CMC/LGC CLOCK SYNCHRONIZATION Routines (R33)

PURPOSE:
1. To synchronize the LGC clock with the CMC clock.

ASSUMPTIONS:
1. Synchronization requires the value of the difference between the two clocks. This value may be obtained directly from co-ordinated reading of the two clocks or may be provided by the ground from downlink monitoring of the clocks.
2. The CMC is on. The LGC must only be on until satisfactory comparative readings have been made by the crew or ground.
3. This routine is selected by the astronaut by DSKY entry.

PROG CMC GROUND CREW CHECKLIST TIME TOTAL
CONT

DO I HAVE A PRECISE VALUE FOR THE DIFFERENCE BETWEEN THE CMC AND LGC CLOCKS SUPPLIED FROM THE GROUND?

Y
N

WAIT FOR KEYBOARD ENTRY.

KEY IN CD 06N65

CONFIRM SELECTION OF THIS ROUTINE (R33) IN THE OTHER VEHICLE.

R33/COLOSSUS
R33/SUNDANCE
WAIT FOR KEYBOARD ENTRY

OBTAIN FROM THE LGC THE
LGC CLOCK TIME
OF SIMULTANEOUS ENTER INTO THE LGC
(VIA VOICE LINK).

COMPUTE TIME DIFFERENCE BETWEEN COMPUTER CLOCK TIMES.

DO I WISH TO TAKE MORE DATA POINTS?

Y N

OBTAIN AVERAGE OF ALL TIME DIFFERENCES AND TRANSMIT TO LM CREW.

TERMINATE DISPLAY
UPON RECEIPT OF KEY PPLEASE

PUSH KEY RELEASE BUTTON

R33/COLOSSUS
R33/SUNDANCE
R33/LUMINARY
CHANGE CONTROL NOTES

LOGIC REV 06  PCR #116 66
**Purpose:**

1. To display at astronaut request CMC calculated rendezvous parameters (range, range rate, phi).

**Assumptions:**

1. Range and range rate are calculated by the CMC on the basis of the stored LM and CSM state vectors and do not require that the ISS be on. The ISS must be on and aligned to a known orientation and the optical subsystem must be on and operational. If a correct display of phi is desired, the range/range rate/phi display is not inhibited however if the phi is not on and aligned.

**Procedure:**

(2) The routine is selected by the astronaut by key entry.

<table>
<thead>
<tr>
<th>Checklist</th>
<th>Time</th>
<th>Total Time</th>
</tr>
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<tbody>
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</tbody>
</table>

*CREW
*ROUTINE
*SELECTION
*...

---

START

RENDZVOUIS PARAMETER DISPLAY ROUTINE NO 2 (024)

---

**#10**

**#20**

**#30**
See EXTRAPOLATE FSM AND LM STATE VECTORS TO T USING COASTING INTEGRATION ROUTINE.

---

SET TF=PRESENT TIME.

---

EXTRAPOLATE FSM AND LM STATE VECTORS TO T USING COASTING INTEGRATION ROUTINE.

---

SET TF=PRESENT TIME.

---

IS AVERAGE G RUNNING?

---

SET TF=PRESENT TIME.

---

EXTRAPOLATE LM AND FSM STATE VECTORS TO TF FROM T USING KEPHER SUBROUTINE.

---

SET TF=AVERAGE G TIME.

---
SAG +4 ST +7 EN HOP "ON CYTOPOL ATSC LM STATE 814 TE FPAM JOU TNE. COASTING THTEGH «© RATTAN ROUTINE, CALCULATS PF ANGE, QANGE PATE apn DH FLASH VFR-NDHM Tn DPEQIEST RESPAMSE AND ATSPLAY PEMNEZ VAS PAT AMETFORS: VI6é N53 RY-R ANTE QI-RANGE RATT Q AwOUY PANGE-CALCHILATED DU ANGE TO LM, IM NAIIATIAL MTL ES TO NFAQEST AY NM, RANGE-TA PMTF—CALCULATED PANGE DATE BETWEEN COM AND LM. NEGATIVE STGM TNDECATES CLOSING TN EPR TA MPARPEST wo} FOS PHT-ANGLE POTWEo OPTICS STAR LEME OF STAUT ANN THE Loe Ay HPOTTAMTAL BLAME AT TRE MPecenT Tyee, AMCEE OTS ALWAYS coq4 a TO 4 MONTT AP SKY? APCERVE YER R-NTM FLASH TO REQUEST RESPONSE AND NEST AY OF SENN EZ YOYS PAQAMFTERS, (NOTE? THESF PAP A- METERS WELL RE YPRATED FYEBY TWO SECOMNNS.
LUNAR LANDMARK SELECTION ROUTINE (R35)  LOGIC REV 09 11/27/68

PURPOSE:
1. To display to the astronaut the time at which the spacecraft will pass over the landing site.
2. To calculate and display five landmarks which will be suitable for navigation.
3. To calculate and display the time at which the spacecraft will pass over each landmark.

