<table>
<thead>
<tr>
<th>PART NO.</th>
<th>S/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKB32100082-310</td>
<td>1001</td>
</tr>
</tbody>
</table>
APOLLO 13

CSM G&C CHECKLIST

MARCH 27, 1970

PREPARED BY: [Signature]
JOHN J. MONROE
BOOK MANAGER
SPACERAFT SYSTEMS BRANCH

APPROVED BY: [Signature]
M. E. DEMENT
CHIEF, SPACERAFT SYSTEMS BRANCH

It is requested that any organization having comments, questions, or suggestions concerning this document contact John J. Monroe, Spacecraft Systems Branch, Building 4, Room 252, telephone 483-4371.

This document is under the configuration control of the Crew Procedures Control Board (CPCB). All proposed changes should be submitted to the Apollo Flight Data File Manager, Mr. T. W. Holloway, CF34, Room 230, telephone HU3-4271.

Distribution of this document is controlled by Mr. J. W. O'Neill, Chief, Flight Planning Branch, Flight Crew Support Division.
## LIST OF EFFECTIVE PAGES

* INDICATES CURRENT CHANGE

<table>
<thead>
<tr>
<th>PAGE NUMBER</th>
<th>ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Basic</td>
</tr>
<tr>
<td>G/TC-1 thru G/TC-4</td>
<td>Basic</td>
</tr>
<tr>
<td>G/1-1 thru G/1-25</td>
<td>Basic</td>
</tr>
<tr>
<td>*G/1-26</td>
<td>3/27/70</td>
</tr>
<tr>
<td>G/1-27 thru G/1-32</td>
<td>Basic</td>
</tr>
<tr>
<td>G/2-1 thru G/2-5</td>
<td>Basic</td>
</tr>
<tr>
<td>G/3-1 thru G/3-12</td>
<td>Basic</td>
</tr>
<tr>
<td>G/4-1 thru G/4-10</td>
<td>Basic</td>
</tr>
<tr>
<td>*G/4-11</td>
<td>3/27/70</td>
</tr>
<tr>
<td>G/4-12 thru G/4-18</td>
<td>Basic</td>
</tr>
<tr>
<td>G/5-1 thru G/5-15</td>
<td>Basic</td>
</tr>
<tr>
<td>G/6-1 thru G/6-10</td>
<td>Basic</td>
</tr>
<tr>
<td>G/7-1 thru G/7-7</td>
<td>Basic</td>
</tr>
<tr>
<td>*G/8-1</td>
<td>3/27/70</td>
</tr>
<tr>
<td>G/8-2</td>
<td>Basic</td>
</tr>
<tr>
<td>*G/8-3</td>
<td>3/27/70</td>
</tr>
<tr>
<td>G/8-4 and G/8-5</td>
<td>Basic</td>
</tr>
<tr>
<td>G/9-1 thru G/9-6</td>
<td>Basic</td>
</tr>
<tr>
<td>G/10-1 thru G/10-21</td>
<td>Basic</td>
</tr>
<tr>
<td>G/11-1 and G/11-2</td>
<td>Basic</td>
</tr>
<tr>
<td>G/12-1 and G/12-2</td>
<td>Basic</td>
</tr>
<tr>
<td>G/13-1 thru G/13-4</td>
<td>Basic</td>
</tr>
<tr>
<td>*G/13-5 and G/13-6</td>
<td>3/27/70</td>
</tr>
<tr>
<td>*G/13-6A</td>
<td>(new page)</td>
</tr>
<tr>
<td>G/13-7 and G/13-8</td>
<td>Basic</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

1. **CMC GENERAL**
   - Star List 1-1
   - VERB List (Decimal) 1-2
   - NOUN List (Decimal) 1-4
   - VO5 N09 Alarm Codes 1-8
   - VSO N25 Checklist Codes 1-14
   - VO4 N06 (N12)Option Codes 1-14
   - Flag Word Listing 1-15
   - Octal-To-Binary Conversion 1-17
   - CMC IMPUT/OUTPUT Channels 1-18
   - Flag Word & Channel Set/Reset 1-19
   - Octal-To-Decimal Conversion 1-20
   - Review Data In Erasable Memory 1-20
   - To Change Data In Erasable Memory 1-20
   - Monitor Of INPUT/OUTPUT Channels 1-20
   - RCS DAP ATT Deadband Increase 1-21
   - VHF RNG DSKY Display 1-21
   - G&N Recovery Procedures 1-22
   - General System Checkout 1-23
   - Check for Reasonableness 1-23

### EXTENDED VERBS

- V35 DSKY Condition Light Test 1-24
- V41 N91 Coarse Align OCU's 1-24
- V41 N20 Coarse Align ICDU's 1-25
- V42 Gyro Torquing 1-25
- V48 DAP Data Load & Activate Procedure 1-26
- V49 Crew Defined Maneuver 1-27
- V55 CMC Time Update 1-27
- V64 HI Gain Antenna Pointing 1-27
- V67 W-matrix Error Display 1-28
- V74 CMC Downlink 1-28
- V79 DAP PTC/Orb rate 1-28
- V82 Orbit Parameter Display 1-29
- V83 Rendezvous Parameter Display #1 1-30
- V85 Rendezvous Parameter Display #2 1-30
- V87 Set VHF RNG Flag 1-30
- V89 Rendezvous Final Attitude 1-31
- V90 Out Of Plane Display 1-32
- V91 Compute Banksum 1-32
- V93 Enable W-matrix Initialization 1-32
2. G & C SYSTEM MANAGEMENT
   IMU Power Up Procedure 2-1
   IMU Power Down Procedure 2-1
   Measurement & Loading Of PIPA BIAS 2-2
   CMC Power Up Procedure 2-2
   PO6 - CMC Power Down Program 2-2
   CMC Self Check 2-3
   Optics Power Up Procedure 2-3
   Optics Power Down 2-3
   Optics Manual Drive Procedure 2-3
   SCS Power Up 2-4
   SCS Power Down 2-4
   SCS Attitude Reference Comparison 2-5
   ΔV Null Bias Check 2-5

3. NAVIGATION
   P17 TPI Search (P77 LM) 3-1
   P20 Rendezvous Navigation 3-2
   P21 Ground Track Determination 3-4
   P22 Orbital Navigation 3-5
   P23 Optics Calibration 3-7
   P23 Cislunar Midcourse Nav Measurement 3-8
   P27 CMC Update 3-11
   Voice Transmission.Update 3-12

4. PRETHRUST (P30's & 70's)
   P30 External ΔV 4-1
   P31 General Lambert Prethrust 4-1
   P32 CSI Prethrust (P72 LM) 4-2
   P33 CDH Prethrust (P73 LM) 4-3
   P34 TPI Prethrust (P74 LM) 4-4
   P35 TPM Prethrust (P75 LM) 4-6
   P37 Return To Earth PGM 4-7
   P38 SOR Targeting (P78 LM) 4-17
   P39 Stable Orbit MID (P79 LM) 4-18
   P76 Target ΔV 4-18
5. THRUSTING (P40's)
   P40 SPS Thrusting
   SPS vs RCS Criteria
   GIMB ANGS vs WT
   P41 RCS Thrusting
   P47 Thrust Monitor

6. ALIGNMENTS (P50's)
   P51 IMU Orientation
   P52 IMU Realign
   P53 Backup IMU Orient Determination
   P54 Backup IMU Realign
   Star Charts

7. INITIALIZATION PROCEDURES
   Rapid IMU Realign
   Changing Landing Site REFSMMAT For
      Out-of-Plane Burns
   GDC Alignment to IMU Gimbal Angles
   Backup GDC &/or IMU Alignment
   In-Plane GDC Alignment
   PGNS Ordeal Initialization
   SCS Ordeal Initialization
   COAS LOS Determination
   CMC/LGC Clock Sync/TEPHEM Update
   V55 CMC Time Update (See EXT VB pg G/1-27)
   Docked IMU Align
   LM Steerable Ant Pointing

8. PTC/ORB RATE PROCEDURES
   General V79 Properties
   Passive Thermal Control (G&N)
   Passive Thermal Control (SCS)
   Orb Rate Procedure (G&N)
   Orb Rate Procedure (SCS)

9. E-LOAD UPDATE
   Erasable Load Update
   LM or CSM S.V. Readout
10. NO COMM NAVIGATION
    TLC Abort 10-1
    Lunar Orbit Aborts 10-5
    TEC Aborts 10-13
    Gen Sighting Schedule 10-17

11. PLANET VECTORS 11-1

12. NO COMM LM JETTISON 12-1

13. LOI ABORTS 13-1
    LOI 30 Min DPS Abort 13-1
    LOI 2 Hour DPS Abort 13-5
    LOI Docked APS Abort 13-7
<table>
<thead>
<tr>
<th>NO</th>
<th>STAR NAME (Numerical)</th>
<th>STAR NAME (Alphabetical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Planet</td>
<td>Acamar</td>
</tr>
<tr>
<td>1</td>
<td>Alpheratz</td>
<td>Achernar</td>
</tr>
<tr>
<td>2</td>
<td>Diphda</td>
<td>Acrux</td>
</tr>
<tr>
<td>3</td>
<td>Navi</td>
<td>Aldebaran</td>
</tr>
<tr>
<td>4</td>
<td>Achernar</td>
<td>Alkaid</td>
</tr>
<tr>
<td>5</td>
<td>Polaris</td>
<td>Alpheratz</td>
</tr>
<tr>
<td>6</td>
<td>Acamar</td>
<td>Alpheratz</td>
</tr>
<tr>
<td>7</td>
<td>Menkar</td>
<td>Alphard</td>
</tr>
<tr>
<td>10</td>
<td>Mirfak</td>
<td>Alphard</td>
</tr>
<tr>
<td>11</td>
<td>Aldebaran</td>
<td>Alphard</td>
</tr>
<tr>
<td>12</td>
<td>Rigel</td>
<td>Alphadis</td>
</tr>
<tr>
<td>13</td>
<td>Capella</td>
<td>Alphadis</td>
</tr>
<tr>
<td>14</td>
<td>Canopus</td>
<td>Alphadis</td>
</tr>
<tr>
<td>15</td>
<td>Sirius</td>
<td>Alphadis</td>
</tr>
<tr>
<td>16</td>
<td>Procyon</td>
<td>Alphadis</td>
</tr>
<tr>
<td>17</td>
<td>Regor</td>
<td>Alphadis</td>
</tr>
<tr>
<td>20</td>
<td>Dnoes</td>
<td>Alphadis</td>
</tr>
<tr>
<td>21</td>
<td>Alphard</td>
<td>Arcturus</td>
</tr>
<tr>
<td>22</td>
<td>Regulus</td>
<td>Arcturus</td>
</tr>
<tr>
<td>23</td>
<td>Denebola</td>
<td>Arcturus</td>
</tr>
<tr>
<td>24</td>
<td>Gienah</td>
<td>Arcturus</td>
</tr>
<tr>
<td>25</td>
<td>Acruin</td>
<td>Arcturus</td>
</tr>
<tr>
<td>26</td>
<td>Spica</td>
<td>Arcturus</td>
</tr>
<tr>
<td>27</td>
<td>Alkaid</td>
<td>Arcturus</td>
</tr>
<tr>
<td>30</td>
<td>Menkent</td>
<td>Arcturus</td>
</tr>
<tr>
<td>31</td>
<td>Arcturus</td>
<td>Arcturus</td>
</tr>
<tr>
<td>32</td>
<td>Alphadis</td>
<td>Arcturus</td>
</tr>
<tr>
<td>33</td>
<td>Antares</td>
<td>Arcturus</td>
</tr>
<tr>
<td>34</td>
<td>Atria</td>
<td>Arcturus</td>
</tr>
<tr>
<td>35</td>
<td>Rasalhague</td>
<td>Arcturus</td>
</tr>
<tr>
<td>36</td>
<td>Vega</td>
<td>Arcturus</td>
</tr>
<tr>
<td>37</td>
<td>Nunki</td>
<td>Arcturus</td>
</tr>
<tr>
<td>40</td>
<td>Altair</td>
<td>Arcturus</td>
</tr>
<tr>
<td>41</td>
<td>Dabih</td>
<td>Arcturus</td>
</tr>
<tr>
<td>42</td>
<td>Peacock</td>
<td>Arcturus</td>
</tr>
<tr>
<td>43</td>
<td>Deneb</td>
<td>Arcturus</td>
</tr>
<tr>
<td>44</td>
<td>Enif</td>
<td>Arcturus</td>
</tr>
<tr>
<td>45</td>
<td>Fomalhaut</td>
<td>Arcturus</td>
</tr>
<tr>
<td>46</td>
<td>Sun</td>
<td>Arcturus</td>
</tr>
<tr>
<td>47</td>
<td>Earth</td>
<td>Arcturus</td>
</tr>
<tr>
<td>50</td>
<td>Moon</td>
<td>Arcturus</td>
</tr>
<tr>
<td></td>
<td>Verb List (Decimal)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>Display Oct Compnt 1 (R1)</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Display Oct Compnt 2 (R1)</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Display Oct Compnt 3 (R1)</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Display Oct Compnt 1, 2 (R1, R2)</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Display Oct Compnt 1, 2, 3 (R1,R2,R3)</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>Display Decimal (R1 or R1, R2 or R1,R2,R3)</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>Display DP Decimal - (R1,R2)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Monitor Oct Compnt 1 (R1)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Monitor Oct Compnt 2 (R1)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Monitor Oct Compnt 3 (R1)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Monitor Oct Compnt 1, 2 (R1, R2)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Monitor Oct Compnt 1, 2, 3 (R1,R2,R3)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Monitor Decimal (R1 or R1,R2 or R1,R2,R3)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Monitor DP Decimal - (R1,R2)</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Load Compnt 1 (R1)</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Load Compnt 2 (R2)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Load Compnt 3 (R3)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Load Compnt 1, 2 (R1, R2)</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Load Compnt 1, 2, 3 (R1, R2, R3)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Display Fixed Memory</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Request Executive</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Request Waitlist</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Recycle Prog</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Proceed Without DSKY inputs</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Terminate Function</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Test Lights</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Request Fresh Start</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Change Prog (Major Mode)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Zero ICDU (N20)</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Coarse Align CDU (N20 &amp; N91)</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Fine Align IMU</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Load FDAI ATT Error needles</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Set Surface Flag</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Reset Surface Flag</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Activate DAP</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Set LM State Vector into CSM State Vector</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Load DAP (R03)</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Start Crew Defined MNVR(R62)</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Please Perform</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Please Mark</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Marked on offset landing site</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Please Mark alternate LOS</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Start REND backup sighting mark (R23)</td>
<td></td>
</tr>
</tbody>
</table>
NOUN LIST (Decimal)

