Minimum Key Rendezvous

AUTOCHK  Entered from "GOTOPOOL" and "NDUTINPT"

If bit 7(AUTOSEQ) of FLGWRD10 = 0:
    Return

Set restart group 4 to cause a start at next line (priority 138)
    (Tag here "AUTOCHK1"; from "PIKUP20")

Proceed to address specified by AUTPOINT

REND30S  Entered from "V37" if input program number in range 31-38
         and [REFSMMAT] available

TEMPMM = MMNUMBER + 50  (makes 31-38 into 81-88)

If bit 9(UTFLAG) of FLAGWRD8 = 1:
    Set bit 5(TRACKFLG) of FLAGWRD1 = 0
    Set bit 9(UTFLAG) of FLAGWRD8 = 0

If bit 7(RNDVZFLG) of FLAGWRD0 = 0:
    Set bit 7(AUTOSEQ) of FLGWRD10 = 1
    TS = 20
    Perform "AUTOSET" ("NDUTINPT", via "AUTOCHK", returns to next line)

MMNUMBER = TEMPMM

Proceed to "AUTO37"

MINKDISP

AUTPOINT = Return address

TS = (MMNUMBER - 50) and perform "NEWMODEX"

Perform "RELDSP"

TS = 000178

Proceed to "GOPERFl": if terminate, proceed to "GOTOPOOL"
    if proceed, proceed to "STARTAUT" otherwise, proceed

Set bit 7(AUTOSEQ) of FLGWRD10 = 0

Proceed to address specified by AUTPOINT
STARTAUT

Entered from "MINKDISP"

If bit 8(AZIMFLAG) of FLGWRD11 = 0:
    Set bit 8(AZIMFLAG) of FLGWRD11 = 1  (effect of "option 4")
If bit 11(HDSUPFLG) of FLGWRD10 = 1:
    AZIMANGL = 0
If bit 11(HDSUPFLG) of FLGWRD10 = 0:
    AZIMANGL = $\frac{1}{2}$  (i.e. 180°)
If bit 1(RENDWFLG) of FLAGWRD5 = 0:
    Set bit 5(MANEUFILG) of FLGWRD10 = 1
    Set bit 4(PTV93FLG) of FLGWRD10 = 1
    Set bit 1(PCFLAG) of FLGWRD10 = 0
    Set bit 7(AUTOSEQ) of FLGWRD10 = 1
Proceed to address specified by AUTPOINT

AUTOSET

AUTTEMP = Return address

MMNUMBER = TS

Set restart group 4 to cause a start at next line

AUTPOINT = AUTTEMP

Proceed to "AUTO37"

BURNHOW

AUTTEMP = Return address

If $|\text{DEVLVLVC} - K_{dv40d41}| < 0$:
    TS = 41
    Proceed to second line of "AUTOSET"

TS = 40

Proceed to second line of "AUTOSET"
P81
Perform "MINKDISP"
TS = 31
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P82"

P82
Perform "MINKDISP"
TS = 32
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P83"

P83
Perform "MINKDISP"
TS = 33
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P84"

P84
Perform "MINKDISP"
TS = 34
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P85"

P85
Perform "MINKDISP"
TS = 35

MINK-3
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P86"

P86
Perform "MINKDISP"
TS = 36
Perform "AUTOSET"
Perform "BURNHOW"
TS = 36
Perform "AUTOSET"
Perform "BURNHOW"
Proceed to second line of "P87"

P87
Perform "MINKDISP"
TS = 37
Perform "AUTOSET"
TS = 48
Perform "AUTOSET"
Proceed to "GOTOPOOH"

P88
Perform "MINKDISP"
TS = 38
Perform "AUTOSET"

If \(|DELVVLVC| = 0:  \text{(all components below } 2^{-14} \text{ m/cs } \approx 0.02 \text{ fps})\)

Proceed to "GOTOPOOH"

TS = 52
Perform "AUTOSET"

If bit l(PCFLAG) of FLGWRDIO = 1: (reset in "GYCRS" if torque)
   TS = 41
   Perform "AUTOSET"
   Proceed to "GOTOPOOH"

Perform "BURNHOW"

Set bit 15(PCMANFLG) of FLGWRD10 = 1   (Tag here "P86CONT2")
TS = 20
Perform "AUTOSET"  ("PIKUP20", since PCMANFLG = 1, after R61 exits)
Set bit 15(PCMANFLG) of FLGWRD10 = 0
TS = 52
Perform "AUTOSET"

Proceed to "GOTOPOOH"

AUTOW  Entered from "REND4" if bit 7(AUTOSEQ) of FLGWRD10 = 1

If bit 5(MANEUFLG) of FLGWRD10 = 1:
   If bit 4(PTV93FLG) of FLGWRD10 = 1:  (Tag here "AUTOW3")
      Proceed to "REND5C" (initialize W matrix)
   If bit 3(TPIMNFLG) of FLGWRD10 = 1:
      If bit 2(FULTKFLG) of FLGWRD10 = 0: (have both sensors)
         Proceed to "REND5C"
   COUNT3MK = 1   (Tag here "AUTOW4")
   Proceed to "AUTOW2"

If COUNT3MK ≠ 0:
   Proceed to "AUTOW2"
If bit 3(TPIMNFLAG) of FLGWRD10 = 1:  (Tag here "AUTOW1")
   If bit 8(P35FLAG) of FLGWRD10 = 1:  (set in P36)
      Proceed to "REND5C"  (initialize W matrix)
      Proceed to "AUTOW2"

TS = T_{ig}  (Tag here "AUTOW1")
If bit 1(PCFLAG) of FLGWRD10 = 1:
   TS = T_{cdh}  (i.e. TNSR)
If (MARKTIME - C_{wrdtime} - AGEOW) < 0:  (matrix not old enough)
   Proceed to "AUTOW2"
If (OLDMKTIME - MARKTIME + C_{minblk}) < 0:  (too long since last mark)
   COUNT3MK = 1
   Proceed to "AUTOW2"

TS_{1} = MARKTIME - TS
If TS_{1} \geq 0:  (note that this means if delay answering initial P3x display, may force initialization)
   Set bit 4(PGV93FLG) of FLGWRD10 = 0
   Proceed to "REND5C"  (initialize W matrix)
If (TS_{1} + C_{fincomp} + C_{tbefcomp}) < 0:
   Set bit 4(PGV93FLG) of FLGWRD10 = 0
   Proceed to "REND5C"
If (TS + K_{mincon} - C_{fincomp} + C_{brnblk} - AGEOW - C_{maxwtime}) \geq 0:
   Set bit 4(PGV93FLG) of FLGWRD10 = 1
   Proceed to "AUTOW2"

AUTOW2
If bit 1(RENDWFLG) of FLGWRD5 = 0:
   Proceed to "REND5C"
Set bit 1(RENDWFLG) of FLGWRD5 = 1  (unnecessary)
Proceed to "REND7"
P52AUTO

Entered from "PRG52" if bit 7(AUTOSEQ) of FLGWRD1O = 1

If bit 1(PCFLAG) of FLGWRD1O = 1: (i.e. before burn)

\[ TS = (\cos CDU_y) \sgn \Delta V_{LV,AC} \]

Set bit 6(TCOMPFLG) of FLGWRD1O = 0

If \( TS < 0 \):

Set bit 6(TCOMPFLG) of FLGWRD1O = 1

\[ TS = \frac{1}{2} \text{REFSMMAT}_3 \] (Tag here "P52AUTO1")

If bit 1(PCFLAG) of FLGWRD1O = 0: (after burn)

\[ TS = -TS \]

If bit 6(TCOMPFLG) of FLGWRD1O = 1:

\[ TS = -TS \]

\[ X_{smd} = \text{unit}(\frac{1}{2} \text{REFSMMAT}_0 + TS) \]

\[ Z_{smd} = \text{REFSMMAT}_6 \]

\[ Y_{smd} = \text{unit}(Z_{smd} * X_{smd}) \]

Set bit 4(PFRATFLG) of FLAGWRD2 = 1

Proceed to "P52D"

PERF20

Entered from "P52D" if bit 7(AUTOSEQ) of FLGWRD1O = 1

\[ TS = 20_8 \]

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"

if proceed, proceed to "GYCRS"

otherwise, proceed

If bit 1(PCFLAG) of FLGWRD1O = 1: (before burn)

Proceed to second line of "GOTOPOOH"

Perform "ALARM" (pattern 0402_8)

Proceed to "PERF20"
Quantities in Computations

See also list of major variables and list of routines

AGEOFW: See Measurement Incorporation.

AUTPOINT: Single precision cell used for return address storage in the minimum key rendezvous logic. It could be considered as a "pointer" indicating the progress of the computations through the P8x "driver".

AUTTEMP: Single precision cell used as temporary storage for information to be placed in AUTPOINT (to simplify some program logic and for the sake of restart protection).

AZIMANGI: See Orbital and Rendezvous Navigation.

Cbrnblktm: Single precision erasable memory constant, program notation "BRNBLKTm", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used in determination of age of W matrix following next maneuver, for Cmaxwtime check.

Cfincomp: Single precision erasable memory constant, program notation "FINCOMPTm", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used to allow for length of time of final targeting computation.

Cmaxwtime: Single precision erasable memory constant, program notation "MAXWTIME", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used to determine if W matrix age will be excessive after next maneuver.

Cminblktm: Single precision erasable memory constant, program notation "MINBLKTm", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used to check whether time since last mark is excessive (if so, COUNT3MK is set to 1).

Ctbfcomp: Single precision erasable memory constant, program notation "TBFCOMP", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used to check if a sufficient time remains before the final targeting computation so that W matrix reinitialization should take place.

Cwrdtime: Single precision erasable memory constant, program notation "WRDTIME", scale factor B28, units centi-seconds (least increment 163.84 seconds). Used to check if sufficient time has elapsed since the previous W matrix initialization.

COUNT3MK: Single precision counter, scale factor B14, units counts, used to control the initialization of the W matrix after three marks accumulated (hence the name). It is incremented in "REND12", where it is also set zero after reaching 3. If non-zero, checks in "AUTOW", except those immediately following a burn, are bypassed.
DELVLVC: See Burn Control.

K\textsubscript{3mincon}: Single precision constant, program notation "3MINCON", scale factor B28, units centi-seconds. Used double precision with octal value 000018 000028, corresponding to 163.86 seconds or 2.731 minutes.

K\textsubscript{dv40d41}: Constant, program notation "DV40/41", scale factor B7, units meters/centi-second. Value is 0.03048 x 2\textsuperscript{-7}, corresponding to 10 x 0.3048 x 0.01 x 2\textsuperscript{-7}, where first term is value in fps, second converts to meters, third to centi-seconds, and fourth is scale factor.

MARKTIME: See Measurement Incorporation.

MMNUMBER: See General Program Control.

OLDMKTME: See Measurement Incorporation.

T\textsubscript{cdh}: See Rendezvous Computations.

TEMPMM: Temporary storage for program number to be used in searching the program tables in V37 logic (in range 81-88), scale factor B14, single precision. Used in "REND3OS" to allow start-up of P20 and then initiation of the desired program.

X\textsubscript{sm}, Y\textsubscript{sm}, Z\textsubscript{sm}: See Inflight Alignment.
Noun Definitions

**DPTEST**

If $TS_1 = 4, 5, 7, 10$, or $13$, indicate double precision (return to calling address +2)

If $TS_1 = 0, 1, 2, 3, 6, 8, 9, 11, 12$, or $14$, indicate single precision (return to calling address +1)

**GTSFOUT**

$S_{FTEMP1} = K_{sfoT_s}$

Return

**GTSFIN**

$S_{FTEMP1} = K_{sfinT_s}$

Return

**LODNNTAB**

$NNADTE M = K_{ntbNOUNREG}$

$NNTYPEM = K_{ntyNOUNREG}$

If $NOUNREG < K_{mxcen}$:

MIXBR = 1

Return

MIXBR = 2

$TS = NOUNREG - 40$

$RUTMXTEM = K_{rmtmb}T_s$

$TS = \text{bits 10-1 of } NNADTE M$

$IDAD1TE M = K_{idtb}T_s$

$IDAD2TE M = K_{idtb}T_s+1$

$IDAD3TE M = K_{idtb}T_s+2$

Return

**NOTE:** $IDAD1TE M_i$ refers to:

- $IDAD1TE M$ if $i = 1$
- $IDAD2TE M$ if $i = 2$
- $IDAD3TE M$ if $i = 3$
Proceed to address given by the following table:

<table>
<thead>
<tr>
<th>TS</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&quot;DSPALARM&quot; (after setting DSPCOUNT = -19)</td>
</tr>
<tr>
<td>1</td>
<td>&quot;DSPDCEND&quot;</td>
</tr>
<tr>
<td>2</td>
<td>&quot;DEGOUTSF&quot;</td>
</tr>
<tr>
<td>3</td>
<td>&quot;ARTOUTSF&quot;</td>
</tr>
<tr>
<td>4</td>
<td>&quot;DP1OUTSF&quot;</td>
</tr>
<tr>
<td>5</td>
<td>&quot;DP2OUTSF&quot;</td>
</tr>
<tr>
<td>6</td>
<td>&quot;OPDEGOUT&quot;</td>
</tr>
<tr>
<td>7</td>
<td>&quot;DP3OUTSF&quot;</td>
</tr>
<tr>
<td>8</td>
<td>&quot;HMSOUT&quot;</td>
</tr>
<tr>
<td>9</td>
<td>&quot;M/3OUT&quot;</td>
</tr>
<tr>
<td>10</td>
<td>&quot;DP2OUTSF&quot;</td>
</tr>
<tr>
<td>11</td>
<td>&quot;AROUT1SF&quot;</td>
</tr>
<tr>
<td>12</td>
<td>&quot;2INTOUT&quot;</td>
</tr>
<tr>
<td>13</td>
<td>&quot;DPFRACOT&quot;</td>
</tr>
<tr>
<td>14</td>
<td>&quot;ATERROR&quot;</td>
</tr>
</tbody>
</table>

**DEGOUTSF**

If $MPAC+O < -0$:

Set bit 15 of $MPAC+O = 0$

$SFEMPL = K_{dgtb} O$

$MPAC_{dp} = K_{dgtb} MPAC+O + SFEMPL$

Proceed to "DSPDCEND"

**ARTOUTSF**  (no shift)

If $MPAC+O = -0$:

$MPAC_{dp} = -0$

Proceed to "DSPDCEND"

$MPAC_{dp} = SFEMPL MPAC+O$

Proceed to "DSPDCEND"

**DP1OUTSF**  (left shift of 14)

Perform "DPOUT"

$MPAC_{dp} = 2^{14} MPAC_{tp}$  (left shift of 14, overflow information lost)

Proceed to "DSPDCEND"
DP2OUTSF (no shift)
Perform "DPOUT"
Proceed to "DSPDCEND"

OPDECOUT

TS = MPAC+O
If TS > +0:
MPAC+O = MPAC+O + K_{20b}  (overflows propagate to bit 15)
If TS < -0:
MPAC+O = MPAC+O + K_{20b}
If MPAC+O > 0:  (includes case where TS = -0)
MPAC+O = MPAC+O + K_{ngl}
If MPAC+O < -0:
Set bit 15 of MPAC+O = 0
SFTEMPL = K_{dgb2}
MPAC_{dp} = K_{dgb2} MPAC+O + SFTEMPL
Proceed to "DSPDCEND"

DP3OUTSF (left shift of 7)
Perform "DPOUT"
MPAC_{tp} = 2^7 MPAC_{tp}  (left shift 7, OVFINP set if overflow)
Proceed to "DSPDCEND"

HMSOUT

IF MIXBR = 1:
TS = NOUNADD
If MIXBR = 2:
EBANK = bits 11-9 of IDADITEM_{DECOUNT+1}  (i.e. IDAD2TEM for DECOUNT = 1)
TS = 1400_8 + bits 8-1 of IDADITEM_{DECOUNT+1}
MPAC\textsubscript{dp} = \textit{E}_{TS\textsubscript{dp}}, with sign agreement forced
Perform "SEPSECNR"

MPAC\textsubscript{dp} = K_{scn2} \textit{MPAC}_{dp}

DSPCOUNT = 4
Perform "DSPDECWD" (display seconds in R3)
Perform "SEPMIN"

TS\textsubscript{2} = \textit{MPAC}+0 \quad \text{(whole hours)}

\textbf{If} \textit{MPAC}+1 = -0:

\quad MPAC\textsubscript{dp} = -0
\textbf{If} \textit{MPAC}+1 \neq -0:

\quad MPAC\textsubscript{dp} = K_{mncn2} \textit{MPAC}+1

DSPCOUNT = 9
Perform "DSPDECWD" (display minutes in R2)

\textbf{If} TS\textsubscript{2} = -0:

\quad MPAC\textsubscript{dp} = -0
\textbf{If} TS\textsubscript{2} \neq -0:

\quad MPAC\textsubscript{dp} = K_{hrncn} \textit{TS}_2

DSPCOUNT = 14
Perform "DSPDECWD" (display hours in R1)

Proceed to address specified by ENTRET

\textit{M/SOUT}

\textbf{If} MIXBR = 1:

\quad TS = NOUNADD

\textbf{If} MIXBR = 2:

\quad \textit{EBANK} = \text{bits 11-9 of IDAD\textit{ITEM}\textsubscript{DECOUNT}+1} \quad \text{(i.e. IDAD\textit{ITEM}\textsubscript{DECOUNT}+1)}

\quad TS = 14008 + \text{bits 8-1 of IDAD\textit{ITEM}\textsubscript{DECOUNT}+1}
MPAC\textsubscript{dp} = E_{TS\textsubscript{dp}}, \text{ with sign agreement forced}

TS = MPAC\textsubscript{dp}

If |TS| \geq K_{mscn12}:

\begin{align*}
MPAC\textsubscript{dp} &= K_{mscn3} \text{ sgn } MPAC+0 \\
\text{Perform } "\text{SEPSECNR}" \\
\end{align*}

If |TS| < K_{mscn12}:

\begin{align*}
MPAC\textsubscript{dp} &= MPAC\textsubscript{dp} + K_{rn} \text{ sgn } MPAC+1 \\
\text{Perform } "\text{SEPSECNR}" \\
\end{align*}

MPAC\textsubscript{dp} = K_{hisec} MPAC\textsubscript{dp}

DSPCOUNT = DSPCOUNT - 3

Perform "DSPDC2NR" (seconds in digits 4 and 5)

CODE = 0

COUNT = K_{rdDECOUNT} - 2

Perform "DSPIN" (blank digit 3)

Perform "SEPMIN"

MPAC\textsubscript{dp} = K_{himin} MPAC+1

DSPCOUNT = K_{rdDECOUNT}

Perform "DSPDC2NR" (minutes in digits 1 and 2)

Proceed to second line of "DSPCEND"

\textbf{SEPSECNR}

\begin{align*}
\text{MPAC}\textsubscript{tp} &= K_{scn1} \text{ MPAC}\textsubscript{dp} \\
\text{HITEMOUT} &= \text{MPAC}\textsubscript{dp} \\
\text{MPAC}\textsubscript{tp} &= 2^2 \text{ MPAC}\textsubscript{tp} \quad \text{(left shift 2, OVFINP set if overflow)} \\
\text{MPAC}\textsubscript{dp} &= 2^{14} \text{ MPAC}\textsubscript{tp} \quad \text{(left shift 14, overflow information lost, leaves seconds in MPAC}\textsubscript{dp}) \\
\text{Return}
\end{align*}
SEPMIN

\[ \text{MPAC}_{dp} = \text{HITEMOUT} \]

Set bits 12-1 of MPAC+1 = sign bit (i.e. zero magnitude, masking out former information on seconds)

\[ \text{MPAC}_{\text{tp}} = K_{\text{mncnl}} \text{MPAC}_{dp} \]

Return

AROUT1SF (left shift of 14, single precision operand)

If \( \text{MPAC}+O = -0 \):

\[ \text{MPAC}_{dp} = -0 \]

Proceed to "DSPDCEND"

\[ \text{MPAC}_{\text{tp}} = \text{SFTEMPl} \text{MPAC}+O \]

\[ \text{MPAC}_{dp} = 2^{14} \text{MPAC}_{\text{tp}} \] (left shift of 14, overflow information lost)

Proceed to "DSPDCEND"

2INTOUT

Perform "5BLANK" (blanks all digits)

Perform "4ON"

\( \text{TS} = \text{MPAC}+O \)

Perform "DSPDECVN" (puts first cell in digits 1 and 2)

\[ \text{DSPCOUNT} = K_{\text{rdDECOUNT}} - 3 \]

If MIXBR = 1:

\[ \text{TS} = \text{NOUNADD} \]

If MIXBR = 2:

\[ \text{EBANK} = \text{bits 11-9 of IDADITEMDECOUNT+1} \]

\[ \text{TS} = 14008 + \text{bits 8-1 of IDADITEMDECOUNT+1} \]

\[ \text{MPAC}_{dp} = E_{\text{TS}}_{dp} \]

\( \text{TS} = \text{MPAC}+1 \)

Perform "DSPDECVN" (puts second cell in digits 4 and 5)

Proceed to second line of "DSPDCEND"
DPFRACOT

If MIXBR = 1:

TS = NOUNADD

If MIXBR = 2:

EBANK = bits 11-9 of IDADITEM \_DECOUNT+1

TS = 14008 + bits 8-1 of IDADITEM \_DECOUNT+1

MPAC_{dp} = ETS_{dp}

Proceed to "DSPDCEND"

PUTDCSF2

Proceed to address given by the following table:

<table>
<thead>
<tr>
<th>TS</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&quot;AIMCYCLE&quot; (noun octal only)</td>
</tr>
<tr>
<td>1</td>
<td>&quot;BINROUND&quot;</td>
</tr>
<tr>
<td>2</td>
<td>&quot;DEGINSF&quot;</td>
</tr>
<tr>
<td>3</td>
<td>&quot;ARThINSF&quot;</td>
</tr>
<tr>
<td>4</td>
<td>&quot;DPIINSF&quot;</td>
</tr>
<tr>
<td>5</td>
<td>&quot;DPIINSF2&quot;</td>
</tr>
<tr>
<td>6</td>
<td>&quot;OPTDEIGIN&quot;</td>
</tr>
<tr>
<td>7</td>
<td>&quot;DPIINSF&quot;</td>
</tr>
<tr>
<td>8</td>
<td>&quot;HMSIN&quot;</td>
</tr>
<tr>
<td>9</td>
<td>&quot;DSPALARM&quot; (can't load MMBSS)</td>
</tr>
<tr>
<td>10</td>
<td>&quot;DPIINSF4&quot;</td>
</tr>
<tr>
<td>11</td>
<td>&quot;ARTIN1SF&quot;</td>
</tr>
<tr>
<td>12</td>
<td>&quot;DSPALARM&quot; (can't load XXBYY)</td>
</tr>
<tr>
<td>13</td>
<td>&quot;DPIINSF4&quot;</td>
</tr>
<tr>
<td>14</td>
<td>&quot;DSPALARM&quot; (no need to load NO4)</td>
</tr>
</tbody>
</table>

DEGINSF

MPAC_{tp} = K_{dgcnl} MPAC_{dp}

MPAC_{tp} = MPAC_{tp} + K_{btl} \text{sgn} \ MPAC+1 \quad \text{If overflow, set OVFINP}

MPAC_{tp} = 2^{1} MPAC_{tp} \quad \text{(left shift 1)} \quad \text{If overflow, set OVFINP}

Proceed to "DEGINSF2"

DEGINSF2

MPAC_{tp} = 2^{1} MPAC_{tp} \quad \text{(left shift 1)} \quad \text{If overflow, set OVFINP}

If OVFINP set (i.e. non-zero), proceed to "AIMCYCLE"

MPAC_{tp} = 2^{1} MPAC_{tp} \quad \text{(left shift 1)}
If overflow takes place:
\[ \text{OVFINP} = 1 \text{ sgn MPAC+O} \]
If \(\text{MPAC+O} = -0\):
\[ \text{MPAC+O} = +0 \]
If \(\text{MPAC+O} < 0\):
\[ \text{MPAC+O} = \text{MPAC+O} + 0000_8 \quad \text{(for twos complement)} \]
If \(\text{OVFINP} = 0\):
\[ \text{TS} = \text{MPAC+O} \]
Proceed to address specified by DECRET
If \(\text{OVFINP} > 0\):
Set bit 15 of \(\text{MPAC+O} = 1\)
\[ \text{TS} = \text{MPAC+O} \]
Proceed to address specified by DECRET
If \(\text{MPAC+O} = +0\): (OVFINP is < 0 if come here)
\[ \text{MPAC+O} = 40000_8 \]
\[ \text{TS} = \text{MPAC+O} \]
Proceed to address specified by DECRET
Set bit 15 of \(\text{MPAC+O} = 0\)
\[ \text{TS} = \text{MPAC+O} \]
Proceed to address specified by DECRET

**ARTHINSF** \(\text{(left shift of 14)}\)
\[ \text{MPAC}_{tp} = \text{SFTEMPI MPAC}_{dp} \]
If \(\text{MPAC+O} \neq 0\), proceed to "ALMCYCLE"
\[ \text{MPAC}_{dp} = 2^{14} \text{ MPAC}_{tp} \quad \text{(left shift of 14)} \]
Proceed to "BINROUND"

**DPINSF2** \(\text{(left shift of 7)}\)
\[ \text{MPAC}_{tp} = \text{SFTEMPI MPAC}_{dp} \]
\[ \text{MPAC}_{tp} = 2^7 \text{ MPAC}_{tp} \quad \text{(left shift of 7, OVFINP set if overflow)} \]
Proceed to second line of "DPINSF"
OPTDEGPIN

If $\text{MPAC+O} \leq -O$, proceed to "ALMCYCLE"

$$\text{MPAC+O} = \text{MPAC+O} + K_{ngp2}$$

$$\text{MPAC}_{tp} = K_{dgcn2} \text{MPAC}_{dp}$$

$$\text{MPAC}_{tp} = \text{MPAC}_{tp} + K_{btl2}$$ If overflow, set OVFINP

Proceed to "DEGINSF2"

HMSIN

If bits 5-3 of DECBRNCH $\neq 111_2$: (3 decimal inputs not received)

$$\text{VERBSAVE} = -25$$ (force verb 25)

Proceed to "ALMCYCLE"

$$\text{MPAC}_{tp} = K_{whecn} \text{MPAC}_{dp}$$ (MPAC$_{dp}$ contains hours)

$$\text{MPAC}_{tp} = \text{MPAC}_{tp} + \text{MPAC}+2$$

If $\text{MPAC+O} \neq 0$, proceed to "ALMCYCLE"

$$\text{MPAC}_{tp} = K_{hrcon} \text{MPAC}+1$$

If $\text{MPAC+O} \neq 0$, proceed to "ALMCYCLE" (input exceeded 745 hours)

$$\text{TS} = 2^{14} \text{MPAC}_{tp}$$ (left shift 14)

$$\text{MPAC}_{dp} = (\text{YREG}, \text{YREGLP})$$ (MPAC$_{dp}$ loaded with minutes)

$$\text{MPAC}_{tp} = K_{whecn} \text{MPAC}_{dp}$$

$$\text{MPAC}_{tp} = \text{MPAC}_{tp} + \text{MPAC}+2$$

If $\text{MPAC+O} \neq 0$, proceed to "ALMCYCLE"

If $|\text{MPAC+1}| > K_{59\text{min}}$, proceed to "ALMCYCLE"

$$\text{TS} = \text{TS} + K_{\text{mincon}} \text{MPAC}+1$$

If $|\text{TS}| > 2^{28}$ centi-seconds, proceed to "ALMCYCLE"

$$\text{MPAC}_{dp} = (\text{ZREG}, \text{ZREGLP})$$ (MPAC$_{dp}$ loaded with centi-seconds)

$$\text{MPAC}_{tp} = K_{whecn} \text{MPAC}_{dp}$$

$$\text{MPAC}_{tp} = \text{MPAC}_{tp} + \text{MPAC}+2$$

If $\text{MPAC+O} \neq 0$, proceed to "ALMCYCLE"
If \( |\text{MPAC}+1| > 59998c \), proceed to "ALMCYCLE"

\[ TS = TS + \text{MPAC}_{dp} \]

If \( |TS| \geq 2^{28} \) centi-seconds, proceed to "ALMCYCLE"

Force sign agreement of TS

\[ E_{\text{NOUNADD}} = TS_{dp} \]

Proceed to "LOADLV"

**DPINSF4**

(Left shift 3)

\[ \text{MPAC}_{tp} = \text{SPTEMP1 MPAC}_{dp} \]

\[ \text{MPAC}_{dp} = 2^3 \text{MPAC}_{tp} \quad \text{(left shift of 3, OVFINP set if overflow)} \]

Proceed to second line of "DPINSF"

**ARTIN1SF**

(No shift)

\[ \text{MPAC}_{tp} = \text{SPTEMP1 MPAC}_{dp} \]

Proceed to "BINROUND"

**DPFRACIN**

Proceed to 4th line of "DPINSF"

**ATTERROR**

\[ \text{MPAC}+0 = -\text{MPAC}+0 \]

Proceed to "ARTOUTSF"
Quantities in Computations

See also list of major variables and list of routines

CODE, COUNT: See Data Input/Output.

DECBRANCH, DECOUNT, DECRET: See Data Input/Output.

DSPCOUNT: See Data Input/Output.

EBANK, ENTRER: See Data Input/Output.

HITEMOUT: Value of number of minutes in time quantity (computed in "SEPSECNR" for use in "SEPMIN"), scale factor B16, units minutes. Least significant 12 bits of least significant half contain fractional portion of minutes, and therefore must be blanked in "SEPMIN" for proper computation of the number of integral minutes in the time argument. Least significant half "LOTEMOUT".

IDADITEM (I = 1,2,3): Temporary storage for information from mixed-noun tables (see below) for first (R1), second (R2), and third (R3) components of noun. The R1 component, of course, is displayed in register R1 on the DSKY, etc.

K20b: Single precision constant, program notation "20BIAS", scale factor B-3, units revolutions. Octal value is 160403, corresponding to about 19.7754°.

K59min: Single precision constant, program notation "59MIN", scale factor B14, units minutes. Value is 000738, corresponding to 59 minutes.

K5999sec: Single precision constant, program notation "59.99SEC", scale factor B14, units centi-seconds. Value is 135578, corresponding to 5999 centi-seconds (or 59.99 seconds).

Kbtl1: Single precision constant, program notation "BIT11". As used, value corresponds to (1/2 x 2^{-14}) of full scale, or one-half the least increment on the single precision result for "DEGINSF".

Kbtl2: Single precision constant, program notation "BIT12". As used, value corresponds to (1/2 x 2^{-14}) of full scale, or one-half the least increment on the single precision result for "OPTHDEGIN".

Kdegconl: Constant, program notation "DEGCONL", scale factor B3, value 5.555555555 x 2^{13}. Value corresponds to (1000/180) x 2^{-3}, where first term converts from XXX.XX° to B-1 revolutions, and second is the constant's scale factor.
K\text{degno}: Constant, program notation "DEGCON2", scale factor B2, value \(2.22222222 \times 10^{-2}\). Value corresponds to \((100/45) \times 10^{-2}\), where first term converts from \(XX.XX^\circ\) to B-3 revolutions, and second is the constant's scale factor.

K\text{degta}1, K\text{degta}2: Constant, program notation "DEGTAB", scale factor B0, octal value \(05605_8 \ 03656_8\), corresponding to decimal 0.18. Value equivalent to \(180/1000\), to convert from B-1 revolutions to \(XX.XX^\circ\).

K\text{himin}, K\text{hisec}: Single precision constant, program notation "HIMINCON", scale factor B0, value \(23346_8\). Value corresponds to \((0.6 + 2^{-7})\).

K\text{hrcn1}, K\text{hrcn2}: Constant, program notation "HRCON1", scale factor B-14, value \(0.16384\). Value corresponds to \(10^{-5} \times 2^{14}\).

K\text{hrcon}: Constant, program notation "HRCON", scale factor B28, units centi-seconds. Value is \(0.0025837100_8\), corresponding to 360,000 (or 3600 seconds).

K\text{iddq}: Table of constants for mixed noun information, program notation "IDADDTAB", giving address and scaling routine information. See information below.

K\text{mincon}, K\text{mncon1}, K\text{mncon2}, K\text{mscn3}: Single precision constant, program notation "MINCON", scale factor BL4, units centi-seconds. Value is \(13560_8\), corresponding to decimal 6000 (or 60 seconds). Value is \(104.22_8\), corresponding to \((1/60 \times 2^2 + 2^{-28})\), to give hours scaled BL4 in MPAC+0 when return from "SEPMIN" (and fraction of an hour, B0, in MPAC+1).

K\text{mncon2}, K\text{mscn3}: Constant, program notation "M/SCON3", scale factor B28, units centi-seconds. Value is \(00025837016_8\), corresponding to 359,950 centi-seconds (or 59 minutes 59.5 seconds).
K_12: Notation assigned to effect in program of constants "M/SCON1" and "M/SCON2", both single precision with octal values 77753_8 and 41126_8 respectively. The constants information, for program convenience, is stored in negative form (with magnitude of each decremented by one least increment for convenience in forming the absolute value). The net effective value in the program of the combined constant (scale factor B28, units centi-seconds) is 00025_8 36652_8, corresponding to 359,850 centi-seconds (59 minutes 58.5 seconds). A value of time of this value or more would be displayed in "M/SOUT" as 59 59, with appropriate sign.

K_mscn: Single precision constant, program notation "MIXCON", scale factor B14, value 00050_8, corresponding to a noun of 50. Nouns of this value or above are considered "mixed nouns".

K_negl: Single precision constant, program notation "NEG1", scale factor B-3, units revolutions, used to convert from two's complement to ones complement information. Value is 2^-14 (minus one least increment).

K_ngp2: Single precision constant, program notation "NEG.2", value 71527_8. Octal value equivalent to -6250_8: since the constant is added to information scaled XX.XXX, value corresponds to 100 x (-0.197754), or -19.7754° (cf. K2ob).

K_ntb1: Table of constants, program notation "NNADTAB", for loading NNADTEM. See information below.

K_nty1: Table of constants, program notation "NNTYPTAB", for loading NNTYPEM. See information below.

K_rdI: See Data Input/Output.

K_rndcn: Constant, program notation "RNDCON -1", scale factor B28, units centi-seconds. Value is 00000_8 00062_8, corresponding to 50 centi-seconds (0.5 second).

K_rutmib: Table of constants used to specify scaling routines for mixed nouns, program notation "RUTMXTAB". See information below (is used to load RUTMXTEM). First table cell is for noun 40.

K_scn1: Constant, program notation "SECON1", scale factor B-12, value 1.666666666E-4 x 2^12, corresponding to (1/6000) x 2^12 (to convert centi-seconds scaled B28 to minutes scaled B16, cf. HITEMOUT).

K_scn2: Constant, program notation "SECON2", scale factor B0, value 01727_8 01217_8. Value corresponds to 60 x 10^-3.
K_{sfin}^0 : First of a set of input constants selected in "GTSFIN", located in consecutive cells starting at "SFINTAB". Value is 00006\_8 \ 03240\_8, scale factor B28. Value corresponds to \(10^5 \times 2^{-28}\), to convert from the fraction produced by "NUM" to an integer with scale factor B28.

K_{sfin}^1 : Constant, value 0, not assigned.

K_{sfin}^2 : Constant, value 0, used to set initial condition for SFTEMPL for use in "DEGINSF" and "0PDEGIN". The scaling routine itself selects the appropriate scaling constants.

K_{sfin}^3 : Constant, value 10707\_8 \ 03435\_8, scale factor B0. Value corresponds to one least increment more than (100 \times 1/360), to convert from an input of XX.XXX° to BO revolutions. Since there are 21 gyro pulses per revolution, the constant could also be considered to convert to gyro pulses, scale factor B21.

K_{sfin}^4 : Constant, scale factor B3, value 13070\_8 \ 34345\_8. Value corresponds to one least increment more than (1000 \times 1/360) \times 2^{-3}, to convert from XXX.XX° to B3 revolutions (hence use Routine #10, "DPINSF4", to shift result left 3 for a scaling of BO revolutions).

K_{sfin}^5 : Constant, value 00005\_8 \ 21616\_8, scale factor B14. Value corresponds to (1000 \times 1/180) \times 2^{-14}, to convert from XXX.XX° to B-1 revolutions (after performing a left shift of 14).

K_{sfin}^6 : Constant, value 26113\_8 \ 31713\_8, scale factor B0. Value corresponds to \(10^5 \times 0.45359237 \times 2^{-16}\), to convert between XXXXX. pounds and B16 kilograms (single precision).

K_{sfin}^7 : Constant, value 00070\_8 \ 20460\_8, scale factor B0. Value corresponds to \(10^3 \times 1852 \times 2^{-29}\), to convert between XXX.XX nmi and meters scaled B29 (there are 1852 meters in a nautical mile).

K_{sfin}^8 : Constant, value 01065\_8 \ 05740\_8, scale factor B0. Value corresponds to \(10^4 \times 1852 \times 2^{-29}\), to convert between XXX.XX nmi and meters scaled B29 (there are 1852 meters in a nautical mile). See K_{sfin}^8.

K_{sfin}^9 : Constant, value 11414\_8 \ 31463\_8, scale factor B3. Value corresponds to \(10^5 \times 10^{-2} \times 0.3048 \times 2^{-7} \times 2^{-3}\), for the net value to convert from XXXXX. feet/second to B10 meters/centi-second (hence use Routine #10, "DPINSF4", to shift result left 3 for scaling of B7 meters/centi-second).
K_{sf_{10}}: Constant, value 07475.8 16051.8, scale factor B0. Value corresponds to \(10^4 \times 10^{-2} \times 0.3048 \times 2^{-7}\), in order to convert between XXXX.X fps and meters/centi-second with scale factor B7.

K_{sf_{11}}: Constant, value 00001.8 03434.8, scale factor B14. Value corresponds to \(10^2 \times (1/90) \times 2^{-14}\), to convert from XX.XXX° to B-2 revolutions (after performing a left shift of 14 via Routine #3, "ARTHINSF").

K_{sf_{12}}: Constant, value 00002.8 22245.8, scale factor B14. Value corresponds to \(10^3 \times (3600/85.41) \times 2^{-14} \times 2^{-14}\) minus one least increment, to convert between XXXXX.X and B20 "CDU actuator pulses" (after performing a left shift of 14 via Routine #3, "ARTHINSF"). There are 85.41 arc seconds per CDU actuator pulse.

K_{sf_{13}}: Constant, value 00014.35607, scale factor B14. Value corresponds to \(10^7 \times 1.35817948 \times 2^{-5} \times 2^{-14}\), to convert between XXXXXbb. slug-feet² and B20 kilogram-meters² (after performing a left shift of 14 via Routine #3, "ARTHINSF"). The "bb" means that the input is in units of 100 slug-feet². Same constant could also be used to convert between XXXXXbb. foot-pounds and B20 newton-meters. Constant is not used (since functions are computed in "FIXCW" as determined from inputs of vehicle mass).

K_{sf_{14}}: Constant, value 07606.86300, scale factor B3. Value corresponds to one least increment more than \(10^5 \times (1/25766.1973) \times 2^{-1} \times 2^{-3}\), to convert between XXXXX. fps and B1 VSAT units (used in entry, where 1 VSAT = 25766.1973 fps), after performing a left shift of 3 via Routine #10, "DPINSF4".

K_{sf_{15}}: Constant, value 16631.11307, scale factor B0. Value corresponds to \(10^4 \times (1/21622.4965)\), to convert between XXXX.X nmi and BO revolutions. The denominator conversion value corresponds to \(2\pi \times 637338 / 1852\), i.e. an earth radius equal to the value of \(K_{rpad}\) (see Burn Control) used to derive circumference.

K_{sf_{16}}: Constant, value 12000.0000, scale factor B7. Value corresponds to \(10^3 \times (1/25) \times 2^{-7}\), to convert between XXXXX g's and BO "G-units" (25 g's, as used in Entry Computations), after performing a left shift of 7 via Routine #5, "DPINSF2".

K_{sf_{17}}: Constant, value 27176.14235, scale factor B0. Value corresponds to \(10^4 \times (1/3441.3272) \times 2^{-2}\), to convert between XXXX.X nmi and radians scaled B2 (using the pad radius given for \(K_{sf_{15}}\)).

NNDF-15
Value corresponds to \(10^3 \times 0.3048 \times 2^{19}\), to convert between XXXX.XX nmi and meters scaled B20 (first term is for XXXX.XX nmi, second converts from nautical miles to meters, third is for scaling of final answer, and fourth is scaling for constant), after a left shift of 3 via Routine #10, "DPINSF4".

Ksfout : Constant, value 0.022222222, scale factor B0. Value corresponds to \(10 \times (1/360) \times (1/10) \times 2^2\), to convert between X.XXX degrees/second and revolutions/decisec second scaled B-3 (first term is for X.XXX degrees/second, second converts to revolutions, third converts to deisec seconds, fourth is for scaling of final answer), after a left shift of 3 via Routine #10, "DPINSF4".

Ksf0t : First of a set of output constants selected in "GTSFOUT", located in consecutive cells starting at "SFOUTAB". Value is 051748 132618, scale factor B0, with value corresponding to \(10^{-5} \times 2^{14}\), to convert from an integer with scale factor B14 to XXXX.

Ksf1 : Constant, value 0, not assigned.
**Ksfot.:** Constant, value 0, used to load SFTEMPl with proper initial value for use in "DEGOUTSF" and "OPDEGOUT".

**Ksfot.:** Constant, value 00714.314638, scale factor B7. Value 3 corresponds to (360) x 10^-2 x 2^-7, to convert from 60 revolutions to XX.XXX°. Since there are 2^21 gyro pulses per revolution, the constant could also be considered to convert from gyro pulses scaled B21.

**Ksfot.:** Constant, value 13412.075348, scale factor BO. Value 4 corresponds to (360) x 10^-3, to convert from 60 revolutions to XXX.XX°.

**Ksfot.:** Constant, value 05605.036568, scale factor BO. Value 5 corresponds to (180) x 10^-3, to convert from 1-1 revolutions to XXX.XX°.

**Ksfot.:** Constant, value 00001.161708, scale factor B14. Value 6 corresponds to 16 x (1/0.45359237) x 10^-5 x 2^-14, to convert between B16 kilograms and XXX.XX pounds.

**Ksfot.:** Constant, value 03441.343068, scale factor B14. Value 7 corresponds to 2^29 x (1/1852) x 10^-3 x 2^-14, to convert between B29 meters and XXX.XX nmi.

**Ksfot.:** Constant, value 07176.216038, scale factor B7. Value 8 corresponds to (2^29) x (1/1852) x 10^-4 x 2^-7, to convert between B29 meters and XXX.XX nmi (there are 1852 meters in a nautical mile). For N73, converts from units of meters/100 (computed by P21) to XXXX.XX nmi.

**Ksfot.:** Constant, value 15340.153408, scale factor BO (equality of two halves of constant is correct). Value corresponds to (100 x 27/0.3048) x 10^-5, to convert from the navigation scaling of velocity (B7 meters/centi-second) to XXXX.XX fps.

**Ksfot.:** Constant, value 01031.210328, scale factor B7. Value 10 corresponds to (100 x 27/0.3048) x 10^-4 x 2^-7 plus one least increment, to convert from the navigation scaling of velocity (B7 meters/centi-second) to XXXX.XX fps.

**Ksfot.:** Constant, value 34631.231468, scale factor BO. Value 11 corresponds to (90) x 10^-2, to convert from 1-2 revolutions to XX.XXX°.

**Ksfot.:** Constant, value 14340.241458, scale factor BO. Value 12 corresponds to (85.41/3600) x 2^14 x 10^-3, to convert between B14 "CDU actuator pulses" and XXX.XX°. There are 85.41 arc seconds per CDU actuator pulse.
$K_{sfot}$: Constant, value $0.023638037218$, scale factor $B0$. Value
13 corresponds to $20^2 \times (1/1.355817948) \times 10^{-7}$, to convert
between B20 kilogram-meters$^2$ and XXXXbb. slug-feet$^2$ (the
"bb" means that output is in units of 100 slug-feet$^2$).
Same constant could also be used to convert between B20 newton-
meters and XXXXbb. foot-pounds. Constant is not used (see $K_{sfin13}$).

$K_{sfot}$: Constant, value $0.203738021228$, scale factor $B0$. Value
14 corresponds to $2^1 \times 25766.1973 \times 10^{-5}$, to convert between
B1 VSAT units and XXXX. fps (one VSAT is 25766.1973 fps, used
in entry).

$K_{sfot}$: Constant, value $0.00424030446$, scale factor $B7$. Value
15 corresponds to $25 \times 10^{-3}$, to convert between B0 "G-units"
(25 g's, as used in entry computations) and XXX.XX g's.

$K_{sfot}$: Constant, value $0.0063123146$, scale factor $B0$. Value
16 corresponds to $3441.3272 \times 2^2 \times 10^{-4} \times 2^{-7}$, to convert between
B2 radians and XXXX.X nmi (using pad radius, see $K_{sfin17}$).

$K_{sfot}$: Constant, value $17.2010499 \times 2^{-7}$, scale factor $B7$. Value
18 corresponds to $2^9 \times (1/0.3048) \times 10^{-5} \times 2^{-7}$, to convert between
B19 meters and XXXX.XX feet (with a left shift of 7 places
due to scaling of the constant).

$K_{sfot}$: Constant, value $0.032808399$, scale factor $B0$. Value corresponds
19 to $2^{10} \times 10^2 \times (1/0.3048) \times 10^{-4}$, to convert between B0 meters/
centi-second and XXXX.XX fps: first term is for original scaling,
second converts to seconds, third converts to feet, and fourth is
display scale.

$K_{sfot}$: Constant, value $0.703167914$, scale factor $B0$. Value corresponds
20 to $\sim 2^{-9} \times 360 \times 10 \times 10^{-1}$, to convert between revolutions/decisec-and X.XXX degrees/second: first term is for original B-9
scaling of rev/decisecond, second converts to degrees, third converts
to seconds, and fourth is display scale. Value of constant should be
0.703125: actual value is reciprocal of $K_{sfin20}$.

$K_{sfot}$: Constant, value $0.216$, scale factor $B0$. Value corresponds to
21 $360 \times 60 \times 10^{-5}$, to convert between B0 revolutions and XXXX.
arc minutes (first term converts to degrees, second to minutes, and
third is display scale).
\( K_{\text{fot}} \): Constant, value \( 3.280839896 \times 10^{-2} \), scale factor B7. Value 22 corresponds to \( 2^6 \times (1/0.3048) \times 10^2 \times 10^{-4} \times 2^{-7} \), to convert between B6 meters/centi-second and XXX.XX fps: first term is for original scaling, second converts to meters, third converts to seconds, fourth is display scale, and fifth is scaling of constant.

\( K_{\text{fot}} \): Constant, value \( 0.5399568 \times 10^{-6} \), scale factor B0. Value 23 corresponds to \( 2^8 \times (1/1852) \times 10^{-3} \), to convert between B20 meters and XXX.XX nmi.

\( K_{\text{fot}} \): Constant, value \( 45 \times 2^{-7} \), scale factor B7. Value corresponds to \( 2^3 \times 360 \times 10 \times 10^{-1} \times 2^{-7} \), to convert between revolutions/decisecond scaled B-3 and XXX.XXXX degrees/second: first term is for original scaling, second converts to degrees, third converts to seconds, fourth is display scale, and fifth is scaling of constant.

\( K_{\text{whecon}} \): Constant, program notation "WHOLECON", value \( 00006.03240 \), scale factor B28. Value corresponds to \( 10^2 \times 2^{-28} \) (to "compensate" for the scaling done in "NUM").

MIXER: Single precision cell, scale factor B14, set in "LODNNNTAB" to 1 for a "normal" noun and to 2 for a "mixed" noun.

NNADTEM: Temporary storage cell, single precision, loaded in "LODNNNTAB" with the value of \( k_{\text{ntb}} \) corresponding to NOUNREG contents. See information below.

NNTYPTEM: Temporary storage cell, single precision, loaded in "LODNNNTAB" with the value of \( k_{\text{nty}} \) corresponding to NOUNREG contents. See information below.

NOUNADD, NOUNREG: See Data Input/Output.

OVFINP: See Data Input/Output.

RUTMXTEM: Temporary storage cell, single precision, loaded in "LODNNNTAB" with value of \( k_{\text{rtmtn}} \) for "mixed nouns" only. See information below.

SFTEMPI: Temporary storage cell used to contain the appropriate value of \( k_{\text{fin}} \) or \( k_{\text{fot}} \), used for angle bias information (if any) in "DEGOUTSF" and "OPDEGOUT".

VERBSAVE: See Data Input/Output.

YREG, YREGLP: See Data Input/Output (YREGLP described for LPREG).

ZREG, ZREGLP: See Data Input/Output (ZREGLP described for LPRG).
Noun Table Interpretation

"Normal" Nouns
MIXBR = 1

Knty bits 15-11 contain the "component code number", interpreted as follows:

- Bit 15 is 1 if no loading of information by use of the noun with verbs 24 or 25 is allowed.
- Bit 14 is 1 if only decimal input/output by use of the noun is allowed (i.e. no octal verbs may be used).
- Bit 13 is not assigned.
- Bits 12-11 give information on the number of components:
  - 002 for one component
  - 012 for two components
  - 102 for three components

Knty bits 10-6 contain the "scale factor routine code number", used in "DECDSP3" and "PUTDCSF2" to transfer to the proper scaling routine.

Knty bits 5-1 contain the "scale factor constant code number", used in "GTSFOUT" and "GTSFIN" to select the proper scaling constant.

Kntb gives the machine address information with the following interpretations:

- +0 if noun not assigned.
- -0 if previous address to be incremented by +1.
- -1 if a channel is to be loaded or read (channel number is supplied as another input).
- <-1 (usually 400008) if an octal erasable memory address is to be supplied as another input.
- >+0 if the octal erasable memory address is given (for the first component).
"Mixed" Nouns

**MIXBR = 2**

\( K_{nty} \) bits 5-1, 10-6, and 15-11 contain the "scale factor constant code number", used in "GTSFOUT" and "GTSFIN", for component #1, #2, and #3 respectively.

\( K_{ntb} \) bits 15-11 contain the "component code number", with the same bit assignments as for bits 15-11 of \( K_{nty} \) for normal nouns.

\( K_{ntb} \) bits 10-1 contain the relative address (with respect to the start of the \( K_{ndtb} \) table, program notation "IDADDTAB") of the information in that table for the first component of the noun. Is 3(\( \text{NOUNREG -40} \)).

\( K_{ndtb} \) gives the octal erasable memory address for the individual component (if the noun is three components, three consecutive cells are used).

\( K_{rtntb} \) bits 5-1, 10-6, and 15-11 contain the "scale factor routine code number", used in "DECDSP3" and "PUTDCSF2", for component #1, #2, and #3 respectively.

**Notes for Noun Table Information**

1. A decimal display of "hr,mn,sc" appears as:  
   - OXXXX. hr
   - O00XX. mn
   - OXX.XX sc

2. A decimal single-register display of "mn, ,sc" appears with minutes in the first two digits of the register and seconds in the last two digits. The middle (third) digit is blank. Maximum magnitude is 59 59.

3. Vector-type quantities are displayed with the first (e.g. X) component in R1, the second component in R2, and the third in R3.

