Apollo 15 G&C Checklist

Please note that most of the hand-written additions to this document were added during the compilation of the Apollo 15 Flight Journal in 1998 to 2000. To a large extent, they reflect changes read up to the crews during the course of the mission.

David Woods – Editor: Apollo Flight Journal

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Monroe 080-13C

PGM SUBJECT
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OPR MSC

DATE 3/22/71

INDEXING DATA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(JULY 26 LAUNCH)

* APOLLO 15

CSM 112

BASIC

CSM G&C CHECKLIST

PREPARED BY

GUIDANCE & CONTROL
SYSTEMS PROCEDURES BRANCH
CREW PROCEDURES DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

MARCH 22, 1971

APOLLO 15

CSM G&C CHECKLIST

MARCH 22, 1971

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7-16	3/22/71
7-17	3/22/71
8-1	3/22/71
8-2	3/22/71
8-3	3/22/71
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STAR LIST

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

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

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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)

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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/0 (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)	
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 W-mat. reinit.	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 (lcl horiz)	.01°
54	Range	.01 NM
	Range Rate	.1 FPS
	Theta (lcl 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
	RTOGO 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	RTOGO 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	ΔVX,Y,Z (lcl vert)	.1 FPS
82	ΔVX,Y,Z (LV) CDH	.1 FPS
83	ΔVX,Y,Z (Body Control Axis)	.1 FPS
84	ΔVX,Y,Z (Other Vehicle)	.1 FPS
85	VGX,Y,Z (Body Control Axis)	.1 FPS
86	ΔVX,Y,Z (lcl vert)	FPS
87	Opt Calib Data - Shaft (R1)	.01°
	Trunnion(R2)	.001°
88	Planet X	.XXXXX
	Y	.XXXXX
	Z	.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°

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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
lt and NO ATT lt 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 gyr
torquing angles and perform fine ali
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 excessi
Call N22 - maneuver if MGA < 85° or
realign IMU.

00402 Second MINKEY pulse torque must be dor

00404 Target out of view (90 deg test)
(G/3-7,3-11,6-3)

00405 Acceptable star pair is not available
(G/6-3,6-6)

00406 Rend navigation not operating
Select P20 or continue.

00421 W-matrix overflow
Notify MSFN but continue.
W-matrix automatically reinitialized at next mark.

00600 No solution on first iteration in 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).

(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 thar
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
if P62-67, select P00 and then desi
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/5-3,5-18)

(m)03777 ISS warning caused by ICDU fail
(G&N 6)

(m)04777 ISS warning caused by ICDU & PIPA fai
(G&N 6)

(m)07777 ISS warning caused by IMU fail
(G&N 6)

(m)10777 ISS warning caused by IMU & PIPA
fail (G&N6)

(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 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

*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, F37 (no lt)
(P00D00)
*(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

R1 Code	ACTION	FUNCTION
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

R1 Code	Purpose	Input for R2
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 N01E (OCTAL ADD) E
2	F 01 01	R1 DATA R3 OCTAL ADD
3		N15E (For next succeeding word)
4		ENTR (For each succeeding word)

FLAG WORD SET/RESET

1		V25N 07E
	F 21 07	(LOAD FLAG WORD ADDRESS) 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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CHANGE DATA IN ERASABLE MEMORY

	V21 N01E (ADDRESS) E
F 21 01	R3 ADDRESS
	Load New Data in R1 E
	N15E (For next succeeding word)
	ENTR (For each succeeding word)

FLAGWORD ASSIGNMENTS

FLAGWORD	ADDRESS	4	2	1	4	2	1	4	2	1	4	2	1	4	2	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
0	74		JSWITCH	MIDFLAG	MOONFLAG	FARHOR (NORFHOR)	ZMEASURE	NEEDLEFLG	IMUSE	RNDVZFLG	SGTMK (RSSFLAG)	F2RTE	CYC61FLG	FREEFLAG	AMOONFLG	P2NFLAG
1	75	2JETSFLG (NJETSFLG)	STIKFLAG	ERADCOMP (ERADFLAG)	NODOPOI	RCSBURN (ENGZFLG)	LMTRG (TARG1FLG)	LMKTRG (TARG2FLG)	CSMUPDAT (VEHUPFLG)	UPDATFLG	IDLEFAIL	TRACKFLG	MARKFLG	ITER1SW (SLOPESW)	GUESSW	AVEGFLAG
2	76	DRIFTFLG	R2LMARK	Z2DSPFLG	P21FLAG	STEERSW	SKIPVHF	IMPULSW	XDELVFLG	FIRSTFLG HAVEELEV (ETP1FLAG)	FINALFLG	LMACTFLG (AVFLAG)	PFRATFLG	P24MKFLG	CALCMAN2	NODOV3F (NODOFLAG)
3	77	V50N18FL	GLOKFAIL	REFSMFLG	LUNLATLO (LUNAFLAG)	P22MKFLG	VFLAG	POOFLAG	PRECIFLG	CULTFLAG	ORBWFLAG	STATEFLG	CONICINT (INTYPFLG)	CSMINTSW (VINTFLAG)	9D1MMMAT (D6GIMFLG)	WMATINT (D1MOFLAG
4	100	MARKIDLE (MRK1DFLG)	PRIOIDLE (PRIODFLG)	NORMIDLE (NRMIDFLG)	PDSPFLAG	MARKWAIT (MWAITFLG)	NORMWAIT (NWAITFLG)	MRKWTKEY (MRKNVFLG)	NRMWTKEY (NRMNVFLG)	PRONTKEY (PRONVFLG)	PINBRFLG	RUPTMARK MRUPTFLG	RUPTNORM (NRUPTFLG)	MKOVNORM (MKOVFLAG)	VNFLAG	XDSPFLAG
5	101	DSKYFLAG	RETROFLG	SLOWFLG	P23CALIB (V59FLAG)	FSTINCRP (INCORFLG)	NEWTFLAG	DMENFLG	CMCCOMP (COMPUTER)	ENGONFLG	3AXISFLG	BKUPLO (GRRBKFLG)		NOSOLNSW (SOLNSW)	MGLVFLAG	RENDWFLG
6	102	DAPBIT1	DAPBIT2	ENTRYDSP STRULL SW	CMDAPARM	GAMDIFSW	GONEPAST	RELVELSW	EGSW (KNOWNFLG) LDNKNOWN	NOSWITCH	HIND	INRLSW	LATSW	.05G SW	CMDSTBY	GYMDIF
7	103	TERMIFLG	ITSWITCH	IGNFLAG	ASTNFLAG	T1MRFLAG	NORMSW	RVSW	GONEBYTG (GONEBY)		V37FLAG		UPLOCKFL	VERIFLAG	LMATTCH (ATTCHFLG)	TFFSW
8	104	RPQFLAG	NEWLMFLG	NEW1FLG	CMOONFLG	LMOONFLG	ADVTRK	UTFLAG	SURFFLAG	INFINFLG	ORDERSW	APSESW	COGAFLAG	V96NFLG	R67FLAG	360SW
9	105	SWTOVER	P24FLAG	V82EMFLG	MAXDBFLG	V94FLAG	SAVECFLG	VHFRFLAG	VHFSOURC (SOURCFLG)	R22CAFLG	NZZERNDS (NZZERN17)	QUITFLAG	R31FLAG	MIDXFLAG	MIDAVFLG	AVEMIDSW
10	106	PCMANFLG	INTINUSE (INTFLAG)	INTGRAB (REINTFLG)	REJCTFLG	HDSUPFLG	BURNFLAG	RANGFLAG	P33FLAG	AUTOSEQ		MANEUFLG	PTV93FLG	TPIMMFLG	FULTKFLG	PCFLAG
11	107	S32.1F1	S32.1F2	S32.1F3A	S32.1F3B				AZIMFLAG	HAFLAG	CSISFLAG					

MONITOR OF INPUT/OUTPUT CHANNELS

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

CHANNEL SET/RESET

Note: Only channel no's <30 may be used

1 V25N 07E
F 21 07 (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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CMC INPUT/OUTPUT CHANNELS

CHANNEL		NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			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	
CP	1	L			SHFT PULSE			CP REGISTER L, BITS 16-1										
	2	Q			SHFT PULSE			CP REGISTER Q, BITS 16-1										
	3	HISCALAR			SHFT PULSE			HIGH ORDER SCALER CHANNEL BITS 14-1										
	4	LOSCALAR			SHFT PULSE			LOW ORDER SCALER CHANNEL BITS 14-1										
OUT	5	PYJETS							S/M	+Y-YW	Y+YY	Y YY	+Y+Y	+Y P	Y P	Y P	+Y P	
									C/M	-YW-Y+P	+YY Y-P	YY-Y-P	+YY Y+P	P+Z	-P Y YY	P+Z	+P Y+YY	
	6	ROLLJETS							S/M	+Y-R	-Y+R	-Y-R	+Y+R	+Z-R	-Z+R	-Z-R	+Z+R	
									C/M					-R-YY+Z	+R+YY-Z	-R-YY-Z	+R+YY+Z	
CP	7	SUPERBNK									FE7	FE6	FE5					
OUT	10	OUTO	RELAY ADRS 4	RELAY ADRS 3	RELAY ADRS 2	RELAY ADRS 1	RELAY BIT 11	RELAY BIT 10	RELAY BIT 9	RELAY BIT 8	RELAY BIT 7	RELAY BIT 6	RELAY BIT 5	RELAY BIT 4	RELAY BIT 3	RELAY BIT 2	RELAY BIT 1	
	11	OSAIMOUT			SPS ENGINE ON			CAUTION RESET	TEST CONNECTOR OUTBIT		OPERATOR ERROR LAMP	VN FLASH	KEY REL LAMP	TEMP CAUTION LAMP	UPLINK ACTY LAMP	COMP ACTY LAMP	ISS WARNING	
	12	CHAN12	ISS TURNON DELAY COMPLETE	S IV B CUTOFF	S IV B IGN SEQ START		DISABLE OPTICS DAC	ZERO OPTICS	S IV B TAKEOVER ENABLE	TVC ENABLE		ENABLE IMU ERROR COUNTER	ZERO IMU CDUS	COARSE ALIGN ENABLE		ENABLE OPT ERROR COUNTER	ZERO OPTICS CDUS	
	13	CHAN13	ENABLE T5RUPT	RESET TRAP 32	RESET TRAP 31R	RESET TRAP 31A	ENABLE STANDBY	TEST ALARMS		RMAG CTR ENABLE	DNLNK WORD	BLOCK UPLINK	INHIBIT UPLINK	RNG UNIT ACTY	RNG UNIT SEL A	RNG UNIT SEL B	RNG UNIT SEL C	
	14	CHAN14	DRIVE CDUY	DRIVE CDUY	DRIVE CDUZ	DRIVE CDUT	DRIVE CDUS	GYRO ACTY	GYRO	GYRO	GYRO	GYRO ENABLE					UPLINK ACTY	
IN	15	MNKEY IN											MKEY5	MKEY4	MKEY3	MKEY2	MKEY1	
	16	NAVKEY IN									MARK REJECT	MARK	NKEY5	NKEY4	NKEY3	NKEY2	NKEY1	
	30	* CHAN30	TEMP IN LIMITS	ISS TURNON REQUEST	IMU FAIL	ICDU FAIL	IMU CAGE	S/C CONTROL OF SAT	IMU OPERATE		OPTICS CDU FAIL		LIFT OFF	S IV B SEPARATE OR ABORT	SPS READY	SM/CM SEPARATE	ULLAGE THRUST PRESENT	
	31	* CHAN31	G & N AUTOPILOT CONTROL	FREE	HOLD	-Z TRANS	+Z TRANS	-Y TRANS	+Y TRANS	-X TRANS	+X TRANS	RHC -ROLL	RHC +ROLL	RHC -YAW	RHC +YAW	RHC -PITCH	RHC +PITCH	
	32	* CHAN32		PROCEED			LM ATTACHED					MNEM -ROLL	MNEM +ROLL	MNEM -YAW	MNEM +YAW	MNEM -PITCH	MNEM +PITCH	
	33	* CHAN33	OSC ALARM	COMPUTER WARNING	P1PA FAIL	DNLK TOO FAST	UPLINK TOO FAST	BLOCK UPLINK					EMC CTR OPTICS	ZERO OPTICS				
OUT	34	DNTM1							FIRST OF TWO WORDS									
	35	DNTM2							SECOND OF TWO WORDS									
* INVERTED LOGIC			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

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. V25 N7E, 76E, 40000E, 1E (set DRIFT flag)
3. V25 N7E, 77E, 10000E, 1E (set REFSMMAT flag)

if V36 inadvertently keyed in:
1. V25 N7E, 76E, 40000E, 1E (set DRIFT flag)
2. V48
3. V46
4. Perform General System Checkout as necessary

if GO JAM performed:
V74 when convenient, see V36

<u>if</u> All 8's appear spontaneously on DSKY

1. V99 N99
2. V25 N1E
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 V96E
4. Simultaneously press RSET 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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V35 - DSKY CONDITION LIGHT TEST

CMC - on

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 "
Sign positions in R1,R2, R3 show +
V, N windows flash

Wait 5 sec

d. All DSKY warning lts - off

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)

V41 N91 COARSE ALIGN OCDU's

CMC - on
G/N PWR OPTICS - on
OPT MODE - CMC
OPT ZERO - OFF

1 V37E00E

2 V41N 91E

3	F 21 92	SHAFT, TRUN NEW OCDU Load desired shaft and trun	(.01°,.001°)
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 Load desired ICDU angles	(.01°)
3	41	NO ATT lt - on *POSS PROG ALARM * *V5 N9E 211 Coarse align error* *Repeat V41 N20 *	
4		V40E NO ATT lt - off Wait 10 sec	
5		V37E XXE	