01 Specify Machine Address (.XXXXX
  (Fract) (R1,R2,R3)
02 Specify Machine Address (Whole) (R1,R2,R3)
03 Specify Machine Address (can be R1,R2,R3) .01°
05 Angular Error/Diff .01°
06 Option Code (R1 & R2) OCTAL
07 BIT operator: Address,BIT ID, OCTAL Action
08 Add +1 of error OCTAL
  B BANK + SUPERBANK OCTAL
  No of SELF TEST errors 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
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
29 X SM LAUNCH Azimuth .01°
30 Target Code(Gyrocomp verif)
32 Time from Perigee hrs,min,.01sec
33 Time of Ignition (GETI) 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 GETI-TPI hrs,min,.01sec
38 State Vector Time hrs,min,.01sec
39 Δ Time of Transfer hrs,min,.01sec
<table>
<thead>
<tr>
<th>Field</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF GETI/TFC</td>
<td>Min-sec</td>
</tr>
<tr>
<td>VG</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>ΔV (Accumulated)</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>Target</td>
<td></td>
</tr>
<tr>
<td>Apogee Alt (HA)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>Perigee Alt (HP)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>ΔV (Required)</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>Lat</td>
<td>.01°</td>
</tr>
<tr>
<td>Long</td>
<td>(+ North) .01°</td>
</tr>
<tr>
<td></td>
<td>(+ East) .01°</td>
</tr>
<tr>
<td>Alt</td>
<td>.1 NM</td>
</tr>
<tr>
<td>Apogee Alt (HA)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>Perigee Alt (HP) (N50)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>TFF</td>
<td></td>
</tr>
<tr>
<td>Marks</td>
<td></td>
</tr>
<tr>
<td>TF GETI of next burn</td>
<td></td>
</tr>
<tr>
<td>MGA</td>
<td></td>
</tr>
<tr>
<td>DAP Config (R1&amp;R2)</td>
<td>OCTAL</td>
</tr>
<tr>
<td>CSM weight</td>
<td>LBS</td>
</tr>
<tr>
<td>LM Weight</td>
<td>LBS</td>
</tr>
<tr>
<td>Pitch Trim</td>
<td>.01°</td>
</tr>
<tr>
<td>Yaw Trim</td>
<td>.01°</td>
</tr>
<tr>
<td>ΔR</td>
<td>.1 NM</td>
</tr>
<tr>
<td>ΔV</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>SOURCE CODE (1 optics, 2 VHF)</td>
<td>0000X.</td>
</tr>
<tr>
<td>ΔR (miss distance)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>PERIGEE (HP)</td>
<td>.1 NM</td>
</tr>
<tr>
<td>TFF</td>
<td></td>
</tr>
<tr>
<td>RHO</td>
<td>.01°</td>
</tr>
<tr>
<td>GAMMA</td>
<td>.01°</td>
</tr>
<tr>
<td>CENTANG (active veh)</td>
<td>.01°</td>
</tr>
<tr>
<td>RANGE</td>
<td>.01 NM</td>
</tr>
<tr>
<td>RANGE RATE</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>PHI (lcl horiz)</td>
<td>.01°</td>
</tr>
<tr>
<td>Range</td>
<td>.01 NM</td>
</tr>
<tr>
<td>Range Rate</td>
<td>.1 FPS</td>
</tr>
<tr>
<td>Theta (lcl horiz)</td>
<td>.01°</td>
</tr>
<tr>
<td>Precision offset</td>
<td>CODE</td>
</tr>
<tr>
<td>E (ELEV ANGLE)</td>
<td>.01°</td>
</tr>
<tr>
<td>CENTANG (passive veh)</td>
<td>.01°</td>
</tr>
</tbody>
</table>
ΔR offset (SOR) (+ indicates behind target) .1 NM
58 HP alt (post TPI) (SOR for P38) .1 NM
ΔV (TPI) (SOR for P38) .1 FPS
ΔV (TPF) (SOR FINAL for P38) .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 .1 NM
63 RTGO from 0.05 G .1 NM
To Splash
VI0, Predicted Iner Vel FPS
TFE, time from .05G min-sec
64 Drag Acceleration .01 G
VI, Inertial Velocity FPS
RTGO to Target .1 NM
65 Sampled CMC Time hrs, min, .01 sec (fetched in interrupt)
66 Beta, CMD Bank Angle .01°
CRSRNG Error .1 NM
DNRNG Error .1 NM
67 RTGO to Target .1 NM
Lat, Present Position .01° (+ North)
Long, Present Position .01° (+ East)
68 Beta, CMD Bank Angle .01°
VI, Inertial Vel. FPS
H Dot, Alt Rate FPS
69 Beta .01°
DL .01 G
VL FPS
Star Code (before mark)
LMK Data
Horiz data
Star code (after mark)
LMK Data
Horiz data
Δ ang
Δ alt
Search option
ALT (P21)
VEL (P21)
GAMMA (P21)
BETA, CMD Bank Angle
VI, Inertial Velocity
Drag Acceleration
ΔH (CDH)
ΔT
ΔT
PTC/Orb Rate
PTC/Orb deadband
PTC/Orb Code
TF GETI/TFC
VG
ΔV (Accumulated)
ΔVX,Y,Z (lcl vert)
ΔVX,Y,Z (LV) CDH
ΔVX,Y,Z (Body Control Axis)
ΔVX,Y,Z (Other Vehicle)
VGX,Y,Z (Body Control Axis)
Opt Calib Data - Shaft (R1)
Trunnion(R2)
Planet
X
Y
Z
Landmark - Lat
Long/2
Alt
REND out of
Plane para
OCDU Angles Shaft (R1)
Trunnion (R2)
G
1-8

92 New OCDU Angles Shaft (R1)  .01°
   Trunnion (R2)  .001°
93 Delta Gyro Angles X,Y,Z  .001°
94 OCDU ANGLES (R56 & R23)
   R1 SHAFT  .01°
   R2 TRUNNION  .001°
95 Pref att ICDU angles  .01°
96 +X axis att ICDU angles  .01°
97 System Test Inputs
   XXXX.
   XXXX.
   XXXX.
98 System Test Results
   XXXX.
   .XXXXX
   XXXX.
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
00112 Mark reject with no marks being accepted
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
Optics torque has been requested but optics have not been zeroed since last FRESH START or RESTART OPTICS ZERO - OFF then ZERO (15 sec).

In 0.05 sec following mark, an ICDU changed by more than 0.033° Repeat MK.

Marking not called for Continue.

PL7 (77) TPI search unsuccessful (G/3-1)

PIPA saturated
Use SCS control (G&N 12).

The IMU zero routine has been entered with both the GMBL LOCK lit and NO ATT lit on Coarse align to 0,0,0 Reselect V40 N20E.

ISS turn-on request not present for 90 sec
Redo IMU turn on (G&N 12).

The IMU is not operating
Redo IMU turn on. If alarm recurs perform fresh start (V36E).
Consult MSFN. (G&N 12).

Coarse align error
If P51(3)/52(4) in progress record gyro torquing angles and perform fine align check in P52(4).
Otherwise, see G/1-25 (G&N 12).

PIPA fail, but PIPA is not being used PIPA BIAS check (G&N 6/8).

IMU not operating with turn-on request See 00210

Program using IMU when turned OFF See 00210 or exit program.

IMU coarse align or pulse torque difficulty has occurred Reinitiate current program.
If alarm recurs, terminate use of ISS (G&N 12).

IMU orientation unknown
Align or if aligned set REFSMMAT flag.
00401 Desired middle gimbal angle is excessive Call N22 - maneuver if MGA < 85° or realign TMU.

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

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/4-2)

00601 Post CSI Perigee/lune alt <85nm/ 5.8nm (G/4-2)

00602 Post CDH Perigee/lune alt <85nm/ 5.8nm (G/4-2)

00603 Time from TIG (CSI) to TIG (CDH) <10 min (G/4-2)

00604 Time from TIG (CDH) to TIG (TPI) <10 min (G/4-2)

00605 Number of iterations exceeds loop maximum (G/4-2,4-7,4-8)

00606 ΔV (CSI) has been >1000 fps for last two iterations (G/4-2)

00611 No TIG for given ELEV angle (G/4-4,4-5)

00612 State vector in wrong sphere of influence at TIG (G/4-7)

00613 Reentry angle out of limits (G/4-8)

(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 Arccos or arccos input is greater than
    one
    Copy N08, notify MSFN, continue.
(m)01407 VG increasing
    (G/5-6,L/7-6) (G&N 12).
01426 IMU unsatisfactory
    Realign or use SCS.
01427 IMU reversed
    Note FDAI operation is inverted.
01520 V37 request not permitted at this time
    Wait till COMP ACTY lt.
    not on continuously — reselect V37 or if
    P62-67, select POO and then desired
    program.
01600 Overflow in drift test
    This is gnd test alarm only.
01601 Bad IMU torque abort
    See 01600
01602 Bad optics during verification
    See 01600
01703 Insufficient time for integration.
    TIC slipped
    (G/5-4,5-14,L/7-5)
(m)03777 ISS warning caused by ICDU fail
    (G&N 6)
(m) 04777 ISS warning caused by ICDU & PIPA fail (G&N 6)
(m) 07777 ISS warning caused by IMU fail (G&N 6)
(m) 10777 ISS warning caused by IMU & PIPA fail (G&N 6)
(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.
**21103 Unused CCS branch executed
Copy NO8, notify MSFN, initiate V36 recovery
**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 device 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 V92 keyed (P07) during P00 or P01 selected and P11 has already been performed
See 21204

*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

*31207 No vac area for marks
Rset
Reselect program
If alarm recurs, consult MSFN.

*31211 Illegal interrupt of extended verb
Reselect extended verb after optics marking is completed.

(m) - Malf procedure indicated

**(2xxxx) - Generates restart, F37 (no lt)
*(3xxxx) - Restart (no lt) and program continues (i.e. attempted recovery)

NOTE - All **alarms act as *type if they occur when Ave-g is on
# V50 N25 Checklist Codes

<table>
<thead>
<tr>
<th>R1 Code</th>
<th>ACTION</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>00013</td>
<td>Key in</td>
<td>Gyro Torque Option (P52,54)</td>
</tr>
<tr>
<td>00014</td>
<td>Key in</td>
<td>Fine Align Option</td>
</tr>
<tr>
<td>00015</td>
<td>Perform</td>
<td>Celestial Body Acq</td>
</tr>
<tr>
<td>00016</td>
<td>Key in</td>
<td>Terminate Mark Sequence</td>
</tr>
<tr>
<td>00041</td>
<td>Switch</td>
<td>CM/SM SEP to UP</td>
</tr>
<tr>
<td>00062</td>
<td>Key</td>
<td>CMC to STBY</td>
</tr>
<tr>
<td>00202</td>
<td>Perform</td>
<td>PGNS AUTO MNVR</td>
</tr>
<tr>
<td>00204</td>
<td>Key in</td>
<td>Engine gimbal test opt</td>
</tr>
</tbody>
</table>

# V04 N06 (N12) Option Codes

<table>
<thead>
<tr>
<th>R1 Code</th>
<th>Purpose</th>
<th>Input for R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>00001</td>
<td>Specify IMU Orientation</td>
<td>1=PREF, 2=NOM, 3=REFS, 4=LDG SITE</td>
</tr>
<tr>
<td>00002</td>
<td>Specify vehicle</td>
<td>1=CSM, 2=LM</td>
</tr>
<tr>
<td>00003</td>
<td>Specify tracking Attitude</td>
<td>1=Preferred, 2=&gt;X-axis</td>
</tr>
<tr>
<td>00005</td>
<td>Specify SOR Phase</td>
<td>1=First, 2=Second</td>
</tr>
<tr>
<td>00007</td>
<td>Specify Propulsion System</td>
<td>1=SPS, 2=RCS</td>
</tr>
<tr>
<td>TITLE</td>
<td>ADDRESS</td>
<td>BIT</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>-----</td>
</tr>
<tr>
<td>RNDZ</td>
<td>00074</td>
<td>7</td>
</tr>
<tr>
<td>UPDATE</td>
<td>00075</td>
<td>7</td>
</tr>
<tr>
<td>Track</td>
<td>00075</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pref Att</td>
<td>00076</td>
<td>4</td>
</tr>
<tr>
<td>Steer</td>
<td>00076</td>
<td>11</td>
</tr>
<tr>
<td>REFSMMAT</td>
<td>00077</td>
<td>13</td>
</tr>
<tr>
<td>IMU</td>
<td>00074</td>
<td>8</td>
</tr>
<tr>
<td>State Vector</td>
<td>00075</td>
<td>8</td>
</tr>
<tr>
<td>Terminate</td>
<td>00103</td>
<td>15</td>
</tr>
<tr>
<td>Description</td>
<td>Code</td>
<td>Value</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Trunnion drive</td>
<td>00074</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target 1</td>
<td>00075</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target 2</td>
<td>00075</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W-matrix (RNDV)</td>
<td>00101</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W-Matrix (ORB)</td>
<td>00077</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 axis</td>
<td>00101</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External (\Delta V)</td>
<td>00076</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active vehicle</td>
<td>00076</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final comp.</td>
<td>00076</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sighting mark</td>
<td>00074</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CSM 109

Basic Date: 3/9/70

Changed:
CSM 109

Basic Date 3/9/70
Changed

Stick flag 00075 14 RHC out of detent
RHC in détent (auto maneuver enabled)

CMOON flag 00104 12 Permanent CSM
SV in Lunar Sphere of Influence
Permanent CSM SV
in Earth Sphere of Influence

LMOON flag 00104 11 Permanent LM
SV in Lunar Sphere of Influence
Permanent LM SV
in Earth Sphere of Influence

NON-FLAGS

IMODES 30 1320 9 IMU not operating
IMU operating

OCTAL-TO-BINARY CONVERSION

ABCDE = OCTAL WORD
BINARY BIT SET = 1
RESET = 0

<table>
<thead>
<tr>
<th>OCTAL DIGIT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCTAL DIGIT</td>
<td>15 14 13 12 11 10 9 8 7 6 5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0 0 1 0 0 0 1 0 0 1 0 0 1 0 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0 1 0 0 0 0 1 0 1 0 0 0 1 0 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0 1 1 0 0 1 1 0 1 1 0 1 1 0 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 0 0 0 1 0 0 1 0 0 1 0 0 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 0 1 0 1 0 1 1 0 1 1 0 1 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1 1 0 1 1 0 1 1 0 1 1 0 1 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FLAG WORD & CHANNEL SET/RESET
Note: Only channel no's <30 may be used

1  V25N 07E
   F 21 07 (LOAD FLAG WORD ADDRESS OR CHANNEL NUMBER)E

2  F 22 07 (LOAD CODE FOR BIT TO BE CHANGED)ABCDE ENTR

<table>
<thead>
<tr>
<th>BIT</th>
<th>CODE</th>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

3  F 23 07
   (SET BIT) Key 1E
   (RESET BIT) Key 0E

4  (to Verify) V01 N01E (FLAG Word ADD) ENTR
   or V01 N10E (CHANNEL NUMBER) ENTR

5  F 01 01(10) R1 FLAG WORD OR CHANNEL (ABCDE)
   R3 FLAG WORD ADDRESS OR CHANNEL NUMBER
   EXAMPLE: To cause UPLINK ACTY LT

   Key:
   V25N 07E
   11E
   4E
   1E
   This sets bit 3 of
   Channel 11
   Verification should show E > 4

   EXAMPLE: To set REFSMMAT flag:
   Key:
   V25N 07E
   77E
   10000E
   1E
   This sets bit 13 of
   flagword 3
   Verification should show A odd
OCTAL-TO-DECIMAL CONVERSION

1-1  11-9  21-17  31-25  41-33
2-2  12-10  22-18  32-26  42-34
3-3  13-11  23-19  33-27  43-35
4-4  14-12  24-20  34-28  44-36
5-5  15-13  25-21  35-29  45-37
6-6  16-14  26-22  36-30  46-38
7-7  17-15  27-23  37-31  47-39
10-8  20-16  30-24  40-32  50-40

REVIEW DATA IN ERASABLE MEMORY

1  V01 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)

TO CHANGE DATA IN ERASABLE MEMORY

1  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)

MONITOR OF INPUT/OUTPUT CHANNELS

1  V11 N10E
    F 11 10  (LOAD CHANNEL ADDRESS) E
    R1 Octal Contents of Specified
    Channel
RCS DAP ATT DBD INCREASE
CMC - on
ISS - on & aligned
SCS - operating
RCS DAP ACTIVATED

1 SC CONT - CMC/AUTO

2 V79E

3 F 06 79 RATE, DB, CODE (.0001°/sec, .01°, +XXXXX)
   Load R1 = +00000
   R2 = Desired Dead Band
       (Min: .4°; Max: 30°)
   R3 = +00000

4 MAN ATT (R) - ACCEL CMD
   MAN ATT (P,Y) - RATE CMD

5 PRO

6 MAN ATT (R) - RATE CMD

7 TO RETURN TO R03 DEADBAND:
   V46E (DB center shifted)
   or S/C CONT - SCS then CMC (DB center shifted)
   or V37EXXE (DB center not shifted)
   or V48E
   PRO, PRO, PRO (DB center not shifted)

VHF RNG DSKY DISPLAY
VHF RNG - on (up)
P20 - running

1 V87E
   V06 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, 100000E, 1E (set REFSMMAT flag)

if V30 or 31 inadvertently keyed in:
   RECORD N26, NOTIFY MSFN, V74E
   Perform General System Checkout

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

if 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 POO 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
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 "8".
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

f. P00 will be displayed.

g. Key RSET

V41 N91 COARSE ALIGN OCDU's
CMC - on
ISS - on
G/N PWR OPTICS - on
OPT MODE - CMC
OPT ZERO - OFF

1
V41N 91E
F 21 92 SHAFT, TRUN NEW OCU (.01°, .001°)
Load desired shaft and trun

41 OPTICS DRIVE TO SPECIFIED ANGLES

V41 N20 COARSE ALIGN ICDU's
CMC - on
ISS - on

V41N 20E

F 21 22 NEW ICDU ANGLES RPY (.01°)
Load desired ICDU angles

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

V40 N20E
NO ATT lt - off
Wait 20 sec

V37E XXE

V42 GYRO TORQUING
CMC MODE - FREE

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

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

<table>
<thead>
<tr>
<th>VEHICLE CONFIG</th>
<th>QUAD A/C FOR $\ddot{X}$</th>
<th>QUAD B/D for $\ddot{X}$</th>
<th>ERR DEADBAND</th>
<th>RATE SELECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - No DAP</td>
<td>0 - Fail A/C</td>
<td>0 - Fail B/D</td>
<td>0 - $\pm 0.5^\circ$</td>
<td>0 - 0.057/sec</td>
</tr>
<tr>
<td>1 - CSM</td>
<td>1 - Use A/C</td>
<td>1 - Use B/D</td>
<td>1 - $\pm 5.0^\circ$</td>
<td>1 - 0.2/sec</td>
</tr>
<tr>
<td>2 - CSM &amp; LM</td>
<td></td>
<td></td>
<td>2 - 0.5/sec</td>
<td>2 - 0.5/sec</td>
</tr>
<tr>
<td>3 - CSM &amp; SIVB</td>
<td></td>
<td></td>
<td>3 - 2.0/sec</td>
<td>3 - 2.0/sec</td>
</tr>
<tr>
<td>6 - CSM &amp; LM (Ascent Stg only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Roll Quad Select