4. Single component nouns appear in R1 only.

5. If an output quantity is larger than the capacity of the display register scaling, it generally will be displayed modulo that capacity: this assumes, of course, that the basic cell itself as stored in memory has not overflowed. If velocity increment of 12000 fps experienced on an XXXX.X fps scale for display, it would be expected to show 2000(.,)0. This arises from the fact that the \( K_{sfot} \) constants convert the information into the range 0 - 0.99999, with subsequent display output generated by multiplying by 10 and using the integral part of the result (in "DSPDCWD1"). Multiplication by the \( K_{sfot} \) constant takes place before any scaling shifts.
<table>
<thead>
<tr>
<th>Noun</th>
<th>Cell</th>
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<th>Dec. Only</th>
<th>Num- ber</th>
<th>Routine</th>
<th>Con- stant</th>
<th>Decimal</th>
<th>Display</th>
<th>Quantity</th>
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<td>Alternate LOS shaft.</td>
<td></td>
<td></td>
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<tr>
<td>MRKBUF1+3 sp</td>
<td></td>
<td></td>
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<tr>
<td>MRKBUF1+5 sp</td>
<td></td>
<td></td>
<td></td>
<td>XX.XX°</td>
<td>Alternate LOS trunnion.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td></td>
<td>x 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NClTIG</td>
<td></td>
<td>8</td>
<td>0 hr,mn,sc</td>
<td></td>
<td>NCl ignition time.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>96</td>
<td></td>
<td>x 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RANGE</td>
<td></td>
<td>4</td>
<td>7 XXX.XX nm#</td>
<td></td>
<td>CSM out-of-plane pos.</td>
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<td></td>
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<tr>
<td>RRATE</td>
<td></td>
<td>7</td>
<td>10 XXX.XX fps</td>
<td></td>
<td>CSM out-of-plane vel.</td>
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<td></td>
<td></td>
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<tr>
<td>RRATE2</td>
<td></td>
<td>7</td>
<td>10 XXX.XX fps</td>
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<td>OWS out-of-plane vel.</td>
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<tr>
<td>97</td>
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<td>3</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DSPTEM1 sp</td>
<td></td>
<td>3</td>
<td>0 XXXXX.</td>
<td></td>
<td>System test inputs.</td>
<td></td>
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</tr>
<tr>
<td>98</td>
<td></td>
<td>3</td>
<td></td>
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<tr>
<td>DSPTEM2 sp</td>
<td></td>
<td>3</td>
<td>0 XXXXX.</td>
<td></td>
<td>System test results.</td>
<td></td>
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<tr>
<td>DSPTEM2+1 sp</td>
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<td>1</td>
<td>0 XXXXX</td>
<td></td>
<td>System test results.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DSPTEM2+2 sp</td>
<td></td>
<td>3</td>
<td>0 XXXXX</td>
<td></td>
<td>System test results.</td>
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<tr>
<td>99</td>
<td></td>
<td>x 3</td>
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<td></td>
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<td></td>
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<tr>
<td>WWPOS</td>
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<td>7</td>
<td>18 XXXXX. ft</td>
<td></td>
<td>Position W-matrix error/initialization.</td>
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<tr>
<td>WWVEL</td>
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<td>5</td>
<td>19 XXXX.X fps</td>
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<td>Velocity W-matrix error/initialization.</td>
<td></td>
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<tr>
<td>WWOPT</td>
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<td>3</td>
<td>0 XXXXX</td>
<td></td>
<td>Option code.</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

NNDF-31
Quantities in Noun Tables

ACTCENT: See Rendezvous Computations. N52
ADOT: See Digital Autopilot RCS Routines. N56
AGEOFW: See Measurement Incorporation. N31
AK: See Digital Autopilot Interface Routines. N04
ALMCADR: See General Program Control. N08
ALT: See Coordinate Transformations. N43
ALTI: See Boost Computations. N62
AZIMANGL: See Orbital and Rendezvous Navigation. N78
CDU: Major Variable. N20
CDUS, CDUT: See Optics Computations. N91
CHFAIL, CH6FAIL: See Digital Autopilot Docked Jet Selection. N87
CPHIX: See Digital Autopilot RCS Routines. N17
CSMASS: See Digital Autopilot Interface Routines. N47
D: See Entry Computations. N64, N74
DAPDTR1, DAPDTR2: See Digital Autopilot Interface Routines. N46
DAPDTR3: See Digital Autopilot Docked Jet Selection. N87
DBPTC: See Orbital and Rendezvous Navigation. N79
DELVIMU: See Display Computations. N83
DELVLVC: See Burn Control. N81, N86
DELH1: See Rendezvous Computations. N57
DELVT, DELVTP: See Burn Control. N58
DHDSP: See Rendezvous Computations. N84
DHNCC: See Rendezvous Computations. N57
DIFALT: See Rendezvous Computations. N75
DKDB, DKRATE: See Digital Autopilot RCS Routines. N89
DNRNGERR: See Entry Computations. N66
DSPI'EM1: Major Variable. N05, N25, N29, N30, N34, N41, N97
DSPI'EM2: Major Variable. N24, N98
DSPI'EMX: See Display Computations. N16
DVDSPL, DVDSP2: See Rendezvous Computations. N84
DVLOG: See Burn Control. N59
DVTOTAL: See General Program Control. N40, N80
ELEV: See Rendezvous Computations. N55
ERCOUNT: See Testing Routines. N08
FAILREG: See General Program Control. N09
FIXTIME: See Orbital and Rendezvous Navigation. N72
GAMMAEI: See Display Computations. N60
GMAX: See Display Computations. N60
HALFREVS: See Burn Control. N57
HAPO: See Burn Control. N42
HAPOX: See Display Computations. N44
HDOT: See Boost Computations. N62
HEADSUP: See Entry Preparation. N61
HPER: See Burn Control. N42
HPERX: See Display Computations. N44, N50
LASTTIG: See Burn Control. N39
LAT: See Coordinate Transformations. N43, N67
LATANG: See Entry Computations (tag also XRNGERR). N66
LATSPL: See Display Computations. N61
LEMMASS: See Digital Autopilot Interface Routines. N47
LNGSPL: See Display Computations. N61
LONG: See Coordinate Transformations. N43, N67
MRKBUF1+3: See Optics Computations. N94
MRKBUF1+5: See Optics Computations. N94

NNDF-33
mTPER: See Display Computations. N32
N26d2CAD, N26d2CAD+1, N26dPRI: See Data Input/Output. N26
N49DISP, N49DISP+2, N49DISP+4: See Measurement Incorporation. N49
NC1TIG: See Burn Control. N95
NC2TIG: See Burn Control. N28
NNl: See Rendezvous Computations. N55
CGQ: See Coordinate Transformations. N93
OPTION1, OPTION2: See Display Interface Routines. N06
OPTIONX: See Display Computations. N12
OPVEC: See Measurement Incorporation. N77
PAC: See Coordinate Transformations. N92
PACTOFF: See Digital Autopilot TVC Routines. N48
PHETA: See Orbital and Rendezvous Navigation. N77
PIPA: See IMU Computations. N21
pMGA: See Display Computations. N45
Q7: See Entry Computations. N69
RANGE: See Display Computations. N53, N54, N96
RATEPTC: See Attitude Maneuvers. N79
RDOT: See Entry Computations. N68
ROLLC: See Entry Computations. N66, N68, N69, N74
RRATE: See Display Computations. N53, N54, N96
RRATE2: See Display Computations. N96
RSPmRREC: See Display Computations. N50
RTGO: See Display Computations. N63
RTGON67: See Entry Computations. N64, N67
RTHETA: See Display Computations. N53, N54

SAC: See Coordinate Transformations. N92

SMODE: See Testing Routines. N27

STARCODE: See Inflight Alignment. N70, N71

STARSAV3: See Inflight Alignment. N88

SVEC: See Measurement Incorporation. N76

T_{cdh}': See Rendezvous Computations. N13

T_{csi}: See Rendezvous Computations. N11

T_{et}: See Orbital Integration. N38

T_{ig}: Major Variable. N33

T_{now}: Major Variable. N36

T_{st}: See Data Input/Output. N65

T_{togo}: See Burn Control. N35, N40, N45, N80

T_{tphi}: See Rendezvous Computations. N37

T1TOT2: See Burn Control. N75

T2TOT3: See Burn Control. N58, N75

TFF: See Display Computations. N44, N50

TFO: See Orbital and Rendezvous Navigation. N76

THETAD: Major Variable. N18, N22, N23

TRKAZ: See Inflight Alignment. N14

TRKAZOCT: See Inflight Alignment. N19

TRKEL: See Inflight Alignment. N14

TRKKMCNT: See Measurement Incorporation. N45

TTE: See Display Computations. N63

UTPTT, UTYAW: See Orbital and Rendezvous Navigation. N78

V_{gbody}: See Burn Control. N85

VGDISP: See Burn Control. N40, N42, N80

NNDF-35
VGNSR: See Rendezvous Computations. N82
VHFCT: See Measurement Incorporation. N45
VIO: See Display Computations. N63
VL: See Entry Computations. N69
VMAGI: See Boost Computations/Entry Computations. N62, N64, N68, N74
VPRED: See Display Computations. N60
XREG: See Data Input/Output. N07
YACTOFF: See Digital Autopilot TVC Routines. N48
YCSM, YDOTC, YDOTL: See Burn Control. N90
YREG: See Data Input/Output. N07
ZREG: See Data Input/Output. N07
## Internal Noun Uses

Listed below are the routines which cause the values of particular nouns to be displayed, together with the associated verb used for the initial display generation (which is sometimes written over with another verb).

<table>
<thead>
<tr>
<th>Noun</th>
<th>Using Routine (Verb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>&quot;OHWELL1&quot; (21); &quot;OHWELL2&quot; (21); &quot;SOPTION&quot; (05)</td>
</tr>
<tr>
<td>02</td>
<td>&quot;UPVERIFY&quot; (21)</td>
</tr>
<tr>
<td>03</td>
<td>Manual initiation only (angle data, address-to-be-specified)</td>
</tr>
<tr>
<td>04</td>
<td>Manual initiation only (FDAI error needle information)</td>
</tr>
<tr>
<td>05</td>
<td>&quot;R54&quot; (06)</td>
</tr>
<tr>
<td>06</td>
<td>See Checklist and Option Codes</td>
</tr>
<tr>
<td>07</td>
<td>Manual initiation only (with V25, to change flag/channel bits)</td>
</tr>
<tr>
<td>08</td>
<td>Manual initiation only (Alarm data)</td>
</tr>
<tr>
<td>09</td>
<td>See the &quot;D&quot; Error Codes (used with V05)</td>
</tr>
<tr>
<td>10</td>
<td>Manual initiation only (channel-to-be-specified)</td>
</tr>
<tr>
<td>11</td>
<td>&quot;P33&quot; (06)</td>
</tr>
<tr>
<td>12</td>
<td>See Checklist and Option Codes</td>
</tr>
<tr>
<td>13</td>
<td>&quot;P33&quot; (06); &quot;P34&quot; (06)</td>
</tr>
<tr>
<td>14</td>
<td>&quot;R53DISP&quot; (06); &quot;TRKSTAR&quot; (06)</td>
</tr>
<tr>
<td>15</td>
<td>Manual initiation only (increment machine address)</td>
</tr>
<tr>
<td>16</td>
<td>&quot;R36&quot; (06); &quot;V82GOFF1&quot; (06)</td>
</tr>
<tr>
<td>17</td>
<td>Manual initiation only (V63 FDAI error base angles)</td>
</tr>
<tr>
<td>18</td>
<td>&quot;TOBALL&quot; (06); &quot;TOBALL&quot; (06 replaced by 50); &quot;V89RECL&quot; (06)</td>
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<tr>
<td>19</td>
<td>&quot;TRKSTAR&quot; (04)</td>
</tr>
<tr>
<td>20</td>
<td>&quot;GYCRS&quot; (16)</td>
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<tr>
<td>21</td>
<td>Manual initiation only (accelerometer cells)</td>
</tr>
<tr>
<td>22</td>
<td>&quot;IMUATTCK&quot; (25); &quot;P51A&quot; (06); &quot;P52D&quot; (06); &quot;P62.1&quot; (06); &quot;R62DISP&quot; (06); &quot;UPCONTRL&quot; (06); &quot;VBCOARK&quot; (25)</td>
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<tr>
<td>Noun</td>
<td>Using Routine (Verb)</td>
</tr>
<tr>
<td>------</td>
<td>---------------------</td>
</tr>
<tr>
<td>23</td>
<td>&quot;OAVECS&quot; (06)</td>
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<tr>
<td>24</td>
<td>&quot;ALINTIME&quot; (25)</td>
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<tr>
<td>25</td>
<td>See Checklist and Option Codes</td>
</tr>
<tr>
<td>26</td>
<td>Manual initiation only (verb 30 and 31 parameters)</td>
</tr>
<tr>
<td>27</td>
<td>Manual initiation only (computer self-test switch)</td>
</tr>
<tr>
<td>28</td>
<td>&quot;P32&quot; (06)</td>
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<tr>
<td>29</td>
<td>&quot;AZMTHCG1&quot; (06)</td>
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<tr>
<td>30</td>
<td>&quot;GCOMPVER&quot; (05, written over by VO6N4L)</td>
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<tr>
<td>31</td>
<td>Manual initiation only (time of last r/v W matrix initialization)</td>
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<tr>
<td>32</td>
<td>Manual initiation only (time from pericenter computed in R30)</td>
</tr>
<tr>
<td>33</td>
<td>&quot;P30&quot; (06); &quot;P38&quot; (06); &quot;P77&quot; (06)</td>
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<tr>
<td>34</td>
<td>&quot;PASSOUT&quot; (06); &quot;P20OPT&quot; (06); &quot;P21PROG1&quot; (06); &quot;P52B&quot; (06)</td>
</tr>
<tr>
<td>35</td>
<td>Manual initiation only (h,m,s display of e.g.R1 of N40)</td>
</tr>
<tr>
<td>36</td>
<td>Manual initiation only (computer clock)</td>
</tr>
<tr>
<td>37</td>
<td>&quot;P31&quot; (06); &quot;P32&quot; (06); &quot;P33&quot; (06); &quot;P34/P74C&quot; (06); &quot;P55&quot; (06)</td>
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<tr>
<td>38</td>
<td>Manual initiation only (state vector time, ( t_e ))</td>
</tr>
<tr>
<td>39</td>
<td>&quot;P38&quot; (06)</td>
</tr>
<tr>
<td>40</td>
<td>&quot;CLOCKJOB&quot; (06 replaced by 97 or 99); &quot;POSTBURN&quot; (16); &quot;P4OSXYT&quot; (06); &quot;TIC-0&quot; (06); &quot;TIGAVEG&quot; (06); &quot;V97E&quot; (06); &quot;V97P&quot; (06); &quot;V99P&quot; (06)</td>
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<tr>
<td>41</td>
<td>&quot;GCOMPVER&quot; (06, after N30 loads R3)</td>
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<tr>
<td>42</td>
<td>&quot;P30&quot; (06)</td>
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<tr>
<td>43</td>
<td>&quot;LONGPASS&quot; (06, R1 and R3 blanked); &quot;PASSOUT&quot; (06); &quot;P21PROG2&quot; (06)</td>
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<tr>
<td>44</td>
<td>&quot;V82CALL&quot; (16); &quot;V82GOFLP&quot; (16)</td>
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<tr>
<td>45</td>
<td>&quot;P30&quot; (16); &quot;R23CSM1&quot; (16 replaced by 53); &quot;VN1645&quot; (16)</td>
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<tr>
<td>46</td>
<td>&quot;DONOUN46&quot; (04)</td>
</tr>
<tr>
<td>Noun</td>
<td>Using Routine (Verb)</td>
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<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
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<tr>
<td>47 &quot;DONOUN46&quot; (06)</td>
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</tr>
<tr>
<td>48 &quot;DONOUN46&quot; (06)</td>
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</tr>
<tr>
<td>49 &quot;RENDISP2&quot; (06, priority display)</td>
<td></td>
</tr>
<tr>
<td>50 Manual initiation only (optional R30 display, R1 computed in P00 and P11 only)</td>
<td></td>
</tr>
<tr>
<td>52 Manual initiation only (central angle of transfer computed in P35 and P36)</td>
<td></td>
</tr>
<tr>
<td>53 &quot;R31CALL&quot; (16)</td>
<td></td>
</tr>
<tr>
<td>54 &quot;R31CALL&quot; (16)</td>
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</tr>
<tr>
<td>55 &quot;P34/P74C&quot; (06); &quot;P35&quot; (06)</td>
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</tr>
<tr>
<td>56 Manual initiation only (DAP-derived vehicle rates)</td>
<td></td>
</tr>
<tr>
<td>57 &quot;P31&quot; (06); &quot;P32&quot; (06, R1 blanked)</td>
<td></td>
</tr>
<tr>
<td>58 &quot;P34/P74C&quot; (06)</td>
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</tr>
<tr>
<td>59 &quot;P35/P75B&quot; (06)</td>
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<tr>
<td>60 &quot;NEWRNVN&quot; (06)</td>
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<tr>
<td>61 &quot;P61&quot; (06); &quot;P62.1&quot; (06)</td>
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<td>62 &quot;VHHDOT&quot; (06)</td>
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<tr>
<td>63 &quot;NEWRNVN&quot; (16)</td>
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<tr>
<td>64 &quot;P63&quot; (06)</td>
<td></td>
</tr>
<tr>
<td>65 Manual initiation only (sampled computer clock)</td>
<td></td>
</tr>
<tr>
<td>66 &quot;PREFINAL&quot; (06)</td>
<td></td>
</tr>
<tr>
<td>67 &quot;P67.1&quot; (16)</td>
<td></td>
</tr>
<tr>
<td>68 Manual initiation only (entry quantities)</td>
<td></td>
</tr>
<tr>
<td>69 &quot;P65.1&quot; (16)</td>
<td></td>
</tr>
<tr>
<td>70 &quot;R51DSP&quot; (01); &quot;TRKSTAR&quot; (01); &quot;V1N70DSP&quot; (01)</td>
<td></td>
</tr>
<tr>
<td>71 &quot;R53C&quot; (01)</td>
<td></td>
</tr>
</tbody>
</table>
Noun | Using Routine (Verb)
---|---
72 | "P25CSM" (06); "V76CALL" (06); "72SHOWX" (06)
73 | Manual initiation only (quantities computed in P21)
74 | "INITROLL" (06)
75 | "P33/P73B" (06)
76 | "BOTHSHOW" (16); "P47BODY" (16)
77 | "BOTHSHOW" (16); "P47BODY" (16)
78 | "DOV6N78" (06); "V64PERF" (06); "V89CALL" (06, R3 blanked)
79 | "DOV6N78" (06)
80 | Manual initiation only (R2 and R3 different scales from N40)
81 | "NC12H" (06); "N81DISP" (06); "P30" (06); "P33/P73B" (06); "P34/P74C" (06); "P38RECYC" (06); "P77" (06)
82 | "NCDDMP7+17" (06)
83 | "P47BODY" (16)
84 | "NC12DH" (06)
85 | "P4OSXTY" (06); "TIGAVEG" (16); "TIGNOW" (16)
86 | Manual initiation only (different scaling from N81)
87 | "DKDISP" (05)
88 | "PLANET" (06); "V1N70DSP" (06)
89 | "DONOUN89" (06, R3 blanked)
90 | Manual initiation only (out-of-plane parameters)
91 | Manual initiation only (optics CDU angles)
92 | "R53CHK" (06); "VBCOARK" (24)
93 | "GCOMPVER" (06); "IMUFINEK" (25); "R55" (06)
94 | "R23CSM" (06); "R56" (06); "V64PERF" (06)
95 | "P31" (06)

NNDF-40
"R36" (06)
Manual initiation only (DSPTEM1 cells for system test inputs)
"SHOW" (06)
"GOTOPOOH" (37, which then blanks noun); "V67CALL" (06)
Optics Computations

OPTTEST Entered from "PROCEED" every 0.24 seconds

\[ TS = \text{CDUS} \quad \text{Tag here "OPTDRIVE"} \]

\[ TS_1 = |TS| - K_{45dg} \]

If \( TS_1 \leq 0 \):

\[ \text{ZONE} = 0 \]

If \( TS_1 > 0 \):

If \( \text{ZONE} = 0 \):

\[ \text{ZONE} = TS \]

If OPTIND \( \leq -0 \):

If OPTIND \( < -0 \):

Set bit 8(TVC Enable) of channel 12 = 0

Resume

If SWSAMPLE \( < 0 \) \quad \text{(Zero optics mode)}

Resume

If SWSAMPLE = 0: \quad \text{(Manual mode)}

If bit 8(TVC Enable) of channel 12 = 0: \quad \text{Tag here "TVCBCK"}

Set bit 8(TVC Enable) of channel 12 = 1

Resume

If bit 10(ZROPTFIN) of OPTMODES = 0: \quad \text{Tag here "RATEDRV1"}

Perform "ALARM" (pattern 0120_8)

If bit 2(Enable Optics CDU Error Counters) of channel 12 = 0:

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 1

Resume

COMMANDS = (DESOPTS - CDUS), rescaled to Bl revolutions. The ones complement difference of the twos complement numbers is formed, and a rounded shift employed in the rescaling from B-1 to Bl revolutions.
TS = DESOPTT - CDUT  \ (treated as ones complement numbers)

If |TS| < 2^-3 rev (45°):

  COMMANDT = (DESOPTT - CDUT), rescaled to B-1 revolutions.
  The ones complement difference of the twos complement numbers is formed, and a rounded shift employed in the
  rescaling from B-3 to B-1 revolutions.

If |TS| \geq 2^-3 rev (45°):

  COMMANDT = +MAX sgn TS

OPTIND = +0

TS_1 = 0  \ (ITEMPl tag)

If |CDUS| - K_{90dg} \geq 0:  \ (i.e. 2nd or 3rd quadrant)

  If ZONE \neq 0:  \ (should be)

    If sgn ZONE = sgn COMMANDS:  \ (+0 is +, -0 is -)

    TS_2 = |DESOPTS|

    If sgn ZONE \neq sgn COMMANDS:

    TS_2 = +MAX

    If TS_2 - K_{90dg} \leq 0:  \ (i.e. DESOPTS 1st or 4th quad.)

      COMMANDS = - COMMANDS

If SWSAMPLE = 0:  \ (Manual mode; Tag "CMDSETUP")

  CDUSCMD = -0  \ (Tag here "RATEDRV2")

  CDUTCMD = -0

  Set bits 12-11 (Gate outputs from CDUICMD, i = T, S) of
  channel 14 = 1

  Resume

  Set bit 8(TVC Enable) of channel 12 = 0
Perform the following for $i = S, T$: (Tag here "CMDSET")

If $\text{COMMAND}_i = 0$:

$$\text{CDU}_i\text{CMD} = -0$$

If $\text{COMMAND}_i \neq 0$:

$$\text{TS}_1 = \text{TS}_1 + 1 \quad \text{(non-zero command required)}$$

$$\text{TS} = |\text{COMMAND}_i| + K_{\text{mxpsl}}$$

If $\text{TS} > 0$:

$$\text{CDU}_i\text{CMD} = -K_{\text{mxps}} \text{sgn COMMAND}_i$$

If $\text{TS} < 0$:

$$\text{CDU}_i\text{CMD} = \text{COMMAND}_i$$

If $\text{TS}_1 > 0$:

Set bits 12-11 (Gate outputs from CDU_iCMD, $i = T, S$) of channel $14 = 1$

Resume

OPTMON Entered from "PROCEED" every 0.48 seconds

TS = bit 7(Optics CDU Fail complement) of channel 30

If TS $\neq$ bit 7(OCDUFBIT) of OPTMODES:

Perform "OCDUFTST"

If OPTIND = -0:

Resume \hspace{1cm} (note that bit 7 of OPTMODES not updated)

If OPTIND < 0: \hspace{1cm} (set -1 by e.g. "INITSUBA")

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0

Set bit 7(OCDUFBIT) of OPTMODES = TS

Set bits 5-4(OPMD1BIT, OPMD2BIT) of OPTMODES = bits 5-4 (Computer Control of Optics complement and Zero Optics Mode complement) of channel 33

If bits 5-4 of C31FLWRD $\neq 00_2$:

Set bits 5-4 of OPTMODES = bits 5-4 of C31FLWRD

If bits 5-4 of OPTMODES = 11_2:

SWSAMPLE = 0 \hspace{1cm} (Manual mode)
If bits 5-4 of OPTMODES ≠ 11₂:

If bit 5(OPMD1BIT) of OPTMODES = 0:

SWSAMPLE = 15 (Computer Control)

If bit 5(OPMD1BIT) of OPTMODES = 1:

SWSAMPLE = -1

If DESOPMOD > 0: (previous cycle Computer Control; Tag "PROCESSW")

If SWSAMPLE > 0: (still Computer Control; Tag "CSODES")

DESOPMOD = SWSAMPLE

Resume

If SWSAMPLE < 0: (from Computer Control to Zero)

Proceed to "CSCTOZOP"

Proceed to "CSCTOMAN" (from Computer Control to Manual)

If DESOPMOD = 0: (previous cycle Manual mode)

If SWSAMPLE > 0: (from Manual to Computer Control; Tag "MANUDES")

WTOPTION = 0
ZOPTCNT = 0

Proceed to "CSCTOMAN"

If SWSAMPLE = 0: (still Manual)

WTOPTION = WTOPTION - 1, limited ≥ +0
DESOPMOD = SWSAMPLE

Resume

If WTOPTION = 0: (from Manual to Zero)

Proceed to "CSCTOZOP"

Proceed to second line of "CSCTOZOP"
If \( \text{DESOPMOD} < 0 \): (as it will) (previous cycle Zero optics)

If \( \text{SWSAMPLE} > 0 \): (from Zero to Computer Control; Tag "ZOPTDES")

If bit 3(ZOPTCS) of OPTMODES = 0: (Tag "ZTOCSC")

Proceed to "CSCTOMAN"

Perform "ALARM" (pattern \( 01 \times_8 \))

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0

Set bit 1(Zero Optics CDU) of channel 12 = 0

WTOPTION = 0

ZOPTCNT = 0

Proceed to "CSCTOMAN"

If \( \text{SWSAMPLE} = 0 \): (from Zero to Manual)

If bit 3(ZOPTCS) of OPTMODES = 0: (Tag "ZTOCSC")

Proceed to "CSCTOMAN"

Perform "ALARM" (pattern \( 01 \times_8 \))

WTOPTION = 11

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0

Set bit 1(Zero Optics CDU) of channel 12 = 0

Proceed to "CSCTOMAN"

If bit 3(ZOPTCS) of OPTMODES = 0: (still Zero)

\( \text{DESOPMOD} = \text{SWSAMPLE} \)

Resume

If \( \text{ZOPTCNT} > 0 \):

\( \text{ZOPTCNT} = \text{ZOPTCNT} - 1 \)

\( \text{DESOPMOD} = \text{SWSAMPLE} \)

Resume

Set bit 1(Zero Optics CDU) of channel 12 = 1 (Tag "SETZOEND")

OPTC-5
(If DESOPMOD < 0):
   Call "ENDZOPT" in 0.20 seconds
   DESOPMOD = SWSAMPLE
   Resume

   ENDZOPT
   CDUS = 0
   ZONE = 0
   CDUT = - K_200degs
   Set bit 1(Zero Optics CDU) of channel 12 = 0
   Delay 0.20 seconds
   Set bit 10(ZROPTFIN) of OPTMODES = 1
   Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0
   Perform "OCDUFTST"
   End of task

   OCDUFTST
   If bit 7(Optics CDU Fail complement) of channel 30 = 0:
      If bit 2(OCDUINHT) of OPTMODES = 1:
         Return
      If bit 8 of DSPTAB+ll = 0:
         Set bit 8(Tracker) of DSPTAB+ll = 1, and flag for output at next opportunity
         Return
   If bit 1(IMPTSTST) of IMODES33 = 1:
      Return
   If bit 8 of DSPTAB+ll = 1:
      Set bit 8(Tracker) of DSPTAB+ll = 0, and flag for output at next opportunity
      Return

OPTC-6
CSCTOZOP

ZOPTCNT = 32
WTOPTION = 0
Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 1
Set bit 8(TVC Enable) of channel 12 = 0
Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0
DESOPMOD = SWSAMPLE
Resume

CSCTOMAN

IF OPTIND > +0:
    Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0
    Call "ECNAB" in 0.06 seconds
DESOPMOD = SWSAMPLE
Resume

ECNAB

IF SWSAMPLE = 0:    (Manual mode)
    Set bit 8(TVC Enable) of channel 12 = 1
Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 1
End of task

SXTMARK

Perform "TESTMARK"

MARKINDX = 1
OPTCADR = Return address (to routine calling "SXTMARK")
Proceed to "MKVB51"
TESTMARK

Entered from "R56" and "SXTMARK"

If bits 3-2 of EXTVBACT $\neq 00_2$:

Proceed to "BAILOUT" (pattern $31211_8$)

Set bit 2 of EXTVBACT = 1

Return

MKRELEAS

(Tag also "MKRELES")

Inhibit interrupts

OPTIND = -1

MARKINDX = 0

Set bit 4 (MARKFLG) of FLAGWRD1 = 0

Release interrupts

Return

MKVB51

Perform "KLEENEX"

Proceed to "MKVBDSP"

MKVBDSP

TS = 5100 \text{ vn}

Proceed to "GOMARK4": if terminate, proceed to "TERMSXT"
if proceed, proceed to "ENTANSWR"
otherwise, proceed to "MKVB5X"

ENTANSWR

Establish "ENDEXT" (priority $24_8$)

Change priority of present job to $13_8$ (allows "ENDEXT" to be executed)

Proceed to address specified by OPTCADR

MKVB5X

If \( \text{MARKINDX} > 0 \):

Proceed to "MKVB51"

Proceed to "MKVB50"
MKVB50

DSPTEMl = 00016g
TS = 5025 vn
Proceed to "GOMARK4": if terminate, proceed to "TERMSXT"
if proceed, proceed to "ENTANSWR" otherwise, proceed to "MKVB5X"

TERMSXT

Perform "CLEARMRK"
Perform "MKRELEAS"
If MODREG = 03:
    Proceed to "GCOMP5"
Proceed to "GOTOPOOH"

MARKRUPT Entered after receipt of program interrupt #6, navigation panel DSKY key code or optics mark/mark reject

MKCDUT = CDUT
MKCDUS = CDUS
MKCDUY = CDUy
MKCDUZ = CDUz
MKCDUX = CDUx
MKT2Tl = T_now
Tst = MKT2Tl
If bit 6(Optics Mark) of channel 16 = 1:
    TS = Ccduchkwd limited \( \geq \) 1 centi-second (tag here "MARKIT")
    Call "MARKDIF" in TS centi-seconds
    Resume

If bit 7(Optics Mark Reject) of channel 16 = 1:
    Proceed to "MKREJECT"
TS1 = bits 5-1 (DSKY input) of channel 16
If \( T_{S_1} \neq 0 \):

Proceed to "KEYCOM"

Perform "ALARM" (pattern 0113\textsubscript{8})

Resume

MARKDIF

If \( C_{cduchkw} > 0 \):

If any \( |MKCDU_1 - CDU_i| + K_{m3bt} > 0 : \) \( (i = X,Y,Z) \)

Perform "ALARM" (pattern 0121\textsubscript{8})

End of task

If bit \( l_4(R21MARK) \) of FLAGWRD2 = 1: \hspace{1em} (Tag here "MARKCONT")

Proceed to "PUTMARK"

If \( MARKINDEX = 0 \):

Perform "ALARM" (pattern 0114\textsubscript{8})

End of task

MARKINDEX = MARKINDEX - 1 \hspace{1em} (Tag here "MARK2")

Set bit \( l_4(MARKFLG) \) of FLAGWRD1 = 1

Proceed to "PUTMARK"

PUTMARK

\( MKBUFl+i = MKj \) \hspace{1em} \( (i = 0-6; j = T2T_{dp}, CDUY, CDUS, CDUT, CDUX) \)

If bit \( l_4(R21MARK) \) of FLAGWRD2 = 1:

End of task

Proceed to "MARKDONE"

MARKDONE

If \( MARKINDEX = 0 \):

Established "MKVB5X" \hspace{1em} (priority 22\textsubscript{8})

End of task
MKREJECT

If bit 14(R21MARK) of FLAGWRD2 = 1:

If MRKBUF1 > 0:  (i.e. last mark not yet being processed by R22)
  MRKBUF1 = -1
  Resume

If bit 7(R22CAFGLG) of FLAGWRD9 = 1:  (set by "REND1")
  Set bit 12(REJCTFLG) of FLGWRD10 = 1  (for "REND7" use)
  Resume

If bit 4(MARKFLG) of FLAGWRD1 = 0:
  Perform "ALARM"  (pattern 01108)
  Resume

Set bit 4(MARKFLG) of FLAGWRD1 = 0  (Tag here "REJECT3")
MARKINDX = MARKINDX + 1
Establish "MKVBDSP"  (priority 228)
Resume  (Note that "KLEENEX" bypassed, so may have more than F V51 on DSKY, e.g. N25 and R1 = 000168 also)

R23CSM  Established by "GOTOR23" for a V54E

Set bit 14(R21MARK) of FLAGWRD2 = 0
MRKBUF1 = -1
Change priority of present job to 278  (higher than R22)
TS = 0694vn
Proceed to "GOXDSPF": if terminate, proceed to "R21END"
  if proceed, proceed
  otherwise, proceed to previous line
Proceed to "R23CSM1."

R23CSM1

TS = 5345vn
Proceed to "MARKMONR": if terminate, proceed to "R21END"
  if proceed, proceed to "R21END"
  otherwise, proceed
Inhibit interrupts

\[ \text{MRKBUF1} = T_{\text{now}} \]
\[ \text{MRKBUF1} + 2 = \text{CDU}_y \] (MRKBUF1+3 and MRKBUF1+5 loaded by N94 in "R23CSM")
\[ \text{MRKBUF1} + 4 = \text{CDU}_z \]
\[ \text{MRKBUF1} + 6 = \text{CDU}_x \]

Release interrupts

Proceed to "R23CSM1" ("V86PERF", if done promptly, can be used to reject the mark)

**R21END**

Perform "KLEENEX"

\[ \text{MRKBUF1} = -1 \]

Change priority of present job to \(16^8\) (allow R22 to finish if processing mark, with proper R21MARK bit value)

Set bit 14 (R21MARK) of FLAGWRD2 = 1

Proceed to "ENDEXT"

**R52**

Entered from "PIKUP20" and "R51DSP"

SAVQR52 = Return address

DESOPTT = CDUT

DESOPTS = CDUS

OPTIND = +0

Set bit 6 (SGTMK) of FLAGWRDO = 0 (notation R53FLAG)

If bit 10 (LMTRG) of FLAGWRD1 = 1: (notation TARG1FLG, means tracking OWS)

Proceed to "R52H"

Set bit 15 (TERMIFLAG) of FLAGWRD7 = 0

Proceed to "R52C"

**R52C**

If SWSAMPLE \(\geq 0\): (i.e. Computer Control of optics)

Proceed to "R52D"
If bit 6(SGTMK) of FLAGWRDO = 0: (Tag here "R52M")

Establish "R53JOB" (priority 248)
Proceed to "R52F"

R52F

TS = 0.50 second
Delay TS seconds (by putting job to sleep via "DELAYJOB")
If bit 10(LMTRG) of FLAGWRDl = 1:

Proceed to "R52H"

If bit 15(TERMIFLG) of FLAGWRD7 = 1: (set by end of "R53" package)

Proceed to address specified by SAVQR52
Proceed to "R52C"

R52H (Entered only if tracking OWS, from "R52" and "R52F")

Perform "R61CSM"

If bit 5(TRACKFLG) of FLAGWRDl = 0:

Proceed to address specified by SAVQR52

If bit 7(UPDATFLG) of FLAGWRDl = 1:

Proceed to "R52D"

TS = 1.80 seconds
Proceed to second line of "R52F"

R52D

If bit 10(LMTRG) of FLAGWRDl = 1:

\[ T_{\text{decl}} = T_{\text{now}} + K_{2p4secdp} \] (Tag here "LEM52")

Perform "LEMCONIC"

\[ \text{STAR} = R_{\text{att}} \]

\[ T_{\text{decl}} = T_{\text{att}} \]

Perform "CSMCONIC"

\[ TS = \text{unit}(\text{STAR} - R_{\text{att}}) \]
Proceed to "COM52"
If STARIND = 0:
    TS = STARSAY2
If STARIND > 0:
    TS = STARSAY1
Proceed to "COM52"

**COM52**

STAR = unit([REFSMMAT] TS)
Perform "CDUTRIG"
Perform "CALCSXA"
If bit 7 (CULTFLAG) of FLAGWRD3 = 1:
    If bit 10 (LMTRG) of FLAGWRD1 = 0:  (Tag here "R52L")
        TS = 04048
        Perform "PRIOLARM": if terminate, proceed to "TERM52"
        if proceed, skip next line
        otherwise, skip next line
    End of job
    Proceed to "R52F"

PACTEMP = K50dgtr sp
If bit 7 (CULTFLAG) of FLAGWRD3 = 0:
    If (PAC - K50dgtr) < 0 and (PAC - K20dgsmn) > 0:
        PACTEMP = PAC
        Skip next line
        PACTEMP = K50dgtr sp
    If bit 10 (LMTRG) of FLAGWRD1 = 1:  (Tag here "R52JA")
        Proceed to "R52E"
    Proceed to "R53CHK"
R53CHK

If bit 6(SGTMK) of FLAGWRDO = 0:

TS = 0692

Perform "GODSPR"

Proceed to "R52E"

R52E

DESOPTT = PACTEMP
DESOPTS = SAC

Proceed to "R52F"

R53JOB 

Established by "R52C"

Perform "R53"

End of job

TERM52

Entered for V34E response to 040A alarm display

Perform "KLEENEX"

Proceed to "TERMSXT"

R53

R53EXIT = Return address

Set bit 6(SGTMK) of FLAGWRDO = 1  
(program notation R53FLAG)

Perform "SXTMARK"

If MARKINDX > 0:  
(no marks taken)

Proceed to third line of "R53"

Perform "MKRELEAS"  
(Tag here "R53A")

Proceed to "R53Cl"

R53C1

Entered from "R53" and "R56"

TS = 0

Perform "CLEANDSP"

If (MODREG - 32) ≤ 0:  
(should not be)

Set bit 15(TERMIFLG) of FLAGWRD7 = 1

Proceed to address specified by R53EXIT

OPTC-15
If bit 12(P50.1.FL.G) of FLAGWRDO = 1:
    Set bit 15(TERMIFLG) of FLAGWRD7 = 1
    Proceed to address specified by R53EXIT

Proceed to "R53C"

R53C

TS = 0171 vn

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
    if proceed, proceed
    otherwise, proceed to previous line

If STARCODE ≤ -0 or if (bits 6-1 of STARCODE) > 47₈:
    Set bit 7(Operator Error) of channel ll = 1
    Proceed to "R53C"

If bit 7 of STARCODE = 1:
    If STARCODE ≠ 0014₈₈: (i.e. sun not specified)
        Set bit 7(Operator Error) of channel ll = 1
        Proceed to "R53C"

TS = 6 (bits 6-1 of STARCODE)

If STARIND = 0:
    BESTI = TS
If STARIND = 1:
    BESTJ = TS

If MODREG ≠ 50:
    If bit 8 of STARCODE = 0: (e.g. not of form 002xx)
        Set bit 15(TERMIFLG) of FLAGWRD7 = 1
        Proceed to address specified by R53EXIT

Proceed to "R53DISP"
R53DISP

TS = 0614\,\text{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
  if proceed, proceed
  otherwise, proceed to previous line

TS = TRKAZ, rescaled (by doubling) to B-1 rev.

MRKBUF1+3 = TS, modulo 2^{-1} rev. (180°)

If $|TS| \geq \frac{1}{2}$: (i.e. bigger than 180°)
  Set bit 7(Operator Error) of channel 11 = 1

Proceed to "R53DISP"

TS = TRKEL, rescaled (by doubling) to B-1 rev.

MRKBUF1+5 = TS, modulo 2^{-1} rev. (180°)

If $|TS| \geq \frac{1}{2}$: (i.e. bigger than 180°)
  Set bit 7(Operator Error) of channel 11 = 1

Proceed to "R53DISP"

Set bit 15(TERMIFLG) of FLAGWRD7 = 1

Proceed to address specified by R53EXIT

R56

Entered from "P51B" and "R51DSP"

R53EXIT = Return address

TS = 0694\,\text{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
  if proceed, proceed
  otherwise, proceed to previous line

Perform "TESTMARK" (Tag here "R56A")

TS = 0

Perform "CLEANDSP"

TS = 5300\,\text{vn}

Proceed to "GOMARK2": if terminate, proceed to "GOTOPOOH"
  if proceed, proceed to previous line
  otherwise, proceed
SAC = MRKBUF1+3 
(loaded in R1 of N94)
PAC = MRKBUF1+5 
(loaded in R2 of N94)

Inhibit interrupts 

MRKBUF1dp = T_{now}
MRKBUF1+2 = CDU_y
MRKBUF1+4 = CDU_z
MRKBUF1+6 = CDU_x

Release interrupts

Perform "CLEARMRK"

TS = 00016\t8

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to 4th line of "R56"

Proceed to "R53C1"
Quantities in Computations

See also list of major variables and list of routines

BESTI, BESTJ: See Inflight Alignment.

\( C_{\text{cduchkw}} \): Single precision erasable memory constant, program notation "CDUCHKW", scale factor B14, used to specify (if positive non-zero) the number of centi-seconds delay before "MARKDIF" is performed after receiving an optics mark button input. If the cell is zero or negative, the delay is 0.01 second.

C31FLW RD: See Digital Autopilot RCS Routines.

CDUS: Single precision value of counter input cell 0036g, containing the optics CDU shaft angle (also identified with the X axis), scale factor B-1, units revolutions, in twos complement.

CDUT: Single precision value of counter input cell 00358, containing the optics CDU trunnion angle (also identified with the Y axis), scale factor B-3, units revolutions, in twos complement. See K20degs.

CDU1CMD (i = T, S): Single precision value of computer special erasable memory cells 00538 - 00548 respectively. Pulses are generated based on the contents of these cells if bits 12-11 respectively of channel 14 = 1, and the optics CDU error counter is loaded from the 3200 pps pulse train information if bit 2 of channel 12 = 1. For the output to give one revolution, 215 pulses from CDUTCMD, and 213 pulses from CDUSCMD, are required. The same cells are also used for TVCYAW and TVOPITCH commands for the SPS engine (see Digital Autopilot Interface Routines).

COMMANDT, COMMANDS: Raw values of trunnion and shaft commands computed in "OPTTEST", same scaling as CDU1CMD. The sign of COMMANDS may be reversed for shaft-stop avoidance purposes.

DESOPMOD: Single precision value of SWSAMPLE the previous time that "OPTMON" was performed, used to determine if a change has taken place in the setting of the optics mode switches (Computer Control, Manual, or Zero).

DESOPTT, DESOPTS: Single precision values of desired CDUT and CDUS respectively, twos complement with same scaling as CDUT and CDUS respectively. They are used in "OPTTEST" to generate optics driving commands (if OPTIND and SWSAMPLE are satisfactory).

EXTVBACT: See Verb Definitions.

IMODES33: See IMU Computations.
K
124 secdp: Constant, program notation "2.4SECDP", scale factor 10^{-28}, units centi-seconds. Value is 240 \times 10^{-28}, corresponding to 2.4 seconds.

K
20 degs: Single precision constant, program notation "20DEGS", scale factor 10^{-3}, units revolutions. Value is 7199 \times 10^{-14}, but since used in "ENDZOPT" in complement form, value equivalent to 7200 \times 10^{-14}, or 19.7754°. When the optics are "zeroed", the CDUT cell is loaded with -K
20 degs. Consequently, to find the "true" trunnion angle, this 19.7754° value must be added, and to convert "true" to actual cell contents this 19.7754° value must be subtracted. See e.g. "CALCSXA". The octal value of -K
20 degs is 617408.

K
20 degs MN: Constant, program notation "20DEGSMN", scale factor 10^{-3}, units revolutions. Value is -7199 \times 10^{-14} (as a ones complement number), equivalent to -19.7754° (see K
20 degs). Causes limiting of trunnion value if the derived "true" angle is negative.

K
45 deg: Single precision constant, program notation "13,14,15", scale factor 10^{-1}, units revolutions. Value is 700008, corresponding to a value of 10000 as used in program (after a one-bit correction for convenience in forming absolute value), or 45°. If CDUS is = or less than this value, then ZONE is set 0; if greater and ZONE is zero, then ZONE is set to CDUS.

K
50 degs MN: Constant, program notation "38TRDEG", scale factor 10^{-3}, units revolutions. Value is 0.66666667, corresponding to 30° in the value of CDUT, or a "true" trunnion angle of 30 + 19.7754° = 49.7754° (see K
20 degs). Constant formerly was 0.4 (a "true" value of 37.7754°), hence the notation.

K
90 deg: Single precision constant, program notation "NEG1/2", scale factor 10^{-1}, units revolutions. Value is 577778, corresponding to a value of 200018 as used in the program (after a one-bit correction for convenience in forming absolute value), or about 90°. If CDUS magnitude is less than 90°, then there is considered to be no problem with the optics stops.

K
m3bt: Single precision constant, program notation "NEG2", scale factor 10^{-1}, units revolutions. Value is -2 \times 10^{-14}, but used in program in such a way (for convenience in forming absolute value) that the effective value in program is -3, or about -0.033°. A change in an IMU CDU angle of more than 3 least increments in C_{CDU} centi-seconds causes the optics mark to be rejected in "MARKL", provided C_{CDU} is positive non-zero.

K
m4ps: Single precision constant, program notation "MAXPLS", scale factor 10^{-3}, units optics CDU output pulses. Value is -83 \times 10^{-14}. See CDU1CMD above for pulses/revolution: note that B1 revolutions is equivalent to B14 pulses if 2^{-3} pulses = 1 revolution.
**K**<sub>mxps1</sub>: Single precision constant, program notation "MAXPLS1", scale factor B14, units optics CDU output pulses. Value is $-82 \times 2^{-14}$, but used in program (for convenience in forming absolute value) in such a way that effective value is $-83$ (see K<sub>mxps</sub>).

**MARKINDEX**: Single precision cell, scale factor B14, loaded in "SXTMARK" with 1, and decremented in "MARKDIF" so as to contain the count of the number of marks remaining (i.e., decremented to 0; cell a hold-over from earlier design requiring a capability for more than a single mark in some programs). It is incremented in "MKREJECT" when a mark is rejected. "R53" checks the cell and if non-zero re-enters the marking routine, so as to force a mark to be processed.

**MKCDU1, MKT2T1**: Set of buffer cells loaded in "MARKRUPT" with optics and IMU CDU angles (with time in MKT2T1, double precision), and used in "PUTMARK" to load appropriate cells. The scaling of the cells is the same as that of the quantities with which they are loaded, and their sequence is MKT2T1<sub>dp</sub>, MKCDUY, MKCDUS, MKCDUZ, MKCDUT, and MKCDUX.

**MRKBUF1**: Set of cells loaded in "PUTMARK" with optics mark information. The cells have data in the same sequence as described above for MKCDU1, MKT2T1. For common use of processing routines, "R23CSML" and "R56" load these cells with information in the same format as that done for normal optics marks. They are also loaded in "R53DISP" (after the N14 star tracker specification) with TRKAZ (in MRKBUF1+3) and TRKEL (in MRKBUF1+5). Note in this case, however, MRKBUF1+5 has information scaled B-1 revolutions, not B-3 revolutions as it has when it is used for CDUT information (either prime optics or equivalent N94 R2 input). For R22 use, a setting of MRKBUF1 (first cell) to a negative number indicates that no mark data are in the cells. For R22, a mark reject (or V86E) must be done sufficiently promptly (e.g., within 7 seconds) after a mark to avoid having it be incorporated (barring the N49 display). The notation "MRKBUF1" refers to the first cell of the set, i.e., MRKBUF1+0. MRKBUF1+3 is displayed in R1 of N94 and MRKBUF1+5 in R2 of N94.

**OPTCADDR**: Single precision control cell used to contain return address for "SXTMARK".

**OPTIND**: Single precision control cell, scale factor B14, used to control the performance of "OPTTEST". If it is negative, including -0, driving of the optics is bypassed. A setting of -0 means that the optics are "reserved": this setting is done in "S40.6" when the output channel bits are set for TVC use (see CDU1CMD above). The setting to -1 is done in e.g. "INITSUBA" in conjunction with V37 processing.

**OPTMODES**: Single precision flag word used for control of "T4RUPT" computations associated with the optics hardware. The individual bits have the following meanings:

<table>
<thead>
<tr>
<th>Bit</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>ZROPTFIN</td>
<td>Zeroing of optics has been completed since last fresh start or restart if bit is 1.</td>
</tr>
<tr>
<td>Bit</td>
<td>Symbol</td>
<td>Meaning</td>
</tr>
<tr>
<td>-----</td>
<td>-------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>OCDUFBIT</td>
<td>Nominal last sampled value of channel 30 bit 7 (0 if an optics CDU fail indication has been generated by the optics CDU hardware). If OPTIND = -0, the value of the bit is not changed in &quot;OPTMON&quot;, although a channel 30 bit 7 change will cause &quot;OCDUFTST&quot; to be entered to change bit 8 of DSPTAB+11 (the Tracker light).</td>
</tr>
<tr>
<td>5</td>
<td>OPMD1BIT</td>
<td>Last sampled value of channel 33 (or C31FLWRD) bit 5: zero if Computer Control mode of optics desired.</td>
</tr>
<tr>
<td>4</td>
<td>OPMD2BIT</td>
<td>Last sampled value of channel 33 (or C31FLWRD) bit 4: zero if Zero Optics mode of optics desired. If bits 5-4 = 112, Manual mode of optics desired.</td>
</tr>
<tr>
<td>3</td>
<td>ZOPTCS</td>
<td>Bit set 1 in &quot;CSCTOZOP&quot; to indicate that the wait for zeroing of optics is in process. It is set zero in &quot;ENDZOPT&quot;, after the completion of the necessary wait.</td>
</tr>
<tr>
<td>2</td>
<td>OCDUINHT</td>
<td>Bit set 1 to inhibit generation of Tracker alarm (bit 8 of DSPTAB+11) within &quot;OCDUFTST&quot; routine.</td>
</tr>
</tbody>
</table>

PAC: See Coordinate Transformations.

PACTEMP: Single precision cell, same scaling as PAC, used to retain the value of PAC derived in R52, with limiting if necessary, that is subsequently loaded into DESOPTT.

R53EXIT: Single precision cell containing return address from "R53" or "R56" (allowing "R53C1" to be used by both).

SAC: See Coordinate Transformations.

SAVQR52: Single precision cell containing return address from "R52".

STAR: See Coordinate Transformations. Used in "R52D" to retain temporarily the OWS position vector (scale factor B29, units meters).

STARCODE: See Inflight Alignment.

STARIND: See Inflight Alignment. It is set 0 in "ROO".

STARSAV1, STARSAV2: See Inflight Alignment.

SWSAMPLE: Single precision cell containing information on the value of the optics hardware mode last sampled in "OPTMON" (DESOPMOD is loaded with the same value before termination of the routine), scale factor B14. A positive non-zero value (e.g. 15) means Computer Control mode; a zero value means Manual mode; and a negative value (-1) means Zero Optics mode.
Tst: See Data Input/Output.

TRKAZ, TRKEL: See Inflight Alignment.

WTOPTION: Single precision cell, scale factor Bl4, set to 11 in "OPTMON" if switch from Zero to Manual optics mode with zeroing not yet complete (alarm O116g is generated also). It is decremented by 1, with a lower limit of +0, when "OPTMON" is entered with previous and present cycle modes both Manual. If switch back to Zero from Manual before counter decremented to 0 (which occurs in about 5.3 seconds), then ZOPTCNT is not reset to 32. Cell set 0 in "CSTOZOP" and in "OPTMON" if go from Zero to Computer Control.

ZONE: Single precision cell set 0 in "ENDZOPT" or in "OPTTEST" if CDUS magnitude less than 45°, and set in "OPTTEST" if CDUS magnitude exceeds 45° and cell presently 0. It is used in "OPTTEST" in the implementation of the optics shaft stop monitor (if non-zero, only its sign is employed). Cell is required because optics shaft stops are at ±270° from "zero" ("zero" is the position at which optics are left after zero mode employed). If, after zeroing, were to drive optics towards e.g. +70°, then when CDUS exceeded 45° ZONE would be set to positive non-zero. If continued to drive in the same direction, e.g. to +100°, then +140°, then +170° (always with increments of less than 180° from present CDUS, so go "shortest" way, namely in same direction), then ZONE would remain positive non-zero and optics would continue to drive. If, from the 170° point, the next DESOPTS were -160° (or, equivalently, +200°), then "shortest distance" would again be the 30° across the 180° point, and the optics would be driven there, with ZONE remaining untouched (CDUS reading would be "-160° when reach DESOPTS). Note that, however, if had started at the "zero" point, would have driven optics in the opposite direction (i.e. though -30, -70, etc.). If the next DESOPTS were e.g. -100° (i.e. +260°), then here the optics would again be driven in the same direction, with ZONE unchanged, from -160° to -100°, or only 10° away from the stop at +270° (note that "normal" method of reaching -100°, from "zero", would have gone the other way). At the -100° (actually +260° as far as how shaft angle got there is concerned) point, ZONE is still positive non-zero. If the next DESOPTS were e.g. -60° (i.e. +300°), this would generate a COMMANDS of (-60°) - (-100°) = +40°: to drive there directly, however, would require violating the hardware stop at 270°, and hence the stop monitor logic is invoked. With these conditions, all the conditions at the top of page OPTC-2 are satisfied, since CDUS magnitude (100°) exceeds 90°; ZONE ≠ 0; the sign of ZONE = sign of COMMANDS (both positive); and magnitude of DESOPTS is 60° (less than 90°). Consequently, the COMMANDS polarity is reversed, so that instead of driving towards -60°, the optics are driven towards -140° (-100 + -40). Assuming that DESOPTS remains -60°, the next attempt would be to drive towards -220° (+140°, i.e. -140° (-60 + -140)), and so on. When CDUS is driven below 90°, then shaft stop logic is no longer involved, since "shortest path" is likewise one that avoids the optics shaft
stops. Finally, when optics reaches the -60° point (the "long way"), ZONE would have been reset to 0 and then to negative non-zero, to protect the stop at -270° (+90°). If the value of DESOPTS were to "chatter" near a magnitude of 270, then the optics themselves would be driven in alternating directions: in this case, manual selection of optics zeroing should be done.