V42 GYRO TORQUING

CMC MODE - FREE

1		V42E	
	F 21 93	LOAD DELTA GYRO ANGLES (XYZ) (In flight - 90° max)	(.001°)
2	42	NO ATT lt - off Monitor Gyro Torquing on FDAI	

V48 - DAP DATA LOAD & ACTIVATE PROCEDURE

1 V48E

F 04 46 R1 ABCDE*
R2 ABCDE

	VEHICLE CONFIG	QUAD A/C FOR X	QUAD B/D FOR X	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 = ±0.5° 1 = ±5.0°	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 frc
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

G
1-26

V49 CREW DEFINED MANEUVER

CMC - on
ISS - on
SCS - operating

1 V37E 00E
V62E

2 V49E
F 06 22 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

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 10 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 V55E
F 21 24 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 V64E
F 06 51 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 V67E

F 06 99 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 V82E (If AVE G On, Go To 3)

F 04 12 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)
(ΔR-miss dist DISP-P11 & P00) N50E To 4
(TF PER) N32E To 5
(EXIT) PRO

4 F 16 50 ΔR (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

V83 RNDZ PARAMETER DISPLAY #1

Note: If high CMC activity (e.g.P3X or P7X w
P20), POSS PROG ALARM and restart (nc
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		V83E
	F 16 54	RANGE,RANGE RATE,THETA (.01nm,.1fps,.01° PRO

V85 - RNDZ PARAMETER DISPLAY #2

Note: See V83 restrictions

1		V85E
	F 16 53	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

G
1-30

V89 - RENDEZVOUS FINAL ATTITUDE

CMC - on
ISS - on
SCS - operating

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

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V90 - OUT-OF-PLANE DISPLAY

1 V90E

F 06 16 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 2
(EXIT) PRO

V91 - COMPUTE BANKSUM
CMC - on (req)

1 V37E 00E

2 V91E

F 05 01 R1 - Sum of all cells in bank
R2 - Bank number
R3 - Bugger word
Verify R1=R2 or R1+R2=77777 (If not, rcd

(NEXT BANK) PRO
(TERM) V34E

V93 - ENABLE W-MATRIX INITIALIZATION

1 V93E

G
2-1

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 lt - on (90 sec)
NO ATT lt - 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 *

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G&C SYSTEMS

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

4 At T + 1:04 - ENTR
Record (X) R1 ____ (Y) R2 ____ (Z) R3 ____ (±00OAB)

5 V21N 01E (use same sign as above)
F 21 01 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 V48E
F 04 46 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)

CMC SELF CHECK

```
1                    V25 N01E, 1365E
       F 21 01       E,E,E

2                    V15 N01E, 1365E
          15 01      R1 NUMBER OF ERRORS
                     R2 NUMBER OF TESTS STARTED
                     R3 NUMBER OF TESTS SUCCESSFUL

3                    V21 N27E 10E SELF TEST FIXED & ERASABL
                     (4E SELF CHECKS ERASABLE
                      5E SELF CHECKS FIXED)

4         15 01      TEST SUCCESSFUL WHEN R2≥3 (78 sec mini
                              * IF PROG lt - On        *
                              * V05 N09E  01102 SELF   *
                              *                TEST ERROR *
                              *N8E-Rec for MSFN        *
           (TERM)       V21N27E 0E
```

OPTICS POWER UP PROCEDURE

Verify optics manual drive diseng

1 G/N PWR OPTICS - on (up)

2 OPT ZERO - OFF
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 C(
to engage drive (socket backs ou

2 Drive optics either direction
(~1 rev/degree)

3 To disengage, push and rotate
~1 rev CW(button will remain flu

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) - ACT
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

G
2-5

SCS ATTITUDE REFERENCE COMPARISON

CMC - on
IMU - on
SCS - operating
If SIVB SEPARATED: Damp vehicle rate

1 Key V16 N20E (present IMU angs)

2 FDAI SELECT - 1
FDAI SOURCE - ATT SET
ATT SET - GDC
ATT SET dials - null FDAI 1 error needles
Key VERB when nulled (freeze display
Record from DSKY:
R_____°, P_____°, Y_____°
Record ATT SET dials:
R_____°, P_____°, Y_____°

EMS ΔV TEST & NULL BIAS CHECK

EMS MODE - STBY
EMS FUNC - ΔV SET/VHF RNG
SET ΔV ind to 1586.8 fps
EMS MODE - NORMAL
EMS FUNC - ΔV TEST
SPS THRUST Lt - on/off (10 sec)
ΔV ind. stops at -0.1 to -41.5
EMS MODE - STBY
EMS FUNC - ΔV SET/VHF RNG
SET ΔV ind to - 100.0 fps
CMC MODE - FREE (Until meas complete
or BMAG MODE (3) - RATE 2
EMS FUNC - ΔV (wait 5 sec)
Start DET
00:00 EMS MODE - NORM
01:40 EMS MODE - STBY
If ΔV <1 fps, do not bias
If ΔV ≥1 fps but <10 fps, bias if desired
If ΔV >10 fps, EMS is NO-GO
Bias check is invalidated by EMS FUNC - OFF

DATE 5/22/11

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

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 Load values (OMICRON ignored for opt 1) Sim. Bay: 90°, 52.25° OMICRON SEF: 180 BEF: 0 PRO	(.01°)
3	F 06 79*	R2 DEADBAND Load d.b. PRO	(.01°)
4	F 01 70	R1 000DE STARCODE Load code PRO (DE ≠ 00 to 6)	
5	F 06 88	CELESTIAL BODY VECTOR Load vector PRO (If required mnvr <10°, go to 7)	

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6 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 lt *
*(Mnvr >10° 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 2 sec)

To terminate P20 - V56E

P20 - UNIVERSAL TRACKING
Options 0 & 4 - Rendezvous
(0:VECPOINT; 4:3-axis)
CMC - on (req)
ISS - on and aligned (req)
SCS - on (des)
BMAG MODE (3) - RATE 2
G/N OPT PWR - on
OPT ZERO - OFF then ZERO (15 sec)
OPT MODE - CMC
Note: For VHF RNG display
see p G/1-20

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 lt *
*(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 10 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
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

G
3-5

P21 GROUND TRACK DETERMINATION
CMC - on (req)

1		V37E 21E
	F 04 06	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 availab
by V6 N73E
N73 Alt,VEL,GAMMA(10nm,fps,.01°

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P22 - ORBITAL NAVIGATION

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

1 V37E 22E
F 06 45 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)

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

P23 - CISLUNAR MIDCOURSE NAV MEASUREMENT

CMC - on
SCS - on
ISS - on & aligned
G/N PWR OPTICS - on (30 min prior)
OPT ZERO - OFF then 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)

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

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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
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

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3-10

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 AUTO MNVR COMPLETE RETURN TO 13	(.01°)
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 blanked)	
		(TERM) PRO	
18	F 05 71	R1 OOODE STAR ID R2 OOCOO LMK ID R3 OOCDO 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) PRO (DE≠00 to 21)	(.001°+N/E,.01nm)

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20	F 06 88	CELESTIAL BODY VECTOR Verify vector PRO	
21	F 06 49	ΔR,ΔV (SV PARA) (REJECT) V37E 23E (UPDATE) PRO	(.01nm,.1 fps)
22	F 37	XXE OPT ZERO - ZERO G/N PWR OPTICS - OFF	

P24 RATE-AIDED OPTICS TRACKING

CMC - on (req)
ISS - on and aligned
SCS - on
BMAG MODE (3) - RATE 2
G&N PWR OPTICS - on
OPT ZERO - OFF then 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 LOAD LMK COORDS OPT ZERO - OFF MNVR to SIGHTING ATT 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) PRO	(.001°,.001°,.01nm
3	06 92	AUTO OPT SHFT/TRUN *F 05 09 00404 (TRUN >90°)* * MNVR to acquire * * PRO * * or V34E, F 37 * OPTICS MODE - MAN	(.01°,.001°

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4	F 51	MARK REQUEST MARK (as often as desired) To terminate: PRO
5	F 37	XXE 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 lt - on *POSS LOS before completion* *If V33 N02 showing: * * Key ENTR * * UPLINK ACTY lt - out * * P00 or P20 displayed * *If V21 N01 * *or V21 N02 * * Key V34E * * UPLINK ACTY lt - out * * P00 or P20 displayed * *UP TLM (2) - BLOCK *

Update complete:

UPLINK ACTY lt - 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

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
G/N OPT PWR - on
OPT ZERO - OFF then 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 *
* (.1nm, .1fps, 0000X)*
* (REJECT) V32E *
* (ACCEPT) PRO *

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

P30 EXTERNAL ΔV

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

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

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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) ≤ 3, 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

(TORQUE) CMC MODE - FREE
PRO
(16 20 during torque)
Torque complete:
CMC MODE - AUTO
ΔV <7 fps - P41 (step 4)
ΔV ≥7 fps - P40 (step 4)

(BYPASS) ENTR
Perform P41 (step 4)

36.2 Perform P76

36.3 If pulse torque not done, go to P33 step 2.

36.4 If all gimbal angle changes for mnvr back to rend. att < 10°, 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

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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

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		(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 Nπ 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

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```
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 ΔV(CSI)>1000fps 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
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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 Nπ 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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G
4-8

```
*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)
(.01nm,.1fps,.1fps)
PRO

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

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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) PRO	(hrs,min,.01sec)
4	F 16 45	MARKS,TFI,-00001 (RECYCLE) V32E (FINAL COMP) TERM MARKS PRO	(marks,min-sec)
5	F 06 90	Y(Active),YDOT (Active),YDOT (Passive) PRO	(.01nm,.1fps,.1fps)
6	F 06 81	ΔV XYZ (LV) PC PRO (If recycle - to 4)	(.1fps)
7	F 16 45	MARKS, TFI, MGA (MGA = -00002 if no REFSMFLG) SET EVENT TIMER PRO (If MINKEY, to sequencer 36.1)	(marks,min-sec,.01°)
8	F 37		

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P33 CDH PRETHRUST (P73 LM)

1 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 ΔH(CDH),ΔT(TPI-CDH),ΔT(TPI-NOMTPI)
PRO (.1nm,min-sec)

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

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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

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)

1 V37E (35E or 75E)
(If no REFSMFLG or P75, to 3)
F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR

DATE 3/22/71

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

DATE 3/22/71

P79 RNDZ FINAL PROGRAM

1 V37E 79E

2 (All gimbal angle errors <10°, 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 FOUR ITEMS GIVEN IN P 37 PAD — TIG, ΔV, Long °, GET } ENTRY

P37 RETURN TO EARTH PGM

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

LONGITUDE

Perform the following once:
V1N1E
3012E
Verify R1=

LOOKS AT R1 VALUE AT ADDRESS 3012.

1 ENTER P37 V37E 37E
F 06 33 TIG (hrs,min,.01sec)
Load desired TIG FROM P37 PAD
PRO

2 F 06 60 BLANK,ΔV DESIRED, GAMMA EI DESIRED
(fps,01°)
Load desired ΔV: FROM P37 PAD
PAD ΔV IF ON TLC → AS ON OUTWARD PADS
0. IF ON TEC
Load R3=0
PRO

DATE 3/22/71

G
4-15

```
*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 CONIC SOLN

F 06 61 IMPACT LAT, IMPACT LONG (+E) (.01°)
If Impact LONG>12° from desired:
TEC:N40E Record R2 as ΔVmin (fps) TLC: V32E to
V32E to 1 & use |ΔV| >ΔV min Decrease ΔV t
Load ΔV neg to move LONG WEST move LONG WES
Load ΔV pos to move LONG EAST Increase ΔV t
move LONG EAS
Continue recycles til <12° from desired LO
If Impact LONG <12° from desired:
Record Impact LONG as θcl (.01°)
Record ΔVinl (fps)
PRO

is this where the long is entered for the PAD

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

is this where the GET of EI is stored

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 ΔVzcl (.1fps)
N40E
Record R2 as ΔVcl (.1fps)
Make sign of ΔVcT same as ΔVinl
KEY RLSE
PRO

DAT E 3/22/71

53:41

```
*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                *
```

PRECISION SOLN

7 F 06 61 IMPACT LAT,IMPACT LONG (.01°)
Record LONG as θpl (.01°)
If θpl, 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 ΔVxpl (.1fps)
Record R3 as ΔVzpl (.1fps)
V32E to 11

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 θpl:
Load ΔVin2 = ΔVc1-10
(If ΔVin1 = 0 for TEC,
ΔVin2 = -ΔVc1-10)
To move EAST from θpl:
Load ΔVin2=ΔVc1+10
Record ΔVin2 (.1fps)
R2: Load ΔVin2
PRO

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

3/22/71 DATE

13 F 06 61 IMPACT LAT, IMPACT LONG (.01°)
Record LONG as $\underline{\theta c2}$ (.01°)

N81E Record R3 as $\underline{\Delta Vzc2}$ (.1fps)

Compute $K=\left|\frac{\theta c2 - \theta c1}{\Delta Vzc2-\Delta Vzc1}\right|$

Compute $\underline{\Delta\theta \text{ LONG}} = \theta d - \theta pl$ (.01°)
Obtain from chart $\underline{\Delta Vo}$ (fps)
Make sign of ΔVo same as $\Delta\theta$ LONG
Compute ΔVd:
If TLC and $\Delta Vzpl > 3\Delta Vxpl$:
$\Delta Vd = \Delta Vc1 + \Delta Vo$
V32E to step 1 and use
ΔVd in R2 of N60
Otherwise:
$\underline{\Delta Vzd} = \Delta Vzpl + \Delta Vo$

14 $\underline{\Delta Vd} = (\Delta Vzd^2 + \Delta Vxpl^2)^{1/2}$
To solve for ΔVd:
V37E 30E, Use present time in N33.
Load N81:
R1 = $\Delta Vxpl$ (should be)
R2 = 0 (should be)
R3 = ΔVzd (.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

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

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.
(Step 1 TIG + FNL N39)
2. Use 400K time for T-align P52
(Option 2).
If PROG ALARM 401, Yaw 45°
* and V32E *