<table>
<thead>
<tr>
<th>Roll Quad Select</th>
<th>Quad A</th>
<th>Quad B</th>
<th>Quad C</th>
<th>Quad D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - Use B/D</td>
<td>0 - Fail</td>
<td>0 - Fail</td>
<td>0 - Fail</td>
<td>0 - Fail</td>
</tr>
<tr>
<td>1 - Use A/C</td>
<td>1 - Use</td>
<td>1 - Use*</td>
<td>1 - Use</td>
<td>1 - Use</td>
</tr>
</tbody>
</table>

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:
CMC MODE - FREE
V46E

* For SPS burn w/Ascent Stage, A=1, & load total mass
V49 CREW DEFINED MANEUVER
CMC - on
ISS - on
SCS - operating

1
V37E 00E
V62E

2
V49E
F 06 22 NEW ICDU ANGLES RPY
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

V55 - CMC TIME UPDATE

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

V64 HI GAIN ANTENNA POINTING

1
V64E
F 06 51 RHO, GAMMA (.01°, .01°)
HCA TRACK - MAN
Set in required P&Y Angles
S BD ANT - HI GAIN
HCA TRACK - AUTO
PRO
V67 - W-MATRIX ERROR DISPLAY

1

V67E
F 06 99 POS ERR, VEL ERR, OPT CODE (ft., lfps)
R3  00001 = Rend
     00002 = Orbital
     00003 = Cislunar
     00000 = No Reinitialization

Load desired data
PRO

V74 CMC DOWNLINK

1

V74E (Places erasable memory on downlink)

V79 - DAP PTC/Orb rate

PTC - pg G/8-2
ORB RATE - pg G/8-4
V82 ORBIT PARAMETER DISPLAY

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

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

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

3  F 16 44  HA, HP, TFF   (.1nm,.1nm,min-sec)
       (RECYCLE) V32E To 2 (Not Nec If AVE G On)
       (AR-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 (no light)-code 31201 or 31202 stored
If alt above earth or moon >432 nm:
P23 running - do not key V83 (or 85)
P23 not running:
   Wait for no integration (COMP ACTY not on continuously)
V96E (selects P00)
V83E (or 85E) - perform routine
V37E OOE

V83E
F 16 54 RANGE, RANGE RATE, THETA (0.01nm, 1fps, 0.01°)
PRO

V85 - RNDZ PARAMETER DISPLAY #2
Note: See V83 restrictions

V85E
F 16 53 RANGE, RANGE RATE, PHI (0.01nm, 1fps, 0.01°)
PRO

V87 - SET VHF RNG FLAG
VHF AM B - DUPLEX
VHF RNG - on (up)
P20 - running

V87E (starts VHF range sampling)

V88E (TERMINATE)
or V37E XXE
V89 - RENDEZVOUS FINAL ATTITUDE

Note: This routine will change N17 cells
CMC - on
ISS - on
SCS - operating

1
V37E 00E
V62E

2
V89E
F 04 06 R1 00003 SPECIFY TRACKING ATTITUDE
R2 00001 (PREF)
00002 (+X AXIS)
PRO

3
F 06 18 FINAL FDAI RPY ANGLES (.01°)
(AUTO MNVR) PRO
(UPDATE DISPLAY) V32E

4
F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC
CMC MODE - AUTO
PRO
(MAN) MNVR To 6

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

6
F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(TRIM) ALIGN SC In ROLL
PRO To 5
(BYPASS) ENTR
V90 - OUT-OF-PLANE DISPLAY

1
V90E
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
PRO

3
F 06 90 Y, YDOT, PSI (.01nm, .1fps, .01°)
(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 R2)
(NEXT BANK) PRO
(TERM) V34E

V93 - ENABLE W-MATRIX INITIALIZATION

1
V93E
IMU POWER UP PROCEDURE

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

1
G/N IMU PWR - on (up)
NO ATT 1t - on (90 sec)
NO ATT 1t - out
Wait 15 sec

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*
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

VO6 N21 (do not ENTR)
06 21
XYZ PIPA COUNTS

4

At T + 1:04 - ENTR
T1:04
Record
(X) R1 ___ (Y) R2 ___ (Z) R3 ___ (+XXXAB)

5

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

CMC POWER UP PROCEDURE

1

PRO, push until STBY lt - out
(repeat, if necessary)
*CMC warning, RESTART, PROG ALARM*
*RSET and continue *

2 F 37

00E

PO6 - CMC POWER DOWN PROGRAM

1

V48E
F04 46
Load 0 (NO DAP) in left digit of R1
PRO
PRO
PRO
V46E

V37E 06E
F 50 25
00062 CMC PWR DN

PRO, push until STBY lt - on
CMC SELF CHECK

1  V25 N01E, 1365E
   F21 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 & ERASABLE
    (4E SELF CHECKS ERASABLE
     5E SELF CHECKS FIXED)

4  15 01 TEST SUCCESSFUL WHEN R2>3 (78 sec)
   * IF PROG 1t = On    *
   * V05 N09E 01102 SELF *
   * TEST ERROR *
   *N8E-Rec for MSFN *
   (TERM) V21N27E 0E

OPTICS POWER UP PROCEDURE
   Verify optics manual drive disengaged
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

OPTICS MANUAL DRIVE PROCEDURE
   Verify G&N PWR OPTICS - OFF

1  Insert tool E and rotate ~1 rev CCW
to engage drive (socket backs out)

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

3  To disengage, push and rotate
    ~1 rev CW (button will remain flush)
SCS POWER UP
AUTO RCS SELECT (16) - OFF
BMAG MODE (3) - RATE 2
CMC MODE - FREE
SC CONT - CMC
cb SCS LOGIC PWR (4) - close
ΔV CC - as required
LOGIC PWR 2/3 - on (up)
SIG COND/DRIVER BIAS PWR (2) - ACl
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
a/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
SCS ATTITUDE REFERENCE COMPARISON

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

Key V16 N20E (present IMU angs)

1

FDAO SELECT - 1
FDAO SOURCE - ATT SET
ATT SET - GDC
ATT SET dials - null FDAO 1 error needles
Key VERB when nulled (freeze display)
Record from DSKY:
\[ R_{\text{\circ}}, P_{\text{\circ}}, Y_{\text{\circ}} \]
Record ATT SET dials:
\[ R_{\text{\circ}}, P_{\text{\circ}}, Y_{\text{\circ}} \]

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
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*
P17 - TPI SEARCH (P77 LM)

CMC - on (req)

1

V37E (17E or 77E)
F 06 37 GETI (TPI) (hrs, min, .01sec)
Load desired GETI
PRO

2

ΔANG(TPI), ΔALT(TPI), SEARCH OPT
(.01°, .1nm, 0000X)
R3=SEARCH OPT
00001<180°
00002>180°
(change GETI TPI) V32E to 1
(change Search opt) V23E
PRO

*F 05 09 00124 alarm code *
*V32E, RSET to 1 to adjust*
*GETI or SEARCH OPTION *

3

HP, ΔV(TPI), ΔV(TPF) (.1nm,.1fps,.1fps)
(RECYCLE) V32E to 1 to adjust
GETI or Search option
PRO

4

R1=Perigee Code, R3=CENTANG(0000X,.01°)
00001, perigee between TPI and TPF
00002, perigee after TPF
(RECYCLE) V32E to 1 to adjust
GETI or Search option
PRO

5

F 37 XXE
P20 - RENDEZVOUS NAVIGATION
CMC - on (req)
ISS - on and aligned (req)
SCS - on (des)
BMAG MODE (3) - RATE 2
G/N OPT PWR - on (verify)
OPT ZERO - ZERO (verify)
OPT MODE - CMC
Note: For VHF RNG display see p G/1-21

V37E 20E
F 50 18 Request MNVR to FDAI RPY angles (.01°)

(AUTO) SC CONT - CMC
CMC MODE - AUTO
PRO
06 18 RPY (.01) to 1 when MNVR complete
(MAN) SC CONT - SCS
PRO To 1
or V62E
RHC - MNVR To 1

When attitude OK:
CMC MODE - AUTO
ENTR
OPTIC ZERO - OFF
*POSS UPLINK ACTY 1t
*(Mnvr >10° req'd)
*To reestablish F 50 18
* Key V58E
V57E (SXT)
OPT MODE - MAN
OHC - Cntr Target in SXT
MARK (repeat as necessary)

*POSS F 06 49 ΔR,ΔV, source code*  
*   (.lnm,.lfps,0000X)   *
*(REJECT) V32E  
*(ACCEPT) PRO

OPT ZERO - ZERO

PRO (return to program in process)  
(To terminate P20 - V56E)

V54E (COAS)
SHAFT, TRUNNION  (.01°,.001°)
PRO

3

F 06.94

4  F 53

Request Alt LOS MARK
RHC - ALIGN Target in COAS
ENTR (V86E To reject)
*POSS F 06 49 ΔR,ΔV, source code*  
*   (.lnm,.lfps,0000X)   *
*(REJECT) V32E  
*(ACCEPT) PRO

PRO (return to Program in process)  
(To Terminate P20 - V56E)

To display N49 for every measurement:
V1 N1E  
2002E
Rcrd: R1
V21 N1E  
2002E  
77776E

To return:
V21N1E  
2002E
Load previously recorded value
P21 GROUND TRACK DETERMINATION

CMC - on (req)

1
F 04 06
V37E21E
R1 00002, Specify Vehicle
R2 00001, CSM
or 00002, LM
PRO

2
F 06 34
GET LAT, LONG (hrs, min, .01sec)
Load desired GET (for present time, use all zeroes)
PRO

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

4
F 37
XXE

NOTE: Additional Information is available by V6 N73E
N73 Alt, VEL, GAMMA (10nm, fps, .01°)
P22 - ORBITAL NAVIGATION

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

1

V37E 22E
F 06 45 R3=MAX MGA
(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 (ORB PARA) (.1nm, .1fps)
(RECYCLE) V32E to 2
(ACCEPT) Hold for 30 sec
PRO
9  F 06 89  LAT, LONG/2, ALT LMK ID
    (.001°, .001°, .01nm)
    (DONT STORE) V32E to 2
    (STORE-CODE 01) PRO to 2
    (terminate Prog) V34E

10 F 37 XXE
    OPT ZERO - ZERO
    To restore rate limit (CDU transient
detection): V21N1E, 1341E, 5E

P23 OPTICS CALIBRATION
    CMC - on
    OPT ZERO - ZERO (verify)
    OPT MODE - MAN

1  F 05 70 V37E 23E (IMU NOT ALIGNED - to 3)
    STAR ID(ABCDE)/LMK ID/HOR ID
    Insure R1 DE#00, R2=000000, R3=00XX0
    (X=1 or 2)
    PRO

2  F 50 25 00202 MNVR/CALIB REQUEST
    ENTR

3  F 59 PERFORM OPTICS CALIB
    OPT MODE - MAN (verify)
    OPTICS COUPLING - DIRECT
    SPEED - LOW
    OPT ZERO - OFF
    SUPERIMPOSE LLOS TO SLOS
    MARK

4  F 06 87 R2 TRUNNION ANGLE BIAS
    (.001°)
    (repeat until 2 measurements
    agree within .003°)
    For manual load:
    V22 N94E
    XXXXXE
    (ACCEPT) PRO
    (REJECT) MARK to 4

5  F 51 V37E XXE
    OPT ZERO - ZERO
P23 - Cislunar Midcourse NAV Measurement

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

1
V37E 23E

2
F 05 70
R1 0000E STAR ID
R2 00C00 LMK ID
R3 00CD0 HOR ID

STAR/ENH  STAR/LNH  STAR/EL
0000E  0000E  0000E
00000  00000  00100
00110  00210  00000

STAR/EFH  STAR/LFH  STAR/LL
0000E  0000E  0000E
00000  00000  00200
00120  00220  00000

STAR/HOR PRO TO 5 (DE=00 to 4)
STAR/LMK PRO

3
F 06 89
LAT, LONG/2, ALT (LMK) (.001°+N/E, .01nm) |
PRO (DE#00 to 5)

4
F 06 88
CELESTIAL BODY VECTOR
LOAD DESIRED VECTOR
PRO

5
F 50 25
00202 MNVR/CALIB REQUEST
(MNVR) PRO
(CALIB) ENTR to 8
REQUEST MNVR TO FDAI R, P, Y
(AUTO) SC CONT - CMC
CMC MODE - AUTO
BMAG MODE (3) - RATE 2
PRO to 7
(MAN) V62E
MNVR to 6
(BYPASS) ENTR to 8 (CALIB COMPLETED to 10)

AUTO MNVR FDAI R, P, Y
AUTO MNVR COMPLETE RETURN TO 6

REQUEST OPTICS CALIB
(BYPASS) OPT MODE - CMC (verify)
OPT ZERO - OFF
ENTR to 10
(CALIB) OPT MODE - MAN
OPT COUPLING - DIR
SPEED - LOW
OPT ZERO - OFF
SUPERIMPOSE LLOS ON SLOS MARK

R2 TRUN BIAS
For manual load:
V22 N94E
XXXXXE
(RECALIB) MARK to 9
(INCORP OPT MODE - CMC
CALIB) PRO

AUTO OPT SHF/TRUN
(MNVR) V94E to 6
(MARK) MNVR SC TO POSITION LMK/HOR
IN FOV
OPT MODE - MAN
11 F 51  MARK REQUEST  
(MNVR)*  V94E to 6  
(MARK)  
SUPERIMPOSE STAR ON LMK/HOR  
MARK  

12 F 50 25  00016 TERM MARKS  
(REJECT) MARK REJECT to 11  
(TERM)  PRO  

13 F 05 71  R1  0000E STAR ID  
R2  00C00 LMK ID  
R3  00C00 HOR ID  

(STAR/HOR) PRO to 16 (DE=00 to 15)  
(STAR/LMK) PRO to 14  

14 F 06 89  LAT, LONG/2 ALT(LMK)  (.001°+N/E,.01nm)  
PRO (DE≠00 to 16)  

15 F 06 88  CELESTIAL BODY VECTOR  
Verify vector  
PRO  

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

17 F 37  

* If this is first P23 MARK since last:  
CSM S.V. Uplink  
or P20  
or Reinitialization of P23 W-matrix  
by V93 or V67  
or Alarm code 421  

Then key V93E prior to mark
P27 CMC UPDATE
CMC - on (req)

Auto Update:
V37E 00E
1

UP TLM (2) - ACCEPT
UPLINK ACTY lt - on
* POSS LOS before completion *
* If V33 NO2 showing: *
* Key ENTR *
* UPLINK ACTY lt - out *
* P00 displayed *
* If V21 NO1 *
* or V21 NO2 *
* Key V34E *
* UPLINK ACTY lt - out *
* P00 displayed *
* UP TLM (2) - BLOCK *

Update complete:
UPLINK ACTY lt - out
V37E 00E
UP TLM (2) - BLOCK
Voice Transmission Update:

V37E 00E

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

P27 Displayed

F 21 01 R3 UPDATE BUFFER ADD (initially 304)
R1 Data E (R3 Increments)
(If change - To 6)
Repeat Step 4 for all data

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

F 21 02 R3 330
(CHANGE) Load octal ident, XXE to 4
(ACCEPT UPDATE) Key Verb, then PRO

P00 Displayed
P30 EXTERNAL ΔV

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

1  F 06 33  V37E 30E (hrs, min, .01sec)
    GETI
    Load desired GETI PRO

2  F 06 81  ΔVXYZ(LV) (.1fps)
    Load desired ΔV's PRO

3  F 06 42  HA, HP, ΔV(REQ) (.1nm, .1nm, .1fps)
    Set ΔV Counter PRO

4  F 16 45  M, TFI, MGA (MKS, min-sec, .01°)
    Set DET PRO (MGA Set to -00002 IF
    REFSMMAT FLAG NOT SET)

5  F 37

P31 GENERAL LAMBERT PRETHRUST
TARG PARAMS – LOADED FROM GND (P27)

1  F 06 33  V37E 31E (hrs, min, .01sec)
    GETI
    Load desired GETI PRO

2  F 06 81  ΔVXYZ(LV) (.1fps)
    PRO

3  F 06 42  HA, HP, ΔV(REQ) (.1nm, .1nm, .1fps)
    Set ΔV Counter PRO
4  F 16 45  M,TFI,MGA          (MKS,min-sec,.01°)
Set DET
PRO (MGA Set to -00002 IF
    REFSSMAT FLAG NOT SET)

5  F 37

P32 CSI PRETHRUST  (P72 LM)