ASSUMPTIONS:
1. This routine should be selected by the navigator in lunar orbit prior to selection of the orbital navigation program (P22).
2. This routine may be selected only during the CMC idling program (P00).
3. The selected landmarks are not necessarily displayed in chronological order.

EDIT

<table>
<thead>
<tr>
<th>PROG</th>
<th>CMC</th>
<th>GROUND</th>
<th>CREW</th>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONT</td>
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</table>

START LUNAR LMK SELECTION ROUTINE

KEY IN Y79E

IS CURRENT PROGRAM P00?

Y

N

IS ANOTHER EXTENDED VERB

PCN ACTIVE?

586

Y

N

...
TURN ON OPERATOR ERROR LIGHT

MONITOR DSKY: DOES OPERATOR ERROR LIGHT COME ON INDICATING THAT THIS ROUTINE CANNOT BE SELECTED AT THIS TIME?

V
N

IN ORDER TO USE THIS ROUTINE KEY IN V3TE00E AND THEN KEY IN V79E

NOTE: FIRST DISPLAY WILL RE PRESENT G.E.T.

FLASh VERB-NOUN TO REQUEST RESPONSE AND DISPLAY T-LAT-LONG

V06434
R1 00000
R2 00000
R3 00000
IN HOURS-MIN-SEC TO THE NEAREST .01 SEC

NOTE: FIRST DISPLAY WILL RE PRESENT G.E.T.

T-LAT-LONG=G.E.T.

THIS IS THE TIME WHICH THE COMPUTER WILL DEFINE AS THE START OF LMK TRACKING. IT WILL DETERMINE THE NEXT TIME THE LANDING SITE WILL PASS UNDER THE SPACECRAFT AND IT WILL DETERMINE 5 LANDMARKS WHICH WILL PASS UNDER THE SPACECRAFT AFTER T-LAT-LONG AND WHICH WILL BE ALONG THE GROUND TRACK.
WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA

AM I SATISFIED WITH THIS VALUE?

KEY IN VERB 25F AND LOAD A NEW TIME.

KEY IN PROCEED

CALCULATE THE NEXT TIME AFTER T-LATLONG AT WHICH THE LANDING SITE, STORED IN ERASABLE MEMORY, WILL PASS UNDER THE SPACECRAFT.
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY TIME OF LANDING SITE:
VO6N31
R1 000XX
R2 000XX
R3 000XX
IN HOURS-MIN-SEC TO THE NEAREST .01 SEC

WAIT FOR KEYBOARD ENTRY

MONITOR SKY: OBSERVE VERB NOUN FLASH TO REQUEST RESPONSE AND DISPLAY THE NEXT TIME AFTER T-LAT-LONG AT WHICH THE LANDING SITE WILL PASS UNDER THE SPACECRAFT.

RECORD THIS TIME. DO I WISH TO CONTINUE WITH THIS ROUTINE TO OBTAIN LANDMARK INFORMATION?

* N

* Y

* 

* 

* 

* 

KEY IN TERM IN

NOTE:

V34E

* 

* 

* 

* 

** KEY IN PROCEED

**

TERMINATE FLASH UPON RECEIPT OF PROCEED OR TERMINATE

P

R

E

F

T

EXIT R35

R35/COLOSSUS
BASED ON THE COMPUTED GROUND TRACK AND STORED LANDMARKS, SELECT THE NEXT 5 LANDMARKS THAT WILL PASS UNDER THE SPACECRAFT AFTER T-LAT-LONG.

SELECT THE LANDMARK ASSOCIATED WITH THE +60 DEGREE LONGITUDE LINE.

HAVE ALL 5 LANDMARKS BEEN DISPLAYED?

Y

EXIT

SELECT THE NEXT LANDMARK.
HOLD  SNAP

FLASH VERB NOUN
TO REQUEST RESPONSE
AND DISPLAY LAND-
MARK CODE:
VO#N0
R1=BLANK
R2=000XX
R3=BLANK
R2 LMK ID NO

--------------------------

WAIT FOR KEYBOARD
ENTRY

--------------------------

MONITOR DSKY:
OBSEVE VERB NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
THE LANDMARK CODE.

NOTE: THE COMPUTER
WILL CALCULATE 5
LMKS SUITABLE FOR
NAVIGATION AND WILL
DISPLAY THEN
SEQUENTIALY ON
COMMAND STARTING
WITH THE LANDMARK
ASSOCIATED WITH THE
+60 DEGREE LONGITUDE
LINE AND CONTINUING
THROUGH TO THE LAND-
MARK ASSOCIATED WITH
THE -60 DEGREE
LONGITUDE LINE.

