3

F 16 45 MARKS,TFI,-00001 (marks,min-sec)

(RECYCLE) V32E

(FINAL PASS) TERM MARKS

PRO
- 4

F 06 81 ΔV XYZ(LV)TPM (.1fps)

PRO (If recycle - to 3)
- 5

F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)

(MGA SET TO -00002 IF NO

REFSMFLG or If P75)

PRO (If MINKEY, to Sequencer 35.1)
- 6

F 37

P75 - Transmit Mnvr Parameters To LM

To change ATIGINC:

V24N1E

2021E

6 min: 00002E

06240E

10 min: 00003E

25140E

3 min: 00001E

03120E

P79 RNDZ FINAL PROGRAM

1 V37E 79E
2 (All gimbal angle errors $< 10^\circ$, to 3)
F 50 18 Request MNVR to RPY angles (.01°)
(X-axis track)

SC CONT - CMC
CMC MODE - AUTO
PRO

06 18 MNVR in progress (.01°)
When MNVR complete: to 3

3 F 16 54 RANGE, RANGE RATE, THETA (.01nm, .1fps, .01°)
(Ext. vbs. locked out)
PRO

4 F 37

P37 RETURN TO EARTH PGM
(LONG CONTROL CANNOT BE DONE WHEN TIME
TO ENTRY IS < 4 HRS: Lunar return only)

Perform the following once:

V1N1E

3012E

Verify R1 = 01470 (1087 nm)

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

2 F 06 60 BLANK, ΔV DESIRED, GAMMA EI DESIRED
(fps,.01°)

Load desired ΔV :

PAD ΔV IF ON TLC

0. IF ON TEC

Load R3=0 (Good if VEI > 31 K fps)
PRO

DATE 3/15/72

```
*F 05 09 00612 State vector in*
*                Lunar Influence*
*                00605 Solution not *
*                Convergent        *
*V32E, RSET TO 1                    *
*                20607 Conic Routine *
*                Failed              *
*                20610 State vector is*
*                below 400K ft      *
*                altitude           *
*F 37 37E to 1                      *
```

3 INITIAL CONIC SOLN

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

If Impact LONG > 12° from desired:

TEC:N40E Record R2 as ΔV_{min} (fps) TLC: V32E to 1
V32E to 1 & use $|\Delta V| > \Delta V_{min}$ Decrease ΔV to
Load ΔV neg to move LONG WEST move LONG WEST
Load ΔV pos to move LONG EAST Increase ΔV to
move LONG EAST

Continue recycles til < 12° from desired LONG

If Impact LONG < 12° from desired:

Record Impact LONG as oc1 (.01°)
Record last ΔV DESIRED as ΔV_{in1} (fps)
PRO

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

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

6 F 06 81 ΔV XYZ(LV) at TIG
Record R3 as ΔV_{zcl} (.1fps)
N40E
Record R2 as ΔV_{cl} (.1fps)
Make sign of ΔV_{cl} same as ΔV_{in1}
KEY RLSE
PRO

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```
*F 05 09 00605 Solution not *
*                               *
*                               Convergent *
*                               00613 Flt Path Ang *
*                               not reached *
*RSET V32E to 1 *
*                               20607 Conic Routine*
*                               Failed *
*F 37 37E to 1 *
```

INITIAL PRECISION SOLN

7 F 06 61 IMPACT LAT, IMPACT LONG (.01°)
Record LONG as op1 (.01°)
If op1 acceptable, PRO to step 15
PRO

8 F 06 39 ΔT TRANSFER
PRO

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

10 F 06 81 ΔV XYZ(LV) at TIG
Record R1 as ΔV_{xp1} (.1fps)
Record R3 as ΔV_{zp1} (.1fps)
V32E to 11

LONG. ITERATION

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

12 F 06 60 BLANK, ΔV DESIRED, GAMMA EI DESIRED
To move WEST from op1:
Load $\Delta V_{in2} = \Delta V_{c1} - 10$
(If $\Delta V_{in1} = 0$ for TEC,
 $\Delta V_{in2} = -\Delta V_{c1} - 10$)
To move EAST from op1:
Load $\Delta V_{in2} = \Delta V_{c1} + 10$
Record ΔV_{in2} (.1fps)
R2: Load ΔV_{in2} (fps)
PRO

```
*F 05 09 SAME AS IN 2*
*V32E. RSET to 11 *
```

13 F 06 61 IMPACT LAT, IMPACT LONG (.01°)
Record LONG as 0c2 (.01°)

N81E Record R3 as ΔVzc2 (.1fps)

$$\text{Compute } K = \frac{|0c2 - 0c1|}{|\Delta Vzc2 - \Delta Vzc1|}$$

Compute Δθ LONG = 0d - 0p1 (.01°)

Obtain from chart ΔVo (fps)

Make sign of ΔVo same as Δθ LONG

Compute ΔVd:

If TLC and ΔVzp1 > 3ΔVxp1:

$$\Delta Vd = \Delta Vc1 + \Delta Vo$$

V32E to step 1 and use

ΔVd in R2 of N60

Otherwise:

$$\Delta Vzd = \Delta Vzp1 + \Delta Vo$$

14

$$\Delta Vd = (\Delta Vzd^2 + \Delta Vxp1^2)^{1/2}$$

To solve for ΔVd:

V37E 30E, Use present time in N33.

Load N81:

$$R1 = \Delta Vxp1$$

$$R2 = 0 \text{ (should be)}$$

$$R3 = \Delta Vzd \text{ (.1fps)}$$

PRO and rcrd ΔVd (.1fps)

from N42 R3.

Make sign of ΔVd same as ΔVzd

V37E 37E to step 1 and use ΔVd

in R2 of N60

FINAL SOLN

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

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

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17 F 06 81 ΔV XYZ(LV) TIG (.1fps)
(OPTION) N40E - VG MAG avail
in N40 and N80
KEY REL
PRO

18 F 04 06 THRUST OPTION
R1 00007
R2 0000X
X=1 (SPS)
2 (RCS)
Perform R03 (V48) if not performed just
prior to P37 call
PRO

19 F 06 33 TIG (hrs,min,.01sec)
PRO

20 F 16 45 MARKS,TFI,MGA (00 00,min-sec,.01°)
(MGA SET TO -00002 If No
REFSMMAT SET)
PRO

21 F 37 (40E or 41E)

OBTAIN ENTRY REFSMMAT (No Comm)
(Use only after final MCC)

1. Record 400K time from final P37
solution.

(Input TIG + FNL N39)

2. Use 400K time for T-align P52
(Option 2).

If PROG ALARM 401, Yaw 45°
* and V32E *

DATE 3/15/72

P76 - ΔV UPDATE (P77 CSM)