ZOPTCNT: Single precision cell, scale factor B14, set to 32 at the start of optics zeroing (assuming no WTOPTION effect), to give an optics zeroing period of $33 \times 0.48 + 0.4 \sim 16.2$ seconds. An alarm (pattern 1168) is generated if switch out of zeroing before completion of initial part of delay (about 15.8 seconds from when switch first sensed to be in zero mode). See WTOPTION (no setting of WTOPTION is made if switch to Computer Control: it is reset to 0 instead).
Orbital Integration

STATEINT Called by "ENDINT", and restarted via group 2.3
Establish "STATINT1" (priority 0.8)
End of task

STATINT1 Established by "NDUTINPT" if bit 9(UTFLAG) of FLAGWRD8 = 1,
by "STATEINT", and by restart group 2.5 (in "ROO" for POO)

If bit 5(QUITFLAG) of FLAGWRD9 = 1: (set by "VERB96")

Make restart group 2 inactive
Set bit 5(QUITFLAG) of FLAGWRD9 = 0
End of job (must key e.g. V37EOOE to get periodic integration)

T_decl = T_now
Set bit 3(V96ONFIG) of FLAGWRD8 = 0
Perform "INTSTALL"

Set bit 1(NODOV37) of FLAGWRD2 = 1
Set bit 5(STATEFLG) of FLAGWRD3 = 1
Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0
Set bit 9(POOFLAG) of FLAGWRD3 = 1
Set bit 3(CSMINTSW) of FLAGWRD3 = 1 (Tag here "STATEUP")
Set bit 8(PRECIFLG) of FLAGWRD3 = 0
Perform "INTEGRV"

T_decl = T_etc
Perform "INTSTALL"

Set bit 3(CSMINTSW) of FLAGWRD3 = 0
Set bit 5(STATEFLG) of FLAGWRD3 = 1
Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0
If bit 1(RENDWFLG) of FLAGWRD5 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

Perform "INTEGRV"

Set bit 1(NODOV37) of FLAGWRD2 = 0

Proceed to "ENDINT"

ENDINT

Set bit 5(STATEFLG) of FLAGWRD3 = 0

Set restart group 2 to phase 3 (2.3, causing "STATEINT" to be called)

Call "STATEINT" in K_600sc seconds

End of job

CSMREC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "CSMREC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0

Proceed to second line of "INTEGRV"

LEMPREC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "LEMPREC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Proceed to 4th line of "CSMREC"

CSMCONIC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "CSMCONIC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

ORBI-2
Set bit 1(WMATINT) of FLAGWRD3 = 0
Set bit 4(CONICINT) of FLAGWRD3 = 1
Proceed to second line of "INTEGRV"

**LEMCONIC**

Perform "INTSTALL"

IRETURN = Return address (to routine calling "LEMCONIC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 0
Proceed to 4th line of "CSMCONIC"

**INTEGRVS**

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

IRETURN = Return address (to routine calling "INTEGRVS")

TDELTAY = 0

TNUV = 0

Perform "RECTIFY"

Set bit 1(WMATINT) of FLAGWRD3 = 0

Set bit 13(NEWIFLG) of FLAGWRD8 = 1

Proceed to "ALOADED"

**INTSTALL**

QPRET = Return address (since enter in interpretive language)

If bits 14(INTINUSE) and 13(INTGRAB) of FLGWRD10 ≠ 002:

Put present job to sleep (starting address id = 2nd line of "INTSTALL", i.e. check of bits)

Set bit 14(INTINUSE) of FLGWRD10 = 1

Proceed to address specified by QPRET (of present job, of course)
INTWAKE

If bit 13(INTGRAB) of FLGWRD10 = 1: (means restarted)

TBASE2 = QPRET of present job

Set restart group 2 to resume computations at next step

QPRET (of present job) = TBASE2

If bit 13(INTGRAB) of FLGWRD10 = 0: (i.e. got a restart)

Proceed to address specified by QPRET (of present job)

Awaken all jobs with starting address id = 2nd line of "INTSTALL" (Tag here "INTWAKEO")

Set bits 14(INTINUSE) and 13(INTGRAB) of FLGWRD10 = 0

Proceed to address specified by QPRET (of present job)

AVETOMID (Entered from "AVGEND")

EGRESS = Return address

If bit 1(RENDWFLG) of FLAGWRD5 = 1:

TS1 = Tpptm (holds in MPAC) (tag here "INT/W")

Perform "INTSTALL"

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 1(AVEMIDSW) of FLAGWRD9 = 1

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Tdecl = TS1

Perform "INTEGRV"

X2 = 0 (tag here "SETCOAST")

Perform "INTSTALL"

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Rrect = R

RCV = Rrect

Tdecl = Tpptm

Ter = Tpptm
\[ V_{\text{rect}} = V \]
\[ VCV = V_{\text{rect}} \]
\[ \text{TDELTAV} = 0 \]
\[ \text{TNUV} = 0 \]
\[ T_c = 0 \]
\[ XKEP = 0 \quad \text{(notation also "XPREV")} \]

Perform "MOVEACSM"

Set bit 5(STATEFLG) of FLAGWRD3 = 1
Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0
Perform "INTEGRV"

Proceed to address specified by EGRESS

**MIDTOAV1**  
R41 entrance from "P40S/SV" (P40/P41)

IRETURN1 = Return address

Perform "INTSTALL"

Set bit 3(MIDLFLAG) of FLAGWRD9 = 1

\[ TS = T_{\text{now}} + K_{\text{timedt}} \]

If \( (T_{\text{decl}} - TS) < 0 \):  
(i.e. desired time less than \( K_{\text{timedt}} \) from now)

Set bit 3(MIDLFLAG) of FLAGWRD9 = 0

IRETURN1 = IRETURN1 + 1

Perform "ALARM" (pattern 1703g)

TTOADD = \( K_{\text{timedt}} \)

Proceed to 5th line of "MIDTOAV2"

Proceed to 6th line of "MIDTOAV2"
MIDTOAV2

R41 entrance from "P47CSM" (P47/P48) and "S61.1" (P61/P62)

IRETURN1 = Return address

Perform "INSTALL"

Set bit 3(MID1FLAG) of FLAGWRD9 = 0

TTOADD = K timedt

T dec = Tnow + TTOADD  (tag here "ENTMID2")

Set bit 1(WMATINT) of FLAGWRD3 = 0  (tag here "ENTMID1")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 2(MI DAVFLG) of FLAGWRD9 = 1  (causes "DIFF +2" to
transfer to "CKMID2")

Perform "INTEGRV"

R nl = R att

V nl = V att

T pptml = T att

Inhibit interrupts

TS = T pptml - T now', with sign agreement forced

Proceed to address specified by IRETURN1

CKMID2

Entered from "DIFF+2" if bit 2 of FLAGWRD9 = 1

If bit 3(MID1FLAG) of FLAGWRD9 = 0:

If |T dec - T et| - K3csecs < 0:

If (T et - T now - K5p6secs) ≥ 0, proceed to "A-PCHK"

TTOADD = TTOADD + K timedt

T dec = T now + TTOADD

Proceed to "TESTLOOP"
\[ TS = T_{\text{now}} + K_{\text{timedt}} \]

If \( T_{\text{dec}} - TS \geq 0 \):

Proceed to "TESTLOOP"

Set bit 3 (MID1FLAG) of FLAGWRD9 = 0

IRETURN1 = IRETURN1 + 1

Perform "ALARM" (pattern 1703\_g)

\[ T_{\text{TTOADD}} = K_{\text{timedt}} \]

\[ T_{\text{dec}} = T_{\text{now}} + T_{\text{TTOADD}} \]

Proceed to "TESTLOOP"

MOVEACSM

\[
\begin{align*}
R_{\text{rectcm}} &= R_{\text{rect}} \\
V_{\text{rectcm}} &= V_{\text{rect}} \\
T_{\text{etcm}} &= T_{\text{et}} \\
\text{DELTAV}_{\text{cm}} &= \text{TDELTAV} \\
\text{NUV}_{\text{cm}} &= \text{TNUV} \\
R_{\text{cm}} &= \text{RCV} \\
V_{\text{cm}} &= \text{VCV} \\
T_{\text{ccm}} &= T_{\text{c}} \\
X\text{KEP}_{\text{cm}} &= X\text{KEP} \quad \text{(notation also "XPREV")}
\end{align*}
\]

Return

MOVEALEM

\[
\begin{align*}
R_{\text{rectlm}} &= R_{\text{rect}} \\
V_{\text{rectlm}} &= V_{\text{rect}} \\
T_{\text{etlm}} &= T_{\text{et}}
\end{align*}
\]
DELTA_{lm} = TDELTA_{V}
NUV_{lm} = TNUV
RCV_{lm} = RCV
VCV_{lm} = VCV
T_{clm} = T_{c}
XKEP_{lm} = XKEP (notation also "XPREV")

Return

MOVEPCSM

R_{rect} = R_{rectcm}
V_{rect} = V_{rectcm}
T_{et} = T_{etcm}
TDELTA_{V} = DELTA_{Vcm}
TNUV = NUV_{cm}
RCV = RCV_{cm}
VCV = VCV_{cm}
T_{c} = T_{cml}
XKEP = XKEP_{cm} (XKEP notation also "XPREV")

Return

MOVEPLEM

R_{rect} = R_{rectlm}
V_{rect} = V_{rectlm}
T_{et} = T_{etlm}
TDELTA_{V} = DELTA_{Vlm}
TNUV = NUV_{lm}
RCV = RCV_{lm}
VCV = VCV_{lm}
T_{c} = T_{clm}
XKEP = XKEP_{lm} (XKEP notation also "XPREV")

Return
INTEGRV

IRETURN = Return address (to routine calling "INTEGRV")

Set bit 13(NEWIFLG) of FLAGWRD8 = 1

If bit 3(CSMINTSW) of FLAGWRD3 = 1:
   Perform "MOVEPCSM"
   Proceed to "ALOADED"

Perform "MOVEPLEM"

Proceed to "ALOADED"

ALOADED

Reset overflow indicator

T_{dec} = T_{decl}

If bit 4(CONICINT) of FLAGWRD3 = 0, proceed to "TESTLOOP"

TAUORB = T_{dec} - T_{et}

Perform "RECTIFY"

Perform "KEPPREP"

T_{et} = T_{et} + T_c

Proceed to "RECTOUT"

A-PCHK

If bit 5(STATEFLG) of FLAGWRD3 = 0, proceed to "RECTOUT"

Set bit 5(STATEFLG) of FLAGWRD3 = 0

Set bit 13(INTGRAB) of FLGWRD10 = 1 (means restart phase change)

If bit 3(CSMINTSW) of FLAGWRD3 = 1:
   Perform "MOVEACSM"

   If bit 1(AVEMIDSW) of FLAGWRD9 = 0:
      \[ R = RCV + TDELTAV \]
      \[ V = VCV + TNUV \]
      \[ T_{pptm} = T_{et} \]

   Proceed to "RECTOUT"
Perform "MOVEALEM" (bit 3 of FLAGWRD3 = 0, meaning OWS integration)

\[
\begin{align*}
R_{\text{other}} &= R_{\text{CV}} + T_{\text{DELTA}V} \\
V_{\text{other}} &= V_{\text{CV}} + T_{\text{NUV}}
\end{align*}
\]

Time tag is in \( T_{\text{etlm}} \)

Proceed to "RECTOUT"

**RECTOUT**

Perform "RECTIFY"

\[
\begin{align*}
R_{\text{att}} &= R_{\text{rect}} \\
V_{\text{att}} &= V_{\text{rect}} \\
T_{\text{att}} &= T_{\text{et}} \\
R_{\text{att}l} &= R_{\text{rect}} \\
V_{\text{att}l} &= V_{\text{rect}} \\
M_{\text{UpPp}} &= K_{\text{mutab}0} \\
X_1 &= -2
\end{align*}
\]

Push-down list 0D-5D

\[
\text{6D-11D, 12D-13D, 14D-19D, 20D-25D, 26D-27D}
\]

Proceed to "INEXIT"

**INEXIT**

Reset overflow indicator

Set bits 2(MIDAVFLG) and 1(AVEMIDSW) of FLAGWRD9 = 0

Set bits 5(STATEFLG) and 8(PRECIFLG) of FLAGWRD3 = 0

\( X_2 = 0 \)

\( \text{QPRET} = \text{IRETURN} \)

Proceed to "INTAKE" (returns to address in QPRET)

**TESTLOOP**

If bit 5(QUITFLAG) of FLAGWRD9 = 1: (set by "VERB96"; reset by "STATINT1")

Set bit 5(STATEFLG) of FLAGWRD3 = 0

Proceed to "INEXIT"
\[ TS_1 = k_{p3d} \sqrt{RCV/3} / k_{mutab_0} \]  
(scaled B28 in units of centi-seconds)

\[ TS_2 = TS_1 \text{ shifted right 7 places (giving scale factor B35, or least increment of 128 centi-seconds, with low-order bits of } TS_1 \text{ lost)} \]

\[ TS_3 = TS_2 \text{ shifted left 15 places (giving scale factor B20 centi-seconds)} \]

If \( K_{dt2mx} - TS_3 < 0 \), or if overflow taken place:
\[ TS_3 = K_{dt2mx} \]  
(TS_3 in push-down list location 12D)

\[ TS = T_{dec} - T_{et}, \text{ with sign agreement forced} \]

\[ TS = TS, \text{ shifted left 8 places (scale factor B20, units centi-sec)} \]

If \( |TS| - TS_3 > 0 \), or if overflow has taken place:
\[ TS = TS_3 \text{ sgn } TS \]

If \( |TS| - K_{dt2mm} < 0 \):
Proceed to "A-PCHK"

\[ DTd2 = \frac{1}{2} TS \]  
(accomplished by considering scaling of DTd2 B19, whereas TS is scaled B20)

If bit 9(POOFLAG) of FLAGWRD3 = 0, proceed to "TIMESTEP".

If bit 8(PRECIFLG) of FLAGWRD3 = 1, proceed to "TIMESTEP" (not CSM from "STATINTL")

If \( TS - TS_3 < 0 \), proceed to "A-PCHK" (equals case does not transfer)

If bit 13(NEWIFLG) of FLAGWRD8 = 0, proceed to "TIMESTEP"

Set bit 13(NEWIFLG) of FLAGWRD8 = 0 (if get here, came from "STATINTL")

\[ TS_4 = T_{dec} - T_{et} \]  
(scale factor B28, units centi-seconds)

If \( TS_4 < 0 \), proceed to "INTEXIT" (no backwards integration)

\[ TS_5 = TS, \text{ shifted right 6 places (rounded shift, scale factor B26)} \]

If \( TS_4 - 4 \cdot TS_5 < 0 \), proceed to "INTEXIT" ("4" because of scaling)

Proceed to "TIMESTEP" (at least 4 time steps behind)
RECTIFY

\[ R_{\text{rect}} = RCV + (\text{TDELTA}_V, \text{shifted right 7 places}) \]

\[ RCV = R_{\text{rect}} \]

\[ V_{\text{rect}} = VCV + (\text{TNUV}, \text{shifted right 4 places}) \]

\[ VCV = V_{\text{rect}} \]

\[ \text{TDELTA}_V = 0 \]

\[ \text{TNUV} = 0 \]

\[ T_c = 0 \]

\[ \text{XKEP} = 0 \quad \text{(notation also "XPREV")} \]

Return

TIMESTEP

If \(|\text{TDELTA}_V| - K_{3d4} \geq 0\), or if overflow taken place:

Perform "RECTIFY"

Proceed to "INTGRATE"

If \(|\text{TDELTA}_V| / |\text{RCV}| - K_{\text{recrat}} \geq 0\): (\text{TDELTA}_V / \text{shifted right 7 places})

Perform "RECTIFY"

Proceed to "INTGRATE"

If \(|\text{TNUV}| - K_{3d4} \geq 0\), or if overflow has taken place:

Perform "RECTIFY" (Note that sensing overflow resets overflow indicator in all cases)

Proceed to "INTGRATE"

INTGRATE

Set bit 14(JSWITCH) of FLAGWRDO = 0

\[ ZV = \text{TNUV} \]

\[ YV = \text{TDELTA}_V \]

\[ \text{DIFEQcnt} = 0 \]

\[ \text{ALPHA}_V = YV \]
H = 0
Proceed to "ACCOMP"

ACCOMP

FV = 0
BETAV = RCV + ALPHAV  (ALPHAV shifted right 7 places)
If bit 1(WMATINT) of FLAGWRD3 = 1:
    VECTAB = DIFEQCTN = BETAV
ALPHAM = |ALPHAV|
ALPHAV = unitALPHAV
Perform "GAMCOMP"
ALPHAV = BETAV
ALPHAM = BETAM
Proceed to "OBLATE"

GAMCOMP

BETAM = |BETAV|
BETAV = unitBETAV
RHO = ALPHAM / BETAM  computed in quasi-floating point fashion, using $K_{scale}$ for scaling information
LILQ = RHO (RHO - 2 ALPHAV • BETAV)  (same as $(A - 2 B) \cdot A/B^2$ for non-unit vectors)
FOPQ = LILQ $\frac{3 + 3 LILQ + LILQ^2}{1 + (1 + LILQ)^{3/2}}$
TS = ALPHAV + (FOPQ/RHO) BETAV  (scaled B4)
TS1 = $-K_{mutab} \frac{RHO}{BETAM^2 (1 + LILQ)^{3/2}}$  TS  (computed quasi-floating point)
Reset overflow indicator

ORBI-13
\[ FV = FV + TS_1 \quad \text{(using } K_{\text{scale}_0} \text{ and } K_{\text{scale}_1} \text{ for scaling data)} \]

If overflow has taken place, proceed to "GOBAQUE"

Return

**GOBAQUE**

Entered if overflow from "DIFEQ+2", "GAMCOMP", and "OBLATE"

If \( |TDELTAV| = 0 \): (all components below 2 meters)

Proceed to "POODOO" (pattern 20430)

\[
TAUORB = T_{c} - H
\]

\[
T_{et} = T_{et} - H
\]

Perform "KEPPREP"

Perform "RECTIFY"

Proceed to "TESTLOOP"

**OBLATE**

\[
COSPHI = ALPHAV \cdot C_{\text{unitw}}
\]

\[
P_{2}' = 3 \cdot COSPHI
\]

\[
P_{3}' = \frac{1}{2} \cdot (15 \cdot COSPHI^2 - 3)
\]

\[
P_{4}' = (1/3) \cdot (7 \cdot P_{3}' \cdot COSPHI - 4 \cdot P_{2}')
\]

\[
P_{5}' = \frac{1}{4} \cdot (9 \cdot P_{4}' \cdot COSPHI - 5 \cdot P_{3}')
\]

\[
TS = \left( P_{3}' + \frac{1312}{ALPHAM} \left( P_{4}' + \frac{1413}{ALPHAM} P_{5}' \right) \right) \cdot ALPHAV \quad \text{(scaled B6)}
\]

\[
TS = TS - \left( P_{2}' + \frac{1312}{ALPHAM} \left( P_{3}' + \frac{1413}{ALPHAM} P_{4}' \right) \right) \cdot C_{\text{unitw}}
\]

\[
TS = \frac{K_{12}}{ALPHAM^4} \cdot TS \quad \text{computed quasi-floating point}
\]

Reset overflow indicator

\[
TS = FV + TS
\]

If overflow indicator set, proceed to "GOBAQUE"
\[ FV = TS \]

Proceed to "NBRANCH"

**NBRANCH**

If DIFEQCNT = -24, proceed to "DIFEQ+2"

If DIFEQCNT = 0:

\[ PHIY = FV \]

If DIFEQCNT = -12:

\[ PSIY = PHIY + 4 \cdot FV \]
\[ PHIY = PHIY + 2 \cdot FV \]

\[ H = H + DTd2 \]

\[ DIFEQCNT = DIFEQCNT - 12 \]

\[ ALPHA = YV + H \left( ZV + \frac{1}{2} H \cdot FY \right) \]

If bit 14 (JSWITCH) of FLAGWRDO = 1, proceed to "DOW.."

\[ TS = DTd2, \text{ shifted right 9 places (} \frac{1}{2} \text{ interval least increment 1 cs)} \]

If DIFEQCNT = -24:

Round TS to double precision (otherwise, a truncated shift)

\[ TAUORB = Tc + TS \]
\[ Tet = Tet + TS \]

Perform "KEPPREP"

Proceed to "ACCOMP"

**KEPPREP** (Entered from "ALOAD", "GOBAQUE", and "NBRANCH")

\[ A_5 = \frac{1}{2} \cdot \text{unitRCV} \cdot VCV \]

\[ QARG = (TAUORB - Tc) / |RCV| \]

\[ TS = \left( \frac{1}{6} \right) \cdot QARG^2 \cdot \left( K_{\text{mutab}} \cdot \frac{1}{0} \cdot VCV^2 \cdot |RCV| \right) / |RCV| \]

\[ XKEPNEW = XKEP + K_{\text{mutab}} \cdot QARG \left( 1 - A_5 \cdot QARG + 2 \left( A_5 \cdot QARG \right)^2 + TS \right) \]

(XKEP also has notation "XPREV")
KEPTRN = Return address (to routine entering "KEPPREP")
Proceed to "KEPLERN" (with overflow indicator reset just before adding the "1" factor to other terms)

DIFEQ+2

\[ \text{YV} = \text{YV} + H(\text{ZY} + \text{PHIV} \cdot H/6) \]
\[ \text{ZV} = \text{ZV} + H(\text{PSIV} + \text{FY})/6 \]

If bit 14(JSWITCH) of FLGWRDO = 1:

\[ W_{27-COLREG} = ZV \] (shifted left 3 places, compensating for "NEXTCOL" right shift)

\[ T_S = YV \] (shifted left 3 places)

If overflow indicator set:

Set bit 1(WMATINT) of FLGWRD3 = 0
Set bit 1(RENDWFLG) of FLGWRD5 = 0
Set bit 5(STATEFLG) of FLGWRD3 = 1
Perform "ALARM" (pattern 0421 8)
Proceed to "TESTLOOP"

\[ W_{-COLREG} = T_S \]

If \( \text{COLREG} \geq 0 \):

\[ T_{\text{decl}} = T_{\text{dec}} \]
Proceed to third line of "INTEGRV"

\[ \text{COLREG} = \text{COLREG} + 3 \]
Proceed to "NEXTCOL"

If overflow indicator set, proceed to "GOBAQUE" (sensing it resets)

\[ \text{TNUV} = ZV \]
\[ \text{TDELTAV} = YV \]

If bit 2(MIDAVFLG) of FLGWRD9 = 1, proceed to "CKMID2"
If bit 1(WMATINT) of FLGWRD3 = 0, proceed to "TESTLOOP"
Set bit 13(INTGRAB) of FLGWRD10 = 1
If bit 3(CSMINTSW) of FLAGWRD3 = 1:
   Perform "MOVEACSM"
If bit 1(AVEMIDSW) of FLAGWRD9 = 0:
   \[ R = RCV + TDELTAV \]
   \[ V = VCV + TNUV \]
   \[ T_{pptm} = T_{et} \]
If bit 3(CSMINTSW) of FLAGWRD3 = 0:
   Perform "MOVEALEM"
   \[ R_{other} = RCV + TDELTAV \]
   \[ V_{other} = VCV + TNUV \]
   \[ T_{etlm} \] is time tag
Set bit 14(JSWITCH) of FLAGWRD0 = 1
COLREG = -15
Proceed to "NEXTCOL"

**NEXTCOL**

\[ YV = W - \text{COLREG} \] (shifted right 3 places)
\[ ZV = W_{27} - \text{COLREG} \] (shifted right 3 places)
DIFEQCNT = 0
ALPHAV = YV
H = 0
Proceed to "DOW..

**DOW..**

\[ TS = VECTAB - \text{DIFEQCNT} \]
\[ FV = \frac{3 (ALPHAV \cdot \text{unitTS}) \text{unitTS} - ALPHAV}{|TS|^3} \cdot K_{mutab} \]
Proceed to "NBRANCH"
Quantities in Computations

See also list of major variables and list of routines

\(A_5\): Intermediate quantity used in "KEPPREP", scale factor B7, stored in push-down list location 4D (corresponds to gamma times square root of \(\mu\)).

ALPHAM: Value of magnitude of \(ALPHAV\) (before \(ALPHAV\) made a unit vector), same scaling and units.

ALPHAV: Cell used for several purposes. When initially enter "ACCOMP", contains position deviation scaled B22 meters. Subsequently loaded with unit(\(ALPHAV\)), scale factor B1. Is then set to unit position vector (originally \(BETAV\) information), with scaling for \(ALPHAM\) correspondingly B29, and retains this setting when "OBLATE" entered. When \(W\) matrix computations are done, is used to contain value of \(\mathbf{v}_V\) (\(\mathbf{W}_{-\text{COLREG}}\) information. Can also be used as internal communication cells with coordinate transformation routines.

BETAM: Value of magnitude of \(BETAV\) (before \(BETAV\) made a unit vector), same scaling and units.

BETAV: Vector giving vehicle position with respect to body whose acceleration effect is being computed, units meters. In "ACCOMP", initial scale factor B29.

\(C_{\text{unitw}}\): See General Program Control.

COLREG: Single precision cell ("column register") used to control the indexing in "DIFEQ+2" and "NEXTCOL" for the appropriate number of elements of the \(W\) matrix, scale factor B13 (since \(W\) matrix elements double precision).

COSPHI: Argument for "OBLATE" equations, program notation "COSPHI/2", scale factor B1, stored in push-down list location 18D. It is the cosine of the angle between the unit polar vector and the position vector.

\(D_{\text{cm}}, D_{\text{lm}}\): "Permanent" values of \(T_{\text{DELTA}}\) for CSM and OWS respectively, same scaling as \(T_{\text{DELTA}}\). Program notation \(T_{\text{DELTA}}\) for CSM and OWS respectively.

DIFEQNT: Single precision cell, scale factor B14, used for program control purposes, having values 0, -12, and -24 at the beginning, middle, and end of each integration step. It is negative for convenience in using interpreter indexing orders.
DTd2: Value of limited time increment for orbital integration, scale factor B19, units centi-seconds (is actually 1/2 the value of the net increment, e.g., beginning to middle or middle to end). It is derived in "TESTLOOP".

EGRESS: Single precision cell used to retain return address information (e.g., from "AVETOMID").

FOFQ: Function of LILQ used in "GAMCOMP", scale factor (for FOFQ/RHO) B3. Program does not actually divide by RHO, but instead computes FOFQ/RHO directly; FOFQ computation shown as given, however, to facilitate comparison with published equation information.

FV: Value of disturbing acceleration (second time derivative of position deviation), scale factor B-16 in meters/cs². Same cell used in "DOW.." for W-matrix updating, where scale factor is 38 less than ALPHAV scale factor.

H: Value of time since beginning of integration step, scale factor B19, units centi-seconds.

IRETURN: Single precision cell used to retain return address information from the subroutine entered to use the orbital integration package (after "INTSTALL" logic has given control of the package to the routine used).

IRETURN1: Single precision cell used to retain return address information from "MIDTOAV1" and "MIDTOAV2". If "MIDTOAV1" is entered (meaning that integration to a specified time is desired) but insufficient time is available to do the integration, then the time is slipped and IRETURN1 is incremented by 1 (to return to calling address +2) for appropriate disposition by caller. If enter "MIDTOAV2", cell is not incremented.

KEPRTN: See Conic Routines.

K_{3csecs} : Constant, program notation "3CSECS", scale factor B28, units centi-seconds, used as exit tolerance from "CKMID2". Value is $3 \times 2^{-28}$, corresponding to 0.03 seconds (meaning an exit if time difference is 0-2 centi-seconds).

K_{3d4} : Constant, program notation "3/4", used in "TIMESTEP" to check if rectification is required. Value corresponds to 0.75, with scaling same as that of the vector with which compared. Hence will rectify if TDELTAV magnitude is $0.75 \times 2^{22}$ meters or more, or if TNUV magnitude $\geq 0.75 \times 2^{3}$ meters/csec.

K_{5p6secs} : Constant, program notation "5.6SECS", scale factor B28, units centi-seconds. Value is $560 \times 2^{-28}$, corresponding to 5.6 seconds (to ensure that calling routine can successfully blank DSKY for 5 seconds).
K_{600sc}: Constant, program notation "600SECS", scale factor B28, units centi-seconds. Value is 60000 \times 2^{-28}, corresponding to 600 seconds.

K_{ascale_i}: Set of single precision constants used to control performance of "GAMCOMP" as selected by the value of index. Program notation for i = 0 is "ASCALE". Value for i = 0 gives the difference between ALPHAM and BETAM scalings, for use in determining the proper scaling of RHO:

<table>
<thead>
<tr>
<th>i</th>
<th>Value</th>
<th>ALPHAM scale</th>
<th>BETAM scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-7</td>
<td>22</td>
<td>29</td>
</tr>
</tbody>
</table>

Value for i = 1 is used to determine (with RHO scaling information above) the proper scaling of FY information: B-16. The value is (16 - 2 \times \text{BETAM scaling} + \mu \text{scaling}): the "2" factor is required because \(\text{BETAM}^2\) is in computations.

<table>
<thead>
<tr>
<th>i</th>
<th>Value</th>
<th>2 \times \text{BETAM scale}</th>
<th>\mu \text{scale}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-6</td>
<td>58</td>
<td>36</td>
</tr>
</tbody>
</table>

K_{dt2mn}: Constant, program notation "DT/2MIN", scale factor B20, units centi-seconds. Value is 3 \times 2^{-20}, corresponding to 0.03 seconds (hence "TESTLOOP" exits, since original input B28 centi-seconds, if time difference is 0-2 centi-seconds). Could also be considered a minimum for DTd2, in which case value would correspond (scale factor B19) to 0.015 seconds.

K_{dt2mx}: Constant, program notation "DT/2MAX", scale factor B20, units centi-seconds. Value is 4000E2 \times 2^{-20}, corresponding to 4000 seconds. Could also be considered a maximum of DTd2, in which case value would correspond (scale factor B19) to 2000 seconds.

K_{j2}: Constant, program notation "J2REQSQ", scale factor B72. Value is 1.75501139E21 \times 2^{-72}, corresponding to 3.986032E10 \times (6.378165E6)^2 \times (1082.3E-6) \times 2^{-72}, where first term is earth \(\mu\) (in meters\(^3/c^2\)), second is square of earth's radius (gravitational, in meters), and third is second harmonic of earth's potential function (note that 1.5 times it = 1.62345E-3), while 4th is scale factor.

K_{j3j2}: Constant, program notation "2J3RE/J2", scale factor B27. Value is -0.1355426363E5 \times 2^{-27}, corresponding to -0.23E-5 \times 6.378165E6 / 1082.3E-6 \times 2^{-27}, where first term is third harmonic of earth's potential function, second is earth radius in meters, and 3rd is second harmonic, while fourth is scaling.
K_{4j3}: Constant, program notation "J4REQ/J3", scale factor B26. Value is 0.4991607391E7 \times 2^{-26}, corresponding to -1.8E-6 \times 6.378165E6 / -0.23E-5 \times 2^{-26}, where first term is fourth harmonic of earth's potential function, second is earth radius in meters, 3rd is third harmonic, and fourth is scaling.

K_{mutab_0}: See Conic Routines.

K_{p3d}: Constant, program notation ".3D", scale factor B2, value 0.3 \times 2^{-2}.

K_{recrec}: Constant, program notation "RECRATIO", scale factor B0, value 0.01.

K_{timedt}: Constant, program notation "TIMEDELT", scale factor B28, units centi-seconds. Value is 1250 \times 2^{-28}, corresponding to 12.5 seconds.

LILQ: Value for argument of FOFQ, scale factor B2, stored in push-down list location 8D.

LOCCTR: See Display Interface Routines.

MUpPp: Value of $\mu$ for the earth left in push-down list location 26D by "RECTOUT", scale factor B36. Program notation "MU(P)".

NUV_{cm}, NUV_{lm}: "Permanent" values of TNUV for CSM and OWS respectively, same scaling as TNUV.

P_2', P_3', P_4', P_5': Legendre polynomial derivatives computed in "OBLATE", scale factors B6, B5, B7, and B10 respectively, stored in push-down list locations OD, 2D, 4D, and 6D (partially) respectively.

PHIV: Storage for information used in Nystrom numerical integration, scaled (for state vector updates) B-13.

PSIV: Storage for information used in Nystrom numerical integration, scaled (for state vector updates) B-13.

QARG: Intermediate quantity used in "KEPPREP", computed in quasi-floating point fashion, with scaling (for numerator and denominator already normalized) B0. It corresponds to s divided by the square root of $\mu$, and is stored in push-down list location 4D. Hence A_5 QARG has scale factor B7.

QPRET: Single precision cell assigned to each job in the interpretive language, which may be used to retain return address information. Cell is preloaded with proper exit address from orbital integration system of routines before transfer to "INTWAKE"; before using the orbital integration package, subroutine "INTSTALL" is performed which returns immediately to the calling routine if the orbital integration package is not already in use by another user (at a lower job priority), and otherwise retains in QPRET the return address to the routine calling "INTSTALL".
\( \mathbf{R}_{\text{other}} \): Position vector of "other" vehicle (i.e., OWS) transmitted on downlink, scale factor B29, units meters.

\( \mathbf{R}_{\text{rect}} \): Value of position vector within orbital integration (when last rectification or equivalent function was performed), scale factor B29, units meters.

\( \mathbf{R}_{\text{rect}} \text{cm}, \mathbf{R}_{\text{rect}} \text{lm} \): "Permanent" values of \( \mathbf{R}_{\text{rect}} \) for CSM and OWS respectively, same scale factor and units as \( \mathbf{R}_{\text{rect}} \).

\( \mathbf{RCV} \): Value of conic position vector within orbital integration routine, scale factor B29, units meters. Also used as communication cell with orbital integration package (when entered via "INTEGRVS") to specify the position component of the state vector to be integrated.

\( \mathbf{RCV}_{\text{cm}}, \mathbf{RCV}_{\text{lm}} \): "Permanent" value of \( \mathbf{RCV} \) for CSM and OWS respectively, same scale factor and units as \( \mathbf{RCV} \).

\( \mathbf{RHO} \): Ratio of magnitudes of \( \mathbf{ALPHAV} \) and \( \mathbf{BETAV} \) (before becoming unit vectors) computed in "GAMCOMP", scale factor B1, stored in push-down list location 4D.

\( \mathbf{T}_c \): Time (as of start of integration cycle) since last rectification, scale factor B28, units centi-seconds. Set 0 in "RECTIFY", and incremented in Kepler computations (see Conic Routines).

\( \mathbf{T}_{\text{ccm}}, \mathbf{T}_{\text{clm}} \): "Permanent" value of \( \mathbf{T}_c \) for CSM and OWS respectively, same units and scaling.

\( \mathbf{T}_{\text{dec}} \): Value of "decision time", i.e., final value of time to which state vector must be integrated, scale factor B28, units centi-seconds.

\( \mathbf{T}_{\text{et}} \): Value of the time associated with the orbital integration routine state vector, scale factor B28, units centi-seconds. It is incremented in "NBRANCH".

\( \mathbf{T}_{\text{etc}} \text{cm}, \mathbf{T}_{\text{et}} \text{lm} \): "Permanent" value of \( \mathbf{T}_{\text{et}} \) for CSM and OWS state vectors respectively, same units and scaling. \( \mathbf{T}_{\text{et}} \text{lm} \) is called "TETLEM", "TETOTHER", and "T-OTHER" in program.

\( \mathbf{T}_{\text{pptml}} \): See IMU Computations.

\( \mathbf{TAUORB} \): Time within integration cycle since last rectification (or total conic integration time required), scale factor B28, units centi-seconds. Program notation is "TAU.".

ORBI-22
TBASE2: Single precision cell used generally for retention of time base information for restart group 2 (see 3420.5-27), for waitlist restarts. Used in "INTWAKE" to permit retention of QPRET value for restart purposes (since QPRET of job involved would be lost if a restart generated, because it generally is in VAC area as described in 3420.5-27).

TDELTAV: Vector position deviation (from conic) within orbital integration package, scale factor B22, units meters.

TNUV: Vector velocity deviation (from conic) within orbital integration package, scale factor B3, units meters/centi-second.

TTOADD: Value of time increment used in "CKMID2" if MID1FLAG = 0, program notation "T-TO-ADD", scale factor B28, units centi-seconds. Normal value is the same as \( K_{\text{timedt}} \) but it is incremented by that constant if the "CKMID2" check using \( K_{5\text{p6secs}} \) fails.

V_{\text{nl}}: See General Program Control.

V_{\text{other}}: Velocity vector of "other" vehicle (i.e., OWS) transmitted on downlink, scale factor B7, units meters/centi-second.

V_{\text{rect}}: Value of velocity vector within orbital integration (when last rectification or equivalent function was performed), scale factor B7, units meters/centi-second.

V_{\text{rectcm}}, V_{\text{rectlm}}: "Permanent" value of V_{\text{rect}} for CSM and OWS respectively, same units and scaling.

VCV: Value of conic velocity vector within orbital integration routine, scale factor B7, units meters/centi-second. Also used as communication cell with orbital integration package (when entered via "INTEGRVS") to specify the velocity component of the state vector to be integrated.

VCV_{\text{cm}}, VCV_{\text{lm}}: "Permanent" value of VCV for CSM and OWS respectively, same scale factor and units as VCV.

VECTAB_{\text{d}}: Temporary storage for values of position vector of vehicle, loaded in "ACCOMP" and used in "DOW..." for orbital integration updating of W matrix.

W_{\text{i}}: See Measurement Incorporation.

XKEEP: Value of quantity used in previous cycle through Kepler's equation (program notation also "XPREV"), scale factor B17. Set 0 e.g. in "RECTIFY". Units are \( \sqrt{\text{meters}} \).
XKEP\textsubscript{cm}, XKEP\textsubscript{lm}: "Permanent" value of XKEP for CSM and OWS respectively, same scaling.

XKEP\textsubscript{NEW}: "New" value of XKEP computed in "KEPPREP", scale factor B.17.

\texttt{YV}: Communication cell with integration routines, set to TDELTAV in "INTGRATE" and also used for W matrix updating.

\texttt{ZV}: Communication cell with integration routines, set to TNUV in "INTGRATE" and also used for W matrix updating.
Perform "RO2BOTH"

DBPTC = ADB

Set bit 12(R27FLAG) of FLGWRD11 = 0
Set bit 8(CSMUPDAT) of FLAGWRD1 = 1
Set bit 15(V5ON18FL) of FLAGWRD3 = 1 (already 1 from "ISITPOO")
Set bit 5(TRACKFLG) of FLAGWRD1 = 1

OPTION2 = 0

If bit 7(AUTOSEQ) of FLGWRD10 = 0:
   TS = 000248
   Proceed to "GOPERF4": if terminate, proceed to "GOTOPOOH"
   if proceed, proceed otherwise, proceed to previous line

If (bits 2-1 of OPTION2) ≠ 002: (e.g. options 1, 2, or 5)
   Proceed to "DOV6N78"

   UTPIT = K35degang (constant is -35°) (Tag here "PRELOD78")
   UTYAW = 0
   AZIMANGL = 0

   If bit 7(AUTOSEQ) of FLGWRD10 = 1:
      Proceed to "P200PT"
      Proceed to "DOV6N78"

DOV6N78

   TS = 0678 vn
   Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
   if proceed, proceed otherwise, proceed to previous line
TS = 0679\textsubscript{vn}
Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
    if proceed, skip next 3 lines
    otherwise, proceed to previous line

If bit 2 of OPTION2 = 0: (e.g. options 0, 1, 4, or 5)
    \(TS = 1012\textsubscript{bn}\) and perform "BLANKET" (R3BLNK and R1BLNK)
End of job

If bit 3 of OPTION2 = 1: (e.g. option 4 or 5) (Tag here "ENDV6N79")
    Set bit 8(AZIMFLAG) of FLGWRD1l = 1
    Proceed to second line of "P20OPT"

Proceed to "P20OPT"

\textbf{P20OPT}
Set bit 8(AZIMFLAG) of FLGWRD1l = 0
If (bits 2-1 of OPTION2) = 00\textsubscript{2}: (e.g. option 0 or 4)
    Set bit 9(UTFLAG) of FLGWRD8 = 0
    Set bit 7(UPDATFLG) of FLGWRD1 = 1
    Proceed to "NDUTINPT"

OPTNTYPE = (bits 2-1 of OPTION2) - 1 (Tag here "UTKINPUT")
Set bit 9(UTFLAG) of FLGWRD8 = 1
Set bit 7(RNDVZFLG) of FLAGWRD0 = 0
If \(\text{OPTNTYPE} > 0\): (e.g. option 2)
    \(TS = 0634\textsubscript{vn}\) (Tag here "TYPE2IN")
    Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
        if proceed, proceed
        otherwise, proceed to previous line

R67TIME = DSPTEML
Proceed to "NDUTINPT"
Proceed to "V1N70DSP" (e.g. option 1 or 5)
VIN70DSP

TS = 0170

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPFOOH")
  if proceed, proceed
  otherwise, proceed to previous line

If STARCODE < 0:  (contrary to e.g. "R51DSP", -0, i.e. 7777778,
  is not rejected here)
  Set bit 7(Operator Error) of channel 11 = 1
  Proceed to "VIN70DSP"

If STARCODE > 478:
  Set bit 7(Operator Error) of channel 11 = 1
  Proceed to "VIN70DSP"

UTSTARNO = (bits 6-1 of STARCODE)  (note get 778, not defined, for an original input of -0)
  (includes original -0 STARCODE input: will be treated as "earth" in "UTAREA1")

If UTSTARNO > 0:
  Proceed to "NDUTINPT"

TS = 0688

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPFOOH")
  if proceed, proceed
  otherwise, proceed to previous line

PLANVCU = STARSAV3

Proceed to "NDUTINPT"

NDUTINPT

Set restart group 2 to cause a start at next line (priority 268 to PHSPRDT2)

If bit 9(UTFLAG) of FLAGWRD8 = 1:
  Establish "STATINT1"(priority 058)  (Tag here "INTSETUP")
  Set restart group 2 to phase 5(i.e. 2.5, causing "STATINT1" to be established with priority 058 if a restart)
  Set restart group 1 to phase 11(i.e. 1.11, causing "PIKUP20" to be established with priority 108 if a restart)

Proceed to "PIKUP20"
MARKTIME = T_{\text{now}} \quad \text{(communication cell with "SETINTG")}

Perform "SETINTG"

If bit 8(CSMUPDAT) of FLAGWRD1 = 1:

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Perform "INTEGRV"

Set restart group 2 to start at next line

Perform "SETINTG"

If bit 1(RENDWFLG) of FLAGWRD5 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

If bit 8(CSMUPDAT) of FLAGWRD1 = 0:

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Perform "INTEGRV"

Set bit 7(RNDVZFLG) of FLAGWRD0 = 1

Establish "R22" (priority 26_{8})

Set restart group 2 to phase 7 (i.e. 2.7, causing "R22" to be established with priority 10_{8} if a restart)

Set restart group 1 to phase 11 (i.e. 1.11, causing "PIKUP20" to be established with priority 10_{8} if a restart)

Perform "AUTOCHK" \quad \text{(returns immediately if bit 7(AUTOSEQ) of FLGWRD10 is zero)}

Proceed to "PIKUP20"

PIKUP20 \quad \text{(Entered from "NDUTINPT" and due to restart group 1.11)}

Change priority of present job to 14_{8}

If bit 5(TRACKFLG) of FLAGWRD1 = 0:

Proceed to "FIXDB"

If bit 13(REFSMFLG) of FLAGWRD3 = 0:

Proceed to "FIXDB"

R61CNTR = 0
If bit 9(UTFLAG) of FLAGWRD8 = 1:
    Proceed to "CALLR6X"

Call "CTASK" in 0.01 second

Set bit 14(R21MARK) of FLAGWRD2 = 1

Perform "R61CSM"

If bit 15(PCMANFLG) of FLGWRD10 = 1:
    Proceed to third line of "AUTOCHK"

Proceed to "P2OTRACK"

P2OTRACK

    Set bit 10(IMTTRG) of FLAGWRD1 = 1
    Perform "R52"
    Perform "MKRELEAS"
    Proceed to "FIXDB"

PROG21

    OPTION2 = 1
    Set bit 5(TRACKFLG) of FLAGWRD1 = 1
    TS = 000028
    Proceed to "GOPERF4": if terminate, proceed to "GOTOPOOH"
    if proceed, proceed
    otherwise, proceed to previous line

    DSPTEM1 = 0
    Proceed to "P21PROG1"

P21PROG1

    TS = 0634 vn
    Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
    if proceed, proceed
    otherwise, proceed to previous line

    TS = DSPTEM1
    If TS = 0:
        TS = T_now
    Proceed to "P21PROG2"

ORVN-5
P21PROG2

\[ T_{\text{decl}} = TS \]
Perform "INSTSTALL"

If bit 12(P21FLAG) of FLAGWRD2 = 0: (set 0 e.g. in "INITSUB")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

If \(|\text{OPTION2}| \gg 2:\)

Set bit 3(CSMINTSW) of FLAGWRD3 = 0
Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0
Perform "INTEGRV"

If bit 12(P21FLAG) of FLAGWRD2 = 1:

\[ \text{RCV} = \text{P21BASE}\] (tag here "P21CONT")
\[ \text{VCV} = \text{P21BASEV} \]
\[ T_{et} = \text{P21TIME} \]

Set bit 1(WMATINT) of FLAGWRD3 = 0 (Note that bit 4 not set.)
Perform "INTEGRVS"

\[ \text{P21TIME} = T_{\text{att}} \] (Tag here "P21VSAVE")
\[ \text{P21BASE}\] = \( R_{\text{att1}} \)
\[ \text{P21BASEV} = V_{\text{att1}} \]
If bit 10(NEWTFLAG) of FLAGWRD5 = 1: (i.e. from P29)

Set bit 10(NEWTFLAG) of FLAGWRD5 = 0
Proceed to "HOP29DSP"

If bit 1(P29FLAG) of FLAGWRD0 = 1:

Proceed to "LONGPASS"

\[ \text{P21VEL} = |\text{P21BASEV}| \] (X2 used to shift, but 0 from "INTEXIT")
\[
P21GAM = \sin^{-1} \left( \frac{\text{unit} \cdot V_{\text{att}}}{P21VEL} \right)
\]
Set bit 12(P21FLAG) of FLAGWRD2 = 1
\[
\text{ALPHA.Y} = R_{\text{att}}
\]
Set bit 13(ERADCOMP) of FLAGWRD1 = 0
\[
\text{TS} = T_{\text{att}}
\]
Perform "LAT-LONG"
\[
P21ALT = K_{kp01} \text{ ALT}
\]
\[
\text{TS} = 0643 \text{ vn}
\]
Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to "GOTOPOOH"
otherwise, proceed
\[
\text{DSPTEML}_d = P21TIME + K_{600sec}
\]
Proceed to "P21PROG1"

**P25CSM**

Set bit 4(P25FLAG) of FLGWRD11 = 1
Set bit 7(RNDVZFLG) of FLAGWRD0 = 0
\[
\text{TS} = 0672 \text{ vn}
\]
Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line
Perform "N72STUFF"
Call "READCYCL" in 0.01 second
Call "CTASK" in 0.01 second
Delay 2 seconds (by putting job to sleep via "DELAYJOB")
Proceed to "BOTHSHOW"
72SHOWX

TS = 0672\text{vn}
Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
  if proceed, proceed
  otherwise, proceed to previous line

Perform "N72STUFF"
Proceed to "BOTHSHOW"

BOTHSHOW Entered from "P25CSM" and "72SHOWX"

If bit 10(NOUNFIG) of FLGWRD11 = 0:
  TS = 1676\text{vn}
  Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
  if proceed, proceed
  otherwise, proceed to "72SHOWX"

Set bit 10(NOUNFIG) of FLGWRD11 = 1 (tag here "77SHOW")
TS = 1677\text{vn}
Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
  if proceed, proceed
  otherwise, proceed to "72SHOWX"

Proceed to "GOTOPOOH"

READCYCL Called by "P25CSM" and "R27JOB"

Establish "R27JOB" (priority 208)
End of task

R27JOB Established by "READCYCL"

Perform "R27GO"

Call "READCYCL" in 2 seconds
End of job
TIMETASK
Called by "CTASK"

\[ TFO = FIXTIME - BUFTIME \]  (written over below while still in task)

If \( TFO \neq 0 \):  (e.g. manual N72 input to change FIXTIME)

Perform "N72STUFF"

Proceed to "CTASK"

CTASK
Called by "PIKUP20", "P25CSM", "P47CSM" (P48), and "RELINUS"

Call "TIMETASK" in 1 second

\[ TFO = T_{\text{now}} - FIXTIME \]

If \(|TFO| > 0.64\) second:

End of task

If bit 5(TRACKFLG) of FLAGWRD1 = 0:

End of task

CDUSNAP = CDU
CDUSNAPT = CDUT
CDUSNAPS = CDUS

Establish "PHIJOB" (priority 27g)

End of task

N72STUFF
Entered from "P25CSM", "P48CSM", "TIMETASK", and "72SHOWX"

Inhibit interrupts

Set bits 10(NOUNFLG) and 3(TDFLAG) of FLGWRD11 = 0

\[ PHETA = K_{dpm01} \]

If \( \text{FIXTIME}_{sp} = 0 \):

Set bit 10(NOUNFLG) of FLGWRD11 = 1

Set bit 9(N77FLAG) of FLGWRD11 = 0

Release interrupts

\[ BUFTIME = FIXTIME \]

Return
Established by "CTASK"

Delay 0.5 second (by putting job to sleep via "DELAYJOB")

Perform "PHICOMP"

Set bit 6(SNAPFLAG) of FLGWRD11 = 0

End of job

Entered from "PHIJOB" and "THISJAZZ"

\[
\begin{align*}
TS_2+3 &= CDUSNAPS \\
TS_2+5 &= CDUSNAPT \\
X1 &= - "TS_2" \\
\text{Perform } & "SXTNB" \\
VECLOS &= TS \\
\text{If bit 7(FIXFLAG) of FLGWRD11 = 1:} & \\
\text{If } & (T_{\text{now}} - \text{FIXTIME}) \geq 0: \\
& \text{Set bit 3(TDFLAG) of FLGWRD11 = 1} \quad \text{(Tag here "TDSNAP")} \\
T_{\text{decl}} &= \text{FIXTIME} \\
& \text{Perform } "CSMPREC" \\
& \text{Proceed to } "PREANGLE" \\
T_{\text{decl}} &= T_{\text{now}} \quad \text{(Tag here "NOWCOMP")} \\
& \text{Perform } "CSMCONIC" \\
& \text{Proceed to } "PREANGLE" \\
\end{align*}
\]

\[
\begin{align*}
TS_1 &= R_{\text{att}} \quad \text{(in 18D)} \quad \text{(unit } TS_1 \text{ loaded into } OD) \\
TS_2 &= V_{\text{att}} \quad \text{(in 24D)} \\
CDUSPO\_T &= \left( CDUSNAP_y, CDUSNAP_z, CDUSNAP_x \right) \\
& \text{Perform } "QUICTRIG" \\
TS &= VECLOS \\
& \text{Perform } "ANGLER" \\
& \text{Return}
\end{align*}
\]
ANGLER

Enter with \( T_3, T_1, 18D; T_2, 24D; \) unit\( T_3 \), OD, from "PREANGLE" and "THISJAZZ".

Perform "TRG"\( ^{\text{NBSM}} \) starting at 2nd line (cf. "COMPDISP" equations)

\[
T_3 = T_3 \begin{bmatrix} \text{REFSMAT} \end{bmatrix} \quad \text{(in 6D)}
\]

\[
T_3 = \text{unit} \left( T_3 - (T_3 \cdot \text{unit}T_3) \text{unit}T_3 \right) \quad \text{(in 12D)}
\]

\[
T_4 = \left( \text{unit} (T_3 \cdot T_2) \text{unit} T_3 \right) \cdot T_3
\]

\[
\text{PHETA} = \cos^{-1} \left( (T_3 \cdot T_3) \text{sgn} T_4 \right)
\]

If \((T_3 \cdot T_3) < 0:\) (note Vl6 monitor could observe the uncorrected value)

\[
\text{PHETA} = (1 - 2^{-28}) - \text{PHETA}
\]

Return

P29

Set bit 1(P29FLAG) of FLAGWRDO = 1

Proceed to "PROG21" ("P21FROG2" exits to "LONGPASS" since P29FLAG is set)

LONGPASS

\[
T_3 = 0643vn
\]

Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
if proceed, skip next 2 lines
otherwise, proceed to previous line

\[
T_3 = 1012 \text{ and perform "BLANKET" (R3BLNK, R1BLNK)}
\]

End of job

LONGFOR = LONG (LONG contents destroyed)

Proceed to "HOP29DSP"

HOP29DSP

\[
T_3 = \text{unit}Z
\]

\[
T_3 = \text{P21TIME} \quad \text{(tag also P29BASET)}
\]

\[
PASSTIME = T_3
\]

Set bit 1(P29FLAG) of FLAGWRDO = 1

DELTLONG = 0
Perform "RP-TO-R"  

(leaves TS with Z polar vector)

\[ \text{MUSUBE} = \text{unit}(\text{TS} \times \text{P21BASER}) \]  
\[ \text{P21BASER tag also P29BASER} \]

\[ \text{MUSUBC} = \text{unit}(\text{TS} \times \text{MUSUBE}) \]

\[ \text{TS}_1 = \text{unit}(\text{P21BASER} \times \text{P21BASEY}) \]  
\[ \text{P21BASEY tag also P29BASEY} \]

\[ \text{MUSUBS} = \text{unit}(\text{TS}_1 \times \text{P21BASER}) \]

\[ \text{MUSUBN} = \text{TS}_1 \, \text{sgn}(\text{TS}_1 \cdot \text{TS}) \]  
\[ \text{TS from "RP-TO-R"} \]

\[ \text{TS} = \text{P21BASER} \]

Proceed to "HOPALONG"

**HOPALONG**

\[ \text{ALPHAV} = \text{TS} \]

\[ \text{TS} = \text{PASSTIME} \]

Set bit 13(ERADCOMP) of FLAGWRD1 = 0

Perform "LAT-LONG"

\[ \text{LNGERR} = (\text{LONGFOR} - \text{LONG}), \text{ modulo 1 revolution} \]

\[ \text{TS}_1 = \left| \text{LNGERR} \right| - K_{\text{epsilon}} \]

If \( \text{TS}_1 < 0 \):

Proceed to "PASSOUT"

\[ \text{TS}_2 = \text{TS}_1 + K_{\text{twiceeps}} \]

If \( \text{TS}_2 > 1 \):  
\( \text{(the 1 is revolutions)} \)

Proceed to "PASSOUT"

If bit 1(P29FLAG) of FLAGWRDO = 0:  
\( \text{(i.e. not first iteration)} \)

If \( \left( \text{TS}_2 - \frac{1}{2} \right) \geq 0 \):  
\( \text{(Tag here "MODULE")} \)

\[ \text{LNGERR} = \left( \text{TS}_2 - \frac{1}{2} - K_{\text{epsilon}} - \frac{1}{2} \right) \, \text{sgn} \, \text{LNGERR} \]  
\( \text{(same as} \)
\[ \text{LNGERR} - 1 \, \text{sgn} \, \text{LNGERR}) \]

If bit 1(P29FLAG) of FLAGWRDO = 1:  
\( \text{(first iteration)} \)

Set bit 1(P29FLAG) of FLAGWRDO = 0

If \( \text{LNGERR} < 0 \):

\[ \text{LNGERR} = \text{LNGERR} + (1 - 2^{-28}) \]

\[ \text{FUDGE} = K_{\text{fearth}} \]
Reset overflow indicator (Tag here "THETCOMP")

\[ TS = FUDGE \text{ LNEGERR} + \text{ DELTLONG} \]

If overflow has taken place: \( |TS| \geq 1 \text{ rev} \)

\[ TS = P21TIME + K_{600 \text{ sec}} \] (Tag here "ADDTEN")

Set bit 10(NEWTFLAG) of FLAGWRD5 = 1

Proceed to "P21PROG2" (exits to "HOP29DSP")

\[ \text{DETLONG} = TS \]

\[ \text{MUSUBD} = \text{unit} \left( (\text{MUSUBC} \cos \text{DETLONG} + \text{MUSUBC} \sin \text{DETLONG}) \times \text{MUSUBN} \right) \]

\[ \text{ORBDLT} = (\cos^{-1} (\text{unitP21BASE} \cdot \text{MUSUBD}) \text{ sgn} (\text{MUSUBD} \cdot \text{MUSUBS})) \]

\[ \text{SNTH} = \sin \text{ORBDLT} \]

\[ \text{GSTH} = \cos \text{ORBDLT} \]

\[ \text{RVEC} = \text{P21BASE} \]

\[ \text{VVEC} = \text{P21BASEY} \]

Set bit 9(RVSW) of FLAGWRD7 = 0 \( \text{new R, V desired} \)

Perform "TIMETHET"

\[ \text{PASSTIME} = T + \text{P21TIME} \]

\[ TS = TS_{T} \] \( \text{value from "TIMETHET"} \)

Proceed to "HOPALONG"

PASSOUT

\[ \text{DSPTEM1} = \text{PASSTIME} \]

\[ TS = 0634_{\text{vn}} \]

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed otherwise, proceed to "LONGPASS"

\[ TS = 0643_{\text{vn}} \]

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed otherwise, proceed to "P29"

Proceed to "GOTOPOOH"
Quantities in Computations

See also list of major variables and list of routines

ADB: See Digital Autopilot Interface Routines.

ALPHAY: See Coordinate Transformations.

ALT: See Coordinate Transformations.

AZIMANGL: Value of "rotation angle" used in options 4 and 5 (3-axis) of P20, scale factor BO, units revolutions. It is loaded via R3 of N78, and is also modified in "STARTAUT" when a minimum key rendezvous sequence is started. Cell has no effect unless bit 8(AZIMFLAG) of FLGWRD11 = 1; a "heads up" value is 0° and a "heads down" 180°.

BUFTIME: Value of FIXTIME sampled in "N72STUFF", scale factor B28, units centi-seconds, used in "TIMETASK" to determine if a change in FIXTIME made since previous cycle.

CDUS: See Optics Computations.

CDUSNAP: Value of CDU sampled in "CTASK" or "THISJAZZ" and used in "PREANGLE", same scaling and units as CDU (single precision, B-1 revolutions).

CDUSNAPS: Value of CDUS sampled as described for CDUSNAP, same scaling as CDUS.

CDUSNAPT: Value of CDUT sampled as described for CDUSNAP, same scaling as CDUT.

CDUSPOS: See Coordinate Transformations.

CDUT: See Optics Computations.

CSTH: See Conic Routines.

DBPTC: Single precision value of deadband used for P20 maneuvers, scale factor B-1, units revolutions. It is loaded into ADB in "R61CSM" and "R67START" (unless a value of zero is indicated, in which case the 0.5° deadband is used). It is initialized to the current ADB at the start of "PROG20", and can be loaded via R2 of N79.