--------------------------

RECORD DATA. DO I
WISH DISPLAY OF THE
TIME AT WHICH THIS
LMK WILL PASS UNDER
THE SPACECRAFT?

N     Y

--------------------------

KEY IN PROCEED

--------------------------

HAVE ALL 5 LANDMARKS
BEEN DISPLAYED?

N     Y

--------------------------

R35/COLOSSUS
DO I WISH TO
SEE THE LAND-
MARK CODE FOR
THE NEXT LAND-
MARK ON MY
GROUND TRACK?

Y  N

KEY IN
TERM-
INATE
V34E

EXIT
R35

TERMINATE FLASH UPON
RECEIPT OF RECYCLE,
TERMINATE OR PROCEED

R  T
E  F
C  R
Y  N
C  E
L  N
E  A
E  Y
E  E

EXIT
R35
FLASH VERB NOUN TO REQUEST RESPONSE AND DISPLAY TIME OF LANDMARK:
V06N34
R1- O0XXX
R2- O0XXX
R3- O0XXX
IN HOURS-MIN-SEC TO THE NEAREST .01 SEC

WAIT FOR KEYBOARD ENTRY

HAVE ALL 5 LANDMARKS AND THEIR ASSOCIATED TIMES BEEN DISPLAYED?

DO I WISH TO SEE THE NEXT LANDMARK?

TERMINATE FLASHP UPON RECEIPT OF PROCEED OR TERMINATE

MONITOR DSKY:
OBSERVE VERB NOUN FLASH TO REQUEST RESPONSE AND DISPLAY TIME AT WHICH THE LANDMARK, JUST DISPLAYED, WILL PASS UNDER THE SPACECRAFT.

KEY IN TERMINATE
RENDEZVOUS OUT OF PLANE DISPLAY ROUTINE (R36)  LOGIC  REV 06  11/27/68

PURPOSE:  (1) TO DISPLAY AT ASTRONAUT REQUEST CMC CALCULATED RENDEZVOUS OUT OF PLANE PARAMETERS (Y, YDOT, PSI)

ASSUMPTIONS:  (1) THESE PARAMETERS ARE CALCULATED BY THE CMC ON THE BASIS OF THE STORED LM AND CSM STATE VECTORS AND DO NOT REQUIRE THAT THE ISS BE ON.
(2) THE ROUTINE IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

<table>
<thead>
<tr>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>START THE RENDEZVOUS OUT OF PLANE ROUTINE</td>
<td>KEY IN VRRF</td>
<td>#10</td>
<td></td>
</tr>
</tbody>
</table>

* +06 IS ANOTHER EXTENDED VERB ACTIVE? + N Y *
* + TURN ON OPERATOR + ERROR LIGHT + 
* + PCN 586 + 
* + EXIT + 

R36/COLOSSUS
R36/SUNDANCE
R36/LUMINARY
HOLD FLASH VERB NOUN TO REQUEST RESPONSE AND SNAP DISPLAY T(EVENT) IN ++ G.F.T.: +06 V06-N16 ++ R1-(EVENTI)-HRS PCR R2-(EVENTI)-MINS ++ 206 R3-(EVENTI)-SECS

T(EVENT): TIME (G.F.T.) FOR WHICH OUT OF PLANE PARAMETERS ARE DESIRED IN HRS, MINS, AND SECS TO NEAREST .01 SECONDS.

A SPECIAL CASE IS ALL ZERES INDICATING PRESENT TIME

---------------------------------------------------------------------

MONITOR SSKY: OBSERVE VERB NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF TIME AT WHICH OUT OF PLANE PARAMETERS ARE DESIRED.

---------------------------------------------------------------------

DO I WISH TO HAVE THE CMC COMPUTE PARAMETERS FOR THE PRESENT TIME?

Y N

---------------------------------------------------------------------

AM I SATISFIED WITH THE DISPLAYED TIME?

Y N

---------------------------------------------------------------------

ARE ALL THREE REGISTERS EQUAL TO ZERO?

Y N

---------------------------------------------------------------------

R36/COLOSSUS
R36/SUNDANCE
R36/LUMINARY

#40

#50

#60

#70

#80
WAIT FOR KEYBOARD ENTRY:

TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA.

KEY IN PROCEED

NEW DATA

STORE NEW DATA

IS EVENT ZERO?