```

1      F 06 33      V37E (76E or 77E)      (hrs,min,.01sec)
          TIG
          Load TIG
          PRO

2      F 06 84(81)  $\Delta V$  XYZ      (.1fps)
          Load  $\Delta V$ 
          PRO (MINKEY, to Sequencer 3X.3)

3      F 37

```

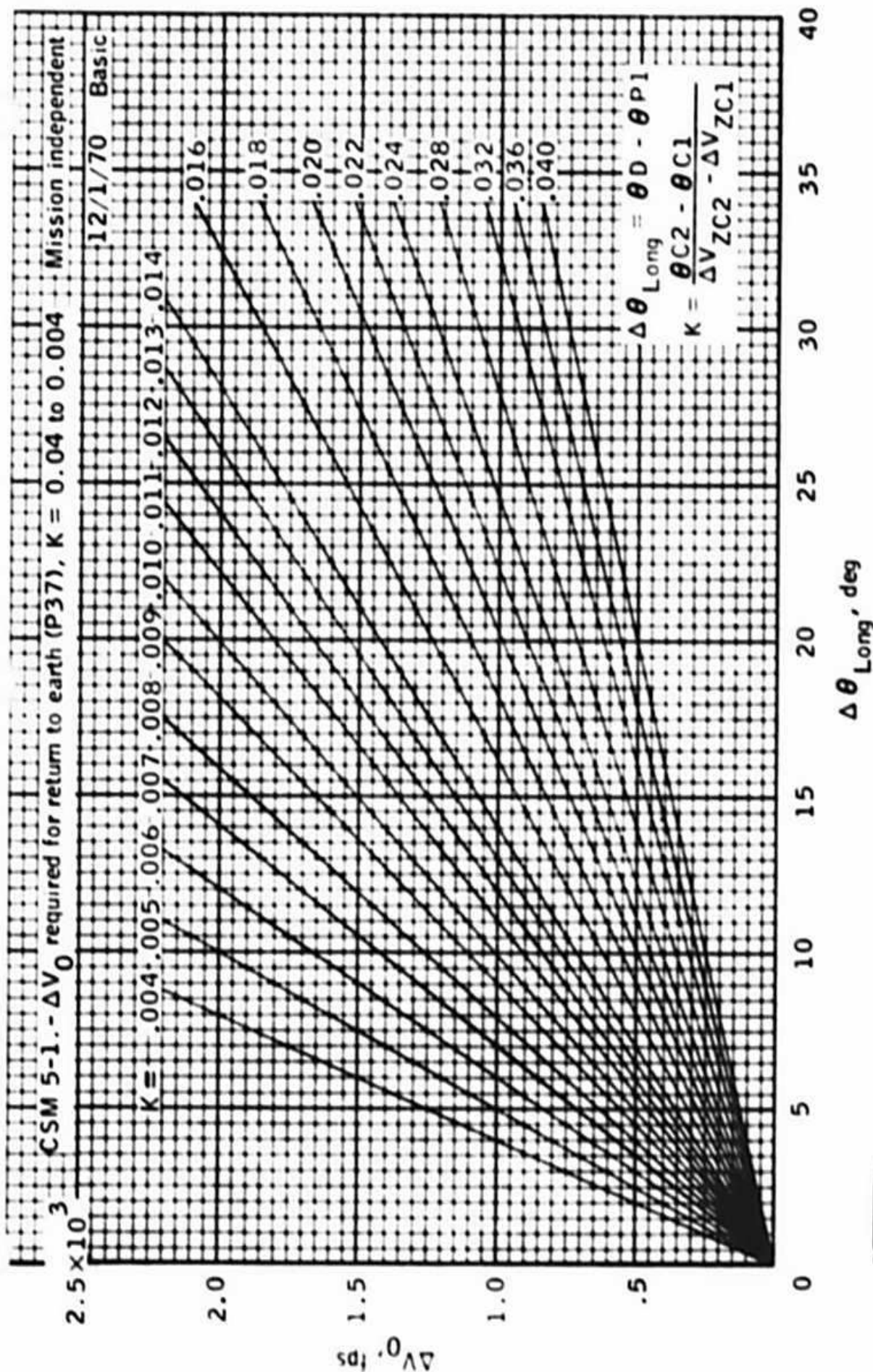
P37 LONGITUDE ITERATION

PARAMETER	STEP	1	2	3	
ΔV_{min}	3	____.	____.	____.	fps
$\theta c1$	3	____.	____.	____.	°
ΔV_{in1}	3	____.	____.	____.	fps
ΔV_{zc1}	6	____.	____.	____.	fps
ΔV_{c1} (Same sign as ΔV_{in1})	6	____.	____.	____.	fps
$\theta p1$	7	____.	____.	____.	°
ΔV_{xp1}	10	____.	____.	____.	fps
ΔV_{zp1}	10	____.	____.	____.	fps
ΔV_{in2}	12	____.	____.	____.	fps
$\theta c2$	13	____.	____.	____.	°
ΔV_{zc2}	13	____.	____.	____.	fps
$ \theta c2 - \theta c1 $	13	____.	____.	____.	°
$ \Delta V_{zc2} - \Delta V_{zc1} $	13	____.	____.	____.	fps
K	13	____.	____.	____.	
θd (desired long)	13	____.	____.	____.	°
$\theta d - \theta p1$ ($\Delta \theta$ long)	13	____.	____.	____.	°
ΔV_o (from chart)	13	____.0	____.0	____.0	fps
ΔV_{zd}	13	____.	____.	____.	fps
ΔV_d	13/14	____.	____.	____.	fps

DATE 12/8/71

DATE 12/8/71

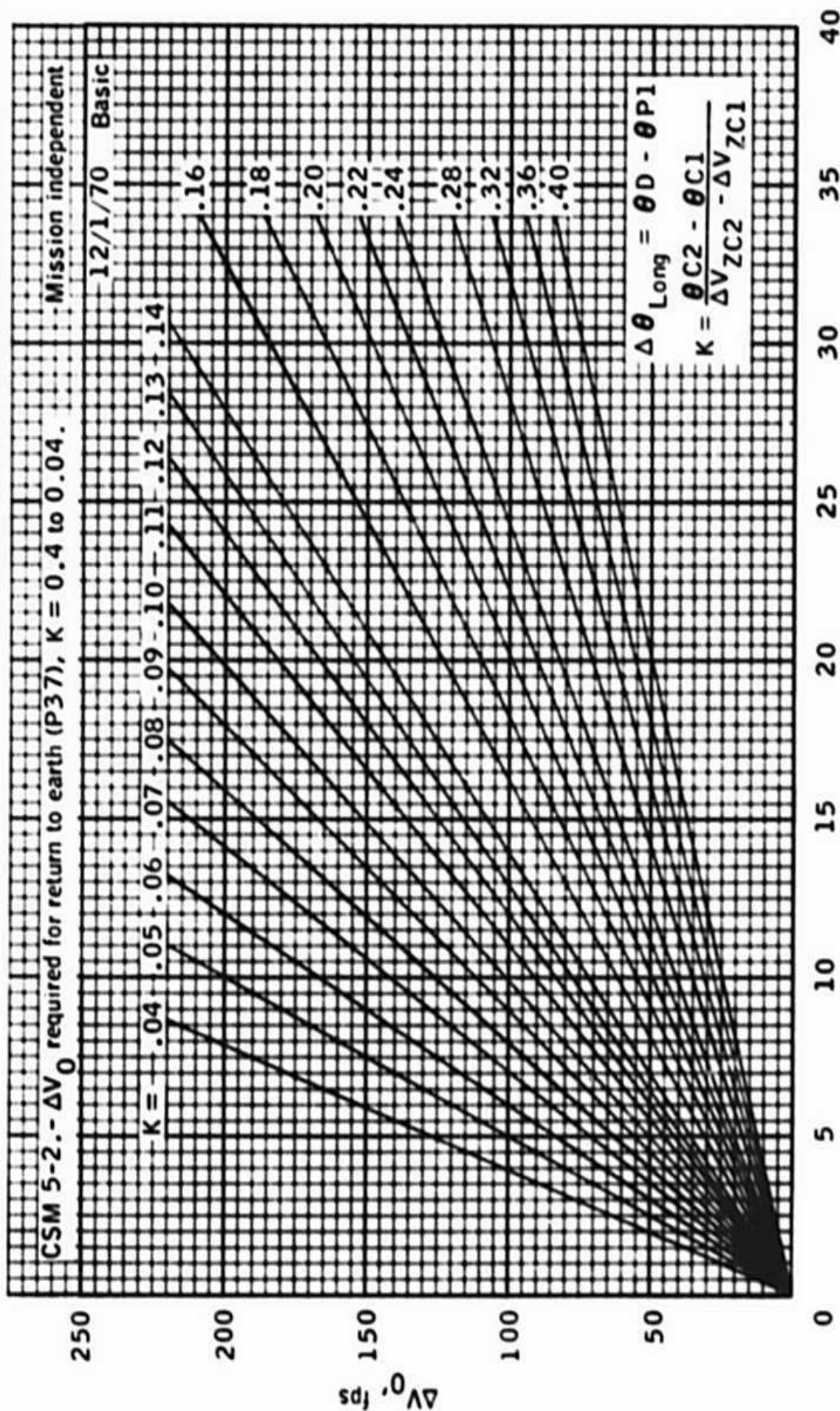
G
4-21



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

ΔV_0 vs $\Delta \theta_{Long}$

ΔV_0 vs $\Delta \theta$ LONG



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

DATE 12/8/71

[illegible]

P37 BLOCK DATA

P37 BLOCK DATA

		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}
		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}
		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}
		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}
		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}
		•				•		GETI
X					X			Δ VT
X					X			LONG
		•				•		GET _{400K}

DATE 12/8/71

P40 SPS THRUSTING

Prethrust Program Complete
Verify SIM BASIC and PRE SPS
BURN SIM PREP (CUE CARD)
CMC & ISS - on
SCS - OPERATING
TEST C/W LAMPS
Perform EMS ΔV TEST & NULL
BIAS CHECK, pg G/2-5
Set ΔVC
EMS FUNC - ΔV
SPS GAUGING - AC1
PUG MODE - ~~NORMAL~~ PRIM
OXID FLOW vlv - ~~PR~~ SEC
BMAG MODE (3) - RATE 2
CMC MODE - FREE
AUTO RCS SELECT(16)-as req'd
LOAD DAP (check roll jets)
ROT CONTR PWR NORM (2) - AC/DC
Set DET
V37E 00E
SC CONT - CMC/AUTO

THRUSTING (P40's)

1 MNVR TO PAD BURN ATT
V49E

2 PERFORM BORESIGHT & SXT STAR CHECK
V41 N91E

3 V37E 40E
(TFI available via N40, N45 or N35)

4 F 50 18 REQUEST MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC/AUTO
PRO

5 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)

DATE 3/29/72
12/8/77

6 F 50 18 REQUEST TRIM MNVR TO FDAI RPY ANGLES
ALIGN S/C ROLL (.01°)
GDC ALIGN

TVC CHECK & PREP

cb STAB CONT SYS (all) - close (Pnl 8)
cb SPS (12) - close
SET Δ VC (verify)
EMS FUNC - Δ V (verify)
MAN ATT (3) - RATE CMD
ATT DB - MIN
RATE - LOW
SCS TVC (2) - RATE CMD
 Δ VCG - LM/CSM or CSM
TVC GMBL DRIVE P&Y - AUTO

+54:00m
(-06:00)

MN BUS TIE (2) - ON
TAPE RCDR - HBR/RCD/FWD/CMD RESET
SPS He vlvs (2) - AUTO (verify)
Check N2 A and N2 B
TVC SERVO PWR #1 - AC1/MNA
TVC SERVO PWR #2 - AC2/MNB
ROT CONTR PWR NORMAL (2) - AC
ROT CONT PWR DIRECT (2) - OFF
BMAG MODE (3) - ATT1/RATE 2
SC CONT - SCS
RHC #2 - ARMED

55:00m
(-05:00)

PRIMARY TVC CHECK

GMBL MOT P1-Y1-START/ON (LMP Confirm)
Verify TRIM CONTROL & SET
Verify MTVC
IF SCS: SCS TVC (2) - AUTO
SC CONT - CMC (SCS)
THC - CW
Verify NO MTVC

SEC TVC CHECK

GMBL MOT P2-Y2-START/ON (LMP Confirm)
SET GPI TRIM
Verify MTVC
THC NEUTRAL
Verify NO MTVC

DATE 12/8/71

Verify GPI returns to 0,0(CMC)or trim
(SCS)

(TRIM) ROT CONT PWR NORM (2) - AC/DC
ROT CONT PWR DIRECT (2) - MNA/MNB
BMAG MODE (3) - RATE 2
PRO
BMAG MODE (3) - ATT1/RATE 2
ENTR

7 F 50 25 00204 GMBL TEST OPTION
(ACCEPT) SC CONT - CMC (verify)
PRO

Monitor GPI Response:
00,20,-20,00,02,-02,00, Trim

*TEST FAIL: *
*SC CONT - SCS *
SCS TVC(2) - AUTO

(REJECT) ENTR

8 06 40 TFI, VG, Δ VM (min-sec,.1fps)
PROG ALARM - TIG Slipped
*V5N9E 01703 *
*KEY RLSE TO 8 *

FDAI SCALE - 5/1
RATE - HIGH
UPDATE DET

59:00
(-01:00)

EMS MODE - NORMAL
TRANS CONT PWR - ON
 Δ V THRUST A(B) - NORMAL
THC - ARMED
RHC (2) - ARMED

59:25
(-00:35)

DSKY BLANKS

DATE 12/8/71

59:30 (AVE G ON)
(-00:30)

06 40 TFI, VG, Δ VM (min-sec, .1fps)
CHECK PIPA BIAS <2fps for 5 sec

59:XX
(-00:XX) ULLAGE

*If no ULLAGE: *
* DIR ULLAGE PB - PUSH*
* Control Att with RHC*

MONITOR Δ VM (R3) COUNTING UP

59:55
(-00:05)
F 99 40 ENG ON ENABLE REQUEST
(AUTO IGN) PRO AT TFI >0 Sec
(BYPASS IGN) ENTR to 11 (Perform switching in 10)
EXIT - V37E 00E

9 00:00 IGN *IF SCS: +X & THRUST PB - PUSH*

06 40 TFC, VG, Δ VM (min-sec, .1fps, .1fps)

*F 97 40 SPS Thrust fail *
* Δ V THRUST B(A)-NORMAL *
*(CONT GUID) PRO to 06 40 *
(RECYCLE) ENTR to TIG-05sec

00:03 SPS THRUST Lt - ON
 Δ V THRUST B(A) - NORMAL
IF SCS: +X & THRUST PB - PUSH

MONITOR THRUSTING

Pc 95-105 psia

EMS COUNTING DOWN

SPS INJ VLVS (4) - OPEN

SPS He vlvs tb-gray

SPS FUEL/OXID PRESS - 170-195 psia