DELTLONG: Change in longitude computed in P29 from the time that "HOPALONG" was initiated, scale factor BO, units revolutions. It is the change from the vector reflected in e.g. P21BASER.

FIXTIME: Value of R27 optimization time loaded by N72, scale factor B28, units centi-seconds. A value of zero means no optimization is to be done. It is incremented in "WUNZMOR" after completion of an optimization pass.
FUDGE: Factor used to convert INGERR information to DELTLONG, scale factor Bl. It approximates the ratio of the number of revolutions of the spacecraft with respect to inertial space to the number with respect to a fixed longitude in equal time periods.

\[ u \]

**K** \(_{35degang} \): Constant, program notation "35DEGANG", scale factor BO, units revolutions. Value is -0.097222222222, corresponding to \(-35^\circ\). Used in "PROG20" to initialize UTFIT for rendezvous options.

\[ v \]

**K** \(_{600sec} \): Constant, program notation "600SEC", scale factor B28, units centi-seconds. Value is 60000 x 2\(^{-28}\), corresponding to 600 seconds or 10 minutes.

**K** \(_{dpmol} \): See Burn Control.

**K** \(_{epsielong} \): Constant, program notation "EPSILONG", scale factor BO, units revolutions. Value is 0.2777777E-4, corresponding to 0.01\(^\circ\) (the P29 convergence criterion).

**K** \(_{fearth} \): Constant, program notation "FEARTH", scale factor Bl, used to load FUDGE in P29. Value is 1.06666667 x 2\(-1\), where first term is nominal value (i.e. 16/15) and second is scale factor. Corresponds roughly to proper FUDGE value for an earth-orbiting spacecraft with a period of 90 minutes (16 revs per 24 hours).

**K** \(_{kpo1} \): Constant, program notation "K.01", scale factor BO, value 0.01. Used to convert output from "LAT-LONG" from units of meters to units of meters/100, so that DSKY display scale, usually XXXX.X nmi, will be XXXXXb. nmi instead for P21ALT.

**K** \(_{twiceeps} \): Constant, program notation "TWICEEPS", scale factor BO, units revolutions. Value is 0.5555556E-4, corresponding to 0.02\(^\circ\), or twice the value of \(K_{epsielong}\).

INGERR: Value of longitude error in P29, scale factor BO, units revolutions. Stored in push-down list location OD.

LONG: See Coordinate Transformations.

LONGFOR: Value of desired longitude (entered into R2 of N43) in P29, scale factor BO, units revolutions.

MARKTIME: See Measurement Incorporation.

MUSUBQ: Unit vector, scale factor Bl, perpendicular to polar vector and MUSUBE, used in P29.

MUSUBD: Unit vector, scale factor Bl, used in P29 iteration to compute ORBDLT. Stored in push-down list locations OD and 6D.
MUSUBE: Unit vector, scale factor Bl, in easterly direction, used in P29.

MUSUBN: Unit vector, scale factor Bl, in plane defined by angular momentum (and same hemisphere as north polar axis), used in P29.

MUSUBS: Unit vector, scale factor Bl, in direction of tangential velocity for P29 computations.

OPTION2: See Display Interface Routines.

OPTNTYPE: Single precision cell, scale factor B14, used to retain information on the P20 option selected: it is set equal to (bits 2-1 of OPTION2) - 1, hence zero for selection of option 1/5 (celestial body) and 1 for selection of option #2 (rotation). Not loaded for option 0/4 (rendezvous).

ORBDLT: Required angle change (converted via "TIMETHET" to a time and a new position vector) in the P29 loop, scale factor BO, units revolutions. Stored in push-down list location OD.

P21ALT: Value of K

P21BASE: Value of P21/P29 "base" vector for position (notation also P29BASE), scale factor B29, units meters. In P21, loaded after completion of integration to specified input time, and used to initialize the integration if bit 12(P21FLAG) of FLAGWRD2 = 1, thus permitting computation time to be saved if it is desired to iterate about a point which is a number of orbital integration time steps removed from the "permanent" GSM or OWS state vector.

P21BASEV: Value of P21/P29 "base" vector for velocity (notation also P29BASEV), scale factor B7, units meters/centi-second. See P21BASE.

P21GAM: Value of flight path angle computed in "P21PROG2" for (optional) display in R3 of N73 in P21, scale factor BO, units revolutions.

P21TIME: Cell used to retain time information (notation also P29BASET), scale factor B28, units centi-seconds. Used to contain the time tag of P21BASE and P21BASEV, and to permit the incrementing of the time associated with the N34 display.

P21VEL: Value of velocity computed in "P21PROG2" for (optional) display in R2 of N73 in P21, scale factor B7, units meters/centi-second.

PASSTIME: Time associated with current iteration in P29 loop, scale factor B28, units centi-seconds. When convergence criterion is satisfied, information in this cell is loaded in DSPI'EMI for N34 display.

PHETA: Value of angle computed in "ANGLER" (initialized to -0.01° in "N72STUFF"), scale factor BO, units revolutions, displayed in R3 of N77. It is analogous to R3 of N54 (R31) in P48, and to R3 of N53 (R34) in R22; in P25, it remains at -0.01°. Also set to -0.01° in "SNAPPY".
PLANVCU: Value of STARSAV3 (N88) information sampled in "VN70DSP" for use in options 1 or 5 of P20 (display generated if N70 = +0). Can be with arbitrary (but consistent) scaling.

R61CNTR: Single precision cell, scale factor B14, used for control of "R61CSM", and as a flag (if negative) that this routine has called R60 (requiring DSKY priority displays for the performance of the maneuver). Positive values cause the cell to be decremented and performance of the remainder of the routine to be bypassed; the setting to 3 causes the routine to be performed every fourth time it is entered, assuming that R61CNTR is not set 0 by the calling routine.

R67TIME: Value of the time at which maneuver is to be started for option 2 of P20, loaded in "P200PT" from N34 information, scale factor B28, units centi-seconds. Used in "CALLR6X" to determine when "R67" should be called, for OPTNTYPE > 0 (i.e. option 2).

RCV: See Orbital Integration.

RVEC: See Conic Routines.

SNTH: See Conic Routines.

STARC0DE: See Inflight Alignment.

STARSAV3: See Inflight Alignment.

T: See Conic Routines.

Tet: See Orbital Integration.

TFO: Time from optimization, scale factor B28, units centi-seconds, displayed in R3 of N76. It is updated in "CTASK" (and used in "TIMETASK" for temporary storage purposes).

UTPIT: Value of "pitch angle" used in P20, scale factor B0, units revolutions. It is loaded via R2 of N78, with a value of -35° the normal rendezvous initialization (preferred tracking axis) value.

UTSTARNO: Value of bits 6-1 of STARC0DE sampled in "VN70DSP", scale factor B14, for use in options 1 or 5 of P20. It is single precision.

UTYAW: Value of "yaw angle" used in P20, scale factor BO, units revolutions. It is loaded via R1 of N78, with a value of zero the normal rendezvous initialization: zeros for UTPIT and UTYAW correspond to +X axis tracking.

VCV: See Orbital Integration.

VECLOS: Temporary storage for sighting information in "PHICOMP", scale factor B1, used to compute required angle information (optics line of sight information).

VEC0: See Conic Routines.
Prelaunch Alignment

GTSCPSS Entered via V37 E 01 E

If bit 12 (NODOP01) of FLAGWRD1 = 1:

Proceed to "POOODO" (pattern 21521_8)

Change priority of present job to 20_8 (was established at 13_8)

GEOCOMPl = 1 (Logic checking this cell not shown)

ldPIPADT = K

LENGTHOT = K bt8

1SECXT1 = K ld2scx

PREMTRXC = 1

PERFDLAY dp = 1 (centi-second)

NEWAZMTH = LAUNCHAZ

OLDAZMTH = LAUNCHAZ

Perform "POSN17C"

Perform "IMUZERO" (Tag here is "GEOIMUTT")

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

NDXCTR = 0

X_{dc} = (1, 0, 0)

Y_{dc} = (0, \sin C_{azmth}, \cos C_{azmth})

Z_{dc} = (0, -\cos C_{azmth}, \sin C_{azmth})

Perform "CALCGA" (comes here if MODREG \neq 3, since should still be 1 at this point)

Perform "IMUCOARS"

If bit 14 (GLOKFAIL) of FLAGWRD3 = 1:

NDXCTR = NDXCTR + 1

Set bit 14 (GLOKFAIL) of FLAGWRD3 = 0

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

If NDXCTR > 0:

Proceed to "PIPACHK" (a check of PIPA's)

PREL-1
Perform "IMUFINE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

Call "GOESTIMS" in PERFDELAY\textsubscript{dp} centi-seconds (set to 1 above)

Put present job to sleep (starting address id = "ESTIMS")

**GOESTIMS**

Awaken job with starting address id = "ESTIMS"

End of task

**SOMERR2**

Perform "ALARM" (pattern 1601\textsubscript{g})

Set bit 8(IMUSE) of FLAGWRDO = 0 (tag here is "ENDTEST1")

TS = -0 and perform "NEWMODEX" (blanks program register)

Perform "MKRELEAS"

Proceed to "ENDEXT"

**POSN17C**

\[ X_{sm} = (0, - \cos \text{NEWAZMTH}, \sin \text{NEWAZMTH}) \]
\[ Y_{sm} = (0, \sin \text{NEWAZMTH}, \cos \text{NEWAZMTH}) \]
\[ Z_{sm} = (-1, 0, 0) \]

Return

**ESTIMS** Entered from awakened job via "GOESTIMS", or from end of "ALFLT" for azimuth change

Inhibit interrupts

GTSWTLT1 = TIME1

PIPA = 0

Release interrupts

\[ \text{INTVECL}_y = 0 \]
\[ \text{INTVECL}_z = 0 \]
\[ \text{FILDELVL}_y = 0 \]
FILDELV1_z = 0
THETAN = 0
GCOMPSW = 0
GCOMP = 0
DELY = 0
ERVECTOR = \text{omegaps} (\sin \text{Ctd}, - \cos \text{Ctd}, 0)
T_{\text{mark}} = T_{\text{now}}
ERCOMP = 0
ERECTIME = LENGTHOT
TS = 02 and perform "NEWMODEX"
Perform "PIPUSE"
LENGTHOT = 9
Proceed to "SLEEPIE"

**SLEEPIE**
Perform "CHKCOMED"
Perform "SETGWLST"
End of job

**CHKCOMED**
Inhibit interrupts
If MODREG = 7:
    Return
If bit 5(Liftoff complement) of channel 30 = 1:
    If bit 5(BKUPLO) of FLAGWRD5 = 0: (set 1 by "LFTFLGON" for a V75E)
        Release interrupts
        Return
Set priority of present job to 22 (was established at that anyhow)
Proceed to "Pl1"
SETGWLIST

Inhibit interrupts

TS = GTSWLT1 - TIME1

If TS > 0:

TS = TS - 163.83 seconds  (should be 163.84)

TS = TS + 1SECXT1

If TS ≤ 0:

TS = 0.04 seconds

Call "ALLOOP" in TS seconds

Return  (interrupts released e.g. by End of job)

ALLOOP

GTSWLT1 = TIME1

Set restart group 5 to cause restart at next line

Set DELV = PIPA and PIPA = +0  (no special restart provisions)

Set restart group 5 to cause restart at next line

Establish "ALFLT"  (priority 22g)

End of task

ALFLT

Perform "CHKCOMED"

Perform "1/PIPA"

\[ TS = \text{DELV} \left[ X_{sm} \right] \]

DPIPAY = − TS\subscript{y}

DPIPAZ = TS\subscript{z}

\[ \text{FILDELV1}_y = \text{FILDELV1}_y + K_{gocl} \left( \text{DPIPAY} - \text{FILVELV1}_y \right) \]  (Tag here is "ALWAYSG")

\[ \text{INTVECl}_y = \text{INTVECl}_y + \text{FILDELV1}_y \]

\[ \text{FILDELV1}_z = \text{FILDELV1}_z + K_{gocl} \left( \text{DPIPAZ} - \text{FILDELV1}_z \right) \]

\[ \text{INTVECl}_z = \text{INTVECl}_z + \text{FILDELV1}_z \]
If ERECTIME ≠ 0:

\[ \text{THETAN}_y = \text{THETAN}_y - K \cdot \text{geoc} (\text{FILDELV}_1 + K \cdot \text{INTVEC}_1) \]

\[ \text{THETAN}_z = \text{THETAN}_z - K \cdot \text{geoc} (\text{FILDELV}_1 - K \cdot \text{geoc} \cdot \text{INTVEC}_1) \]

If ERECTIME = 0:

\[ \text{THETAN}_x = \text{THETAN}_x + K \cdot \text{pipgyr} \cdot \text{FILDELV}_1 \]

\[ \text{THETAN}_y = \text{THETAN}_y - K \cdot \text{geoc} \cdot \text{FILDELV}_1 - K \cdot \text{geoc} \cdot \text{INTVEC}_1 \]

\[ \text{THETAN}_z = \text{THETAN}_z - K \cdot \text{geoc} \cdot \text{FILDELV}_1 \]

If LENGTHOT > 0:

\[ \text{LENGTHOT} = \text{LENGTHOT} - 1 \]

Proceed to "SLEEPIE"

Perform "CHKCOMED"

If IGYRO > 0: (gyros torquing, e.g. from "1/PIPA" compensation)

Proceed to "SLEEPIE"

\[ \text{ERCMP} = \text{ERCMP} + [X_{sm}] \cdot \text{THETAN} \]

Perform "EARTHR~" Note that restart protection from here onward is priority 208 (job established at 228).

\[ \text{THETAN} = 0 \]

If PREMTRXC > 0: (set 0 by "AZMTHCGL")

\[ \text{ERECTIME} = \text{ERECTIME} - 1, \text{limited} \geq 0 \]

\[ \text{LENGTHOT} = 9 \]

Proceed to "SLEEPIE"

\[ \text{TS} = \text{LAUNCHAZ} - \text{OLDAZMTH} \]

If TS = 0:

\[ \text{PREMTRXC} = 1 \]

\[ \text{ERECTIME} = \text{ERECTIME} - 1, \text{limited} \geq 0 \]

\[ \text{LENGTHOT} = 9 \]

Proceed to "SLEEPIE"
PREMTRXC = 1
NEWAZMTH = LAUNCHAZ
ERCOMP_z = TS
Perform "POSN17C" (zero elements not reset 0)
OLDAZMTH = NEWAZMTH
LENGTHOT = K_{bt7}
TS = "ERCOMP"
Perform "IMUPULSE"
Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed
Proceed to "ESTIMS"

EARTH:
TS = T_{now}
TS_1 = TS - T_{mark}
If TS_1 < 0:
    TS_1 = TS_1 + 2^{28} \text{ centi-seconds}
ERCOMP = ERCOMP + [x_{sm}^T] TS_1 \text{ ERVECTOR}
T_{mark} = TS
TS = "ERCOMP"
Perform "IMUPULSE"
Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed
Return
AZMTHCG1 Established by "CHAZFOGC" for V78E, with priority 16g
DSPTEM1 = NEWAZMTH, converted to single precision twos complement, scale factor B-1, units revolutions.
Perform "CLEANDSP"
TS = 0629
Proceed to "GOFLASH": if terminate, skip next line
if proceed, proceed
otherwise, proceed to previous line

LAUNCHAZ = DSPTEM1, converted to double precision ones complement,
scale factor BO, units revolutions

PREMTRXC = 0
Proceed to "PINBRNCH"

GCOMPVER Established by "CKOPTVB" for V65E, with priority 168
TS = 03 and perform "NEWMODEX"

\[ X_{dc} = (1, 0, 0) \]
\[ Y_{dc} = (0, \sin C_{azmth}, \cos C_{azmth}) \]
\[ Z_{dc} = (0, -\cos C_{azmth}, \sin C_{azmth}) \]

Perform "MKRELEAS" (comes here if MODRED = 3, as it should)

Perform the following for i = 1 and then i = 2:

\[ DSPTEM1+2 = i \]
\[ DSPTEM1+0 = TAZ_i \]
\[ DSPTEM1+1 = TEL_i \]

TS = 0530
Perform "GODSPRET"

TS = 0641
Proceed to "GOFLASH": if terminate, proceed to "GCOMP5"
if proceed, proceed
otherwise, proceed to 3rd previous line

\[ TAZ_i = DSPTEM1+0 \]
\[ TEL_i = DSPTEM1+1 \]

STARCODE = 1
TS = 0
Perform "TARGDRVE"

$$\text{STARAD} = \begin{bmatrix} X \\ \sin \text{TEL} \\ - \cos \text{TAZ} \cos \text{TEL} \\ \sin \text{TAZ} \cos \text{TEL} \end{bmatrix}$$

$$\text{STARBD} = \begin{bmatrix} X \\ \sin \text{TEL} \\ - \cos \text{TAZ} \cos \text{TEL} \\ \sin \text{TAZ} \cos \text{TEL} \end{bmatrix}$$

$$X_1 = -"\text{MRKBUP1}"$$

$$\text{CDUSP} = E_2 - X_1$$

Perform "SXTNB" (here if bit 11 (ATMFLAG) of FLAGWRDO = 0, as it should)
Perform "TRG\#NBSM"

$$\text{LOSVEC} = TS$$

$$\text{STARCODE} = 2$$ (Tag here "NEXBNKSS")

TS = 6
Perform "TARGDRVE"

$$X_1 = -"\text{MRKBUP1}"$$

$$\text{CDUSP} = E_2 - X_1$$

Perform "SXTNB" (here if bit 11 (ATMFLAG) of FLAGWRDO = 0, as it should)
Perform "TRG\#NBSM"

$$\text{STARBC} = TS$$

$$\text{STARAG} = \text{LOSVEC}$$

Perform "AXISGEN"
Perform "CALCGTA"

TS = 0693 vn
Proceed to "GOFLASH": if terminate, proceed to "GCOMP5"
if proceed, proceed otherwise, proceed to previous line

$$\text{ERCOMP} = \text{ERCOMP} + \text{CGC}$$
Proceed to "GCOMP5"
GCOMP5

TS = 02 and perform "NEWMODEX"
End of job

TARGDRVE

If TS = 0:

\[ \text{STAR} = (\sin \text{TEL}_1, - \cos \text{TAZ}_1 \cos \text{TEL}_1, \sin \text{TAZ}_1 \cos \text{TEL}_1) \]

If TS = 6:

\[ \text{STAR} = (\sin \text{TEL}_2, - \cos \text{TAZ}_2 \cos \text{TEL}_2, \sin \text{TAZ}_2 \cos \text{TEL}_2) \]

Perform "SXTANG"

DESOPTS = SAC_{sp}  
DESOPTT = PAC_{sp}

Proceed to "RETARG"

RETARG

OPTIND = +0

Perform "SXTMARK"

If MARKINDX > 0:  (no mark obtained)

Proceed to "RETARG"

Perform "MKRELEAS"

Return (to routine calling "TARGDRVE")
Quantities in Computations

See also list of major variables and list of routines

lSECT: Single precision quantity, scale factor Bl4, units centiseconds, giving required period of computations for "ALLOOP". Set to 0.5 seconds for gyro compassing.

C LATITUDE: Erasable memory (double precision) constant, program notation "LATITUDE", scale factor B0, units revolutions. It gives the "local vertical astronomical latitude" of the pad.

C AZIMUTH: Erasable memory (double precision) constant, program notation "AZIMUTH", scale factor B0, units revolutions. It gives the "azimuth of the vehicle Z-axis east of north."

CDUSP: See Coordinate Transformations.

DESOPTS, DESOPTT: See Optics Computations.

DPIPAi (i = Y,Z): Value of accelerometer output modified for use in gyrocompassing. The y axis of this system is south and the z axis is east (from [x, y, z]). Scale factor of DPIPAi is Bl4, units accelerometer counts.

ERCOME: Value of gyro compensation to be sent to gyros, scale factor B21, units pulses (or scale factor B0, units revolutions, since one pulse is 2-21 revolution). Program notation also "ERCOME".

ERECTIME: Single precision length of time to be spent in erection phase, scale factor Bl4, units of five-second gyro compassing cycles. It is set to LENGTHOT in "ESTIMS". Program notation also "ERECTIME".

ERV: Earth rotation vector initialized in "ESTIMS", scale factor B1, units gyro pulses/centi-second.

GCOME, GCOMPSW: See IMU Computations.

GCOM1: Single precision cell set positive non-zero to indicate that gyro-compassing computations are being performed. The logic that checks this cell is not shown in this write-up. See Testing Routines.

GTSWLT: Single precision cell, scale factor Bl4, units centiseconds, giving the value of TIME1 when "ALLOOP" last entered, and used to construct proper waitlist value for the next call in "SETGWLIST".
INTVECl: Summed values of FILDELV_y and FILDELV_z respectively, scale factor Bl4, units accelerometer counts.

K_{ld2scx}: Single precision constant, program notation "1/2SECX", scale factor Bl4, units centi-seconds. Value is 50 x 2^{-14}, corresponding to 0.5 second.

K_{ldppgt}: Single precision constant, program notation "1/PIPAGT", scale factor B8, units centi-seconds. Value is 0.62008, corresponding to 0.5 seconds.

K_{bt7}: Single precision constant, program notation "BIT7", scale factor Bl4, units of five-second gyro compassing cycles. Octal value is 001008, corresponding to decimal 64, used to load LENGTHOT, and thence ERECTIME, for a change in input azimuth: value gives 64 x 5 = 320 seconds for vertical erection.

K_{bt8}: Single precision constant, program notation "BIT8", scale factor Bl4, units of five-second gyro compassing cycles. Octal value is 002008, corresponding to decimal 128, used to load LENGTHOT, and thence ERECTIME, at start of PO1 (in "GTSCPSS"): value gives 128 x 5 = 640 seconds for vertical erection at start of PO2.

K_{geocl}: Constant, program notation "GEOCONS1", scale factor B0, value 0.1.

K_{geoc2}: Constant, program notation "GEOCONS2", scale factor B0, value 0.005.

K_{geoc3}: Constant, program notation "GEOCONS3", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.062, corresponding to a "true" value of 7.936.

K_{geoc4}: Constant, program notation "GEOCONS4", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.000384, corresponding to a "true" value of 0.0384.

K_{geoc5}: Constant, program notation "GEOCONS5", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.5, corresponding to a "true" value of 64.

K_{omegms}: Constant, program notation "OMEG/MS", scale factor B0, units gyro pulses/centi-second. Value is 0.24339048, corresponding approximately to \( (1/86164.0932) \times 10^{-2} \times 221 \), where first term is earth rotation period in seconds (used to derive constant), second converts to centi-seconds, and third is number of gyro torquing pulses in one revolution.

K_{pipgyr}: Dummy constant used to indicate change in units between accelerometer pulses and gyro torquing pulses, scale factor B7. Value is 1.00, corresponding to 27 or 128.
LAUNCHAZ: Value of desired launch azimuth, scale factor B0, units revolutions. Since is used at the start of POL, should form part of prelaunch erasable load, although it can also be updated in "AZMTHCG1" (via V78E). Program notation also "LUNCHAZ1".

LENGTHOT: Single precision cell, scale factor B14, loaded in "GTSCPSS" with K_b78 (for loading into ERECTIME) and at the end of "ALFLT", if a new azimuth specification received, with K_b77. It is also used as a counter of the number of half-seconds that have elapsed since the previous entrance to "EARTH" (via an initial setting to 9 and a 1SECXTL setting to 0.5 seconds).

LGYRO: See IMU Computations.

LOSVEQ: Unit vector, scale factor B1, serving in "GCOMPVER" as a temporary storage cell for the sighting vector to the first target.

MARKINDX, MRKENUF1: See Optics Computations.

NDXCTR: Single precision cell, scale factor B14, used in "GTSCPSS" to retain information on bit 14(GLOKFAL) of FLAGWRD, which should be 0 if do POL.

NEWAZMTH: Communication cell with "POSN17C", scale factor B0, units revolutions, used to compute the required orientation of the stable member. Program notation also "NEWAZI". Set to LAUNCHAZ in "GTSCPSS" and "ALFLT" (if an input azimuth change).

OGC: See Coordinate Transformations.

OLDAZMTH: Value of azimuth angle presently reflected in computations, scale factor B0, units revolutions. If, with PREMTRXC = 0, LAUNCHAZ = OLDAZMTH, it is concluded that no input change took place, and no re-initialization (via entrance to "ESTIMS") of gyro compassing is done. OLDAZMTH is set as described for NEWAZMTH, but at a slightly different time for restart considerations.

OPTIND: See Optics Computations.

PAC: See Coordinate Transformations.

PERFDAY: Communication cell with routine calling "GOESTIMS", set to one centi-second at start of "GTSCPSS", scale factor B28, units centi-seconds (the "LONGCALL" entrance to the waitlist system is used).

PIPA: See IMU Computations.
PREMTRXC: Single precision cell, scale factor BL4, initialized to 1 in "GTSCPSS" and set 0 at the end of "AZMTHCG1". If sensed as 0 in "ALFLT" (when LENGTHOT has run down), then, if LAUNCHAZ ≠ OLDAZMTH, gyro compassing is re-initialized. In any event, PREMTRXC is reset to 1. Program notation also "PREMTRX1".

SAC: See Coordinate Transformations.

STAR: See Coordinate Transformations.

STARAQ, STARAQ, STARBQ, STARBQ: See Coordinate Transformations.

STARCODE: See Inflight Alignment (setting in "GCOMPVER" is not functional, since the cell is not displayed by the mark routine).

Tmark: Value of time when previous earth-rate compensation was made, scale factor B28, units centi-seconds.

TAZ1, TAZ2, TEL1, TEL2: Single precision erasable memory cells (which could be set as part of erasable memory load) giving azimuth (TAZi) and elevation (TELi) for targets #1 and #2 used in POJ. For azimuth information, scale factor is B-1 in twos complement; for elevation, scale factor is B-2: in both cases, units are revolutions.

THETAN: Value of required number of gyro torquing pulses (before rotation by [Xsm]T, and hence in the vertical, south, east system), scale factor B21, units pulses. Program notation also "THETAN1".
Rendezvous Computation

\[ T_{\text{dec2}} = T_{\text{dec1}} \]
Perform "LEMPREC"

\[ R_{\text{pass3}} = R_{\text{att}} \]
\[ V_{\text{pass3}} = V_{\text{att}} \]
\[ T_{\text{decl}} = T_{\text{dec2}} \]
Perform "CSMPREC"

\[ R_{\text{act3}} = R_{\text{att}} \]
\[ V_{\text{act3}} = V_{\text{att}} \]
\[ U_{\text{P1}} = \text{unit}(\text{unit} R_{\text{pass3}} \cdot V_{\text{pass3}}) \]
\[ \text{CMYDOT} = V_{\text{act3}} \cdot U_{\text{P1}} \]
\[ \text{AUTOY} = R_{\text{act3}} \cdot U_{\text{P1}} \]
\[ \text{UNRM} = \text{unit}(R_{\text{act3}} \cdot V_{\text{act3}}) \]
\[ \text{LMYDOT} = V_{\text{pass3}} \cdot \text{UNRM} \]

Return

S33/34.1 Entered from "P33/P73B" (P34) and "P34/P74C" (P35)

\[ \text{TITER} = -16383 \]
\[ \text{SECMAX} = K_{\text{max250}} \]
\[ R_{\text{aprec}} = R_{\text{act3}} \]
\[ V_{\text{aprec}} = V_{\text{act3}} \]
\[ R_{\text{pprec}} = R_{\text{pass3}} \]
\[ V_{\text{pprec}} = V_{\text{pass3}} \]
Proceed to "ELCALC"
ELCALC

ULOS = unit(R\_pass3 - R\_act3)
UNRM = unit(R\_act3 \* V\_act3)
UP = unit (ULOS - (ULOS \* unitR\_act3) unitR\_act3)
TS\_1 = (UNRM \* R\_act3) \* UP
TS = \cos^{-1} \left( (UP \cdot ULOS) \text{ sgn } TS\_1 \right) \text{ (elevation angle)}
If (ULOS \cdot R\_act3) < 0:
  TS = (1 - 2^{-28}) - TS

If bit 14(ITSWITCH) of FLAGWRD7 = 0:
  T\_tpi = T\_tpi + NOMTP1
  If bit 7(HAVEELEV) of FLAGWRD2 = 0:
    ELEV = TS \text{ (TS derived above, elevation angle)}
    TS = 0 \text{ (non-error return flag)}
    Return (to routine calling "S33/34.1")

DELELO = DELEL

DELEL = TS - ELEV
If |DELEL| - K\_eeps < 0:
  TS = 0 \text{ (non-error return flag)}
  Return (to routine calling "S33/34.1")

TS = \frac{1}{2} TITER \text{ (Tag here "FIGTIME")}
If TS\_sp = 0:
  Return (to routine calling "S33/34.1": TS \neq 0, indicating error)

TITER = TS\_sp
TS = (\frac{1}{2} - ELEV) \text{ sgn } \left( |R\_pass3| - |R\_act3| \right) \text{ (The } \frac{1}{2} \text{ is } 180^\circ)
If TS < 0:
  \left( |R\_pass3| \text{ in } 12D; |R\_act3| \text{ in } 14D; \text{ units } 0D \& 6D \right)
  \text{ Return (to routine calling "S33/34.1": TS \neq 0, indicating error)
PD28CS = \left| R_{\text{act}3} \right| \cos \left( \frac{1}{2} - \text{ELEV} \right) / \left| R_{\text{pass}3} \right|

TS = 1 - \left| PD28CS \right|

If \( TS < 0 \):

Return (to routine calling "S33/34.1": TS \neq 0, indicating error)

PDOMEGA = \left| R_{\text{pass}3} \right| \left( \text{unit} \left( \text{UNRM} \ast \text{unit}_{\text{act}3} \right) \right) \ast V_{\text{act}3}

TS = \text{unit}_{\text{pass}3} \ast V_{\text{pass}3}

PDOMEGAP = \left| R_{\text{act}3} \right| \left( \text{unit} \left( TS \ast \text{unit}_{\text{pass}3} \right) \right) \ast V_{\text{pass}3}

TS_1 = \left( \text{unit}_{\text{act}3} \ast \text{unit}_{\text{pass}3} \right) \ast \text{UNRM}

PDALFMPI = \left( \cos^{-1} \left( \text{unit}_{\text{pass}3} \ast \text{unit}_{\text{act}3} \right) \right) \text{sgn} \ TS_1 - \frac{1}{2} + \text{ELEV}

TS_2 = \left( \frac{1}{2} - \cos^{-1} PD28CS \right) \text{sgn} \left( \left| R_{\text{pass}3} \right| - \left| R_{\text{act}3} \right| \right) \left( \frac{1}{2} \right. \text{ is } 180^\circ)

PDDELTM = K_{\text{two}pi} \left| R_{\text{act}3} \right| \left| R_{\text{pass}3} \right| \left( PDALFMPI + TS_2 \right) \left( \frac{PDDELTM}{PDOMEGA - PDOMEGAP} \right)

If \( |PDDELTM| - \text{SECMAX} \geq 0 \):

PDDELTM = \text{SECMAX} \text{ sgn PDDELTM}

If TITER < 0: (i.e. first pass) (Tag here "OKMAX")

TITER = 377778

DELTEEO = PDDELTM

NOMTPI = NOMTPI + DELTEEO

Proceed to "ADTIME+3"

If (DELEL DELELO) < 0: (i.e. sign change in angle)

SECMAX = \text{SECMAX} / 3

DELTEEO = - \frac{1}{2} |PDDELTM| \text{ sgn DELTEEO}

NOMTPI = NOMTPI + DELTEEO

Proceed to "ADTIME+3"

REND-3
If \(|\text{DELELO} - |\text{DELEL}|| \geq 0:

\[
\text{DELTEEO} = |\text{PDDELM}| \, \text{sgn} \, \text{DELTEEO}
\]

\[\text{NOMTPI} = \text{NOMTPI} + \text{DELTEEO}\]

Proceed to "ADTIME+3"

\[
\text{TS} = \text{DELTEEO}
\]

\[
\text{DELTEEO} = -\frac{1}{2} \text{DELTEEO}
\]

\[\text{NOMTPI} = \text{NOMTPI} - \text{TS} + \text{DELTEEO} \quad \text{(same as } \text{NOMTPI} - 1.5 \text{DELTEEO}_{n-1})\]

Proceed to "ADTIME+3"

**ADTIME+3**

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If \(\text{NOMTPI} \neq 0\): \((\text{as it would be expected to be})\)

Set bit 4(CONICINT) of FLAGWRD3 = 1

\[
T_{\text{decl}} = \text{NOMTPI}
\]

\[
T_{\text{et}} = 0
\]

\[
\text{RCV} = R_{\text{aprec}}
\]

\[
\text{VCV} = V_{\text{aprec}}
\]

Perform "INTEGRVS"

\[
R_{\text{act3}} = R_{\text{att}}
\]

\[
V_{\text{act3}} = V_{\text{att}}
\]

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If \(\text{NOMTPI} \neq 0\):

Set bit 4(CONICINT) of FLAGWRD3 = 1

\[
T_{\text{decl}} = \text{NOMTPI}
\]

\[
T_{\text{et}} = 0
\]

\[
\text{RCV} = R_{\text{pprec}}
\]

REND-4
VCV = V \_\text{pprec}

Perform "INTEGRVS"

R\_\text{pass3} = R\_\text{att}

V\_\text{pass3} = V\_\text{att}

Proceed to "ELCALC"

\textbf{S34/35.2} Entered from "P34/P74C" (P35) and "P35/P75B" (P36)

SUBEXIT = Return address

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If NNI\_\text{sp} = 0:

Set bit 4(CONICINT) of FLAGWRD3 = 1

T\_\text{decl} = T\_\text{pass4}

T\_\text{et} = \text{INTIME}

RCV = R\_\text{pass3}

VCV = V\_\text{pass3}

Perform "INTEGRVS"

R\_\text{targ} = R\_\text{att}

Proceed to "S3435.25"

\textbf{S3435.25}

V\_\text{pass4} = V\_\text{att}

TS\_1 = \text{(unitR}\_\text{act3} \times \text{unitR}\_\text{targ}) \times \text{UNRM}

TS = \text{(cos}^{-1} (\text{unitR}\_\text{act3} \times \text{unitR}\_\text{targ})) \times \text{sgn} \text{TS}\_1

If TS < 0:

TS = TS + (1 - 2^{-28})

ACTCENT = TS

DELT4 = T\_\text{pass4} - \text{INTIME}

TS\_1 = NNI\_\text{sp}
\[ TS_2 = K_{\text{epsfour}} \]
\[ R_{\text{init}} = R_{\text{act3}} \]
\[ V_{\text{init}} = V_{\text{act3}} \]
Perform "INITVEL"
\[ TS_2 = - \text{UNRM} \]
\[ TS_3 = - \text{unitR}_{\text{act3}} \]
\[ TS_1 = TS_3 \times \text{UNRM} \]
\[ \text{DELVVVC} = \begin{bmatrix} TS_1 \\ TS_2 \\ TS_3 \end{bmatrix} \]
\[ \text{DELVVEET} = \begin{bmatrix} TS_1 \\ TS_2 \\ TS_3 \end{bmatrix} \]
\[ TS_1 = \text{ULOS} \]
\[ TS_3 = - \text{unit(ULOS} \times \text{UNRM)} \]
\[ TS_2 = TS_3 \times \text{ULOS} \]
\[ \text{DVLOS} = \begin{bmatrix} TS_1 \\ TS_2 \\ TS_3 \end{bmatrix} \]
Proceed to address specified by SUBEXIT

S34/35.3 Entered from "P34/P740" (P35) and "P35/P75B" (P36) if new velocity components input
Perform "INTSTALL"
Set bit 4(CONICINT) of FLAGWRD3 = 0
Set bit 4(CONICINT) of FLAGWRD3 = 1 (superseding previous line)
\[ T_{\text{decl}} = T_{\text{pass4}} \]
\[ T_{\text{et}} = T_{\text{ig}} \]
\[ RCV = R_{\text{act3}} \]
\[ VCV = V_{\text{act3}} + \text{DELVVEET} \]
Perform "INTEGRVS"

\[ R_{\text{targ}} = R_{\text{att}} \]
\[ TS_2 = - \text{UNRM} \]
\[ TS_3 = - \text{unitR}_{\text{act3}} \]
\[ TS_1 = TS_3 \times \text{UNRM} \]
\[ \text{DELVLVC} = [TS_1 \quad TS_2 \quad TS_3] \]
\[ \text{DELVEET}_3 \]
\[ TS_1 = \text{ULOS} \]
\[ TS_3 = - \text{unit}(\text{ULOS} \times \text{UNRM}) \]
\[ TS_2 = TS_3 \times \text{ULOS} \]
\[ \text{DVLOS} = [TS_1 \quad TS_2 \quad TS_3] \]

Return

**INITVEL**

Entered with TS\(_1\), OD, set to iterations; TS\(_2\), 2D, angle to 180°

Set bit 2(GUESSSW) of FLAGWRD1 = 1

\[ R_{\text{targl}} = R_{\text{targ}} \quad \text{(Tag here "HAVEGUES", entered from "S40.9")} \]
\[ ITCTR = -1 \]
\[ \text{COZY4} = \cos TS_2 \quad \text{(TS}_2 \text{ set before enter, cell 2D, 00 revs.)} \]
\[ \text{VTARGTAG} = TS_1 \quad \text{(TS}_1 \text{ set before enter, cell OD, B14)} \]
\[ R1\text{VEC} = R_{\text{init}} \]
\[ R2\text{VEC} = R_{\text{targl}} \]
\[ TDESIRED = \text{DELLT}_4 \]
\[ UN = \text{unit}(\text{unitR}_{\text{init}} \times V_{\text{init}}) \]
\[ \text{COZY4} = \text{COZY4} + \text{unitR}_{\text{targl}} \cdot \text{unitR}_{\text{init}} \]
Set bit 10(NORMSW) of FLAGWRD7 = 0
Proceed to "INITVEL2"

**INITVEL2**

If COZY4 < 0:
  
  Set bit 10(NORMSW) of FLAGWRD7 = 1
  
  \[ R_{2VEC} = \left| R_{2VEC} \right| \text{unit} \left( R_{2VEC} - (R_{2VEC} \cdot \text{UN}) \cdot \text{UN} \right) \]
  
  If ITCTR < 0: (i.e. first pass)
  
  \[ R_{\text{target}} = R_{2VEC} \]
  
  \[ T_S = - \text{unit}\text{R}\text{VE}_Q \ast \text{unit}\text{R}\text{VE}_Q \]
  
  If \( T_S \cdot \text{unit}\text{R}\text{VE}_Q < 0: \)
  
  \[ T_S = - T_S \]
  
  \[ \text{GEOMSGN} = 22437s \cdot \text{sgn} \left( (T_S \ast \text{unit}\text{R}\text{VE}_Q) \cdot \text{unit}\text{R}\text{VE}_Q \right) \]
  
  Perform "LAMBERT"

  Set bit 2(GUESSSW) of FLAGWRD1 = 0

  \[ V_{\text{iprime}} = \text{VVE}_Q \]
  
  If VTARGTAG = 0:

  Proceed to "INITVEL7"

  Perform "INTSTALL"

  \[ R_{1VEG} = R_{\text{init}} \]
  
  \[ R_C = R_{\text{init}} \]
  
  \[ W_C = V_{\text{iprime}} \]
  
  \[ T_{et} = \text{INTIME} \]
  
  Set bit 4(CONICINT) of FLAGWRD3 = 0

  \[ T_{\text{decl}} = \text{INTIME} + \text{DELLT}_4 \]

  Perform "INTGRVS"

  \[ V_{\text{target}} = V_{\text{attl}} \]
ITCTR = ITCTR + 1
If ITCTR = VTARGTAG:
\[ R_{\text{targ1}} = R_{2}\text{VEC} \]
Proceed to "INITVEL7"
\[ R_{2}\text{VEC} = R_{2}\text{VEC} + R_{\text{targ1}} - R_{\text{attl}} \]
Proceed to "INITVEL2"

**INITVEL7**

\[ \text{DELVEET3} = v_{tprime} - v_{\text{init}} \]
\[ v_{tprime} = v_{\text{target}} \quad (v_{\text{target}} \text{ computed in "INITV" if VTARGTAG} = 0) \]
\[ R_{\text{targ}} = R_{\text{targ1}} \]
Set bit 8(XDELVFLG) of FLAGWRD2 = 0
Return (to routine calling "INITVEL")

**CDHMVR**
Entered from "P33/P73B" (P34)

\[ \text{UNVEC} = \text{unit}R_{\text{act2}} \]
\[ \text{CSTH} = \text{unit}R_{\text{pass2}} \cdot \text{UNVEC} \]
\[ \text{SNTH} = \sqrt{1 - \text{CSTH}^2} \cdot \text{sgn} \left( (-R_{\text{act2}} \cdot R_{\text{pass2}}) \cdot UPl \right) \]
\[ \text{RVEC} = R_{\text{pass2}} \]
Set bit 9(RVSW) of FLAGWRD7 = 0 (means new \( \vec{r}, \vec{v} \) are desired)
\[ \text{VVEC} = v_{\text{pass2}} \]
Perform "TIMETHET"

\[ \text{PD18V} = T_{v} \]
\[ \text{PDO2R} = |T_{r}| \]
\[ \text{DIFFALT} = \text{PDO2R} - |R_{\text{act2}}| \]
\[ \text{PDSEMAP} = R_{1} / R_{\text{dA}} \quad \text{(semi-major axis of passive vehicle)} \]
\[ \text{PDSEMAA} = \text{PDSEMAP} - \text{DIFFALT} \]
PDVAV = (PD18Y \cdot UNVEG) \left(\text{PDSEMAP} \div \text{PDSEMAA}\right)^{3/2}

TS = 2 \frac{K_{\text{rtmu}} / |R_{\text{act2}}| - K_{\text{rtmu}} / \text{PDSEMAA}}{PDVAV^2}

PDVAH = \sqrt{TS - PDVAV^2}

V_{\text{act3}} = PDVAH \left(\text{unit(UP1)} \cdot \text{UNVEG}\right) + PDVAV \cdot \text{UNVEG}

DELVEET2 = V_{\text{act3}} - V_{\text{act2}}

Return

NC12ST  Entered from "NC12H", "P31", and "P32"

PH1 = 9  (the 9 is from most significant half of K_{25fds})

CF = 0

PH2 = 0

DVH1 = K_{165fds}

If bit 5(NC12FIG) of FLAGWRDO = 1: (P32)

NC = C_{nh1}

DVC = K_{165fds}

If bit 5(NC12FIG) of FLAGWRDO = 0: (P31)

DVC = K_{225fds}

DVH2 = K_{25fds}

PI = 0.5  (units of revolutions, i.e. 180°)

TN = TIMEC

T_{\text{decl}} = TIMEC

Perform "CSMPREC"

Set bit 13(ITERFIG) of FLAGWRD2 = 0

R_{\text{tig}} = R_{\text{att}}

R_{\text{ac}} = R_{\text{att}}

R_{\text{act2}} = R_{\text{ac}}  \text{ (same cell)}

V_{\text{tig}} = V_{\text{att}}

REND-10
\begin{align*}
V_{ac} &= V_{att} \\
T_{decl} &= \text{TIMEC} \\
\text{Perform "LEMCONIC"}
\end{align*}

\begin{align*}
V_{pc} &= V_{att} \\
R_{pc} &= R_{att} \\
\text{Proceed to "PHSMCH"}
\end{align*}

**PHSMCH**

Entered also from end of "NC12J"

\begin{align*}
AM_1 &= \text{unit}(R_{pc} \ast V_{pc}) \\
UP_1 &= AM_1 \quad \text{(same cell)} \\
UR_{pd} &= \text{unit}\left[\left(\text{unit}(R_{ac} \ast V_{ac}) \ast R_{ac}\right) \ast AM_1\right] \\
TS_1 &= \pi - \cos^{-1}\left(\text{unit}R_{pc} \cdot UR_{pd}\right) \\
\text{TH2} &= \pi - TS_1 \cdot \text{sgn}\left((UR_{pd} \ast R_{pc}) \cdot AM_1\right)
\end{align*}

If $\text{TS}_1 > 0$:

- If $\text{NC} - 18 \geq 0$:
  - If $\pi \neq 0$:
    \begin{align*}
    TS_1 &= R_{pc} \quad \text{(OD)} \\
    TS_2 &= V_{pc} \quad \text{(6D)} \\
    TS_3 &= \text{TMEC} \quad \text{(12D)} \\
    TS_4 &= 1 \quad \text{(B5 rev, 14D)}
    \end{align*}
  - Perform "REVUP"
  - $TN = TN - (\text{RTEMP} - \text{TMEC})$
  - Proceed to "NC12J"

If $|\text{TH2}| - C_{\epsilon ps1} < 0$:

- Tag here "NC12B"

If $\text{PH1} \neq 0$:

- $\text{PH1} = \text{PH1} - 1$

Proceed to "NC12J"
\[ R_{ac} = |R_{ac}| \text{ unit } \left( R_{ac} - (R_{ac} \cdot A_{ML}) A_{ML} \right) \]  
(Tag here "PSMAIRM")

\[ R_{act2} = R_{ac} \quad \text{(same cell)} \]

\[ TS = 600 \text{ s} \]

Proceed to "DISPALM"

**NC12J**  
Entered from "PHSMCH"

Set bit 9(RVSW) of FLAGWRD7 = 1  
(new \( R, \) \( V \) not desired)

\[ \text{CSTH} = \cos |\theta_2| \]

\[ \text{SNTH} = \sin |\theta_2| \]

\[ R_{VEC} = R_{pc} \]

\[ V_{VEC} = V_{pc} \quad \text{sgn} \ \theta_2 \]

Perform "TIMETHET"

If \( \pi \neq 0 \):

\[ \pi = 0 \]

\[ R_{pc} = R_{other} \]

\[ V_{pc} = V_{other} \]

\[ T_{pc} = T_{etlm} \]

Set bit 2(NCINTFLG) of FLAGWRD0 = 0  
(Tag here "NC12C")

\[ TS = T_{pc} \quad \text{(save for integration below)} \]

\[ TN = TN - T \quad \text{sgn} \ \theta_2 \]

\[ T_{pc} = TN \]

\[ T_{\text{decl}} = TN \]

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If bit 2(NCINTFLG) of FLAGWRD0 = 1:  
(should not be)

Set bit 4(CONICINT) of FLAGWRD3 = 1

\[ T_{et} = TS \quad \text{(TS saved above)} \]
Perform "INTEGRVS"

\[
V_{pc} = V \quad \text{and} \quad R_{pc} = R
\]

Perform "INTEGRVS"

\[
V_{pc} = V \quad \text{and} \quad R_{pc} = R
\]

Proceed to "PHSMCH"

**NC12F**

Entered from "PHSMCH" if \[|T_{H2}| < \epsilon_{psl}\]

\[
PH1 = 0
\]

\[
R_{ac} = \left| R_{ac} \right| \cdot \text{unit} \left( R_{ac} - (R_{ac} \cdot AML) \cdot AML \right)
\]

\[
R_{act2} = R_{ac} \quad \text{(same cell)}
\]

\[
V_{ac} = \left| V_{ac} \right| \cdot \text{unit} \left( V_{ac} - (V_{ac} \cdot AML) \cdot AML \right)
\]

Set bit 2(NCINTFLG) of FLAGWRD0 = 1

\[
T_{decl} = T_{tpi}
\]

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If bit 2(NCINTFLG) of FLAGWRD0 = 1: (should be)

Set bit 4(CONICINT) of FLAGWRD3 = 1

\[
T_{et} = T_{pc}
\]

\[
V_{pc} = V \quad \text{and} \quad R_{pc} = R
\]

Perform "INTEGRVS"

Set bit 2(NCINTFLG) of FLAGWRD0 = 1

\[
V_{ptpi} = V \quad \text{and} \quad R_{ptpi} = R
\]

DELH = DELHL1

Perform "QRDTPPI"

\[
R_{afd} = R_j - \text{DELHL unit}R_j
\]

Proceed to "NC1LOOP"
NC1LOOP

Also entered from end of "NC12G"

\[ TS_1 = R_{ac} \quad \text{(OD)} \]
\[ TS_2 = V_{ac} + \text{DVC unit} (\text{AM}_1 * R_{ac}) \quad \text{(6D)} \]
\[ TS_3 = \text{TIMEC} \quad \text{(12D)} \]
\[ TS_4 = NC \quad \text{(14D)} \]

Perform "REVUP"

If bit 5(\text{NC12FIG}) of \text{FLAGWRDO} = 1: \quad \text{(P32)}

\[ \begin{align*}
R_{ah2} &= R_{att} \quad \text{(Tag here "NC2A")} \\
V_{ah2} &= V_{att} \\
\text{TH2} &= \text{RATEMP}
\end{align*} \]

Proceed to "NC12D"

\[ \begin{align*}
R_{ahl} &= R_{att} \quad \text{(P31 if get here)} \\
V_{ahl} &= V_{att} \\
\text{TH1} &= \text{RATEMP} \\
\text{TS} &= \text{CF}
\end{align*} \]

If \text{TS} \neq 0: \quad \text{(Means have done "NC12G" at least once)}

\[ \text{TS} = 0.5 \]

\[ \text{CI} = \text{TS} \]

Proceed to "NC2LOOP"

NC2LOOP

Also entered from end of "EHCOMP" (\text{NCLPFIG} = 0)

\[ \begin{align*}
TS_1 &= R_{ahl} \quad \text{(OD)} \\
TS_2 &= V_{ahl} + \text{DVH1 unit} (\text{AM}_1 * R_{ahl}) \quad \text{(6D)} \\
TS_3 &= \text{TH1} \quad \text{(12D)} \\
TS_4 &= C_{nhl} \quad \text{(14D)}
\end{align*} \]

Perform "REVUP"

\[ \begin{align*}
V_{ah2} &= V_{att}
\end{align*} \]
TH2 = RATEMP

TS = R\_att (in OD)

Set bit 9(NCFLPFLG) of FLAGWRD1 = 0

R\_ah2 = R\_att

DELTMP = DHNCC

Proceed to "EHCOMP"

\textbf{NC12D} Entered from "NC1LOOP" (P32) and "EHCOMP" (NCFLPFLG = 0 & converged)

TS = CF

If TS \neq 0: (Means have done "NC12G" at least once)

\[ TS = 0.5 \]

CI = TS

Proceed to "NC1LOOP"

\textbf{NC1LOOP} Also entered from "EHCOMP" (NCFLPFLG = 1)

Set bit 2(NCINTFLG) of FLAGWRD0 = 1

T\_as = TH2 + C\_tcs

T\_decl = T\_as

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If bit 2(NCINTFLG) of FLAGWRD0 = 1: (should be)

Set bit 4(CONICINT) of FLAGWRD3 = 1

T\_et = TH2

WC\_V = V\_ah2 + DVH2 unit(AML \* R\_ah2)

RC\_V = R\_ah2

Perform "INTEGRVS"

V\_as = V\_att

R\_as = R\_att

TS = R\_att (OD, same cell)
Perform "RADUP"

\[
\text{DELIH} = |T_{S_1} - |R_{as}|
\]

\[
T_{S_1} = T_{S_1} \quad \text{(OD, same cell)}
\]

Perform "COE"

\[
V_{asf} = PDVA
\]

Set bit 2(NCINTFLG) of FLAGWRDO = 1

\[
T_{decl} = T_{tpi}
\]

Perform "INSTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If bit 2(NCINTFLG) of FLAGWRDO = 1: \hspace{1cm} \text{(should be)}

Set bit 4(CONICINT) of FLAGWRD3 = 1

\[
T_{et} = T_{as}
\]

\[
V_{CV} = V_{asf}
\]

\[
R_{CV} = R_{as}
\]

Perform "INTEGRVS"

\[
R_{af} = R_{att}
\]

\[
TS = R_{att}
\]

Set bit 9(NCLPFLG) of FLAGWRD1 = 1

\[
\text{DELHTMP} = \text{DELIH}
\]

Proceed to "EHCOMP"

NC12G \hspace{1cm} \text{Entered from "EHCOMP" (NCLPFLG = 1 & converged)}

\[
PDEP = \cos^{-1} \left( \frac{\text{unit}R_{af} \cdot \text{unit}R_{afd}} {\text{sgn} \left( (R_{af} \cdot R_{afd}) \cdot \text{AM1} \right)} \right)
\]

If \((|PDEP| - 4 \epsilon_{\text{eps1}}) < 0:\)

. Proceed to "NC12OUT"

\[
PDTIX = DVC \quad \text{(2D)}
\]

REND-16
Perform "ITER"

If bit 13(ITERFIG) of FLAGWRD2 = 1:

Proceed to "OLPALRM" (602g alarm)

CF = TS (updated PDITC)
DVC = PDITX
DVOC = DVO
EOP = EO

Proceed to "NC1LOOP"

EHCMP

Entered from "NC2LOOP" (NCLPFIG = 0) and "NCGLOOP" (NCLPFIG = 1)

RATEMP = |TS|

Perform "RADUP"

PDEH12 = |TSr| - RATEMP - DLHTMP

PDITP = PH1 (OD)

If bit 9(NCLPFIG) of FLAGWRD1 = 1:

PDITP = PH2

If PDITP ≠ 0:

If (|PDEH12| - Ceps2) < 0:

If bit 9(NCLPFIG) of FLAGWRD1 = 0: (Tag here "LOOPX")

Proceed to "NCL2D"

Proceed to "NCL2G"

PDITX = DVH1 (2D) (Tag here "ITERUP")
If bit 9(NCLPFLAG) of FLAGWRD1 = 1:
    PDITX = DVH2
    PDITE = PDEH12  (4D)
    PDITC = CI     (6D)
    X1 = PSHFT1

If bit 9(NCLPFLAG) of FLAGWRD1 = 1:
    X1 = PSHFT2

Perform "ITER"

If bit 13(ITERFLAG) of FLAGWRD2 = 1:
    TS = 601_8   (Tag here "ILPAIRM")
    Proceed to "DISPAIM"

CI = TS

If bit 9(NCLPFLAG) of FLAGWRD1 = 1:
    PSHFT2 = X1
    DVH2 = PDITX
    PH2 = PDITP
    Proceed to "NCCLOOP"

DVH1 = PDITX  (Tag here "NC2ITR")

PSHFT1 = X1
PH1 = PDITP

Proceed to "NC2LOOP"

NC12OUT       Entered from start of "NC12G" and "OLPAIRM" (PRO)

DEVLVLC = (DVC, 0, 0)

TS_2 = - AM1

TS_3 = - unitR_as

TS_1 = TS_3 * AM1
\[
\begin{bmatrix}
T_{S_1} \\
T_{S_2} \\
T_{S_3}
\end{bmatrix}
\]

(WGNSR = (v_{asf} - v_{as})

\[T_{cdh} = T_{as} \quad (T_{cdh \text{ notation also } TNSR})\]

\[T_{csi} = TH2 \quad (T_{csi \text{ notation also } TNCC})\]