1  F 06 11  TIG (CSI)          (hrs,min,.01sec)
PRO

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

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

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

*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 1 Adjust
*    Inputs
5  F 06 75  \( \Delta H(\text{CDH}), \Delta T(\text{CDH-CSI}), \Delta T(\text{TPI-CDH}) \)
   PRO (.1nm, min-sec)

6  F 06 81  \( \Delta V \text{XYZ(LV)CSI} \) (.1fps)
   (For Out-of-Plane Corr in Final Comp ONLY)
   V90E
   F 04 12 R1 00002 Specify Vehicle
   R2 00001 CSM
   00002 LM
   PRO
   F 06 16 GET EVENT (hrs, min, .01sec)
   PRO
   F 06 90 Y, YDOT, PSI (.01nm, .1fps, .01°)
   Record Y DOT
   PRO
   Insert \(-Y\) DOT in R2 of \(\Delta V\) (CSI)
   PRO

7  F 06 82  \( \Delta V \text{XYZ(LV)CDH} \) (.1fps)
   PRO (If Recycling to 4)

8  F 16 45  MARKS, TFI, MGA (marks, min-sec, .01°)
   SET EVENT TIMER TO TFI
   PRO (MGA Set to -00002 If No
   REFSSMAT Set or If P72)

9  F 37

P72 - Transmit mnvr Parameters to LM

P33 CDH PRETHRUST (P73 LM)

1  F 06 13  V37E (33E or 73E)
   TIG(CDH) (hrs, min, .01sec)
   PRO

2  F 16 45  MARKS, TFI, -00001 (marks, min-sec)
   (RECYCLE) V32E to 3
   (FINAL PASS) TERM MARKS
   PRO
3  F 06 75  ΔH(CDH), ΔT(TPI-CDH), ΔT(TPI-NOMTPI)
   PRO  (.1nm, min-sec)

4  F 06 81  ΔV XYZ(LV)CDH  (.1fps)
   (For Out-of-Plane Corr in Final Comp ONLY)
   V90E
   F 04 12 R1 00002 Specify Vehicle
   R2 00001 CSM
   00002 LM
   PRO
   F 06 16 GET EVENT  (hrs, min, .01sec)
   PRO
   F 06 90 Y, YDOTH, PSI  (.01nm, .1fps, .01°)
   Record Y DOT
   PRO
   Insert -Y DOT in R2 of ΔV (CDH)
   PRO (If Recycling to 2)

5  F 16 45  MARK, TFI, MGA  (marks, min-sec, .01°)
   SET EVENT TIMER TO TFI
   PRO (MGA Set to -00002 If No
   REFSMMAT Set or If P73)

6  F 37

   P73 - Transmit mnvr Parameters to LM

   P34 TPI PRETHRUST (P74 LM)

1  F 06 37  TIG (TPI)  (hrs, min, .01sec)
   Load desired TIG
   PRO
2  F 06 55  PRECISION OFFSETS, ELEV ANGLE, \( \omega_t \)
(0000X, .01°, .01°)
Load desired values
(+00000 in R2 to CALC ELEV
ANGLE AT TIG TIME)
PRO

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

*F 05 09 (00611 NO SOL)*
*PRO To 1*

4  F 06 37  TIG (TPI)
(hrs, min, .01 sec)
(IF ELEV ANGLE COMPUTED BY CMC
THIS DISPLAY WILL BE REPLACED
BY F 06 55 AS IN 2 ABOVE)
PRO

5  F 06 58  HP, \( \Delta V(TPI), \Delta V(TPF) \)
(.1 nm, .1 fps, .1 fps)
PRO (If Recycle – To 7)
(If Final – To 6)

6  F 06 81  \( \Delta VXYZ(LV)TPI \)
(.1 fps)
PRO
ΔVXYZ(LOS)TPI (.1fps)
PRO (If Recycle - To 3)

MARKS,TFI,MGA (marks,min-sec,.01°)
PRO (MGA SET To -00002 IF NO
REFSMMAT SET or If P74)

P74 - Transmit Mvnr Parameters To LM

P35 TPM PRETHRUST (P75 LM)

V37E (35E or 75E)

MARK,TFI,-00001 (marks,min-sec)
(RECYCLE) V32E To 3
(FINAL PASS) TERM MARKS
PRO

ΔVXYZ(LV)TPI (.1fps)
PRO

ΔVXYZ(LOS)TPI (.1fps)
PRO (If Recycle - To 1)

MARKS,TFI,MGA (marks,min-sec,.01°)
PRO (MGA SET TO -00002 IF NO
REFSMMAT SET or If P75)

P75 - Transmit Mvnr Parameters To LM
P37 RETURN TO EARTH PGM
(LONG CONTROL CANNOT BE DONE WHEN TIME
TO ENTRY IS <4 HRS)

Perform the following once:
V1N1E
3376E
Verify R1= 01603(1185.6nm)

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

2  F 06 60 BLANK, ΔV DESIRED, GAMMA EI DESIRED
Load desired ΔV:
   PAD ΔV IF ON TLC
   0.       IF ON TEC
Load R3=0
R2 XXXXX
PRO

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

3  F 06 61 IMPACT LAT, IMPACT LONG
If Impact LONG <12° from desired:
   Record Impact LONG as θcl ___ ___ ___°
   PRO
If Impact LONG>12° from desired:
   TEC:N40E Record R2 as ΔVmin ___ fps
V32E to 1 & use |ΔV| >ΔV min
ΔV neg to move LONG WEST
ΔV pos to move LONG EAST
   TLC: V32E to 1
   Decrease ΔV to move LONG WEST
   Increase ΔV to move LONG EAST
F 06 39 ΔT TRANSFER
   PRO
   (RECYCLE) V32E To 1

F 06 60 BLANK, V PRED, GAMMA EI
   PRO
   (RECYCLE) V32E To 1

F 06 81 ΔVXYZ(LV) at TIG
   Record R3 as ΔVzcl= _______ fps
   N40E
   Record R2 as ΔVcl= _______ fps
   KEY RLSE
   PRO
   *F 05 09 00605 Solution not *
   * Convergent *
   * 00613 Flt Path Ang *
   * not reached *
   *RSET V32E to 1 *
   * 20607 Conic Routine *
   * Failed *
   *F 37 37E to 1 *

F 06 61 IMPACT LAT, IMPACT LONG
   (°.01°)
   Record LONG as θp1 = _______°
   If θ p1, acceptable, PRO to step 15

F 06 39 ΔT TRANSFER
   PRO

F 06 60 BLANK, VPRED, GAMMA EI
   PRO
10 F 06 81 ΔVXYZ(LV) at TIG
   Record R1 as ΔVxpl = _________ fps
   Record R3 as ΔVzpl = _________ fps
   N40E
   R2 XXXX.X Record as ΔVpl = _________ fps
   V32E to 11

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

12 F 06 60 BLANK, ΔV DESIRED, GAMMA E1 DESIRED
   To move West from θpl
   TEC: Load ΔVc2 = -ΔVc1-10
   TLC: Load ΔVc2 = ΔVc1-10
   To move EAST from θpl
   TLC or TEC: Load ΔVc2=ΔVc1+10
      Record ΔVc2 _________ fps
   R2 XXXXX.
   PRO

*F 05 09  SAME AS IN 2*
*V32E.  RSET to 11  *
13 F 06 61  IMPACT LAT, IMPACT LONG (.01°)
Record LONG as θc2 = _______.

Compute K:

N81E Record R3 as

\[ \Delta V_{cz2} = _______. \text{ fps} \]

\[ K = \frac{\theta c2 - \theta c1}{\Delta V_{zc2} - \Delta V_{zc1}} \]

K = +. __________

Compute \( \Delta \theta \text{LONG} = \theta d - \theta pl = + \) _______.

Obtain from chart \( \Delta V_o = + \) _______. fps

Make sign of \( \Delta V_o \) same as \( \Delta \theta \text{LONG} \)
Compute \( \Delta V_d \):

\[ \Delta V_{zd} = \Delta V_{zpl} + \Delta V_o \]

\[ \Delta V_d = \left( \Delta V_{zd}^2 + \Delta V_{xpl}^2 \right)^{1/2} \]

Make sign of \( \Delta V_d \) same as \( \Delta V_{zd} \)

\[ \Delta V_d = \] __________

14 V32E to step 1 & use \( \Delta V_d \) in R2 of N60
   (Step 2)

15 F 06 39 \( \Delta T \) TRANSFER (RECYCLE) V32E To 1
   (hrs, min, .01sec)

   PRO
16  F 06 60  BLANK, V PRED, GAMMA E1 (fps,.01°) (RECYCLE) V32E To 1 PRO

17  F 06 81  ΔVXYZ(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 if not performed just
    prior to P37 call
    PRO

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

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

21  F 37  (40E or 41E)
OBTAINE ENTRY REFSMMAT (No Comm)
1. Record 400K time from final P37 solution
   (Step 1 TIG + FN L N39)
2. Use 400K time for T-align P52 (Option 2).
   NOTE: P37 MCC used to compute T-align
   must be performed prior to step 2.
\[ K = 0.004 \cdot 0.005 \cdot 0.006 \cdot 0.007 \cdot 0.008 \cdot 0.009 \cdot 0.010 \cdot 0.011 \cdot 0.012 \cdot 0.013 \cdot 0.014 \]

\[ \Delta \theta_{\text{Long}} = \theta_D - \theta_{\text{P1}} \]

\[ K = \frac{\theta_{\text{C2}} - \theta_{\text{C1}}}{\Delta V_{\text{ZC2}} - \Delta V_{\text{ZC1}}} \]

\[ \Delta V_0 \text{ versus } \Delta \theta_{\text{Long}}, K = 0.04 \text{ to } 0.004. \]
\( \Delta V_0 \) vs \( \Delta \theta_{\text{LONG}} \)

\[
K = \frac{\theta_{C2} - \theta_{C1}}{\Delta V_{ZC2} - \Delta V_{ZC1}}
\]

\( \Delta \theta_{\text{Long}} = \theta_D - \theta_{P1} \)

\( \Delta V_0 \) versus \( \Delta \theta_{\text{Long}} \), \( K = .4 \) to \( .04 \).

CSM 109

Basic Date 3/9/70
Changed
<table>
<thead>
<tr>
<th>P37 BLOCK DATA</th>
<th>G 4-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>GETI</td>
<td>ΔVT</td>
</tr>
<tr>
<td>LONG</td>
<td>GET 400K</td>
</tr>
<tr>
<td>GET 400K</td>
<td></td>
</tr>
<tr>
<td>GETI</td>
<td>ΔVT</td>
</tr>
<tr>
<td>LONG</td>
<td>GET 400K</td>
</tr>
<tr>
<td>GET 400K</td>
<td></td>
</tr>
<tr>
<td>GETI</td>
<td>ΔVT</td>
</tr>
<tr>
<td>LONG</td>
<td>GET 400K</td>
</tr>
<tr>
<td>GET 400K</td>
<td></td>
</tr>
<tr>
<td>GETI</td>
<td>ΔVT</td>
</tr>
<tr>
<td>LONG</td>
<td>GET 400K</td>
</tr>
<tr>
<td>GET 400K</td>
<td></td>
</tr>
<tr>
<td>GETI</td>
<td>ΔVT</td>
</tr>
<tr>
<td>LONG</td>
<td>GET 400K</td>
</tr>
<tr>
<td>GET 400K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P37 BLOCK DATA</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GETI</td>
</tr>
<tr>
<td></td>
<td>ΔVT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
<tr>
<td></td>
<td>GET 400K</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
P38 SOR TARGETING (P78 LM)

1  F 06 33  V37E (38E or 78E)  (hrs, min, .01sec)
   TIG (SOR)  Load desired TIG
   PRO

2  F 06 55  R3 wtt  (.01°)
   Load desired wtt
   PRO

3  F 04 06  R1 00005  Specify Phase Option
   R2 0000X X=1 or 2
   PRO (To 6 If R2=2)

4  F 06 57  ΔR SOR  (.1nm)
   Load desired ΔR
   PRO

5  F 06 34  SOR TIME  (hrs, min, .01sec)
   PRO

6  F 16 45  MARK, TFI, -00001  (mark, min-sec, .01°)
   (RECYCLE) V32E
   (FINAL PASS) PRO (Terminate Marks)

7  F 06 58  HP(SOR), ΔV(SOR), ΔV(SOR-FINAL)
   PRO  (.1nm, .1fps, .1fps)

8  F 06 81  ΔVXYZ(LV)  (.1fps)
   PRO (If Recycle - To 6)

9  F 16 45  MARKS, TFI, MGA  (marks, min-sec, .01°)
   PRO (MGA SET TO -00002 IF NO
   REFSMMAT SET OR P78)

10 F  37

P78 - Transmit Mnvr Parameters To LM
P39 STABLE ORBIT MID (P79 LM)

1  V37E (39E or 79E)

2  F 16 45 MARK,TFI,-00001 (mark,min-sec,.01°) (RECYCLE) V32E (FINAL PASS) PRO (Terminate Marks)

3  F 06 81 ΔVXYZ(LV) (.1fps) PRO (If Recycle - To 2)

4  F 16 45 MARK,TFI,MGA (mark,min-sec,.01°) PRO (MGA SET TO -00002 IF NO REFSMMAT SET or P79)

5  F 37

P79 - Transmit Mnvr Parameters To LM

P76 - TARGET ΔV

1  V37E 76E

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

2  F 06 84 ΔV XYZ (.1fps) Load ΔV PRO

3  F 37 00E

V82E (check LM parameters)

4  F 04 12 R1 00002 Specify vehicle Load R2 - 00002 PRO

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

6  F 16 44 HA,HP,TFF (.1nm,min-sec) *R3 - 59B59HP > 49.4nm/35K ft* PRO

Basic Date — 3/9/70

CSM 109

Changed
P40-SPS THRUSTING

Check for water in tunnel area
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 - AC1
PUGS MODE - NORMAL
OXID FLOW vlv - PRI
BMAG MODE (3) - RATE 2
CMC MODE - FREE
AUTO RCS SELECT(16)-as req'd
LOAD DAP
ROT CONTR PWR NORM (2) - AC/DC
Set DET

V37E 00E
SC CONT - CMC/AUTO

MNVR TO PAD BURN ATT

1
V62E

2
V49E

3  F 06 22  DESIRED FINAL GMBL ANGLES (.01°)
    LOAD MNVR PAD GMBL ANGLES
    PRO
THRUSTING (P401's)

4  F 50 18  REQ MNVR TO FDAI RPY ANGLES (.01°)
     (AUTO)  PRO
     (MAN)  SC CONT - SCS
            MNVR To 6

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

6  F 50 18  REQ TRIM TO FDAI RPY ANGLES (.01°)
     (AUTO TRIM)  PRO To 5
     (BYPASS)  ENTR

7  BORESIGHT & SXT STAR CHECK
     OPT MODE - CMC
     OPT ZERO - OFF

8  V41 N91E

9  F 21 92  SHAFT, TRUN (.01°, .001°)
     LOAD SXTS angles

10  41  OPTICS DRIVE

     CHECK SXT STAR
     OPT ZERO - ZERO
     CHECK BORESIGHT STAR (If avail)

11  V37E 40E

12  F 50 18  REQUEST MNVR TO FDAI RPY ANGLES (.01°)
     (AUTO)  BMAG MODE (3) - RATE 2
            SC CONT - CMC/AUTO
            PRO To 13
     (MAN/DAP)  BMAG MODE (3) - RATE 2
               SC CONT - CMC/HOLD
               MNVR To 14
     (MAN/SCS)  SC CONT - SCS
               MNVR To 14

13  06 18  AUTO MNVR TO FDAI RPY ANGLES (.01°)
REQUEST TRIM MNVR TO FDAI RPY ANGLES
ALIGN S/C ROLL (.01°)
CDC ALIGN

TVC CHECK & PREP
- cb STAB CONT SYS (Pnl 8) - close
- cb SPS (12) - close
- SET ΔVC (verify)
- EMS FUNCT - ΔV (verify)
- MAN ATT (3) - RATE CMD
- LIMIT CYCLE - on (up)
- 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
BMAQ MODE (3) - ATT1/RATE 2
SC CONT - SCS
RHC #2 - ARMED

55:00m
(-05:00)

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

SEC TVC CHECK
GMBL MOT P2-Y2 - START/ON(LMP Confirm
SET GPI TRIM
Verify MTVC
THC NEUTRAL
Verify NO MTVC.
Verify GPI returns to 0,0 (CMC) or trim (SCS)
ROT CONT PWR NORM (2) - AC/DC
ROT CONT PWR DIRECT (2) - MNA/MNB

(TRIM) BMAG MODE (3) - RATE 2
PRO

(BYPASS) BMAG MODE (3) - ATT1/RATE 2 (verify)
ENTR

15 F 50.25 00204 GMBL TEST OPTION
(ACCEPT) SC CONT - CMC (verify)
PRO

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

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

(REJECT) ENTR

16. 06 40 TFI, VG, ΔVM (min-sec,.1fps)