PUGS - BALANCED

DATE 12/8/71

XX:XX ECO

10 F 16 40 TFC (STATIC), VG, Δ VM (min-sec,.1fps)
 Δ V THRUST A&B - OFF
 VERIFY THRUST OFF
 SPS INJ VLVS (4) - CLOSED
 SPS He vlvs tb (2) - bp
 GMBL MTRS (4) - OFF (LMP Confirm)
 TVC SERVO PWR 1&2 - OFF

PRO

11 F 16 85 VG XYZ (CM) (.1fps)
 NULL RESIDUALS
 RHC & THC - LOCKED
 TRANS CONT PWR - OFF
 ROT CONTR PWR DIRECT (2) - OFF
 cb DIRECT ULLAGE (2) - open
 cb SPS P1 & Y1 - open
 RECORD Δ V COUNTER & RESIDUALS Δ VC
 EMS FUNC - OFF VGX
 EMS MODE - STBY VGY
 PRO (If MINKEY, to Sequencer VGZ
 3X.2)
 ATT DB - MAX
 BMAG MODE (3) - RATE 2
 MN BUS TIE (2) - OFF
 PCM BIT RATE - LOW

PROP CONS

DATE 12/8/71

12 F 37 V82E

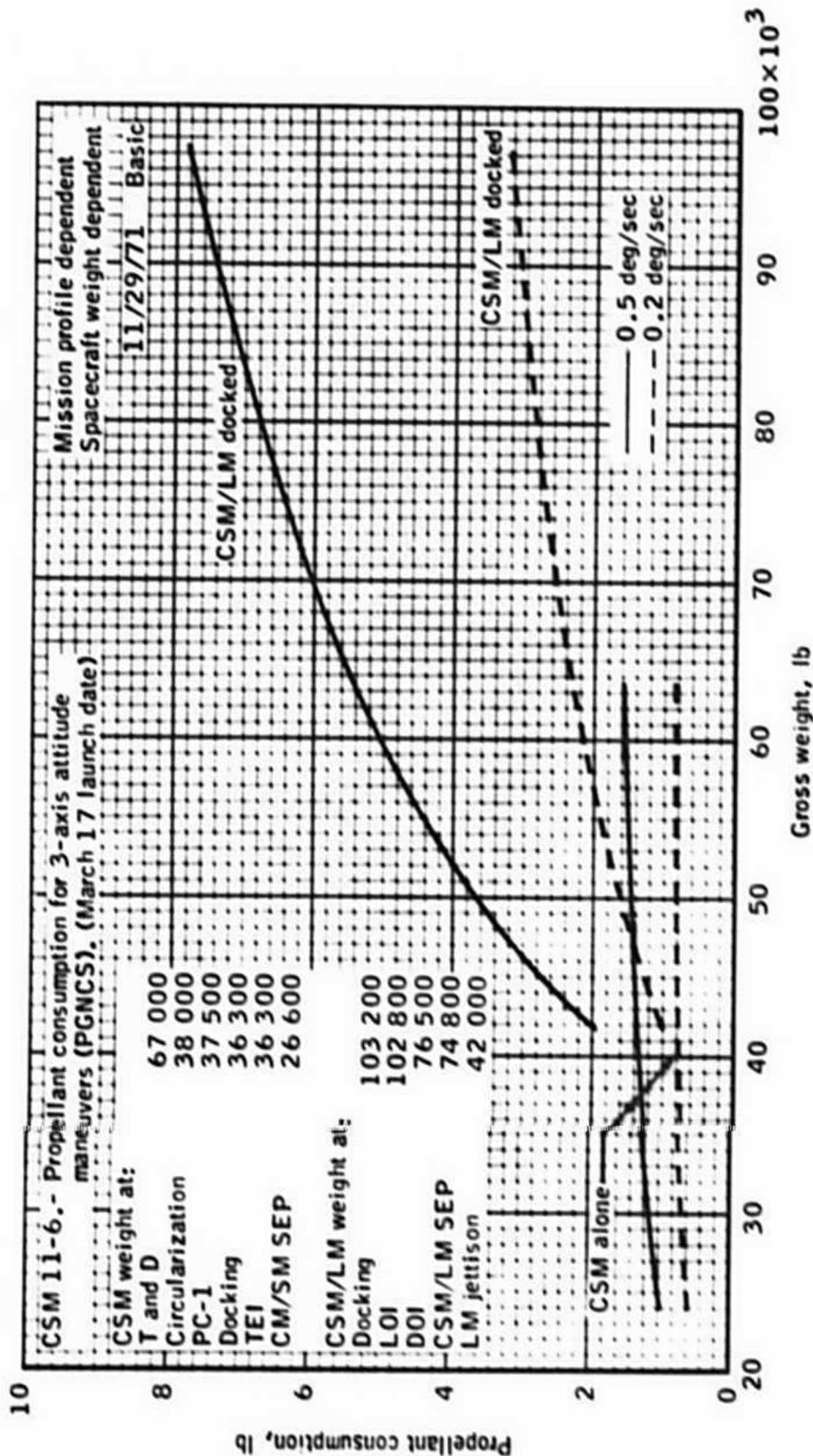
13 F 16 44 HA,HP,TFF (.1nm,min-sec)

PRO

14 F 37 OOE

PROP CONS

5-6



Propellant consumption 3-axis attitude maneuvers (PGNCS).

DATE 12/8/71

DATE 12/8/71

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

SM RCS PROPELLANT TRANSLATION COST

APOLLO 16

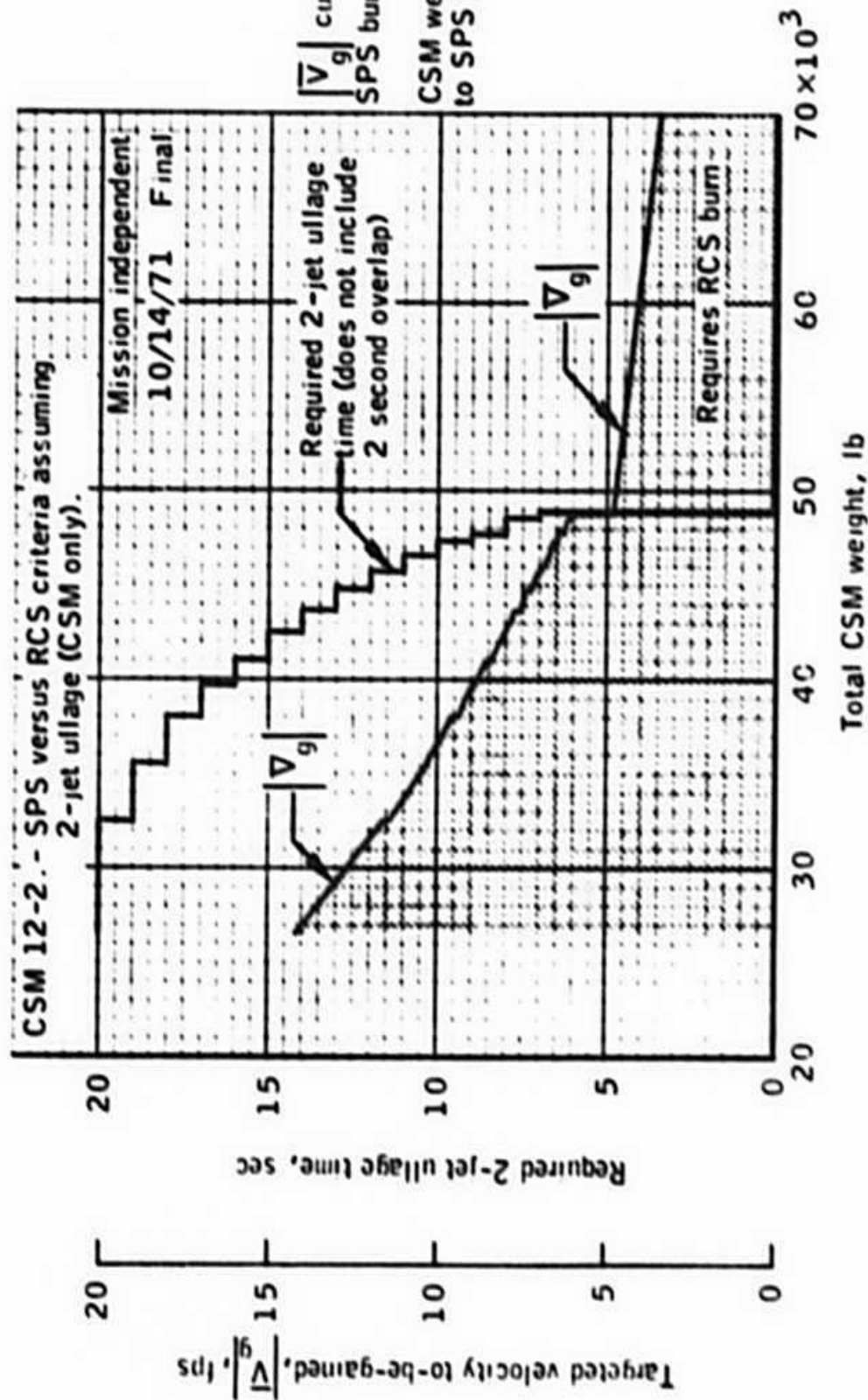
(CSM 113/LM-11)

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

5-7
G

SPS vs RCS CRITERIA

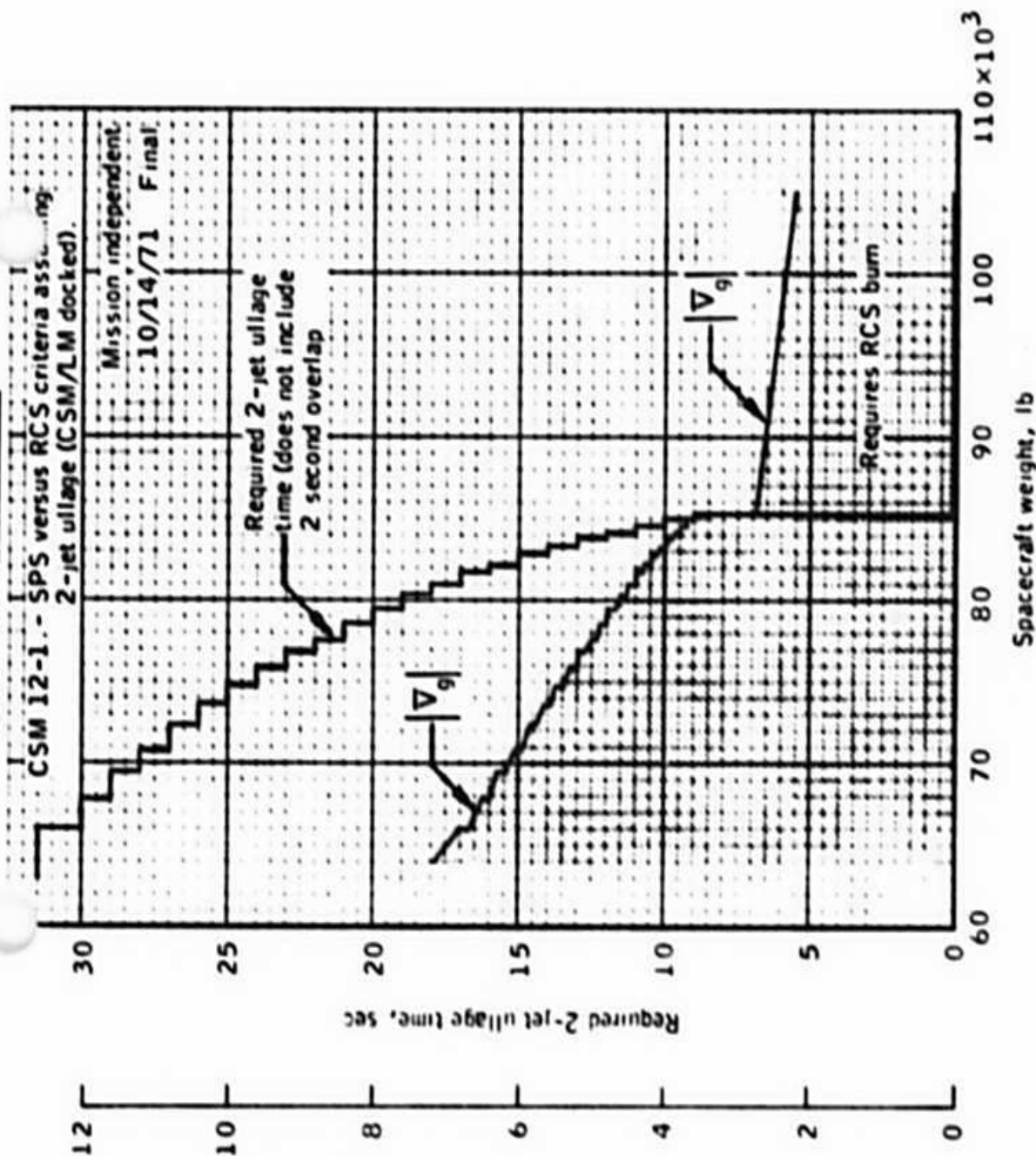
SPS vs RCS CRITERIA



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

DATE 12/8/71

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Assumptions

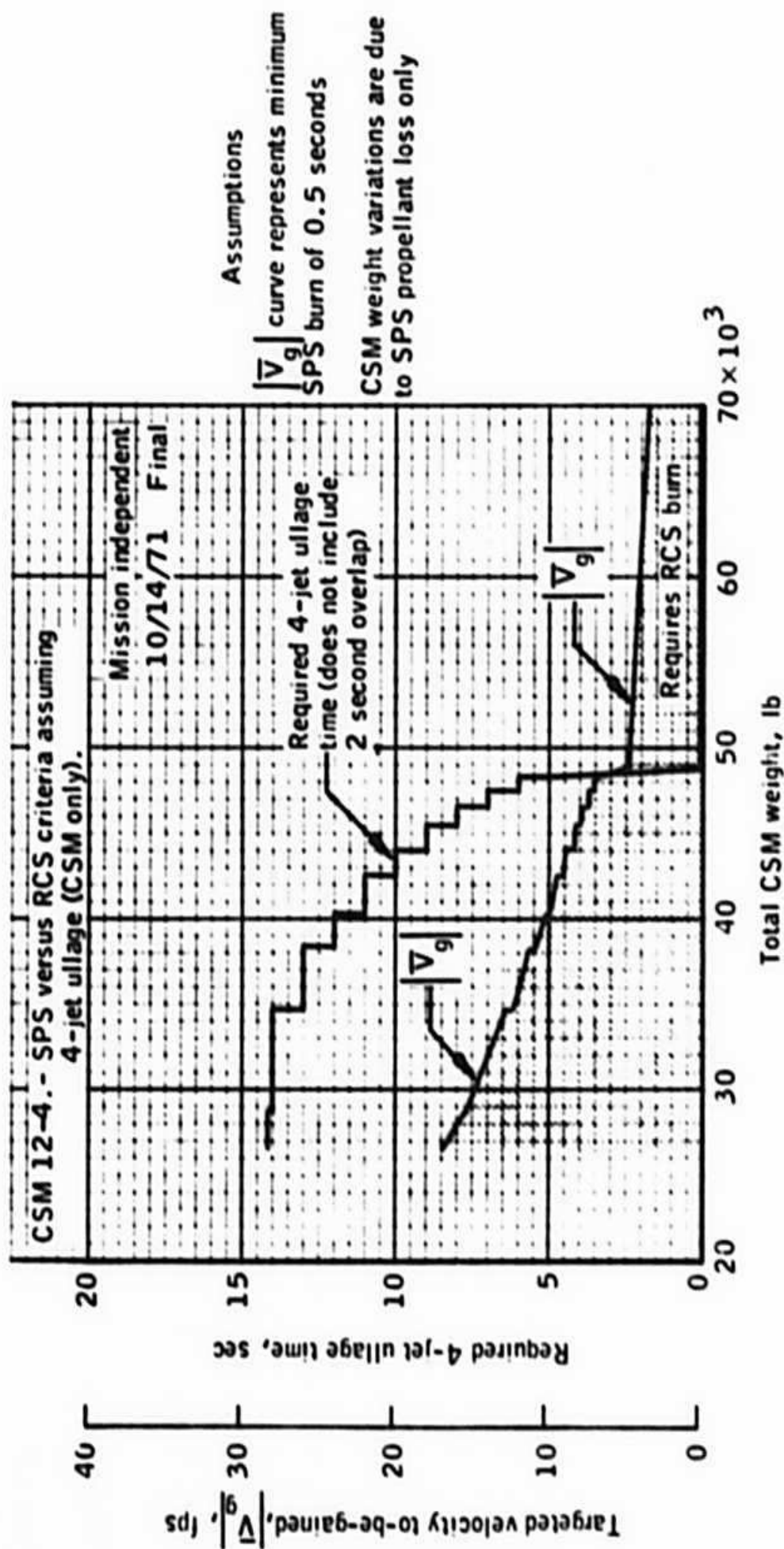
Spacecraft weight assumed to consist of CSM and fully loaded LM

$|\nabla g|$ curve represents minimum SPS burn of 0.5 seconds

CSM weight variations are due to SPS propellant loss only

5-9 G

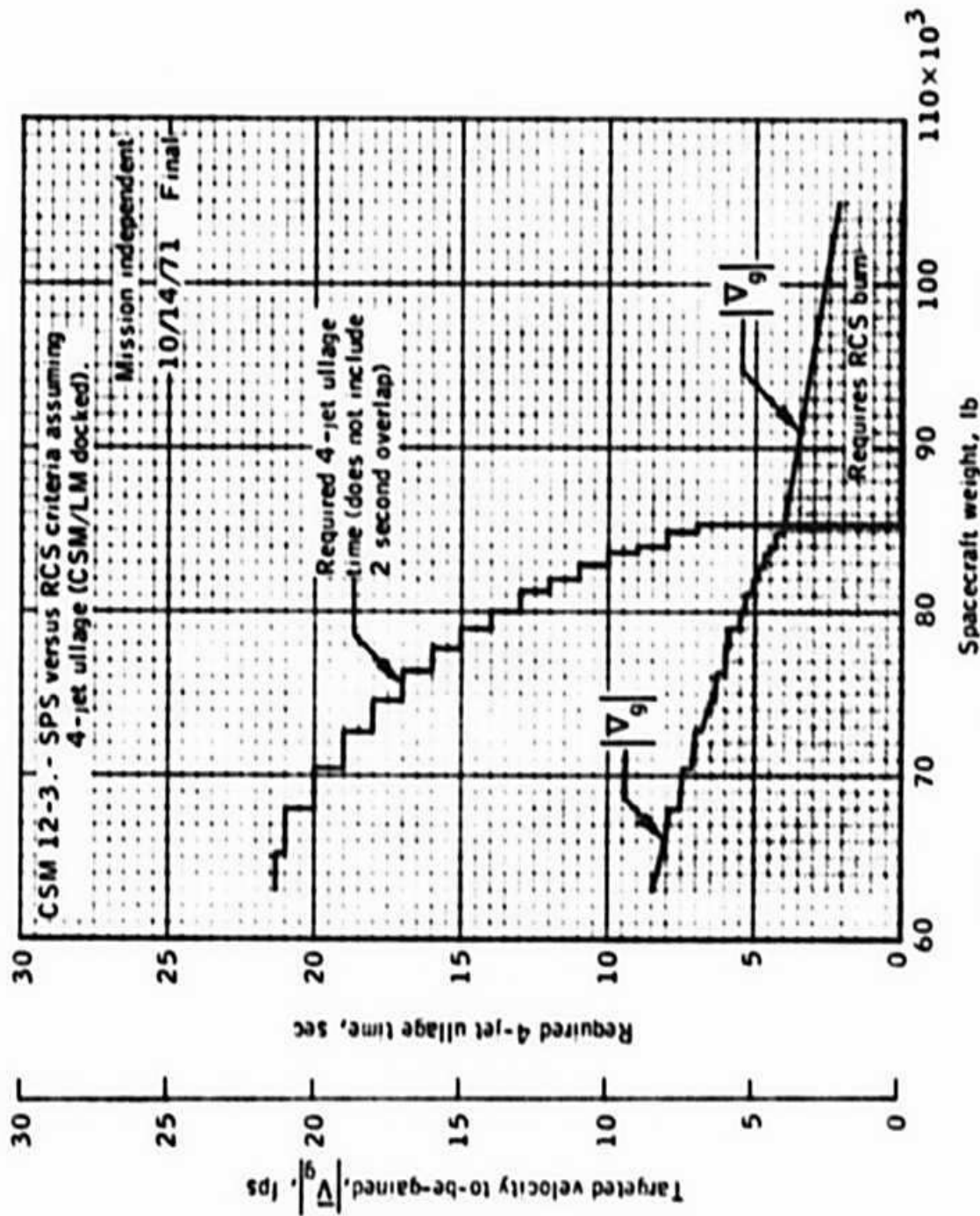
SPS versus RCS criteria assuming 2-jet ullage (CSM/LM docked).



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

DATE 12/8/71

DATE 12/8/71



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

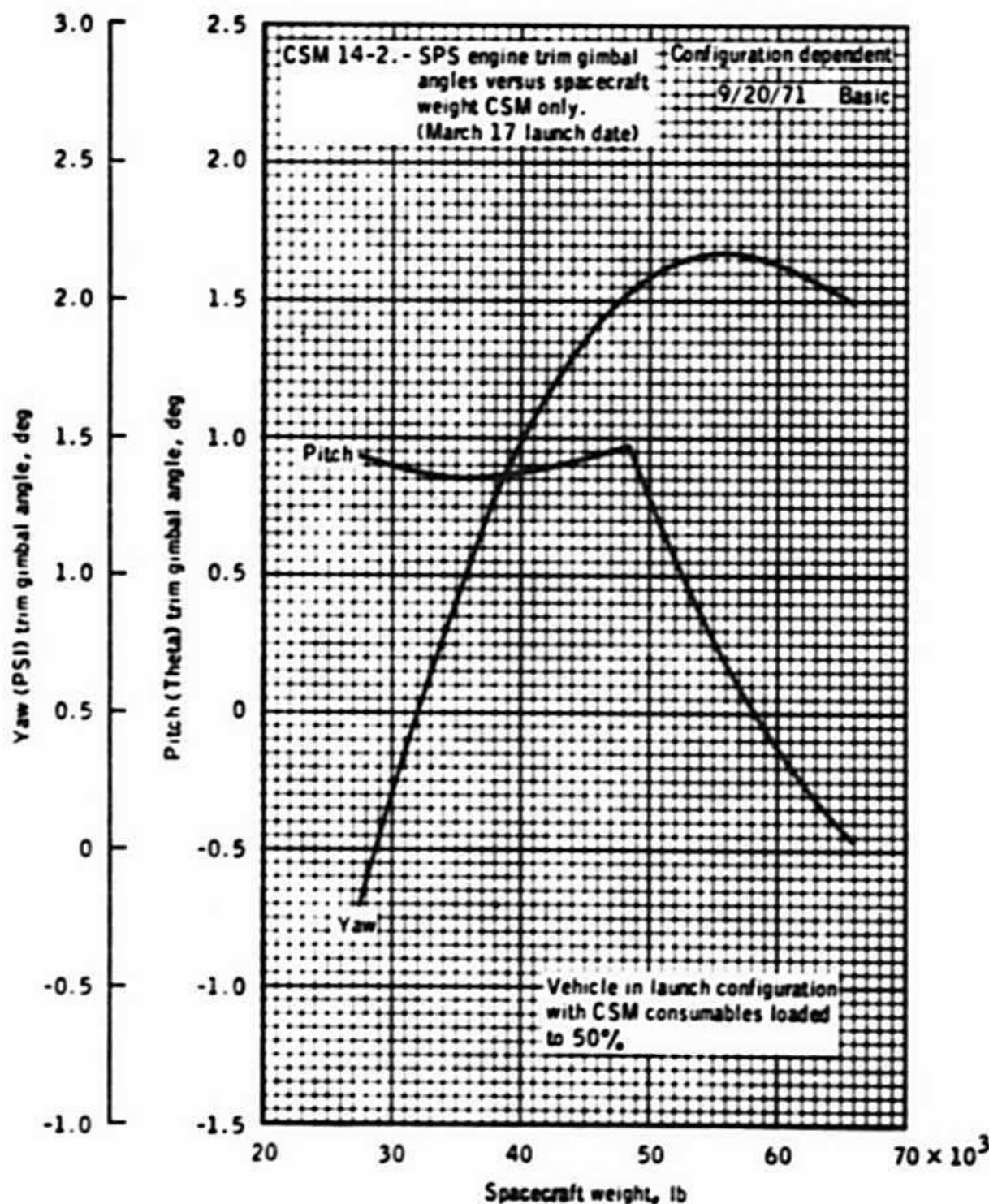
GIMB ANGVS vs WT

Assumptions

Spacecraft weight assumed to consist of CSM and fully loaded LM

$|V_g|$ curve represents minimum SPS burn of 0.5 seconds

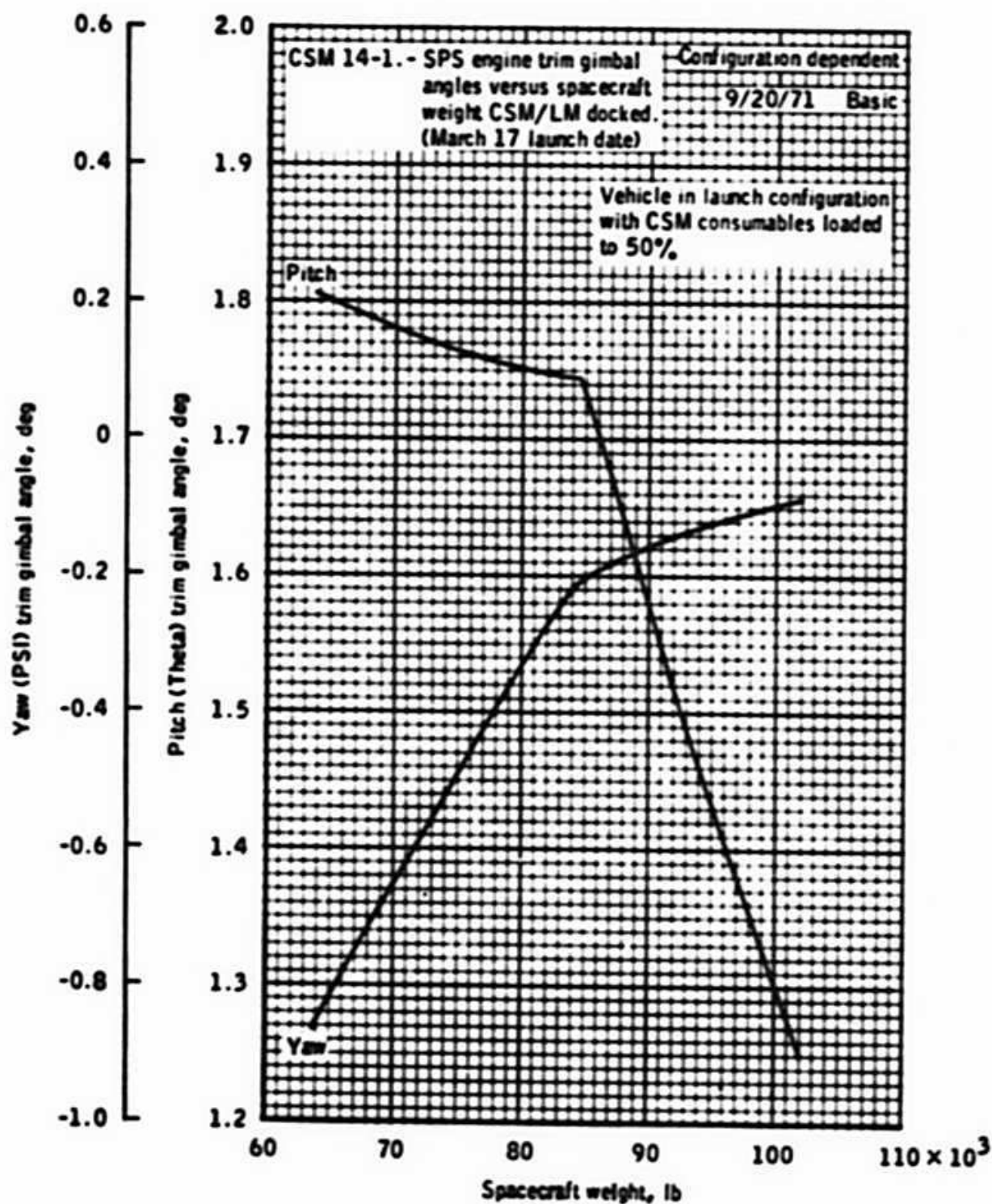
CSM weight variations are due to SPS propellant loss only



DATE 12/8/71

SPS engine trim gimbal angles versus spacecraft weight CSM only.

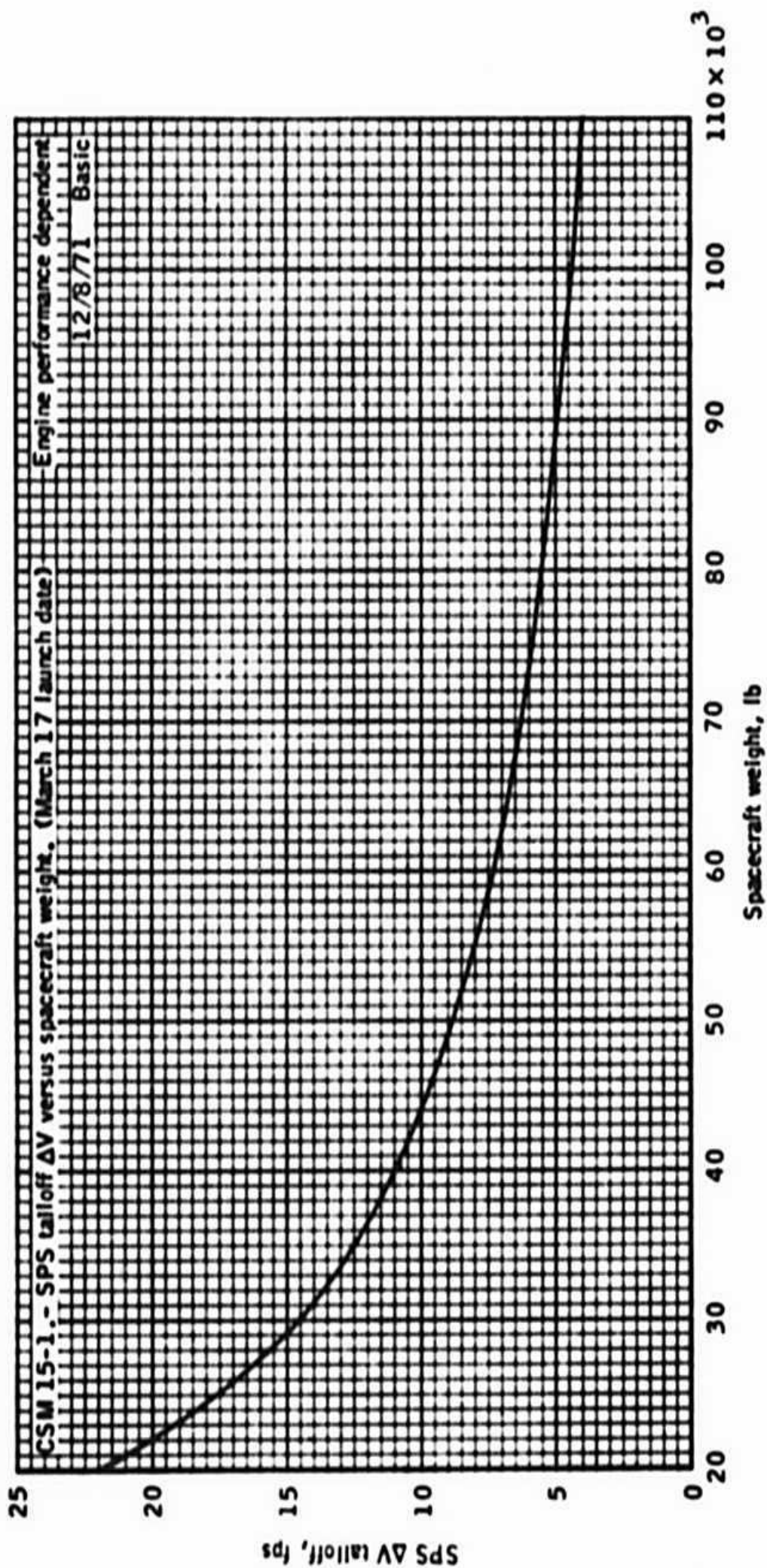
Does not include SPS Propellant



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

Does not include SPS Propellant

DATE 12/8/71



SPS talloff ΔV versus spacecraft weight.

DATE 12/8/71

P41 - RCS THRUSTING

Prethrust Program Complete
Verify SIM BASIC CONFIGURATION
(CUE CARD)
CMC - on
ISS - on
SCS - OPERATING
TEST C/W LAMPS
Perform EMS ΔV TEST & NULL
BIAS CHECK, pg G/2-5
Set ΔVC
EMS FUNC - ΔV
BMAG MODE (3) - RATE 2
CMC MODE - FREE
AUTO RCS SELECT (16) - as Req'd
LOAD DAP (check roll jets)
ROT CONTR PWR NORMAL (2) - AC/DC
ROT CONTR PWR DIRECT (2) - MNA/B
Set DET
V37E 00E
SC CONT - CMC/AUTO

1 MNVR TO PAD BURN ATTITUDE
V49E

2 PERFORM BORESIGHT & SXT STAR CHECK
V41 N91E

3 V37E 41E
(TFI available via N40, N45 or N35)

4 F 50 18 REQUEST MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC/AUTO
PRO

5 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)

DATE 12/8/71

6 F 50 18 REQUEST MNVR TO FDAI RPY ANGLES (.01°)
(AUTO TRIM) BMAG MODE (3) - RATE 2
ALIGN SC ROLL
SC CONT - CMC/AUTO

PRO

MAN ATT (3) - RATE CMD
ATT DB - MIN
RATE - LOW
BMAG MODE (3) - ATT1/RATE 2
GDC ALIGN

ENTR

7 06 85 VG X,Y,Z (.1fps)

* PROG Alarm 1t *
* V5N9E - 01703 - TIG SLIPPED *
* KEY RLSE To 7 *

55:00
(-05:00)

TRANS CONT PWR - on (up)
HAND CONTROLLERS - ARMED

59:25
(-00:35)

DSKY BLANKS

59:30
(-00:30)

8 16 85 VG X,Y,Z (AVE G ON)
TAPE RCDR - HBR/RCD/FWD/CMD RESET
LIMIT CYCLE - OFF
EMS MODE - NORMAL

DATE 12/8/71

00:00
9 F 16 85 VG X,Y,Z
NULL COMPONENTS
RHC & THC - LOCKED
TRANS CONT PWR - OFF
ROT CONTR PWR DIRECT - OFF
RECORD ΔV COUNTER & RESIDUALS ΔVC _____
EMS FUNC - OFF VGX _____
EMS MODE - STBY VGY _____
PRO (If MINKEY, to sequencer 3X.2) VGZ _____
BMAG MODE (3) - RATE 2
TAPE RCDR - off (ctr)
PCM BIT RATE - LOW

10 F 37 V82E

11 F 16 44 HA,HP,TFF (.1nm,min-sec)

PRO

12 F 37 00E

P47 Thrust Monitor Program

CMC - on
ISS - on & aligned

1 F 16 83 V37E 47E
 ΔV XYZ(CSM) (.1fps)

VI,HDOT,H available by N62E
*KEY RLSE to return to N83 *

(RECYCLE) V32E
(TERM) PRO

2 F 37 00E

DATE 12/8/71

P51 - IMU ORIENTATION

CMC - on
 ISS - on
 SCS - operating
 BMAG MODE (3) - RATE 2
 OPT ZERO - OFF
 OPT MODE - MAN
 G/N PWR OPTICS - on
 OHC - Drive Trun $< 10^\circ$
 OPT ZERO - ZERO (15 sec)

- 1 V37E 51E
 F 50 25 00015 MNVR TO ACQ STARS
 (Coarse Align IMU To 0,0,0) - ENTR to 2
 (BYPASS) PRO to 3
- 2 41 22 DESIRED GIMBAL ANGLES (0,0,0)
 NO ATT lt - on then off, to 1
- 3 F 51 PLEASE MARK
 OPT ZERO - OFF
 MARK
- 4 F 50 25 00016 TERMINATE MARKS
 PRO
- 5 F 01 71 000DE STAR CODE
 Load desired code
 PRO to 3 after 1st MARK (to 6 if DE=00)
 to 7 after 2nd MARK (to 6 if DE=00)
- 6 F 06 88 CELESTIAL BODY VECTOR
 Load desired vector
 PRO to 3 after 1st MARK