If bit 5(NC12FIG) of FLAGWRDO = 1: (P32)

\[DVDS1 = DVH2 \quad \text{ (Tag here } "NC2N80")\]

\[DVDS2 = |WGNSR|\]

\[DHDSP = DHNC\]

Proceed to "NC12DH"

\[DVDS2 = DVH2 \quad \text{ (P31 if here)}\]

\[DVDS1 = DVH1\]

\[NC2TIG = TH1\]

\[TS = R_{ahl}\]

Perform "RADUP"

\[DHDSP = |T_{S_1}| - |R_{ahl}|\]

Proceed to "NC12DH"

REVUP

Entered with TS_1 position, TS_2 velocity, TS_3 time tag, TS_4 revs

\[PDA = 1/(2/|T_{S_1}| - K_{ldmu} (TS_2 \cdot TS_2))\]

Set bit 2(NCINTFIG) of FLAGWRDO = 1

\[RATEMP = TS_3 + TS_4 K_{2pib3} K_{ldmu} \sqrt{PDA} PDA\]

\[T_{decl} = RATEMP\]

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If bit 2(NCINTFIG) of FLAGWRD3 = 1: (should be)

Set bit 4(CONICINT) of FLAGWRD3 = 1
Tet = TS₃
VCV = TS₂
RCV = TS₁
Perform "INTEGRVS"
Return

RADUP    Entered with TS, OD, vector to be matched

VVEC = Vₜₚ
RVEC = Rₜₚ
TS₁ = RVEC * VVEC
TS₂ = (RVEC * TS) * TS₁
TS = (cos⁻¹(unitRVEC * unitTS)) sgn TS₂
CSTH = cos TS
Set bit 9(RVSW) of FLAGWRD7 = 0   (new r, v desired)
SNTH = sin TS
Perform "TIMETHET"
Return    (TSᵣ in MPAC; TSᵥ in OD)

ITER    Entered from "EHCOMP", "GETRJ", and "NCL23"

If PDITC = 0:
    TS = K₁fds
    Proceed to "ITER3"
If (PDITC - 0.5) = 0:
    TS = (PDITE / PDITP), shifted left X₁ places
    Proceed to "ITER3"
If PDITE - EO = 0:
    TS = K₀p₃fds    (constant is 3 fps for velocity)
    Proceed to "ITER3"
PD8D = (PDITE - EO), with number of leading zeros stored in X1
PDITE = PD8D / (PDITX - DVO)
If (PDITC - 14) \geq 0:
    Set bit 13(ITERFLG) of FLAGWRD2 = 1
Return
TS = PDITE / PDITP
Proceed to "ITER3"

ITER3
PD8D = TS
EO = PDITE
DVO = PDITX
PDITX = DVO - PD8D (in 2D)
TS = PDITC + 1 (in 4D)
Return

DISP45A Entered from "P33" and "N81DISP"
Perform "VNL645"
T \text{ dec1} = T_{\text{csi}} \quad (T_{\text{csi}} \text{ notation also TNCC})
INTIME = T_{\text{csi}}
Perform "CSPREC"
R \text{ init} = R_{\text{att}}
R \text{ pass3} = R_{\text{att}} \quad (\text{used to restore } R_{\text{init}} \text{ in "NCCMP7+17"})
V \text{ init} = V_{\text{att}}
V \text{ act3} = V_{\text{att}}
T \text{ dec1} = T_{\text{cdh}} \quad (T_{\text{cdh}} \text{ notation also TNSR})
Perform "LEMPREC"
Set bit 13(ITERFLG) of FLAGWRD2 = 0

VCV = \( V_{\text{att}} \)  

RCV = \( R_{\text{att}} \)  

(note that this violates "INTSTALL" lockout constraints generally observed elsewhere)

UP1 = \( \text{unit}(RCV \times VCV) \)

\( T_{\text{decl}} = T_{\text{tpi}} \)  
(Tag here "NCCDMP4")

Perform "LEMPREC"

Set bit 2(NEINTFG) of FLAGWRD0 = 0

\( R_{\text{ptpi}} = R_{\text{att}} \)

\( V_{\text{ptpi}} = V_{\text{att}} \)

DEHL = DEHL1

Perform "QRDTPI"

\( T_{S1} = R_{j} \)

\( T_{S2} = V_{j} \)

Perform "COE"

Perform "INTSTALL"

RCV = PDRA

VCV = PDVA

\( T_{et} = T_{\text{tpi}} \)

Set bit 4 (CONINT) of FLAGWRD3 = 0

\( T_{\text{decl}} = T_{\text{cdh}} \)  
(Tcdh notation also TNSR)

Perform "INTEGRVS"

\( R_{\text{nsr}} = R_{\text{att}} \)

\( R_{\text{act2}} = R_{\text{nsr}} \)  
(same cell)

\( R_{\text{targ}} = R_{\text{att}} \)

\( V_{\text{nsrp}} = V_{\text{att}} \)

DELLT4 = \( T_{\text{cdh}} - T_{\text{csi}} \)  
(Tcsi notation also TNCC)
\[ TS_1 = 2 \]
\[ TS_2 = K_{15} \text{deg} \]
Perform "INITVEL"
\[ TS = \frac{v_{nsrp}}{v_{tprime}} \]
\[ V_{\text{init}} = \frac{v_{tprime}}{v_{tprime}} \]
\[ R_{\text{init}} = R_{nsr} \]
Perform "GET.LVC"
\[ \text{DELVLVC}_y = \frac{v_{tprime}}{v_{tprime}} \cdot U_{pl} \]
\[ \text{VGNSR} = \text{DELVLVC} \]
Proceed to "NCCDMP7+17"

**QRDTPI** Entered from "NC12F" and "DISP45A"

\[ DTQRD = 0 \]
\[ ITERCNT = 0 \]
If \((\text{ELEV} - \frac{1}{2}) \geq 0:\]
\[ \text{ELEV} = \text{ELEV} - \frac{1}{2} \]
\[ \text{COS} = \cos \text{ELEV} \]
Proceed to "GETRJ"

**GETRJ**
Perform "INTSTALL"
Set bit 4(CONICINT) of FLAGWRD3 = 0
\[ RCV = R_{ptpi} \]
\[ VCV = V_{ptpi} \]
\[ T_{et} = T_{ptpi} \]
\[ T_{\text{decl}} = T_{ptpi} + DTQRD \]
If bit 2(NCINTFLG) of FLAGWRDO = 1:
\[ \text{Set bit 4(CONICINT) of FLAGWRD3 = 1} \]
Perform "INTEGRVS" (Tag here "GOPREC")
\[ R_j = R_{\text{att}} \quad \text{(same cell)} \]
\[ V_j = V_{\text{att}} \quad \text{(same cell)} \]
\[ UR_j = \text{unit} R_{\text{att}} \]
\[ RJMAG = |R_{\text{att}}| \]
\[ TS = (V_{\text{ptp1}} \times R_{\text{ptp1}}) \cdot (\text{unit} R_{\text{ptp1}} \times UR_j) \quad \text{\( \text{B38 m}^2/\text{cs} \)} \]

If \( TS \neq 0 \):

\[ TS = (\cos^{-1} (\text{unit} R_{\text{ptp1}} \cdot UR_j)) \cdot \text{sgn} \ TS \]

\[ PDET = \frac{1}{2} - \left[ \sin^{-1} \left( \frac{(RJMAG - \text{DELH}) \cdot \text{COSE}}{R_{\text{ptp1}}} \right) + \text{ELEV} \right] - TS \]

If \( (|PDET| - C_{\text{epl1}}) < 0 \):

Return (to routine calling "QRDTPF")

\[ PDITX = \text{DTQRD} \]
\[ PDITE = PDET \]
\[ PDITC = \text{ITERCNT} \]

Perform "ITER"

If bit 13(ITERFIG) of FLAGWRD2 = 1:

\[ TS = 603_8 \quad \text{(Tag here "QRDALRM")} \]

Proceed to "DISPALM"

\[ \text{ITERCNT} = TS \]
\[ \text{DTQRD} = \text{PDITX} \]

Proceed to "GETRJ"

\[ \text{COE} \quad \text{Entered with } TS_1 \text{ position; } TS_2 \text{ velocity} \]

\[ PDRM = |TS_1| - \text{DELH} \]

\[ PDRA = PDRM \cdot \text{unit} TS_1 \quad \text{(left in MPAC when exit)} \]

\[ PDCA = \frac{K_{\text{mm}_4\text{,}2}}{2} \left( K_{\text{mm}_4\text{,}2} \left| TS_1 \right| \cdot |TS_2|^2 \right) \]

\[ PDCA_{\text{AD}} = PDCA - \text{DELH} \]
\[ TS = \left( \frac{PDCA}{PDCAD} \right)^3 \left( \text{unit}T_{S1} \cdot T_{S2} \right)^2 \]

\[ PDVV = \sqrt{TS} \ \text{sgn} ( \text{unit}T_{S1} \cdot T_{S2} ) \]

\[ TS_3 = K_{mum42} \left( 2 \frac{PDCAD}{PDRM} \right) / (PDCAD \ PDRM) - TS \quad (R14) \]

\[ PDVA = \sqrt{TS_3} \ \text{unit} \left( (\text{unit}T_{S1} * T_{S2}) * \text{unit}T_{S1} \right) + PDVV \ \text{unit}T_{S1} \]

Return
Quantities in Computations

See also list of major variables and list of routines

ACTCENT: Value of CSM (active vehicle) central angle of transfer computed in "S3435.25" (entered for P35 and P36), scale factor B0, units revolutions, in range 0 - 360°. It can be displayed at crew option in R1 of N52: if too close to 180°, then the maneuver parameters should be reconsidered.

AM1: Unit vector, scale factor Bl, computed in "PHSMCH" in direction perpendicular to passive vehicle plane. It is assigned to the same cell as UPl, but a separate loading of UPl (for compatibility with subsequent computations) is shown for documentation convenience.

AUTOY: See Burn Control.

C eps1: Erasable memory constant, program notation "EPS1" (alternate notation "UDTHET"), scale factor B0, units revolutions. It is used as a loop convergence criterion in "PHSMCH", "NCL2G" (where multiplied by 4 before use), and "GETRJ".

C eps2: Erasable memory constant, program notation "EPS2", scale factor B29, units meters, used as a loop convergence criterion in "EHCOMP".

C nhl: Single precision erasable memory constant, program notation "NH1", scale factor B5, units revolutions, used to initialize NC in "NCL2ST" (for P32) and to specify number of revolutions for "REVUP" in "NC2LOOP". It specifies the number of revolutions between the NC2 (P32) and NCC (P33) maneuvers.

C tcs: See Burn Control.

CF: Loop counter (contains integer values only), scale factor B5, units counts. It is initialized to zero at the start of "NCL2ST" and incremented in "NCL2G" logic (due to "ITER" computations).

CI: Loop counter, initialized to 0 or 0.5 in "NC1LOOP" and "NCL2D", scale factor B5, units counts. The value of 0.5 is used as a first-pass indicator in "ITER" provided a non-zero value of partial (PDTP) is available.

CMYDOT: See Burn Control.

COSE: Value of cos ELEV computed in "QRDTP", scale factor Bl.

COZY4: Criterion used in "INITVEL2" to decide if input position vector forms an angle with the target position vector that is too close to 180°, scale factor B2. It is initially loaded with cos TS2, where TS2, stored in push-down list location 2D as an angle, BO revolutions, is angle away from 180° within which "INITVEL2" rotates the target vector to be in the plane of R init and V init.
CSTH: See Conic Routines.

DELEL: Value of error between derived and specified values of elevation angle in "ELCALC", scale factor B0, units revolutions.

DELELO: Value of previous DELEL, scale factor B0, units revolutions, stored in 26D.

DELH: Altitude difference used as a communication cell with "QRDTPI" and "COE", scale factor B29, units meters.

DELH1: Value of altitude difference between orbits at ignition time for (TPI) NSR (P34), scale factor B29, units meters. It is displayed in R3 of N57, and would also be expected to form part of the prelaunch load.

DELHTMP: Communication cell with "EHCOMP" used to contain DHNCC (if from "NC2LOOP") or DELH1 (if from "NCCLOOP"), scale factor B29, units meters.

DELLT4: Communication cell with "INITVEL", containing desired time of flight from $R_i$ to $R_f$, scale factor B28, units centi-seconds. It is loaded into TDESIRED for use in Lambert routine.

DELTEEO: Value of time increment information in "ELCALC" (generally the value added to NOMTPI), scale factor B28, units centi-seconds.

DELTEET1: Value of DELVEET2 sampled at start of "P33/P73B" (part of P34) for use subsequently to compute N81 display information there, scale factor B7, units meters/centi-second.

DELTEET2: Vector velocity change required for P34 burn (computed in "CDHMVR"), scale factor B7, units meters/centi-second.

DELTEET3: Vector velocity increment required to perform maneuver, scale factor B7, units meters/centi-second. It is loaded at end of "INITVEL7". DELVSIN is same cell, but for documentation convenience (interface with "VN1645") loading of DELVSIN into DELVEET3 shown where necessary. Also loaded in P35 ("P34/P74C") and P36 ("P35/P75B") from revised noun inputs if required.

DELVLC: See Burn Control.

DHDSP: Value of altitude difference for next maneuver, scale factor B29, units meters, displayed in R2 of N84. It is loaded in "NC12OUT" and is used in "NC12DH" (for P32), after display, to load DHNCC.

DHNCC: Value of altitude difference between orbits at ignition time for NCC (P33), scale factor B29, units meters, displayed in R2 of N57. It is loaded from DHDSP in "NC12DH" for P32 (after the display of N84), and would also be expected to form part of the prelaunch load.
DIFFALT: Difference in altitude between OWS and CSM at the NSR (P34) maneuver, scale factor B29, units meters, computed in "CDHMVR". It is displayed in R1 of N75.

DTQRD: Value of time increment to $T_{tpi}$ used in "QRDTPI" routine, scale factor B28, units centi-seconds.

DVC: Value of maneuver magnitude used in outer iteration loop (NC1 for P31, NC2 for P32), scale factor B7, units meters/centi-second. It is initialized in "NC12ST", used at start of "NC1LOOP" to compute velocity for input to "REVUP", is updated in "NC12G", and forms x component of DELVLV in "NC12OUT".

DVDSPl: Value of velocity increment loaded in "NC12OUT" for display in R1 of N84, scale factor B7, units meters/centi-second. It is loaded with DVH1 for P31 and DVH2 for P32 (i.e. the P32 and P33 maneuver magnitudes respectively).

DVDSP2: Value of velocity increment loaded in "NC12OUT" for display in R3 of N84, scale factor B7, units meters/centi-second. It is loaded with DVH2 for P31 and \{VGN5\} for P32 (i.e. the P33 and P34 maneuver magnitudes respectively).

DVH1: Value of velocity increment for NC2 maneuver (P32) initialized in "NC12ST", scale factor B7, units meters/centi-second. It is updated in "EHCOMP" if bit 9(NCLPFLG) of FLAGWRDL = 0, and used to load DVDSPl for P31, as well as to compute velocity in "NC2LOOP" for input to "REVUP".

DVH2: Value of velocity increment for NC3 maneuver (P33) initialized in "NC12ST", scale factor B7, units meters/centi-second. It is updated in "EHCOMP" if bit 9(NCLPFLG) of FLAGWRDL = 1, and used to load DVDSPl for P32 and DVDSP2 for P31.

DVLOG: See Burn Control.

DVO: Value of independent variable (PDITX) being iterated, stored in "ITER3" (also sampled and initialized in "NC12G"). For "ITER" entrances from "EHCOMP" and "NC12G", scale factor B7, units meters/centi-second; for entrance from "GEIRJ", scale factor B28, units centi-seconds.

DVOC: Cell used to initialize and retain value of DVO in "NC12G", scale factor B7, units meters/centi-second.

ELEV: Value of elevation angle between the CSM/OWS vehicle line of sight and the CSM vehicle local horizontal at TPI ignition time, scale factor B0, units revolutions ("QRDTPI" reduces to range 0 - 180°). It is displayed in R2 of N55, and would also be expected to form part of the prelaunch load. An input value of 0 in P35 causes the angle to be derived from the specified time; a non-zero value causes the time to be computed in routine starting at "S33/34.1".
EO: Value of dependent variable (PDITE) being iterated, stored in "ITER3" (also sampled and initialized in "NCLG") For entrances to "ITER" from "GETRJ" and "NCLG", scale factor is BO, units revolutions; from "EHCOMP", scale factor is B29, units meters.

EOP: Value of EO used to initialize and retain quantity in "NCLG", scale factor BO, units revolutions.

GEOMSGN: See Conic Routines. The magnitude of the number (provided that it is non-zero) is not significant, but only the sign: the magnitude loaded in "INITVEL2", for programming convenience, is the most significant half of K_{mutab_0} (see Conic Routines).

INTIME: Communication cell with "INITVEL" containing the time tag of the state vector in \( \mathbf{R}_{init} \) and \( \mathbf{V}_{init} \), scale factor B28, units centi-seconds. It is not required if VTARGTAG = 0.

ITCTR: Single precision counter, scale factor B14, of the number of iterations of "INITVEL" computations which have been performed. It is set to an initial condition of -1, so that a value of +1, for example, would mean that 2 passes through "LAMBERT" and "INTEGRVS" are performed, with the output of "LAMBERT" used in the "INTEGRVS" routine to refine the target position. The desired number of iterations is specified by the contents of VTARGTAG.

ITERCNT: Counter (contains integer values only), scale factor B5, units counts, of the number of iterations in "QRDTP1" loop (initialized to 0 in "QRDTP1" and updated in "GETRJ" due to "ITER" computations).

K_{op3fs}: Constant, program notation "0.3F/S", used in "ITER" if PDITE = EO. When "ITER" entered from "EHCOMP" and "NCLG", scale factor is B7, units meters/centi-second; when entered from "GETRJ", scale factor is B28, units centi-seconds. Nominal value is 0.009144 x 2^{-7}, corresponding (for B7 meters/centi-second) to 3.0 x 0.01 x 0.3048 x 2^{-7}, where first term is value in fps (note that it is ten times the value suggested by the mnemonic), second converts to centi-seconds, third converts to meters, and fourth is scale factor. For units of centi-seconds, octal value is 00001 05350 8, corresponding to 191.76 seconds.

K_{ldmue}: Constant, program notation "1/MUE", scale factor B-34, units \( \text{cs}^2/\text{m}^3 \). Value is 0.25087606E-10 x z^{2 \frac{34}{3}} (see K_{mutab_2} in Conic Routines).

K_{ldsqmu}: Constant, program notation "1/SQMU", scale factor B-17, units \( (\text{cs}^2/\text{m}^3)^{\frac{1}{2}} \). Value is 0.50087529E-5 x z^{2 \frac{17}{2}} (see K_{mutab_6} in Conic Routines).
K₁fds : Constant, program notation "1F/S", used in "ITER" if PDITC = 0.
When "ITER" entered from "EHCOMP" and "NCL2G"; scale factor is B7, units meters/centi-second; when entered from "GETRJ", scale factor is B28, units centi-seconds. Nominal value is 0.003048 x 2⁻⁷, corresponding (for B7 meters/centi-second) to 1.0 x 0.01 x 0.3048 x 2⁻⁷, where first term is value in fps, second converts to centi-seconds, third converts to meters, and fourth is scale factor. For units of centi-seconds, octal value is 00000 14370₈, corresponding to 63.92 seconds.

K₁5deg : Constant, program notation "15DEG", scale factor B0, units revolutions. Value is 0.04166667, corresponding to 15 x (1/360), where first term is value in degrees and second converts to revolutions.

K₁65fds : Constant, program notation "165F/S", scale factor B7, units meters/centi-second. Value is 0.50292 x 2⁻⁷, corresponding to 165 x 0.01 x 0.3048 x 2⁻⁷, where first term is value in fps, second converts to centi-seconds, third converts to meters, and fourth is scale factor.

K₂pib3 : Constant, program notation "2PIB3", scale factor B3. Value is 6.2831853 x 2⁻³, corresponding to 2 x 3.14159265 x 2⁻³, where first term is equation factor, second is π, and third is scale factor.

K₂5fds : Constant, program notation "25F/S", scale factor B7, units meters/centi-second. Value is 0.07620 x 2⁻⁷, corresponding to 25 x 0.01 x 0.3048 x 2⁻⁷, where first term is value in fps, second converts to centi-seconds, third converts to meters, and fourth is scale factor. Octal value is 00011 30073₈, allowing a single precision load of most significant half (i.e. octal 11 or decimal 9) to be used to initialize PH1 at the start of "NC12ST" (PH1 then is B14).

K₂25fds : Constant, program notation "225F/S", scale factor B7, units meters/centi-second. Value is 0.68580 x 2⁻⁷, corresponding to 225 x 0.01 x 0.3048 x 2⁻⁷, where first term is value in fps, second converts to centi-seconds, third converts to meters, and fourth is scale factor.

Kₑeps : Constant, program notation "ELEPS", scale factor B0, units revolutions. Value is 0.27777777E⁻³, corresponding to 0.1°.

Kₑpsfour : Constant, program notation "EPSFOUR", scale factor B0, units revolutions. Value is 0.0416666666, corresponding to 15°.

Kₘax250 : Constant, program notation "MAX250", scale factor B28, units centi-seconds. Value is 25E3 x 2⁻²⁸, corresponding to 250 seconds.

Kₘum4₂ : Constant, program notation "MU(-42)", scale factor B4₂, units meters³/centi-seconds². Value is 3.986032E10 x 2⁻⁴² (see Kₘutab₀ in Conic Routines).

Kₙtmu : Constant, program notation "RTMU", scale factor B36, units meters³/centi-seconds². Value is 3.986032E10 x 2⁻³⁶ (see Kₘutab₀ in Conic Routines).
K_twopi: Constant, program notation "TWOPI", scale factor B4, value 6.283185307 x 2^-4. Value corresponds to 2 x 3.1415926535 x 2^-4, where first term is equation factor, second is π, and third is scale factor.

LMYDOT: See Burn Control.

NC: Number of revolutions between burn being targeted and subsequent burn, scale factor B5, units revolutions. It is set to Clphl for P32 computations in "NC12ST". For P31 use, it is loaded with HALPREVS (modulo 32 revolutions or 64 half-revolutions) in "P31" (similar loading done in "P32", but written over by Cnphl subsequently).

NC2TIG: See Burn Control.

NN1: Value of number of offsets desired in Lambert targeting, scale factor B14, units counts, displayed by R1 of N55 (program notation also "NN"). A value of 0 (as done at start of "P35" before display) means that conic targeting is to be used; typical precision setting is 2. The setting is effective only for P35 and P36 use.

NOMTP: Value of computed correction to Ttpi, scale factor B28, units centi-seconds, loaded in "ELCALC". This scheme permits Rtpi Epprec Rpprec state vector time tag to remain Ttpi while the iteration continues for the proper updated value of Ttpi.

PDO2R: Value of magnitude of OWS vehicle position vector used in "CDHMVR" to compute DIFFALT, scale factor B29, units meters, stored in push-down location 02D.

PD18V: Value of OWS velocity vector used in "CDHMVR", scale factor B7, units meters/centi-second. It is the velocity vector at the point corresponding to PDO2R (i.e. radially above/below CSM), and is stored in push-down location 18D.

PD28CS: Value of ratio of active to passive vehicle radius magnitudes times cos ELEV (i.e. times - cos (π - ELEV)), scale factor B1, stored in push-down list location 28D.

PD8D: Temporary storage cell used in "ITER" routine, corresponding to push-down list location 8D, variable scaling and units. Left in "ITER3" with same scaling and units as PDITX.

PDA: Value of semi-major axis computed in "REVUP", scale factor B24, units meters, stored in push-down list.

PDALFMPI: Value of guidance equation quantity α minus π, scale factor B0, units revolutions, stored in push-down list location 18D.

PDCA: Value of semi-major axis computed in "COE", scale factor B29, units meters, stored in push-down list location 22D (axis of OWS).
PDCAD: Value of desired (CSM) semi-major axis computed in "COE", scale factor B28, units meters, stored in push-down list location 32D.

PDDELTM: Value of guidance equation quantity \( \delta t \), scale factor B28, units centi-seconds, stored in push-down list location 12D.

PDEH12: Altitude error quantity computed in "EHCOMP", scale factor B29, units meters, stored in push-down list location 2D.

PDEP: Angular error between \( R_{af} \) and \( R_{afd} \) computed in "NC12G", scale factor B0, units revolutions, stored in push-down cell 2D, used as a check on phasing at TPI.

PDET: Value of difference between the desired central angle between the CSM and OWS position vectors and actual angle computed in "QRDTPF" routine, scale factor B0, units revolutions, stored in push-down list location 12D.

PDITC: Communication cell with "ITER" routine loaded with value of counter to be used to check for excessive iterations, scale factor B5, units counts. It is stored in push-down list location 6D. The updated count is left in 4D when exit from routine (from which the calling routine samples the value for storage in calling routine cell).

PDITE: Value of dependent variable used as input to "ITER", and stored in push-down list location 4D when enter. For entrances from "GETRJ" and "NC12G", scale factor is B0, units revolutions; for entrances from "EHCOMP", scaling is B29, units meters.

PDITP: Value of partial of dependent variable with respect to independent one in "ITER" package, required as input only for PDITC = 0.5 (i.e. for entrance to "ITER" from "EHCOMP"). Scaling information is variable, with information on number of leading zeros contained in X1 when enter routine. Stored in push-down list location 0D.

PDITX: Value of independent variable used as input to "ITER", and derived by it (as updated value). It is stored in push-down list location 2D. For entrances from "EHCOMP" and "NC12G", scale factor is B7, units meters/centi-second; for entrances from "GETRJ", scale factor is B28, units centi-seconds.

PDOMEQA: Value of CSM angular velocity information times radius magnitude ratio (for convenience in scaling), scale factor B37, stored temporarily in push-down list location 16D. Location subsequently modified to contain \( PDOMEQA - PDOMEQGP \), with scale factor information in X1 also.

PDOMEQGP: Value of OWS angular velocity information times radius magnitude ratio (for convenience in scaling: the reciprocal of the ratio used for PDOMEQA is employed), scale factor B37, stored as described under PDOMEQA.
PDRA: Position vector computed by "COE" routine, scale factor B29, units meters, stored initially in push-down list location 14D, but left in MPAC when exit from routine.

PDRM: Magnitude of PDRA computed by "COE" routine, scale factor B29, units meters, stored in push-down list location 12D.

PDSEMAA: Value of semi-major axis of CSM computed in "CDHMVR", scale factor B29, units meters, stored in push-down list location 4D.

PDSEMAP: Value of semi-major axis of OWS computed in "CDHMVR", scale factor B29, units meters, stored temporarily in push-down list location 4D (then that location used for PDSEMAA).

PDVA: Velocity vector computed by "COE" routine, scale factor B7, units meters/centi-second, left in push-down list location OD when exit from the routine.

PDVAH: Value of "horizontal" component of required CSM velocity vector after P34 (NSR) maneuver, computed in "CDHMVR". Scale factor is B7, units meters/centi-second, and stored in push-down location 10D.

PDVAV: Value of "vertical" (i.e. radial) component of required CSM velocity vector after P34 (NSR) maneuver, computed in "CDHMVR". Scale factor is B7, units meters/centi-second, and stored in push-down location 8D.

PDVV: Value of radial component of PDVA computed in "COE", scale factor B7, units meters/centi-second, stored in push-down list location 30D.

PH1: Cell used for two purposes. At start of "NC12ST", initialized to 9 (B14) for use as a loop counter in "PHSMCH". Set 0 at start of "NC12F" and then used in "EHCOMP" to retain previous PDITP (for use in initializing that quantity) if bit 9(NCLPFLG) of FLAGWRD1 = 0. Scaling there same as PDITP.

PH2: Cell initialized to 0 at start of "NC12ST" and then used in "EHCOMP" to retain previous PDITP (for use in initializing that quantity) if bit 9(NCLPFLG) of FLAGWRD1 = 1. Scaling same as PDITP.

PI: Cell used as a first-pass indicator and in computation of TH2 in "PHSMCH", scale factor B0, units revolutions. Initialized to 180° in "NC12ST" and set 0 in "NC12J".

PSHFT1: Single precision cell, scale factor B14, used to contain scaling information for PH1 (determined in "ITER" routine), employed to initialize X1 (and retain its value) in "EHCOMP".

PSHFT2: Single precision cell, scale factor B14, used to contain scaling information for PH2 (determined in "ITER" routine), employed to initialize X1 (and retain its value) in "EHCOMP".
\( R_{ac} \): Value of CSM position vector at ignition time for next burn, scale factor B29, units meters. It is initially computed in "NC12ST" (time of TIMEC), and is rotated into OWS plane in "NC12F" (or, for an alarm exit, in "PHSMCH"). It is assigned the same cell as \( R_{act2} \), but for documentation convenience a separate loading of \( R_{act2} \) is shown where necessary.

\( R_{act2} \): Value of CSM position vector at ignition, scale factor B29, units meters. It occupies the same cell as \( R_{ac} \) and \( R_{NSR} \), but for documentation convenience separate loading is shown where necessary. It is also computed in "ADVANCE" for use in "CDHMVR". Notation arises because was formerly used for CDH state vector (with CSI being "#1").

\( R_{act3} \): Value of CSM position vector computed in "PRECSET" for specified input time, scale factor B29, units meters. It is used in the computations associated with TPI (P34, P35, and P36).

\( R_{af} \): Value of CSM position vector at TPI time computed in "NCC1LOOP", scale factor B29, units meters, used in determining altitude error (via "EHCOMP" routine) and PDEP (in "NC12G").

\( R_{afd} \): Desired CSM position vector at TPI computed in "NC12F", scale factor B29, units meters.

\( R_{ahl} \): Value of CSM position vector at NC2 point (based on NC and DVC for P31) loaded in "NCC1LOOP", scale factor B29, units meters. It is not loaded for P32.

\( R_{ahz} \): Value of CSM position vector at NCC point (based on NC and DVC for P32 in "NCC1LOOP", and DVHL and Cnhl for P31), scale factor B29, units meters.

\( R_{aprec} \): Value of \( R_{act3} \) at entrance to "S33/34.1", scale factor B29, units meters. It is used to form a standard initial condition for performance of conic integration in "ADTIME+3" by the amount of time in NOMTPI (to avoid buildup of error due to successive conic computations).

\( R_{as} \): Value of CSM position vector at NSR point computed in "NCC1LOOP", scale factor B29, units meters.

\( R_{init} \): Value of position vector at start of burn (or of Lambert evaluation), used as a communication cell with "INITVEL", scale factor B29, units meters. If an iteration is required, the time tag for the state vector is in INTIME.

\( R_{j} \): Value of position vector determined by "QRDTPI" routine, scale factor B29, units meters, stored in push-down list location OD (same cell as \( R_{act} \), but separate loading shown for documentation convenience). It is the desired OWS3 vector determined by the routine.
R\textsubscript{nsr}: Value of CSM position vector at NSR time computed in "DISP45A", scale factor B29, units meters. It occupies the same cell as \(R\textsubscript{act2}\), but for documentation convenience a separate loading of \(R\textsubscript{act2}\) is shown where necessary.

R\textsubscript{other}: See Orbital Integration.

R\textsubscript{pass2}: Value of OWS state vector, scale factor B29, units meters, loaded in "ADVANCE" with \(R\textsubscript{pass3}\) and used in "CDHMVR". See \(R\textsubscript{act2}\).

R\textsubscript{pass3}: Value of OWS state vector, scale factor B29, units meters, loaded in "PRESET" based on the input time argument. In "DISP45A" loaded with active vehicle state vector instead for use in "NCCD" in restoring \(R\textsubscript{init}\) (required due to erasable memory assignments).

R\textsubscript{pc}: Value of OWS vector at TIMEC, scale factor B29, units meters, computed in "NC12ST". It is subsequently updated in "NC12J" to achieve a "phase match" with the CSM state vector at NC1 time (P31) or NC2 (P32).

R\textsubscript{pprec}: Value of \(R\textsubscript{pass3}\) at entrance to "S33/34.1", scale factor B29, units meters, used to form a standard initial condition for performance of conic integration in "ADTIME+3" (see \(R\textsubscript{aprec}\)).

R\textsubscript{ptpi}: Communication cell with "QRDTPI" giving OWS position vector at TPI time, scale factor B29, units meters.

R\textsubscript{targ}: Communication cell with "INITVEL" containing position of target vector (or vehicle) DELLT4 centi-seconds after the time in INTIME, scale factor B29, units meters. Loaded with updated target vector position (if a change made) before exit from routine.

R\textsubscript{targl}: Value of \(R\textsubscript{targ}\) used within "INITVEL" package, scale factor B29, units meters.

R\textsubscript{tig}: See Burn Control.

R\textsubscript{l}: See Conic Routines.

R\textsubscript{lVEQ}, R\textsubscript{2VEQ}: See Conic Routines.

R\textsubscript{ATEMP}: Cell used as communication cell with "REVUP", left when exit with time tag of state vector after required advancement, scale factor B28, units centi-seconds. Also used at start of "EHCOMP" to contain magnitude of calling argument vector, scale factor B29, units meters.

RCV: See Orbital Integration.

RdA: See Conic Routines.
RJMAG: Magnitude of \( R_j \) computed in "GETRJ", scale factor B29, units meters.

RVEG: See Conic Routines.

SEOMAX: Value of maximum time increment used in iteration for TPI time for P34/P35, scale factor B28, units centi-seconds. It is initialized to \( K_{\text{max250}} \) in "S33/34.1".

SNTH: See Conic Routines.

SUBEXIT: Single precision cell used to retain return address information.

T: See Conic Routines.

T : NSR time loaded in "NCCLOOP", scale factor B28, units centi-seconds. As loaded into \( T_{\text{cdh}} \) in "NC120UT".

\( T_{\text{cdh}} \): Value of NSR time displayed by N13 (program notation also "TNSR"), scale factor B28, units centi-seconds. Loaded from \( T \) in "NC120UT" and also initialized (using \( C_{\text{tcg}} \) and \( T_{\text{csi}} \)) in "P33" as before initial display.

\( T_{\text{csi}} \): Value of NCC time displayed by N11 (program notation also "TNCC"), scale factor B28, units centi-seconds. Loaded from TH2 in "NC120UT".

\( T_{\text{dec2}} \): Time to which integration is to be performed by "PRECSET", scale factor B28, units centi-seconds. Used to achieve the same \( T_{\text{decl}} \) setting for the CSM integration as for the OWS integration.

\( T_{\text{et}} \): See Orbital Integration.

\( T_{\text{etlm}} \): See Orbital Integration.

\( T_{\text{pass4}} \): See Burn Control.

\( T_{\text{pc}} \): Time tag associated with \( R_{\text{pc}} \) and \( V_{\text{pc}} \) updating in "NC12J", scale factor B28, units centi-seconds.

\( T_{\text{tpi}} \): Value of Transfer Phase Initiation time, scale factor B28, units centi-seconds, displayed by N37. Can be derived in P35 if an elevation angle is specified (iteration starts from specified input time, however), and would also be expected to form part of the prelaunch load.

TDESIRED: See Conic Routines.

TH1: Time tag for NC2 maneuver computed in P31 (loaded in "NC1LOOP" based on "REVUP" results and loaded into NC2TIG for P31 in "NC120UT"), B28 centi-sec.

TH2: Time tag for NC2 maneuver computed in P32 (in "NC1LOOP") and P31 (in "NC2LOOP"), scale factor B28, units centi-seconds. It is loaded into \( T_{\text{csi}} \) in "NC120UT". Prior to this use, employed in "PHSMCH"/"NC12J" area to contain the angle between the CSM and OWS vehicles, scale factor B0, units revolutions.
TIMEC: Time tag for the next maneuver loaded before entrance to "NC12ST" with NC1TIG for P31 and NC2TIG for P32, scale factor B28, units centi-seconds.

TITER: Single precision cell used in "S33/34.1" to protect against excessive iterations. Initialized to a negative number, and then reset in "ELCALC" (where used as flag for first pass) to 377778. Subsequently shifted right 1 place if DELEL not less than K; the 15th right shift will make the single precision value zero (the double precision value non-zero, serving as an error flag), causing an error exit.

TN: Time used for phase-match iteration, scale factor B28, units centi-seconds (initialized to TIMEC in "NC12ST" and updated in "PHSMCH"/"NC12J").

ULOS: Value of unit vector, scale factor B1, in line-of-sight direction, i.e. in direction of \((R_{pass3} - R_{act3})\).

UN: See Conic Routines. It is computed in "INITVEL" as the perpendicular to plane defined by \(R_{init}\) and \(V_{init}\), but is written over in Lambert routine (subroutine "GEOV") if the NORMSW (bit 10 of FLAGWRD7) is 0, meaning that the transfer is not too close to 180° as specified by COZY4 information.

UNRM: Value of unit vector, scale factor B1, in direction \((R_{act3} * V_{act3})\).

UNVEC: Unit vector formed from \(R_{act2}\) at the start of "CDHMVR", scale factor B1.

UP: Unit vector, scale factor B1, giving direction of local horizontal plane of CSM at \(T_{cdh}\) for use in computing ELEV in "ELCALC", stored in push-down list location OD.

UP1: Unit vector, scale factor B1, in direction of \(r \times y\) of passive vehicle at ignition time (computed in "PRECSRT", "PHSMCH", and "DISP45A" (where is at \(T_{cdh}\), i.e. NSR time)). Cell occupies same location as AM1, but for documentation convenience separate loading shown where necessary.

URpd: Vector, scale factor B1, computed in "PHSMCH" to be "colinear with the intersection of the OWS plane and the plane perpendicular to the CSM plane that contains the CSM position vector." It is a unit vector.

URJ: Value of unit \(R_j\) computed in "GETRJ", scale factor B1.

\(V_{ac}\): Value of CSM velocity vector at ignition time for next burn, scale factor B7, units meters/centi-second. It is initially computed in "NC12ST", and is rotated into OWS plane in "NC12F".
$V_{act2}$: Value of CSM velocity vector, scale factor $B_7$, units meters/centi-second, loaded in "ADVANCE" with velocity rotated into OWS plane.

$V_{act3}$: Value of CSM velocity vector computed in "PRECSET" for specified input time, scale factor $B_7$, units meters/centi-second. Also loaded at end of "CDHMWR" with required velocity after maneuver computed there.

$V_{ahl}$: Value of CSM velocity vector at NC2 point (see $R_{ahl}$), scale factor $B_7$, units meters/centi-second.

$V_{ah2}$: Value of CSM velocity vector at NCC point (see $R_{ah2}$), scale factor $B_7$, units meters/centi-second.

$V_{aprec}$: Value of $V_{act3}$ at entrance to "S33/34.1", scale factor $B_7$, units meters/centi-second (see $R_{aprec}$).

$V_{as}$: Value of CSM velocity vector at NSR point computed in "NCCLOOP", scale factor $B_7$, units meters/centi-second.

$V_{asf}$: Coelliptic velocity required at NSR point, scale factor $B_7$, units meters/centi-second, computed in "NCCLOOP". Used to compute $V_{NSR}$ in "NC12OUT".

$V_{init}$: Value of velocity vector at start of burn (or of Lambert evaluation), used as a communication cell with "INITVEL", scale factor $B_7$, units meters/centi-second. If iteration is required, the time tag for the state vector is in INTIME.

$V_{iprime}$: Value of required velocity computed by Lambert routine (i.e. $VVEC$ value when return from routine) at the time INTIME. Scale factor $B_7$, units meters/centi-second.

$V_j$: Value of velocity vector determined by "QRDTPX" routine, scale factor $B_7$, units meters/centi-second, stored in push-down list location 6D (same cell as $V_{att}$, but separate loading shown for documentation convenience).

$V_{nsrp}$: Value of velocity at $T_{cdh}$ computed in "DISP45A", scale factor $B_7$, units meters/centi-second, program notation "VNSR+"(after burn).

$V_{other}$: See Orbital Integration.

$V_{pass2}$: Value of OWS velocity vector (see $R_{pass2}$), scale factor $B_7$, units meters/centi-second.

$V_{pass3}$: Value of OWS velocity vector, scale factor $B_7$, units meters/centi-second, loaded in "PRECSET" based on the input time argument.
$V_{pass4}$: Value of OWS velocity vector at intercept ($T_{pass4}$) time, scale factor $B7$, units meters/centi-second.

$V_{pc}$: Value of OWS velocity vector updated as described for $R_{pc}$, scale factor $B7$, units meters/centi-second.

$V_{pprec}$: Value of $V_{pass3}$ at entrance to "S33/34.1", used to form a standard initial condition for performance of conic integration in "ADTIME+3", scale factor $B7$, units meters/centi-second (see $R_{aprec}$).

$V_{ptpi}$: Communication cell with "QRDTP1" giving OWS velocity vector at TPI time, scale factor $B7$, units meters/centi-second.

$V_{target}$: Value of CSM velocity at intercept (after doing the burn), scale factor $B7$, units meters/centi-second. If VTARGTAG is non-zero, the value is computed by precision integration in "INITVEL2"; if VTARGTAG is 0, value computed by "INITV" at the end of Lambert iteration.

$V_{tig}$: See Burn Control.

$V_{tprime}$: Value of $V_{target}$ when return from "INITVEL", scale factor $B7$, units meters/centi-second. See also Burn Control.

VCV: See Orbital Integration.

VGNR: Velocity to be gained for NSR (P34) maneuver, scale factor $B7$, units meters/centi-second, displayed by N82. It is loaded in "NC120UT" and "DISP45A".

VTARGTAG: Single precision cell, scale factor $B14$, used to store the required number of Lambert iterations. Information originally set in push-down list location OD (called TS in writeup), with a value of zero meaning that no iterations are required.

VVEC: See Conic Routines.
Steering Computations

**S40.1**

Entered from "P40S/F" (in P40/P41)

Set bit 7 (FIRSTFLG) of FLAGWRD2 = 1

BDT = 0

If bit 8 (XDELVFLG) of FLAGWRD2 = 0:

Proceed to "S40.1B"

**DELVSAB = [DELVSIN]**

\[ V_{\text{init}} = V_{\text{tig}} \]

\[ T_{S1} = \text{unit} (V_{\text{tig}} \times R_{\text{tig}}) \quad \text{(stored in UT cell)} \]

\[ R_{\text{init}} = R_{\text{tig}} \]

\[ T_{S} = K_{\text{thetcon}} |V_{\text{tig}} \times R_{\text{tig}}| \quad \text{(rounded multiplication, least increment in result 216 m/cs)} \]

**BURNANG = TS \times \text{DELVSAB} \times \text{MASS}_{dp} / (\text{CAPF} \times R_{\text{tig}}^2) \]

\[ T_{S2} = (\text{DELVSIN} \times T_{S1}) \times T_{S1} \]

\[ T_{S3} = \text{DELVSIN} - T_{S2} \quad \text{(in-plane component of specified velocity)} \]

\[ V_{\text{gtig}} = T_{S2} + T_{S3} \left( \text{unit} (T_{S3} \times T_{S1}) \sin \text{BURNANG} + \text{unit} T_{S3} \cos \text{BURNANG} \right) \]

\[ \text{UT} = \text{unit} V_{\text{gtig}} \]

\[ T_{S} = V_{\text{gtig}} \]

Perform "GET.LVC"

Proceed to "S40.2,3"

**S40.1B**

\[ T_{\text{decl}} = T_{\text{ig}} - K_{\text{twodt}} \]

\[ \text{DELLT4} = T_{\text{pass4}} - T_{\text{decl}} \]

Perform "AGAIN"

\[ T_{S4} = V_{\text{iprime}} \quad \text{(stored in UT cell)} \]

\[ T_{\text{decl}} = T_{\text{ig}} \]

\[ \text{DELLT4} = T_{\text{pass4}} - T_{\text{decl}} \]

Perform "AGAIN"

\[ V_{\text{gtig}} = \text{DELVEET}_2 \]
TS = $V_{gtig}$
Perform "GET.LVC"

TS = $R_{tig}$
Perform "CALC.NGRAV"

TS = CSTEER \left( \frac{(V_{prime} - TS_4)/K_{200cs} - GDTJ/K_{200cs}}{T^2} \right)

QFCT = TS - \left( \text{unit}V_{gtig} \cdot TS \right) \text{unit}V_{gtig}

TS_1 = \frac{\text{CAPF}}{(\text{MASS}_{dp})}

UT = \text{unit} \left( \frac{QFCT + \sqrt{TS_1^2 - |QFCT|^2}}{\text{unit}V_{gtig}} \right)

Proceed to "S40.2,3"

AGAIN

Perform "CSMPREC"

$R_{tig} = R_{att}$

$R_{init} = R_{att}$

$V_{tig} = V_{att}$

$V_{init} = V_{att}$

$TS_1 = 0$

$TS_2 = K_{\text{eps}45}$

If bit 10(\text{NORMSW}) of \text{FLAGWRD7} = 0:

$TS_2 = K_{\text{eps}10}$

Perform "INITVEL"

Return

S40.2.3 Entered for P40/P41 from "S40.1" and "S40.1B"

POIN\text{T}VSM = \left[ \text{REPSMMAT} \right] \text{UT}

If bit 11(\text{RCSBURN}) of \text{FLAGWRD11} = 1:

Proceed to "S40.2,3B"
\[
\begin{align*}
\text{YAWANG} &= K_{\text{trims}} \text{YACOFF} + K_{\text{ybias}} \\
\text{PITANG} &= K_{\text{trims}} \text{PACTOFF} + K_{\text{pbias}} \\
X_{\text{smd}} &= (\cos \text{PITANG} \cos \text{YAWANG}, -\cos \text{PITANG} \sin \text{YAWANG}, \sin \text{PITANG}) \\
Z_{\text{smd}} &= (-\sin \text{PITANG} \cos \text{YAWANG}, \sin \text{PITANG} \sin \text{YAWANG}, \cos \text{PITANG}) \\
Y_{\text{smd}} &= (\sin \text{YAWANG}, \cos \text{YAWANG}, 0) \text{ Note } x,z,y \text{ sequence & use below.} \\
\text{SCAXIS} &= (\cos \text{PITANG} \cos \text{YAWANG}, \sin \text{YAWANG}, -\sin \text{PITANG} \cos \text{YAWANG}) \\
\text{TS}_1 &= \text{UT} \\
\text{TS} &= -\text{unit}R_{\text{tig}} \times \text{UT} \\
\text{TS}_2 &= \text{unit}TS \\
\text{If } |\text{TS}| < K_{\text{minmag}}: \\
\text{TS}_2 &= -\text{unit} \left( (\text{unit}R_{\text{tig}} + 0.125 \text{unit}V_{\text{tig}}) \times \text{UT} \right) \\
\text{TS}_3 &= -\text{TS}_2 \times \text{TS}_1 \\
\text{[TS]} &= \begin{bmatrix} \text{TS}_1 \\ \text{TS}_2 \\ \text{TS}_3 \end{bmatrix} \\
X_{\text{smd}} &= X_{\text{smd}} \begin{bmatrix} \text{TS} \end{bmatrix} \\
Y_{\text{smd}} &= Y_{\text{smd}} \begin{bmatrix} \text{TS} \end{bmatrix} \\
Z_{\text{smd}} &= Z_{\text{smd}} \begin{bmatrix} \text{TS} \end{bmatrix} \\
\text{Proceed to "P4OSXY"} \\
\text{S40.2.3B} \\
\text{SCAXIS} &= \text{unit}X \\
X_{\text{smd}} &= \text{UT} \\
\text{TS} &= \text{UT} \times R_{\text{tig}} \\
\text{TS}_2 &= \text{unit}TS \\
\text{If } |\text{TS}| < K_{\text{minmagr}}: \\
\text{TS}_2 &= -\text{unit} \left( (\text{unit}R_{\text{tig}} + 0.125 \text{unit}V_{\text{tig}}) \times \text{UT} \right)
\end{align*}
\]

STER-3
\[ y_{\text{smd}} = T_{S2} \]
\[ z_{\text{smd}} = - (y_{\text{smd}} * x_{\text{smd}}) \]

Proceed to "P409XTY"

**UPDATEVG**

Entered from "CALCN85" and "S40.8"

If bit 8 (XDELVFLG) of FLAGWRD2 = 0:

If NBRCYCLS < 0: (set negative as initial condition and at end of "S40.9")

Proceed to "SETUP.9"

\[
\text{DELVSUM} = \text{DELVSUM} + \text{DELVREF} \\
\text{NBRCYCLP} = \text{NBRCYCLS} + 1 \\
\text{NBRCYCLS} = \text{NBRCYCLP}
\]

Proceed to "VGCOMP"

**VGCOMP**

\[
V_g = V_{\text{gtig}} + \text{BDT} - \text{DELVREF} \\
V_{\text{gtig}} = V_g \\
|V_g| = \text{VGDISP} \\
V_{\text{gtig}} = V_g
\]

Return (to caller of "UPDATEVG")

**SETUP.9**

If bit 7 (FIRSTFLG) of FLAGWRD2 = 0:

\[
V_{\text{gtig}} = \text{DELVEET2} + \text{NBRCYCLP \ BDT} - \text{DELVSUM} \\
V_{\text{gtig}} \text{ also has notation "VGPREV"; } \\
\text{DELVEET2} \text{ also "VGTEMP"}
\]

Establish "S40.9" (priority 10) (Restart protect by group 1.5, see "REDO40.9")

\[
R_{\text{init}} = R \\
V_{\text{init}} = V \\
T_{\text{init}} = T_{\text{pptm}} \\
\text{DELLT4} = T_{\text{pass4}} - T_{\text{init}} \\
\text{DELVSUM} = 0 \\
\text{NBRCYCLS} = 0 \\
\text{NBRCYCLP} = 0
\]

Proceed to "VGCOMP"
Entered due to AVEGEXIT setting in "P40SXTY"

Perform "UPDATEVG"

MASSTMP = CSMMASS

If(|DELVREF| - \(C_{\text{dthresh}}\) \(<\) 0:

If bit 11(STEERSW) of FLAGWRD2 = 0: (Tag here "LOTHRUST")

Proceed to "SERVEXIT"

If bit 6(IDLEFAIL) of FLAGWRD1 = 1: (set/reset by "V97")

Proceed to "SERVEXIT"

OMEGAQ = 0

REPFRAC = 0

NWORD1 = 0 (causes "CLOCKJOB" to generate V97 display)

Set bit 11(STEERSW) of FLAGWRD2 = 0

Proceed to "SERVEXIT"

CSMMASS = MASSTMP - \(C_{\text{emdot}} K_{2\text{secnds}}\)

If bit 11(STEERSW) of FLAGWRD2 = 0:

Proceed to "SERVEXIT"

If bit 15(SWTOVER) of FLAGWRD9 = 1: (Tag here "CGTRACK")

REPFRAC = \(K_{\text{repfrac}}\)

Skip next 2 lines

\(j = \text{bit 14 of DAPDATR1}\) (1 for LM on, 0 for LM off)*

REPFRAC = \(C_{\text{repfrac}} j\)

\(TS_1 = BD - \text{DELVREF}\) (Tag here "TGOCALC")

\(TS_2 = \text{unit} TS_1 \cdot V_g\)

If \(TS_2 > 0\):

Perform "ALARM" (pattern 14078) (Tag here "INCR SVG")

Proceed to "SERVEXIT"

*NOTE: "LM" references are from Apollo 15 program, and have been retained for mnemonic usefulness.
\[ T_{go} = K_{mfourdt} \left(1 + \frac{TS_2}{K_{2vexh}}\right) / (|TS_1|) - C_{tdecay} \]

\[ T_{ig} = T_{pptm} + T_{go} \quad \text{(for e.g. "CLOKTASK", giving GET of cutoff)} \]

If \( T_{go} - K_{foursec} \leq 0 \):

Proceed to "S40.81"

\[ \text{DELTAM} = \text{CSTEER} \cdot \text{BDT} - \text{DELVREF} \]

\[ TS = \left[ \text{REFSMAT} \right] \text{(unit} V_{g} \text{ * unitDELTAM)} \]

Perform "**SMNB**"

\[ \text{OMEGAC} = K_{PRIME} \cdot TS \]

Proceed to "SERVEXIT"

**S40.9**

(Established if a Lambert burn by "SETUP.9")

\[ TS_1 = 0 \]

\[ TS_2 = K_{ep45} \]

If bit 10(NORMSW) of FLAGWRD7 = 0:

\[ TS_2 = K_{ep10} \]

Set bit 2(GUESSSW) of FLAGWRD1 = 0

Perform "INITVEL" (starting at second line)

See "RED040.9" for

restarts.