P76 - ΔV UPDATE (P77 CSM)

1		V37E (76E or 77E)	
	F 06 33	TIG	(hrs,min,.01sec)
		Load TIG	
		PRO	
2	F 06 84(81)	ΔV XYZ	(.1fps)
		Load ΔV	
		PRO (MINKEY, to Sequencer 3X.3)	
3	F 37		

DATE 3/22/71

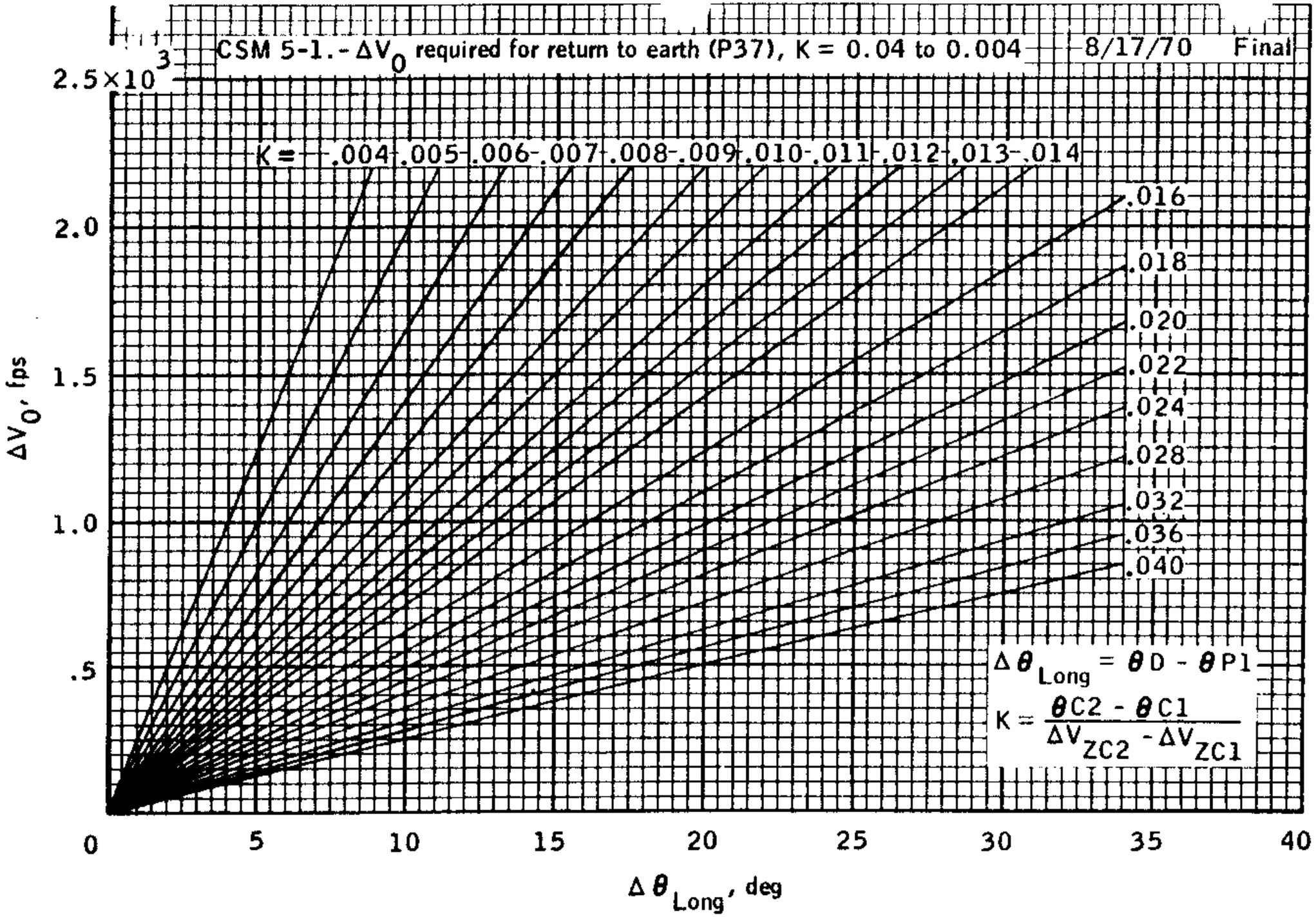
G
4-20

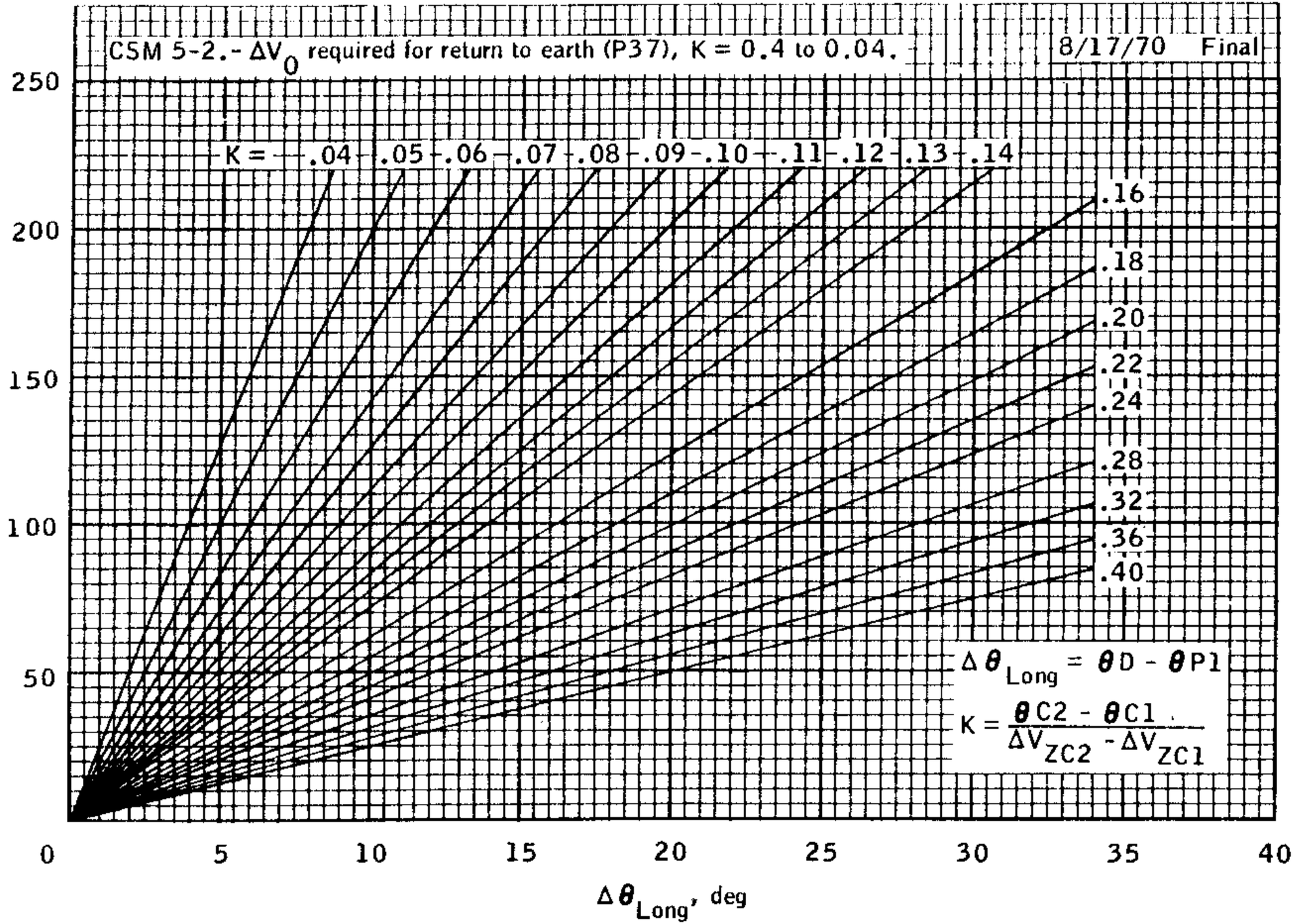
P37 LONGITUDE ITERATION

PARAMETER	STEP	1	2	3	
ΔVmin	3	_____.	_____.	_____.	fps
θcl	3	___.__	___.__	___.__	°
ΔVinl	3	_____.	_____.	_____.	fps
ΔVzcl	6	____._	____._	____._	fps
ΔVcl (Same sign as ΔVinl)	6	____._	____._	____._	fps
θpl	7	___.__	___.__	___.__	°
ΔVxpl	10	____._	____._	____._	fps
ΔVzpl	10	____._	____._	____._	fps
ΔVin2	12	____._	____._	____._	fps
θc2	13	___.__	___.__	___.__	°
ΔVzc2	13	____._	____._	____._	fps
|θc2-θc1|	13	___.__	___.__	___.__	°
|ΔVzc2-ΔVzc1|	13	____._	____._	____._	fps
K	13	.____	.____	.____	
θd(desired long)	13	___.__	___.__	___.__	°
θd-θpl(Δθ long)	13	___.__	___.__	___.__	°
ΔVo(from chart)	13	____.0	____.0	____.0	fps
ΔVzd	13	____._	____._	____._	fps
ΔVd	13/14	____._	____._	____._	fps

DATE 3/22/71

DATE 3/22/71


CSM 5-1. - ΔV_0 required for return to earth (P37), K = 0.04 to 0.004
8/17/70 Final
2.5×10^3
2.0
1.5
1.0
.5
0
5
10
15
20
25
30
35
40
ΔV_0, fps
$\Delta \theta_{Long}$, deg
K = .004 .005 .006 .007 .008 .009 .010 .011 .012 .013 .014 .016 .018 .020 .022 .024 .028 .032 .036 .040
$\Delta \theta_{Long} = \theta D - \theta P1$
$K = \frac{\theta C2 - \theta C1}{\Delta V_{ZC2} - \Delta V_{ZC1}}$



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

DATE 3/22/71

P37 BLOCK DATA

										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}

DATE 3/22/71

P37 BLOCK DATA

										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}
										GETI
X					X					ΔVT
X					X					LONG
										GET_{400K}

DATE 3/22/71

changes read down at 58:59:03
They are meant for G2C Dictionary
This version out of date.

Should be a line:
VERIFY SIM PAMFDOWN
After this, insert
CB, SPS PILOT VALVES (2) OPEN. VERIFY
CB EPS, GROUP 5, (2) CLOSED, VERIFY

EMS FUNCTION, OFF. VERIFY
CB EMS MN A + B (2) CLOSE

G
5-1

P40 SPS THRUSTING

Prethrust Program Complete
CMC & ISS - on
Cycle CRYO FANS
SCS - OPERATING
TEST C/W LAMPS
Perform EMS ΔV TEST & NULL
BIAS CHECK, pg G/2-5
Set ΔVC
EMS FUNC - ΔV
SPS GAUGING - ACT
PUG MODE - NORMAL
OXID FLOW vlv - PRI
MAP CAMR ON - STBY
PAN CAMR PWR - BOOST
SM/AC PWR - on (up)
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

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 3/22/71 3/22/71 DATE

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)~~ (10) - close
SET ΔVC (verify) changes due to SPS short.
EMS FUNC - ΔV (verify) ch @ 59:22:34
MAN ATT (3) - RATE CMD

ATT DB - MIN
RATE - LOW
TRANS CONT PWR - ON
SCS TVC (2) - RATE CMD
ΔVCG - LM/CSM or CSM
TVC GMBL DRIVE P&Y - AUTO

+54:00m (-06:00)
MN BUS TIE (2) - ON
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 PT-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 3/22/71

changes due to
SPS short
ch @ 59:00:34

G
5-3

Verify GPI returns to 0,0(CMC) or t
(SCS)
ROT CONT PWR NORM (2) - AC/DC
ROT CONT PWR DIRECT (2) - MNA/MNB
(TRIM) BMAG MODE (3) - RATE 2
PRO
BMAG MODE (3) - ATT1/RATE 2 (verify
ENTR

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

changes due to
SPS short
ch @ 59:00:34

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

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

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

FDAI SCALE - 5/5

RATE - HIGH
UPDATE DET
SPS He vlvs (2) - AUTO (verify)
Check N2 A and N2 B

58:00
(-02:00)

CB SPS PILOT VALVE MAIN B, CLOSE
~~ΔV THRUST A(B) - NORMAL~~
THC - ARMED
RHC (2) - ARMED
TAPE RCDR - HBR/RCD/FWD/CMD RESET

59:25
(-00:35) DSKY BLANKS

3/22/71
DATE

changes due to SPS Short:
ch 9 59:01:54

59:30 (AVE G ON)
(-00:30) EMS MODE - NORMAL

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

59:XX ULLAGE
(-00:XX)
*If no ULLAGE: *
* DIR ULLAGE PB - PUSH*
* Control Att with RHC*

MONITOR ΔVM (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

ΔV THRUST A+B (2) NORMAL

9 00:00 IGN *IF SCS: THRUST PB - PUSH*

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

*F 97 40 SPS Thrust fail *
CB SPS PILOT VALVE MN A-CLOSE ~~*ΔV THRUST B(A) NORMAL~~ *
*(RESTART) PRO to IGN *
(RECYCLE) ENTR to TIG-05sec

SPS THRUST Lt - ON
00:03 ~~ΔV THRUST B(A) NORMAL~~
CB SPS PILOT VALVE MN A-CLOSED
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 NO PUGS AFTER 6 MINS