 to 7 after 2nd MARK
- 7 F 06 05 STAR ANGLE DIFFERENCE (.01°)
N 05 LIMITS
 2 stars: SXT $\leq$ + 00003
 SCT $\leq$ + 00011
 Star/planet: SXT $\leq$ + 00018
 SCT $\leq$ + 00021
 (RECYCLE) V32E to 1
 (ACCEPT) PRO

DATE 12/8/71

8 F 37 52E - bypass ZERO OPTICS
or
XXE
OHC - Drive Trun $<10^\circ$
OPT ZERO - ZERO

P52 IMU REALIGN

CMC - on
ISS - on
SCS - operating
BMAG MODE (3) - RATE 2
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - on
OHC-Drive Trun $<10^\circ$
OPT ZERO - ZERO (15 sec)
OPT MODE - CMC

Note: MINKEY displays not shown

- 1 F 04 06 V37E 52E
R1 00001 IMU ALIGN OPTION
R2 00001 PREF PRO to 4
2 NOM PRO to 2
3 REFSMAT PRO to 7
4 LDG SITE PRO to 2
- 2 F 06 34 GET ALIGN (0,0,0 initially)
(hrs,min,.01sec)
Load desired GET
TO SPECIFY PRESENT TIME - PRO on (0,0,0)
PRO (NOM go to 4)
- 3 F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
Load ldg site coords
PRO
- 4 F 06 22 NEW ICDU ANGLES OG, IG, MG (.01°)
(IF MG $>70^\circ$, MNVR) V32E - to 4
PRO
- 5 F 50 25 00013 GYRO TORQUE
(COARSE) PRO - NO ATT 1t - on then off - to 7
(TORQUE) CMC MODE - FREE
ENTR

DATE 12/8/71

6 16 20 ICDU ANGLES (.01°)
When torque complete - go to 17

7 F 50 25 00015 STAR SELECT
(MNVR If Necessary)
(PICAPAR) PRO

*F 05 09 00405 NO PAIR *
(CREW SPECIFY) PRO - to 8
*(PICAPAR) MNVR-V32E to 7 *

(MAN ACQ) ENTR

8 F 01 70 000DE STAR CODE
Load desired code
OPT MODE - CMC (verify)
OPT ZERO - OFF
PRO to 10 (to 9 if DE=00)
F 05 09 00404 (TA>90°)
*MNVR - PRO to 10 *

9 F 06 88 CELESTIAL BODY VECTOR
Load desired vector
PRO

F 05 09 00404 (TA>90°)
*MNVR - PRO to 10 *

10 06 92 SHAFT, TRUN (.01°, .001°)

(MARK ROUTINE) OPTICS MODE - MAN

11 F 51 PLEASE MARK
MARK

12 F 50 25 00016 TERMINATE MARKS
PRO

13 F 01 71 000DE STAR CODE
Load code (if necessary)
PRO to 8 after 1st MARK (to 14 if DE=00)
to 15 after 2nd MARK (to 14 if DE=00)

DATE 12/8/71

14 F 06 88 CELESTIAL BODY VECTOR
Verify vector
PRO to 8 after 1st MARK
to 15 after 2nd MARK

15 F 06 05 STAR ANGLE DIFFERENCE (.01°)
N 05 LIMITS
2 stars: SXT $\leq$ + 00003
SCT $\leq$ + 00011

Star/planet: SXT $\leq$ + 00018
SCT $\leq$ + 00021

(REJECT) V32E to 17
(ACCEPT) PRO

16 F 06 93 TORQUING ANGLES OG, IG, MG (.001°)
(TORQUE) CMC MODE - FREE
PRO
(BYPASS) V32E

17 F 50 25 00014 ALIGNMENT CHECK
(RECHECK) PRO to 7
(BYPASS) ENTR

18 F 37
XXE
OHC - Drive Trun <10°
OPT ZERO - ZERO
G/N PWR OPTICS - OFF

P53 - BACKUP IMU ORIENT DETERMINATION
CMC - on
ISS - on
SCS - operating
MAN ATT (3) - MIN IMP
COAS LOS DETERMINATION - complete

1
F 50 25 V37E 53E
00015 MNVR To ACQ STARS
(BYPASS) (Coarse Align IMU to 0,0,0) - ENTER to 2
PRO to 3

DATE 12/8/71

2 41 22 DESIRED GIMBAL ANGLES (0,0,0)
NO ATT 1t - on then off, to 1

3 F 06 94 ALT LOS OPT ANG SHAFT, TRUN (.01°, .001°)
Load proper angles
COAS NOM: Shaft +00000
Trun +57470
PRO

4 F 53 PLEASE MARK
Center Target
ENTR

5 F 50 25 00016 TERMINATE MARKS
(REJECT) ENTR to 4
PRO

6 F 01 71 000DE STAR CODE
Load desired code
PRO to 3 after 1st MARK (to 7 if DE=00)
to 8 after 2nd MARK (to 7 if DE=00)

7 F 06 88 CELESTIAL BODY VECTOR
Load desired vector
PRO to 3 after 1st MARK
to 8 after 2nd MARK

8 F 06 05 STAR ANGLE DIFFERENCE (.01°)
N 05 LIMITS (COAS)
2 stars: $\leq + 00070$
Star/planet: $\leq + 00072$
(RECYCLE) V32E to 1
(ACCEPT) PRO

9 F 37 XXE

P54 - BACKUP IMU REALIGN

CMC - on
ISS - on
SCS - operating
MAN ATT (3) - MIN IMP
COAS LOS DETERMINATION - complete

DATE 12/8/71

- 1

F 04 06 V37E 54E
 R1 00001 IMU ALIGN OPTION
 R2 00001 PREF PRO to 4
 2 NOM PRO to 2
 3 REFSMMAT PRO to 7
 4 LDG SITE PRO to 2
- 2

F 06 34 GET ALIGN (0,0,0 initially)
 (hrs,min,.01sec)
 Load desired GET
 TO SPECIFY PRESENT TIME - PRO on (0,0,0)
 PRO (NOM go to 4)
- 3

F 06 89 LAT, LONG/2, ALT (.001°, .001°, .01nm)
 Load ldg site coords
 PRO
- 4

F 06 22 NEW ICDU ANGLES OG, IG, MG (.01°)
 (IF MG>+70°, MNVR) V32E to 4
 PRO
- 5

F 50 25 00013 GYRO TORQUE
 (COARSE) PRO - NO ATT 1t - on
 then off - to 7
 (TORQUE) CMC MODE - FREE
 ENTR
- 6

16 20 ICDU ANGLES (.01°)
 When Torque complete go to 17
- 7

F 50 25 00015 STAR SELECT
 (Mnvr If Necessary)
 (PICAPAR) PRO
 *F 05 09 00405 NO PAIR *
 *(CREW SPECIFY) PRO to 8 *
 (PICAPAR) MNVR-V32E to 7
 (MAN ACQ) ENTR
- 8

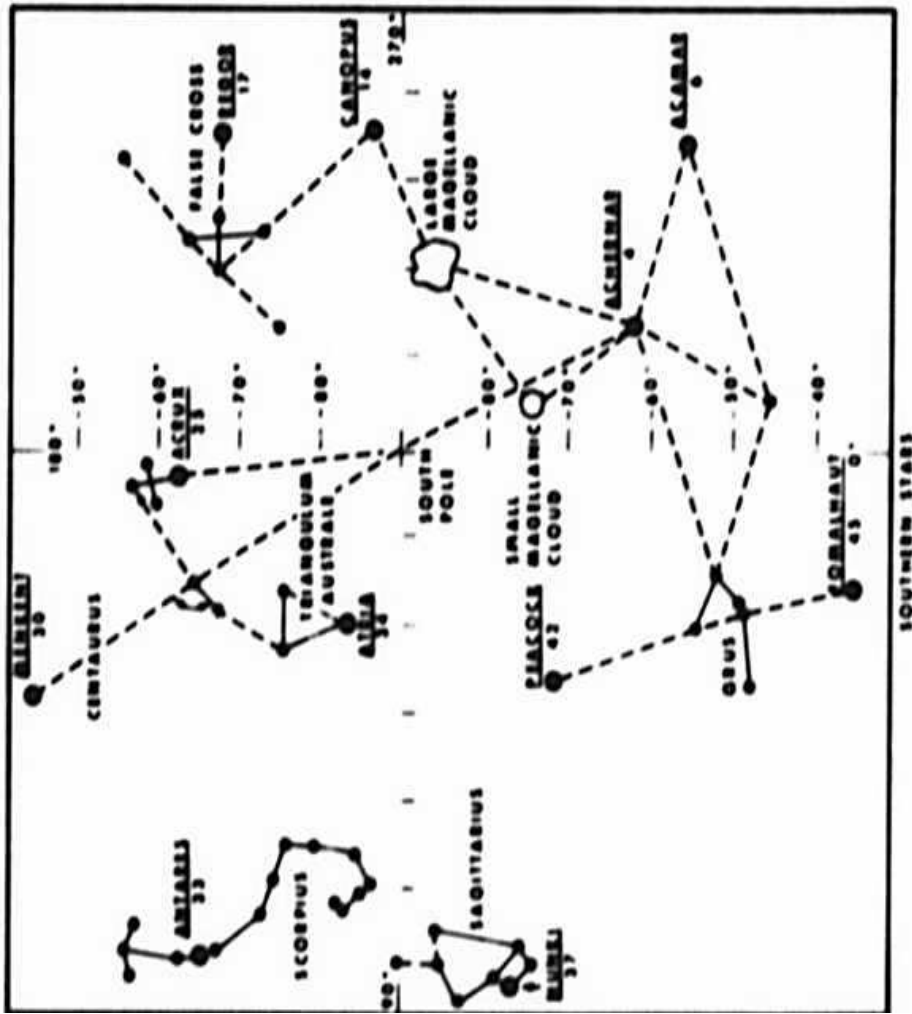
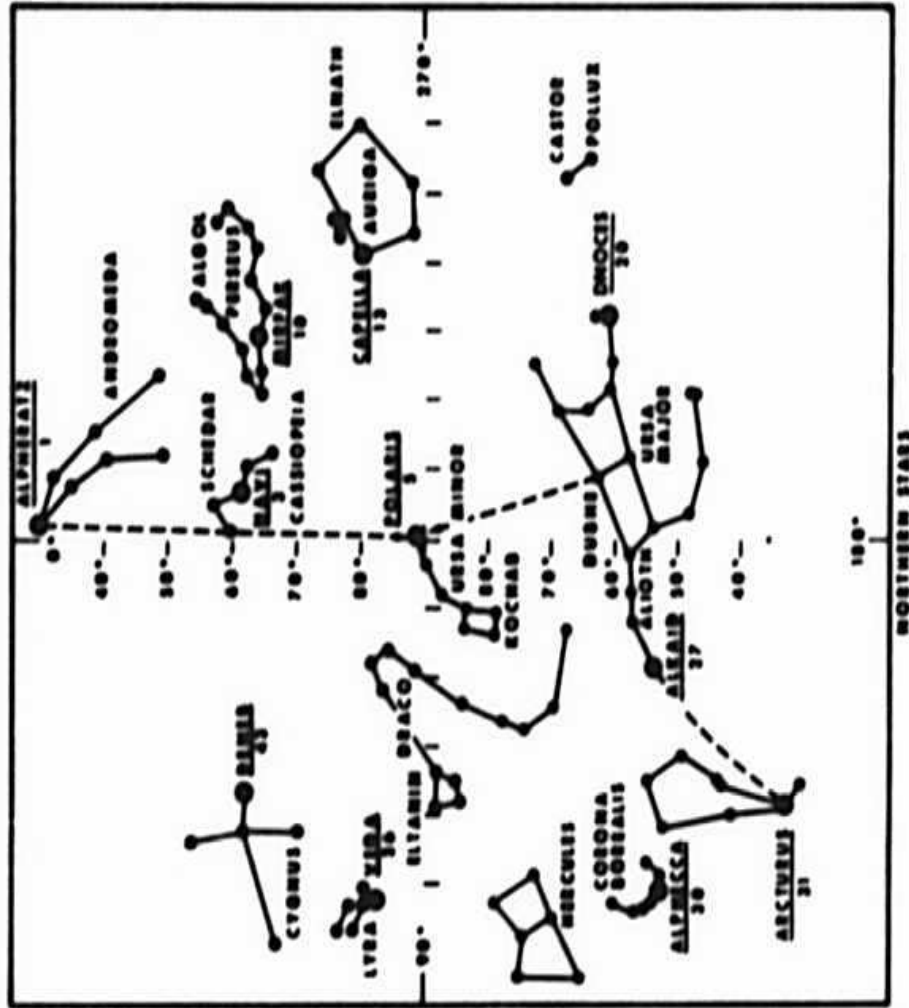
F 01 70 000DE STAR CODE
 Load desired code
 PRO to 10 (to 9 if DE=00)

DATE 12/8/71

- 9 F 06 88 CELESTIAL BODY VECTOR
Load desired vector
PRO
- 10 F 06 94 ALT LOS OPT ANG SHAFT, TRUN(.01°, .001°)
Load angles
COAS Nom: Shaft +00000
Trun +57470
PRO
- 11 F 53 PLEASE MARK
Center Target
ENTR
- 12 F 50 25 00016 TERMINATE MARKS
(REJECT) ENTR to 11
PRO
- 13 F 01 71 000DE STAR CODE
Load code (if necessary)
PRO to 8 after 1st MARK (to 14 if DE=00)
to 15 after 2nd MARK (to 14 if DE=00)
- 14 F 06 88 CELESTIAL BODY VECTOR
Verify vector
PRO to 8 after 1st MARK
to 15 after 2nd MARK
- 15 F 06 05 STAR ANGLE DIFFERENCE (.01°)
N 05 LIMITS (COAS)
2 stars: $\leq + 00070$