If bit 7(FIRSTFLG) of FLAGWRD2 = 0:

\[ \text{BDT} = \left(V_{iprime} - V_{rprev}\right) \left(\frac{K_{200cs}}{T_{nit} - T_{nitprev}}\right) - GDT \]

\[ \text{DELVEET}_3 = \text{DELVEET}_3 + K_{earth} \left(\frac{T_{pptm} - \text{NOMTIG}}{\text{GOBL} \left|R\right|^2}\right) \]

\[ T_{nitprev} = T_{nit} \]

\[ V_{rprev} = V_{iprime} \]

Set bit 7(FIRSTFLG) of FLAGWRD2 = 0

\[ \text{NBRCYCLS} = -1 \]

End of job
RED040.9 Entered if a restart encountered from time of establishing "S40.9" in "SETUP.9" until return from "INITVEL" in "S40.9", due to restart group 1.5

DELVSUM = 0

NBRCYCLP = 0

DELVEET3 = \( V_{gtig} \) (for "SETUP.9" restoration)

NBRCYCLES = -1

End of job

S40.13 Established by "TIG-5" and "V97E"

\[ TS_1 = \text{VGDISP} \] (in PD OD)

SBVGMAG = \( TS_1 / K_{kpi2} \) (double precision load, low half

PASTDV = SBVGMAG not meaningful here)

If bit 7 (+X translation complement) of channel 31 = 0:

\[ TS = K_{rcsf} / M_{dp} \]

If bit 15 (2JETSFLG) of FLAGWRD1 = 0:

\[ TS = 2 \times TS \] (i.e. 4-jet translation)

\[ TS_1 = TS_1 - TS \]

\[ TS_2 = M_{dp} \times TS_1 \left( 1 - TS_1 / K_{vexh} \right) \]

If \( |TS_2| > 2^{14} \): (or other overflow) \( (TS_2 \) units same as \( C_{implsec} \))

Set bit 3 (SBFLAG) of FLAGWRD2 = 0

End of job

\[ TS_3 = 100B_{ml4} \left( TS_2 - C_{implsec} \right) / C_{efimpl6} \] (Bl4, PD 2D)

If \( (TS_3 - 500B_{ml4}) \geq 0 \):

Set bit 3 (SBFLAG) of FLAGWRD2 = 0

End of job

STER-7
If \( TS_3 > 0 \):

If bit 3(SBFLAG) of FLAGWRD2 = 1: (Tag here "S40.134")

\[
TS = \text{MASS}_{dp} - (TS_3 + K_{100bml4}) \text{Cemdot}_{dp}
\]

\[
DVTAIL = \frac{(\text{Cefimpl6} / K_{100b3}) \text{Ctdcay}_{dp}}{K_{kpip2} TS}
\]

PIPA = 0

TZEROED = \( T_{pptml+1} \) (i.e. least significant half)

PASTT = \( G_{DT1 \times sp} \) (due to double precision store order)

If \( TS_3 < 0 \):

\[
TS_3 = \frac{C_{efimpl6} TS_3}{C_{efimp01}} \quad (B14)
\]

Set bit 3(SBFLAG) of FLAGWRD2 = 0

Set bit 9(IMPULSW) of FLAGWRD2 = 1 (Tag here "S40.132")

Force sign agreement of \( TS_3 \)

\[
T_{go} = (TS_3 + K_{100bml4}), \text{rescaled to scale factor B28}
\]

End of job

S41.1

Perform "CDUTRIG"

\[
TS = [\text{REFSMMAT}] \quad TS
\]

Perform "*SMNB*"

\[
TS = K_{tenb4} [\text{QUADROT}] \quad TS \quad \text{(now in control coordinates)}
\]

Return

SBTASK Initially called by "IGNITION"

PREST = TIME1

TS = PREST - TZEROED

If \( TS \leq 0 \):

\[
TS = (\text{bits } 14-1 \text{ of } TS) + 1 \text{ centi-second} \quad \text{(compensates for TIME1 overflow)}
\]

TDELTA = TS

Note Maximum is 163.83 seconds.
VELSS = 0

Perform the following for i = z, y, x:

\[ TS = (\text{PIPA}_i + \text{PIPAPI}_i) + C_{\text{pipascf}_i} (\text{PIPA}_i + \text{PIPAPI}_i) - C_{\text{pipabias}_i} \text{TDELTA} \]

VELSS = VELSS + TS^2

If VELSS ≠ 0:

Perform "SQRRTASK"

\[ TS = \text{SBVGMAG} - (2 \text{PRESDV} + \text{DVTAIL}) + \text{PASTDV} \]

If TS ≤ 0: (same as SBVGMAG - PRESDV - (PRESDV - PASTDV) - DVTAIL)

Proceed to "ENGOFF"

PASTT = PREST (Tag here "BURNMORE")

PASTDV = PRESDV (as "least significant half" of PASTT/PREST)

Call "SBTASK" in 0.10 second

End of task

**ENGOFF**

\[ TS_1 = \text{PREST} - \text{PASTT} \]

If TS_1 ≤ 0:

\[ TS_1 = \text{(bits 14-1 of } TS_1) + 1 \text{ centi-second} \]

TDELTA = TS_1

\[ TS_2 = \text{PRESDV} - \text{PASTDV} \]

\[ TS_3 = (TS + TS_2) \text{TDELTA} / TS_2 \]

(TS + TS_2) = (SBVGMAG^2 - PRESDV - DVTAIL)

If TS_3 ≤ 0:

Proceed to "ENGNOFF"

T_{go+1} = TS_3

Call "ENGNOFF" in TS_3 centi-seconds

End of task
SQRTTASK

X = WELSS, considered to have scale factor BO

TS = X, normalized to lie between $\frac{1}{2}$ and $< 1$. This is accomplished by shifting X left in increments of 2 shifts, and storing the required number of shifts divided by 2 in VRSSmSL

If $TS \geq \frac{1}{2}$, $TS_2 = K_{\text{hislope}} TS_{\text{sp}} + K_{\text{hibias}}$

If $TS < \frac{1}{2}$, $TS_2 = K_{\text{loslope}} TS_{\text{sp}} + K_{\text{lobias}}$

$TS_2 = (\frac{1}{2} \times TS_{\text{sp}}) / TS_2 + \frac{1}{2} \times TS_2$ (TS$_2$ single precision)

PRES DV = $TS_2$, shifted right by VRSSmSL places

Return
Quantities in Computations

See also list of major variables and list of routines

BDT: "Effect of rate of change of required velocity, and gravity, acting
during the two-second computing interval, upon velocity-to-be-gained," scale factor B7, units meters/centi-second. Set 0 in "S40.1".

BURNANG: Value of one-half the central angle estimated to be traveled
during the External Delta-V burn, scale factor B0, units revolutions,
stored in push-down location 14D.

dethresh: Single precision erasable memory constant, program notation
"DVTHRESH", scale factor B-2, units meters/centi-second, giving
velocity gate used in "S40.8" for concluding that engine failure
has taken place. Program shifts constant right 9 places before use,
to scale it B7 meters/centi-second (double precision). In order to
avoid improper performance, constant should exceed the velocity
increment obtained by ullage (in a 2-second interval).

eimplsec: Single precision erasable memory constant, program notation
"EMPISEC", scale factor B14, units kilogram-meters/centi-second.
When divided by mass of vehicle, would give the SPS impulse velocity
acquired in the first second of burn. For a value in pound-seconds,
PSEC, the fraction in the cell may be computed as PSEC x 10^{-2} x
9.80665 x 0.45359237 x 2^{-14}, where first term is value, second converts
to centi-seconds, third is g, fourth converts from pounds to kilograms,
and fifth is scale factor. Constant is used double precision, with
least significant half the cell used for C_{efimp01}.

efimp01: Single precision erasable memory constant, program notation
"EFIMP01", scale factor B14, units kilogram-meters/centi-second second.
It gives the slope of the SPS impulse curve from 0 to 1 second. For
a value in pound-seconds/second, PNDSSC, the fraction in the cell may
be computed as PNDSSC x 10^{-2} x 9.80665 x 0.45359237 x 2^{-14}, where first
term is value, second converts to centi-seconds, third is g, fourth converts from pounds to kilograms, and fifth is scale factor. Constant
is used double precision, with least significant half the cell used
for C_{eimp16}.

efimp16: Single precision erasable memory constant, program notation
"EFIMP16", scale factor B14, units kilogram-meters/centi-second second.
It gives the slope of the SPS impulse curve from 1 to 6 seconds (and
may be computed by the formula given for C_{efimp01} above). The constant
is used double precision, with least significant half the cell used
for C_{adpad} (see Entry Computations). Is equivalent to thrust, of course.

emdot: Single precision erasable memory constant, program notation "EMDOT",
scale factor B3, units kilograms/centi-second, giving the nominal
mass flow rate for the SPS engine. The least significant half is
assigned to the most significant half of C_{rvar} (see Measurement
Incorporation).

STER-11
Cerepfrac: See Digital Autopilot TVC Routines.

Cpipbias: See IMU Computations.

Cpipscf: See IMU Computations.

tdecay: Single precision erasable memory constant, program notation "ETDECAY", scale factor B14, units centi-seconds, giving value of thrust decay time (i.e., equivalent full-thrust time). It is subtracted from the "raw" time-to-go, and therefore should be a positive number in the memory. Used in "S40.8" s.p. (for SPS burns). Least significant half is Ctkprime.<sup>0</sup>

CAPF: See Burn Control.

CSMMASS: See Digital Autopilot Interface Routines.

CSTEEER: Scalar in cross-product steering law, scale factor B2. It is set to 1.0 in "P40CSM" (provided a Lambert burn specified); otherwise, it has a value of 0.

DAPDATRl: See Digital Autopilot Interface Routines.

DELT4: See Rendezvous Computations.

DELTAM: Value of (CSTEEER BDT - DELVREF), scale factor B7, units meters/centi-second. Its unit vector (scale factor B1) is stored temporarily in the push-down list.

DELVEET3: See Rendezvous Computations (DELVSIN occupies the same cells).

DELVREF: See General Program Control.

DELVSAB: Absolute value of DELVSIN used in "S40.1" in the computation of BURNANG for External Delta-V burns, scale factor B7, units meters/centi-second.

DELVSIN: See Burn Control.

DELVSUM: Value of sum of DELVREF outputs from Average-G computed in "UPDATEG" for Lambert burn, used to correct \( \Delta V \) for accelerometer-output velocity gained since "S40.9" established. Scale factor B7, units meters/centi-second. Initialized to 0 in "SETUP.9".

DVTAIL: Single precision value of tail-off impulse computed in "S40.13", scale factor B14, units accelerometer pulses, used in "SBTASK". The initial loading done double precision (least significant half TDELT4).

GDT, GDT1: See General Program Control.

GOBL: See General Program Control.

K<sub>100b8</sub>: Constant, program notation "100B+8", scale factor B8, units centi-seconds. Value is 100 \( \times 2^{-8} \), corresponding to one second (to convert centi-seconds to seconds).
\( K_{100bl4} \): Constant, program notation "100B-14", scale factor Bl4, units centi-seconds. Value is \( 100 \times 2^{-14} \), corresponding to one second.

\( K_{200cs} \): Constant, program notation "200CS", scale factor Bl2, units centi-seconds. Value is \( 200 \times 2^{-12} \), corresponding to 2 seconds.

\( K_{500bl4} \): Constant, program notation "500B-14", scale factor Bl4, units centi-seconds. Value is \( 500 \times 2^{-14} \), corresponding to 5 seconds.

\( K_{rcsf} \): Constant, program notation "S40.135", scale factor B23, nominal value \( 69.6005183 \times 2^{-23} \). Value corresponds to \( 796 K_{rcsf} \) times \( 2^{-23} \), i.e. the velocity increment (after dividing by MA$55s$) for 7.96 seconds of two-jet RCS thrusting. See Burn Control for \( K_{rcsf} \) value. Octal value is \( 000008 \, 042638 \), corresponding to \( 69.59375 \times 2^{-23} \). Before original ignition, "S40.13" is entered 5 seconds before ignition time, with last Average-G sample made 5.96 seconds before ignition. Program zeros channel 5 (ullage jets) at end of "IGNITION" routine, 2 seconds after ignition.

\( K_{2secnds} \): Constant, program notation "FOURSEC +1", scale factor Bl3, units centi-seconds. Octal value is \( 006208 \, 000008 \), corresponding to \( 200 \times 2^{-13} \), or two seconds.

\( K_{2vexh} \): Constant, program notation "2VEXHUST", scale factor B7, units meters/centi-second. Value is \( 63.020792 \times 2^{-7} \), corresponding to \( 2 \times 31.510396 \times 2^{-7} \), where first term is an equation factor of two, second is the exhaust velocity in meters/centi-second, and the third is the scale factor. Exhaust velocity of \( 3151.0396 \) meters/second (10338.05643 fps) corresponds to an \( I \), dividing by \( 9.80665 \), of about 321.32 seconds, or \( 20500/63.8 \) sp.

\( K_{earthmu} \): Constant, program notation "EARTHMU", scale factor B36, value earthmu = \( -3.986032E10 \times 2^{-36} \), corresponding to earth \( -\mu \) (in units of meters²/centi-second²).

\( K_{ep10} \): Constant, program notation "EP4(10)L", scale factor B0, units revolutions. Value is \( 0.027777777 \), corresponding to ten degrees.

\( K_{ep45} \): Constant, program notation "EP4(45)L", scale factor B0, units revolutions. Value is \( 0.125 \), corresponding to 45 degrees.

\( K_{eps10} \): Constant, program notation "EP4(10)H", scale factor B0, units revolutions. Value is \( 0.027777777 \), the same as \( K_{ep10} \) (duplicate storage in "high" part of memory).

\( K_{eps45} \): Constant, program notation "EP4(45)H", scale factor B0, units revolutions. Value is \( 0.125 \), the same as \( K_{ep45} \).

\( K_{foursec} \): Constant, program notation "FOURSEC", scale factor B28, units centi-seconds. Value is \( 400 \times 2^{-28} \), corresponding to four seconds.
K\text{repfrac} : See Digital Autopilot TVC Routines.

K_{hibias} : Single precision constant, program notation "HIBIAS", scale factor B1, value 0.4192 x 2^{-1}. See square root routine in Mathematical Functions.

K_{hislope} : Single precision constant, program notation "HISLOPE", scale factor B0, value 0.5884.

K_{kpip2} : Constant, program notation "KPIP2", scale factor B-7, units meters/centi-second. Value is 5.85E-4 x 2^{7}, corresponding to 5.85 x 10^{-2} x 10^{-2} x 2^{7}, where first term is nominal accelerometer scale factor in units of centimeters/second per count, second converts to meters, third converts to centi-seconds, and fourth is scale factor.

K_{lobias} : Single precision constant, program notation "LOBIAS", scale factor B1, value 0.2974 x 2^{-1}.

K_{loslope} : Single precision constant, program notation "LOSLOPE", scale factor B0, value 0.8324.

K_{mfourd16} : Constant, program notation "-FOURDT", scale factor B16, units centi-seconds. Value is -800 x 2^{-16}, corresponding to (-1) x 200 x 2^{-16}, where first term is an equation factor, second is computing interval (i.e. 2 seconds), and third is scale factor.

K_{minmagr} : See Attitude Maneuvers (equivalent effect achieved to use of explicit constant, by checking most significant half of magnitude for 0).

K_{minmag} : Dummy constant used to show effect of checking for magnitude of vector information, scale factor B30, units meters. Value is equivalent to 2^{-14} (cf. K_{minmagr}), or 2^{16} meters.

K_{pbiass} : Constant, program notation "PBIAS", scale factor B0, units revolutions. Value is -0.00597222222, corresponding to -2.15 degrees (the "pitch mechanical bias with thrust on"). Hence a PACTOFF input of +2.15 degrees would be considered to line up the bell in pitch along +X.

K_{tenb4} : Constant, program notation "TENBNK14", scale factor B4, value 10 x 2^{-4}, corresponding to 10. Used to correct for the fact that matrix elements of \text{QUADRO} are multiplied by 0.1 because of the cycle rate during Attitude Maneuvers.

K_{thetcon} : Constant, program notation "THETACON", scale factor B6, value 0.31830989 x 2^{-6}. Value corresponds to \frac{1}{2} \times \frac{1}{2} \times 2^{-6}, where first term is an equation factor of one-half (to obtain half the central angle traveled during the burn), second converts from radians to revolutions, and third is scale factor.

K_{trims} : Constant, program notation "TRIMSCAL", scale factor B-13, value 0.7975111 x 2^{-1}. Value corresponds to 85.41 x 1/(360 x 3600) x 2^{-1}, where first term is bit weight in arc seconds for PACTOFF and YACTOFF, second converts to revolutions, and third is scale factor.
**Ktwodt**: Constant, program notation "TWODT", scale factor B28, units centi-seconds. Value is $200 \times 2^{-28}$, corresponding to 2 seconds.

**Kybias**: Constant, program notation "YBIAS", scale factor BO, units revolutions. Value is $+0.00263888889$, corresponding to $+0.95$ degrees (the "yaw mechanical bias with thrust on"). Hence a YACTOFF input of $-0.95$ degrees would be considered to line up the bell in yaw along $+X$.

**KPRIMEDT**: See Digital Autopilot TVC Routines.

**MASS**: See Digital Autopilot Interface Routines. Incorrect "double precision".

**MASSTMP**: Temporary storage for CSMMASS in "S40.8", scale factor Bl6, units kilograms, used to achieve restart protection there.

**NBRCYCLP**: Single precision counter, scale factor Bl4, of the number of cycles of DELVREF information that have been summed in DELVSUM. It is incremented in "UPDATEVG" and reset in "SETUP.9". It is used for restart protection purposes (with NBRCYCLS, which is in the preceding cell), and also to update $\Psi_{gt}$ by the suitable amount of BDT for the time elapsed since "S40.9" was established.

**NBRCYCLS**: Single precision counter, scale factor Bl4, used in conjunction with NBRCYCLP. At the end of "S40.9", it is set to $-1$ as a flag to "UPDATEVG" that a new Lambert solution has been obtained. It is also set to an initial condition of $-1$ in "P40SXTY" (for P40 and P41) before Average-G is started.

**NOMTIG**: See Burn Control.

**NVWORDl**: See Burn Control.

**OMEGAC**: See Digital Autopilot TVC Routines.

**PACTOFF**: See Digital Autopilot TVC Routines.

**PASTDV**: Single precision value of PRESDV (accelerometer output information) from previous cycle, scale factor Bl4, units accelerometer counts. It is initialized in "S40.13", and loaded from PRESDV in "SBTASK".

**PASTT**: Single precision value of PREST (time tag for PRESDV) from previous cycle, scale factor Bl4, units centi-seconds, loaded from PREST at end of "SBTASK".

**PIPA**: See IMU Computations.

**PIPAPl**: Single precision cumulative sum of accelerometer output, scale factor Bl4, units accelerometer counts, initialized to zero in "S40.13" and incremented by accelerometer readout in "READACCS".

**PITANG**: Value of angle in pitch axis used in "S40.2,3", scale factor BO, units revolutions. It is used to calculate the desired position of the SPS engine bell in spacecraft coordinates.
POINTVSM: See Attitude Maneuvers.

PRESVD: Single precision magnitude of accelerometer output (compensated for accelerometer scale factor and bias errors) since PIPAPI zeroed, scale factor Bl4, units accelerometer counts.

PREST: Single precision time tag associated with PRESVD, scale factor Bl4, units centi-seconds.

QFCT: Value of quantity computed in "S4D.1B", scale factor B-5, units meters/centi-second2, stored in push-down list location 12D.

[QUADROT]: See Attitude Maneuvers.

Rinit: See Rendezvous Computations.

Rtgt: See Burn Control.

REPFRAC: See Digital Autopilot TVC Routines.

SBVGMA: Single precision value of required velocity to be gained (measured at the time of "S4D.13" performance), scale factor Bl4, units accelerometer counts. Loaded double precision, but least significant half subsequently used for DVTAIL.

SCAXIS: See Attitude Maneuvers.

Tgo: Value of time-to-go computed in "S4D.8" (and "S4D.13"), scale factor B28, units centi-seconds. Least significant half loaded with required delay before cutoff (for restart protection purposes), scale factor Bl4.

Tnit: Value of time tag associated with state vector loaded by "SETUP.9", scale factor B28, units centi-seconds.

Tnitprev: Value of Tnit for previous entry into "S4D.9", loaded at the end of "S4D.9", scale factor B28, units centi-seconds. Used with Tnit to determine the proper divisor (with K200cs) for difference of required velocities, in computation of BDT. Since accelerometer sampling at 2 second intervals, value used to divide velocity difference would be expected to be an integer (e.g. 2 if four seconds elapsed). Time difference shifted left 17 places after being formed, giving result modulo 211 centi-seconds (20.48 seconds).

Tpass: See Burn Control.

Tptml: See IMU Computations.

TDELT: Time interval information (corrected for possible overflow of TIMEI, the least significant half of the computer clock), scale factor Bl4, units centi-seconds, single precision.

TZEROED: Value of least significant half of Tptml sampled in "S4D.13" giving the value of TIMEI associated with the zeroing of PIPAPI (since PIPAPI zeroed when Tptml is loaded). It is single precision, scale factor Bl4, units centi-seconds.
UT: Unit vector, scale factor B1, in the direction of desired thrust (expressed in reference coordinates). Cell also used for temporary storage purposes.

\( \mathbf{V}_g \): Velocity-to-be-gained vector, scale factor B7, units meters/centi-second, in reference coordinates.

\( \mathbf{V}_g^{\text{tig}} \): See Burn Control (during Average-G running, retains the previous value of \( \mathbf{V}_g \)).

\( \mathbf{V}_{\text{init}} \): See Rendezvous Computations.

\( \mathbf{V}_{\text{iprime}} \): See Rendezvous Computations.

\( \mathbf{V}_{rprev} \): Value of previous \( \mathbf{V}_{\text{iprime}} \) (i.e. the one associated with \( \mathbf{V}_{\text{initprev}} \)), scale factor B7, units meters/centi-second.

\( \mathbf{V}_{\text{tig}} \): See Burn Control.

VELSS: Square of "net" accelerometer output, including effects of scale factor and bias error compensation, scale factor B28, units of accelerometer counts. The square root is PRESDV.

VGDISP: See Burn Control.

VRSSmSL: Single precision counter, scale factor B14, units counts, used in "SQRTTASK" to count the number of pairs of shifts required for X in order to make it be in range \( \frac{1}{4} \) to \( < 1 \).

X: Dummy argument used in "SQRTTASK" for documentation convenience (cf. square root routine in Mathematical Functions). The VELSS cells themselves are used to store X in program.

\( \mathbf{X}_{\text{smd}}, \mathbf{Y}_{\text{smd}}, \mathbf{Z}_{\text{smd}} \): See Inflight Alignment. Program notation also \( [\mathbf{X}_{\text{scref}}] \).

YACTOFF: See Digital Autopilot TVC Routines.

YAWANG: Value of angle in yaw axis used in "S40.2,3", scale factor B0, units revolutions. Cf. PITANG.
Telemetry

DODOWTM

Entered after receipt of program interrupt #8, telemetry end pulse (from telemetry system)

If bit 7 (Word Order Code) of channel 13 = 0:

Perform "CL3STALL"

Set bit 7 (Word Order Code) of channel 13 = 1

Proceed to address specified by DNTMGOTO

DNPHASE1

Initial condition set in "STARTSUB" for DNTMGOTO

SUBLIST = -1

DNECADR = -1

DNTMGOTO = "DNPHASE2"

CTLIST = \( K_{\text{dntableDNLSTCOD}} \) (Tag here is "NEWLIST")

Perform "CL3STALL"

Set bit 7 (Word Order Code) of channel 13 = 0

Channel 34 = DNLSTCOD

Channel 35 = 773408 (i.e. -004378)

Resume

DNPHASE2

If DNECADR > 0: (i.e. sending data)

Proceed to "FETCH2WD"

If SUBLIST > 0: (i.e. sending sublist)

Proceed to "NEXTINSL"

If CLIST < 0: (End of list reached, start over)

Proceed to 4th line of "DNPHASE1"

ADR = E_{CTLIST} (Tag here "NEXTINCL", get here e.g. next interrupt after doing "DNPHASE1")

If ADR > 0:

CTLIST = CLIST + 1
If ADR < 0:

   CTLIST = - CTLIST  (end of list reached)

DNECADR = |ADR|

If DNECADR = "TIME2":  (i.e. computer clock)

   Perform "CL3STALL"

   Set bit 7(Word Order Code) of channel 13 = 0

   Proceed to "SETO2+2"

SETO2+2

   TS = DNECADR - 30000_8

If TS ≤ 0:  (i.e. bits 14-12 of DNECADR less than 6)

   Proceed to "FETCH2WD"

   TS = TS - 04000_8

If TS > 0:  (i.e. bits 14-12 of DNECADR are 7)

   TS_1 = Channel # (DNECADR - 34000_8 + 1)  (Tag here "DODNCHAN")

   TS_2 = Channel # (DNECADR - 34000_8)  (34000_8 subtracts bits 14-12 = 7)

   DNECADR = -1

   Channel 34 = TS_2
   Channel 35 = TS_1

   Resume

SUBADR = E DNECADR - 30000_8  (bits 14-12 of DNECADR are 6; tag here is "DODNPTR")

If SUBADR > 0:

   SUBLIST = DNECADR

   Proceed to "NEXTINSL"

   SUBLIST = DNECADR  (SUBADR negative, meaning snapshot)

   SUBADR = |SUBADR| - 1

   TMINDEX = 0

   Proceed to "SNAPLOOP"
SNAPLOOP

EBANK = bits 11-9 of SUBADR
TS = 14018 + (bits 8-1 of SUBADR)
DNTMBUFF_P = E_{TS_{dp}}
TMINDEX = TMINDEX + 2
SUBLIST = SUBLIST + 1
SUBADR = E_{SUBLIST} - 30000_8

If SUBADR > 0:
  SUBADR = SUBADR - 1
Proceed to "SNAPLOOP"

SUBLIST = |SUBADR| - 1
DNECADR = -1
TS = SUBLIST
SUBLIST = -1
EBANK = bits 11-9 of TS
TS = 14018 + (bits 8-1 of TS)
(Channel 34, Channel 35) = E_{TS_{dp}}

Resume

FETCH2WD

EBANK = bits 11-9 of DNECADR
TS = (bits 8-1 of DNECADR)
DNECADR = DNECADR + 74001_8
TS = 14008 + TS
(Channel 34, Channel 35) = E_{TS_{dp}}

Resume

(Channel 34, Channel 35) = E_{TS_{dp}}

(subtracts 1 from bits 14-12 and adds 2, for double precision, to bits 11-1: 74001_8 = -04000_8 + 00002_8)
NEXTINSL

SUBADR = E

If SUBADR ≥ 0:

SUBLIST = SUBLIST + 1

If SUBADR < 0:

SUBLIST = -1 (end of list reached)

DNECADR = SUBADR

Proceed to "SETW0+2"

DNDUMP1  Entered by the setting of DNTMGOTO to "DNDUMP1" in "DNE_DUMP" for a V74E

DUMPLOC = 0

Perform "SENDID"

DNTMGOTO = "DNDUMP1"

Channel 34 = DUMPLOC

Channel 35 = TIME1

Resume

SENDID

DNTMGOTO = Return address

Perform "C13STALL"

Set bit 7(Word Order Code) of channel 13 = 0

Channel 34 = 17778

Channel 35 = 773408

Resume

DNDUMP1

DNTMGOTO = "DNDUMP"

EBANK = bits 11-9 of DUMPLOC

TS = 14CO8 + (bits 8-1 of DUMPLOC)

(Channel 34, Channel 35) = E

(Read by mask using -0 to avoid affecting shift register cells, 00208 - 00238)

Resume
DNDUMP

DUMPLOC = DUMPLOC + 2 (modulo $2^{14}$)

If bits 8-1 of DUMPLOC ≠ 0:

Proceed to second line of "DNDUMPl"

If bit 13 of DUMPLOC = 1: (2 complete dumps)

Proceed to "DNPHASEl"

Proceed to second line of "DNDUMPI"

VAC5STOR

Entered from "BAILOUT", "GOPROG", and "POODOO" to save data in VAC area #5 for ground checking (after e.g. V74E)

VAC5+31_dp = (LOC, BANKSET) (i = 0-6) Job register set starting addresses

VAC5+2+31 = PRIORITY (i = 0-6) Job priorities

VAC5+19+2i_dp = (PHSNAMEi) (i = 1-6) 2CADR variable-type restarts starting addresses

VAC5+32+1 = PHASE1 (i = 1-6) Restart-group phase values

VAC5+39 = MPAC+3 Used in display interface routines for return address

VAC5+40_dp = NEWLOC Contains starting address for job being established

VAC5+22 = NEWJOB Control of job selection

VAC5+26 = NEWPRIO Priority of new job

Return

NOTE: See 3420.5-27 for details of the significance of the above quantities. They are intended to be an aid to determining "what happened" when other methods (such as flag words or program alarms) give insufficient detail. Use of these quantities would require access to the program listing, and a detailed understanding of the coding implementation. Such details (absolute machine addresses, and all restart points) can be obtained from the listing as necessary; they are not included in this document.
Quantities in Computations

See also list of major variables and list of routines

ADR: Single precision dummy cell used for temporary storage of the address information taken from the cell whose address is in CLIST (i.e. the "control", or master, telemetry list). If it is read as negative, this means that the end of the master list (the final entry) has been reached. When the necessary number of telemetry transmissions have taken place based on this last entry, the list is started again (CLIST is complemented if ADR is found negative, for control in "DNPHASE2").

CLIST: Single precision cell initialized in "DNPHASE1" with the starting address for the "control", or master, telemetry list, and subsequently incremented in "DNPHASE2" as quantities are read from this list. When the final quantity is read, CLIST is complemented (see ADR) to cause list to be restarted again.

DNECADR: Single precision erasable memory cell used to contain the address (and other) information associated with the transmission of a series of words based upon a single entry into the control or sublist table. Bits 8-1 give the S-register portion of the word in E-memory (the most significant half), while bits 11-9 give the EBANK. If bits 14-12 are in the range 0-5, they control the transmission of 1-6 respectively consecutive erasable memory pairs. While this transmission is going on, DNECADR will be positive, causing branching at the start of "DNPHASE2" to "FETCH2WD", where bits 14-12 are decremented by 1 and bits 11-1 incremented by 2 (for double precision operation). When final cell has been sent based on a given table entry, DNECADR becomes negative, allowing further checks in "DNPHASE2". If bits 14-12 of DNECADR are 6, this means a "sublist" (i.e. a list of telemetry quantities that can be common to several master lists, hence serving as a quasi "sub-routine" list), with bits 11-1 giving its starting address. Finally, if these bits are 7, they indicate transmission of channel information.

DNLISTCOD: Single precision cell, scale factor Bl4, loaded by various mission programs (e.g. in V37 processing, transition to P11 or P62, or start of P27) with the desired serial number (in range 0-3) of the master downlist to be sent. It is used in "DNPHASE1" to index K"dtable to select the proper starting address, and for list id.
DNTMBUFF: Set of 12 erasable memory cells which can be loaded in "SNAPLOOP" with values of quantities (such as vehicle state vector) requiring sampling at a single point in the computation cycle. A "snapshot" is indicated by bits 14-12 of DNECADR being 6 (a sublist) and the first word in that list being negative. Looping continues in "SNAPLOOP" until the next negative word is found: this word is not used for address information to be placed into DNTMBUFF, but instead is used to read the memory directly and send the indicated word. Consequently, 7 double precision cells, e.g. position, velocity, and time, can be subject to the "snapshot" process at a given telemetry interrupt.

DNTMGOTO: Single precision cell containing address to which transfer is to be made when a telemetry interrupt (#8) is received. Except for initialization, it would be expected to remain at "DNPHASE2" for normal (i.e. not erasable memory dump) downlists.

DUMPLOC: Single precision cell (assigned same erasable memory cell as TMINDEX) used to control the performance of the erasable memory dump program. Initialized to zero at the start of "DNNDUMP", and subsequently incremented by 2 in "DNDUMP" to permit selection of the next set of erasable memory cells. Bits 8-1 (0000 - 3773) select the cell within the erasable memory bank, since each bank has 256 cells. Bits 11-9 (carries propagate from bit 8, of course) select the erasable memory bank (0 - 7). Bits 13-12 serve as a counter of the number of complete erasable dumps which have been performed (when bit 13 becomes 1, indicating 2 dumps, dumps cease).

EBANK: See Data Input/Output.

Kdntablei: Table of single precision starting addresses for master telemetry downlists, used in "DNPHASE1" to load the proper initial conditions for CTLIST based upon the present value of DNLSTCOD. Program notation for first table entry is "DNTABLE". Values are:

<table>
<thead>
<tr>
<th>1</th>
<th>Starting Address</th>
<th>Identification of List Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&quot;CMCSTADL&quot;</td>
<td>Coast and Align</td>
</tr>
<tr>
<td>1</td>
<td>&quot;CMENTRDL&quot;</td>
<td>Entry and Update</td>
</tr>
<tr>
<td>2</td>
<td>&quot;CMRENDDL&quot;</td>
<td>Rendezvous &amp; Prethrust</td>
</tr>
<tr>
<td>3</td>
<td>&quot;CMPOWEDEL&quot;</td>
<td>Powered</td>
</tr>
</tbody>
</table>

SUBADR: Single precision dummy cell used for temporary storage of the address information taken from the cell whose address is in SUBLIST (i.e. a "sublist", see DNECADR). If it is read as negative, this means that the end of the sublist has been reached. When the necessary number of telemetry transmissions based on this last entry have taken place, the master list is used again (SUBLIST is set negative in "NEXTINSL", for control in "DNPHASE2"). Function is analogous to ADR's for a master list.
SUBLIST: Single precision cell initialized in "SETWO+2" to DNECADR for a non-snapshot list (for bits 14-12 of DNECADR = 6), giving then the starting address of the required sublist. While positive, "DNPHASE2" will transfer to "NEXTINSL" whenever DNECADR becomes negative: "NEXTINSL" increments SUBLIST until a negative readout (see SUBADR) is encountered, when SUBLIST is set to -1 to cause "DNPHASE2" to return to the master list. Function is analogous to CTLIST's for a master list. In "SNAPLOOP", it is used to index the readout of the snapshot sublist, and is left at -1 when "SNAPLOOP" is done to cause "DNPHASE2" to take next entry from master list (which should be a requirement to transmit DNTMBUFF cells).

TMINDEX: Single precision cell, scale factor B14, initialized to 0 in "SETWO+2" for use in indexing DNTMBUFF storage in "SNAPLOOP". It is assigned the same cell as DNECADR.

VAC5: First address in VAC area #5 (see 3420.5-27), the last to be assigned, and hence used in "VAC5STOR" to retain trouble-shooting information.

Information on the downlists appears on the following pages:

Telemetry Table Interpretation
Coast and Align List
Entry and Update List
Rendezvous & Prethrust List
Powered List
Special Erasable Memory Dump List

TELE-9
TELE-11
TELE-16
TELE-21
TELE-26
TELE-31

TELE-8
Telemetry Table Interpretation

To satisfy mission requirements, four different sets of downlinked memory cells can be specified. The mission program achieves the required specification by setting a quantity between 0 and 3 into DNLSTCOD (usually as part of the processing of a V37 program change). This quantity is used to index a table of fixed memory addresses in order to find the starting address of the particular list of downlinked memory cells required (powered flight, coast and align, etc.). In order to minimize the amount of fixed memory required for storage of this information, and maximize the flexibility of the information that is telemetered, a special storage format for the required addresses is used.

The table whose starting address is found by using DNLSTCOD is known as the "control" (or master) downlist. There is a separate such list for each different downlink set of information, and except for the first word in each 100-word set, the transmission of the information in the downlink set is under the control of information in this control list.

Within this control list, several different types of options can be employed:

a) A single (double precision, i.e. 2 consecutive erasable memory cells) downlink transmission can be specified. This is done by storing the ECADR (see 3420.5-27) of the first word in bits 11-1 of the fixed memory cell. The assembler operation is "1DNADR".

b) Two downlink transmissions (giving four cells in a row) can be specified. This is done by storing the ECADR for the first word in bits 11-1 of the fixed memory cell and putting a 1 in bit 12. The assembler operation in this case is "2DNADR".

c) Three downlink transmissions (giving six cells in a row) can be specified. Here again, the ECADR of the first word is in bits 11-1 of the fixed memory cell and a 1 is put in bit 13. The assembler operation in this case is "3DNADR".

d) Four, five, or six (giving 8, 10, or 12 cells in a row) can also be specified. The ECADR of the first word is in bits 11-1 of the fixed memory cell and bits 14-12 contain the (number - 1) of the transmissions desired: bit 14 is a 1 and bit 12 is a 1 for six transmissions, for example. The assembler operations are nDNADR.

e) A "sublist" can be specified. This permits a sequence of cells, such as state vector information, that may be common to more than one list to be specified only once (a sort of quasi "sub-routine" capability). In this case, bits 11-1 contain the address of the sublist (S-register portion, since in same bank) and bits 14-12 contain 6 (assembler operation is "DNPTR"). This particular assignment makes the 15-bit memory word of the form 3XXXX: rather than subtracting or masking out the "3" (as
indicated in this writeup), the coding takes advantage of the fact that this is the proper form for a "clear add" instruction (hence merely indexes on 000008).

f) A single downlink transmission of a pair of channels can be specified. In this case, bits 6-1 would contain the channel number and bits 14-12 would contain 7. The assembler operation for this is "DNCHAN", and advantage is taken of the "7" by indexing to form the required order, rather than subtracting or masking it out as indicated in this writeup.

g) The end of the control list (indicating that the list should be started again) is flagged by having the cell be negative (e.g. "-6DNADR" instead of "6DNADR").

If, per item e, a "sublist" in specified, then two options are available:

1. A "normal" sublist, in which case information can be stored in a manner exactly like the control list, except that option "e" should not be used (sublists cannot reference other sublists). The end of the sublist is flagged by a negative cell (as in option "g"), indicating in this case that information should again be taken from the control (master) list (at the line after the DNPTR).

2) A "snapshot" sublist, flagged by the fact that the first item in the sublist is negative (i.e. "-1DNADR"). The "snapshot" feature allows up to seven double precision words to be sampled at the same telemetry interrupt point, to achieve on the downlink a consistency of this information (e.g. position, velocity, and time of state vector). In this case, the remaining items in the sublist must be "1DNADR" form; the cell data specified by the first table entry through the next-to-last are stored in a special telemetry buffer (DNTMBUFF). The last entry in the sublist is negative, and in this case only is the first cell address transmitted. In all other cases, addresses in the lists are stored in the order in which they are transmitted. In order to cause transmission of the DNTMBUFF cells, the entry in the control list following the DNPTR cell for the snapshot should require transmission of DNTMBUFF cells (e.g. "6DNADR DNTMBUFF").

Except for specification of snapshot lists, which can occur only by DNPTR orders in the master (control) list, there is no maximum to the number of individual entries in either the control or sublists, except of course the convention that a complete telemetry cycle involves 100 double precision words. In addition, downlink processing format requires that word #51 (the computer clock) have a word order code bit of 0: a check for transmission of this word is made only for readouts from the master list (address 00248).
Information in Telemetered Words

There are four different downlists that may be transmitted during the flight (plus the special erasable memory dump initiated by a V74E). These four lists are implemented in the computer memory as the addresses of cells in erasable memory: the contents of the cells, in turn, can depend upon the phasing of the telemetry interrupts with respect to the other computations. In addition, cells are frequently time shared among different mission phases. The information below should be augmented by more detailed material on the telemetry data for items not covered.

Unless otherwise specified, the contents of the words below reflect both Channel 34 and Channel 35 (i.e. a double precision number). In those cases for which the information in the two channels is not closely related, "a" signifies the Channel 34 information and "b" the Channel 35 information.

Coast and Align List

This list, with starting address of "CMCSTADL", is selected for DNLSTCOD = 0. It is used in P00, P01, P02, P03, P06, P07, P50, P51, P52, P53, P54, and P55.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>777778</td>
<td>Identification of list (-0).</td>
</tr>
<tr>
<td>1b</td>
<td>773408</td>
<td>Special synchronization bits.</td>
</tr>
<tr>
<td>Snapshot Group #1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>R</td>
<td>Position state vector (word 2 x component).</td>
</tr>
<tr>
<td>5-7</td>
<td>V</td>
<td>Velocity state vector (word 5 x component).</td>
</tr>
<tr>
<td>8</td>
<td>T_pptm</td>
<td>State vector time.</td>
</tr>
<tr>
<td>Snapshot Group #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Words 9-13</td>
<td>are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.</td>
<td></td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>9, 10a</td>
<td>CDU</td>
<td>IMU CDU angles.</td>
</tr>
<tr>
<td>10b</td>
<td>CDUT</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>11-13</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates).</td>
</tr>
</tbody>
</table>

**Erasable Group #1**

Words 14-44 are sampled as the telemetry interrupt for them is received.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,15a</td>
<td>AK</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>15b</td>
<td>RCSFLAGS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>16,17a</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines (these are not N22 quantities).</td>
</tr>
<tr>
<td>17b</td>
<td>DELCDUX</td>
<td>See Attitude Maneuvers.</td>
</tr>
<tr>
<td>18</td>
<td>T_ig</td>
<td>Ignition time (or predicted cutoff time).</td>
</tr>
<tr>
<td>19a</td>
<td>BESTI</td>
<td>See Inflight Alignment.</td>
</tr>
<tr>
<td>19b</td>
<td>BESTJ</td>
<td>See Inflight Alignment.</td>
</tr>
<tr>
<td>20-23a</td>
<td>MARKDOWN</td>
<td>Cells MARKDOWN+0 to MARKDOWN+6 (see Measurement Incorporation).</td>
</tr>
<tr>
<td>23b</td>
<td>RM</td>
<td>See Measurement Incorporation.</td>
</tr>
<tr>
<td>24-27a</td>
<td>MARK2DWN</td>
<td>Cells MARK2DWN+0 to MARK2DWN+6 (see Inflight Alignment).</td>
</tr>
<tr>
<td>27b</td>
<td>BVECTOR_y,sp</td>
<td>See Measurement Incorporation.</td>
</tr>
<tr>
<td>28</td>
<td>HAPOX</td>
<td>See Display Computations.</td>
</tr>
<tr>
<td>29</td>
<td>HPERX</td>
<td>See Display Computations.</td>
</tr>
<tr>
<td>30a</td>
<td>PACTOFF</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>30b</td>
<td>YACTOFF</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>31-33</td>
<td>V_gtig</td>
<td>See Burn Control.</td>
</tr>
</tbody>
</table>
| 34-36  | REFSMMAT\_0 | First row of $\begin{bmatrix} \text{REFSMMAT}\_0 \end{bmatrix}$.
| 37-39  | REFSMMAT\_3 | Second row of $\begin{bmatrix} \text{REFSMMAT}\_0 \end{bmatrix}$.

**TELE-12**
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-44</td>
<td>FLAGWRDO-</td>
<td>Program control flag words.</td>
</tr>
<tr>
<td></td>
<td>FLAGWRD9</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Display Table Group</strong></td>
<td></td>
</tr>
<tr>
<td>45-50</td>
<td>DSPTAB+0-</td>
<td>Words 45-50 are sampled as the telemetry</td>
</tr>
<tr>
<td></td>
<td>DSPTAB+11</td>
<td>interrupt for them is received.</td>
</tr>
<tr>
<td></td>
<td>&quot;Display table&quot; information (DSPTAB+0 is 45a). See Data Input/Output.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Computer Clock</strong></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>T\text{now}</td>
<td>Word 51 is sampled when the telemetry interrupt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for it is received.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Present value of computer clock (TIME2,TIME1).</td>
</tr>
<tr>
<td></td>
<td><strong>Snapshot Group #3</strong></td>
<td></td>
</tr>
<tr>
<td>52-54</td>
<td>R\text{other}</td>
<td>Words 52-58 are all sampled at the same telemetry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrupt time, with words 53-58 stored in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>55-57</td>
<td>V\text{other}</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>58</td>
<td>T\text{etlm}</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td></td>
<td><strong>Snapshot Group #4</strong></td>
<td></td>
</tr>
<tr>
<td>59-63</td>
<td>CDU</td>
<td>Words 59-63 are all sampled at the same telemetry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrupt time, with words 60-63 stored in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>59,60a</td>
<td></td>
<td>IMU CDU angles.</td>
</tr>
<tr>
<td>60b</td>
<td>CDUT</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>61-63</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines (roll, pitch,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>yaw respectively).</td>
</tr>
<tr>
<td></td>
<td><strong>Erasable Group #2</strong></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>OPTION1,2</td>
<td>Words 64-90 are sampled as the telemetry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrupt for them is received.</td>
</tr>
<tr>
<td>65</td>
<td>T\text{et}</td>
<td>See Display Interface Routines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See Orbital Integration.</td>
</tr>
</tbody>
</table>

**Tele-13**
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>66,67a</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>67b</td>
<td>DELCDUX&lt;sub&gt;sp&lt;/sub&gt;</td>
<td>See Attitude Maneuvers.</td>
</tr>
<tr>
<td>68</td>
<td>RSBBQ&lt;sub&gt;dp&lt;/sub&gt;</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>69a</td>
<td>Channel 76</td>
<td>Not meaningful.</td>
</tr>
<tr>
<td>69b</td>
<td>Channel 77</td>
<td>Hardware restart information.</td>
</tr>
<tr>
<td>70a</td>
<td>C31FLWRD</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>70b,71</td>
<td>FAILREG</td>
<td>FAILREG+0 to FAILREG+2 (see General Program Control).</td>
</tr>
<tr>
<td>72a</td>
<td>CDUS</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>72b,73</td>
<td>PIPA</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>74</td>
<td>OGC</td>
<td>See Coordinate Transformations.</td>
</tr>
<tr>
<td>75</td>
<td>IGC</td>
<td>See Coordinate Transformations.</td>
</tr>
<tr>
<td>76</td>
<td>MGC</td>
<td>See Coordinate Transformations.</td>
</tr>
<tr>
<td>77a</td>
<td>FLGWRDIO</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>77b</td>
<td>FLGWRDII</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>78</td>
<td>Tevt</td>
<td>Event (e.g. liftoff or engine on/off) time.</td>
</tr>
<tr>
<td>79</td>
<td>LAUNCHAZ</td>
<td>See Prelaunch Alignment.</td>
</tr>
<tr>
<td>80a</td>
<td>OPTMODES</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>80b</td>
<td>HOLDFLAG</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>81a</td>
<td>LEMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>81b</td>
<td>CSMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82a</td>
<td>DAPDATR1</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82b</td>
<td>DAPDATR2</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>83,84a</td>
<td>ERROR</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>84b</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>85-87</td>
<td>WBODY</td>
<td>See Digital Autopilot RCS Routines (same cells used for commanded rates in TVC).</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>88a, 89a</td>
<td>REDOCTR</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>88b, 89b</td>
<td>THETAD</td>
<td>Desired CDU angles (e.g. N22).</td>
</tr>
<tr>
<td>90a</td>
<td>IMODES30</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>90b</td>
<td>IMODES33</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Channel Quantities</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Words 91-94 are sampled as the telemetry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrupt for them is received.</td>
</tr>
<tr>
<td>91a</td>
<td>Channel 11</td>
<td>Outputs.</td>
</tr>
<tr>
<td>91b</td>
<td>Channel 12</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92a</td>
<td>Channel 13</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92b</td>
<td>Channel 14</td>
<td>Outputs.</td>
</tr>
<tr>
<td>93a</td>
<td>Channel 30</td>
<td>Inputs.</td>
</tr>
<tr>
<td>93b</td>
<td>Channel 31</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94a</td>
<td>Channel 32</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94b</td>
<td>Channel 33</td>
<td>Inputs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Erasable Group #3</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Words 95-100 are sampled as the telemetry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrupt for them is received.</td>
</tr>
<tr>
<td>95, 96a</td>
<td>Teeph</td>
<td>See Boost Computations.</td>
</tr>
<tr>
<td>96b</td>
<td>Rother, x, sp</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>97a</td>
<td>SLOPE</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>97b</td>
<td>ADB</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>98a</td>
<td>DAPDTR3</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>98b</td>
<td>CH5FAIL</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>99a</td>
<td>CH6FAIL</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>99b</td>
<td>DERRATE</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>100a</td>
<td>DKDB</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>100b</td>
<td>WHICHDAP</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
</tbody>
</table>
Entry and Update List

This list, with starting address of "CMENTRDL", is selected for DNLSTCoders = 1. It is used in P27, P62, P63, P64, P65, P66, and P67.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>77776&lt;sub&gt;8&lt;/sub&gt;</td>
<td>Identification of list (-1).</td>
</tr>
<tr>
<td>1b</td>
<td>77340&lt;sub&gt;8&lt;/sub&gt;</td>
<td>Special synchronization bits.</td>
</tr>
<tr>
<td>Snapshot Group #1</td>
<td></td>
<td>Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>2-4</td>
<td>R</td>
<td>Position state vector.</td>
</tr>
<tr>
<td>5-7</td>
<td>V</td>
<td>Velocity state vector.</td>
</tr>
<tr>
<td>8</td>
<td>T&lt;sub&gt;pptm&lt;/sub&gt;</td>
<td>State vector time.</td>
</tr>
<tr>
<td>Snapshot Group #2</td>
<td></td>
<td>Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>9, 10a</td>
<td>CDU</td>
<td>IMU CDU angles.</td>
</tr>
<tr>
<td>10b</td>
<td>CDUT</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>11-13</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates). When Entry DAP is turned on, cells used for XPIFBUF and XOLDBUF (see General Program Control).</td>
</tr>
<tr>
<td>Erasable Group #1</td>
<td></td>
<td>Words 14-44 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>14,15a</td>
<td>AK</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>15b</td>
<td>RCSFLAGS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>--------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>16,17a</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>17b</td>
<td>DELCDUX&lt;sub&gt;sp&lt;/sub&gt;</td>
<td>See Attitude Maneuvers. In entry, word 17 contains Q7 (see Entry Computations) and word 16 contains (QAXERR, RAXERR) (see Digital Autopilot Entry Routines).</td>
</tr>
<tr>
<td>18a</td>
<td>CMDAPMOD</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>18b</td>
<td>PREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>19a</td>
<td>QREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>19b</td>
<td>RREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>20</td>
<td>LdD1</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>21-30</td>
<td>UPBUFF</td>
<td>See Uplink Processing (UPBUFF+0 through UPBUFF+19). Same cells used during entry DAP for CMTMTIME, SWdNDX, and ENDBUF (see Digital Autopilot Entry Routines). Words 29b and 30a are also V1 (see Entry Computations), and 30b AO&lt;sub&gt;sp&lt;/sub&gt; (see Entry Computations).</td>
</tr>
<tr>
<td>31a</td>
<td>COMPNUMB</td>
<td>See Uplink Processing.</td>
</tr>
<tr>
<td>31b</td>
<td>UPOLDMOD</td>
<td>See Uplink Processing.</td>
</tr>
<tr>
<td>32a</td>
<td>UPVERB</td>
<td>See Uplink Processing.</td>
</tr>
<tr>
<td>32b</td>
<td>UPCOUNT</td>
<td>See Uplink Processing.</td>
</tr>
<tr>
<td>33a</td>
<td>PAXERR1</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>33b</td>
<td>ROLLTM</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>34</td>
<td>LATANG</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>35</td>
<td>RDOT</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>36</td>
<td>THETAH</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>37</td>
<td>LATSPL</td>
<td>See Display Computations.</td>
</tr>
<tr>
<td>38</td>
<td>LNGSPL</td>
<td>See Display Computations.</td>
</tr>
<tr>
<td>39a</td>
<td>ALFA&lt;sub&gt;180&lt;/sub&gt;</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>39b</td>
<td>BETA&lt;sub&gt;180&lt;/sub&gt;</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>40-44</td>
<td>FLAGWRDO-FLAGWRD9</td>
<td>Program control flag words.</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>---------</td>
<td>------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Display Table Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-50</td>
<td>DSPTAB+0-DSPTAB+11</td>
<td>&quot;Display table&quot; information. See Data Input/Output.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Clock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>$T_\text{now}$</td>
<td>Word 51 is sampled when the telemetry interrupt for it is received.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snapshot Group #3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>$T_{pptml}$</td>
<td>words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>53-55</td>
<td>DELV</td>
<td>Sampled accelerometer output (if least significant halves = 0, is uncompensated; otherwise is compensated data).</td>
</tr>
<tr>
<td>56</td>
<td>TTE</td>
<td>See Display Computations. Also used for LdDCALC (see Entry Computations).</td>
</tr>
<tr>
<td>57</td>
<td>VIO</td>
<td>See Display Computations. Also used for LEWD (see Entry Computations).</td>
</tr>
<tr>
<td>58</td>
<td>VPRED</td>
<td>See Display Computations. Also used for VL (see Entry Computations).</td>
</tr>
<tr>
<td>Snapshot Group #4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59,60a</td>
<td>CDU</td>
<td>IMU CDU angles.</td>
</tr>
<tr>
<td>60b</td>
<td>CDUT</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>61-63</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines. See also words 11-13 above in this list (which are same cells).</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Erasable Group #2</td>
<td></td>
<td>Words 64-90 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>64</td>
<td>OPTION1,2</td>
<td>See Display Interface Routines.</td>
</tr>
<tr>
<td>65</td>
<td>Tet</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>66, 67a</td>
<td>ERROR</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>67b, 68</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines. Words 66-68 also contain (single precision): VDTd18O, mVTd18OE, unreflected LCXd36O, QAXERR, RAXERR, and Q7 (see Entry Computations for Q7 and Digital Autopilot Entry Routines for the others).</td>
</tr>
<tr>
<td>69a</td>
<td>CMDAPMOD</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>69b</td>
<td>FREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>70a</td>
<td>QREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>70b</td>
<td>RREL</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>71-80</td>
<td>UPBUFF</td>
<td>See Uplink Processing (UPBUFF+0 through UPBUFF+19). See also words 21-30 above (same cells).</td>
</tr>
<tr>
<td>81a</td>
<td>LEMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>81b</td>
<td>CSMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82a</td>
<td>DAPDATR1</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82b</td>
<td>DAPDATR2</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>83a</td>
<td>ROLLTM</td>
<td>See Digital Autopilot Entry Routines.</td>
</tr>
<tr>
<td>83b</td>
<td>ROLLc_sp</td>
<td>See Entry Computations.</td>
</tr>
<tr>
<td>84a</td>
<td>OPTMODES</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>84b</td>
<td>HOLDFLAG</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>85-87</td>
<td>WBODY</td>
<td>See Digital Autopilot RCS Routines. Same cells used for commanded rates in TVC. They are also loaded with ASPSpTMp (see Entry Computations).</td>
</tr>
<tr>
<td>88a</td>
<td>REDOCTR</td>
<td>See General Program Control.</td>
</tr>
</tbody>
</table>

TELE-19
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>88b,89</td>
<td>THETAD</td>
<td>Desired CDU angles (e.g. N22). Same cells for RDOTREF and VREF&lt;sub&gt;sp&lt;/sub&gt; (see Entry Computations).</td>
</tr>
<tr>
<td>90a</td>
<td>IMODES30</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>90b</td>
<td>IMODES33</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td></td>
<td><strong>Channel Quantities</strong></td>
<td></td>
</tr>
<tr>
<td>91a</td>
<td>Channel 11</td>
<td>Outputs.</td>
</tr>
<tr>
<td>91b</td>
<td>Channel 12</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92a</td>
<td>Channel 13</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92b</td>
<td>Channel 14</td>
<td>Outputs.</td>
</tr>
<tr>
<td>93a</td>
<td>Channel 30</td>
<td>Inputs.</td>
</tr>
<tr>
<td>93b</td>
<td>Channel 31</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94a</td>
<td>Channel 32</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94b</td>
<td>Channel 33</td>
<td>Inputs.</td>
</tr>
<tr>
<td></td>
<td><strong>Erasable Group #3</strong></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>RSBBQ&lt;sub&gt;dp&lt;/sub&gt;</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>96a</td>
<td>Channel 76</td>
<td>Not meaningful.</td>
</tr>
<tr>
<td>96b</td>
<td>Channel 77</td>
<td>Hardware restart information.</td>
</tr>
<tr>
<td>97a</td>
<td>C31FLWRD</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>97b,98</td>
<td>FAILREG</td>
<td>FAILREG+0 to FAILREG+2 (see General Program Control).</td>
</tr>
<tr>
<td>99a</td>
<td>FLGWRD10</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>99b</td>
<td>FLGWRD11</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>100a</td>
<td>GAMMAEI</td>
<td>See Display Computations. Same cell used for PREDANG (see Entry Computations), and GAMMAL.</td>
</tr>
<tr>
<td>100b</td>
<td>JJ</td>
<td>Loaded with RTGO&lt;sub&gt;sp&lt;/sub&gt; (see Display Computations); JJ itself is in Entry Computations.</td>
</tr>
</tbody>
</table>
Rendezvous and Prethrust List

This list, with starting address of "CMRENDDL", is selected for DNLSTCOD = 2. It is used in P20, P21, P25, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38, and P77 (and "P81" - "P88").