FOR LOI, AT 6 MIN INTO BURN
SPS PILOT VALVE MN A-OPEN

FOR TEI: CUT-OFF -10Secs, CB SPS PILOT VALVE MN A-OPEN

DATE 3/22/71

G
5-5

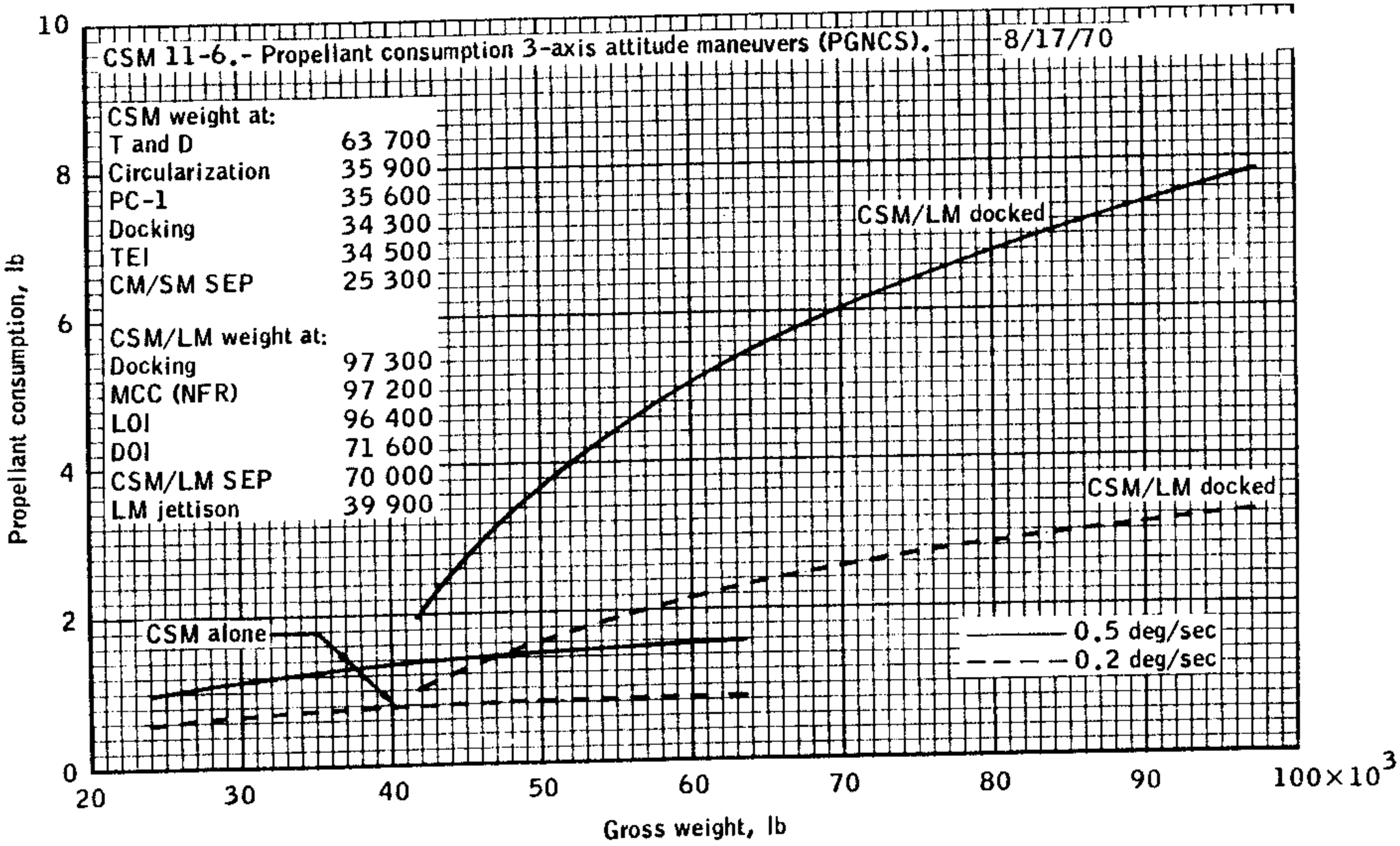
changes due to SPS
Short ck @
59:01.54

	00:XX		ECO	
10	F 16 40		TFC (STATIC), VG, ΔVM	(min-sec,.1fps)
			ΔV 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	
			MN BUS TIE (2) - OFF	
			PRO	
11	F 16 85		VG XYZ (CM)	(.1fps)
			NULL RESIDUALS	
			RECORD ΔV COUNTER & RESIDUALS	ΔVC ____
			EMS FUNC - OFF	VGX ____
			EMS MODE - STBY	VGY ____
			RHC & THC - LOCKED	VGZ ____
			ATT DB - MAX	
			TRANS CONT PWR - OFF	
			ROT CONTR PWR DIRECT (2) - OFF	
			BMAG MODE (3) - RATE 2	
			cb DIRECT ULLAGE (2) - open	
			cb SPS P1 & Y1 - open	
			PCM BIT RATE - LOW	
			MAP CAMR ON - OFF	DELETED FOR TEI
			PAN CAMR PWR - OFF	
			SM/AC PWR - OFF	
			PRO	(If MINKEY, To Sequence 3X.2)
12	F 37		V82E	
13	F 16 44		HA,HP,TFF	(.1nm,min-sec)
			PRO	
14	F 37		00E	

FOR LOI + TEI
CB SPS PILOT VLV MN B — OPEN
FOR TEI
CB EMS(2) MN A+B — OPEN

DATE 3/22/71

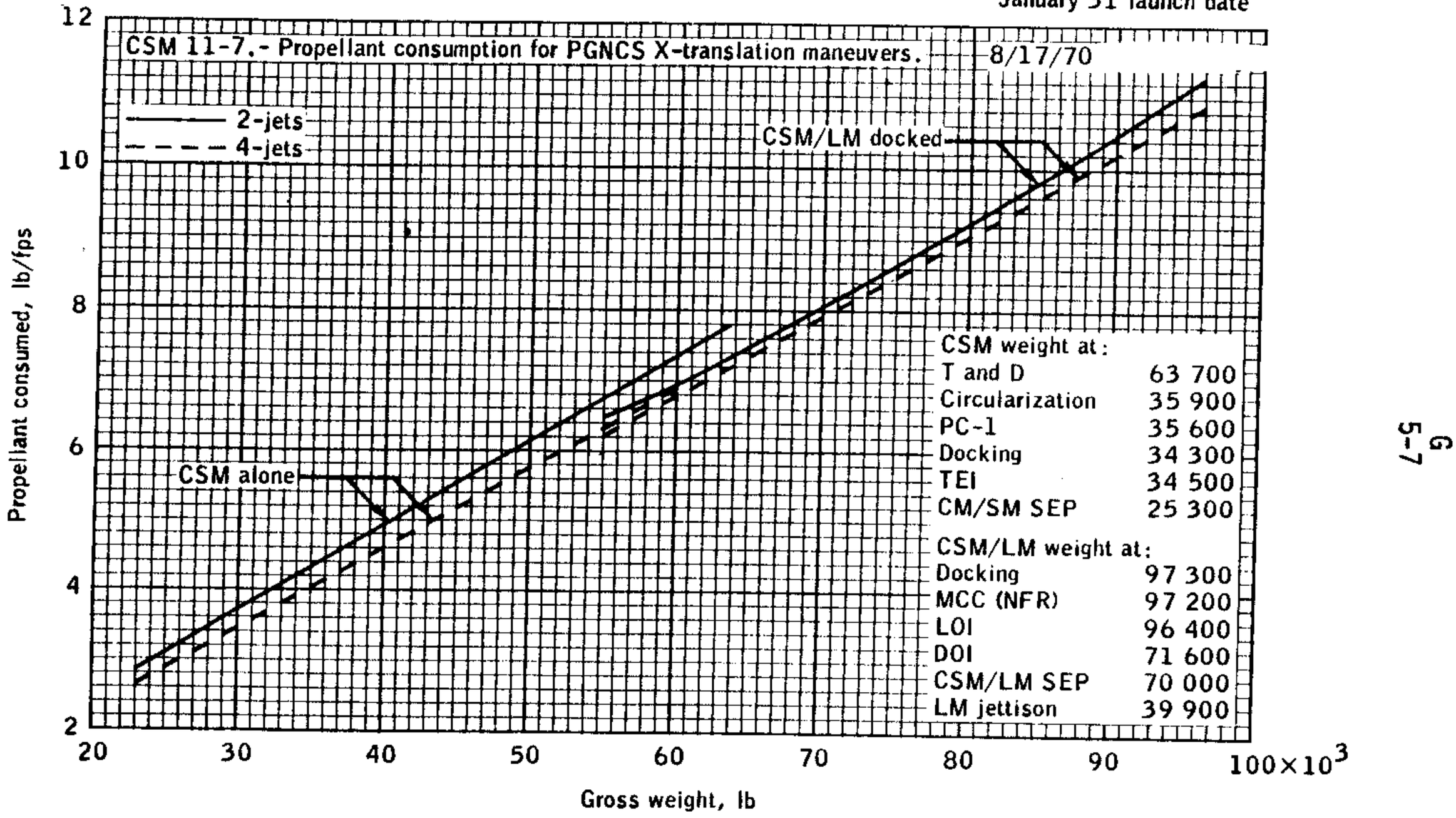
Jaunuary 31 launch date



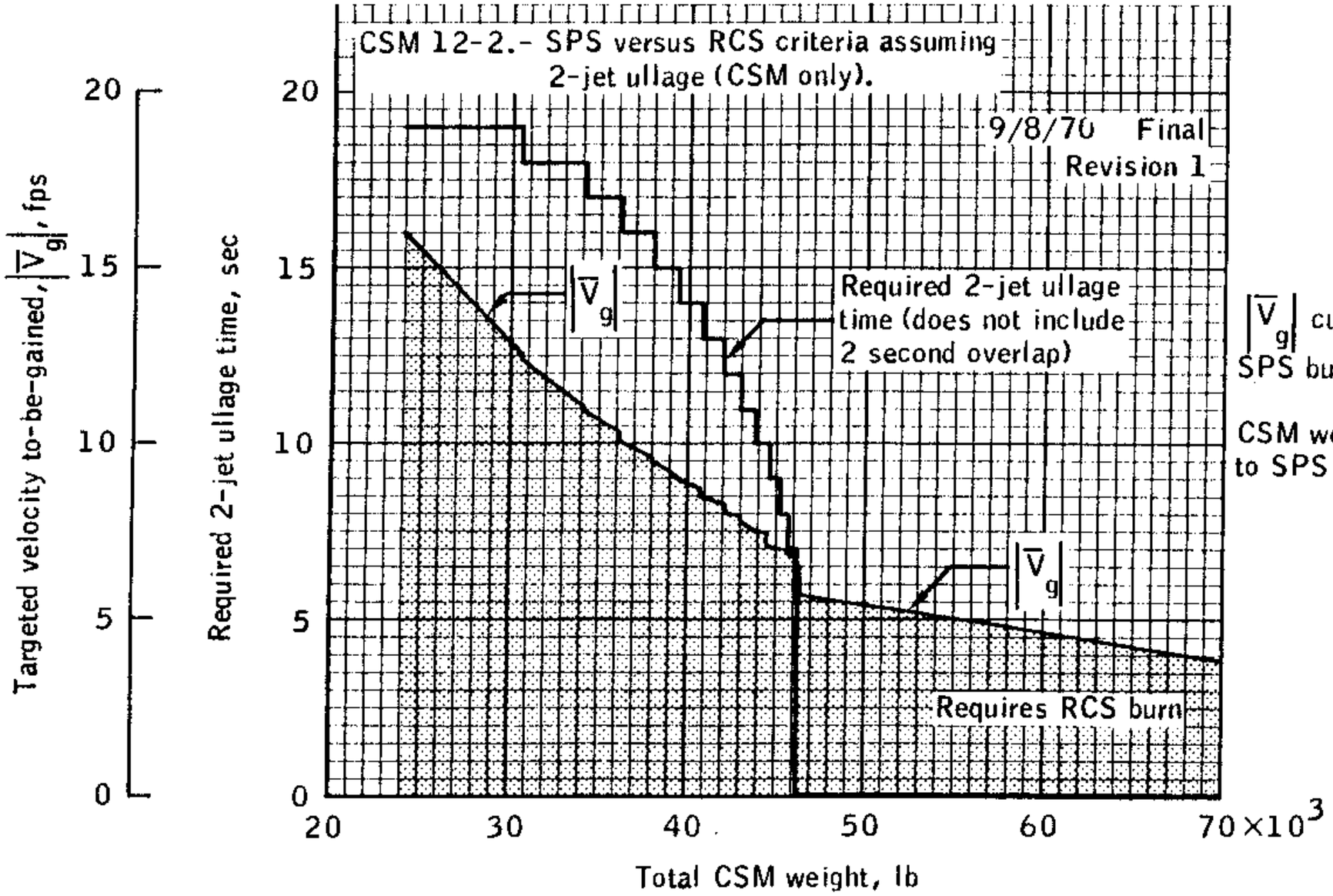
Propellant consumption 3-axis attitude maneuvers (PGNCS).