Star/planet: $\leq + 00072$
(REJECT) V32E to 17
(ACCEPT) PRO
- 16 F 06 93 TORQUING ANGLES OG, IG, MG (.001°)
(TORQUE) CMC MODE - FREE
PRO
(BYPASS) V32E
- 17 F 50 25 00014 ALIGNMENT CHECK
(RECHECK) PRO to 7
(BYPASS) ENTR
- 18 F 37 XXE

DATE 1/2/8/21

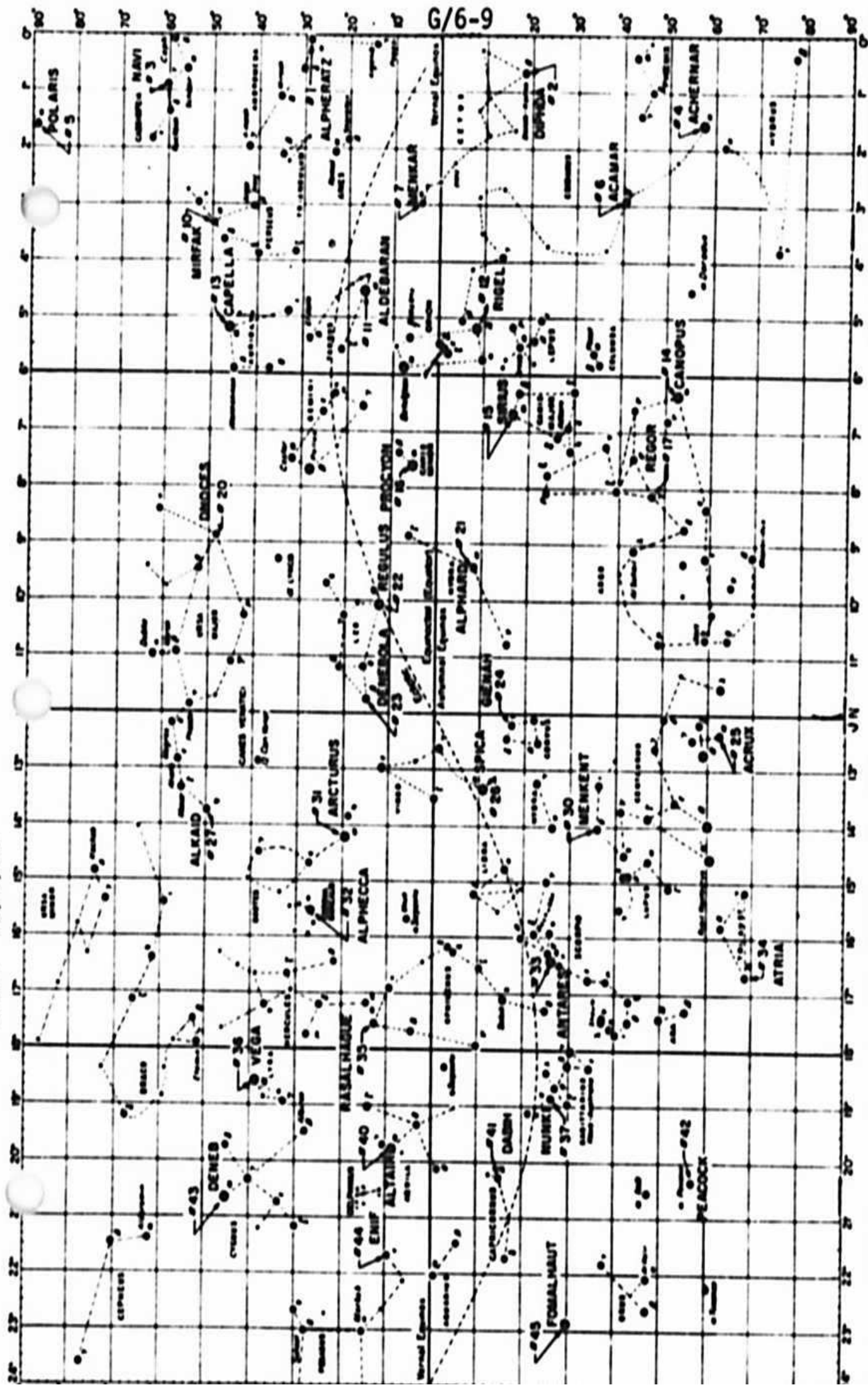
G/6-8



DATE 12/8/71

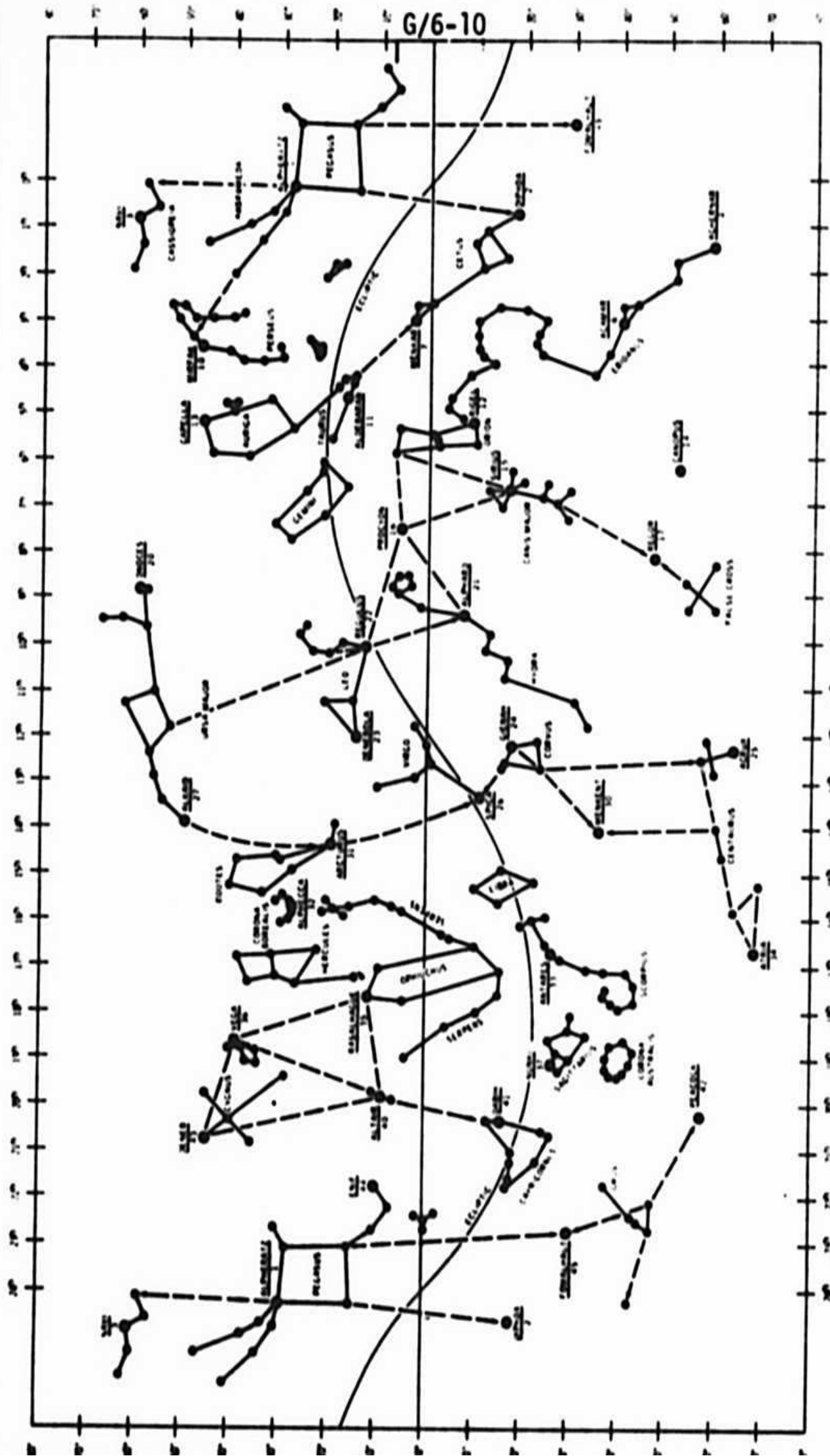
DATE 12/8/71

G/6-9



STAR CHARTS

STAR CHARTS



DATE 12/8/71

RAPID IMU REALIGN

NOTE: This procedure assumes a
good GDC alignment

- 1 V41 N20E
Load R,P,Y from GDC Ball
- 2 V40
Verify R,P,Y on GDC Ball - ENTR
(Releases Platform And Recovers PGNS
Control Modes)
- 3 V25 N07E
77E, 10000E, 1E (Sets REFSMMAT FLAG)
- 4 V37E 51E, PRO (Sets Drift Flag)
V37E 00E
- 5 Perform P52, Option 3

NOTE: If Loss of Alignment Is Due
To Temporary Loss of DC
BUS, Update CMC Clock With
V55 To Complete Recovery.

CHANGING LANDING SITE REFSMMAT FOR OUT-OF-PLANE BURNS

- 1 V37E 52E
- 2 F 04 06 R1=00001
R2=00004 (LOAD LANDING SITE OPTION)
PRO
- 3 F 06 34 GET ALIGN
PRO (SPECIFIES PRESENT TIME)
- 4 F 06 89 LAT, LONG/2, ALT (.001, .001°, .01nm)

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INITIALIZATION
PROCEDURES

	<u>Present Pitch</u>	<u>ΔV_y</u>	<u>R1</u>
Load R1:	$0 \pm 90^\circ$	$\pm$	RLS LAT $\pm 35^\circ$
	$180 \pm 90^\circ$	$\pm$	RLS LAT $\mp 35^\circ$

PRO

5 F 06 22 NEW ICDU ANGLES
PRO

6 F 50 25 R1=00013
CMC MODE-FREE
ENTR TO GYRO TORQUE

7 16 20 UNTIL TORQUING COMPLETE

8 F 50 25 R1=00014 ALIGNMENT CHECK
CMC MODE - AUTO
ENTR

9 P30

10 P40

11 YAW BACK TO 0° (MANUALLY)

12 V37E 52E

13 F 04 06 R1=00001
R2=00004 (LOAD LANDING SITE OPTION)
PRO

14 F 06 34 GET ALIGN (LOAD TIME OBTAINED FROM MSFN)
PRO

15 F 06 89 LAT, LONG/2, ALT (LAT WILL BE CHANGED BACK
PRO TO STORED RLS)

16 F 06 22 NEW ICDU ANGLES
PRO

INITIALIZATION
PROCEDURES

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- 17 F 50 25 R1=00013
CMC MODE-FREE
ENTR TO START TORQUING
- 18 16 20 UNTIL TORQUING COMPLETE
- 19 F 50 25 R1=00014 ALIGNMENT CHECK
CMC MODE - AUTO
PRO (TO SELECT 2 STARS IF TIME PERMITS)
ENTR (TO LEAVE P52)

GDC ALIGNMENT TO IMU GIMBAL ANGLES

IMU - on
SCS - operating

- 1 Damp vehicle rates
- 2 ATT SET dials - set to IMU angles on
FDAI 1
- FDAI SELECT - 1
FDAI SOURCE - ATT SET
ATT SET - IMU
ATT SET dials - null FDAI 1 err
needles
- ATT SET - GDC
GDC ALIGN PB - push until needles
nulled
- FDAI SEL - 1/2

BACKUP GDC AND/OR IMU ALIGNMENT
(IMU or CMC failed)

SCS - operating
RECORD: R,P,Y ALIGN from MSFN

- 1 IMU PWR - OFF
Wait ~5 min for gyros to run
down before step 8
- 2 Set SCT to 0° SHFT, 352.5° TRUN
OPTICS PWR - OFF
- 3 ATT SET dials - R,P,Y ALIGN

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4

Mnvr to position stars in SCT
0° mark - Sirius (15)
R line - Rigel (12)

or

	<u>NORTH</u>		<u>SOUTH</u>
0° mark -	Navi (3)		Acrux (25)
R line -	Polaris (5)		Atria (34)

5

FDAI SELECT - 1
ATT SET - GDC
GDC ALIGN PB - push until needles
nulled

6

ATT SET dials - 0,0,0

7

MNVR to 0,0,0 and null error needles

8

IMU PWR - on (up)
(IMU drives to 0°, 0°, 0°)
Wait 90 sec.

9

Uncage IMU
IMU CAGE - on (up) ~5 sec
then release

IN-PLANE GDC ALIGNMENT

CMC - on
ISS - on
SCS - operating

1

F 04 06 V37E 52E
00001
Load R2=00002
PRO

2

F 06 34 GET ALIGN 0,0,0
PRO

3

F 06 22 R,P,Y

4

Set ATT SET dials to R,P,Y on DSKY

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5 FDAI SELECT - 1
ATT SET - GDC
GDC ALIGN - push

6 V37E XXE

PGNS ORDEAL INITIALIZATION
(In-Plane Alignment Req'd)

1 FDAI 1 or 2 - ORB RATE
EARTH/LUNAR - as req'd

2 V82E
F 04 12 00002 SPECIFY VEHICLE
00001
PRO

3 F 06 16 GET EVENT (hrs,min,.01sec)
PRO

4 F 16 44 HA, HP (.1nm,.1nm)
Calculate Average
ALT SET - Set Average
PRO

5 V83E
F 16 54 R,RDOT,THETA (.01nm,.1fps,.01°)
MODE - HOLD/FAST
SLEW - To THETA
MODE - OPR/SLOW
PRO

SCS ORDEAL INITIALIZATION
(IN-PLANE GDC ALIGNMENT REQ'D)

1 FDAI 1 or 2 - ORB RATE
EARTH/LUNAR - as req'd

2 MSFN Supply Altitude
ALT SET - Set

3 SC +X At the Horizon

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MODE - HOLD/FAST
SLEW FDAI (See table)
MODE - OPR/SLOW

LUNAREARTH

<u>Alt(nm)</u>	<u>Angle*</u>	<u>Alt(nm)</u>	<u>Angle*</u>
8	7°	100	14°
60	20°	200	19°
170	32°	500	29°

*Angle from +X S/C axis to horiz

COAS LOS DETERMINATION

CMC - on
ISS - on
SCS - operating
SC CONT - SCS
MAN ATT (3) - MIN IMP
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - on
OHC - Drive trun <10°
OPT MODE - CMC
OPT ZERO - ZERO (15 sec)

1 V37E 52E

2 F 04 06 00001
00003
PRO

3 F 50 25 00015
ENTR

4 F 01 70 000DE STAR CODE
LOAD BORESIGHT STAR CODE
OPT ZERO - OFF
PRO

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5 06 92 SHAFT, TRUN (.01°, .001°)
Center target
MARK with VERB key
Record SHAFT, TRUN _____
(REPEAT) KEY RLSE
(EXIT) V37E XXE
OPT MODE - MAN
OHC - Drive trun <10°
OPT ZERO - ZERO

CMC/LGC CLOCK SYNC/TEPHEM UPDATE
V16 N65E (On LM request)
(hr,min,.01sec)