*PROG ALARM - TIG Slipped*
*V5N9E 01703 *
*KEY RLSE TO 16 *

FDAI SCALE - 5/5
LIMIT CYCLE - OFF
RATE - HIGH
UPDATE DET
SPS He v1vs (2) - AUTO (verify)

58:00
(-02:00) ΔV THRUST A(B) - NORMAL
THC - ARMED
RHC (2) - ARMED
TAPE, RCDR - HBR/RCD/FWD/CMD RESET

59:25 (-00:35) DSKY BLANKS

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 AS REQ
(-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 19
EXIT - V37E 00E

17 00:00 IGN *IF SCS: THRUST PB - PUSH*

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

*F 97 40 SPS Thrust fail  *
*ΔV THRUST B(A)−NORMAL  *
*(RESTART) PRO to IGN  *
*(RECYCLE) ENTR to TIG−05sec*

SPS THRUST Lt - ON
ΔV THRUST B(A) - NORMAL
*IF SCS: +X & THRUST PB - PUSH*

MONITOR THRUSTING
Pc 95-105 psia
EMS COUNTING DOWN
SPS INJ VLVS (4) - OPEN
SPS He vlvs tb-gray
SPS FUEL/OXID PRESS - 170-195 psia
PUGS - BALANCED
*PROG ALARM *
*V5 N9E 01407 VG INC*
*LOI & TEI: *
*THC-CW, FLY MTVC *
*DOI & MCC: *
*ΔV THRUST A&B-OFF*

00:XX ECO

*EMER SPS CUTOFF: *
*ΔV THRUST A&B - OFF*
*LOI - BT +10 sec *
*DOI - BT +1 sec *
*TEI - BT +2 sec & *
*ΔV CTR < -40 fps *

18 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

19 F 16 85 VG XYZ (CM) (.1fps)
NULL RESIDUALS (TEI & MCC)
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
cb DIRECT ULLAGE (2) - open
cb SPS P1 & Y1 - open
BMAG MODE (3) -RATE 2
PCM BIT RATE - LOW

PRO
20 F 37 V82E

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

*R3-59B59HP >49.4 nm/35K ft*

PRO

22 F 37 00E

23 When COMP ACTY lt not on continuously: V66E (If LM S.V. not needed)

**BURN STATUS REPORT**

<table>
<thead>
<tr>
<th>ATIG</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>HDOT</td>
</tr>
<tr>
<td>VGX</td>
<td>H</td>
</tr>
<tr>
<td>R</td>
<td>ΔVC</td>
</tr>
<tr>
<td>P</td>
<td>FUEL</td>
</tr>
<tr>
<td>Y</td>
<td>OXID</td>
</tr>
<tr>
<td></td>
<td>UNBAL</td>
</tr>
</tbody>
</table>

**REMARKS**
SPS versus RCS criteria (CSM alone).

Csm 109

Basic Date 3/9/70

Changed
SPS versus RCS criteria (CSM/LM docked)
CSM 14-2  SPS ENGINE TRIM GIMBAL ANGLES
VERSUS SPACECRAFT WEIGHT
CSM ONLY

GIMB ANGS vs WT
YAW (PSI) TRIM GIMBAL ANGLE (DEG)
PITCH (THETA) TRIM GIMBAL ANGLE (DEG)

SPACECRAFT WEIGHT (LBS X 10^-4)

Basic Date — 3/9/70
Changed

CSM 109
CSM 14-1  SPS ENGINE TRIM GIMBAL ANGLES
VERSUS SPACECRAFT WEIGHT
CSM/LM DOCKED

Basic Date
3/9/70

Changed YAW (Psi) TRIM GIMBAL ANGLE (DEG)

Pitch (Theta) TRIM GIMBAL ANGLE (DEG)

YAW

Pitch

Spacecraft Weight (LBS x 10^-4)
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
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
   V62E

2 V49E

3 F 06 22 DESIRED FINAL GMBL ANGLES (.01°)
   LOAD MNVR PAD GMBL ANGLES
   PRO
4 F 50 18  REQUEST MNVR TO FDAO RPY ANGLES (.01°)
   (AUTO) PRO
   (MAN) SC CONT - SCS
   MNVR To 6

5 06 18  AUTO MNVR To FDAO RPY ANGLES (.01°)

6 F 50 18  REQUEST TRIM To FDAO RPY ANGLES (.01°)
   (AUTO TRIM) PRO To 5
   (BYPASS) ENTR

7  BORESIGHT & SXT STAR CHECK
    OPT MODE - CMC
    OPT ZERO - OFF

8  V41 N91E

9 F 21 92  SHAFT, TRUN (.01°, .001°)
   LOAD SXTS angles

10 41  OPTICS DRIVE

    CHECK SXT STAR
    OPT ZERO - ZERO
    CHECK BORESIGHT STAR (If avail)

11  V37E 41E

12 F 50 18  REQUEST MNVR TO FDAO RPY ANGLES (.01°)
   (AUTO) BMAG MODE (3) - RATE 2
   SC CONT - CMC/AUTO
   PRO To 13
   (MAN/DAP) BMAG MODE (3) - RATE 2
   SC CONT - CMC/HOLD
   MNVR To 14
   (MAN/SCS) SC CONT - SCS
   MNVR To 14

13 06 18  AUTO MNVR TO FDAO RPY ANGLES (.01°)
REQUEST MNVR TO FDAI RPY ANGLES (.01°)  
(AUTO TRIM)  BMAG MODE (3) - RATE 2  
ALIGN SC ROLL  
SC CONT - CMC/AUTO  
PRO To 13  
(BYPASS)  ATT DB - MIN  
RATE - LOW  
MAN ATT (3) - RATE CMD  
BMAG MODE (3) - ATT1/RATE 2  
GDC ALIGN  

VG X,Y,Z  (.1fps)  

* PROG Alarm lt  
* V5N9E - 01703 - TIG SLIPPED  
* KEY RLSE To 15  

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

DSKY BLANKS  

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

VG X,Y,Z  

NULL COMPONENTS  
RECORD ΔV COUNTER & RESIDUALS  
TAPE RCDR - off (ctr)  
PCM BIT RATE - LOW  
HAND CONTROLLERS - LOCKED  
EMS FUNC - OFF  
EMS MODE - STBY  
TRANS CONT PWR - OFF  
BMAG MODE (3) - RATE 2  

PRO
18 F 37 V82E
19 F 16 44 HA, HP, TFF (mnm, min-sec)
   * R3-59B59 HP>49.4 nm/35K ft *
   PRO
20 F 37 00E
21 When COMP ACTY lt not on continuously:
   V66E (If LM S.V. not needed)

P47 Thrust Monitor Program
   CMC - on
   ISS - on & aligned
   F 16 83 ΔV XYZ (CSM) (lfps)
   *VI, HDOT, H available by N62E*
   *KEY RLSE to return to N83 *

   (RECYCLE) V32E
   (TERM) PRO
2 F 37 XXE
P51 - IMU ORIENTATION
CMC - on
ISS - on
SCS - operating
BMAG MODE (3) - RATE 2
G/N PWR OPTICS - on (verify)
OPT ZERO - ZERO (verify)
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 1t - 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°)
(RECYCLE) V32E to 1
(ACEPT) PRO

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 (verify)
OPT ZERO - ZERO (verify)
OPT MODE - CMC

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)
   (hr,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 ICDO 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  ICDO ANGLES
   (.01°)
When torque complete - go to 17

7  F 50 25  00015 STAR SELECT
   (MNVR If Necessary)
   (PICAPAR) PRO
(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 (0.01°, 0.001°)

(MARK ROUTINE) OPTICS MODE - MAN

11 F 51 PLEASE MARK
MARK

12 F 50 25 00016 TERMINATE MARKS
PRO

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

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  (.01°)
    (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
    OPT ZERO - ZERO
    XXE

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  DESIRERED GIMBAL ANGLES (0,0,0)
    NO ATT 1t - on then off, to 1

3  F 06 94  ALT LOS OPT ANGS SHAFT, TRUN (.01°,.001°)
    Load proper angles
    PRO

4  F 53  PLEASE MARK
    Center Target
    ENTR
5  F 50 25  00016  TERMINATE MARKS
    (REJECT)  ENTR to 4
    PRO

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

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

8  F 06 05  STAR ANGLE DIFFERENCE  (.01°)
    (RECYCLE)  V32E to 1
    (ACCEPT)  PRO

9  F 37.  XXE

P54 - BACKUP IMU REALIGN
    CMC - on
    ISS - on
    SCS - operating
    MAN ATT (3) - MIN IMP
    COAS LOS DETERMINATION - complete

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)
    (hr,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 ICUDR 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  ICUDR 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

10 F 06 94  ALT LOS OPT ANGS SHAFT, TRUN(.01°,.001°)
   Load angles
   PRO

11 F 53  PLEASE MARK
   Center Target
   ENTR

12 F 50 25  00016 TERMINATE MARKS
   (REJECT) ENTR to 11
   PRO
13 F 01 71 000DE STAR CODE
    Load code (if necessary)
    PRO to 8 after 1st MARK (to 14 if DE=00)
    to 15 after 2nd MARK (to 14 if DE=00)

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

15 F 06 05 STAR ANGLE DIFFERENCE
    (REJECT) V32E to 17
    (ACCEPT) PRO

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

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

18 F 37 XXE
RAPID IMU REALIGN

NOTE: This procedure assumes a good GDC alignment

1 V41 N20E
   Load R,P,Y from GDC Ball

2 V40 N20
   Verify R,P,Y on GDC Ball - ENTR
   (Releases Platform And Recovers PGNS
    Control Modes)

3 V25 N7E, 76E,
   40000E, 1E (Sets Drift Flag)

4 V25 N07E
   77E, 10000E, 1E (Sets REFSMMAT FLAG)

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
   PRO (SPECIFIES PRESENT TIME)

4 F 06 89 LAT, LONG/2,ALT (LOAD R1: +35000 FOR +AVy
   or -35000 FOR -AVy)

5 F 06 22 NEW ICDU ANGLES
6  F 50 25  R=00013
CMC MODE-FREE
ENTR TO GYRO TORQUE

7  16 20  UNTIL TORQUING COMPLETE

8  F 50 25  R1=00014 ALIGNMENT CHECK
ENTR

9  P30

10 P40

11  YAW BACK TO 0° (MANUALLY)

12  V37E 52E

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

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

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

16  F 06 22  NEW ICDU ANGLES

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

18  16 20  UNTIL TORQUING COMPLETE

19  F 50 25  R1=00014 ALIGNMENT CHECK
PRO (TO SELECT 2 STARS IF TIME PERMITS)
ENTR (TO LEAVE P52)
GDC ALIGNMENT TO IMU GIMBAL ANGLES

IMU - on
SCS - operating

1. Damp vehicle rates

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

BACKUP GDC AND/OR IMU ALIGNMENT
(IMU or CMC failed)
SCS - operating
RECORD: R,P,Y ALIGN from MSFN

1. IMU PWR - OFF
   Wait ~5 min for gyros to run down before step 8

2. Set SCT to 0° SHFT, 352.5° TRUN
   OPTICS PWR - OFF

3. ATT SET dials - R,P,Y ALIGN

4. Mnvr to position stars in SCT
   0° mark - Arcturus (31)
   R line - Denebola (23)
   or

   NORTH
   0° mark - Navi (3)
   R line - Polaris (5)

   SOUTH
   Acrux (25)
   Atria (34)
FDAI SELECT = 1
ATT SET = GDC
GDC ALIGN PB - push until needles nulled

ATT SET dials = 0,0,0

MNVR to 0,0,0 and null error needles

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

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

IN-PLANE GDC ALIGNMENT
CMC - on
ISS - on
SCS - operating

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

F 06 34 GET ALIGN 0,0,0
PRO

F 06 22 R,P,Y

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

FDAI SELECT = 1
ATT SET = GDC
GDC ALIGN = push

V37E XXE
PGNS ORDEAL INITIALIZATION
(In-Plane Alignment Req'd)

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

2
 V82E
 F 04 12 00002 SPECIFY VEHICLE
 00001
 PRO

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

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

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

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

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

2
 MSFN Supply Altitude
 ALT SET - Set

3
 SC +X At the Horizon

4
 MODE - HOLD/FAST
 SLEW FDAI (See table)
 MODE - OPR/SLOW
<table>
<thead>
<tr>
<th>LUNAR</th>
<th>EARTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt(nm)</td>
<td>Angle*</td>
</tr>
<tr>
<td>8</td>
<td>7°</td>
</tr>
<tr>
<td>60</td>
<td>20°</td>
</tr>
<tr>
<td>170</td>
<td>32°</td>
</tr>
</tbody>
</table>

*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 - ZERO (verify)

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
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)

DOCKED IMU ALIGN
ATT DB - MIN
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 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)
GENERAL V79 PROPERTIES

1. Max att DB: 30°
   Min att DB: 0.4°

2. Max rate: 8.9999°/sec
   Min rate: 0 may be loaded but forced firing will occur unless appropriate jet is disabled

3. To Terminate V79 PTC/ORB RATE:
   Select one of the following ACTIONS then enable all necessary jets via AUTO RCS SELECT and MAN ATT sw's

<table>
<thead>
<tr>
<th>EFFECT</th>
<th>ACTION</th>
<th>ZERO COMMANDED RATE</th>
<th>RETURN TO D.B. SPECIFIED IN R03</th>
<th>ZERO ATTITUDE ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V46E</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>CYCLE</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>S/C CONT</td>
<td></td>
<td>(D.B. Center Shifting)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SW -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMC-SCS-CMC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMC MODE-HOLD</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V37EXXE</td>
<td>X</td>
<td>X</td>
<td>(D.B. Center not shifted)</td>
</tr>
<tr>
<td></td>
<td>KALCMANU</td>
<td>*</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>RHC out-of-detent</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>V48E, PRO, PRO, PRO</td>
<td></td>
<td>X</td>
<td>(D.B. Center not shifted)</td>
</tr>
</tbody>
</table>

*KALCMANU Generates new commanded rates
PASSIVE THERMAL CONTROL (G&N)

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

1 V48E (Select 0.5° DB)
   V37E 00E
   V49E

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

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

4 06 18 AUTO MANEUVER
   F 50 18

5 Damp vehicle rates:
   ENTR
   Disable all jets on two adjacent quads
   Wait 20 minutes for rates to damp
   MAN ATT (PITCH & YAW) - ACCEL CMD
   MAN ATT (ROLL) - RATE CMD

6 V79E

7 F 06 79 Rate, Deadband, Code (.0001°/sec, .01°, +XXXXX)
   Load desired values in R1 and R2
   and +00000 in R3
   Enable all jets
   PRO

8 MAN ATT (ROLL) - ACCEL CMD
   MAN ATT (PITCH & YAW) - RATE CMD
To disable RCS:
AUTO RCS SEL (16) - OFF
ROT CONTR PWR DIR (2) - OFF

To exit G&N PTC
1. MAN ATT (3) - ACCEL CMD
   AUTO RCS SEL (12) - MNA/B
2. Verify DAP load
3. Select new desired att:
   V49E
   F 06 22 New ICDU angles
   SC CONT - SCS, then CMC
   PRO
   F 50 18
4. Start auto maneuver:
   PRO within 180° (in direction of roll)
   of new att
   MAN ATT (3) - RATE CMD

For simple termination: See "GENERAL V79 PROPERTIES"

PASSIVE THERMAL CONTROL (SCS)

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

1. DEADBAND - MIN
   RATE - LOW
   LIMIT CYCLE - ON(up)
   MAN ATT (3) - RATE CMD
   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. DEADBAND - MAX
   MAN ATT (ROLL) - ACCEL CMD or MIN IMP
   FDAI SCALE - 5/1
Initiate Desired Roll Rate

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

TERMINATE PTC

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

PITCH ORBIT RATE MANEUVER (G&N)

Note: V79 orb rate is designed to operate most efficiently at 7.25° roll. A roll angle of 180° will yield the proper rate for low values (\(\approx 0.05^\circ/\text{sec}\)) but will use \(\approx 6\) times as much fuel as roll=0°.