DATE 3/22/71

DATE 3/22/71



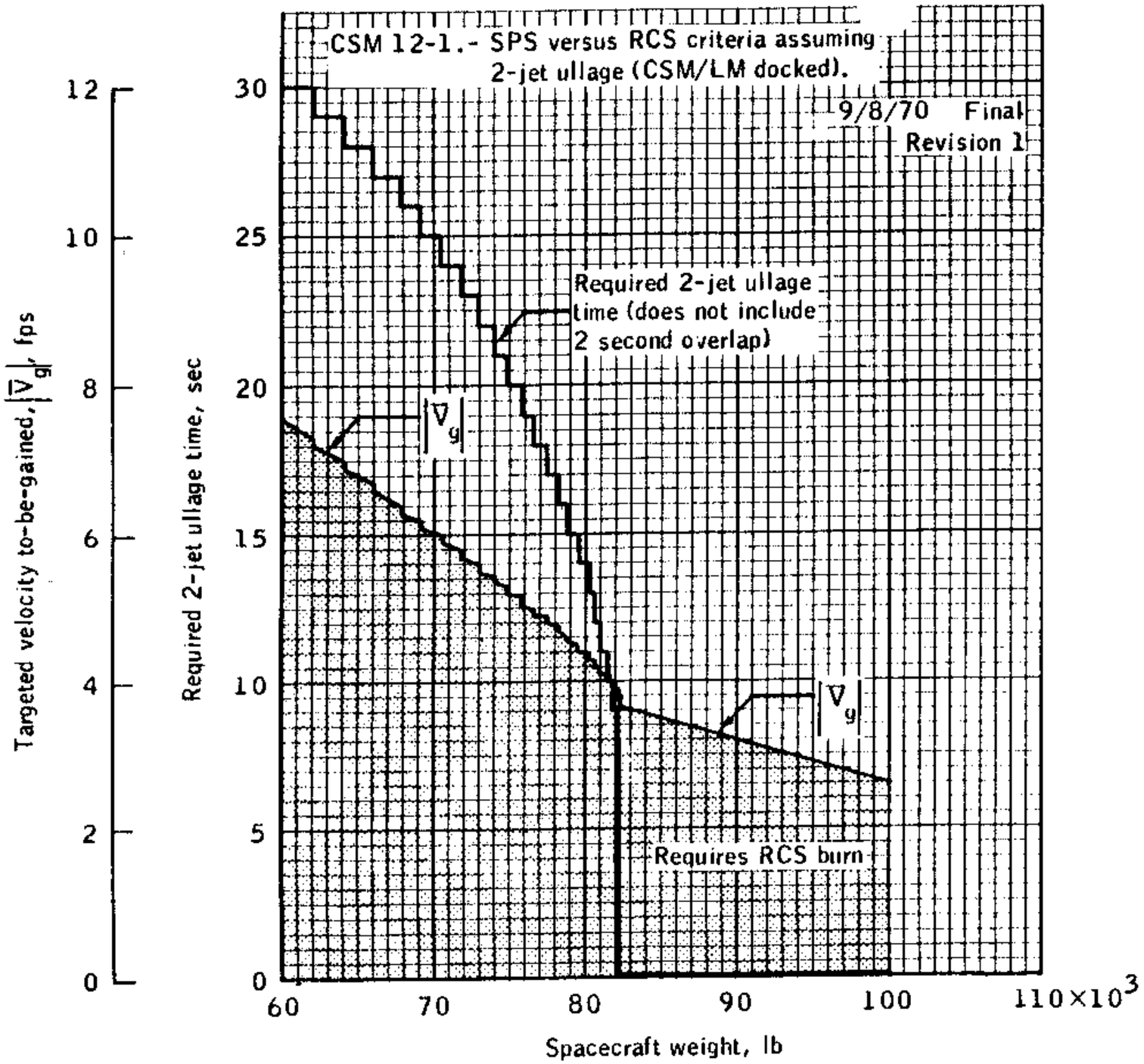
5-7



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

DATE 3/22/71

DATE 3/22/71



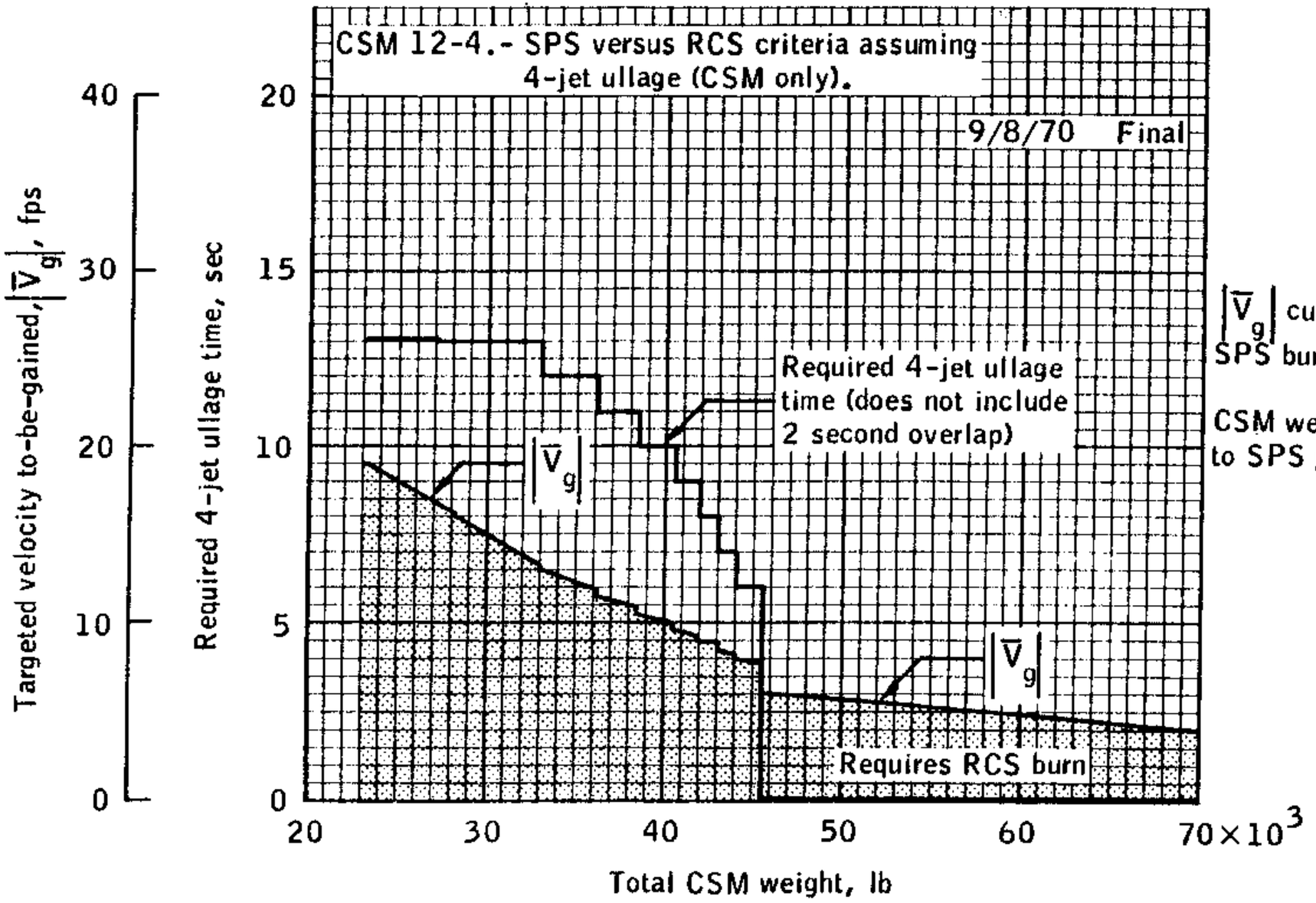
Assumptions

Spacecraft weight assumed to consist of CSM and fully loaded LM

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

CSM weight variations are due to SPS propellant loss only

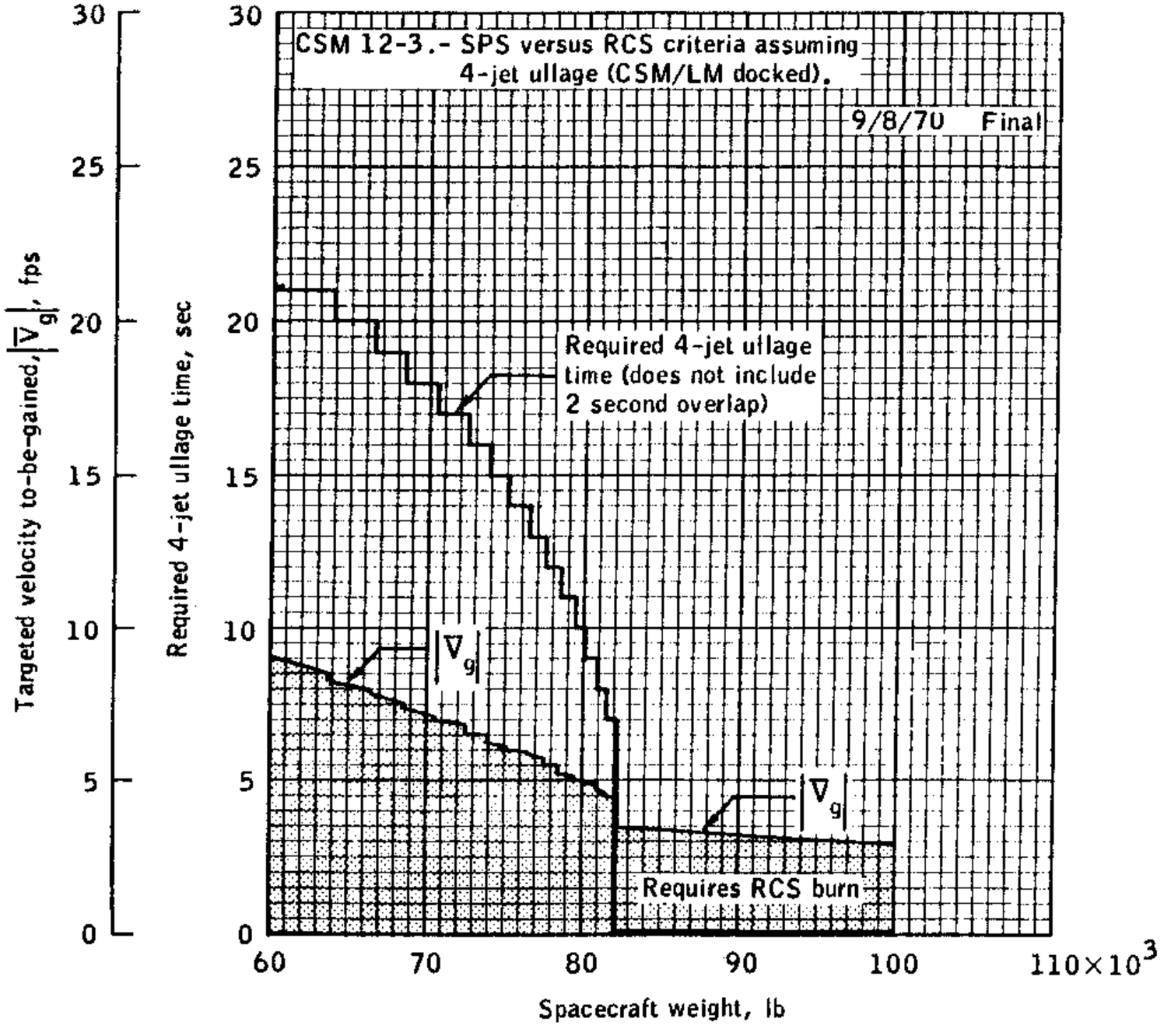
5-9



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

DATE 3/22/71

DATE 3/22/71



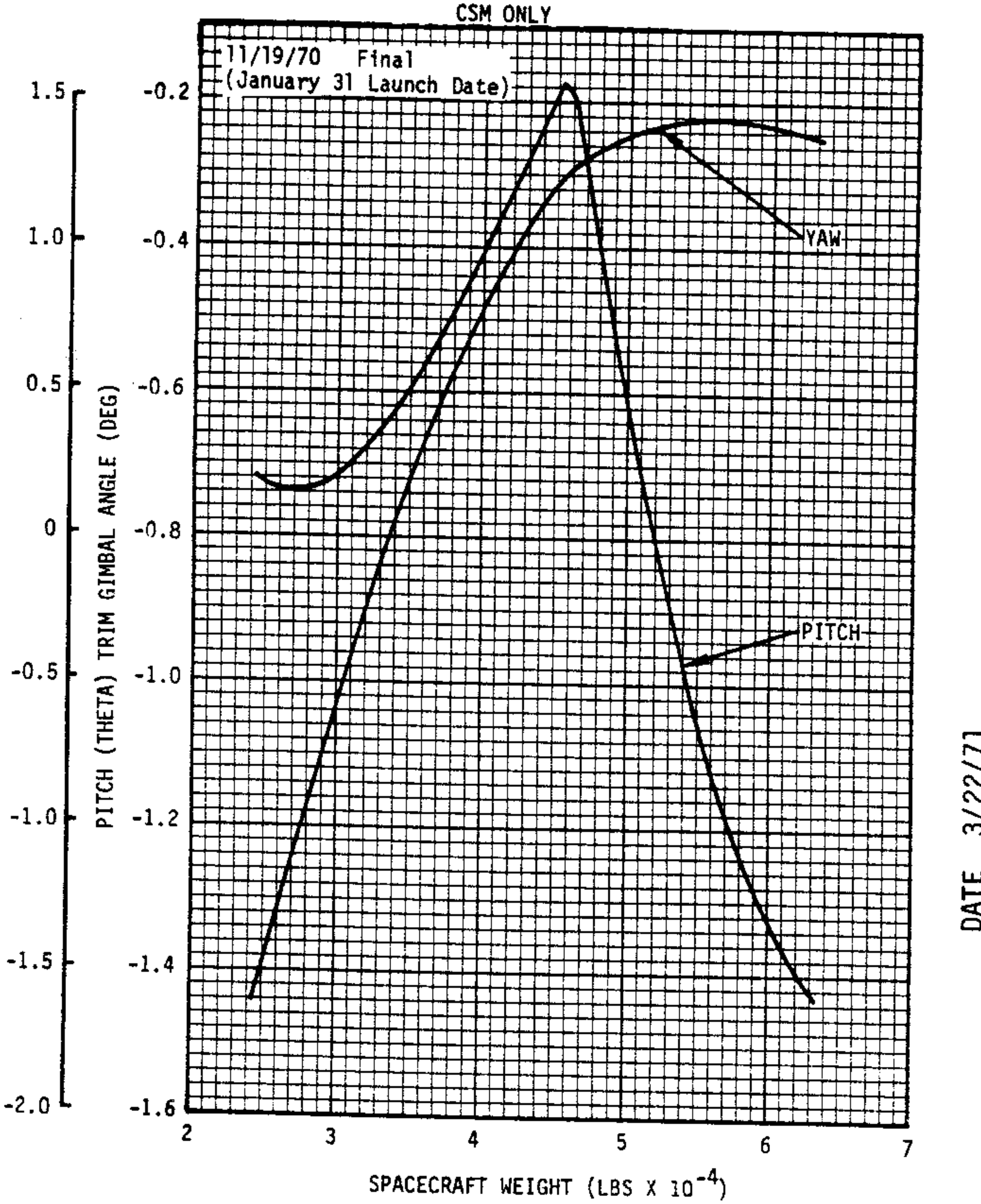
Assumptions

Spacecraft weight assumed to consist of CSM and fully loaded LM

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

CSM weight variations are due to SPS propellant loss only

CSM 14-2 SPS ENGINE TRIM GIMBAL ANGLES VERSUS SPACECRAFT WEIGHT



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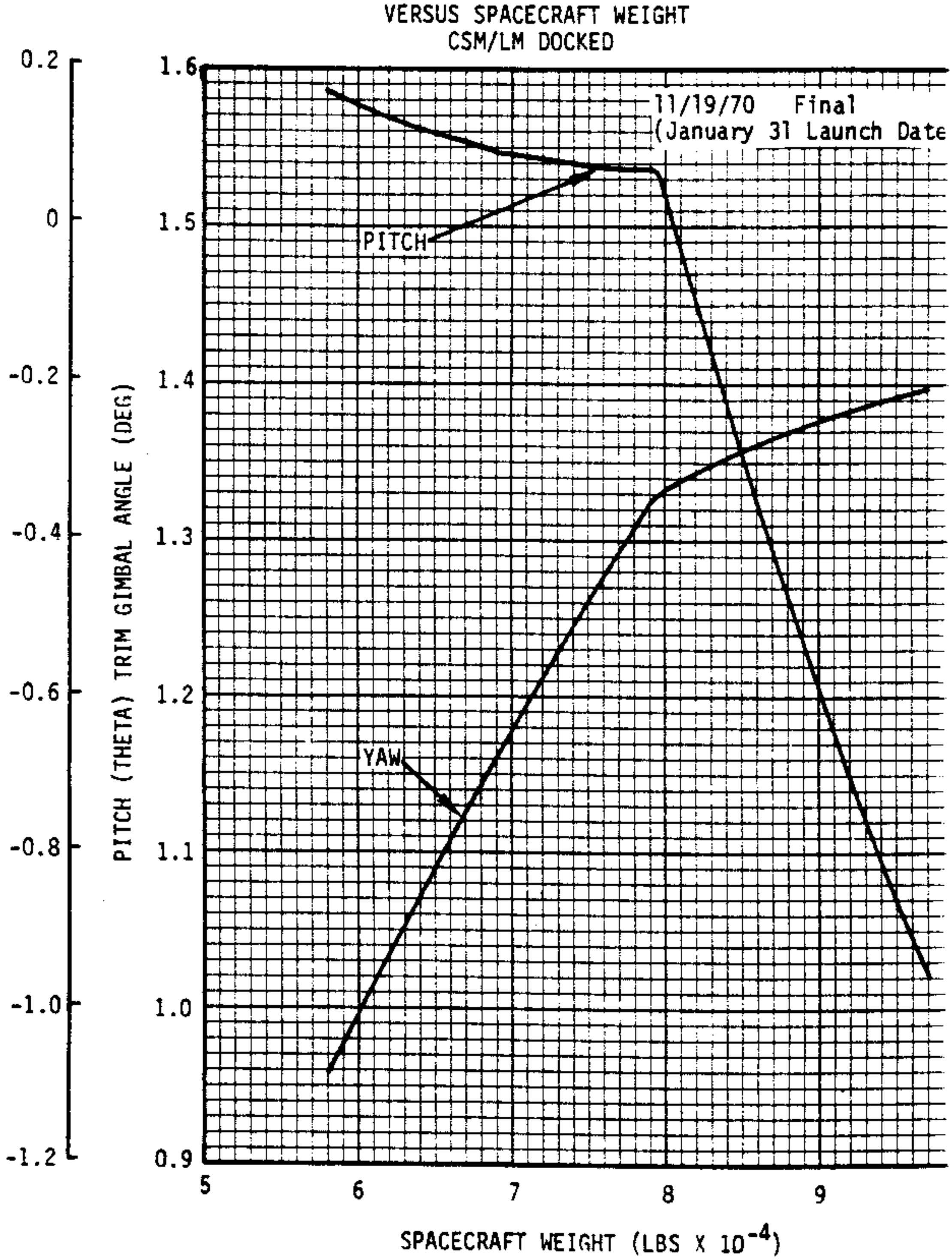
CSM 14-1 SPS ENGINE TRIM GIMBAL ANGLES VERSUS SPACECRAFT WEIGHT

CSM/LM DOCKED



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G&N CRITICAL BURNS

IF NO START OR ISS LITE + PROG LITE
IF CMC LITE, PROG ALARM 1407 OR EARLY CUTOFF

SCS TVC (2) - AUTO
SC CONT - SCS
✓ ATTITUDE
SPS THRUST - DIRECT (momentary), if req'd

IF ABNORMAL DYNAMICS

THC CW, control rates by MTVC
After SHUTDOWN, AUTO RCS (16) - OFF

IF MN BUS A LOST

TVC GMBL DR (P&Y) - 2, Go to pg EMER/1-10

IF NO CUTOFF AFTER ΔV THRUST (BOTH - OFF

cb SPS PILOT VLVS - open

IF EMS & N40 (R3) STILL COUNTING AFTER SHUTDOWN

SC CONT - SCS
TRANS CONT PWR - OFF
cb DIR ULLAGE (2) - open
IF CONDITION PERSISTS, AUTO RCS SEL (16) - OFF
SM RCS PRPLNT (AFFECTED QUAD) - OFF

IF SPS PRESS LITE

CONTINUE CRITICAL BURN
IF FUEL & OX PRESS (both) > 200 psi
  SPS HE vlvs (2) - OFF, then control manually
    between 170-200 psi
IF FUEL/OX ΔP > 20 psi, SPS HE vlvs (2) - OFF
IF CONDITION PERSISTS, SPS HE vlvs (2) - ON

SCS CRITICAL BURN

IF NO START OR EARLY CUTOFF

SPS THRUST - DIRECT (momentary)

IF RATE NEEDLE HARDOVER & FDAIs DIVERGE OPPOSITE

BMAG MODE (3) - RATE 1
THC - CW, use MTVC

IF ABNORMAL DYNAMICS IN AUTO MODE

THC - CW, use MTVC
BMAG MODE (3) - RATE 2

IF ABNORMAL DYNAMICS IN MTVC MODE

THC - CW
IF PROBLEM PERSISTS, SHUTDOWN
AUTO RCS (16) - OFF

IF MN A LOST

TVC GMBL DR (P&Y) - 2
SCS TVC (2) - RATE CMD, use MTVC, Go to pg EMER/1-10

IF MN B LOST

SCS TVC (2) - RATE CMD, use MTVC, Go to pg EMER/1-11

IF AC BUS 1 LOST

TVC SERVO PWR 2 - AC2/MNB
SCS TVC (2) - RATE CMD, use MTVC, Go to pg EMER/1-11

IF AC BUS 2 LOST

TVC SERVO PWR 1 - AC1/MNA
BMAG MODE (3) - RATE 1
SCS TVC (2) - AUTO
ΔV CG - LM/CSM, MTVC w/trim tw's, Go to pg EMER/1-11

P41 RCS THRUSTING

Prethrust Program Complete
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°)

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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 lt *
* 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

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00:00

9 F 16 85 VG X,Y,Z
NULL COMPONENTS