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>la</td>
<td>777753</td>
<td>Identification of list (-2).</td>
</tr>
<tr>
<td>lb</td>
<td>773408</td>
<td>Special synchronization bits.</td>
</tr>
</tbody>
</table>

Snapshot Group #1

Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.

| 2-4 | R | Position state vector. |
| 5-7 | V | Velocity state vector. |
| 8 | T\_pptm | State vector time. |

Snapshot Group #2

Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.

| 9,10a | CDU | IMU CDU angles. |
| 10b | CDUT | See Optics Computations. |
| 11-13 | ADOT | See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates). |

Erasable Group #1

Words 14-22 are sampled as the telemetry interrupt for them is received.

| 14,15a | AK | See Digital Autopilot Interface Routines. |
| 15b | RCSFLAGS | See Digital Autopilot Interface Routines. |
| 16,17a | THETADX | See Digital Autopilot RCS Routines. |
| 17b | DELCDUX\_sp | See Attitude Maneuvers. |
### Word # | Quantity | Meaning
--- | --- | ---
18 | $T_{lg}$ | Ignition time (or predicted cutoff time). See Digital Autopilot RCS Routines.
19a | SLOPE | See Digital Autopilot RCS Routines.
19b | ADB | See Digital Autopilot RCS Routines.
20a | DAPDATR3 | See Digital Autopilot Docked Jet Selection.
20b | CH5FAIL | See Digital Autopilot Docked Jet Selection.
21a | CH6FAIL | See Digital Autopilot Docked Jet Selection.
21b | DKRATE | See Digital Autopilot RCS Routines.
22a | DKDB | See Digital Autopilot RCS Routines.
22b | WHICHDAP | See Digital Autopilot RCS Routines.

**Snapshot Group #3**

Words 23-28 are all sampled at the same telemetry interrupt time, with words 24-28 stored in DNTMBUFF for subsequent transmission.

23 | VHPTIME | See Measurement Incorporation.
24-27a | MARKDOWN | Cells MARKDOWN+0 to MARKDOWN+6 (see Measurement Incorporation).
27b | RM | See Measurement Incorporation.
28a | VHFCNT | See Measurement Incorporation.
28b | TRKMKCNT | See Measurement Incorporation.

**Erasable Group #2**

Words 29-44 are sampled as the telemetry interrupt for them is received.

29 | $T_{tpi}$ | See Rendezvous Computations.
30 | SVEC$+2$ | See Measurement Incorporation.
31 | DELVTPF | See Burn Control.
32 | $T_{cdh}$ | See Rendezvous Computations (NSR time).
33 | $T_{csi}$ | See Rendezvous Computations (NCC time).
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>T_pass4</td>
<td>See Burn Control.</td>
</tr>
<tr>
<td>35-37</td>
<td>DELVLVC</td>
<td>See Burn Control.</td>
</tr>
<tr>
<td>38</td>
<td>RANGE</td>
<td>See Display Computations (same cell used for WWPOS, see Measurement Incorporation).</td>
</tr>
<tr>
<td>39</td>
<td>RRATE</td>
<td>See Display Computations (same cell used for HAPOX, Display Computations, and WWVEL, see Measurement Incorporation).</td>
</tr>
<tr>
<td>40-44</td>
<td>FLAGWROD-FLAGWROD9</td>
<td>Program control flag words.</td>
</tr>
<tr>
<td></td>
<td>Display Table Group</td>
<td>Words 45-50 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>45-50</td>
<td>DSPTAB+0-DSPTAB+11</td>
<td>&quot;Display table&quot; information. See Data Input/Output.</td>
</tr>
<tr>
<td></td>
<td>Computer Clock</td>
<td>Word 51 is sampled when the telemetry interrupt for it is received.</td>
</tr>
<tr>
<td>51</td>
<td>T_now</td>
<td>Present value of computer clock (TIME2,TIME1).</td>
</tr>
<tr>
<td></td>
<td>Snapshot Group #4</td>
<td>Words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>52-54</td>
<td>R_other</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>55-57</td>
<td>V_other</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>58</td>
<td>Tetlm</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td></td>
<td>Snapshot Group #5</td>
<td>Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.</td>
</tr>
<tr>
<td>59,60a</td>
<td>CDU</td>
<td>IMU CDU angles.</td>
</tr>
<tr>
<td>60b</td>
<td>CDUT</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>61-63</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
</tbody>
</table>
Words 64-90 are sampled as the telemetry interrupt for them is received.

64  OPTION1,2  See Display Interface Routines.
65  T£  See Orbital Integration.
66,67a  THETADX  See Digital Autopilot RCS Routines.
67b  DELCDUXsp  See Attitude Maneuvers.
68  RSBBQdp  See General Program Control.
69a  Channel 76  Not meaningful.
69b  Channel 77  Hardware restart information.
70a  C31FLWRD  See Digital Autopilot RCS Routines.
70b,71  FAILREG  FAILREG+0 to FAILREG+2 (see General Program Control).
72a  CDUS  See Optics Computations.
72b,73  PIPA  See IMU Computations.
74  NC1TIG  See Burn Control.
75  NC2TIG  See Burn Control.
76  DHDSP  See Rendezvous Computations.
77-79  DELVEET3  See Rendezvous Computations.
80a  OPTMODES  See Optics Computations.
80b  HOLDFLAG  See Digital Autopilot Interface Routines.
81a  LEMMASS  See Digital Autopilot Interface Routines.
81b  CSIMASS  See Digital Autopilot Interface Routines.
82a  DAPDATR1  See Digital Autopilot Interface Routines.
82b  DAPDATR2  See Digital Autopilot Interface Routines.
83,84a  ERROR  See Digital Autopilot RCS Routines.
84b  THETADX  See Digital Autopilot RCS Routines.
85-87  WBOIJI  See Digital Autopilot RCS Routines (same cells used for commanded rates in TVC).
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>88a</td>
<td>REDOCTR</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>88b, 89</td>
<td>THETAD</td>
<td>Desired CDU angles (e.g. N22).</td>
</tr>
<tr>
<td>90a</td>
<td>IMODES30</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>90b</td>
<td>IMODES33</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td></td>
<td>Channel Quantities</td>
<td>Words 91-94 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>91a</td>
<td>Channel 11</td>
<td>Outputs.</td>
</tr>
<tr>
<td>91b</td>
<td>Channel 12</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92a</td>
<td>Channel 13</td>
<td>Outputs.</td>
</tr>
<tr>
<td>92b</td>
<td>Channel 14</td>
<td>Outputs.</td>
</tr>
<tr>
<td>93a</td>
<td>Channel 15</td>
<td>Inputs.</td>
</tr>
<tr>
<td>93b</td>
<td>Channel 16</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94a</td>
<td>Channel 17</td>
<td>Inputs.</td>
</tr>
<tr>
<td>94b</td>
<td>Channel 18</td>
<td>Inputs.</td>
</tr>
<tr>
<td></td>
<td>Erasable Group #4</td>
<td>Words 95-100 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>95</td>
<td>RTHETA</td>
<td>See Display Computations (same cell used for WWOPT, see Measurement Incorporation, and RRATE2 and HPERX, Display Computations).</td>
</tr>
<tr>
<td>96</td>
<td>DVDSP1</td>
<td>See Rendezvous Computations.</td>
</tr>
<tr>
<td>97</td>
<td>DVDSP2</td>
<td>See Rendezvous Computations.</td>
</tr>
<tr>
<td>98</td>
<td>UTPIT</td>
<td>See Orbital and Rendezvous Navigation.</td>
</tr>
<tr>
<td>99</td>
<td>UTYAW</td>
<td>See Orbital and Rendezvous Navigation.</td>
</tr>
<tr>
<td>100a</td>
<td>FLGWRD10</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>100b</td>
<td>FLGWRD11</td>
<td>Program control flag word.</td>
</tr>
</tbody>
</table>
Powered List

This list, with starting address of "CMPOWEDL", is selected for DNLSTCOD = 3. It is used in P11, P40, P41, P47, P48, and P61.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>la</td>
<td>777748</td>
<td>Identification of list (-3).</td>
</tr>
<tr>
<td>lb</td>
<td>773408</td>
<td>Special synchronization bits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Snapshot Group #1

Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.

|        |        |         |
|        |        |         |
|        |        |         |

2-4   R   Position state vector.
5-7   V   Velocity state vector.
8     T_pptm   State vector time.

Snapshot Group #2

Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.

|        |        |         |
|        |        |         |
|        |        |         |

9,10a  CDU   IMU CDU angles.
10b    CDUT   See Optics Computations.
11-13  ADOT   See Digital Autopilot RCS Routines. Same cells are used for OMEGAB (see Digital Autopilot TVC Routines).

Erasable Group #1

Words 14-29 are sampled as the telemetry interrupt for them is received.

|        |        |         |
|        |        |         |
|        |        |         |

14,15a  AK   See Digital Autopilot Interface Routines.
15b    RCSFLAGS   See Digital Autopilot Interface Routines.
16,17a  THETADX   See Digital Autopilot RCS Routines.
17b    DELCDUX_sp   See Attitude Maneuvers.
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>$T_{ig}$</td>
<td>Ignition time (or predicted cutoff time).</td>
</tr>
<tr>
<td>19a</td>
<td>SLOPE</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>19b</td>
<td>ADB</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>20a</td>
<td>DAPDATR3</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>20b</td>
<td>CH5FAIL</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>21a</td>
<td>CH6FAIL</td>
<td>See Digital Autopilot Docked Jet Selection.</td>
</tr>
<tr>
<td>21b</td>
<td>DKRATE</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>22a</td>
<td>DKDB</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>22b</td>
<td>WHICHDAP</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>23</td>
<td>$T_{go}$</td>
<td>See Steering Computations. Should not be confused with $T_{togo}$ (Burn Computations) of N40 etc.</td>
</tr>
<tr>
<td>24</td>
<td>$T_{pptml}$</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>25-27</td>
<td>DELV</td>
<td>Sampled accelerometer output (if least significant half zero, is uncompensated; otherwise is compensated data).</td>
</tr>
<tr>
<td>28a</td>
<td>PACTOFF</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>28b</td>
<td>YACTOFF</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>29a</td>
<td>PCMD</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>29b</td>
<td>YCMD</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
</tbody>
</table>

**Snapshot Group #3**

Words 30-3l are sampled at the same telemetry interrupt time, with 3l stored in DNTMBUFF for subsequent transmission.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>30a</td>
<td>CSTEER</td>
<td>See Steering Computations.</td>
</tr>
<tr>
<td>30b</td>
<td>RM</td>
<td>See Measurement Incorporation (also is least significant half of CSTEER).</td>
</tr>
<tr>
<td>31</td>
<td>MARKTIME</td>
<td>See Measurement Incorporation.</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>Erasable Group #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>FIXTIME</td>
<td>Words 32-44 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td>33</td>
<td>DVTOTAL</td>
<td>See Orbital and Rendezvous Navigation.</td>
</tr>
<tr>
<td>34-36</td>
<td>REFSSMMAT₀</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>37-39</td>
<td>REFSSMMAT₃</td>
<td>First row of ([\text{REFSSMMAT}]).</td>
</tr>
<tr>
<td>40-44</td>
<td>FLAGWRD0-FLAGWRD9</td>
<td>Second row of ([\text{REFSSMMAT}]).</td>
</tr>
</tbody>
</table>

| Display Table Group |
| 45-50 | DSPTAB+0-DSPTAB+11 | Program control flag words. |

| Computer Clock |
| 51 | T_now | "Display table" information. See Data Input/Output. |

| Snapshot Group #4 |
| 52-54 | R_other | See Orbital Integration. |
| 55-57 | V_other | See Orbital Integration. |
| 58 | T_telm | See Orbital Integration. |

<p>| Snapshot Group #5 |
| 59,60a | CDU | Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission. |
| 60b   | CDUT | IMU CDU angles. |
|       |       | See Optics Computations. |</p>
<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>61-63</td>
<td>ADOT</td>
<td>See Digital Autopilot RCS Routines. Same cells are used for OMEGAB (see Digital Autopilot TVC Routines).</td>
</tr>
</tbody>
</table>

**Erasable Group #3**

Words 64–90 are sampled as the telemetry interrupt for them is received.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>64,65a</td>
<td>AK</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>65b</td>
<td>RCSFLAGS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>66,67a</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>67b</td>
<td>DELCUX&lt;sub&gt;sp&lt;/sub&gt;</td>
<td>See Attitude Maneuvers.</td>
</tr>
<tr>
<td>68</td>
<td>RSBBQ&lt;sub&gt;dp&lt;/sub&gt;</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>69a</td>
<td>Channel 76</td>
<td>Not meaningful.</td>
</tr>
<tr>
<td>69b</td>
<td>Channel 77</td>
<td>Hardware restart information.</td>
</tr>
<tr>
<td>70a</td>
<td>C31FLWRD</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>70b,71</td>
<td>FAILREG</td>
<td>FAILREG to FAILREG+2 (see General Program Control).</td>
</tr>
<tr>
<td>72a</td>
<td>CDUS</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>72b,73</td>
<td>PIPA</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>74</td>
<td>ELEV</td>
<td>See Rendezvous Computations.</td>
</tr>
<tr>
<td>75</td>
<td>SVEC+2</td>
<td>See Measurement Incorporation.</td>
</tr>
<tr>
<td>76</td>
<td>T&lt;sub&gt;et&lt;/sub&gt;</td>
<td>See Orbital Integration.</td>
</tr>
<tr>
<td>77a</td>
<td>FLGWRRD10</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>77b</td>
<td>FLGWRRD11</td>
<td>Program control flag word.</td>
</tr>
<tr>
<td>78</td>
<td>T&lt;sub&gt;evt&lt;/sub&gt;</td>
<td>Event (e.g. liftoff or engine on/off) time.</td>
</tr>
<tr>
<td>79a</td>
<td>PCMD</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>79b</td>
<td>YCMD</td>
<td>See Digital Autopilot TVC Routines.</td>
</tr>
<tr>
<td>80a</td>
<td>OPTMODES</td>
<td>See Optics Computations.</td>
</tr>
<tr>
<td>80b</td>
<td>HOLDFLAG</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>Word #</td>
<td>Quantity</td>
<td>Meaning</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>81a</td>
<td>LEMMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>81b</td>
<td>CSMMASS</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82a</td>
<td>DAPDATR1</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>82b</td>
<td>DAPDATR2</td>
<td>See Digital Autopilot Interface Routines.</td>
</tr>
<tr>
<td>83,84a</td>
<td>ERROR</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>84b</td>
<td>THETADX</td>
<td>See Digital Autopilot RCS Routines.</td>
</tr>
<tr>
<td>85-87</td>
<td>WBODY</td>
<td>See Digital Autopilot RCS Routines. Same cells used for OMEGAC (see Digital Autopilot TVC Routines).</td>
</tr>
<tr>
<td>88a</td>
<td>REDOCTR</td>
<td>See General Program Control.</td>
</tr>
<tr>
<td>88b,89</td>
<td>THETAD</td>
<td>Desired CDU angles (e.g. N22).</td>
</tr>
<tr>
<td>90a</td>
<td>IMODES30</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td>90b</td>
<td>IMODES33</td>
<td>See IMU Computations.</td>
</tr>
<tr>
<td></td>
<td>Channel Quantities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>91a Channel 11 Outputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>91b Channel 12 Outputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>92a Channel 13 Outputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>92b Channel 14 Outputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>93a Channel 30 Inputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>93b Channel 31 Inputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>94a Channel 32 Inputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>94b Channel 33 Inputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Erasable Group #4</td>
<td>Words 91-94 are sampled as the telemetry interrupt for them is received.</td>
</tr>
<tr>
<td></td>
<td>95-97 $V_{gtig}$</td>
<td>See Burn Control.</td>
</tr>
<tr>
<td></td>
<td>98-100 DELVLVC</td>
<td>See Burn Control.</td>
</tr>
</tbody>
</table>
Special Erasable Memory Dump List

Input of a V74E causes DNTMGO TO to be switched so as to start at the next telemetry interrupt the transmission of a "dump" of the erasable memory (all cells are sent sequentially for two times, i.e. two complete passes through the erasable memory). The erasable memory hardware is divided into eight "banks" of 256 cells each, and a similar division is made for downlinking of information: the first two words are used for control data, and the next 128 contain the 256 words in the particular bank set identified by the first two words. The format of the information is:

<table>
<thead>
<tr>
<th>Word #</th>
<th>Quantity</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>01777_8</td>
<td>Identification of list.</td>
</tr>
<tr>
<td>1b</td>
<td>77340_8</td>
<td>Special synchronization bits.</td>
</tr>
<tr>
<td>2a</td>
<td>DUMPLOC</td>
<td>See Telemetry (page TELE-7).</td>
</tr>
<tr>
<td>2b</td>
<td>TIME1</td>
<td>Least significant half of computer clock.</td>
</tr>
</tbody>
</table>

Erasable Memory Bank

3-130 Cells in bank (addresses sent in consecutive increasing order).
Testing Routines

SELFCHK  Address set as initial condition for SELFRET in "STARTSB2"
          Perform "SMODECHK" (will not return unless self-check is desired)
          Proceed to "ERASCHK"

SMODECHK

SKEEPl = Return address

Perform "CHECKNJ" (returns immediately if no new job waiting, and otherwise returns after doing job(s))

If SMODE = +0:
          Proceed to second line of "SMODECHK"

If |SMODE| ≤ 8:
          SCOUNT = SCOUNT + 1

If SMODE = -0, proceed to address specified by SKEEPl

If |SMODE| = 1, 2, 3, 6, 7, or 8: (10g = decimal 8)
          Proceed to address specified by SKEEPl

If |SMODE| = 4, proceed to "ERASCHK"

If |SMODE| = 5, proceed to "ROPECHK"

SMODE = 0 (magnitude exceeded 8)
          Proceed to "SELFCHK"

PRERRORS

If ERESTORE = 0, proceed to "ERRORS"

E'SKEEPl = SKEEPSt (from other part of routine)

ERESTORE = 0

Proceed to "ERRORS"

ERRORS

Inhibit interrupts (released upon return from alarm routine)

SFAIL = Return address (to routine calling "PRERRORS" or "ERRORS")
ALMCADR = SFAIL
ERACOUNT = ERACOUNT + 1
Perform "ALARM2" (pattern 1102₈)
If SMODE = -0:

Proceed to address specified by SFAIL

If SMODE > 0:

SMODE = +0

Proceed to "SELFCHK"

ERASCHK

SKEEP₂ = 1 (flag to check cells 006₁₈ - 137₃₁₈)
EBANK = 0
SKEEP₇ = 146₁₈ (first cell in bank 0 to be checked, since cells 0 - 60₈ are "special" erasable cells)
SKEEP₃ = 177₇₁₈ (last cell)

Proceed to "ERASLOOP"

ERASLOOP

Inhibit interrupts
SKEEP₄ = EBANK  (non-zero EBANK loads bits 1₁₁ - 9)
SKEEP₅dp = E⁻SKEEP₇dp  (address also determined by EBANK)
ERESTORE = SKEEP₇
E⁻SKEEP₇ = SKEEP₇  (loads with own S-register address)
E⁻SKEEP₇+₁ = SKEEP₇ + 1
If E⁻SKEEP₇ - E⁻SKEEP₇+₁ ≠ -₁, perform "PRERRORS"
If ERESTORE ≠ 0:

E⁻SKEEP₇dp = -E⁻SKEEP₇dp
If E⁻SKEEP₇+₁ - E⁻SKEEP₇ ≠ -₁, perform "PRERRORS"
If ERESTORE ≠ 0:

E⁻SKEEP₇dp = SKEEP₅dp
ERESTORE = 0
Release interrupts
Perform "CHECKNJ"

EBANK = bits 11-9 of SKEEP4

SKEEP7 = SKEEP7 + 1

If SKEEP3 - SKEEP7 ≠ 0:
    Proceed to "ERASLOOP"

If SKEEP2 > 0:
    SKEEP2 = SKEEP2 - 1 (sets 0)
    SKEEP7 = 00618 (unswitched erasable form of bank 0)
    SKEEP3 = 13738 (SKEEP4 - SKEEP7 not checked, cells 1374 - 7)
    Proceed to "ERASLOOP"

SKEEP2 = 1
EBANK = EBANK + 1, modulo 8 (7 + 1 = 0)

If EBANK = 2:
    SKEEP7 = 14008
    SKEEP3 = 17738 (cells 1374-7 not checked)
    Proceed to "ERASLOOP"

If EBANK ≠ 0:
    SKEEP7 = 14008
    SKEEP3 = 17778
    Proceed to "ERASLOOP"

EBANK = 3

Read out cells from 00608 to 00108 to check on their parity (addresses 00078 - 00008 have no parity bits), by a CS (Clear Subtract) order

Check cycle and shifting registers; if difficulty, perform "PRERRORS"

SCOUNT+1 = SCOUNT+1 + 1

Perform "SMODECHK"

Proceed to "ROPECHK" (if return from "SMODECHK")
ROPECHK

SKEEP6 = -0  (indicates "ROPECHK" option)
SKEEP4 = 0    (bank number)
SKEEP7 = 1    (counter for reading fixed-fixed banks)
SKEEP1 = 0    (sum)
SKEEP3 = 0    (address read)
SKEEP5 = 1    (counts two TC self words for end of bank data)

Proceed to "COMADRS"

SHOWSUM+2  Entered from "GOSHOSUM" for V91E

SKEEP6 = 1  (indicates "SHOWSUM" option)
SMODE = +0
SELFRET = "SELFCHK"

Proceed to second line of "ROPECHK"

COMADRS

SKEEP2 = SKEEP3, SKEEP4  (address determined by 2000_8 + SKEEP3
for S-register; bits 15-11 of SKEEP4
for FBANK; bits 7-5 of SKEEP4 for FEXT)
SKEEP1 = SKEEP1 + SKEEP2

If |SKEEP1| ≥ 16384:

SKEEP1 = SKEEP1 - 16383 sgn SKEEP1

TS = (2000_8 + SKEEP3) - SKEEP2  (zero if cell contains TC self
order, since TC is op code "0")

Proceed to "ADRSCHK"

ADRSCHK

If bits 10-1 of SKEEP3 = 1777_8, proceed to "SOPTION"  (just read
last bank cell)

If SKEEP5 < 0, proceed to "SOPTION"  (just read cell following
two TC self orders)

If TS ≠ 0, SKEEP5 = 1

If TS = 0, SKEEP5 = SKEEP5 - 1  (goes +1, +0, -1)
If SKEEP6 = -0:
  Perform "CHECKNJ"

If SKEEP6 > 0:
  Check NEWJOB cell for job of higher priority than present
  job (which has priority 308 from "KEYCOM"), and do
  that job if it exists, proceeding when present job
  again of highest priority.

  SKEEP3 = SKEEP3 + 1

If SKEEP7 > 0, proceed to "COMADRS"

Proceed to "FXADRS"

**FXADRS**

  SKEEP2 = E^{SKEEP3} \quad (S-register contents determined by SKEEP3 only
  for fixed-fixed memory cell)

  SKEEP1 = SKEEP1 + SKEEP2

If |SKEEP1| > 16384:
  SKEEP1 = SKEEP1 - 16383 \text{ sgn SKEEP1}

  TS = SKEEP3 - SKEEP2

Proceed to "ADRSCHK"

**SOPTION**

  TS = bits 15-11 of SKEEP4, cycled left 5 places (puts FBANK
  information in bits 5-1)

If bits 8-1 of SKEEP4 ≠ 0: \quad (reading super-bank cells, i.e. > 308)
  TS = bits 3-1 of TS + (bits 8-2 of SKEEP4 shifted right 1 place)

If SKEEP6 > 0:
  SKEEP3 = SKEEP2
  SKEEP2 = TS
  MPAC+2 = "SKEEP1"
(If SKEEP6 \(> 0\)):

\[ \text{TS} = 0501_{\text{vn}} \]

Proceed to "GOXDSPF": if terminate, proceed
else, proceed to "NXTBNK"

SKEEP1 = "SELFCHK"

Proceed to "ENDEXT"

SKEEP1 = \(|\text{SKEEP1}|\)

If SKEEP1 - TS - 1 \(\neq -1\), perform "PHRRORS"

Proceed to "NXTBNK"

**NXTBNK**

If SKEEP4 = \(K_{\text{stbnk}}\):

If SKEEP6 \(> 0\), proceed to second line of "ROPECHK"

Proceed to "SELFCHK"

Increment bits 14-11 of SKEEP4 by 1 (FBANK scaling)

If SKEEP4 overflows (i.e. previous value of these bits 17\(\_8\)):

\[ \text{SKEEP4} = 20_{\text{g}} \text{ (in bits 15-11)} \]

If SKEEP4 bits 15-11 = 0 (i.e. previous value 37\(\_8\)):

\[ \text{SKEEP4} = \text{SKEEP4} + 60020_{\text{g}} \text{ (sets FBANK to 30\(\_8\) in bits 15-11, and increments FEXT in bits 7-5)} \]

If SKEEP4 = 60000\(\_8\): (bits 15-11 = 30\(\_8\))

\[ \text{SKEEP4} = 60060_{\text{g}} \text{ (sets FEXT bits, 7-5, to 3)} \]

If SKEEP7 \(> 0\):

\[ \text{SKEEP7} = \text{SKEEP7} - 1, \text{ limited} \geq +0 \]

Proceed to fourth line of "ROPECHK"

If SKEEP7 = +0:

\[ \text{TS} = 1 \]

Proceed to "FXFX"

**TEST-6**
If $SKEEP7 = -1$:

$$TS = +0$$

Proceed to "FXFX"

If $SKEEP7 = -0$:

$$SKEEP7 = 64 \text{ (larger than number of remaining banks)}$$

Proceed to fourth line of "ROPECHK"

**FXFX**

$$SKEEP7 = -TS$$

If $TS \neq 0$:

$$SKEEP3 = 04000_8 \text{ (first cell in "bank 2")}$$

If $TS = 0$:

$$SKEEP3 = 06000_8 \text{ (first cell in "bank 3")}$$

$SKEEP1 = 0$

$SKEEP5 = 1$

Proceed to "FXADRS"

**IMU Performance Testing**

The computations associated with the IMU performance testing (PO7) have been partially removed from fixed memory. For continuity purposes, the following information on the computations formerly done at the start of PO7 (based on the H2 flight program) is provided.

1. Program display set to 07.
2. DRIFTT $sp$ set 0.
3. GEOCOMP1 set 0 (logic checking for this cell = 0 not shown).
4. LENGTHOT set to 898 seconds.
5. 1SECXT1 and 1dPIPADT set to one second interval.
6. WANGI set to $- \cos \theta$; WANGO set to $\sin \theta$.
7. IMU coarse aligned to 0°.
8. Computations progressed to "GEOIMUTT".
GEOIMUTT

Perform "IMUZERO"

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

NDXCTR = 0

WANGT = 0

\[ X_{dc} = (1, 0, 0) \]

\[ Y_{dc} = (0, \sin \text{azimuth}, \cos \text{azimuth}) \]

\[ Z_{dc} = (0, -\cos \text{azimuth}, \sin \text{azimuth}) \]

Perform "CALCGLA"  (here if MODREG ≠ 3, since should be 7)

Perform "IMUOARS"

If bit 14(GLOKFAIL) of FLAGWRD3 = 1:

\[ \text{NDXCTR} = \text{NDXCTR} + 1 \]

Set bit 14(GLOKFAIL) of FLAGWRD3 = 0

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

If NDXCTR > 0:

Proceed to "PIPACHK"

Perform "IMUFINE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

Call "GOESTIMS_d" in PERFDLAYdp centi-seconds

Put present job to sleep (starting address id = "ESTIMS_d")

\[ \text{GOESTIMS}_d \]

Awaken job with starting address id = "ESTIMS_d"

End of task  (since WANGT = 0, "ONCEMORE" will go to "TORQUE")
Inhibit interrupts

GTSWTLTl = TIME1

PIPA = 0

Release interrupts

Zero erasable memory cells 5,1453 - 5,1570: includes least significant half of DRIFTT, KGAINAZ, KGINVRD, KGINNSD, ANGX, ANGY, ANGZ, INTY, INTZ, DRIFT0, DRIFT1, VLAUN, VLAUNz, ACCWDy, ACCWDz, POSNVy, POSNVz, and ALTIM.

GCOMPSW = 0
ALX1S = 144
CMPX1 = -1
KGAINPIP = K soupy0
KGAINERC = K soupy2
GCOMP = 0
DELY = 0

Proceed to "SLEEPIE_d"

SLEEPIE_d

If WANGT > 0:

Perform "EARTH"*

Perform "CHKCOMED"

Inhibit interrupts

TS = GTSWTLTl - TIME1

If TS > 0:

TS = TS - 163.83 seconds (should be 163.84)

TS = TS + 1SECXTl

If TS ≤ 0:

TS = 0.04 seconds

Call "ALLOOP_d" in TS seconds
Release interrupts
End of job

\textbf{ALLOOP}d

\texttt{GTSWTLT1 = TIME1}
\texttt{TS = ALTIM}
Set restart grp. 5 to cause restart at next line
If \( TS = +0 \):
  \texttt{ALTIMS} = +0
  \texttt{ALTIM} = -0
If \( TS = -0 \):
  \texttt{ALTIM} = +0
If \( TS < 0 \): (should not be positive non-zero)
  \texttt{ALTIM} = - (|\texttt{ALTIM}| - 1) \ (\text{if was -1, result is -0})
Set \texttt{DELV} = \texttt{PIPA} and \texttt{PIPA} = +0 \ (\text{no special restart provisions})
Set restart group 5 to cause restart at next line
Establish "\texttt{ALFLT}_d" \ (priority 22d)
End of task

\textbf{ALFLT}_d

\texttt{TS = DELV \left[ X_{sm} \right]}
\texttt{DPIPAY = - TS}\_y
\texttt{DPIPAZ = TS}\_z
If \( ALTIMS \geq 0 \):
  \texttt{TS} = 144 - \texttt{ALXIS}
  \texttt{ALTIM} = \texttt{ALFDK}\_TS (\text{for T seconds, set to } -(T - 2))
  \texttt{ALTIMS} = \texttt{ALFDK}\_TS+1 \ (\text{e.g. set to -1})
  \texttt{BUFTCP} = \texttt{ALFDK}\_TS+2 \ (\text{"a}_1\)"
  \texttt{BUFTCERC} = \texttt{ALFDK}\_TS+4 \ (\text{"a}_2\)"

\texttt{TEST-10}
(if ALTIMS > 0):

\[
\begin{align*}
BUFSLP_AZ &= \text{ALFD}X_{TS+6} \quad (\text{"a}_3") \\
BUFSLP_VRD &= \text{ALFD}X_{TS+8} \quad (\text{"a}_4") \\
BUFSLP_NSD &= \text{ALFD}X_{TS+10} \quad (\text{"a}_5") \\
\text{ALXIS} &= \text{ALXIS} - 12 \\
\text{INTY} &= \text{INTY} - K_{\text{pipasc}} \quad \text{(i.e. "p}_0\text{"), south PIPA)} \\
\text{DELM}_y &= K_{\text{vesc}} \text{ VLAUN}_y - \text{INTY} \quad (\text{"A}_M^1") \\
\text{INTZ} &= \text{INTZ} - K_{\text{pipasc}} \quad \text{("p}_0\text{", east PIPA)} \\
\text{DELM}_z &= K_{\text{vesc}} \text{ VLAUN}_z - \text{INTZ} \quad (\text{"A}_M^2") \\
\text{KGAINPIP} &= \text{BUFTCPIP} \text{ KGAINPIP} \quad (\text{"K}_1") \\
\text{KGAINERC} &= \text{BUFTCERC} \text{ KGAINERC} \quad (\text{"K}_2") \\
\text{INTY} &= \text{INTY} + \text{KGAINPIP} \text{ DELM}_y \quad (\text{"p}_0\text{"}) \quad \text{(tag "AIKLp")} \\
\text{KGAINAZ} &= \text{KGAINAZ} + \text{BUFSLP_AZ} \quad (\text{"K}_3") \\
\text{ANGX} &= \text{ANGX} + 4 \text{ KGAINAZ} \text{ DELM}_y \quad (\text{"alpha")} \\
\text{VLAUN}_y &= \text{VLAUN}_y + K_{\text{asko}} \text{ DELM}_y \quad (\text{"v}_1\text{"}) \\
\text{ANGZ} &= \text{ANGZ} + \text{KGAINERC} \text{ DELM}_y \quad (\text{"gamma")} \quad \text{(tag "AIKLp")} \\
\text{KGAINVRD} &= \text{KGAINVRD} + \text{BUFSLP_VRD} \quad (\text{"K}_4") \\
\text{DRIFTO} &= \text{DRIFTO} + 4 \text{ KGAINVRD} \text{ DELM}_y \quad (\text{"d}_x") \\
\text{ACCWD}_y &= \text{ACCWD}_y + K_{\text{ask2}} \text{ DELM}_y \quad (\text{"a}_8") \\
\text{INTZ} &= \text{INTZ} + \text{KGAINPIP} \text{ DELM}_z \quad (\text{"p}_0\text{")} \quad \text{(tag "AIKLp")} \\
\text{KGAINNSD} &= \text{KGAINNSD} + \text{BUFSLP_NSD} \quad (\text{"K}_5") \\
\text{DRIFTI} &= \text{DRIFTI} + 4 \text{ KGAINNSD} \text{ DELM}_z \quad (\text{"d}_y") \\
\text{VLAUN}_z &= \text{VLAUN}_z + K_{\text{asko}} \text{ DELM}_z \quad (\text{"v}_1\text{e")} \\
\text{ANGY} &= \text{ANGY} + \text{KGAINERC} \text{ DELM}_z \quad (\text{"beta")} \quad \text{(tag "AIKLp")} \\
\text{ACCWD}_z &= \text{ACCWD}_z + K_{\text{ask2}} \text{ DELM}_z \quad (\text{"a}_e") \quad \text{(for indexing, a dummy "K}_6\text{", value 0, is generated)} \\
\text{T}_Z &= [\text{TRANSM}] \quad (\text{POSNV}_y, \text{ VLAUN}_y, \text{ ACCWD}_y) \quad (\text{tag "LOOSE")} \\
(\text{POSNV}_y, \text{ VLAUN}_y, \text{ ACCWD}_y) &= \text{T}_Z \\
\text{T}_Z &= [\text{TRANSM}] \quad (\text{POSNV}_z, \text{ VLAUN}_z, \text{ ACCWD}_z)
\end{align*}
\]

TEST-11
\[
(\text{POSNV}_z, \text{VLAUN}_z, \text{ACOWD}_z) = T_S
\]
\[
\text{SNANG}_i = \sin K_{\text{georgj}} \text{ ANGi} \quad (i = X,Y,Z)
\]
\[
\text{CSANG}_i = \cos K_{\text{georgj}} \text{ ANGi} \quad (i = X,Y,Z)
\]
Proceed to erasable memory cell 34008 (E7,1400)

NOTE: Following coding was in earlier programs (Sundisk) and is supplied for continuity purposes only. Fixed memory information is at "ONCEMORE" and onward.

\[
\text{INTY} = \text{INTY} + \text{SNANGZ}
\]
\[
\text{INTZ} = \text{INTZ} + \text{SNANGY \ CSANGZ}
\]
\[
\text{WPLAT} = \text{DRIFTO} - \text{WANGO} (\text{CSANGY \ CSANGZ}) - \text{WANGI} (\text{SNANGX \ SNANGY} + \text{CSANGX \ CSANGY \ SNANGZ})
\]
\[
\text{WPLAT} = \text{WANGT} \text{ WANGI} + \text{WANGO} \text{ SNANGZ} + \text{DRIFTI} - \text{WANGI} \text{ CSANGX \ CSANGZ}
\]
\[
\text{WPLAT} = \text{DRIFTT} - \text{WANGO} \text{ SNANGY \ CSANGZ} + \text{WANGI} (\text{SNANGX \ CSANGY} - \text{CSANGX \ SNANGY \ SNANGZ})
\]
\[
\text{TS} = (\text{WPLAT} \text{ CSANGX} + \text{WPLAT} \text{ SNANGY})/ \text{CSANGZ}
\]
\[
\text{ANGX} = \text{ANGX} + K_{\text{georgk}} \text{ TS}
\]
\[
\text{ANGY} = \text{ANGY} + K_{\text{georgk}} (\text{WPLAT} + \text{TS} \text{ SNANGZ})
\]
\[
\text{ANGZ} = \text{ANGZ} + K_{\text{georgk}} (\text{WPLAT} \text{ CSANGY} - \text{WPLAT} \text{ SNANGY})
\]
If overflow has taken place since start of job:

Proceed to "SOMEERRR"

NOTE: This ends coding taken from earlier programs (Sundisk); presumably the erasable coding now transfers to "ONCEMORE"

\[
\text{ONCEMORE}
\]
If LENGTHOT > 0:

\[
\text{LENGTHOT} = \text{LENGTHOT} - 1
\]
Proceed to "SLEEPED"

If WANGT > 0:

\[
\text{LOSVC} = \text{CDU}_X
\]
\[
\text{OGC} = \left[\frac{X}{sm}\right] (- K_{\text{georgj}}) \text{ (ANGX, ANGY, ANGZ)}
\]
\[
\text{TS} = "\text{OGC}"
\]

TEST-12
Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2" otherwise, proceed

If $WANGT > 0$:

Proceed to "VALMIS"

$\text{ERVVECTOR} = K_{\omega} (\sin C_{\omega d}, -\cos C_{\omega d}, 0)$

$T_{\text{mark}} = T_{\text{now}}$

$\text{ERCOMP} = 0$

Proceed to "TORQUE"

SOMEERRR

Perform "ALARM" (pattern 16008)

Proceed to second line of "SOMERR2"

TORQUE

$\text{DSPTEM2} = 0$ (forces R1 of N98 = 0)

$\text{DSPTEM2+1} = \text{DRIFTI}_{\text{sp}}$

$\text{TS} = \text{POSITON} - 1$

$\text{SOUTHDRTS} = \text{DRIFTI}_{\text{sp}}$

Perform "SHOW"

Proceed to "PIPACHK"

PIPACHK

Proceed to erasable memory cell 20008 (E4,1400)

VALMIS

$\text{DSPTEM2+1} = \text{DRIFTO}_{\text{sp}}$

$\text{DSPTEM2+0} = 0$ (forces R1 of N98 = 0)

Perform "SHOW"

Proceed to second line of "SOMERR2"
SHOW

DSPTEM2+2 = POSITON

T3  0698 vn

Proceed to "GOFLASH": if terminate, proceed to 2nd line of "SOMERR2"
   if proceed, proceed
   otherwise, proceed to "SHOW"

Return
Quantities in Computations

See also list of major variables and list of routines

ldPIPADT: See IMU Computations.

1SECXT1: See Prelaunch Alignment (set to 1 second for gyro drift determination).

ACCWD, ACCWD: Value of "horizontal acceleration of launch vehicle" (due to gravity) in north-south and east-west directions respectively, scale factor B9, units cm/sec^2.

ALFDK: Table of erasable memory quantities used in "ALFLT" to update values of parameters to be used for filtering in gyro drift computations. The table consists of five double precision constants, one single precision constant (the setting for ALTIM), and a reset value of ALTMS (which could be e.g. -1 for all tables). Values must be initialized by an erasable memory load (with the first value at "ALFDK", octal cell 2022), with settings for ALTIM, ALTMS, BUFTCPIP, BUFTCERC, BUFSLPAZ, BUFSLPVRD, and BUFSLPNSD stored in that order (first two single precision, remainder double precision). Scale factor of first two assumed B14, and the remainder assumed B0, in this writeup. See below for "typical" values (obtained from Sundisk program, when information was in fixed memory).

ALMCADR: See General Program Control.

ALTIM: Single precision value of time remaining prior to change in filter constants for drift measurements, scale factor B14, units seconds. To cause a set of gains to be used for T seconds, ALTIM is set to -(T - 2).

ALTMS: Single precision flag cell set to 0 when a gain change should be made (see ALTIM), and then reset (e.g. to -1) when the gain change has been done, scale factor B14.

ALX1S: Single precision cell, scale factor B14, used to control selection of values from ALFDK erasable memory table (set to 144 in "ESTIMS_d").

ANGX, ANGY, ANGZ: Values of determined angle changes about vertical, south, and east axes respectively, scale factor B0, units revolutions: they are "azimuth alignment angle", "south axis leveling angle", and "east axis leveling angle" respectively (alpha, beta, gamma in official equation documentation).

BUFSLPAZ, BUFSLPNSD, BUFSLPVRD: Set of buffer cells used to contain the values of the slopes of the gains for azimuth angle, north-south drift, and vertical drift respectively, scale factor B0, read from ALFDK table set. Cells are ALDK+4, ALDK+8, and ALDK+6 respectively.

BUFTCERC, BUFTCPIP: Set of buffer cells used to contain the values of the "time constants" for the erection angles ("east axis leveling angle" and FIPPA outputs, scale factor B0, as read from ALFDK table set. Cells are ALDK+2 and ALDK.
Catd: See Prelaunch Alignment.

C azimuth: See Prelaunch Alignment.

CMPXl: Single precision cell, scale factor B14, used to set proper contents of index register X1 to permit use of an index loop (X1 is set successively to ± 1) to perform calculations in "ALFITd": use of the cell is not shown in this writeup.

CSANGi (i = X,Y,Z): Values of cosine of ANGX, ANGY, and ANGZ, scale factor B1, stored in push-down list locations 16D, 18D, and 20D respectively.

DELM, DELM: Value of measurement quantity in south and easterly directions used in drift test, scale factor B-2, units radians.

DPIPAY, DPIPAZ: See Prelaunch Alignment.

DRIFTI: Value of gyro drift measurement output displayed in "TORQUE", scale factor (assumed) B0, units "radians", giving the "south gyro drift".

DRIFTO: Value of gyro drift measurement output displayed in "VALMIS", scale factor (assumed) B0, units "radians", giving the "vertical gyro drift".

DRIFTT: Input "drift" to gyro drift determination routine (to separate "east gyro drift" from "azimuth error"), scale factor B0, units radians. It has only its most significant half loaded by calling routines, with the least significant half set 0.

EBANK: See Data Input/Output.

ERCOMP: See Prelaunch Alignment.

ERCOUNT: Single precision cell, scale factor B14, used to count the number of errors encountered in the self-check routine. The cell is initialized to 0 as part of a verb 36 fresh start, and may be read as the third component of noun 08.

ERESTORE: Single precision cell, initialized to 0 as part of a fresh start, used for control purposes in functions associated with the erasable memory checking ("ERASLOOP") portion of the self-check program. It is set to the S-register portion of the lower of the two erasable memory cells being checked (the same as SKEEP?) before these cells are altered. If a restart is encountered, the "GOPROG" routine checks that bits 15-11 of the word are zero (i.e. it is less than 2000, as required for erasable memory cells), and that it is equal to SKEEP? (assuming, of course, the word in non-zero). Both conditions must be satisfied before SKEEP? (for EBANK) and SKEEP? address information are used to restore the cells; if one is not, then a fresh start is performed. Since
the ERESTORE cell (address 1360 Hex) is subject to erasable memory cell checks, when it does not necessarily contain the same data as SKEEP7, a fresh start may be forced even though SKEEP4 and SKEEP7 (neither of these cells are used for change purposes in the erasable memory check routine, since upper limit is 1373 Hex) is sufficient to permit restoration of erasable memory contents.

ERVECTOR: See Prelaunch Alignment.

FBANK: Hardware register cell (address 0004 Hex) used to contain the fixed memory bank number (if in range 30 Hex - 37 Hex, FEXT is also used). See 3420.5-27 for details (only bits 15-11 are used).

FEXT: Computer hardware channel (channel 07, also referred to as SUPERBANK) used to select the appropriate fixed-memory bank for FBANK settings of 30 Hex or more. Only bits 7-5 are used, with a setting of 3 selecting banks 3i; a setting of 4 selecting banks 4i (bank 43 is the last one in the computer). See 3420.5-27 for details.

GCOMP: See IMU Computations.

GCOMPSW: See IMU Computations.

GEOCOMPl: See Prelaunch Alignment. Set to +0 to indicate gyro drift measurement, but this logic not shown in this writeup. Instead, the zero-value case is in this writeup and the non-zero case in Prelaunch Alignment.

GTSWTLTl: See Prelaunch Alignment.

INTY, INTZ: Value of filtered accelerometer output (corrected for vehicle sway etc.) used in gyro drift test, scale factor B-2, units radians. Could also be considered to be "south" and "east" velocity increments expressed in units of g's (see \( K_{\text{pipasc}} \)).

\( K_{\text{ask0}} \): Constant, program notation "ALSK", scale factor B12, value 0.17329931. Value corresponds to 0.72402338 x 980.402 x 2^{-12}, where first term is "wind-induced sway velocity gain" (official equation documentation notation \( K_{\text{w}} \)), second converts DELM to units of cm/sec (i.e. units of \( V_{\text{LAN}} \), cf. \( K_{\text{pipasc}} \)), and third term is scale factor.

\( K_{\text{ask2}} \): Constant, program notation "ALSK +2", scale factor B12, value -0.00835370. Value corresponds to 0.03490074 x (-1) x 980.402 x 2^{-12}, where first term is "wind-induced sway accelerometer gain" (official equation documentation notation \( K_{\text{8}} \)), second is an equation factor, third converts to units of cm/sec^2 (cf. \( K_{\text{pipasc}} \)), and fourth term is scale factor.
K_georgj: Constant, program notation "GEORGEJ", scale factor B-2, value 0.63661977. Value corresponds to \((1/2\pi) \times 2^2\), to convert between radians and revolutions (the interpretive language trig functions require angle measurements in revolutions).

K_georgk: Constant formerly incorporated in fixed memory for use in IMU calibration computations. Value was 0.59737013, scale factor B-13. This corresponded to about \(7.2921158 \times 2^{-13}\), where first term is earth rate in rad/sec (period of about 86164.0912 seconds).

K_omegms: See Prelaunch Alignment.

K_pipasc: Constant, program notation "PIPASC", scale factor B-7, value 0.76376833. Value corresponds to \(5.85 \times (1/980.402) \times 2^7\), where first term is nominal accelerometer scale factor (cm/sec per count), second is normalization factor (acceleration due to gravity), and third is scale factor. For convenience in description, a fourth factor of "1/second" has been assumed reflected in this constant, giving for units of result (in INTY etc.) "radians".

K_soupy0: Constant, program notation "SOUPLY", scale factor B0, used in "ESTIMS_d" to initialize KGAINPIP. Value is 0.93505870.

K_soupy2: Constant, program notation "SOUPLY +2", scale factor B2, used in "ESTIMS_d" to initialize KGAINERC. Value is 0.26266423, corresponding to a "true value" of about 1.05065692.

K_stbnk: Single precision constant, program notation "LSTBNKCH", octal value 66100, corresponding to an FBANK value (bits 15-11) of 33 and an FEXT value (bits 7-5) of 4, i.e. a final "bank" readout of bank 43, the final computer hardware fixed memory bank.

K_vesc: Constant, program notation "VELSC", scale factor B-9, value -0.52223476. Value corresponds to \((-1) \times (1/980.402) \times 2^9\), where first term is an equation factor, second converts for acceleration due to gravity (cf. K_pipasc), and third is scale factor.

KGAINAZ, KGAINERC, KGAINNSD, KGAINPIP, KGAINVRD: Values of gains updated each cycle in gyro drift determination computations. KGAINERC and KGAINPIP are initialized to non-zero values in "ESTIMS_d" and multiplied by "time constants" for "ejection angles" and "PIPA outputs" respectively, with scale factors due to initialization of B2 (KGAINERC) and B0. The others (KGAINAZ, KGAINNSD, and KGAINVRD) are initialized to 0 values in "ESTIMS_d", and are incremented each cycle to achieve varying gains for "azimuth angle", "north-south drift", and "vertical drift" respectively: all are considered to have scale factor B0 (see ALFDK). Program notation for the quantities is ALK+4, ALK+2, ALK+8, ALK+0, and ALK+6 respectively.

LENGTHOT: Single precision cell, scale factor B14, used to contain time duration information. Initialization must be done as part of erasable memory pre-load (in Prelaunch Alignment is initialized by coding).

LOSVC2: Single precision cell, program notation "LOSVEC +1", scale factor B-1, units revolutions, loaded with CDU in "ONCEMORE".
NDXCTR: Single precision cell, scale factor B14, initialized to 0 in "GEOMUTT" and incremented to 1 for a "gimbal lock" return from "CALOGA" (angle of 60° or more).

NEWJOB: See General Program Control.

OGC: See Coordinate Transformations (used also as communication cell).

PERFDLAY: See Prelaunch Alignment (for gyro drift test, must be set manually to some value).

PIPA: See IMU Computations.

POSITION: Single precision cell, scale factor B14, used for indexing and display purposes (used in previous programs to select desired stable member orientation from fixed memory information). Must be loaded manually (inputs in "SHOW" do not change it).

POSNV_y, POSNV_z: Values of "horizontal displacement of launch vehicle" in south and east directions respectively, assumed scale factor B9, units cm ("assumed" since scaling of [TRANSMIT] elements not known, but treated as B1).

SCOUNT, SCOUNT+1: Pair of single precision counters, scale factor B14, used to count the number of executions of portions of the self-check program. SCOUNT is incremented each time "SMODECHK" is entered with SMODE ≠ +0 and with magnitude below 9; SCOUNT+1 is incremented each time "ERASLOOP" is completed (at the end of the test). Both quantities are modulo 2^14, and would have to be initialized manually since they are not preset as part of a fresh start (V36E), if a "true count" were desired. A value of SCOUNT = 3 (if set 0 before SMODE made e.g. 1) means that the self-test erasable and fixed memory checks have been completed. Addresses are 1366_8 and 1367_8 respectively.

SELFRET: See General Program Control.

SFAIL: Single precision cell used in "ERRORS" routine to retain return address information (and hence data on the cause of the self-check difficulty). Contains the same information as ALMCGADR if no subsequent alarms (from sources other than self-check) are generated; it is not preset 0 by program unless error reset input.

SKEEP1: Self-check register #1, used to retain return address information from "SMODECHK" and the value of the bank sum while being formed. If the "SHOWSUM" option (V91E) is used, it contains the value of the sum as displayed in R1 (can be either + or -, and if + should be equal to the bank number; if minus should be the complement of the bank number). If self-check memory verification is done, is replaced by the magnitude of the sum before checking against the bank number.
SKEEP2: Self-check register #2, used in erasable memory check routine as a flag (if non-zero) to cause unswitched erasable to be checked (cells 0061g - 1372g, plus 1373A partially) after completion of checks for each erasable bank (these cells are in banks 0-2, which should be read for any value of EBANK). Cell is used in fixed memory check routine to contain the contents of the fixed memory cell just read; in the "SHOWSUM" option, it contains the fixed memory bank number (00 - 43g) displayed in R2, which should be the same as the magnitude of SKEEPI (value of SKEEPI is displayed in R1).

SKEEP3: Self-check register #3, used in erasable memory check routine to contain the value of the last address to be checked (i.e. one more than the final value of SKEEP7 actually used). The routine checks cells in pairs in ascending order (starting with the cell initialized in SKEEP7), and SKEEP3 specifies the final cell forming the upper half of a pair (SKEEP7 +1). Cell is used in fixed memory check to contain for fixed-fixed memory the S-register information (4000g - 7777g), and for fixed-switchable memory the S-register information decreased by 2000g. For the "SHOWSUM" option, cell is loaded with the final value of SKEEP2, which gives the final word read from memory (the "bugger word", designed to make the sum of all words in the memory, including itself, equal in magnitude to the bank number) for the bank, and is displayed in R3.

SKEEP4: Self-check register #4, used in erasable memory check routine to contain the erasable memory bank of the cells being checked (employed in "G0PROG" to reset EBANK, cf. ERESTORE). In fixed memory check routine, bits 15-11 are used to contain the appropriate setting for FBANK and bits 7-5 the appropriate value for FEXT.

SKEEP5: Self-check register #5, used with SKEEP6 in erasable memory check routine to retain the previous value of the cell being checked (to permit restoration of the cell in "G0PROG" or at the end of the test segment checking the cell). Used in fixed memory check routine to monitor for the presence of two TC self ("transfer control to the present step") orders, indicating that the following cell should be the final one entering the sum (bank sum also halted after last cell in bank has been read). If step not a TC self, SKEEP5 set to +1; if it is, cell is decreased by 1, and after reaching -1 the routine is halted for that bank after the next ("bugger", see SKEEP3) word is incorporated into the sum. Since the operation code for the TC order is 0, a "TC self" instruction (which, of course, would cause a hardware restart if encountered in the course of a program execution) appears as OAAAAg, where AAAA is the S-register address of the cell in question, in range 2000g - 7777g.
SKEEP6: Self-check register #6, used with SKEEP5 in erasable memory check routine to retain the previous value of the upper half of the pair of cells being checked (cf. SKEEP5). In the fixed memory check routine, is set to -0 to indicate that the "ROPECHK" option is used (automatic check for proper memory sum, part of self-check sequence, with no display unless difficulty); and is set to +1 to indicate that the "SHOWSUM" option is used (enabled by verb 91 from "GOSHOSUM", giving a DSKY display of each bank's sum, number, and "bugger word", with no automatic check for proper memory sum).

SKEEP7: Self check register #7, used in erasable memory check routine to contain the S-register portion of the erasable memory address of the lower half of the pair of cells being checked (see discussion with ERRESTORE above). In fixed memory check, is used as an identification of when the two fixed-fixed banks (bank 2 and bank 3, S-register addresses starting at 4000₇ and 6000₇ respectively) are to be read.

SMODE: Single precision cell, scale factor B14, used to control the performance of the computer self-check routines, and examined whenever no active jobs are to be done (and, of course, no tasks). It is set to +0 as part of a fresh start, and can be loaded using N27. A +0 value causes the self-check routine to be bypassed; values of magnitude 9 or more cause SMODE to be reset to 0; a value of 4 causes the erasable memory check to be done; a value of 5 causes the fixed memory check to be done; and other values (-0, 1,2,3,6,7, or 8) cause the complete self-check to be done. If SMODE is positive, an error will cause it to be reset 0, while if it is negative the self-check will be started again (except for a value of -0, which causes the self-check computations to be started at the point after the failure, as determined by SFAIL).

SNANGi (i = X,Y,Z): Value of sine of ANGX, ANGY, and ANGZ, scale factor B-2, stored in push-down list locations 10D, 12D, and 14D respectively.

SOUTHDR.: Indexed cell used in "TORQUE" to retain the value of DRIFTI for subsequent use by erasable memory program.

Tmark: See Prelaunch Alignment.
[TRANSML]: Transformation matrix used as a "sway transition matrix", contained in erasable memory (must be initialized to values as part of an erasable memory load before running test). Assumed scaling in this writeup for all elements is B1 (after being used to perform multiplication, a left shift of 1 is done). Values from a previous program (Sundisk, which used fixed memory cells) were:

\[
\begin{bmatrix}
0.47408845 & 0.23125894 & 0.14561689 \\
-0.06360691 & -0.16806746 & 0.15582939 \\
-0.06806784 & -0.75079894 & -0.24878704
\end{bmatrix}
\]

These values are the "stored" ones, and must be multiplied by two to find the "true" values:

\[
\begin{bmatrix}
0.94817690 & 0.46251788 & 0.29123378 \\
-0.12721382 & -0.33613492 & 0.31165878 \\
-0.13613568 & -1.50159788 & -0.49757408
\end{bmatrix}
\]

VLAUN, VLAUN: Value of "horizontal velocity of launch vehicle" (due to sway) in north-south and east-west directions respectively, scale factor B9, units cm/sec.