N Y

EXTRAPOLATE CSM AND LM VECTORS TO THE PRESENT TIME USING PRECISION INTEGRATION

EXTRAPOLATE CSM AND LM STATE VECTORS TO THE TIME DEFINED BY EVENT USING PRECISION INTEGRATION
CALCULATE OUT-OF-PLANE PARAMETERS:

Y
Y DOT
PSI

FLASH VFR NOUN TO REQUEST RESPONSE AND DISPLAY RENDEZVOUS OUT OF PLANE PARAMETERS:

V06 N90
R1 Y
R2 Y DOT
R3 PSI

Y-NOTE: FOR DEFINITION OF PARAMETERS REFER TO SECTION 5.6.7.4 OF THIS DOCUMENT. IN NAUTICAL MILES TO THE NEAREST .01 NM.

Y DOT-RATE OF CHANGE OF Y (+ IS INCREASING AND - IS DECREASING) IN FPS TO THE NEAREST .1 FPS.

PSI-ANGLE BETWEEN THE CSM ORBITAL PLANE AND THE LCS TO THE LM PROJECTED INTO THE HORIZONTAL PLANE IN DEGREES TO THE NEAREST .01 DEGREES.

MONITOR DSKY:

OBSERVE VFR NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF RENDEZVOUS OUT OF PLANE PARAMETERS

DO I WISH TO RECEIVE ANOTHER DATA POINT FOR A DIFFERENT TIME?

R36/COLOSSUS
R36/SUNDANCE
R36/LUMINARY
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE

CHANGE CONTROL NOTES

LOGIC REV 04 PCR MIT 66
LOGIC REV 05 PCR 436
REV 06 PCR 206 EDITORIAL PCN 546
SPS THRUST FAIL ROUTINE (R40)

PURPOSE:
1. To indicate to the astronaut that the GNCS has detected a thrust failure.
2. To provide the astronaut a flashing display to which he can respond as described in the flow.

ASSUMPTION:
1. The GNCS has detected a thrust failure and has shut off cross product steering and has stopped the calculations of time from cutoff and has stopped C.G. tracking.
2. If the astronaut keys in proceed on this display thrust failure detection will be inhibited for 2 seconds to prevent a premature thrust fail indication.
3. This routine is selected by the SPS THRUSTING PROGRAM (P40)

Routine: CMC GROUND CREW CHECKLIST TIME TOTAL

<table>
<thead>
<tr>
<th>CMC ROUTINE SELECTION</th>
<th>CHECKLIST</th>
<th>TIME</th>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

HOLD: Flash verb-noun to monitor display of thrusting parameters

MON: Monitor display of thrusting parameters

#10

#20
SHALL I TERMINATE THE ENGINE ON COMMAND AND RETURN TO THE V99 FLASH WHICH WILL ALLOW ME TO EITHER REISSUE THE ENGINE ON COMMAND OR CONTINUE ON TO THE DISPLAY OF VGX, VGY, VGZ FOR RCS THRUSTING?

WAIT FOR KEYBOARD ENTRY

---

.KEY IN ENTER

---

HAS THRUST COME BACK ON?

.KEY IN PROCEED

---

SHALL I TERMINATE THE ENGINE ON COMMAND AND THE SPS THRUSTING PROGRAM (P40)?
TURN OFF TVC DAP

SET NARROW DEADBAND IN RCS DAP

DRIVE SPS ENGINE BELL TO TRIM POSITION.
NOTE: THE TRIM POSITION IS THAT LAST DEFINED BY THE C.G. TRACKING COMPUTATION.

TURN ON RCS DAP IN 6 SEC

GO TO "MAN" IN P40
STATE VECTOR INTEGRATION ROUTINE (R411)  LOGIC REV. 03  11/29/69

PURPOSE:  (1) TO INTEGRATE THE STATE VECTOR OF THIS VEHICLE TO THE TIME AT WHICH THE AVERAGE G ROUTINE WILL BE TURNED ON BY THE CALLING PROGRAM.

(2) TO DEFINE A NEW TIC FOR PROGRAMS 40 OR 41 IN THE EVENT THE STATE VECTOR CAN NOT BE INTEGRATED TO THE TIME DEFINE BY PROGRAMS 40 OR 41 AND TO LIGHT THE ALARM LIGHT TO INFORM THE CREW THAT TIC HAS BEEN SLIPPED.

ASSUMPTIONS:  (1) THERE IS A SIGNIFICANT AMOUNT OF TIME REQUIRED BY THE CMC TO TURN ON THE AVERAGE G ROUTINE. THIS TIME IS VARIABLE ACCORDING TO THE FOLLOWING CONSIDERATIONS REGARDING THE CSM STATE VECTOR:

- 1.4 SECONDS PER TIME STEP IN EARTH ORBIT
- 2.5 SECONDS PER TIME STEP IN LUNAR ORBIT

WHERE TIME STEP IS EQUAL TO:

- 240 SECONDS IN EARTH ORBIT
- 350 SECONDS IN LUNAR ORBIT

(2) THE ROUTINE IS ONLY AUTOMATICALLY SELECTED.

