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		

PRETHRUST
(P30's & 70's)

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MINKEY SEQUENCER

PRETHRUST (P30's & 70's)

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

31.2 Perform P76

31.3 Go to P32, step 2

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

32.2 Perform P76

32.3 R1 of N55 (P32) < 4, Go to P36, step 2
= 4, Go to P31, step 2
> 4, Go to P32, step 2

36.1 If ΔV mag. = 0, go to 36.2

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

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

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

(BYPASS) ENTR
Perform P41 (step 4)

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36.2 Perform P76

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

36.4 If desired: Manually MNVR back to original GDC att.
If all gimbal angle changes for mnvr back to rend. att < 10°, go to 36.5

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

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

36.5 52 in MM lights

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

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

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

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

33.2 Perform P76

33.3 Go to P34, step 2

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

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P31 HAM PRETHRUST

1		V37E 31E (If no REFSMFLG, To 3)
	F 50 25 (ACCEPT) (REJECT)	00017 MINKEY OPTION PRO 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 N_π from CSI, load non-zero in R3) Load data PRO
5	F 06 37	TIG (TPI) (hrs,min,.01sec) Load data PRO
6	F 06 33	TIG (HAM) (hrs,min,.01sec) PRO

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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 $N\pi$ from CSI, load non-zero in R3)
Load data
PRO

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

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

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

7	F 06 75	ΔH(CDH),ΔT(CDH-CSI),ΔT(TPI-CDH) PRO (.1nm,min-sec)
8	F 06 90	Y(Active), YDOT(Active), YDOT (Passive) (.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 When MNVR complete: MINKEY to 3 non-MINKEY to 2	(.01°)
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)
P32(72) COMPLETE

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

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

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

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

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

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

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

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

11 F 37
P74 - Transmit Mnvr Parameters To LM

P35 TPM PRETHRUST (P75 LM)
P34(74) COMPLETE
1 V37E (35E or 75E)
(If no REFSMFLG or P75, to 3)
F 50 25 00017 MINKEY OPTION
(ACCEPT) PRO
(REJECT) ENTR

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

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

3 F 16 45 MARKS,TFI,-00001 (marks,min-sec)
(RECYCLE) V32E
(FINAL PASS) TERM MARKS
PRO

4 F 06 81 ΔV XYZ(LV)TPM (.1fps)
PRO (If recycle - to 3)

5 F 16 45 MARKS,TFI,MGA (marks,min-sec,.01°)
(MGA SET TO -00002 IF NO
REFSMFLG or If P75)
PRO (If MINKEY, to Sequencer 35.1)

6 F 37
P75 - Transmit Mnvr Parameters To LM

To change ATIGINC:
V24N1E
2021E

6 min: 00002E
06240E

10 min: 00003E
25140E

3 min: 00001E
03120E

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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

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

Perform the following once:
V1N1E
3012E
Verify R1 = 01470 (1087 nm)

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

2 F 06 60 BLANK,ΔV DESIRED, GAMMA EI DESIRED
(fps,.01°)
Load desired ΔV:
PAD ΔV IF ON TLC
0. IF ON TEC
Load R3=0 (Good if VEI > 31 K fps)
PRO

DATE 3/15/72

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

3 INITIAL CONIC SOLN

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

If Impact LONG>12° from desired:

TEC:N40E Record R2 as ΔVmin (fps) TLC: V32E to 1

V32E to 1 & use |ΔV| >ΔV min Decrease ΔV to

Load ΔV neg to move LONG WEST move LONG WEST

Load ΔV pos to move LONG EAST Increase ΔV to move LONG EAST

Continue recycles til <12° from desired LONG

If Impact LONG <12° from desired:

Record Impact LONG as θcl (.01°)

Record last ΔV DESIRED as ΔVinl (fps)

PRO

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

PRO

(RECYCLE) V32E To 1

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

PRO

(RECYCLE) V32E To 1

6 F 06 81 ΔV XYZ(LV) at TIG

Record R3 as ΔVzcl (.1fps)

N40E

Record R2 as ΔVcl (.1fps)

Make sign of ΔVcl same as ΔVinl

KEY RLSE

PRO

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

      INITIAL PRECISION SOLN
7     F 06 61   IMPACT LAT,IMPACT LONG            (.01°)
                Record LONG as 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
      LONG. ITERATION
11    F 06 33   TIG                    (hrs,min,.01sec)
                Load same value used initially
                PRO