1

V79E

2 F 06 79 RATE, DB, CODE (.0001°/sec, .01°, +XXXXX)
Load desired values in R1&R2 & non-zero in R3

3 To Terminate: See "GENERAL V79 PROPERTIES"
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 3 MIN) (DUMP E MEMORY)
V36E
V48E (LOAD DAP AS DESIRED - USE 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)
P52-OPTION 3-AUTO OPTICS
  AUTO OPTICS SUCCESSFUL, REFSMMAT VALID
  AUTO OPTICS UNSUCCESSFUL, DO P51
V16 N65 VERIFY CMC CLOCK (UPDATE)

VERIFY E MEMORY (MAY BE USED WHEN DESIRED)
  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)
  3. RETURN TO 1

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

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 PO0 TO BRING S.V. TO PRESENT TIME.
<table>
<thead>
<tr>
<th>OID</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>00021</td>
<td>00015</td>
<td>00010</td>
<td>00013</td>
<td>00023</td>
<td>00023</td>
<td>00024</td>
</tr>
<tr>
<td>02</td>
<td>01452</td>
<td>01706</td>
<td>01345</td>
<td>01767</td>
<td>02000</td>
<td>02021</td>
<td>02042</td>
</tr>
<tr>
<td>03</td>
<td>77316</td>
<td>00011</td>
<td>06510</td>
<td>00001</td>
<td>00137</td>
<td>00001</td>
<td>00003</td>
</tr>
<tr>
<td>04</td>
<td>74561</td>
<td>03366</td>
<td>07025</td>
<td>24315</td>
<td>00763</td>
<td>03120</td>
<td>02526</td>
</tr>
<tr>
<td>05</td>
<td>77143</td>
<td>11000</td>
<td>00620</td>
<td>00000</td>
<td>00023</td>
<td>00001</td>
<td>00015</td>
</tr>
<tr>
<td>06</td>
<td>74705</td>
<td>30623</td>
<td>00000</td>
<td>22274</td>
<td>00001</td>
<td>03120</td>
<td>00107</td>
</tr>
<tr>
<td>07</td>
<td>77667</td>
<td>37367</td>
<td>27340</td>
<td>00552</td>
<td>00000</td>
<td>00311</td>
<td>00022</td>
</tr>
<tr>
<td>10</td>
<td>71220</td>
<td>00000</td>
<td>37723</td>
<td>02210</td>
<td>00000</td>
<td>31177</td>
<td>35751</td>
</tr>
<tr>
<td>11</td>
<td>77646</td>
<td>23066</td>
<td>25231</td>
<td>00471</td>
<td>77700</td>
<td>00012</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>77332</td>
<td>00000</td>
<td>12160</td>
<td>00364</td>
<td>55774</td>
<td>24655</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>76617</td>
<td>26474</td>
<td>03363</td>
<td>04400</td>
<td>77762</td>
<td>00077</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>00710</td>
<td>37777</td>
<td></td>
<td></td>
<td>77772</td>
<td>55732</td>
<td>25776</td>
</tr>
</tbody>
</table>

CSM 109

Basic Date 3/9/70

Changed
<table>
<thead>
<tr>
<th>OID</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>00023</td>
<td>37777</td>
<td></td>
<td></td>
<td>46750</td>
<td>00011</td>
<td>77747</td>
</tr>
<tr>
<td>16</td>
<td>00665</td>
<td></td>
<td></td>
<td></td>
<td>77773</td>
<td>14374</td>
<td>50503</td>
</tr>
<tr>
<td>17</td>
<td>77731</td>
<td></td>
<td></td>
<td></td>
<td>57473</td>
<td>11272</td>
<td>77764</td>
</tr>
<tr>
<td>20</td>
<td>00000</td>
<td></td>
<td></td>
<td></td>
<td>00006</td>
<td>77767</td>
<td>75066</td>
</tr>
<tr>
<td>21</td>
<td>77615</td>
<td></td>
<td></td>
<td></td>
<td>06361</td>
<td>77461</td>
<td>00010</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>00002</td>
<td>00006</td>
<td>32477</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>26244</td>
<td>07520</td>
<td></td>
<td>77616</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55641</td>
<td></td>
</tr>
<tr>
<td>OID</td>
<td>H</td>
<td>I</td>
<td>J</td>
<td>K</td>
<td>L</td>
<td>M</td>
<td>S.V.</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>01</td>
<td>00024</td>
<td>00024</td>
<td>00022</td>
<td>00023</td>
<td>00021</td>
<td>00017</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>02064</td>
<td>02106</td>
<td>02130</td>
<td>03000</td>
<td>03025</td>
<td>00110</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>77703</td>
<td>02200</td>
<td>00104</td>
<td>00436</td>
<td>37777</td>
<td>01164</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>50475</td>
<td>26131</td>
<td>30027</td>
<td>02732</td>
<td>00000</td>
<td>01341</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>77433</td>
<td>10341</td>
<td>17316</td>
<td>00000</td>
<td>00000</td>
<td>00005</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>73503</td>
<td>33317</td>
<td>12110</td>
<td>00000</td>
<td>54360</td>
<td>01477</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>77501</td>
<td>77034</td>
<td>07464</td>
<td>77777</td>
<td>21075</td>
<td>00000</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>77051</td>
<td>65247</td>
<td>05025</td>
<td>77777</td>
<td>37777</td>
<td>02377</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>77621</td>
<td>77617</td>
<td>03227</td>
<td>42757</td>
<td>60465</td>
<td>00142</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>53532</td>
<td>73321</td>
<td>30062</td>
<td>11463</td>
<td>00000</td>
<td>03021</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>76161</td>
<td>77302</td>
<td>67162</td>
<td>05605</td>
<td>54360</td>
<td>01000</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>64227</td>
<td>43346</td>
<td>44435</td>
<td>74133</td>
<td>21075</td>
<td>03022</td>
<td></td>
</tr>
</tbody>
</table>

CSM 109
Basic Date 3/9/70
Changed
<table>
<thead>
<tr>
<th>OID</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>S.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>00476</td>
<td>67237</td>
<td>16760</td>
<td>00075</td>
<td>37777</td>
<td>00232</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>02346</td>
<td>71001</td>
<td>16057</td>
<td>00005</td>
<td>57142</td>
<td>03376</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>00213</td>
<td>73231</td>
<td>06373</td>
<td>00123</td>
<td>33106</td>
<td>01603</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>01672</td>
<td>43753</td>
<td>07034</td>
<td>00175</td>
<td>50741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>00643</td>
<td>72065</td>
<td>00531</td>
<td>17433</td>
<td>31162</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>27314</td>
<td>42562</td>
<td>10621</td>
<td>04500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>04076</td>
<td>00471</td>
<td>00334</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>21423</td>
<td>15165</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LM OR CSM S.V. READOUT

1  V83E

2  After Integration: V05N01E

<table>
<thead>
<tr>
<th>CSM S.V.</th>
<th>LM S.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2254E</td>
<td>2224E</td>
</tr>
<tr>
<td>E,2257E</td>
<td>E,2227E</td>
</tr>
<tr>
<td>E,2262E</td>
<td>E,2240E</td>
</tr>
<tr>
<td>E,2265E</td>
<td>E,2243E</td>
</tr>
<tr>
<td>E,2342E</td>
<td>E,2342E</td>
</tr>
<tr>
<td>PRO</td>
<td>PRO</td>
</tr>
</tbody>
</table>

Basic Date: 3/9/70

3  Transmit S.V. & Time Tag To LM

LM OR CSM S.V. LOADING

1  V37E00E
   V71E
   21E
   1501E
   (CSM S.V.) 00002E, Plus Xmitted Pad
   (LM S.V.) 77775E, Plus Xmitted Pad
   V33E
I. Loss of communications navigation procedures for abort from translunar coast at 8:00 hrs GET.

A. Make abort burn

B. Reinitialize the W matrix. Use extended verb 67 and at the V06N99 display, load:

\[ R1 + 80000 \text{ (80,000 ft)} \]
\[ R2 + 00070 \text{ (7 ft/sec)} \]
\[ R3 + 00003 \text{ (Cislunar Navigation Code)} \]

C. Determine the return length and look at the corresponding table below in H for the schedule to be followed. For all return lengths less than 20 hours, Schedule 1 should be used. For all return lengths greater than 20 hours, Schedule 2 should be used.

D. Times given for each batch of data are referenced to entry interface. (P-37 may be used to determine the time reference.)

E. Start tracking with the first batch of data following the current time.

F. Calibrate optics at the beginning of each batch and every half hour while navigation sightings are in progress. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 1 bit (.003°).

G. Large \( \Delta R, \Delta V \) values may be expected at the following times:

1. At the initiation of tracking (the first mark on each star of the first batch of data taken).

2. After a long period of no sightings.

3. During the last 6 hours before entry interface.

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

H. Sighting schedules for aborts from translunar coast at 8:00 hours GET due to a communications loss
Table I
Sighting Schedule for an Abort from Translunar Coast
at 8:00 Hours, Short Return (GMT of EI=April 12, 17 hrs., 57 min.)

<table>
<thead>
<tr>
<th>Time</th>
<th>Star</th>
<th>Horizon</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI-14</td>
<td>33 (Antares)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*125</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-11.5</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*125</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-9</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 76</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-7</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*221</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-5</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>214</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>224</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-2.5</td>
<td>1 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*224</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*223</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

* Alternate Sightings
Table II

Sighting Schedule for an Abort from Translunar Coast
at 8:00 Hours, Long Return (GMT of EI=April 13, 18 hrs., 32 min.)

<table>
<thead>
<tr>
<th>EI-</th>
<th>Star</th>
<th>Horizon</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI-38</td>
<td>33 (Antares)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 40 (Altair)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-35</td>
<td>33 (Antares)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>40 (Altair)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-27</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-24</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-21</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*212</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-12</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>214</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>42 (Peacock)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-9.5</td>
<td>37 (Nunki)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>214</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 40 (Altair)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

*Alternate Sightings
Table II
(Continued)

<table>
<thead>
<tr>
<th>EI-7</th>
<th>1 (Alpheratz)</th>
<th>EN</th>
<th>00110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>40 (Altair)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-5</th>
<th>1 (Alpheratz)</th>
<th>EN</th>
<th>00110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>224</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-2.5</th>
<th>1 (Alpheratz)</th>
<th>EN</th>
<th>00110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

* Alternate Sightings
II. Loss of communications navigation procedures for aborts from lunar orbit.

A. Aborts from lunar orbit due to communications loss:

1. Make the abort burn.

2. Reinitialize W matrix. Use extended verb 67 and at the V06N99 display, load:

   \[ R_1 + 30000 \text{ (30,000 ft)} \]
   \[ R_2 + 00300 \text{ (30 ft/sec)} \]
   \[ R_3 + 00003 \text{ (Cislunar Navigation Code)} \]

3. Determine the day of entry of the abort and look at the table in 8 below for the schedule to be followed. For aborts returning on April 20, Schedule 1 should be used. For aborts returning on April 21, Schedule 2 should be used.

4. Time is referenced from TEI time for the first 35 hours, and EI time thereafter. This is done to provide for varying return lengths.

5. Calibrate optics at the beginning of each batch and every half hour while navigation sightings are in progress. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 1 bit (.003°).

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

   a. At the initiation of tracking (for the first mark on each star of the first batch of data).

   b. At the first switch of reference bodies.

   c. After a long period of no sightings.

   d. During the last hours of the TE coast when the vehicle is near the earth.
If a large state vector correction (greater than 50 nautical miles in position and 50 feet per second in velocity) is displayed during the V06N49 display in P23, the mark should be rejected and repeated. If the large correction occurs again, it should be accepted and incorporated. (Corrections this large should not be expected in cases other than a and b above.)

7. If a $W$ matrix reinitialization occurs after optical sightings are initiated due to a communications loss, the following procedures should be followed.

a. If the reinitialization does not occur while sightings are being taken, the $W$ matrix should be reinitialized at the next batch to the diagonal value associated with that batch.

b. If the reinitialization occurs while a batch is in progress, the $W$ matrix should be reinitialized to the diagonal value associated with the batch during which the loss occurred, and the batch restarted immediately. (See II-B-3 for values.)

c. The current onboard state vector at the time of the $W$ matrix reinitialization is retained.

d. The remainder of the optical schedule is followed as if the $W$ matrix reinitialization had not occurred.

8. Tables of sighting schedules for aborts from lunar orbit.
Table I
Sighting Schedule for Aboris from Lunar Orbit
GMT of entry interface = April 20, 20 hours

<table>
<thead>
<tr>
<th>Time</th>
<th>Star</th>
<th>Horizon</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEI+1.5</td>
<td>34 (Atria)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>35 (Rasalague)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>25 (Acrux)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>33 (Antares)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>TEI+13</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 02 (Diphda)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>TEI+16</td>
<td>30 (Menkent)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>31 (Arcturus)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>32 (Alphecca)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td>TEI+20</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>TEI+24</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>TEI+28</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-28</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-23</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-20</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-8</td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

*alternate stars
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EI-5</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
<td></td>
</tr>
<tr>
<td>33 (Antares)</td>
<td>MF</td>
<td>00220</td>
<td></td>
</tr>
<tr>
<td>23 (Denebola)</td>
<td>MN</td>
<td>00210</td>
<td></td>
</tr>
<tr>
<td>24 (Gienah)</td>
<td>MN</td>
<td>00210</td>
<td></td>
</tr>
<tr>
<td>30 (Menkent)</td>
<td>MF</td>
<td>00220</td>
<td></td>
</tr>
<tr>
<td><strong>EI-2.5</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
<td></td>
</tr>
<tr>
<td>22 (Regulus)</td>
<td>MN</td>
<td>00210</td>
<td></td>
</tr>
<tr>
<td>23 (Denebola)</td>
<td>MN</td>
<td>00210</td>
<td></td>
</tr>
<tr>
<td>* 24 (Gienah)</td>
<td>MN</td>
<td>00210</td>
<td></td>
</tr>
<tr>
<td>* 30 (Menkent)</td>
<td>MF</td>
<td>00220</td>
<td></td>
</tr>
</tbody>
</table>
Table II
Sighting Schedule for Aborts from Lunar Orbit
GMT of entry interface = April 21, 20 hours

<table>
<thead>
<tr>
<th>Time</th>
<th>Star</th>
<th>Horizon</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEI+1.5</td>
<td>37 (Nunki)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>35 (Rasalague)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>42 (Peacock)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>30 (Menkent)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>34 (Atria)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>TEI+13</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+15.5</td>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>33 (Antares)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>24 (Gienah)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>*31 (Arcturus)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td>TEI+20</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+24</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+28</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-32</td>
<td>01 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-28</td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-23</td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

* alternate stars
<table>
<thead>
<tr>
<th>EI-20</th>
<th>45 (Formalhaut)</th>
<th>EF</th>
<th>00120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>44 (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>224</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-12</td>
<td>44 (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>224</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>EI-5</td>
<td>33 (Antares)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>24 (Gienah)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>23 (Denebola)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>30 (Menkent)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>EI-2.5</td>
<td>33 (Antares)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>23 (Denebola)</td>
<td>MF</td>
<td>00220</td>
</tr>
</tbody>
</table>

* alternate stars
B. Communications loss during transearth coast following an abort from lunar orbit.

If you have received the entry pad, then no tracking is performed. If not true, then proceed.

1. Check to see if schedules given in II-A-8 are applicable. If not, go to Section IV. (In general, very short and very long aborts are not covered by the charts.)

2. Start tracking with the first batch of data following the current time.

3. Reinitialize W matrix. Use extended verb 67 and at the VO6N99 display, load:

   a. Com loss before Batch 1

      R1 + 30000 (30,000 ft)
      R2 + 00300 (30. ft/sec)
      R3 + 00003 (Cislunar Navigation Code)

   b. Com loss after Batch 1 with no state vector update after TEI:

      R1 + 99000 (99,000 ft)
      R2 + 00020 (2. ft/sec)
      R3 + 00003 (Cislunar Navigation Code)

   c. Com loss after Batch 1 with at least one state vector update after TEI

      R1 + 45000 (45,000 ft)
      R2 + 00006 (0.6 ft/sec)
      R3 + 00003 (Cislunar Navigation Code)

4. General rules in III for loss of communications during transearth coast are applicable. (See III-B, D, E, and G)
III. Loss of communications navigation procedures during nominal transearth trajectory.

If you have received the entry pad, then no tracking is performed. If above not true, then proceed.

A. The schedule provided below in G is references to launch azimuth and TLI opportunity. It is valid for nominal transearth situations between 72° launch azimuth, first TLI opportunity and 96° launch azimuth, second TLI opportunity on April 11.

B. Start tracking with the first batch of data following the current time.

C. Reinitialize the W matrix. Use extended verb 67 and at the V06N99 display, load:

1. Com loss before first batch
   
   R1 + 30000 (30,000 ft)
   R2 + 00300 (30 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)

2. Com loss after first batch with no state vector update after TEI:
   
   R1 + 99000 (99,000 ft)
   R2 + 00020 (2 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)

3. Com loss after batch 1 with at least one state vector update after TEI:
   
   R1 + 45000 (45,000 ft)
   R2 + 00006 (0.6 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)

D. Calibrate the optics at the beginning of each batch and every half hour while navigation sightings are in progress. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 1 bit (.003°).
E. Large state vector corrections may be expected at the following times:

1. At initiation of tracking (For the first mark on each star of the first batch of data)

2. At the first switch of reference bodies

3. After a long period of no sightings

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

If a large state vector correction (greater than 50 nautical miles in position and 50 feet per second in velocity) is displayed during the V06N49 display in P23, the mark should be rejected and repeated. If the large correction occurs again, it should be accepted and incorporated. (Corrections this large should not be expected in cases other than 1 and 2 above.)