<table>
<thead>
<tr>
<th>PROG CONT</th>
<th>CMC</th>
<th>GROUND CREW</th>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>#10</td>
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</table>

CMC ROUTINE SELECTION

-----

<table>
<thead>
<tr>
<th>READ PRESENT TIME, TO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>IS THE TIC FLAG SET?</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, Y</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IS TREE-10 SEC GREATER THAN OR EQUAL TO TO?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y, N</td>
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</table>

<p>| |</p>
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#10

#20
INTEGRATE THIS VEHICLE STATE UP TO ONE TIME STEP USING THE STATE VECTOR INTERACTION.

ACCORDINGLY, THE COMPUTER ACTIVITY PLOTTED ALONG TIME 035. THE DEPENDS ON THE STATE VECTOR INTERACTION.

IF THIS ALARM CONDITION OCCURS, THE STATE VECTOR INTERACTION WILL BE TERMINATED.

IF THE STATE VECTOR INTERACTION TERMINATES PRIOR TO THE STATE VECTOR INTERACTION FINISHING, THE STATE VECTOR INTERACTION WILL BE TERMINATED.
PURPOSE:

1. To point the star LOS of the optics at a star or landmark defined by the program or by DSKY input (astronaut).
2. To point the star LCS of the optics at the LM during rendezvous tracking operations.
3. To do the tracking attitude routine (R61) approximately every 2 seconds during rendezvous tracking operations.

ASSUMPTIONS:

1. The routine is automatically selected during IMU realign program (P52) by the rendezvous navigation program (P20), or by the orbital navigation program (P22), or by the cislunar navigation program (P23).
2. This routine is self-perpetuating and is terminated by the sighting mark routine (R53) for star or LM and by resetting the track flag for LM.

<table>
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</tr>
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</table>

CMC ROUTINE

SELECTION

START AUTO OPTICS POSITIONING ROUTINE (R52) #10

SET TRUNNION DRIVE FLAG #20

R52/COLOSSUS
SELECT DESIRED IMU INERTIAL ORIENTATION FROM STORAGE (PROVIDED BY CALLING PROGRAM).

CALCULATE REQUIRED FINAL GIMBAL ANGLES TO GIVE DESIRED IMU INERTIAL ORIENTATION

IS ANY REQUIRED GIMBAL ANGLE CHANGE GREATER THAN 1 DEGREE?

SWITCH ISS TO COARSE ALIGN MODE. TERMINATE ATTITUDE HOLD OF VEHICLE

COARSE ALIGN THE IMU
TERMINATE COARSE
ALIGN MODE IN ISS.
RESUME ATTITUDE
HOLD OF VEHICLE

EXIT R50

CHANGE CONTROL NOTES

LOGIC REV 03   PCR 464
PURPOSE:
(1) TO POINT THE STAR LOS OF THE OPTICS AT A STAR OR LANDMARK DEFINED BY THE PROGRAM OR BY DSKY INPUT (ASTRONAUT).
(2) TO POINT THE STAR LCS OF THE OPTICS AT THE LM DURING RENDEZVOUS TRACKING OPERATIONS.
(3) TO DO THE TRACKING ATTITUDE ROUTINE (R61) APPROXIMATELY EVERY 2 SECONDS DURING RENDEZVOUS TRACKING OPERATIONS.

ASSUMPTIONS:
(1) THE ROUTINE IS AUTOMATICALLY SELECTED DURING IMU REALIGN PROGRAM (P52) BY THE RENDEZVOUS NAVIGATION PROGRAM (P20), OR BY THE ORBITAL NAVIGATION PROGRAM (P22), OR BY THE CISLUNAR NAVIGATION PROGRAM (P23).
(2) THIS ROUTINE IS SELF PERPETUATING AND IS TERMINATED BY THE SIGHTING MARK ROUTINE (R53) FOR STAR OR LMK AND BY resetting the track flag for LM.

PROG CONT CMC GROUND CREW CHECKLIST TIME TOTAL TIME

CMC ROUTINE
SELECTION

START AUTO OPTICS
POSITIONING ROUTINE
(R 52)

SET TRU NNION DRIVE
FLAG

#10

#20

R52/C OLOSSUS
IS THE PREFERRED ATTITUDE FLAG SET?

NO YES

IS UPDATE FLAG SET?

N Y

WAIT ABOUT 1.3 SECONDS

EXTRAPOLATE CSM AND LM STATE VECTORS TO THE PRESENT TIME 1.3 SECONDS USING CONIC EQUATIONS

READ PRESENT VEHICLE ATTITUDE FROM THE ICDCUS

COMPUTE TARGET VECTOR FROM CSM TO LM
CALCULATE THE REQUIRED OPTICS ANGLES TO POINT THE STAR LINE OF SIGHT AT THE LMK.