12    F 06 60   BLANK,ΔV DESIRED, GAMMA EI DESIRED
                To move WEST from 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 (fps)
                PRO
                    *F 05 09    SAME AS IN 2*
                    *V32E.  RSET to 11      *
```

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

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

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

Compute $\Delta\theta$ LONG = $\theta d - \theta p1$ (.01°)
Obtain from chart ΔVo (fps)
Make sign of ΔVo same as $\Delta\theta$ LONG
Compute ΔVd:
If TLC and $\Delta Vzp1 > 3\Delta Vxp1$:
$\Delta Vd = \Delta Vc1 + \Delta Vo$
V32E to step 1 and use
ΔVd in R2 of N60
Otherwise:
$\Delta Vzd = \Delta Vzp1 + \Delta Vo$

14 $\Delta Vd = (\Delta Vzd^2 + \Delta Vxp1^2)^{1/2}$
To solve for ΔVd:
V37E 30E, Use present time in N33.
Load N81:
R1 = $\Delta Vxp1$
R2 = 0 (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

FINAL SOLN

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

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

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

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

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

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

21 F 37 (40E or 41E)

OBTAIN ENTRY REFSMMAT (No Comm)
(Use only after final MCC)
1. Record 400K time from final P37
solution.
(Input TIG + FNL N39)
2. Use 400K time for T-align P52
(Option 2).
If PROG ALARM 401, Yaw 45°
* and V32E *

DATE 3/15/72

P76 - ΔV UPDATE (P77 CSM)

1		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		

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P37 LONGITUDE ITERATION

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