F. If a W matrix reinitialization occurs after optical sightings are initiated due to a communications loss, the following procedures should be followed.

1. If the reinitialization does not occur while sightings are being taken, the W matrix should be reinitialized at the next batch to the diagonal value associated with that batch.

2. If the reinitialization occurs while a batch is in progress, the W matrix should be reinitialized to the diagonal value associated with the batch during which the reinitialization occurred, and the batch restarted immediately. (See III-C above for values.)

3. The current onboard state vector at the time of the W matrix reinitialization is retained.

4. The remainder of the optical schedule is followed as if the W matrix reinitialization had not occurred.

G. Tables of sighting schedules for loss of communications during nominal transearth coast.
Table I
Sighting Schedule for the Nominal Transearth Coast for 72°
Launch Azimuth, First TLI Opportunity, Through a 96° Launch Azimuth,
Second TLI Opportunity, for a Launch on April 11, 1970 (CMT of
EI = April 21, 20 hr., 15 min.)

<table>
<thead>
<tr>
<th>Time</th>
<th>Star</th>
<th>Horizon</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEI+1</td>
<td>37 (Nunki)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>30 (Menkent)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>34 (Atria)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>41 (Dabih)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>35 (Rasalague)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>TEI+13</td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 44 (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+15.5</td>
<td>26 (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>33 (Antares)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td></td>
<td>31 (Arcturus)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>* 24 (Gienah)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>* 25 (Acrux)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>TEI+20</td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 1 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+24</td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 1 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>TEI+28</td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 1 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>*126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>EI-32</td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45 (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>* 1 (Alpheratz)</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>* 44 (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
</tbody>
</table>
### Table I - Continued

<table>
<thead>
<tr>
<th>EI-28</th>
<th>221</th>
<th>EF</th>
<th>00120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>45  (Formalhaut)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>*</td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>*</td>
<td>44  (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-23</th>
<th>45  (Formalhaut)</th>
<th>EF</th>
<th>00120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>*</td>
<td>44  (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>*</td>
<td>126</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-20</th>
<th>45  (Formalhaut)</th>
<th>EF</th>
<th>00120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>221</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td>*</td>
<td>44  (Enif)</td>
<td>EF</td>
<td>00120</td>
</tr>
<tr>
<td>*</td>
<td>102</td>
<td>EN</td>
<td>00110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-10</th>
<th>44  (Enif)</th>
<th>EF</th>
<th>00120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>103</td>
<td>EN</td>
<td>00110</td>
</tr>
<tr>
<td></td>
<td>224</td>
<td>EF</td>
<td>00120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-5</th>
<th>33  (Antares)</th>
<th>MN</th>
<th>00210</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26  (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>24  (Gienah)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>23  (Denebola)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>31  (Arcturus)</td>
<td>MF</td>
<td>00220</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EI-2.5</th>
<th>33  (Antares)</th>
<th>MN</th>
<th>00210</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26  (Spica)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td></td>
<td>24  (Gienah)</td>
<td>MN</td>
<td>00210</td>
</tr>
<tr>
<td>*</td>
<td>23  (Denebola)</td>
<td>MF</td>
<td>00220</td>
</tr>
<tr>
<td>*</td>
<td>31  (Arcturus)</td>
<td>MF</td>
<td>00220</td>
</tr>
</tbody>
</table>

* Alternate Stars
V. Rules for a do-it-yourself sighting schedule.

If you have received the entry pad, then no tracking is performed. If not true, then proceed.

A. General rules

1. A sighting or set is to consist of three marks.

2. Reinitialize W matrix and schedule a tracking interval as soon as possible after the burn; or in the case of the lunar flyby, about 1 hour after perilune. If sightings are performed translunar for any reason, reinitialize the W matrix 1 hour after perilune for transearth sightings. W matrix values are given below in the discussion for each return type. (See B and C.)

3. Star availability is related to GMT not GET. Therefore, a chart which approximates the GMT of a particular situation can be used as a clue to determine stars available.

4. A batch is to consist of at least three star/horizon sighting; although as many as five can be advantageous, particularly following a sleep period.

5. All available stars should be used in the sighting schedule. No more than three marks should be taken on a star within a batch of data.

6. Sightings during the last 10 hours before entry interface are important. Five earth horizon sightings should be scheduled at EI-5 hours and three earth horizon sightings should be scheduled following the MCC at EI-3 hours. If no earth horizon sightings are available, lunar horizon sightings should be used.
7. Whenever possible, the navigation batches should be scheduled so that, immediately following a time period of length \( \Delta t \) (not to exceed 3 hours) in a non-PTC mode, five times \( \Delta t \) should be spent in a PTC mode (thermal constraints). This rule will be violated most frequently in the following situations: (1) aborts from a translunar trajectory with short return lengths, (2) time critical aborts, (3) the 10-hour period before entry interface.

8. If possible, both near and far horizons should be included in each batch of data.

9. Calibrate the optics at the beginning of each batch and every half hour while navigation sightings are in progress. The sextant calibration will be repeated until agreement of at least two checks (not necessarily sequential ones) are within 1 bit (.003\(^\circ\)).

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

a. At initiation of tracking (for the first mark on each star of the first batch of data.)

b. At the first switch of reference bodies.

c. After a long period of no sightings.

d. During the last 10 hours of before entry interface.

If a large state vector correction (greater than 50 nautical miles in position and 50 feet per second in velocity) is displayed during theVN4 display in P23, the mark should be rejected and repeated. If the large correction occurs again, it should be accepted and incorporated. ( Corrections this large should not be expected in cases other than a and b above.)

B. Aborts from a translunar trajectory:

1. Make abort burn

2. Read general rules contained in IV-A.
3. Initialize the W matrix. Use extended verb 67 and at the V06N99 display, load:

- RL + 80000 (80,000 ft)
- R2 + 00070 (7.0 ft/sec)
- R3 + 00003 (Cislunar Navigation Code)

4. Only star/earth horizon marks will be made.

5. If return length <20 hours, three sets should be scheduled every 2.5 hours with a batch of five sets at EI-5 hours before the last MCC at EI-3 hours, and three sets after the midcourse.

6. If return length >20 hours, sleep periods of 8 hours may be provided. Astronauts should be awake the last 10 hours before entry interface. Three sets should be scheduled every three hours while awake with five sets scheduled before each sleep period. Five sets should be taken before the last midcourse at TI-3 hours, and three sets after the midcourse.

7. If a W matrix reinitialization occurs after the optical sightings are initiated, the following procedures should be followed:

a. If the reinitialization does not occur while sightings are being taken, the W matrix should be reinitialized at the next batch to the diagonal value given in B-3.

b. If the reinitialization occurs while a batch is in progress, the W matrix should be reinitialized to the diagonal value given in B-3 and the batch restarted immediately.

c. The current onboard state vector at the time of the W matrix reinitialization is retained.

d. The remainder of the optical schedule is followed as if the W matrix reinitialization had not occurred.

C. Communications loss for flyby, aborts from lunar orbit, etc.

1. Make abort burn or wait until perilune.

2. Read general rules in IV-A.
3. Reinitialize W matrix. Use extended verb 67 and at the V06W99 display, load:
   
a. Com loss before Batch 1 (at TEI + 1 hour or perilune + 1 hour):
   
   R1 + 30000 (30,000 ft)
   R2 + 00300 (30 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)
   
b. Com loss after Batch 1 (at TEI + 1 hour or perilune + 1 hour) with no state vector update after TEI:
   
   R1 + 99000 (99,000 ft)
   R2 + 00020 (2.0 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)
   
c. Com loss after Batch 1 (at TEI + 1 hour or perilune + 1 hour) with at least one state vector update after TEI:
   
   R1 + 45000 (45,000 ft)
   R2 + 00006 (0.6 ft/sec)
   R3 + 00003 (Cislunar Navigation Code)
   
4. If return length ≥ 70 hours
   
a. Refer to Table 1 Section III for placement of batches of star/horizon sightings and relate the times given at "TEI +" and "EI -" to the specific transearth situation.
   For each batch scheduled, take three marks on each available star (up to 5 stars).
   
b. Schedule three earth horizon sightings for every 5 hours between TEI + 32 and EI - 40 hours, or if an additional sleep period is needed for very slow returns, schedule five earth horizon sightings before the sleep period and five earth horizon sightings upon awakening.
   
5. For return lengths < 70 hours
   
a. Sleep periods of 8 hours should be provided. Astronauts should be awake the last 10 hours before entry interface.
b. Three sets of star horizon observations should be scheduled every three hours while awake with five sets scheduled before and after each sleep period.

(1.) A batch of lunar horizon sightings should be taken at TEI + 1 hour or perilune + 1 hour.

(2.) The second batch of data should consist of earth horizon sightings.

(3.) The third batch of data should consist of lunar horizon sightings.

(4.) The remainder of the data should be earth horizon sightings. If no earth horizon sightings are available, lunar horizon sightings should be substituted.

c. Five earth/horizon sets should be scheduled at EI - 5 hours before the MCC at EI = 3 hours. Three sets should be taken after the midcourse. If no earth horizon sightings are available, lunar horizon sightings should be substituted.

6. If a W matrix reinitialization occurs after optical sightings are initiated due to a transearth communications loss, the following procedures should be followed.

a. If the reinitialization does not occur while sightings are being taken, the W matrix should be reinitialized at the next batch to the diagonal value associated with that batch. (W matrices are given in C-3.)

b. If the reinitialization occurs while a batch is in progress, the W matrix should be reinitialized to the diagonal value associated with the batch during which the loss occurred, and the batch restarted immediately.

c. The current onboard state vector at the time of the W matrix reinitialization is retained.

d. The remainder of the optical schedule is followed as if the W matrix reinitialization had not occurred.
## VENUS HALF-UNIT VECTORS

**APRIL 11, 19 HOUR GMT LAUNCH**

<table>
<thead>
<tr>
<th>TIME (GMT) MD DA HR</th>
<th>TIME (GET) HOURS</th>
<th>X(R1)</th>
<th>Y(R2)</th>
<th>Z(R3)</th>
<th>TIME (GMT) MD DA HR</th>
<th>TIME (GET) HOURS</th>
<th>X(R1)</th>
<th>Y(R2)</th>
<th>Z(R3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 11 19</td>
<td>0</td>
<td>.38103</td>
<td>.29788</td>
<td>.12682</td>
<td>4 17 5</td>
<td>130.0</td>
<td>.34089</td>
<td>.33565</td>
<td>.14537</td>
</tr>
<tr>
<td>4 12 0</td>
<td>5.0</td>
<td>.37957</td>
<td>.29942</td>
<td>.12757</td>
<td>4 17 10</td>
<td>135.0</td>
<td>.33926</td>
<td>.33701</td>
<td>.14605</td>
</tr>
<tr>
<td>4 12 5</td>
<td>10.0</td>
<td>.37810</td>
<td>.30095</td>
<td>.12832</td>
<td>4 17 15</td>
<td>140.0</td>
<td>.33762</td>
<td>.33835</td>
<td>.14672</td>
</tr>
<tr>
<td>4 12 10</td>
<td>15.0</td>
<td>.37663</td>
<td>.30248</td>
<td>.12906</td>
<td>4 17 20</td>
<td>145.0</td>
<td>.33598</td>
<td>.33970</td>
<td>.14739</td>
</tr>
<tr>
<td>4 12 15</td>
<td>20.0</td>
<td>.37515</td>
<td>.30399</td>
<td>.12980</td>
<td>4 18 1</td>
<td>150.0</td>
<td>.33433</td>
<td>.34103</td>
<td>.14805</td>
</tr>
<tr>
<td>4 12 20</td>
<td>25.0</td>
<td>.37365</td>
<td>.30551</td>
<td>.13054</td>
<td>4 18 6</td>
<td>155.0</td>
<td>.33268</td>
<td>.34236</td>
<td>.14871</td>
</tr>
<tr>
<td>4 13 1</td>
<td>30.0</td>
<td>.37217</td>
<td>.30701</td>
<td>.13128</td>
<td>4 18 11</td>
<td>160.0</td>
<td>.33102</td>
<td>.34368</td>
<td>.14937</td>
</tr>
<tr>
<td>4 13 6</td>
<td>35.0</td>
<td>.37067</td>
<td>.30851</td>
<td>.13201</td>
<td>4 18 16</td>
<td>165.0</td>
<td>.32935</td>
<td>.34499</td>
<td>.15002</td>
</tr>
<tr>
<td>4 13 11</td>
<td>40.0</td>
<td>.36916</td>
<td>.31000</td>
<td>.13274</td>
<td>4 18 21</td>
<td>170.0</td>
<td>.32768</td>
<td>.34630</td>
<td>.15068</td>
</tr>
<tr>
<td>4 13 16</td>
<td>45.0</td>
<td>.36765</td>
<td>.31148</td>
<td>.13347</td>
<td>4 19 2</td>
<td>175.0</td>
<td>.32600</td>
<td>.34760</td>
<td>.15132</td>
</tr>
<tr>
<td>4 13 21</td>
<td>50.0</td>
<td>.36613</td>
<td>.31296</td>
<td>.13419</td>
<td>4 19 7</td>
<td>180.0</td>
<td>.32432</td>
<td>.34889</td>
<td>.15197</td>
</tr>
<tr>
<td>4 14 2</td>
<td>55.0</td>
<td>.36460</td>
<td>.31443</td>
<td>.13491</td>
<td>4 19 12</td>
<td>185.0</td>
<td>.32263</td>
<td>.35017</td>
<td>.15261</td>
</tr>
<tr>
<td>4 14 7</td>
<td>60.0</td>
<td>.36305</td>
<td>.31590</td>
<td>.13563</td>
<td>4 19 17</td>
<td>190.0</td>
<td>.32093</td>
<td>.35145</td>
<td>.15325</td>
</tr>
<tr>
<td>4 14 12</td>
<td>65.0</td>
<td>.36152</td>
<td>.31735</td>
<td>.13635</td>
<td>4 19 22</td>
<td>195.0</td>
<td>.31923</td>
<td>.35272</td>
<td>.15389</td>
</tr>
<tr>
<td>4 14 17</td>
<td>70.0</td>
<td>.35997</td>
<td>.31880</td>
<td>.13706</td>
<td>4 20 3</td>
<td>200.0</td>
<td>.31752</td>
<td>.35398</td>
<td>.15452</td>
</tr>
<tr>
<td>4 14 22</td>
<td>75.0</td>
<td>.35842</td>
<td>.32025</td>
<td>.13777</td>
<td>4 20 8</td>
<td>205.0</td>
<td>.31581</td>
<td>.35524</td>
<td>.15516</td>
</tr>
<tr>
<td>4 15 3</td>
<td>80.0</td>
<td>.35685</td>
<td>.32168</td>
<td>.13847</td>
<td>4 20 13</td>
<td>210.0</td>
<td>.31409</td>
<td>.35648</td>
<td>.15578</td>
</tr>
<tr>
<td>4 15 8</td>
<td>85.0</td>
<td>.35529</td>
<td>.32311</td>
<td>.13918</td>
<td>4 20 18</td>
<td>215.0</td>
<td>.31237</td>
<td>.35772</td>
<td>.15640</td>
</tr>
<tr>
<td>4 15 13</td>
<td>90.0</td>
<td>.35371</td>
<td>.32452</td>
<td>.13988</td>
<td>4 20 23</td>
<td>220.0</td>
<td>.31064</td>
<td>.35895</td>
<td>.15702</td>
</tr>
<tr>
<td>4 15 18</td>
<td>95.0</td>
<td>.35213</td>
<td>.32595</td>
<td>.14058</td>
<td>4 21 4</td>
<td>225.0</td>
<td>.30890</td>
<td>.35918</td>
<td>.15764</td>
</tr>
<tr>
<td>4 15 23</td>
<td>100.0</td>
<td>.35055</td>
<td>.32735</td>
<td>.14127</td>
<td>4 21 9</td>
<td>230.0</td>
<td>.30716</td>
<td>.36018</td>
<td>.15825</td>
</tr>
<tr>
<td>4 16 4</td>
<td>105.0</td>
<td>.34895</td>
<td>.32875</td>
<td>.14196</td>
<td>4 21 14</td>
<td>235.0</td>
<td>.30542</td>
<td>.36140</td>
<td>.15887</td>
</tr>
<tr>
<td>4 16 9</td>
<td>110.0</td>
<td>.34735</td>
<td>.33015</td>
<td>.14265</td>
<td>4 21 19</td>
<td>240.0</td>
<td>.30366</td>
<td>.36281</td>
<td>.15947</td>
</tr>
<tr>
<td>4 16 14</td>
<td>115.0</td>
<td>.34575</td>
<td>.33153</td>
<td>.14334</td>
<td>4 22 0</td>
<td>245.0</td>
<td>.30191</td>
<td>.36650</td>
<td>.16008</td>
</tr>
<tr>
<td>4 16 19</td>
<td>120.0</td>
<td>.34413</td>
<td>.33291</td>
<td>.14402</td>
<td>4 22 5</td>
<td>250.0</td>
<td>.30014</td>
<td>.36919</td>
<td>.16068</td>
</tr>
<tr>
<td>4 17 0</td>
<td>125.0</td>
<td>.34252</td>
<td>.33428</td>
<td>.14470</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### MARS HALF-UNIT VECTORS