RECORD ΔV COUNTER & RESIDUALS ΔVC_____
EMS FUNC - OFF VGX_____
EMS MODE - STBY VGY_____
RHC & THC - LOCKED VGZ_____
TRANS CONT PWR - OFF
ROT CONTR PWR DIRECT - OFF
BMAG MODE (3) - RATE 2
TAPE RCDR - off (ctr)
PCM BIT RATE - LOW
PRO (IF MINKEY, to sequencer 3X.2)

10 F 37 V82E

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

PRO

12 F 37 00E

13 When COMP ACTY lt out:
V66E (If LM S.V. not needed)

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P47 Thrust Monitor Program

CMC - on
ISS - on & aligned

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

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

(RECYCLE) V32E
(TERM) PRO

2 F 37 00E

P51 IMU ORIENTATION

CMC - on
ISS - on
SCS - operating
BMAG MODE (3) - RATE 2
G/N PWR OPTICS - on
OPT ZERO - OFF then ZERO (15 sec)
OPT MODE - MAN

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 $\underline{<}$ + 00003 SCT $\underline{<}$ + 00011 Star/planet: SXT $\underline{<}$ + 00018 SCT $\underline{<}$ + 00021 (RECYCLE) V32E to 1 (ACCEPT) PRO

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8 F 37 52E - bypass ZERO OPTICS
or XXE
OPT ZERO - ZERO

P52 IMU REALIGN

CMC - on
ISS - on
SCS - operating
BMAG MODE (3) - RATE 2
G/N PWR OPTICS - on
OPT ZERO - OFF then ZERO (15 sec)
OPT MODE - CMC

Note: MINKEY displays not shown

1 V37E 52E
F 04 06 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 lt - on then off - to 7
(TORQUE) CMC MODE - FREE
ENTR

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

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```
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=0

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

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

Star/planet: SXT $\leq$ + 00018
SCT $\underline{\leq}$ + 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
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 V37E 53E
F 50 25 00015 MNVR To ACQ STARS
(BYPASS) (Coarse Align IMU to 0,0,0) - ENTER to 2
PRO to 3

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

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

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```
4     F 53          PLEASE MARK
                    Center Target
                    ENTR

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

6     F 01 71   OOODE 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:  ≤ + 00070
                    Star/planet:  ≤ + 00072
          (RECYCLE) V32E to 1
          (ACCEPT)  PRO

9     F 37          XXE
```

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P54 - BACKUP IMU REALIGN

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

```
1                 V37E 54E
      F 04 06     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 lt - 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)

9 F 06 88 CELESTIAL BODY VECTOR
Load desired vector
PRO

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```
10   F 06 94   ALT LOS OPT ANGS 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=0C