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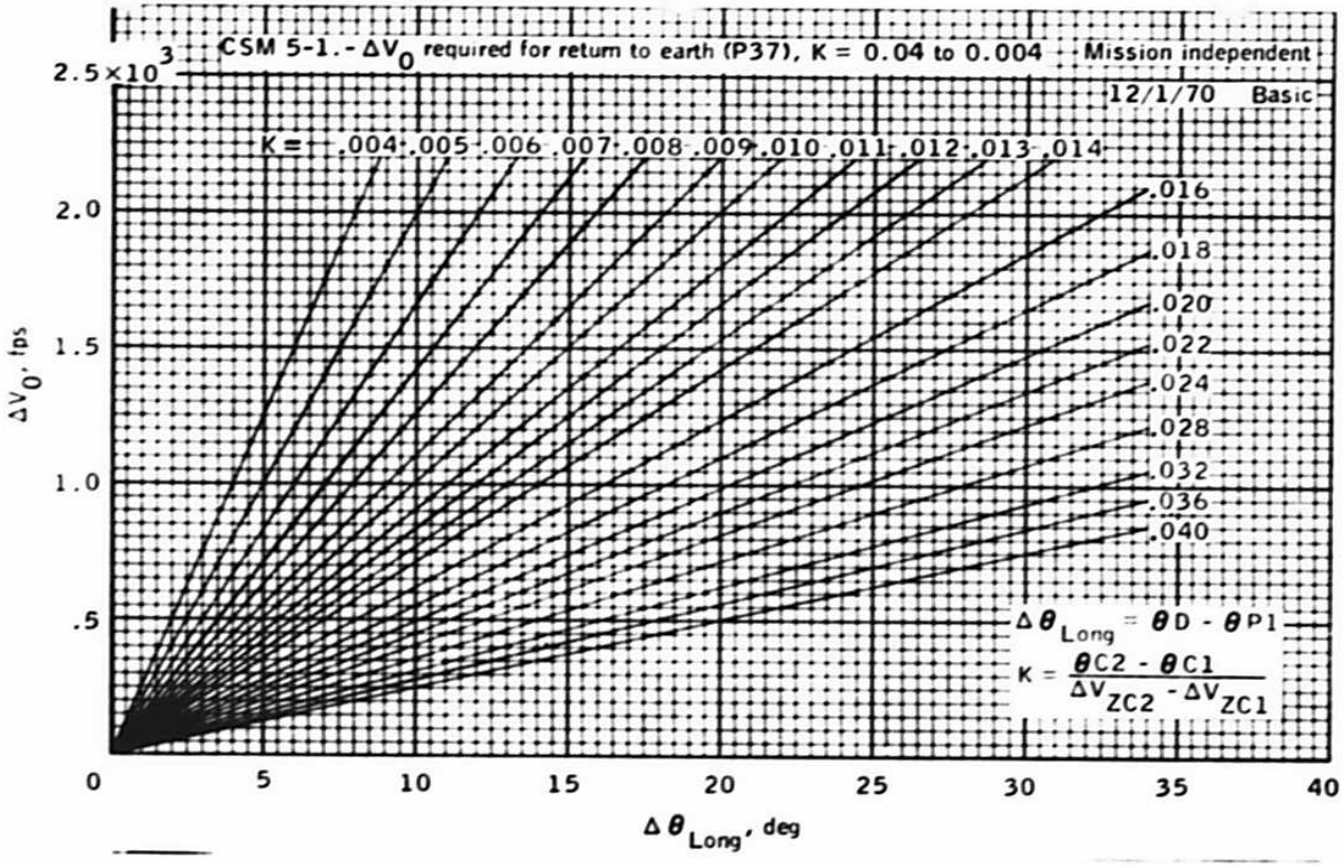
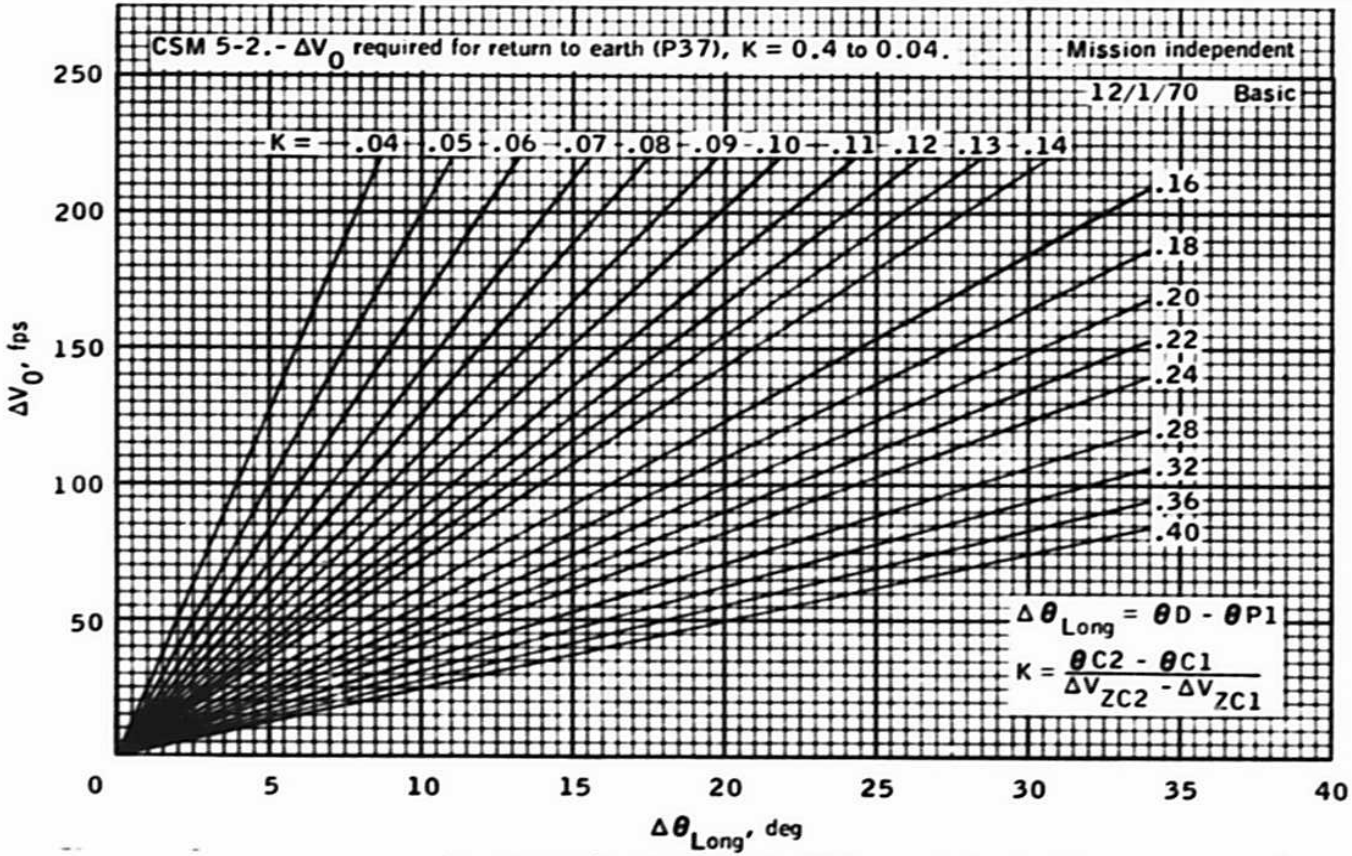


ΔV_0 required for return to earth (P37), K = 0.04 to 0.004.

ΔV_0 vs $\Delta\theta$ LONG

ΔV_0 vs $\Delta\theta$ LONG



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

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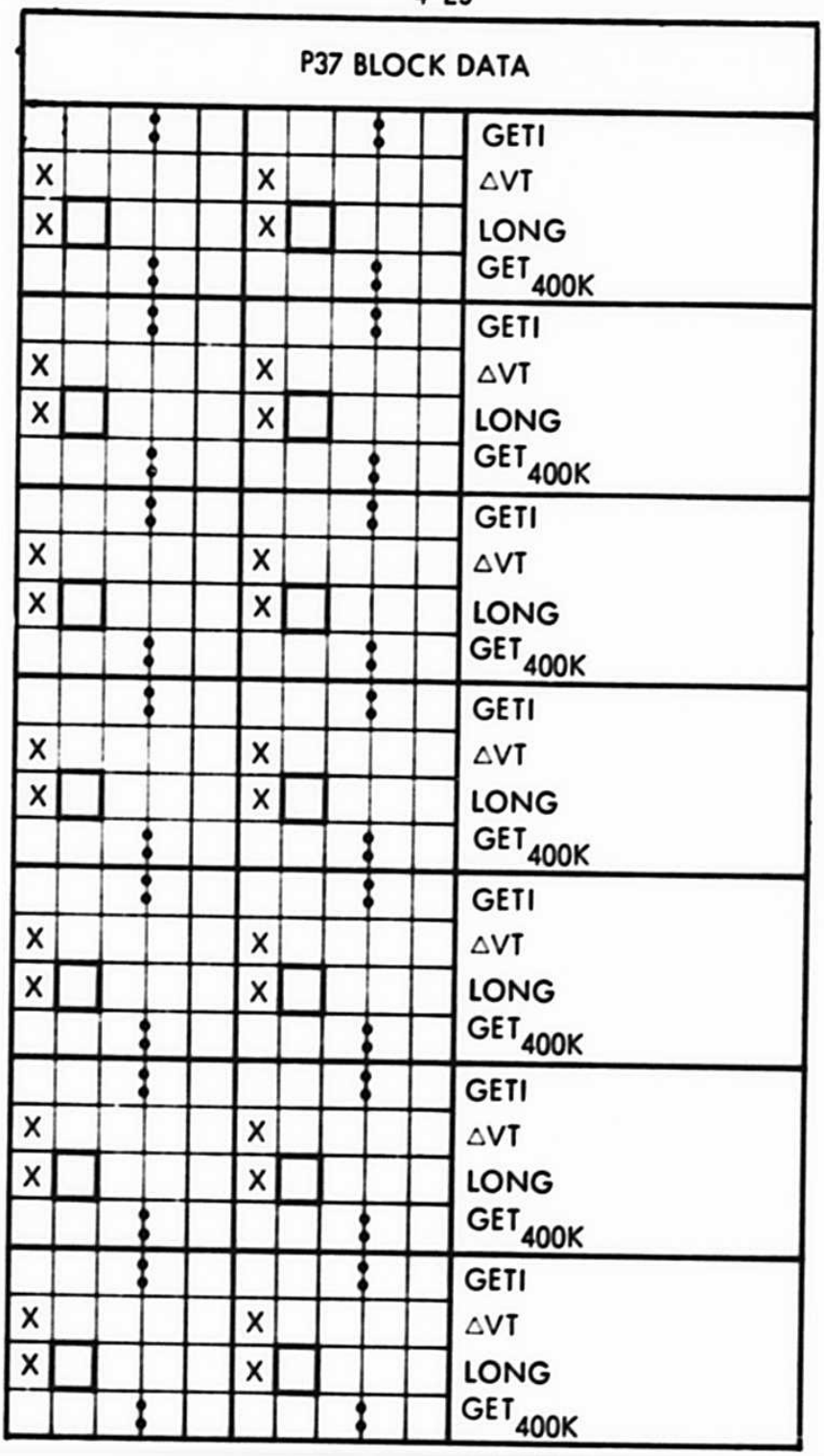

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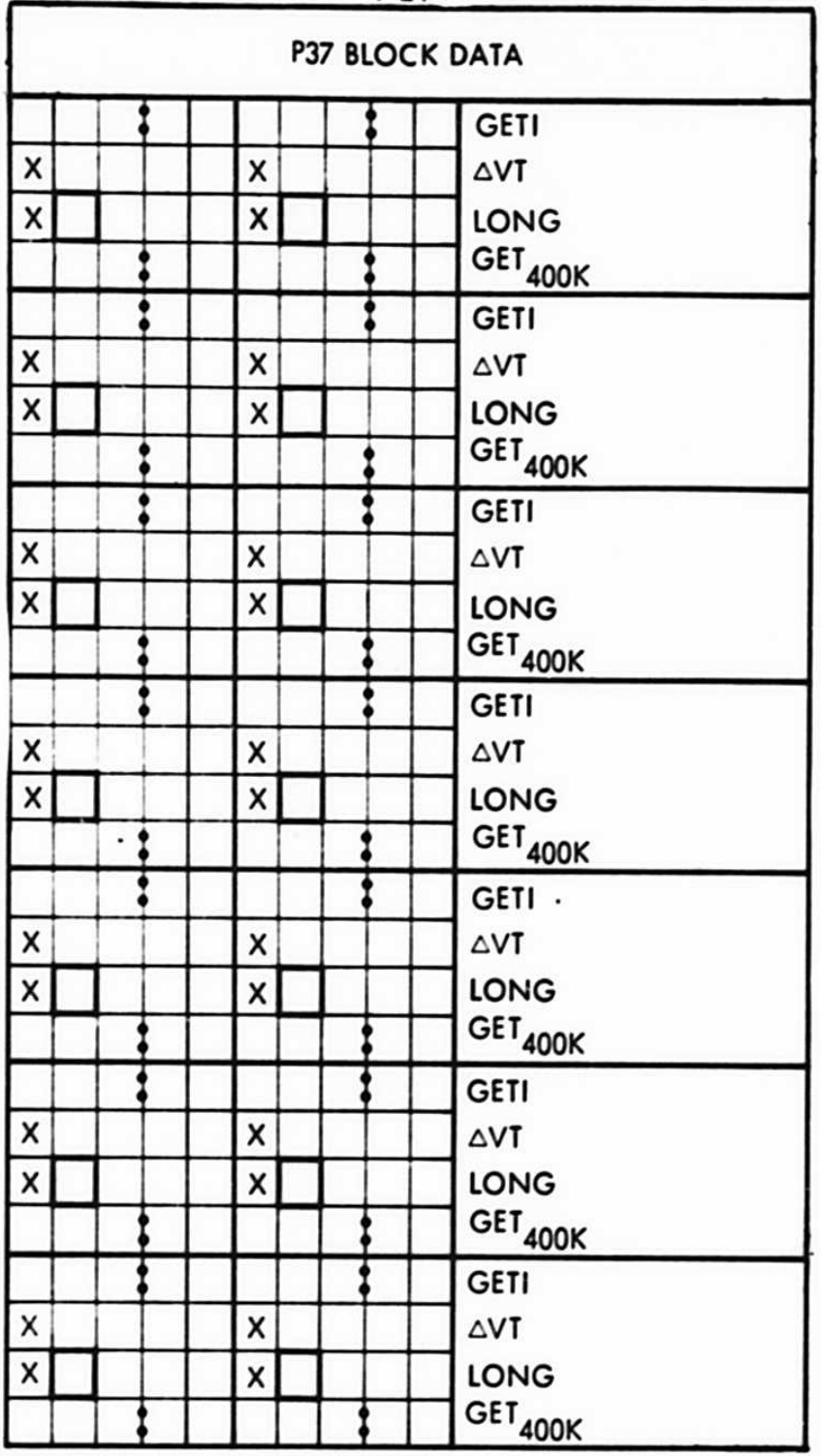
P37 BLOCK DATA



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P37 BLOCK DATA