**EDIT**

IS A TRUINION ANGLE GREATER THAN 50 Deg.
REQUIRED TO POINT THE STAR LINE OF SIGHT AT THE LMK?

Y  YES

SET THE TRUINION DRIVE FLAG.

TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE 407.

CHECK OPTICS MODE DISCREPANCY IS THE OSS IN THE CMC MODE?

Y NO

IS THE TRUINION DRIVE FLAG SET?

Y  NO

MONITOR PROGRAM ALARM LIGHT: IF THE PROGRAM ALARM LIGHT COMES ON AT THIS TIME THE ASTRONAUT SHOULD VERIFY ALARM (BY KEYING IN W05N09E) AND EITHER MANUALLY MANEUVER THE VEHICLE BACK TO THE PREFERRED TRACKING ATTITUDE (DESIRED GIMBAL ANGLES MAY BE DISPLAYED BY KEYING IN V16N22E AND DESIRED OPTICS BY KEYING IN V16N22F) OR ALLOW THE GNCS TO AUTOMATICALLY MANEUVER BY SWITCHING TO CMC AUTO CONTROL AND/OR BY KEYING IN V58E.
DRIVE SHAFT AND TRUNNION ONLY CDO'S

DO THE TRACKING ATTITUDE ROUTINE

WAIT 0.5 SEC

GC TO "A" ABOVE

"A" FROM ABOVE
FROM AROVE

IS TERMINATE
FLAG SET?

THE AUTOMATIC OPTICS POSITIONING IS NOW RUNNING. TO MARK ON THE TARGET, SWITCH THE OPTICS MODE SWITCH TO MANUAL. THIS WILL CALL THE SIGHTING MARK ROUTINE R53. IF R53 IS TERMINATED THIS ROUTINE WILL ALSO TERMINATE. IF THE ASTRONAUT SWITCHES BACK TO CMC MODE PRIOR TO TERMINATION OF R53 V51 WILL REMAIN FLASHING AND THE ASTRONAUT MAY CONTINUE WITH R53 BUT THE OPTICS WILL BE POINTED AT THE TARGET AUTOMATICALLY

EXIT R52

...
CALL SIGHTING MARK ROUTINE (R53) IF NOT ALREADY CALLED

++
++09
++ EDIT

++
++09
++ WAIT .5 SEC

GET PRESENT IMU ORIENTATION FROM STORAGE (REFSMAT)

READ PRESENT VEHICLE ATTITUDE FROM ICDUS

IS THE TARGET FLAG STAR OR LANDMARK

++ (STAR) (LMK)

++
++09
++ GET STAR DATA
++ FROM CMC
++ EDIT STORAGE
**++ 09**

**++ 09**

PCN 594

**++ 09**

**++**

EDIT

**-----**

IS LANDMARK CODE GREATER THAN 32?

**-----**

NO YES

**-----**

**++ 09**

**++**

COMPUTE TARGET VECTOR TO A POINT ON THE SURFACE OF THE MOON 60 DEG Forward OF PRESENT LOCATION AND ON THE GROUND TRACK OF THE DESIRED ORBIT (DESIRED ORBIT IS DEFINED AS THAT NUMBER OF ORBITS AHEAD OF THE PRESENT ORBIT INDICATED BY THE LEAST SIGNIFICANT DIGIT IN THE LANDMARK CODE)

**++ 09**

**++**

PCN 594

**-----**

GET LMK COORDINATES FROM CMC STORAGE

**-----**
COMPUTE TARGET VECTOR FROM CSM TO DESIGNATED LANDMARK.

COMPUTE TARGET VECTOR FROM CSM TO DESIGNATED STAR.

CALCULATE THE REQUIRED OPTICS ANGLES TO POINT THE STAR LOS OF THE OPTICS ALONG THE TARGET VECTOR.

IS A TRUNNION ANGLE REQUIRED TO POINT THE STAR LOS OF THE OPTICS AT THE TARGET GREATER THAN 90 DEG?

N  Y

R52/COLOSSUS
PASS
PRIO
HOLD *
SNAP *

FLASH VERB-NOUN
TO REQUEST RESPONSE AND DISPLAY
ALARM CODE:
VO90
R1-
R2-
R3-

EXPECTED ALARM
ALARM CODE AT THIS TIME IS 404

++
09
++
EDIT
PCR
206

WAIT 2 SECONDS

---------------

MONITOR DSKY:

ONE ALARM CODE
DISPLAY INDICATE
THAT THE TARGET IS NOT WITHIN THE HEMISPHERE OF OPTICS VISIBILITY?

Y  N

---------------

FOR STAR/LANDMARK SIGHTINGS THERE ARE TWO OPTIONS:

(A) MANUALLY MANEUVER VEHICLE UNTIL OPTICS CAN ACQUIRE THE DESIRED TARGET.