Voice CMC time to LM
V05 N01E 1706E (On LM request)
Voice TEPHEM to LM

V55 CMC TIME UPDATE
(See EXT VERBS pg. G/1-27)

ALIGN LM IMU TO CSM IMU
ATT DB - MIN
RATE - LO
LIMIT CYCLE - ON
SC CONT - SCS
MAN ATT (3) - RATE CMD
BMAG MODE (3) - ATT1/RATE2
V06 N20E
Voice ICDU angles to LM*
Terminate attitude hold on LM cmd
V06 N20 (On LM request)
On LM MARK, Key ENTR
Copy ICDU angles and transmit to
MSFN

*LM (IGA)p = $P20 + 180^\circ$
LM (OGA)y = $300^\circ - R20 + \Delta\theta$
LM (MGA)r = $360^\circ - Y20$

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Align LM IMU to CSM GDC

SCS - on
GDC - on and aligned

- 1 On LM Request, hold att:
ATT DB - MIN
RATE - LO
LIMIT CYCLE - ON
BMAG MODE (3) - ATT 1/RATE 2
- 2 On LM Request, Read GDC FDAI R,P,Y then
ATT SET dials - Set to FDAI R,P,Y
FDAI SELECT - 1
FDAI SOURCE - ATT SET
FDAI SCALE - 5/1
ATT SET - GDC
Null FDAI 1 error needle using ATT SET dials
Read ATT SET dial angles to LM

- 3 On LM Request, terminate att hold

ALIGN LM AGS TO CSM IMU/GDC

CMC - on
ISS - on and orientation known

or

SCS - on
GDC - on and aligned

- 1 Upon LM request, MNVR to
R = $300^\circ + \Delta\theta$
P = 180°
Y = 0°
and hold att., min DB
(If SCS: RATE-LO, LIMIT CYCLE-ON)
- 2 Notify LM when at attitude
- 3 When LM alignment complete - terminate att hold

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Align CSM GDC to LM IMU

GDC - on (req)

- 1 Request LM to Hold Attitude, Min DB
- 2 Request and copy LM Readout of V06N20 angles:

LM(OGA)y	_____	°
LM(IGA)p	_____	°
LM(MGA)r	_____	°

- 3 ATT SET dials - Set to
 - R = $300^\circ + \Delta\theta - \text{LM (OGA)}_y$
 - P = $\text{LM (IGA)}_p - 180^\circ$
 - Y = $360^\circ - \text{LM (MGA)}_r$

- 4 FDAI SELECT - 1
ATT SET - GDC
GDC ALIGN - Push

- 5 Notify LM att hold not req

Align CSM GDC to LM AGS

- 1 Request LM MNVR to 0,0,0 on AGS FDAI, min DB

- 2 ATT Set dials - Set to
 - R = $300^\circ + \Delta\theta$
 - P = 180°
 - Y = 0°

- 3 FDAI SELECT - 1
ATT SET - GDC

- 4 When LM at Attitude:
GDC ALIGN - Push

- 5 Notify LM Att Hold not req'd

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Align CSM IMU to LM IMU

CMC - on
ISS - on
SCS - on

- 1 Verify LM in MIN DB, ATT HOLD
- 2 Request and copy LM Readout of V06N20E

LM(OGA)y	.	°
LM(IGA)p	.	°
LM(MGA)r	.	°
- 3 Calculate Gimbal Angles:

$$CM (OGA) = 300^\circ + \Delta\theta - LM (OGA)y$$

$$CM (IGA) = LM (IGA)p - 180^\circ$$

$$CM (MGA) = 360^\circ - LM (MGA)r$$
- 4 V41N20E
Load Gimbal Angles
- 5 V40E
Allow 10 sec before step 7
Notify LM Att Hold Not Req.
- 6 Set REFSMFLG:
V25N7E, 77E, 10000E, 1E
- 7 V37E51E
PRO
V37E00E
- 8 Request MSFN Uplink REFSMMAT
then Perform P52 (OPT 3)
or
V06N20 On CM Mark - ENTR
Voice Angles to MSFN for calculation
of Gyro Torquing Angles.
Perform V42 GYRO TORQUING using ground
calculated Torquing Angles (p. G/1-24)

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Align CSM IMU TO LM AGS

CMC - on
ISS - on

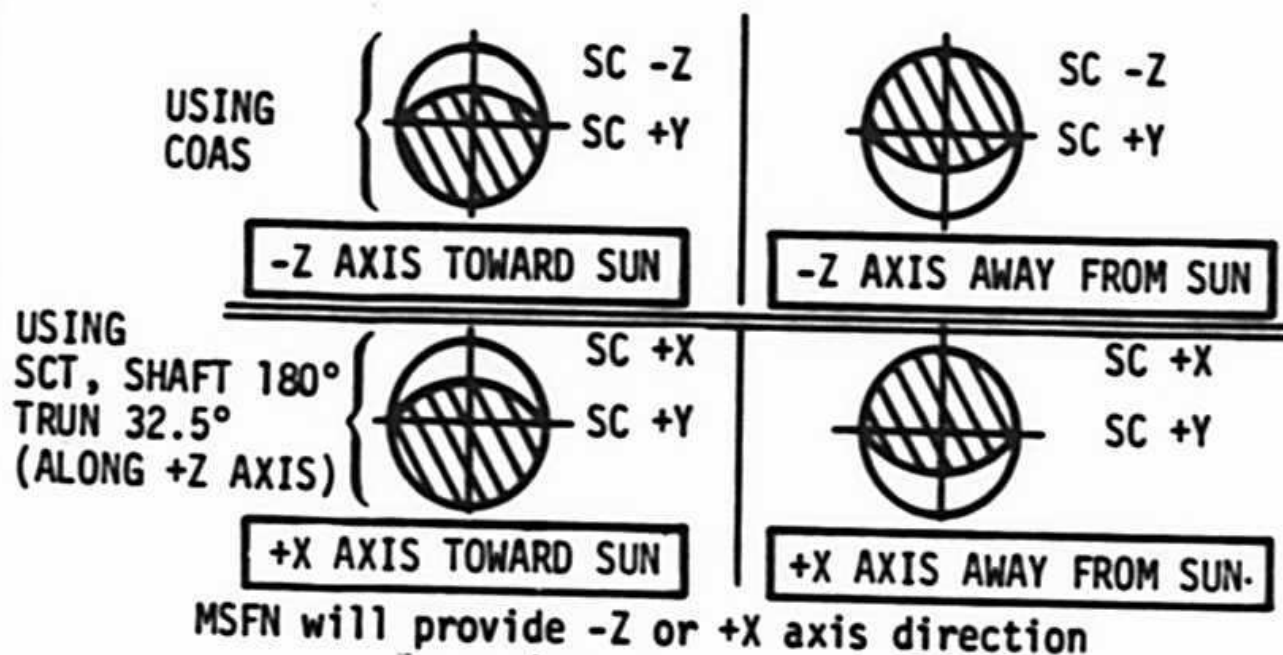
- 1 Request LM MNVR to 0,0,0
on AGS FDAI
- 2 When LM at Attitude:
V41N20E
LOAD: $R1 = 300^\circ + \Delta\theta$
 $R2 = 180^\circ$
 $R3 = 0^\circ$
- 3 V40E
Allow 10 sec before step 5
Notify LM Att Hold not req.
- 4 Set REFSMFLG:
V25N7E, 77E, 10000E, 1E
- 5 V37E51E
PRO
V37E00E
- 6 Request MSFN Uplink REFSMMAT,
then, if desired, perform P52 (OPT 3)

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CRESCENT ALIGN

If SCT: Drive optics to 180,32.5
G&N PWR OPT - OFF

- 1 MNVR to acquire EARTH in Optical System's field-of-view. Then MNVR to align required Reference line along Earth's Crescent.



- 2 (For GDC only, see step 8)
If CMC not avail:
Verify IMU PWR - OFF (5 min)
Go to Step 9
- 3 V41N20E, load desired angles
from MSFN or 0,0,0
- 4 V40, Verify Ref. Line Aligned with Crescent
ENTR
Allow 10 sec before step 6
- 5 V25N07E, 77E, 10000E, 1E
- 6 V37E51E, PRO, V37E00E
Request MSFN uplink REFSMMAT and,
if desired, do P52 (OPT 3)

- 7 Align GDC to IMU, if desired
or
- 8 FDAI SELECT - 1
ATT SET - GDC
ATT SET DIALS - 0,0,0 (or angles from MSFN)
Verify Ref line aligned to crescent, then:
GDC ALIGN - Push
- 9 Do not perform this step if CMC avail:
IMU PWR - ON (up)
Wait 90 sec
IMU CAGE - on (up) ~5 sec then release

GDC REFSMMAT DETERMINATION

GDC - on
CMC - on
IMU - off
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - ON
OHC - Drive trun <10°
OPT ZERO - ZERO (15 sec)

- 1 Acquire Apollo Nav star
in optics
FDAI Scale - 5/1
Hold att (ATT DB - MIN, RATE - LO)
Align GDC to 0,0,0
V25 N20E
E,E,E
- 2 V37E00E
V96E

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- 3 Initiate P51 logic
 as follows:
 V21N1E
 1214E
 63E (65 if P53 desired)
 V25N26E
 13001E
 3425E
 30005E
 V30E
 (Note: Major mode lts. on DSKY do not
 change from 00 to 51)
- 4 F 50 25 00015 ACQ STARS
 PRO
- 5 F 51 PLEASE MARK
 If necessary, mnvr and:
 V25N20E
 Load present GDC angles
 OPT ZERO - OFF
 Null FDAI needles with Min imp
 then:
 MARK
- 6 F 50 25 00016 TERM MARKS
 PRO
- 7 F 01 71 000DE STAR CODE
 Load star code
 PRO to 5 after 1st MARK (8 if DE = 00)
 to 9 after 2nd MARK (8 if DE = 00)
- 8 F 06 88 CELESTIAL BODY VECTOR
 Load vector
 PRO to 5 after 1st MARK
 to 9 after 2nd MARK
- 9 F 06 05 STAR ANGLE DIFFERENCE (.01°)
 (Expect <.1°)
 (RECYCLE) V32E to 4
 (AcCEPT) PRO

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10 F 37

OOE

OHC - Drive trun <10°
OPT ZERO - ZERO
CMC has now calculated
a REFSMMAT for the GDC,
has set REFSMFLG and
DRIFTFLG.

GDC REFSMMAT REALIGN (P52)

GDC - on and REFSMMAT Known (pg G/7-13)
CMC - on
SCS - operating
IMU - off
OPT ZERO - OFF
OPT MODE - MAN
G/N PWR OPTICS - ON
OHC - Drive trun <10°
OPT ZERO - ZERO (15 sec.)

1

Acquire nav. target in
optics
Hold att (ATT DB-MIN, RATE-LO)
V25N20E
Load GDC angles
V37E52E

2

F 04 06

R1 00001
R2 00001 PREF PRO to 5
2 NOM PRO to 3
3 REFSMMAT PRO to 7 (P51 preferable)
4 LDG SITE PRO to 3

3

F 06 34

GET ALIGN (0,0,0 initially)
(hr,min,.01 sec)
Load desired GET
TO SPECIFY PRESENT TIME - PRO on (0,0,0)
PRO (NOM go to 5)

4

F 06 89

LAT, LONG/2, ALT (.001°, .001°, .01nm)
Load ldg site coords
PRO

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- 5 F 06 22 NEW ICDU ANGLES OG,IG,MG (.01°)
 (If MG > + 70°, MNVR and reload N20)
 V32E - to 5
 Align GDC to new angles
 V25N20E
 Load new angles
 PRO

- 6 F 50 25 00013 GYRO TORQUE
 PRO (NO ATT 1t-on then off,
 PROG ALM - ignore)

- 7 F 50 25 00015 ACQ STARS
 (opt 3) PRO
 (Not opt 3) OPT ZERO - ZERO
 G/N PWR OPTICS - OFF
 V37EXXE - procedure complete

- 8 F 01 70 000DE STAR CODE
 Load desired code
 OPT MODE - CMC (verify)
 OPT ZERO - OFF
 PRO to 10 (to 9 if DE = 00)
 *F 05 09 00404 (TA > 90°) *
 MNVR & reload N20 - PRO to 10

- 9 F 06 88 CELESTIAL BODY VECTOR
 Load desired vector
 PRO
 *F 05 09 00404 (TA > 90°) *
 MNVR & reload N20 - PRO to 10

- 10 06 92 SHAFT, TRUN (.01,.001°)
 (MARK ROUTINE) OPTICS MODE - MAN

- 11 F 51
 (If required) PLEASE MARK
 V25N20E
 Load present GDC angles
 Null FDAI needles with
 min imp, then:
 MARK

- 12 F 50 25 00016 TERMINATE MARKS
 PRO

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13 F 01 71 000DE STAR CODE
Load code (if necessary)
PRO to 8 after 1st MARK (to 14 if DE=00)
to 15 after 2nd MARK (to 14 if DE=00)

14 F 06 88 CELESTIAL BODY VECTOR
Verify vector
PRO to 8 after 1st MARK
to 15 after 2nd MARK

15 F 06 05 STAR ANGLE DIFFERENCE (.01°)
(Expect < .1°, if not V32E to 17)
(Accept) PRO

16 F 06 93 TORQUING ANGLES OG,IG,MG (.001°)
N93 is indicative of BMAG drift
since last alignment
If torque angles excessive
perform P51
Otherwise: OHC - Drive trun <10°
OPT ZERO - ZERO
G/N PWR OPTICS - OFF
V37EXXE - procedure complete

17 F 50 25 00014 ALIGNMENT CHECK
PRO to 7

LM STEERABLE ANT POINTING

1. Select V64 (pg G/1-27)
2. Mnvr to N51 angles:

R1 = +03000, R2 = 09000 (+Z orien)
R1 = -03000, R2 = 27000 (-Z orien)

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P20 - Opt 2 (PTC/Orb rate)

- 1 F 04 06 V37E 20E
R1 00024 TRACKING OPTION
R2 00000
Load 2 in R2
PRO
- 2 F 06 78 AXIS YAW, AXIS PITCH, OMICRON (.01°)
Load values (OMICRON ignored)
PRO
- 3 F 06 79 RATE, DEADBAND, Blank (.0001°/sec,.01°)
Load desired values
PRO
- 4 F 06 34 START TIME (hrs,min,.01 sec)
Load desired GET
(all 0's for present time)
PRO
- 5 Maneuver starts at requested GET

Selection of the following programs will
not stop rotation:
P21, P22, P24, P27, P29,
P30
P52,P54
P72-P75

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PTC/ORB RATE

PASSIVE THERMAL CONTROL (G&N)

RHC - Locked
FDAI SCALE - 5/1
RCS DAP - Activated

1 V48E (Select 0.5° DB)
V37E 00E
V49E

2 F 06 22 Load PTC Attitude R - Present
P - 90° (TLC) or 270°
Y - 0° (TEC)
PRO

3 F 50 18 BMAG MODE (3) - RATE 2
SC CONT - CMC
CMC MODE - AUTO
PRO

4 06 18 AUTO MANEUVER
F 50 18

5 Damp vehicle rates:
ENTR
Disable all jets on two adjacent quads

Wait 20 minutes for rates to damp
AUTO RCS SEL (2)-MNA or MNB as follows:

+ROLL	-ROLL
A1,C1	A2,C2
or B1,D1	or B2,D2

Remaining AUTO RCS SEL (14) - OFF
MAN ATT (ROLL) - RATE CMD

6 Perform P20, opt-2 (p. G/8-1)
Use 0,0,0 in N78
Use .42/sec and .5° in N79
Prior to final PRO: cycle CMC
MODE - FREE/AUTO
After one jet firing:
MAN ATT (ROLL) - ACCEL CMD

PTC/ORB RATE

DATE 3/15/72

7

Disable RCS and Term. P20
AUTO RCS SEL (16) - OFF
ROT CONTR PWR DIR (2) - OFF (verify)
V56E

To exit G&N PTC to new att:

1. CMC MODE - FREE
2. AUTO RCS SELECT (12) - MNA/B
3. Verify P00
4. MAN ATT (3) - RATE CMD
5. CMC MODE - AUTO
(PTC rates will stop)
6. V49E to new att.

PASSIVE THERMAL CONTROL (SCS)

SCS - operating
S/C CONT - SCS
ROT CONTR PWR NORMAL #2 - AC/DC

1

MAN ATT (3) - RATE CMD
LIMIT CYCLE - on(up)
DEADBAND - MIN
RATE - LOW
BMAG MODE (3) - ATT 1/RATE 2

2

AUTO RCS SEL -
Configure for single jet operation
(Wait 20 min to allow rates to damp)

3

FDAI SCALE - 5/1
MAN ATT (ROLL) - ACCEL CMD or MIN IMP
DEADBAND - MAX