WANGI: Value of (- cos C_\text{atd}), scale factor BO.

WANGO: Value of (sin C_\text{atd}), scale factor BO.

WANGT: Quantity set to 0 if no torquing is performed and to 1 (scale factor BO) if torquing is to be performed via "EARTHST" at the start of "SLEEPIE". Program notation also "TORQNDX, TORQNDX+1". If it is non-zero, WANGI term is included in computation of WPLATI.

WPLATI, WPLATO, WPLATT: Quantities computed in "ALFLT_d", scale factor BO, normalized by earth rotation rate (hence are converted to angles, for the one-second gyro drift evaluation cycle, by multiplication by K_\text{georga}). The "I" is south, the "O" is vertical ("azimuth"), and the "T" is east.
Values of ALFDK information from an earlier program (Sundisk)

<table>
<thead>
<tr>
<th>Index</th>
<th>Time</th>
<th>ALTIM</th>
<th>BUFTCIP</th>
<th>BUFTCERC</th>
<th>BUFSLPAZ</th>
<th>BUFLPVRD</th>
<th>BUFLPNSD</th>
</tr>
</thead>
<tbody>
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<td>-28</td>
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<td>.81193187</td>
<td>-.00035882</td>
<td>-.00000029</td>
<td>.00013262</td>
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<td>.98940595</td>
<td>-.00079010</td>
<td>-.00000265</td>
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<td>.99852047</td>
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<td>.00043452</td>
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</tr>
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<td>.99888274</td>
<td>.00000064</td>
<td>-.00040120</td>
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<td>791-1200</td>
<td>-408</td>
<td>.99963845</td>
<td>.99913162</td>
<td>.00000090</td>
<td>.00002927</td>
<td>-.00000026</td>
</tr>
<tr>
<td>84</td>
<td>1201-1700</td>
<td>-498</td>
<td>.99934865</td>
<td>.99868793</td>
<td>.00000055</td>
<td>.00001183</td>
<td>-.00000005</td>
</tr>
<tr>
<td>96</td>
<td>1701-2100</td>
<td>-398</td>
<td>.99947099</td>
<td>.99894799</td>
<td>.00000018</td>
<td>.00000300</td>
<td>-.00000001</td>
</tr>
<tr>
<td>108</td>
<td>2101-2700</td>
<td>-598</td>
<td>.99957801</td>
<td>.99916095</td>
<td>.00000007</td>
<td>.00000096</td>
<td>0</td>
</tr>
<tr>
<td>120</td>
<td>2701-3400</td>
<td>-698</td>
<td>.99966814</td>
<td>.99933952</td>
<td>.00000002</td>
<td>.00000028</td>
<td>0</td>
</tr>
<tr>
<td>132</td>
<td>3401-4000</td>
<td>-598</td>
<td>.99972716</td>
<td>.99945654</td>
<td>.00000001</td>
<td>.00000010</td>
<td>0</td>
</tr>
</tbody>
</table>

The "index" column gives the value of the ALFDK index required to obtain the ALTIM setting (see "ALFLT_d"). The columns are headed with the cells into which the ALFDK information is loaded (ALTIMS, a single precision cell, could be loaded with the same value, e.g. -1, for all entries to the table).
Uplink Processing

V70UPDAT (verb 70)

UPVERBSV = 0

Proceed to second line of "V73UPDAT"

V71UPDAT (verb 71)

UPVERBSV = 1

Proceed to second line of "V73UPDAT"

V72UPDAT (verb 72)

UPVERBSV = 2

Proceed to second line of "V73UPDAT"

V73UPDAT (verb 73)

UPVERBSV = 3

Perform "TESTXACT"

If |MODREG| ≠ 0:

If bit 9(UTFLAG) of FLAGWRD8 = 1:

If MODREG = 20:

Proceed to "UPDATEOK"

If MODREG ≠ 2:

Set bit 7(Operator error) of channel 11 = 1

Set bit 3(Uplink activity) of channel 11 = 0

Proceed to "ENDEXT"

Proceed to "UPDATEOK"

UPDATEOK

UPOLDMOD = MODREG

UPVERB = UPVERBSV

UPCOUNT = 1

DNLSTC0D = 1  (Tag here "UPPART2")

UPLK-1
TS = 27 and perform "NEWMODEX"

If UPVERB = 0 or 3:
    COMPNUMB = 2
    Proceed to "OHWELL2"

    Proceed to "OHWELL1"

**OHWELL1**

MPAC+2 = "UPBUFF"

TS = 2101 vn

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"
    if proceed, proceed to second line of "OHWELL1"
    otherwise, proceed

If MPAC+0 = 32, proceed to second line of "OHWELL1" (recycle verb)
If UPBUFF - 2 < 0, proceed to second line of "OHWELL1"
If UPBUFF - 21 > 0, proceed to second line of "OHWELL1"

    COMPNUMB = UPBUFF+0
    UPCOUNT = UPCOUNT +1
    Proceed to "OHWELL2"

**OHWELL2**

MPAC+2 = "UPBUFF" + UPCOUNT - 1

TS = 2101 vn

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"
    if proceed, proceed to second line of "OHWELL2"
    otherwise, proceed

If MPAC+0 = 32, proceed to second line of "OHWELL2" (recycle verb)
If COMPNUMB - UPCOUNT > 0:
    UPCOUNT = UPCOUNT + 1
    Proceed to "OHWELL2"

    Proceed to "UPVERIFY"
**UPVERIFY**

\[ MPAC+2 = "UPTEMP" \]

\[ TS = 2102\text{ vn} \]

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"  
if proceed, proceed to "UPSTORE"  
otherwise, proceed

If \( MPAC+0 = 32 \), proceed to second line of "UPVERIFY" (recycle verb)
If \( UPTEMP \leq 0 \), proceed to "UPVERIFY"
If \( \text{COMPNUMB} + 1 - \text{UPTEMP} \leq 0 \), proceed to "UPVERIFY"

\[ MPAC+2 = \text{"UPBUFF"} + \text{UPTEMP} - 1 \]

Proceed to second line of "OHWELL2"

**UPSTORE**

Complement bit 3(VERIFLAG) of FLAGWRD7

If \( UPVERB \geq 3 \):

\[ \text{UPBUFF}+8_{dp} = \text{UPBUFF}+0_{dp} \]

Perform "TIMEDIDL": if error return, proceed
otherwise, skip next line

Set bit 7(Operator error) of channel 11 = 1

Proceed to second line of "UPOUT"

Establish "UPJOB" (priority 308) (has a VAC area for "INTSTALL")

End of job

**UPJOB**

Perform "INTSTALL"

Set bit 13(INTGRAB) of FIGWRD10 = 1

If \( UPVERB = 0 \):

\[ \text{UPBUFF}+8_{dp} = - \text{UPBUFF}+0_{dp} \]
(If UPVERB = 0):

Perform "TIMEDIDL": if error return, proceed otherwise, skip next 2 lines

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

\[ \text{UPBUFF+1}_d p = - \text{UPBUFF+0}_d p \]
\[ \text{UPBUFF+2}_d p = - \text{UPBUFF+0}_d p \]

Set \( \text{TS} = \text{UPBUFF+1}_d p \) and \( \text{UPBUFF+1}_d p = 0 \)

\[ \text{Tetcm} = \text{Tetcm} + \text{TS} \]

Set \( \text{TS} = \text{UPBUFF+2}_d p \) and \( \text{UPBUFF+2}_d p = 0 \)

\[ \text{Tetlm} = \text{Tetlm} + \text{TS} \]

Set \( \text{TS} = \text{UPBUFF+0}_d p \) and \( \text{UPBUFF+0}_d p = 0 \)

\[ \text{Teph} = \text{Teph} + \text{TS} \]

Proceed to "UPOUT"

If UPVERB = 1:

\[ \text{EBANK} = \text{bits 11-9 of UPBUFF+1} \]
\[ \text{UPTEMP} = \text{bits 8-1 of UPBUFF+1} \]
\[ \text{TS} = \text{UPTEMP} + \text{COMPNUMB} - 3 \]

If \(|\text{TS}| > 0:\)

If bit 9 of \( \text{TS} \) = 1: (e.g. 4008, indicating next EBANK)

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

\[ \text{TS} = \text{COMPNUMB} - 3 \]

\[ \text{TS}_1 = 14008 + \text{UPTEMP} \]

Perform the following for \( i = \text{TS} \) to \( i = 0 \): (interrupts inhibited)

\[ E_{\text{TS}_1+i} = \text{UPBUFF}_{2+i} \]
\[ i = i - 1 \]

Proceed to "UPOUT"
If UPVERB = 2: (as it will)

If bit 1 of COMPNUMB = 0: (i.e. not an odd number)

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

TS = COMPNUMB - 2

Perform the following for i = TS to i = 1: (interrupts inhibited)

EBANK = bits 11-9 of UPBUFF

TS  = 1400s + bits 8-1 of UPBUFF

ETS  = UPBUFF  

i = i - 2

Proceed to "UPOUT"

TIMEDIDL

Set UPBUFF + 18dp = T_now and T_now = 0

Set TS = UPBUFF + 8dp and UPBUFF + 8dp = 0

TS = TS + UPBUFF + 18dp

If |TS| ≥ 2^28:

Set TS = UPBUFF + 18dp and UPBUFF + 18dp = 0

T_now = T_now + TS

Return to calling address +1 (indicating an error)

Force sign agreement of TS

T_now = T_now + TS

Return to calling address +2 (non-error return)

UPOUT

Proceed to "INTWAKEU" (which exits to next line)

TS = UPOLDMOD and perform "NEWMODEX"

TS = MODREG - 1

If |TS| = 1: (i.e. UPOLDMOD was 0 or 2)

DNLSTCOD = 0
If TS > 1: (i.e. UPOLDMOD was 20)

DNLSTCOD = 2

Set bit 3(Uplink activity) of channel 11 = 0

Proceed to "ENDEXT"

**INTWAKEU**

If UPSVFLAG ≠ 0:

R' = rect
V' = Vrect
TDELTAV = 0
TNUV = 0
Tc = 0
XKEEP = 0

If UPSVFLAG > 0:

Perform "MOVEACSM"

If bit 1(AVEMIDSW) of FLAGWRD9 = 0:

\[ R = R' + TDELTAV \]
\[ V = V' + TNUV \]
\[ T_{pptm} = T_{et} \]

If UPSVFLAG < 0:

Perform "MOVEALEM"

\[ R_{\text{other}} = R' + TDELTAV \]
\[ V_{\text{other}} = V' + TNUV \]

(Time tag T_{etlm})

Set bit 1(RENDWFLG) of FLAGWRD5 = 0 (Tag here "INTWAKEX")

Channel 77 = 0 (resets restart monitor flip-flops)

UPSVFLAG = 0

QPRET = Return address (to line after next)

Perform "INTAKE" (starting at 3rd from last line, awaken jobs)

Proceed to second line of "UPOUT"
Quantities in Computations

See also list of major variables and list of routines

**COMPNUMB**: Single precision cell, scale factor B/4, containing the total number of uplink data quantities to be sent. It is set to 2 for verbs 70 and 73; for verb 71 it is set to the first data quantity (and hence must be equal to the number of data words +1 (for address of first word) +1 (for its own setting)); for verb 72, it is likewise set to the first data quantity (since each data word is preceded by its address, it therefore must be 2 x data words +1). For verbs 71 and 72, values of COMPNUMB below 3 (the minimum for one data word) or above 20 are rejected: this gives for verb 71 a maximum of 18 single precision data words (or 9 double precision ones, sufficient e.g. for a 3 x 3 matrix), and for verb 72 a maximum of nine single precision data words.

**DNLSTCOD**: See Telemetry.

**EBANK**: See Data Input/Output.

**MPAC+0**: Cell loaded in display routine with the verb that is received (also used for other functions).

**MPAC+2**: Cell used for communication purposes with display routine, to provide the address into which a quantity (for e.g. noun 01 or 02) is to be loaded (also used for other functions).

**QPRET**: See Orbital Integration.

R
other, R_rect**: See Orbital Integration.

**RCV**: See Orbital Integration.

T
_c**: See Orbital Integration.

T
eph**: See Boost Computations.

T
et', T etcm, T etlm**: See Orbital Integration.

**TDELTAV, TNUV**: See Orbital Integration.

**UPBUFF**: Set of 20 cells (UPBUFF+0 through UPBUFF+19) used to contain the uplinked information as it is received. Also used for temporary storage of time information, after completion of the update sequence, for verbs 70 and 73. Cells are loaded during the entry phase of flight with guidance parameters for telemetry purposes. The address of UPBUFF+0 is 003048. The last 18 cells of the UPBUFF set also are used for storage of \(X_{\text{state}}\): consequently, if it is desired to uplink this preferred IMU alignment for use in P52/P54, this must be the last uplink that is sent before P52/P54 uses the data.
UPCOUNT: Single precision quantity, scale factor Bl4, containing the serial number of the UPBUFF cell to be loaded next. If cell UPBUFF+n is to be loaded, UPCOUNT = (n +1). When UPCOUNT = COMPNUMB, it is concluded that the basic load has been completed, and the option for "line-by-line" corrections is enabled, during which UPCOUNT does not change.

UPOLDMOD: Single precision cell, scale factor Bl4, used to contain the value of MODRED when an update verb is received, and used to restore its proper value (-0, 0, 2, or 20) after the end of the update sequence.

UPSVFLAG: Single precision cell, scale factor Bl4, assigned a cell in erasable memory just before the first component of R, rect, and set by the update loading process to cause proper processing of a state vector update. The cell is checked in "INTWAKEU", and if non-zero it is concluded that a state vector update was done (if positive, a CSM state vector; if negative, an OWS state vector), and after processing the cell is reset 0 (which is also the initial condition set in "DOFSTART").

UPTEMP: Single precision cell used for temporary storage purposes. In the "line-by-line" correction mode, it contains the loaded value of the component serial number (defined as for UPCOUNT) into which the correction is to be loaded, scale factor Bl4. The address of UPTEMP is 003308.

UPVERB: Single precision quantity, scale factor Bl4, containing information on the update verb being performed: for verbs 70-73, it is set to 0-3 respectively.

UPVERBSV: Single precision cell, scale factor Bl4, used to retain information on the update verb received while a determination is made if it is allowed: if it is, then UPVERBSV is loaded into UPVERB.

\( \vec{V}_{\text{other}}, \vec{V}_{\text{rect}} \): See Orbital Integration.

VCV: See Orbital Integration.

XKEP: See Orbital Integration.
Uses of Update Verbs

Verb 70

Verb 70 could be considered a "liftoff time update." Its transmission format is:

\[ V\,70\,E\,XXXXX\,E\,XXXXX\,E \quad (\text{then} \, V\,33\,E) \]

where the "X" information is an octal double precision increment to be added to \( T_{\text{now}} \) and subtracted from the computer clock and the state vector times for CSM and OWS, scale factor \( B_{28} \), units centi-seconds. If liftoff were sensed 5 seconds late, for example, then the transmission should be:

\[ V\,70\,E\,77777\,E\,77013\,E \quad (V\,33\,E) \quad (\text{then} \, V\,33\,E) \quad (-\,77013_8 = 764_8 = 500 \, \text{cs}) \]

in order to correct the AGC time information to reflect the proper "liftoff time" (note that V70 keeps the sum of \( T_{\text{now}} \) and the computer clock constant by changing them in opposite directions). If only the computer clock (\( T_{\text{now}} \)) is to be updated, then verb 73 could be used.

Verb 71

Verb 71 is used to perform a "contiguous block update". Its transmission format is:

\[ V\,71\,E\,ii\,E\,AAAA\,E\,XXXXX\,E\,XXXXX\,E \quad \ldots \quad XXXX\,E \quad (V\,33\,E) \]

where the "ii" information is the setting for COMPNUMB, and is two more than the number of data words (i.e. number of XXXX E's +2). The AAAA information is the erasable memory address into which the first XXXXX data word is to be loaded (successive words are loaded into successive cells), and must be sufficiently compatible with the value of ii so as to avoid requiring erasable memory bank switching. AAAA is in ECADR format, meaning that bits 11-9 give the E-bank number and bits 8-1 the address within the bank (which, for hardware reasons, is added to 1400_8 within the program). Since there is no lockout (aside from bank-switching constraints) on the value of AAAA, caution must be observed to avoid destroying computer control cells (the "ENDSAFE" lockout present in e.g. Sundisk has been deleted).

Verb 72

Verb 72 is used to perform a "scatter update". Its transmission format is:

\[ V\,72\,E\,ii\,E\,A_1\,A_1\,A_1\,A_1\,E\,XXXXX\,E\,A_2\,A_2\,A_2\,A_2\,E\,XXXXX\,E \quad \ldots \quad (V33E) \]

where the "ii" information is again the setting for COMPNUMB, and is equal to two times the number of data words plus 1 (and hence must be odd, as well as at least 3 and below 21, i.e. maximum 19 here). The A's are specified for each 15-bit word individually, with no constraints imposed by the software on addresses which may be changed.
Verb 73

Verb 73 is used to perform an "octal clock increment" (verb 55 can be used to perform the same function for decimal input of hours, minutes, and centi-seconds), and has the following transmission format:

V 73 E XXXXX E XXXXX E (then V 33 E)

where the "X" information is an octal double precision increment to be added to the computer clock (note that the V70 uplink time is subtracted from the computer clock), scale factor B28, units centi-seconds.

Sample Update Sequences

1. To load the components of \([\text{REFSMMAT}]\) (double precision elements, scale factor B1), the following sequence could be used:

V 71 E 24 E 1717 E (COMPNUMB = 20; "REFSMMAT" = 3,1717)

XXXXX E XXXXX E (row 1 column 1)
XXXXX E XXXXX E (row 1 column 2)
etc.
XXXXX E XXXXX E (row 3 column 3)
V 33 E (accept)

2. To load the components of \([\mathbf{x}_{\text{smd}}]\) (preferred IMU orientation, see Inflight Alignment), the same sequence as in #1 could be used, except that the address instead of being 1717 should be 0306("\mathbf{x}_{\text{smd}}" = "UPBUFF" +2).

3. To load a CSM state vector update, the following sequence could be used:

V 71 E 21 E 1501 E (COMPNUMB = 17; "UPSVFLAG" = 3,1501)

00001 E
XXXXX E XXXXX E \(R_{\text{rect}}\)
Y-component
Z-component
XXXXX E XXXXX E \(V_{\text{rect}}\)
Y-component
Z-component
XXXXX E XXXXX E \(T_{et}\) value
V 33 E (accept)

4. To load an OWS state vector update, the same sequence as in #3 could be used, except that the UPSVFLAG setting, rather than being 00001, should be 77776.
5. To load an External Delta-V (P30) update, the following sequence could be used:

\[ V \, 71 \, E \, 12 \, E \, 3404 \, E \quad \text{(COMPNUMB} = 10; \text{"DELVLVG"} = 7,1404) \]

\[ \begin{align*}
XXXXX \, E \, XXXXX \, E \quad & \quad \text{DELVLVG}_x \\
\text{Y-component} & \\
XXXXX \, E \, XXXXX \, E \quad & \quad \text{DELVLVG}_y \\
\text{Z-component} & \\
V \, 33 \, E \\
\text{(accept)}
\end{align*} \]

6. To load an External Delta-V (P30) update for deorbit, the following sequence could be used:

\[ V \, 71 \, E \, 16 \, E \, 3400 \, E \quad \text{(COMPNUMB} = 14; \text{"LATSPL"} = 7,1400) \]

\[ \begin{align*}
XXXXX \, E \, XXXXX \, E \quad & \quad \text{LATSPL} \\
XXXXX \, E \, XXXXX \, E \quad & \quad \text{LNGSPL} \\
& \quad \text{(continue on as in item #5)}
\end{align*} \]

7. To perform an update of merely the entry parameters, the sequence of #6 could be used, stopping after LNGSPL (hence first few quantities would be \[ V \, 71 \, E \, 6 \, E \, 3400 \, E \]).

8. To load new values for erasable memory constants (such as IMU compensation parameters), see the list of cells in Erasable Memory Prelaunch Load (which is arranged in sequence of increasing addresses).
Verb Definitions

VERBFAN

If \((\text{VERBREG} - K_{st2cn}) \leq 0\):

Proceed to address specified by \(K_{\text{vtb,VERBREG}}\)

\(TS = \text{VERBREG} - K_{st2cn}\)

Perform "RELDSP"

Proceed to address specified by \(K_{st2fn,TS}\)

AIM/END

Set bit 7(Operator error) of channel 11 = 1

Proceed to "FINBRNCH"

TESTXACT

If \(\text{EXTVBACT} > 0\):

Proceed to "ALM/END"

If bits 14(PRICIDLE), 12(PDSPFLAG), and 7(PROWTKEY) of \(\text{FLAGWRD4} \neq 0\):

Proceed to "ALM/END" (priority display using DSKY)

\(\text{EXTVBACT} = 000248\) (sets bits 5 and 3 to 1)

\(TS = -2\) and perform "NVSUB": if busy, proceed (blank R1-R3 otherwise, proceed and noun)

Check for new job waiting to be performed, and do it if required

Return

VBSTLTS (verb 35)

If \(\text{MODREG} \neq 0\):

Proceed to "ALM/END"

Inhibit interrupts (released in "DELAYJOB" performance)

Set bit 1(IMPTSTBT) of \(\text{IMODES33} = 1\)

Set bits 7(Operator error), 6(Flash), 5(Key Release), 4(Temperature Caution), 3(Uplink Activity), and 1(ISS Warning) of channel 11 = 1
DSPTAB+11 = 006508 and flag for output at next opportunity
(bit 9 is Program alarm, bit 8 Tracker alarm, bit 6
Gimbal lock, and bit 4 No attitude) (Note if restart, "GOPROG"
put IMU into coarse align)

Set bit 10 (Test DSKY lights) of channel 13 = 1

Set DSPTAB+0 to DSPTAB+10 so that all registers display "8" and
R1, R2, and R3 display plus signs, and flag for output at
next opportunity

NOUT = 11

Delay K shots seconds (by putting job to sleep via "DELAYJOB")
Proceed to "TSTLTS3"

TSTLTS3

Set bits 7, 4, 3, and 1 of channel 11 = 0 (interrupts inhibited
during routine)
Set bit 10 of channel 13 = 0

TS = bit 4 (Coarse align) of channel 12

DSPTAB+11 = TS, and flag for output at next opportunity (bit 4 is
No attitude) (Note that bit 9, Program alarm, set 0 even
if FAILREG+0 ≠ 0)

Set bit 1 (LMPTSTBT) of IMODES33 = 0
Set bits 13–11 (PIP2FLBT, DNLKFAIL, UPLKFAIL) of IMODES33 = 1
Set bit 15 (TLIMBIT) of IMODES30 = 0
Set bits 13, 12, and 10 (IMUFLEIT, ICDFLEIT, PIPAFLBT) of IMODES30 = 1
Set bit 7 (OCDUFBIT) of OPTMODES = 1
Estimate "DSPMMJB" (priority 308)
MONSAVE1 = 400008 (sets bit 15 to 1)
Set bit 6 (Flash) of channel 11 = 0
Perform "RELDSP"
If CADRSTOR ≠ 0:
    Proceed to "PINBRNCH"
End of job
VBZERO (verb 40)
If IMUCADR ≠ 0:

Proceed to "ALM/END"
Perform "IMUZERO"
Perform "IMUSTALL": if error return, proceed otherwise, proceed

Proceed to "PINBRNCH"

VBCOARK (verb 41)
If NOUNREG ≠ 20: (ICDU)

If NOUNREG ≠ 91: (OCDU)

Proceed to "ALM/END"
If NOUNREG = 20:

Perform "TESTXACT" (Tag here "IMUCOARK")
TS = 2522 vn
Proceed to "GOXDSPP": if terminate, proceed to "ENDEXT"
if proceed, proceed otherwise, proceed

TS = 4100 vn
Perform "EXDSPRET"
If IMUCADR ≠ 0:

Set bit 7 (Operator error) of channel 11 = 1
Proceed to "ENDEXT"
Perform "IMUCOARS"
Perform "IMUSTALL": if error return, proceed otherwise, proceed

Proceed to "ENDEXT"
If MODREG ≠ 0: (N91) (Tag here "OPTCOARK")

Proceed to "ALM/END"
Perform "TESTXACT"

If SWSAMPLE \leq 0:  (switch not at computer position)
    Set bit 7 (Operator error) of channel 11 = 1
    Perform "ALARM" (pattern 0115g)

If OPTIND = -0:  (Not expected in view of POO restriction)
    Perform "ALARM" (pattern 0117g)
    Proceed to "ENDEXT"

TS = 2492vn
Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
    if proceed, proceed otherwise, proceed

DESOPTS = SAC  (loaded in R1 of N92)
DESOPTT = PAC  (loaded in R2 of N92)
TS = 4100vn
Perform "EXDSPRET"

OPTIND = 1
Proceed to "ENDEXT"

IMUFINEK  (verb 42)
Perform "TESTXACT"

TS = 2593vn
Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
    if proceed, proceed otherwise, proceed

TS = 4200vn
Perform "EXDSPRET"

If IMUCADR \neq 0:
    Set bit 7 (Operator error) of channel 11 = 1
    Proceed to "ENDEXT"

Perform "IMUFINE"
Perform "IMUSTALL": if error return, proceed to "ENDEXT"
otherwise, proceed

TS = "OGC"

Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed
otherwise, proceed

Proceed to "ENDEXT"

**IMUATTCK** (verb 43)

If MODREG ≠ 0, proceed to "AIM/END"

If bits 4-5 (IMU Coarse align, IMU Zero) of channel 12 ≠ 002:

Proceed to "AIM/END"

Perform "CKLFTBTS": if after liftoff, proceed
if before liftoff, skip next line

Perform "TESTXACT"

Set bits 6 (Enable CDU IMU Error Counters) and 4 (IMU Coarse Align) of channel 12 = 0

TS = 2522 vn

Proceed to "GOXDSPF": if terminate, proceed to "TRMATTCK"
if proceed, proceed
otherwise, proceed

Perform "NEEDLE11"

Perform "NEEDLER2"

Call "ATTCK1" in 0.02 seconds

Proceed to "TRMATTCK"

**TRMATTCK**

Perform "CKLFTBTS": if after liftoff, proceed to "ENDEXT"
if before liftoff, proceed

Proceed to "PINBRNCH"

**ATTCK1**

AK = THETAD

Perform "NEEDLES"

End of task

VBDF-5
If bit 5(BKUPL0) of FLAGWRD5 = 0:

If bit 5(Liftoff complement) of channel 30 = 1:

Return to calling address +2 (before liftoff)

Return to calling address +1 (after liftoff)

DKDISP (verb 44)

See Digital Autopilot Interface Routines

DKDAPON (verb 45)

See Digital Autopilot Interface Routines

STABLISH (verb 46)

See Digital Autopilot Interface Routines

LMTOCMSV (verb 47)

Establish "LMTOCM" (priority 108)

End of job

Perform "INTSTALL"

Inhibit interrupts

\[ R_{\text{rectcm}} = R_{\text{rectlm}} \]

\[ V_{\text{rectcm}} = V_{\text{rectlm}} \]

\[ T_{\text{etcm}} = T_{\text{etlm}} \]

\[ \Delta V_{\text{cm}} = \Delta V_{\text{lm}} \]

\[ N_{\text{nuv}}_{\text{cm}} = N_{\text{nuv}}_{\text{lm}} \]

\[ R_{\text{rcv}}_{\text{cm}} = R_{\text{rcv}}_{\text{lm}} \]

\[ V_{\text{vcv}}_{\text{cm}} = V_{\text{vcv}}_{\text{lm}} \]

\[ T_{\text{ccm}} = T_{\text{clm}} \]

\[ X_{\text{KEP}}_{\text{cm}} = X_{\text{KEP}}_{\text{lm}} \]

Proceed to "TACHEXIT"
TACHEXIT

Release interrupts
Perform "MOVEPCSM"

If bit 1(AVEMIDSW) of FLAGWRD9 = 0:

\[ R = RCV + TDELTAV \]
\[ V = VCV + TNUV \]
\[ T_{pptm} = T_{et} \]
\[ R_{other} = RCV + TDELTAV \]
\[ V_{other} = VCV + TNUV \]

Perform "INTWAKE" (starting at 3rd from last line, awaken jobs)
Proceed to "PINBRNCH"

DAPDISP (verb 48)

See Digital Autopilot Interface Routines

CREWMANU (verb 49)

If MODREG ≠ 0, proceed to "ALM/END"
Perform "TESTXACT"
Establish "R62DISP" (priority 108)
End of job

GOLOADLV (verbs 50, 51, 53, 97, and 99)

Set bit 6(Flash) of channel 11 = 0
Proceed to "LOADLV"

GOTOR23 (verb 54)

Perform "TESTXACT"

If bit 7(RNDVZFLG) of FLAGWRDO = 1:

If bit 5(TRACKFLG) of FLAGWRDl = 1:

Establish "R23CSM" (priority 168)
End of job
Perform "ALARM" (pattern 0406_8)
Proceed to "ENDEXT"

ALINTIME (verb 55)
Perform "TESTXACT"

TS = 2524_vn
Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed to "ENDEXT"
otherwise, proceed

If MPAC+O \neq 23: (final verb not 23)
Proceed to "ENDEXT"

Inhibit interrupts
Set TS = T_{now} and T_{now} = 0
TS = TS + DSPEM2+1_{dp}, with sign agreement forced (DSPEM2+1_{dp} contents destroyed)
T_{now} = T_{now} + TS
Release interrupts
Proceed to "ENDEXT"

TRACKTRM (verb 56) Also entered from R60 or V34E to V06N49 in P20

Set bit 2(R67FLAG) of FLAGWRD8 = 0
If bit 9(UTFLAG) of FLAGWRD8 = 0:
  If bit 7(RNDVZFLG) of FLAGWRDO = 0:
    Proceed to "PINBRNCH"
    Set bit 7(AUTOSEQ) of FLAGWRD10 = 0
    Set bit 14(R21MARK) of FLAGWRD2 = 0
    Set bit 7(UPDATFLG) of FLAGWRD1 = 0
If bit 5(TRACKFLG) of FLAGWRD1 = 0:
  Set bit 7(RNDVZFLG) of FLAGWRDO = 0
  Set bit 9(UTFLAG) of FLAGWRD8 = 0
Proceed to "PINBRNCH"
Set bit 5(TRACKFLG) of FLAGWRD1 = 0
Set bit 8(IMUSE) and bit 7(RNDVZFLG) of FLAGWRDO = 0
Set bit 9(UTFLAG) of FLAGWRD8 = 0
Perform "INITSUBA"
Perform "INTSTALL"
Make restart groups 1 and 2 inactive
Inhibit interrupts
Proceed to "ENEMA"

V57CALL (verb 57)
Perform "TESTXACT"
OPTIONX = 4
TS = 0
If bit 2(FULTKFLG) of FLGWRD10 = 1: (bit used in "AUTOW", zero means have VHF and optics)
    TS = 1
OPTIONX+1 = TS
TS = 0412
Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
   if proceed, proceed to "ENDEXT" otherwise, proceed
If OPTIONX+1 = 0:
    Set bit 2(FULTKFLG) of FLGWRD10 = 0
If OPTIONX+1 ≠ 0:
    Set bit 2(FULTKFLG) of FLGWRD10 = 1
Proceed to third line of "V57CALL"

ENATMA (verb 58)
Set bit 15(V5ON18FL) of FLAGWRD3 = 1
Set bit 14(STIKFLAG) of FLAGWRD1 = 0
Proceed to "PINBRNCH"

NOTE that action taken based on data enter, not PRO, giving difficulty for display interruptions
DKJTENBL (verb 59)

CH5FAIL = 0

CH6FAIL = 0

Proceed to "PINBRNCH"

V60 (verb 60)

CPhix = CDU

Proceed to "PINBRNCH"

V61 (verb 61)

Set bit 9(NEEDLFLG) of FLAGWRDO = 0  (display DAP error)

Proceed to "PINBRNCH"

V62 (verb 62)

Set bit 6(N22ERNDS) of FLAGWRD9 = 1  (display N22 error)

Set bit 9(NEEDLFLG) of FLAGWRDO = 1

Proceed to "PINBRNCH"

V63 (verb 63)

Set bit 6(N22ERNDS) of FLAGWRD9 = 0  (display N17 error)

Set bit 9(NEEDLFLG) of FLAGWRDO = 1

Proceed to "PINBRNCH"

R64 (verb 64)

Perform "TESTXACT"

Establish "V64PERF" (priority 10^8)

End of job

CKOPTVB (verb 65)

If MODREG ≠ 02:

Proceed to "ALM/END"

Establish "GCOMPVER" (priority 16^8)

Proceed to "PINBRNCH"
ATTACHED (verb 66)

Establish "ATTACHIT" (priority 10g)

End of job

ATTACHIT

Perform "INTSTALL"

Inhibit interrupts

\[ R_{\text{rectlm}} = R_{\text{rectcm}} \]
\[ V_{\text{rectlm}} = V_{\text{rectcm}} \]
\[ T_{\text{tclm}} = T_{\text{tccm}} \]
\[ \text{DELTAV}_{\text{lm}} = \text{DELTAV}_{\text{cm}} \]
\[ \text{NUV}_{\text{lm}} = \text{NUV}_{\text{cm}} \]
\[ \text{RCV}_{\text{lm}} = \text{RCV}_{\text{cm}} \]
\[ \text{VCV}_{\text{lm}} = \text{VCV}_{\text{cm}} \]
\[ T_{\text{tclm}} = T_{\text{tccm}} \]
\[ \text{XKEP}_{\text{lm}} = \text{XKEP}_{\text{cm}} \]

Proceed to "TACHEXIT" (NOTE that Average-G cells \( R \) and \( V \) overwritten)

V67 (verb 67)

Perform "TESTXACT"

Establish "V67CALL" (priority 05g)

End of job

V7OPD (verb 70)

See Uplink Processing

V71UPDAT (verb 71)

See Uplink Processing

V72UPDAT (verb 72)

See Uplink Processing
V73UPDAT (verb 73)

See Uplink Processing

DNEDUMP (verb 74)

DNTMGOTO = "DNEDUMP"

Proceed to "PINBRNCH"

LPTFLGON (verb 75)

Set bit 5(BKUPLO) of FLAGWRD5 = 1

Proceed to "PINBRNCH"

V76CALL (verb 76)

Perform "TESTXACT"

TS = 0672

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"

if proceed, proceed

otherwise, proceed to previous line

Inhibit interrupts

Set bit 2(R27UP2) and bit 1(R27UP1) of FLGWRD11 = 0

Set bit 12(R27FLAG) of FLGWRD11 = 1

Proceed to "ENDEXT"

V77CALL (verb 77)

Set bit 12(R27FLAG) of FLGWRD11 = 0 (contrary to "RESETVHF",

Tracker light left alone)

Proceed to "PINBRNCH"

CHAZFOGC (verb 78)

If MODREG ≠ 02:

Proceed to "ALM/END"

Establish "AZMTHCG1" (priority 16)

Proceed to "PINBRNCH"
LEMVEC (verb 80)
Set bit 8(CSMUPDAT) of FLAGWRD1 = 0
Proceed to "PINBRNCH"

CSMVEC (verb 81)
Set bit 8(CSMUPDAT) of FLAGWRD1 = 1
Proceed to "PINBRNCH"

V82PERF (verb 82)
Perform "TESTXACT"
Change priority of present job to 07,8
Proceed to "V82CALL"

V83PERF (verb 83)
Perform "TESTXACT"
Set bit 4(R31FLAG) of FLAGWRD9 = 1
Establish "R31CALL" (priority 05,8)
End of job

V85PERF (verb 85)
Perform "TESTXACT"
Set bit 4(R31FLAG) of FLAGWRD9 = 0
Establish "R31CALL" (priority 05,8)
End of job

V86PERF (verb 86)
If MRKBUF1 > 0: (see notes with "MREJECT")
MRKBUF1 = -1
Proceed to "PINBRNCH"
If bit 7(R22CAFLG) of FLAGWRD9 = 1:
Set bit 12(REJCTFIG) of FLGWRD10 = 1
Proceed to "PINBRNCH"
SETVHFLG (verb 87)

Set bit 9(VHFRFLAG) of FLAGWRD9 = 1
Proceed to "PINBRNCH"

RESETVHF (verb 88)

Inhibit interrupts
Set bit 8(Tracker) of DSPTAB+11 = 0, and flag for output at next opportunity
Set bit 7(ODUFBIT) of OPTMODES = 1
Release interrupts
Set bit 9(VHFRFLAG) of FLAGWRD9 = 0
Proceed to "PINBRNCH"

V89PERF (verb 89)

If MODREG ≠ 0, proceed to "AIM/END"
Perform "TESTXACT"
Establish "V89CALL" (priority 10,)
End of job

V90PERF (verb 90)

Perform "TESTXACT"
Establish "R36" (priority 07,)
End of job

GOSHOSUM (verb 91)

If MODREG ≠ 0, proceed to "AIM/END"
Perform "TESTXACT"
Proceed to "SHOWSUM+2"

WMATRIXNG (verb 93)

Set bit 1(RENDWFLG) of FLAGWRD5 = 0
Proceed to "PINBRNCH"
VERB96 (verb 96)

Set bit 5 (QUITFLAG) of FLAGWRD9 = 1
Set bit 3 (V960NFLG) of FLAGWRD8 = 1 (reset in "STATINT1")
TS = 0

Proceed to "V37"
Quantities in Computations

See also list of major variables and list of routines

AK: See Digital Autopilot Interface Routines.

CADRSTOR: See Data Input/Output.

CH5FAIL, CH6FAIL: See Digital Autopilot Docked Jet Selection.

CPHIX: See Digital Autopilot RCS Routines.

DELTAV, DELTAV: See Orbital Integration.

DESOPTS, DESOPTT: See Optics Computations.

DNTMGOTO: See Telemetry.

EXTVBACT: Single precision cell several of whose bits are used to control various performance features of the extended verbs. If the cell is non-zero, this means that the "extended verb display system" is busy, and other users are locked out (hence the cell can be set non-zero deliberately to lock out other users). The individual bits are used as follows:

<table>
<thead>
<tr>
<th>Bit</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Set at start of &quot;P61&quot; and in &quot;NEWRNVN&quot; to inhibit extended verbs from using coding also used by P61 computations (e.g. R30 time-of-flight information).</td>
</tr>
<tr>
<td>12</td>
<td>Bit set 1 at end of &quot;COMPDISP&quot;, used in &quot;R31CALL&quot; (for R31 and R34) to delay start of first display until completion of loading of data cells.</td>
</tr>
<tr>
<td>5</td>
<td>Bit set 1 by &quot;TESTXACT&quot;, and used in &quot;COMPDISP&quot;, &quot;TICKTEST&quot;, and &quot;V82GON1&quot; to indicate, if 0, that a display response has been received (hence the cycling for updating of display should be stopped).</td>
</tr>
<tr>
<td>3</td>
<td>Set 1 in &quot;TESTXACT&quot; to indicate that display system extended verb portion is &quot;busy&quot; (not in general set for those extended verbs that do not require use of the display system &quot;mark/extended verb&quot; priority).</td>
</tr>
<tr>
<td>2</td>
<td>Set 1 in &quot;TESTMARK&quot; to indicate that optics marking system is in use.</td>
</tr>
</tbody>
</table>

IMODES30, IMODES33: See IMU Computations.

IMUCADR: See IMU Computations.
Kshots: Single precision constant, program notation "SHOLTS", scale
tfactor B14, units centi-seconds. Value is 500 x 2\(^{-14}\), corresponding
to 5 seconds.

K\(_{st2cn}\): Single precision constant, program notation "LST2CON", scale
factor B14, value 40. VERBREG values of this amount or greater are
considered "extended verbs".

K\(_{st2fn}\): Table of single precision addresses, program notation "LST2FAN",
giving (in the form of TC/TCF orders) starting addresses for
processing of VERBREG values between K\(_{st2cn}\) and 99. See table
below.

K\(_{vbt}\): Table of single precision addresses, program notation "VERBTAB",
giving (in the form of CADR addresses) the starting addresses
for processing of VERBREG values less than K\(_{st2cn}\). See table below.

MONSAVE1: See Data Input/Output.

MPAC+O: See Display Interface Routines (loaded with verb that is received).

MRKBUF1: See Optics Computations.

NOUNREG: See Data Input/Output.

NOUT: See General Program Control.

NUV\(_{cm}\), NUV\(_{lm}\): See Orbital Integration.

OGC: See Coordinate Transformations (scale factor could be considered
B21 in units of gyro pulses as well as B0 revolutions): is loaded
by N93.

OPTIND: See Optics Computations.

OPTIONX: See Display Computations.

OPTMODES: See Optics Computations.

PAC: See Coordinate Transformations (loaded by N92).

R\(_{other}\): See Orbital Integration.

R\(_{rectcm}\), R\(_{rectlm}\): See Orbital Integration.

RCV, RCV\(_{cm}\), RCV\(_{lm}\): See Orbital Integration.

SAC: See Coordinate Transformations (loaded by N92).

SWSAMPLE: See Optics Computations.

T\(_{ccm}\), T\(_{clm}\): See Orbital Integration.
T_{et}, T_{etcm}, T_{etlm}: See Orbital Integration.

T_{DELTAV}, T_{NUV}: See Orbital Integration.

V_{other}: See Orbital Integration.

\frac{V}{rectcm}, \frac{V}{rectlm}: See Orbital Integration.

\frac{V}{cm}, \frac{V}{cm}, \frac{V}{lm}: See Orbital Integration.

VERBREG: See Data Input/Output.

X_{KEP}_{cm}, X_{KEP}_{lm}: See Orbital Integration.
<table>
<thead>
<tr>
<th>Verb</th>
<th>Starts at</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>01</td>
<td>&quot;DSPA&quot;</td>
<td>Display in octal first component.</td>
</tr>
<tr>
<td>02</td>
<td>&quot;DSPB&quot;</td>
<td>Display in octal second component.</td>
</tr>
<tr>
<td>03</td>
<td>&quot;DSPC&quot;</td>
<td>Display in octal third component.</td>
</tr>
<tr>
<td>04</td>
<td>&quot;DSPAB&quot;</td>
<td>Display in octal first and second components.</td>
</tr>
<tr>
<td>05</td>
<td>&quot;DSPABC&quot;</td>
<td>Display in octal all three components.</td>
</tr>
<tr>
<td>06</td>
<td>&quot;DECDSP&quot;</td>
<td>Decimal display.</td>
</tr>
<tr>
<td>07</td>
<td>&quot;DSPDPDEC&quot;</td>
<td>Double precision decimal display.</td>
</tr>
<tr>
<td>08-10</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>11-17</td>
<td>&quot;MONITOR&quot;</td>
<td>Perform monitor function of type specified by least significant digit of verb (e.g. verb 13 does &quot;DSPC&quot; periodically).</td>
</tr>
<tr>
<td>18-20</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>21</td>
<td>&quot;ALOAD&quot;</td>
<td>Load first component.</td>
</tr>
<tr>
<td>22</td>
<td>&quot;BLOAD&quot;</td>
<td>Load second component.</td>
</tr>
<tr>
<td>23</td>
<td>&quot;CLOAD&quot;</td>
<td>Load third component.</td>
</tr>
<tr>
<td>24</td>
<td>&quot;ABLOAD&quot;</td>
<td>Load first and second components.</td>
</tr>
<tr>
<td>25</td>
<td>&quot;ABCLOAD&quot;</td>
<td>Load all three components.</td>
</tr>
<tr>
<td>26</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>27</td>
<td>&quot;DSPFMEM&quot;</td>
<td>Display contents of fixed memory.</td>
</tr>
<tr>
<td>28-29</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>30</td>
<td>&quot;VBRQEXEC&quot;</td>
<td>Request executive system (for a job).</td>
</tr>
<tr>
<td>31</td>
<td>&quot;VBRQWAIT&quot;</td>
<td>Request waitlist system (for a task).</td>
</tr>
<tr>
<td>32</td>
<td>&quot;VBRSEQ&quot;</td>
<td>Recycle verb (same calling-routine return as a data enter).</td>
</tr>
<tr>
<td>33</td>
<td>&quot;VBPROC&quot;</td>
<td>Proceed (without data) verb.</td>
</tr>
<tr>
<td>Verb</td>
<td>Starts at</td>
<td>Function</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>34</td>
<td>&quot;VBTERM&quot;</td>
<td>Terminate (activity or function) verb.</td>
</tr>
<tr>
<td>35</td>
<td>&quot;VBTSTLTS&quot;</td>
<td>Test lights of display system.</td>
</tr>
<tr>
<td>36</td>
<td>&quot;SLAP1&quot;</td>
<td>Perform a (manually initiated) fresh start.</td>
</tr>
<tr>
<td>37</td>
<td>&quot;MMCHANG&quot;</td>
<td>Change program (&quot;major mode&quot;).</td>
</tr>
<tr>
<td>38-39</td>
<td>&quot;DSPALARM&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>40</td>
<td>&quot;VBZERO&quot;</td>
<td>Zero IMU CDU's.</td>
</tr>
<tr>
<td>41</td>
<td>&quot;VBCOARK&quot;</td>
<td>Coarse align (IMU CDU N20; optics CDU N91).</td>
</tr>
<tr>
<td>42</td>
<td>&quot;IMUFINEK&quot;</td>
<td>Fine align IMU (optional pulse torquing).</td>
</tr>
<tr>
<td>43</td>
<td>&quot;IMUATTCK&quot;</td>
<td>Load FDAO attitude error needles.</td>
</tr>
<tr>
<td>44</td>
<td>&quot;DKDISP&quot;</td>
<td>Load Docked DAP (R04).</td>
</tr>
<tr>
<td>45</td>
<td>&quot;DKDAPON&quot;</td>
<td>Activate Docked DAP.</td>
</tr>
<tr>
<td>46</td>
<td>&quot;STABILISH&quot;</td>
<td>Activate Undocked DAP.</td>
</tr>
<tr>
<td>47</td>
<td>&quot;LMTOCSMV&quot;</td>
<td>Move OWS state vector into CSM state vector.</td>
</tr>
<tr>
<td>48</td>
<td>&quot;DAPDISP&quot;</td>
<td>Load Undocked DAP (R03).</td>
</tr>
<tr>
<td>49</td>
<td>&quot;CREWMANU&quot;</td>
<td>Start crew-defined maneuver (R62).</td>
</tr>
<tr>
<td>50</td>
<td>&quot;GOLOADLV&quot;</td>
<td>Please perform.</td>
</tr>
<tr>
<td>51</td>
<td>&quot;GOLOADLV&quot;</td>
<td>Please mark.</td>
</tr>
<tr>
<td>52</td>
<td>&quot;ALM/END&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>53</td>
<td>&quot;GOLOADLV&quot;</td>
<td>Please mark alternate LOS.</td>
</tr>
<tr>
<td>54</td>
<td>&quot;GOTOR23&quot;</td>
<td>Start rendezvous backup sighting mark routine (R23).</td>
</tr>
<tr>
<td>55</td>
<td>&quot;ALINTIME&quot;</td>
<td>Increment computer clock (decimal input data).</td>
</tr>
<tr>
<td>56</td>
<td>&quot;TRACKTRM&quot;</td>
<td>Terminate tracking (P20).</td>
</tr>
<tr>
<td>57</td>
<td>&quot;V57CALL&quot;</td>
<td>Select FULTKFLG option (number of sensors).</td>
</tr>
<tr>
<td>58</td>
<td>&quot;ENATMA&quot;</td>
<td>Enable automatic attitude maneuvers in R61 and R67.</td>
</tr>
<tr>
<td>59</td>
<td>&quot;DKJTNBL&quot;</td>
<td>Enable all jets in Docked DAP.</td>
</tr>
<tr>
<td>Verb</td>
<td>Starts at</td>
<td>Function</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>60</td>
<td>&quot;V60&quot;</td>
<td>Set CPHI (N17) = CDU (N20).</td>
</tr>
<tr>
<td>61</td>
<td>&quot;V61&quot;</td>
<td>Display autopilot following error (the DAP &quot;Mode I&quot;) on FDAI error needles.</td>
</tr>
<tr>
<td>62</td>
<td>&quot;V62&quot;</td>
<td>Display autopilot total attitude error with respect to N22 (the DAP &quot;Mode II&quot;) on FDAI error needles.</td>
</tr>
<tr>
<td>63</td>
<td>&quot;V63&quot;</td>
<td>Display autopilot total attitude error with respect to N17 (the DAP &quot;Mode III&quot;) on FDAI error needles.</td>
</tr>
<tr>
<td>64</td>
<td>&quot;R64&quot;</td>
<td>Start Optics Angle Transform calculation (R64).</td>
</tr>
<tr>
<td>65</td>
<td>&quot;CKOPTVB&quot;</td>
<td>Optical verification of prelaunch alignment (P03).</td>
</tr>
<tr>
<td>66</td>
<td>&quot;ATTACHED&quot;</td>
<td>Move CSM state vector into OWS state vector.</td>
</tr>
<tr>
<td>67</td>
<td>&quot;V67&quot;</td>
<td>Start W-matrix RSS error display.</td>
</tr>
<tr>
<td>68</td>
<td>&quot;ALM/END&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>69</td>
<td>(one-step loop)</td>
<td>Cause a hardware restart (one-step loop).</td>
</tr>
<tr>
<td>70</td>
<td>&quot;V70UPDAT&quot;</td>
<td>Liftoff time update (P27).</td>
</tr>
<tr>
<td>71</td>
<td>&quot;V71UPDAT&quot;</td>
<td>Block address update (P27).</td>
</tr>
<tr>
<td>72</td>
<td>&quot;V72UPDAT&quot;</td>
<td>Single address update (P27).</td>
</tr>
<tr>
<td>73</td>
<td>&quot;V73UPDAT&quot;</td>
<td>Increment computer clock (P27). Input is in units of centi-seconds, as contrasted with the hours, minutes, seconds input of V55.</td>
</tr>
<tr>
<td>74</td>
<td>&quot;DNEDUMP&quot;</td>
<td>Initialize downlink erasable memory dump.</td>
</tr>
<tr>
<td>75</td>
<td>&quot;LFTFIGN&quot;</td>
<td>Set liftoff flag (for backup liftoff).</td>
</tr>
<tr>
<td>76</td>
<td>&quot;V76CALL&quot;</td>
<td>Enable R27 in R22.</td>
</tr>
<tr>
<td>77</td>
<td>&quot;V77CALL&quot;</td>
<td>Disable R27 in R22.</td>
</tr>
<tr>
<td>78</td>
<td>&quot;CHAZFOGC&quot;</td>
<td>Change gyrocompass launch azimuth.</td>
</tr>
<tr>
<td>79</td>
<td>&quot;ALM/END&quot;</td>
<td>Not assigned.</td>
</tr>
<tr>
<td>Verb</td>
<td>Starts at</td>
<td>Function</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>80</td>
<td>&quot;LEMVEC&quot;</td>
<td>Cause OWS state vector to be updated by navigation measurements (in P20).</td>
</tr>
<tr>
<td>81</td>
<td>&quot;CSMVEC&quot;</td>
<td>Cause CSM state vector to be updated by navigation measurements (in P20).</td>
</tr>
<tr>
<td>82</td>
<td>&quot;V82PERF&quot;</td>
<td>Request orbital parameter display (R30).</td>
</tr>
<tr>
<td>83</td>
<td>&quot;V83PERF&quot;</td>
<td>Request rendezvous parameter display #1 (R31, +X axis angle).</td>
</tr>
<tr>
<td>84</td>
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<td>85</td>
<td>&quot;V85PERF&quot;</td>
<td>Request rendezvous parameter display #2 (R34, optics angle).</td>
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<td>86</td>
<td>&quot;V86PERF&quot;</td>
<td>Reject rendezvous backup sighting mark.</td>
</tr>
<tr>
<td>87</td>
<td>&quot;SETVHFLG&quot;</td>
<td>Set VHF range flag (for R22).</td>
</tr>
<tr>
<td>88</td>
<td>&quot;RESETVHFLG&quot;</td>
<td>Reset VHF range flag (for R22).</td>
</tr>
<tr>
<td>89</td>
<td>&quot;V89PERF&quot;</td>
<td>Start rendezvous final attitude routine (R63).</td>
</tr>
<tr>
<td>90</td>
<td>&quot;V90PERF&quot;</td>
<td>Request rendezvous out-of-plane display (R36).</td>
</tr>
<tr>
<td>91</td>
<td>&quot;GOSHOSUM&quot;</td>
<td>Compute banksoms (of each fixed memory bank).</td>
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<td>93</td>
<td>&quot;WMATRIXNG&quot;</td>
<td>Reset W matrix flag (RENDWFLC) to enable initialization.</td>
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<td>94</td>
<td>&quot;ALM/END&quot;</td>
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<td>96</td>
<td>&quot;VERB96&quot;</td>
<td>Terminate integration and go to POO.</td>
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<td>97</td>
<td>&quot;GOLOADLV&quot;</td>
<td>Please perform engine-fail logic (R40).</td>
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<tr>
<td>99</td>
<td>&quot;GOLOADLV&quot;</td>
<td>Please enable engine ignition.</td>
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</table>
Index of Routines

The routines listed below are those included by specific tag in this document. They are arranged in the "alphabetical" order of the listing of symbols at the end of the program: "+", "+", "-", "/", A-Z, and 0-9.

<table>
<thead>
<tr>
<th>Symbol</th>
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<td>DATA-5</td>
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<td>MINK-6</td>
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<td>DATA-17</td>
<td>AUTO37</td>
<td>GENF-16</td>
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<td>DPRC-22</td>
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<td>REND-4</td>
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<td>STER-2</td>
<td>BAILOUT</td>
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<td>BIASEDZ</td>
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<td>GENF-24</td>
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<td>PREL-4</td>
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X-1
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<td>MEAS-14</td>
<td>DSPAB</td>
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<td>MEAS-22</td>
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<td>DPIR-2</td>
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<td>DPTV-3</td>
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<td>DATA-25</td>
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<td>PREL-2</td>
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<td>DATA-26</td>
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<td>DATA-25</td>
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<td>DATA-15</td>
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<td>DINT-2</td>
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<td>DATA-24</td>
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<td>DPTV-11</td>
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<td>GENP-7</td>
<td>FIXCW</td>
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<td>ATTM-14</td>
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<td>DATA-25</td>
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<td>GENP-7</td>
<td>FORCE</td>
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<td>DXCOMP</td>
<td>CONC-3</td>
<td>FREEFUNC</td>
<td>DPDF-9</td>
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<td>BURN-25</td>
<td>FWDFLTR</td>
<td>DPTV-9</td>
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<td>GEOIMUTT</td>
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<td>CONC-13</td>
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