(B) TERMINATION OF THE PROGRAM AND ROUTINE.

A  B

---------------

MANUALLY MANEUVER VEHICLE UNTIL IT IS ESTIMATED THAT OPTICS CAN ACQUIRE THE TARGET.

MONITOR FOA TO AVOID GIMBAL LOCK.

---------------

WAIT FOR KEYBOARD ENTRY.

KEY IN PROCEED

---------------

R52/COLOSSUS
TERMINATE FLASH UPON RECEIPT OF PROCEED, OR TERMINATE.

KEY IN TERMINATE. V34E

++
++09
++ EDIT

WAIT .5 SEC

DO ROUTINE ROO

EXIT R52 AND CALLING PROGRAM

IS THE TRUNCUT ANGLE REQUIRED TO POINT THE STAR LOS OF THE OPTICS AT THE TARGET GREATER THAN 50 DEGREES?

DO ROUTINE ROO

EXIT R52 AND CALLING PROGRAM

R52/COLOSSUS
SET TRUNNION
DRIVE FLAG

RESET TRUNNION
DRIVE FLAG.

TURN ON PROGRAM
ALARM LIGHT AND
STORE ALARM CODE
2407

MONITOR PROGRAM
ALARM LIGHT: IF THE
PROGRAM ALARM LIGHT
COMES ON AT THIS
TIME THE ASTRONAUT
SHOULD VERIFY THE
ALARM BY KEYING
IN V9N09E AND
THEN REVIEW THE
OPTICS ANGLE: IF
THEY ARE BEING
DISPLAYED (THEY WILL
BE UNLESS R53 HAS
BEEN PREVIOUSLY
SELECTED). IF THEY
ARE NOT BEING
DISPLAYED KEY IN
V9N92F. IF TRUNNION
(R2) IS GREATER THAN
49.775 THE ASTRONAUT
SHOULD MANUALLY
MANEUVER THE
VEHICLE.

IS THE SIGHTING
MARK FLAG SET?

Y N

+9 +9 EDIT

R52/COLOSSUS
MON +09

EDIT

PCR 206

**

DISPLAY ON DSKY:

V06N92
R1-SHAFT
R2-TRUNNION
R3-BLANK

SHAFT-DESIRED SHAFT ANGLE. IN DEGREES TO NEAREST .01 DEGREE.

TRUNNION-DESIRED TRUNNION ANGLE. IN DEGREES TO NEAREST .001 DEGREE.

---------------------------------

CHECK OPTICS MODE DISCRETE. IS THE OSS IN CMC MODE?

Y N

IS TRUNNION DRIVE FLAG SET?

Y N

DRIVE ORIVE SHAFT AND CDU TRUN- ONLY CDUS

WAIT 0.9 SEC

---------------------------------
PURPOSE:
   (1) TO PERFORM A SATISFACTORY NUMBER OF OPTICAL SIGHTING MARKS FOR THE REQUESTING PROGRAM FOR CONTINUITY.

ASSUMPTIONS:
   (1) SIGHTINGS ARE MADE WITH EITHER SET OR SET AS REQUIRED.
   (2) SIGHTINGS MAY BE MADE ON A STAND OR LANDMARK.
   (3) WHEN THE CREW ACCIDENT A MARK AT PICKUP AND STORES AN INDEX (3 SETS AND 3 INCHES) AND THE TIME OF THE MARK.
   (4) MIRROH LINES FOR MARK THRESHOLDS ARE ESTABLISHED UTILIZING A MARK COUNTER. THIS MARK COUNTER WILL INCREASE EACH TIME A MARK IS MADE AND DECREASE EACH TIME A MARK OBJECT IS MADE. THE MARK COUNTER WILL BE COMPARED AGAINST A MARK INDEX. THE INDEXING IS THIS INDEX WILL BE SELECTED BY THE PROGRAM FOR ROUTINING SELECTING THERIGHT MARK AS FOLLOWS:

   (5) STAND - 1
   (6) LANDMARK - 6

   THE ROUTINE REQUIRES THAT AT LEAST ONE MARK BE TAKEN FOR NORMAL TERMINATION. IF FOR SOME REASON TARGET NOT VISIBLE, DISTINGUISHABLE, ETC., THE CREW IS INTO THIS ROUTINE AND EFFECT NOT TO MARK HE SHOULD ENTER KEY IN VALUE WHICH WILL CALL NOT OR CALL A NEW PROGRAM BY KEYING IN WAVE.
GO TO MAN ABOVE

SET MARK FLAG

STORE FIVE ANGLES AND TIME AND INCREMENT MARK COUNTER BY ONE.

IS MARK COUNTER STILL LESS THAN MARK INDEX?