RATE - HIGH

4

Enable jet couple in roll
Initiate Desired Roll Rate

5

AUTO RCS SEL (16) - OFF
ROT CONTR PWR DIR (2) - OFF (verify)
BMAG MODE (3) - RATE 2

DATE 3/15/72

G
8-4
TERMINATE PTC

AUTO RCS SEL (12) - MNA/B
Null Rates

PITCH ORBIT RATE MANEUVER (G&N)

Note: P20, opt 1 or 5 (p. G/3-1) may
also be used to achieve orb rate.

1. Establish initial attitude
2. Perform P20 Opt. 2 (p. G/8-1)
3. To terminate: V56E

PITCH ORBIT RATE MANEUVER (SCS)

ORDEAL - initialized (p G/7-5)
SCS - Operating

- 1 FDAI SCALE - 5/1
- 2 Maneuver to desired LCL Vert
Att (Roll = 7.25° or 187.25°)
- 3 BMAG MODE (3) - ATT 1/ RATE 2
DEADBAND - MAX
RATE - LOW
MAN ATT (ROLL, YAW) - RATE CMD
MAN ATT (PITCH) - MIN IMP
- 4 Establish desired Pitch Rate
using MIN IMP & ORDEAL FDAI
- 5 To terminate:
MAN ATT (PITCH) - RATE CMD

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With active P20 opt. 2, the following MODES of suspension or termination have the effect shown

MODE	DB Centered	DB Source	Rates Nullled
V56E		DAP (R03)	X
V37E00E		DAP (R03)	X
SC CONT-SCS	X	SCS (Return to CMC re- establishes N79 db)	X (Return to CMC re- establishes N79 rate)
CMC MODE-HOLD	Not proper HOLD func. RHC deflection rec- ommended for HOLD	N79	(Jet firings pos- sible)
CMC MODE- FREE/AUTO	X	N79	
RHC deflection	X	N79	X
V46E	X	N79	
V48E, PRO		DAP (R03)	(Jet firings pos- sible)

ERASABLE LOAD UPDATE

In the event of PROG ALARM 1107, perform the following:

V74E (Wait 42 sec:HBR) (DUMP E MEMORY)
V36E
V48E (LOAD DAP as DESIRED - use
V46E latest known weights)
V25N07E 77E 10000E 1E (set REFSMFLG)
VIN1E 104E (verify CMOON FLAG and LMOON FLAG)
(BITS 11 AND 12 SHOULD BE 0 IN
EARTH SPHERE and 1 in MOON SPHERE)

Verify E MEMORY (should be done ASAP)

VIN1E
XXXXE (LOAD OID 2 OF UPDATE)
N15E, READ R1, E REPEAT FOR UPDATES A-L

FOR UPDATES M,N and O

- VIN1E
1. XXXXE (LOAD EVEN OID'S)
2. READ R1, E (READ ODD OID'S IN R1)
RETURN TO 1

IN CASE OF A DISCREPANCY
LOAD THAT UPDATE AS A NORMAL P27

V37E51E, PRO
V37E00E (Sets drift flag)
OPT ZERO - OFF
OPT ZERO - ZERO

P52-OPTION 3-AUTO OPTICS

AUTO OPTICS SUCCESSFUL, REFSMMAT VALID
AUTO OPTICS UNSUCCESSFUL, DO P51
V16 N65 verify CMC CLOCK (UPDATE)

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TO CHECK STATE VECTOR CALL P21
AND LOAD PRESENT TIME. WHEN COMP CYCLE
IS COMPLETE

V06 N73E

READ R1 (R1 X 10=CURRENT ALT (NM))

COMPARE TO SOME KNOWN VALUE (E.G., FLIGHT PLAN)

IF ANSWER COMPARES - STATE VECTOR IS OK AND

P23 SHOULD BE USED TO IMPROVE IT.

IF GROSS ERRORS ARE OBSERVED, P23 IS UNLIKELY
TO CORRECT THEM. IN THIS CASE PERFORM

V71 LOAD OF LATEST PAD S.V. - SELECT

P00 TO BRING S.V. TO PRESENT TIME.

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OID	A	B	C	D	E	F	G	H
	V71	V71	V71	V71	V71	V71	V71	V71
01	00021	00013	00012	00011	00023	00023	00024	00024
02	01452	01706	01341	01763	02000	02021	02042	02064
03	77667 77450	00011	00005	01532 01545	00137	00001	00003	00031
04	72727 73716	11522	06510	02064 02077	00763	03120	16503	14567
05	03773 03706	13000	07025	01634 01571	00023	00001	00023	00115
06	52152 52016	00000	00620	12160	00001	03120	33241	26534
07	77426 77362	34355	00000	03363	00000	00311	77777	77463
10	72727 70354	00000	33260	00233 00251	00000	34350	61527	73546
11	00214 00000	14715	37723	00476 00522	00471	00070	00001	77642
12	77714 00046	37777	01145 01146		00364	01504	16222	52154
13	77446	37777			04400	77736	77765	76151
14	00230				77777	72015	54467	43216

DATE 3/15/72
3/27/72

**G
9-5**

[illegible]

OID	I	J	K	L	M	N	O	S.V.
	V71	V71	V71	V71	V72	V72	V72	V71
01	00024	00022	00023	00021	00017	00023	00011	
02	02106	02130	03000	03025	00737	02354	00374	
03	02051	00351	00436	37777	37777	00036	00000	
04	05125	25674	02732	00000	01477	02367	01016	
05	10007	16450	00000	00000	00000	00000	00000	
06	00042	12150	00000	54360	02377	02370	01017	
07	75152	10721	77777	21075	00142	33102	00000	
10	77347	03577	77777	37777	03021	02371	01020	
11	77244	03671	42757	60465	01000	00017	00000	
12	53172	32360	10510	00000	03022	02372		
13	74357	65574	06477	54360	00232	00002		
14	61224	76301	74552	21075	03375	02373		

DATE 3/15/72

DATE 3/15/72
3/29/72

6
9-7

OID	I	J	K	L	M	N	O	S.V.
	V71	V71	V71	V71	V72	V72	V72	V71
15	67670	16101	01470	37777	00000	00005		
16	53324	14665	00100 00102	57142	03376	02374		
17	73567	06100	00123	33106	00000	00005		
20	45641	12514	00175	50741		02375		
21	72307	00530	17433	31162		00026		
22	73523	10737	04500			02376		
23	01715		00334			00003		
24	26726							

LM OR CSM S.V. READOUT

1

V96E, V83E

2

After Integration: V05N01E

CSM S.V.

2253E

E,2256E

E,2261E

E,2264E

E,2333E

PRO

LM S.V.

2223E

E,2226E

E,2237E

E,2242E

E,2333E

PRO

3

Transmit S.V. & Time Tag
To LM

LM OR CSM S.V. LOADING

V37E00E

V71E

21E

1501 E

Earth: (CSM S.V.) 00001E, Plus Xmitted Pad
(LM S.V.) 77776E, Plus Xmitted Pad
Lunar: (CSM S.V.) 00002E, Plus Xmitted Pad
(LM S.V.) 77775E, Plus Xmitted Pad
V33E

DATE 12/8/71