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:  ≤ + 00070
                          Star/planet:  ≤ + 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
```

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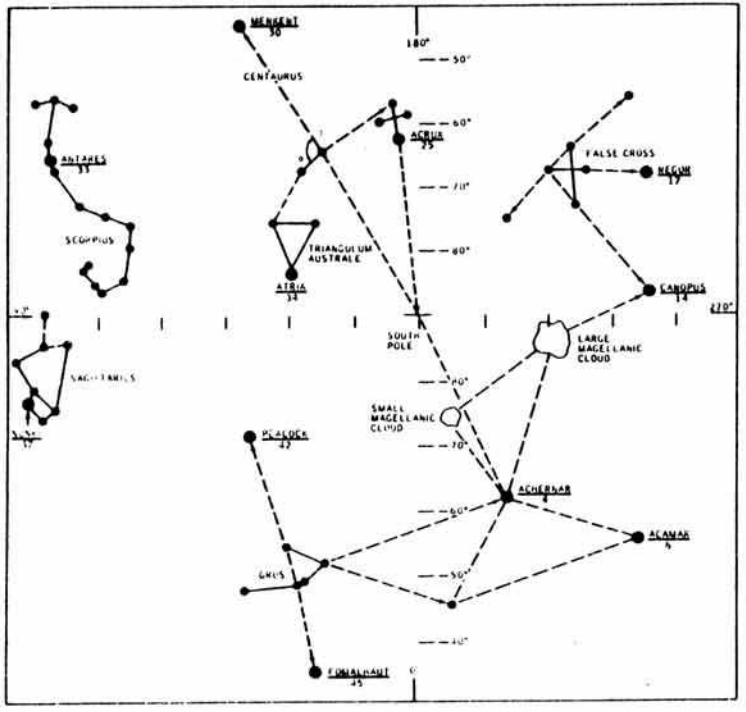
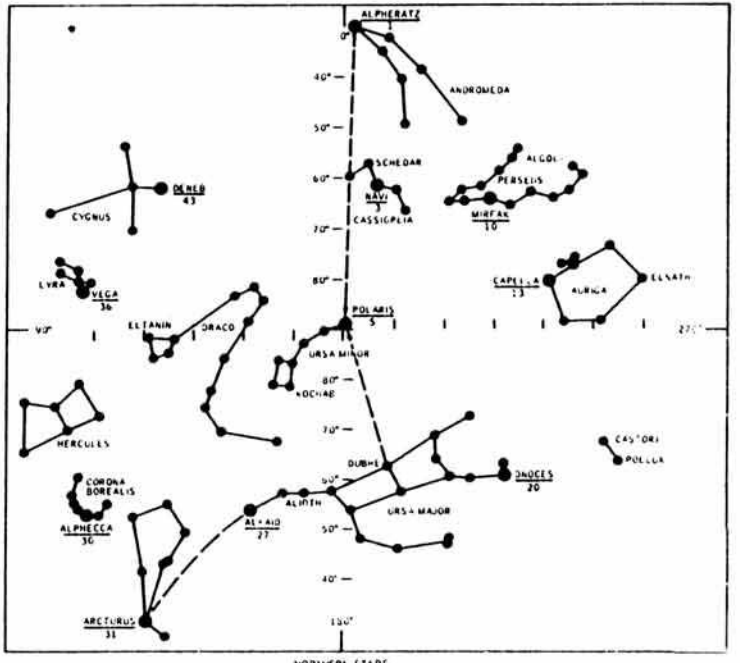


SOUTHERN STARS



NORTHERN STARS

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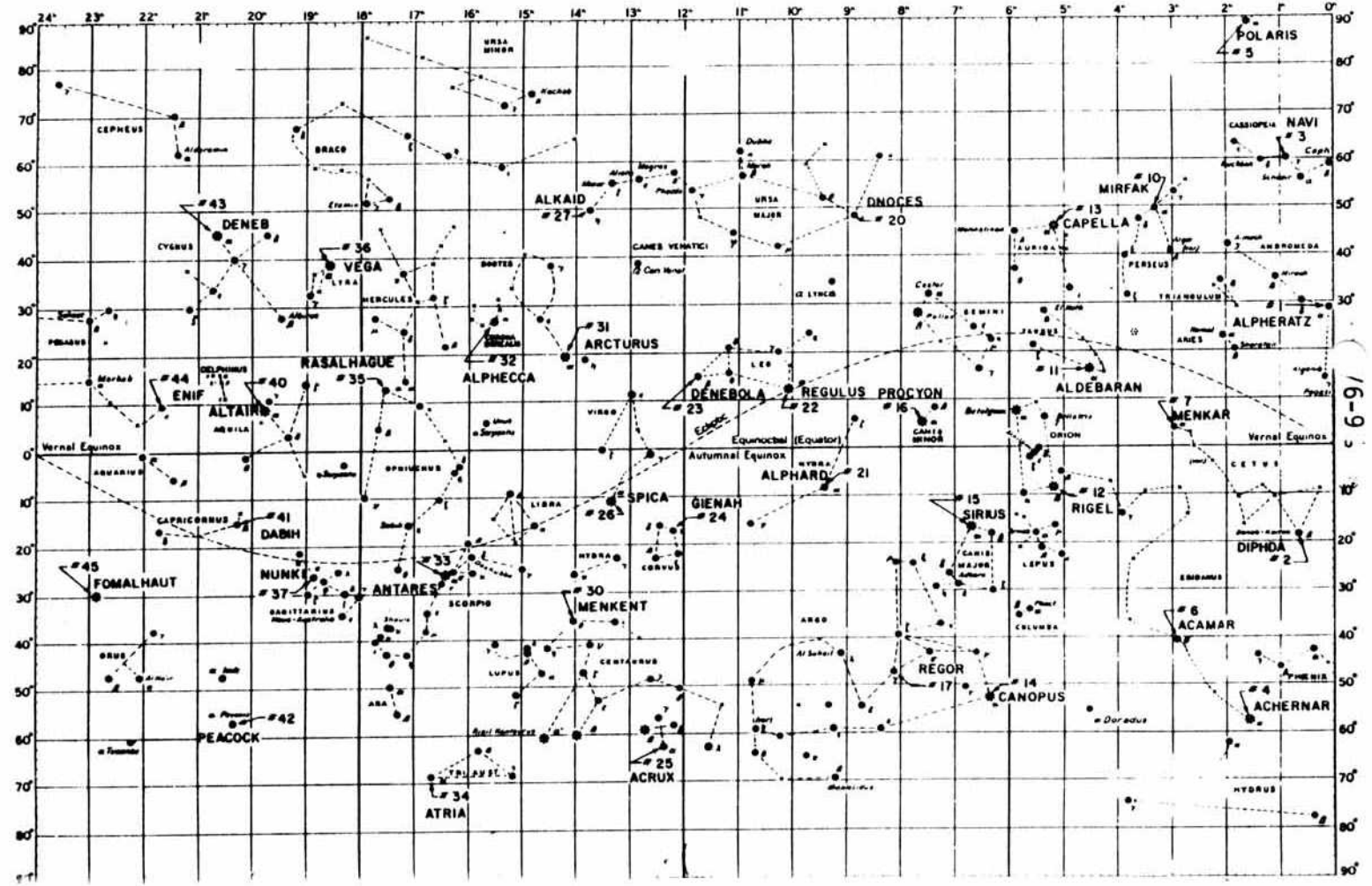
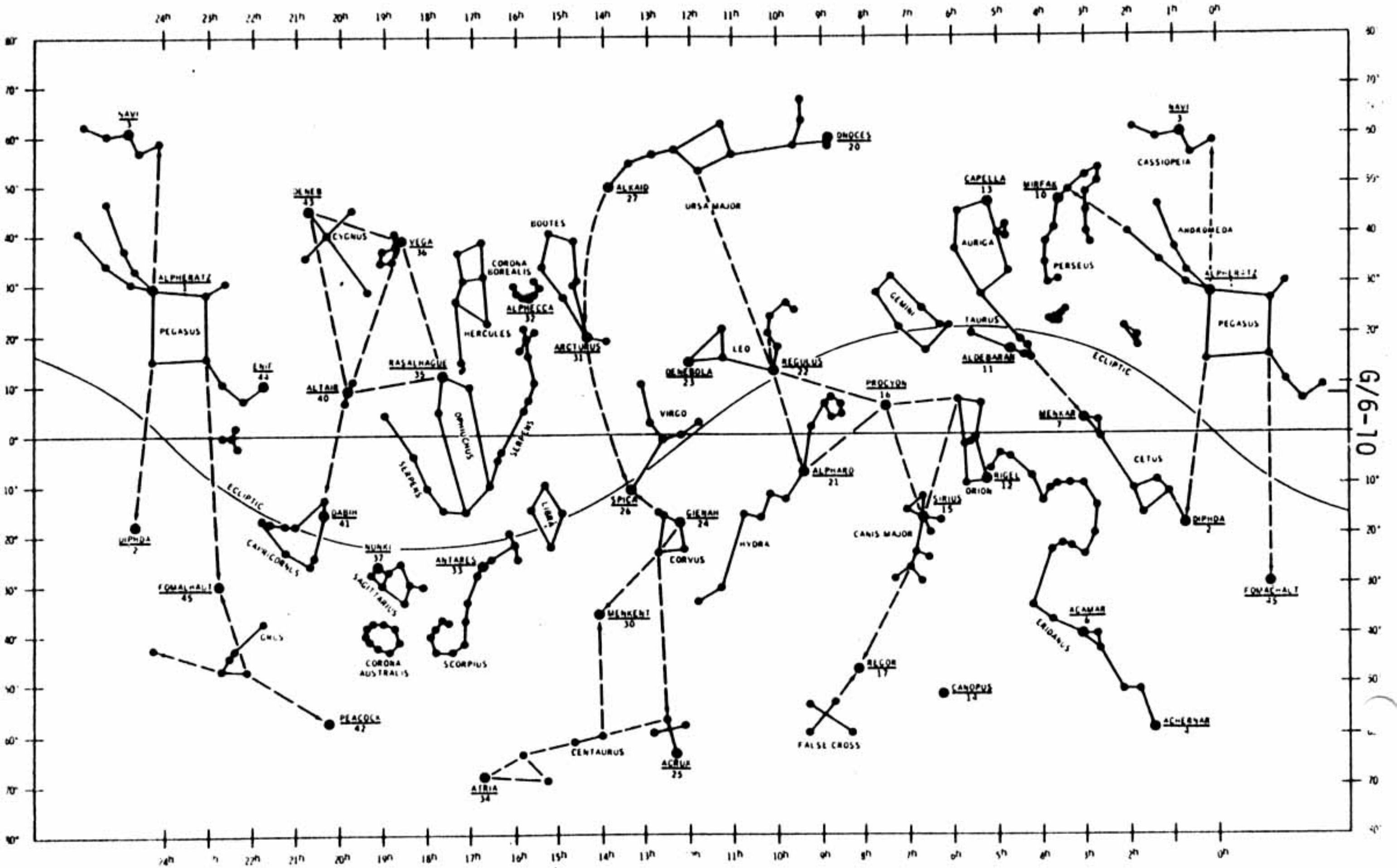

POLARIS
#5
NAVI
#3
MIRFAK
#10
CAPELLA
#13
ALKAID
#27
DNOCES
#20
DENEB
#43
VEGA
#36
ALPHERATZ
#1
ARCTURUS
#31
ALPHECCA
#32
RASALHAGUE
#35
ENIF
#44
ALTAIR
#40
DENEBOLA
#23
REGULUS
#22
PROCYON
#16
ALDEBARAN
#11
MENKAR
#7
ALPHARD
#21
SPICA
#26
GIENAH
#24
SIRIUS
#15
RIGEL
#12
DIPHDA
#2
DABIH
#41
FOMALHAUT
#45
NUNKI
#37
ANTARES
#33
MENKENT
#30
ACAMAR
#6
REGOR
#17
CANOPUS
#14
ACHERNAR
#4
PEACOCK
#42
ACRUX
#25
ATRIA
#34
Vernal Equinox
Autumnal Equinox
Equinoctial (Equator)
Ecliptic
URSA MINOR
URSA MAJOR
CASSIOPEIA
CEPHEUS
BRACO
CYGNUS
LYRA
HERCULES
BOOTES
CANES VENATICI
GEMINI
AURIGA
PERSEUS
ANDROMEDA
TRIANGULUM
ARIES
TAURUS
ORION
CETUS
ERIDANUS
LEPUS
COLUMBA
CANIS MAJOR
CANIS MINOR
HYDRA
CORVUS
VIRGO
LIBRA
SCORPIO
OPHIUCHUS
SAGITTARIUS
CAPRICORNUS
AQUARIUS
AQUILA
DELPHINUS
PEGASUS
CENTAURUS
LUPUS
ARA
ARGO
CARINA
PUPPIS
PHOENICIA
HYDRUS
DORADUS
1969



24h 23h 22h 21h 20h 19h 18h 17h 16h 15h 14h 13h 12h 11h 10h 9h 8h 7h 6h 5h 4h 3h 2h 1h 0h
80° 70° 60° 50° 40° 30° 20° 10° 0° 10° 20° 30° 40° 50° 60° 70° 80°
NAVI 3
ALPHERATZ 1
PEGASUS
ENIF 44
DENEB 43
CYGNUS
VEGA 36
ALTAIR 40
RASALHAGUE 35
OPHIUCHUS
SERPENS
HERCULES
CORONA BOREALIS
ALPHECCA 32
BOOTES
ARCTURUS 31
ALKAID 27
URSA MAJOR
DNOCES 20
DENEBOLA 23
LEO
REGULUS 22
VIRGO
SPICA 26
GIENAH 24
CORVUS
HYDRA
ALPHARD 21
PROCYON 16
GEMINI
CAPELLA 13
AURIGA
MIRFAK 10
PERSEUS
CASSIOPEIA
ANDROMEDA
TAURUS
ALDEBARAN 11
ECLIPTIC
MENKAR 7
CETUS
ORION
RIGEL 12
SIRIUS 15
CANIS MAJOR
DIPHDA 2
FOMACHALT 45
ACAMAR 6
ERIDANUS
ACHERNAR
CANOPUS 14
REGOR 17
FALSE CROSS
ACRUX 25
CENTAURUS
MENKENT 30
ATRIA 34
LIBRA
ANTARES 33
SCORPIUS
NUNKI 37
SAGITTARIUS
CORONA AUSTRALIS
DABIH 41
CAPRICORNUS
FOMALHAUT 45
GRUS
PEACOCK 42

G/6-10

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)

3 F 06 34 GET ALIGN

	Present Pitch	ΔVy	R1
Load R1:	0 ± 90°	±	RLS LAT ±35°
	180 ± 90°	±	RLS LAT ∓35°

5 F 06 22 NEW ICDU ANGLES

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

16 20 UNTIL TORQUING COMPLETE

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

P30

P40

YAW BACK TO 0° (MANUALLY)

V37E 52E

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

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

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

F 06 22 NEW ICDU ANGLES

F 50 25 R1=00013
CMC MODE-FREE
ENTR TO START TORQUING

16 20 UNTIL TORQUING COMPLETE

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 o 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

4 Mnvr to position stars in SCT
0° mark - Vega (36)
R line - Deneb (43)

or

	NORTH		SOUTH	
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 V37E 52E
F 04 06 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

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

6 V37E XXE

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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 PRO	(hrs,min,.01sec)
4	F 16 44	HA, HP Calculate Average ALT SET - Set Average PRO	(.1nm,.1nm)
5		V83E	
	F 16 54	R,RDOT,THETA MODE - HOLD/FAST SLEW - To THETA MODE - OPR/SLOW PRO	(.01nm,.1fps,.01°)

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

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LUNAR		EARTH	
Alt(nm)	Angle*	Alt(nm)	Angle*
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
G/N PWR OPTICS - on
OPT MODE - CMC
OPT ZERO - OFF then ZERO (15 sec)

1		V37E 52E	
2	F 04 06	00003 PRO	
3	F 50 25	00015 ENTR	
4	F 01 70	000DE STAR CODE LOAD BORESIGHT STAR CODE OPT ZERO - OFF PRO	
5	06 92	SHAFT, TRUN	(.01°,.001°)
		Center target MARK with VERB key Record SHAFT, TRUN ____,____	
(REPEAT)		KEY RLSE	
(EXIT)		V37E XXE OPT ZERO - ZERO	

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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°
LM (OGA)y = 300° -R20 + Δ∅
LM (MGA)r = 360° -Y20

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° + ΔØ
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

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° + $\Delta\phi$ - LM (OGA)y
P = LM (IGA)p - 180°
Y = 360° - 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° + $\Delta\phi$
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

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° + $\Delta\phi$ - LM (OGA)y
CM (IGA) = LM (IGA)p - 180°
CM (MGA) = 360° - 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 (pg. 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° + Δ∅
R2 = 180°
R3 = 0°

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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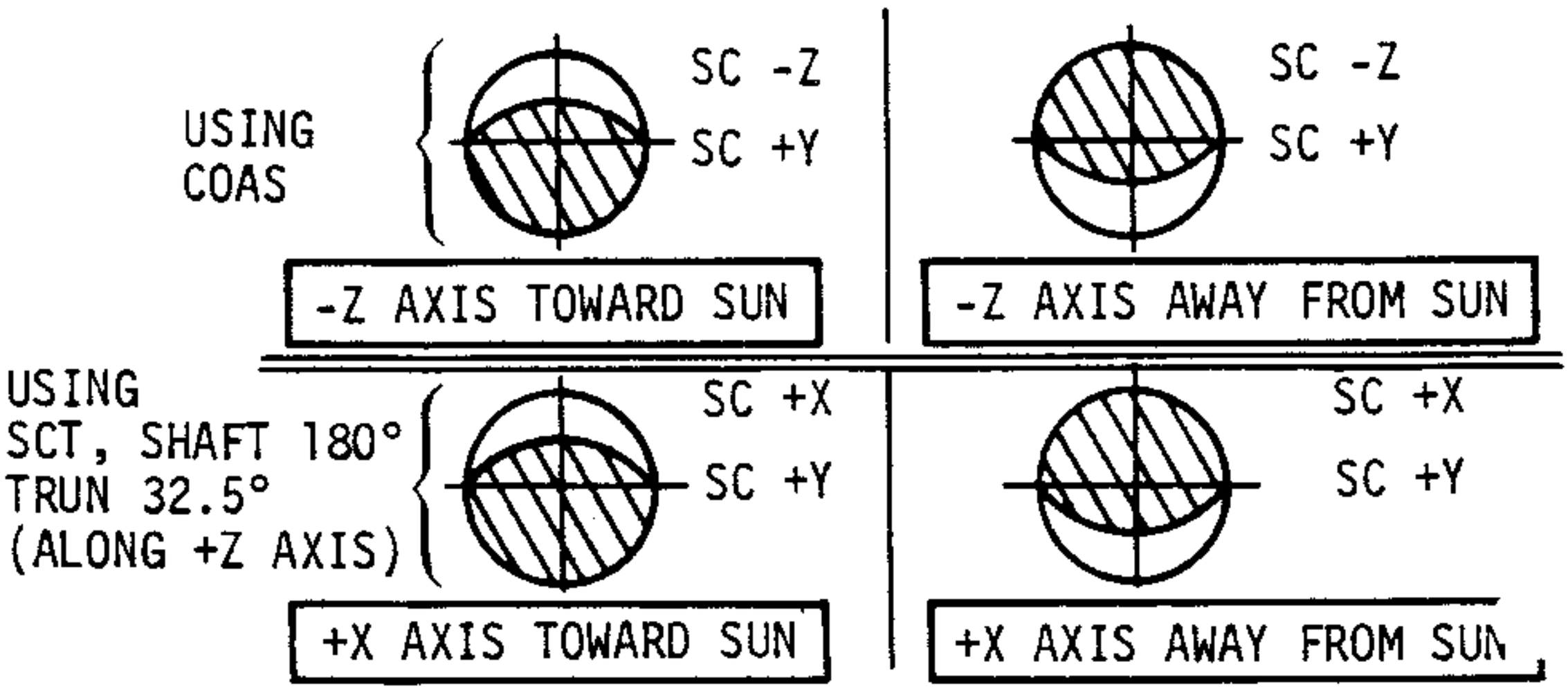
CRESCENT ALIGN

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.



MSFN will provide -Z or +X axis direction

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

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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
G/N PWR OPTICS - on
OPT ZERO - OFF THEN ZERO (15 se
OPT MODE - MAN

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

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)

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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 1
(ACCEPT) PRO

10 F 37 XXE
OPT ZERO - ZERO
CMC has now calculated
a REFSMMAT for the GDC,
has set REFSMFLG and
DRIFTFLG.

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GDC REFSMMAT REALIGN (P52)

GDC - on and REFSMMAT Known (pg G/7-13)
CMC - on
SCS - operating
IMU - off
G/N PWR OPTICS - on
OPT ZERO - OFF THEN ZERO (15 sec.)
OPT MODE - MAN

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 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
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 lt-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		PLEASE MARK
	(If required)		V25N20E
			Load present GDC angles
			Null FDAI needles with min imp, then:
			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)
14	F 06 88		CELESTIAL BODY VECTOR
			Load vector
			PRO to 8 after 1st MARK
			to 15 after 2nd MARK

15	F 06 05	STAR ANGLE DIFFERENCE (Expect < .1°, if not V32E to 17) (Accept) PRO	(.01°)
16	F 06 93	TORQUING ANGLES OG,IG,MG N93 is indicative of BMAG drift since last alignment If torque angles excessive perform P51 Otherwise: OPT ZERO - ZERO G/N PWR OPTICS - OFF V37EXXE - procedure complete	(.001°)
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)

P20 Opt 2 (PTC/Orb rate)

1		V37E 20E
	F 04 06	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

PASSIVE THERMAL CONTROL (G&N)

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

1			V48E (Select 0.5° DB)
		CHANGE PROG TO "00"	V37E 00E
		MANEUVER REQ	V49E
2	F 06 22	Load PTC Attitude (ALLOWS LOAD?)	R - Present P - 90° (TLC) or 270° Y - 0° (TEC)