**APRIL 11, 19 HOUR GMT LAUNCH**

<table>
<thead>
<tr>
<th>TIME (GMT)</th>
<th>TIME (GET)</th>
<th>X(R1)</th>
<th>Y(R2)</th>
<th>Z(R3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO DA HR</td>
<td>HOURS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 11 19</td>
<td>0.0</td>
<td>0.28542</td>
<td>0.37462</td>
<td>0.16790</td>
</tr>
<tr>
<td>4 12 5</td>
<td>10.0</td>
<td>0.28334</td>
<td>0.37583</td>
<td>0.16651</td>
</tr>
<tr>
<td>4 12 15</td>
<td>20.0</td>
<td>0.28124</td>
<td>0.37723</td>
<td>0.16910</td>
</tr>
<tr>
<td>4 13 1</td>
<td>30.0</td>
<td>0.27915</td>
<td>0.37852</td>
<td>0.16970</td>
</tr>
<tr>
<td>4 13 11</td>
<td>40.0</td>
<td>0.27704</td>
<td>0.37980</td>
<td>0.17029</td>
</tr>
<tr>
<td>4 13 21</td>
<td>50.0</td>
<td>0.27494</td>
<td>0.38107</td>
<td>0.17087</td>
</tr>
<tr>
<td>4 14 7</td>
<td>60.0</td>
<td>0.27283</td>
<td>0.38233</td>
<td>0.17145</td>
</tr>
<tr>
<td>4 14 17</td>
<td>70.0</td>
<td>0.27071</td>
<td>0.38357</td>
<td>0.17202</td>
</tr>
<tr>
<td>4 15 3</td>
<td>80.0</td>
<td>0.26859</td>
<td>0.38480</td>
<td>0.17259</td>
</tr>
<tr>
<td>4 15 13</td>
<td>90.0</td>
<td>0.26646</td>
<td>0.38603</td>
<td>0.17316</td>
</tr>
<tr>
<td>4 15 23</td>
<td>100.0</td>
<td>0.26434</td>
<td>0.38724</td>
<td>0.17371</td>
</tr>
<tr>
<td>4 16 9</td>
<td>110.0</td>
<td>0.26220</td>
<td>0.38844</td>
<td>0.17426</td>
</tr>
<tr>
<td>4 16 19</td>
<td>120.0</td>
<td>0.26007</td>
<td>0.38963</td>
<td>0.17480</td>
</tr>
<tr>
<td>4 17 5</td>
<td>130.0</td>
<td>0.25793</td>
<td>0.39080</td>
<td>0.17535</td>
</tr>
<tr>
<td>4 17 15</td>
<td>140.0</td>
<td>0.25578</td>
<td>0.39197</td>
<td>0.17588</td>
</tr>
<tr>
<td>4 18 1</td>
<td>150.0</td>
<td>0.25363</td>
<td>0.39312</td>
<td>0.17642</td>
</tr>
<tr>
<td>4 18 11</td>
<td>160.0</td>
<td>0.25148</td>
<td>0.39427</td>
<td>0.17694</td>
</tr>
<tr>
<td>4 18 21</td>
<td>170.0</td>
<td>0.24933</td>
<td>0.39540</td>
<td>0.17747</td>
</tr>
<tr>
<td>4 19 7</td>
<td>180.0</td>
<td>0.24717</td>
<td>0.39652</td>
<td>0.17798</td>
</tr>
<tr>
<td>4 19 17</td>
<td>190.0</td>
<td>0.24501</td>
<td>0.39763</td>
<td>0.17849</td>
</tr>
<tr>
<td>4 20 3</td>
<td>200.0</td>
<td>0.24284</td>
<td>0.39873</td>
<td>0.17900</td>
</tr>
<tr>
<td>4 20 13</td>
<td>210.0</td>
<td>0.24067</td>
<td>0.39982</td>
<td>0.17950</td>
</tr>
<tr>
<td>4 20 23</td>
<td>220.0</td>
<td>0.23850</td>
<td>0.40090</td>
<td>0.18000</td>
</tr>
<tr>
<td>4 21 9</td>
<td>230.0</td>
<td>0.23632</td>
<td>0.40196</td>
<td>0.18050</td>
</tr>
<tr>
<td>4 21 19</td>
<td>240.0</td>
<td>0.23414</td>
<td>0.40302</td>
<td>0.18098</td>
</tr>
<tr>
<td>4 22 5</td>
<td>250.0</td>
<td>0.23195</td>
<td>0.40406</td>
<td>0.18147</td>
</tr>
</tbody>
</table>

### JUPITER HALF-UNIT VECTORS

**APRIL 11, 19 HOUR GMT LAUNCH**

<table>
<thead>
<tr>
<th>TIME (GMT)</th>
<th>TIME (GET)</th>
<th>X(R1)</th>
<th>Y(R2)</th>
<th>Z(R3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO DA HR</td>
<td>HOURS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 11 19</td>
<td>0.0</td>
<td>0.38580</td>
<td>0.29856</td>
<td>0.10910</td>
</tr>
<tr>
<td>4 13 21</td>
<td>50.0</td>
<td>0.38443</td>
<td>0.30026</td>
<td>0.10983</td>
</tr>
<tr>
<td>4 15 23</td>
<td>100.0</td>
<td>0.38296</td>
<td>0.30195</td>
<td>0.11054</td>
</tr>
<tr>
<td>4 18 1</td>
<td>150.0</td>
<td>0.38150</td>
<td>0.30345</td>
<td>0.11126</td>
</tr>
<tr>
<td>4 20 3</td>
<td>200.0</td>
<td>0.38002</td>
<td>0.30505</td>
<td>0.11196</td>
</tr>
<tr>
<td>4 22 5</td>
<td>250.0</td>
<td>0.37854</td>
<td>0.30662</td>
<td>0.11267</td>
</tr>
</tbody>
</table>

### SATURN HALF-UNIT VECTORS

**APRIL 11, 19 HOUR GMT LAUNCH**

<table>
<thead>
<tr>
<th>TIME (GMT)</th>
<th>TIME (GET)</th>
<th>X(R1)</th>
<th>Y(R2)</th>
<th>Z(R3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO DA HR</td>
<td>HOURS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 11 19</td>
<td>0.0</td>
<td>-0.42242</td>
<td>-0.25034</td>
<td>-0.09430</td>
</tr>
<tr>
<td>4 13 21</td>
<td>50.0</td>
<td>-0.42363</td>
<td>-0.24857</td>
<td>-0.09353</td>
</tr>
<tr>
<td>4 15 23</td>
<td>100.0</td>
<td>-0.42484</td>
<td>-0.24679</td>
<td>-0.09277</td>
</tr>
<tr>
<td>4 18 1</td>
<td>150.0</td>
<td>-0.42603</td>
<td>-0.24502</td>
<td>-0.09201</td>
</tr>
<tr>
<td>4 20 3</td>
<td>200.0</td>
<td>-0.42721</td>
<td>-0.24324</td>
<td>-0.09125</td>
</tr>
<tr>
<td>4 22 5</td>
<td>250.0</td>
<td>-0.42837</td>
<td>-0.24147</td>
<td>-0.09050</td>
</tr>
</tbody>
</table>

---

CSM 109

Basic Date 3/9/70

Changed ________

G 11-2
NO COMM LM JETTISON

EARTH ORBIT - (LM/CSM CONTINGENCY DEORBIT)

MNVR TO POSIGRADE/HEADS DOWN ATTITUDE
POSITION 31.7° LINE ON HORIZON

RETRO FIRE - 20 MIN

JETTISON LM
PERFORM -X 4 JET TRANSLATION (24 SEC)
MNVR TO RETRO FIRE ATTITUDE

TRANS Lunar COAST - (DIRECT ABORT FROM TLC)

PITCH 180° FROM ABORT ATTITUDE

ABORT BURN - 30 MIN

JETTISON LM
PERFORM -X TRANSLATION (ΔV = 1 FPS)
MNVR TO ABORT BURN ATTITUDE

LUNAR ORBIT - (CONTINGENCY TEI)

(PERFORM 8½1 HOUR (NO LATER THAN 30 MIN) PRIOR
TO TEI)

MNVR TO LV/LH ATT R = 180° (HEADS DOWN)
P = 000°
Y = 000°

USE P47 OR EMS TO MONITOR SEP MNVR
TEI - 1 HR

JETTISON LM
PERFORM -X TRANSLATION (NET ΔV = 1 FPS RETROGRADE)

MNVR TO TEI ATTITUDE

TRANSEARTH COAST - (LATE LM JETTISON)

(PERFORM 1/2 TO 45 MIN PRIOR TO EI)
REALIGN IMU TO ENTRY REFSMMAT
MNVR TO INERTIAL ATT R = +0 (ARBITRARY)
P = +196
Y = +45
USE P47 OR EMS TO MONITOR SEP MNVR

EI - 1 HOUR

JETTISON LM
PERFORM -X TRANSLATION (NET ΔV = 3 FPS)
MNVR TO ENTRY ATTITUDE
LOI 30 MIN DPS ABORT

ΔV Thrust A/B - OFF
SPS INJ vlvs (4) - CLOSED
SPS He tb (2) - bp
GMBL MOTS(4) - OFF (LMP Verify)
TVC SERVO PWR. (2) - OFF
SC CONT - SCS
PCM BIT RATE - LOW
EMS MODE - STBY (verify)

RECORD DATA AND COMPUTE PAD

F 97 40
   Record TFC
   VG
   ΔVM
   EMS ΔVC

F 99 40
   ENTR

F 16 85
   Record VGX
   VGY
   VGZ
   R
   P
   Y
   PRO

F 37 00E
   When CMC ACTY 1t out:
   V66E

ALTERNATE

ΔVC LOI PAD
EMS ΔVC(Shutdown)
ΔVC(Burned)
ΔVC ABORT(Chart)

PRIMARY

ΔVM
ΔVC ABORT(Chart)

GET LOI +30:00
GET TEI ABORT : :
MNVR TO PAD BURN ATTITUDE  
V62E  

F 06 22    V49E    NEW ICDU ANGLES RPY (.01°)  
Load desired angles  
PRO  

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  

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

F 50 18    REQ TRIM MNVR TO FDAI RPY ANGLES  
(TRIM)    PRO To 4  
(BYPASS)    ENTR  
EMS FUNC - OFF  
Set ΔVC= +100.0  
EMS FUNC - ΔV  

28:00  
(-02:00)    V37E 47E  
F 16 83    ΔV XYZ(CSM) (.1fps)  

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

29:30  
(-00:30)    EMS MODE - NORMAL  

29:58  
(-00:02)    CMC MODE - FREE (on LM request)  

30:00  
(00:00)    DPS IGNITION
RECORD ΔV COUNTER & RESIDUALS

ΔVC
VGX
VGY
VGZ

(RECYCLE) V32E
(TERM) PRO

EMS FUNC - OFF
EMS MODE - STBY
LOI 2 HR DPS ABORT

ΔV Thrust A/B - OFF
SPS INJ v1vs (4) - CLOSED
SPS He tb (2) - BP
GMBL MTRS (4) - OFF (LMP verify)
TVC SERVO PWR (2) - OFF
SC CONT - SCS
PCM BIT RATE - LOW
EMS MODE - STBY

RECORD DATA AND COMPUTE PAD

F 97 40
Record TFC
VG
ΔVM
EMS ΔVC
ENTR
F 99 40
ENTR
F 16 85
Record VGX R
VGY P
VGZ Y

PRO
V 37 00E
When CMC ACTY 1t out, V66E
Perform P52, OPT 3

ASSIST IN LM ACTIVATION

LM Set MSN TMR to CSM MSN TMR on MARK
Configure for VHF Simplex B and respond to LM comm check
Configure for VHF Simplex A
Verify CSM in min DB and ATT HOLD
VO6 N20E; Read CSM ICDU ANGLES to LM
ENTR on LM MARK and note time. Compare CSM & LM ICDU ANGLES

<table>
<thead>
<tr>
<th>OG</th>
<th>IG</th>
<th>MG</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>CM</td>
<td>CM</td>
</tr>
<tr>
<td>LM</td>
<td>LM</td>
<td>LM</td>
</tr>
</tbody>
</table>

V16 N65E, call CSM time to LM : : :
LM ENTR time on CSM MARK
V 06 N65E on LM MARK and compare with
LM N65
CSM Time __:__:
LM Time __:__:

V 05N01E 1706E, Call TEPHEM to LM
R1
R2
R3
Maintain wide DB and ATT HOLD for LM RCS check. Copy P-30 Pad

MNVR TO PAD BURN ATTITUDE AND MONITOR BURN
Cycle CRYO FANS
Perform star check if possible
Set DET Counting Up to Burn
BMAG MODE (3) – RATE 2
SC CONT – CMC
CMC MODE – AUTO
MNVR to PAD BURN ATT, then maintain ATT
HOLD
-06:00 CMC – FREE (or) SC CONT – SCS with
MAN ATT (3) – ACCEL CMD
EMS FUNC – ΔV SET VHF/RNG
Set ΔVC +100.0
TVC SERVO PWR #1 – AC1/MNA
EMS FUNC – ΔV
BMAG MODE (3) – ATT1/RATE 2
-02:00 V37 E 47E, monitor F 16 83 (ΔV XYZ)
-00:30 EMS MODE – NORMAL
00:00 DPS IGNITION
After engine cutoff (and on LM callout)
CMC MODE – AUTO
Record ΔV COUNTER & RESIDUALS
ΔVC ___________ R ___________
VCX ___________ P ___________
VGY ___________ Y ___________
VGZ ___________
PRO
F 37 XXE
EMS FUNC – OFF
EMS MODE – STBY
TVC SERVO PWR #1 – OFF
BMAG MODE (3) – RATE 2
Velocity to be gained, $V_g$, fps

<table>
<thead>
<tr>
<th>Burntime</th>
<th>$\Delta VM$</th>
<th>Mode</th>
<th>SPS</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1:45</td>
<td>0 - 750</td>
<td>I</td>
<td>TIGHT</td>
<td>DPS at 2 hr (RTCC or Crew Chart)</td>
</tr>
<tr>
<td>1:45 - 2:50</td>
<td>750 - 1245</td>
<td>II</td>
<td>LOOSE</td>
<td>DPS at 2 hr + DPS at perilune (RTCC)</td>
</tr>
<tr>
<td>2:50 - 3:50</td>
<td>1245 - 1700</td>
<td>III</td>
<td>LOOSE</td>
<td>DPS at perilune (RTCC)</td>
</tr>
<tr>
<td>3:50 - Cutoff</td>
<td>1700 - Cutoff</td>
<td>III</td>
<td>TIGHT</td>
<td>DPS at perilune (RTCC)</td>
</tr>
</tbody>
</table>

DPS $\Delta V$, available

Abort $\Delta V$, fps

LOI $\Delta V$ magnitude, DVM, fps

GET 1G 79:24:53

CSM FDAO angles
- R 300
- P 263
- Y 359

LM FDAO angles
- R 1
- P 83
- Y 0

NASA — MSC
50:00  START DET
(-10:00) START DET

1  MNVR TO PAD BURN ATTITUDE
   V62E

2  V49E
   F 06 22  NEW ICDU ANGLES RPY
         Load desired angels
         PRO

3  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 5

4  06 18  AUTO MNVR TO FDAI RPY ANGLES

5  F 50 18  REQ TRIM MNVR TO FDAI RPY ANGLES
    (TRIM)  PRO To 4
    (BYPASS) ENTR

54:00  CMC MODE - FREE
      - SCS
      BMAG MODE(3) - ATT 1/RATE 2
      V48E, 61102, 01111
      EMS FUNC - OFF
      Set ∆VC= +100.0
      EMS FUNC - ∆V

58:00  V37E 47E
(-02:00) V37E 47E
       F 16 83 ∆V XYZ(CSM)

*VI,HDOT,H available by N62*
*KEY RLSE to return to N83*
59:30          EMS MODE - NORMAL

59:58          SC CONT - CMC (on LM request)
               BMAG MODE(3) - RATE 2

00:00          APS IGNITION

RECORD ΔV COUNTER & RESIDUALS
   ΔVC
   VGX
   VGY
   VGZ

(RECYCLE) V32E
(TERM)   PRO

F 37          XXE

EMS FUNC - OFF
EMS MODE - STBY