		DISP DEC ANGLES	PRO
3	F 50 18		BMAG MODE (3) - RATE 2
		PLEASE PERFORM AUTO MANEUVER	SC CONT - CMC CMC MODE - AUTO PRO
		DISP AUTO MANEU	
4	06 18		AUTO MANEUVER
	F 50 18		
		PLEASE PERF	
5		AUTO MANEU	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
7			Disable RCS and Term. P20 AUTO RCS SEL (16) - OFF ROT CONTR PWR DIR (2) - OFF (verify) V56E

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To exit G&N PTC to new att:

1. MAN ATT (3) - ACCEL CMD
   AUTO RCS SEL (12) - MNA/B
2. Verify DAP load
3. Select new desired att:
   V37E00E
   V49E
   F 06 22 New ICDU angles
   PRO
   F 50 18
4. Start auto manevuer:
   PRO within 180° (in direction of roll)
   of new att
   MAN ATT (3)-RATE CMD

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

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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

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 REFSMMAT)
V1N1E 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)

V1N1E
XXXXE (LOAD OID 2 OF UPDATE)
N15E, READ R1, E REPEAT FOR UPDATES A-L

FOR UPDATE M

V1N1E
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
	V71	V71	V71	V71	V71	V71	V71
01	00021	00013	00012	00015	00023	00023	00024
02	01452	01706	01346	01765	02000	02021	02042
03	77143	00006	00005	00001	00137	00001	00001
04	71737	33304	06510	27404	00763	03120	33443
05	00110	07000	07025	00000	00023	00001	00003
06	67635	00000	00620	15514	00001	03120	02115
07	76745	17356	00000	00542	00000	00311	77775
10	72727	00000	33260	02210	00000	31727	70001
11	00477	22764	37723	36321	00471	77700	77777
12	77115	37777	01163	12160	00364	60177	40174
13	00314	37777		03363	04400	77762	77774
14	00000			00233	77772	55276	62760

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OID	A	B	C	D	E	F	G
	V71	V71	V71	V71	V71	V71	V71
15	77640			00502	53647	00007	00004
16	01371				00002	04312	36300
17	00023				12573	07147	00002
20	00071				00001	77775	15226
21	77706				35676	77411	00077
22					00002	00003	03412
23					27310	31036	77754
24							75526

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QID	H	I	J	K	L	M	S.V.
	V71	V71	V71	V71	V71	V72	V71
01	00024	00024	00022	00023	00021	00017	
02	02064	02106	02130	03000	03025	00736	
03	77771	01077	02375	00436	37777	37777	
04	72235	27652	04715	02732	00000	01477	
05	77461	02631	14650	00000	00000	00000	
06	70714	37371	12113	00000	54360	02377	
07	77510	70643	65411	77777	21075	00142	
10	61414	71747	72642	77777	37777	03021	
11	77622	74315	73351	42757	60465	01000	
12	70025	55007	43037	10510	00000	03022	
13	76777	66437	14427	06477	54360	00232	
14	71317	70077	13747	74470	21075	03376	

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QID	H	I	J	K	L	M	S.V.
	V71	V71	V71	V71	V71	V72	V71
15	01363	75440	14732	01605	37777	00000	
16	04371	54216	02326	00105	57142	03377	
17	00555	76105	05465	00123	33106	00000	
20	13342	73515	20402	00175	50741		
21	04303	76002	00545	17433	31162		
22	36426	71056	36577	04500			
23	01477	04770		00334			
24	27000	07136					

Apollo 14

LM OR CSM S.V. READOUT

1 V83E

2 After Integration: V05N01E

CSM S.V.		LM S.V.	
2253E		2223E	
E,2256E		E,2226E	
E,2261E		E,2237E	
E,2264E		E,2242E	
E,2333E		E,2333E	
PRO		PRO	

3 Transmit S.V. & Time Tag
To LM

LM OR CSM S.V. LOADING

V37E00E
V71E
21E
1501E
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

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CSM 6-1.- Venus unit vectors.

9/8/70 Final

0 HR GET = 1:31:20:20 GMT
LO = 1:31:__:__

TIME (GET) HOURS	VENUS UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
.0	-.08900	-.93419	-.34550
4.0	-.08591	-.93439	-.34575
8.0	-.08282	-.93457	-.34600
12.0	-.07973	-.93475	-.34624
16.0	-.07664	-.93492	-.34648
20.0	-.07355	-.93508	-.34672
24.0	-.07046	-.93523	-.34695
28.0	-.06737	-.93537	-.34718
32.0	-.06428	-.93551	-.34741
36.0	-.06118	-.93563	-.34764
40.0	-.05809	-.93574	-.34786
44.0	-.05499	-.93585	-.34808
48.0	-.05189	-.93595	-.34830
52.0	-.04879	-.93603	-.34851
56.0	-.04569	-.93611	-.34872
60.0	-.04259	-.93618	-.34893
64.0	-.03948	-.93624	-.34914
68.0	-.03638	-.93629	-.34934
72.0	-.03327	-.93633	-.34954
76.0	-.03016	-.93636	-.34974
80.0	-.02705	-.93639	-.34993
84.0	-.02394	-.93640	-.35012
88.0	-.02083	-.93640	-.35031
92.0	-.01771	-.93640	-.35049
96.0	-.01459	-.93638	-.35067
100.0	-.01148	-.93636	-.35085
104.0	-.00836	-.93633	-.35103
108.0	-.00524	-.93629	-.35120
112.0	-.00211	-.93623	-.35137
116.0	.00101	-.93617	-.35153
120.0	.00414	-.93610	-.35170
124.0	.00727	-.93603	-.35186
128.0	.01040	-.93594	-.35201
132.0	.01353	-.93584	-.35217
136.0	.01667	-.93573	-.35232
140.0	.01980	-.93562	-.35246

CSM 6-1.- Concluded.

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0 HR GET = 1:31:20:20 GMT
LO = 1:31:__:__

TIME (GET) HOURS	VENUS UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
144.0	.02294	-.93549	-.35261
148.0	.02608	-.93536	-.35275
152.0	.02922	-.93521	-.35288
156.0	.03237	-.93506	-.35302
160.0	.03551	-.93489	-.35315
164.0	.03866	-.93472	-.35327
168.0	.04181	-.93454	-.35340
172.0	.04496	-.93435	-.35352
176.0	.04812	-.93415	-.35363
180.0	.05128	-.93393	-.35375
184.0	.05443	-.93371	-.35386
188.0	.05759	-.93348	-.35396
192.0	.06076	-.93325	-.35406
196.0	.06392	-.93300	-.35416
200.0	.06709	-.93274	-.35426
204.0	.07026	-.93247	-.35435
208.0	.07343	-.93219	-.35444
212.0	.07660	-.93190	-.35452

TIME (GET) HOURS	VENUS UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
216.0	.07978	-.93161	-.35460
220.0	.08295	-.93130	-.35468
224.0	.08613	-.93098	-.35475
228.0	.08932	-.93066	-.35482
232.0	.09250	-.93032	-.35489
236.0	.09568	-.92998	-.35495
240.0	.09887	-.92962	-.35501
244.0	.10206	-.92925	-.35506

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CSM 6-2.- Mars, Jupiter, Saturn unit vectors.

0 HR GET = 1:31:20:20 GMT
LO = 1:31:__:__

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TIME (GET) HOURS	MARS UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
.0	-.41404	-.83881	-.35351
10.0	-.40993	-.84048	-.35432
20.0	-.40582	-.84214	-.35512
30.0	-.40170	-.84378	-.35592
40.0	-.39758	-.84540	-.35671
50.0	-.39345	-.84699	-.35749
60.0	-.38932	-.84857	-.35826
70.0	-.38518	-.85014	-.35903
80.0	-.38104	-.85168	-.35979
90.0	-.37689	-.85320	-.36055
100.0	-.37274	-.85471	-.36129
110.0	-.36858	-.85620	-.36203
120.0	-.36441	-.85767	-.36277
130.0	-.36023	-.85913	-.36350
140.0	-.35605	-.86057	-.36422
150.0	-.35186	-.86199	-.36494
160.0	-.34765	-.86339	-.36565
170.0	-.34344	-.86477	-.36635
180.0	-.33922	-.86614	-.36705
190.0	-.33499	-.86750	-.36774
200.0	-.33075	-.86883	-.36842
210.0	-.32650	-.87015	-.36910
220.0	-.32224	-.87145	-.36977
230.0	-.31797	-.87274	-.37044
240.0	-.31369	-.87401	-.37109
250.0	-.30940	-.87526	-.37175

TIME (GET) HOURS	JUPITER UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
.0	-.45824	-.82167	-.33894
50.0	-.45392	-.82372	-.33978
100.0	-.44974	-.82568	-.34057
150.0	-.44570	-.82755	-.34134
200.0	-.44178	-.82935	-.34207
250.0	-.43797	-.83107	-.34278

TIME (GET) HOURS	SATURN UNIT VECTOR (LAUNCH JAN 31,1971 20.0HR GMT) X(R1)	Y(R2)	Z(R3)
.0	.69562	.67354	.24992
100.0	.69393	.67492	.25091

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