GO TO MAN ABOVE
CELESTIAL BODY CODE - CELESTIAL BODY DESIGNATION FROM CURRENT DATA.

TERMINATE FLASH UHN OR NEW DATA.

NEW DATA

STORE NEW DATA

IS CELESTIAL BODY CODE 00?

NO

YES

IS THE TARGET A STAR OR THE EARTH WHEN NO SUN?

NO

YES

EXIT

OBTAIN STAR VECTOR FROM STORED Ephemeris
CALCULATE CEL-DEEP BODY VECTOR FOR THE BODY DEPLOYED BY THE STARPONE.

HELP

MORE

MAP

**+X**

**+Y**

**+Z**

MONITOR ASKED

FREEVE VERSHA

FIELD TO REQUEST

REFERENCE AND DISPLAY

OF PLANET POSITION

VECTOR.

Y PL - THE Y

COMPONENT OF 1/-

UNIT POSITION

VECTOR OF THE

PLANET AT GET.

IN REFERENCE

COORDINATES.

TO THE FIFTH

PLACE (YYYYY).

Y PL - SAME AS

REFERENCE OR

NEW X PL FOR Y

COMPONENT.

Y PL - SAME AS

Y PL FOR Y

COMPONENT.
<table>
<thead>
<tr>
<th>PV 04</th>
<th>OCR WIT 46</th>
<th>OCR WIT 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFV 07</td>
<td>OCR 206</td>
<td>OCR 440</td>
</tr>
<tr>
<td>FFV 08</td>
<td>OCR 206 EDITORIAL</td>
<td>OCR 440</td>
</tr>
<tr>
<td>FFV 08</td>
<td>OCR 440, EDITORIAL</td>
<td>OCR 440</td>
</tr>
</tbody>
</table>

**Change Control Notes**
**Purpose:**
To test the accuracy of a pair of celestial body sightings.

**Assumptions:**
1. The routine is normally automatically selected by the IMU orientation determination program (P51), by the IMU realign program (P52), by the back-up IMU orientation determination program (P53), or by the back-up IMU realign program (P54).

### Prog CMC Ground Crew Checklist Time Total Time

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>CMC</td>
<td>ROUTINE SELECTION</td>
<td></td>
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<td></td>
<td>-----------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>START SIGHTING DATA</td>
<td></td>
<td></td>
<td></td>
<td>#10</td>
</tr>
<tr>
<td></td>
<td>DISPLAY ROUTINE R54</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>CALCULATE ANGLE BETWEEN TWO CELESTIAL BODIES USING STORED EPHEMERIS DATA (ACTUAL)</td>
<td></td>
<td></td>
<td>#20</td>
<td></td>
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<td>-----------------------</td>
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<tr>
<td></td>
<td>CALCULATE ANGLE BETWEEN TWO CELESTIAL BODIES USING CELESTIAL BODY VECTORS DERIVED FROM MARK ANGLES (INDICATED)</td>
<td></td>
<td></td>
<td>#30</td>
<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>
Flash verb-noun to request response and display sighting angle difference.

Monitor DSKY: observe flashing verb-noun and display of sighting angle diff.

Does the sighting angle difference exceed the acceptable tolerance?

Yes, proceed with bad data?

Exit "A" from RS4 continue as defined in calling program/routine.

Wait for keyboard entry.

Key in proceed.
PURPOSE:  (1) TO CALCULATE GYR C TORQUING ANGLES FOR FINAL (FINE) ALIGNMENT OF THE INERTIAL PLATFORM DURING AN INFLIGHT ALIGNMENT, TO DISPLAY THESE ANGLES AND TO TORQUE THE GYROS.

ASSUMPTIONS:  (1) THE ROUTINE IS NORMALLY AUTOMATICALLY SELECTED BY THE IMU REALIGN PROGRAM (P52), OR BY THE BACKUP IMU REALIGN PROGRAM (P54).

<table>
<thead>
<tr>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM C</td>
<td>#10</td>
<td></td>
</tr>
<tr>
<td>ROUTINE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SELECTION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

START GYR C TORQUING ROUTINE (R55)

CALCULATE REQUIRED TORQUING ANGLES FOR EACH GYRO

HOLD . FLASH VERB-NOUN TO REQUEST RESPONSE SNAP . NSE AND DISPLAY V06 NO3 R1-X GYRO R2-Y GYRO R3-Z GYRO

MONITOR DSKY: OBSERVE VERB-NOUN FLASH AND DISPLAY OF GYRO TORQUING ANGLES
GYRO TERQUING
ANGLES—THE ANGLE
THRU WHICH EACH
GYRO MUST BE
TORQUED TO COM-
PLETE THE FINAL
ALIGNMENT. ALL
ANGLES IN DEGREES
TO NEAREST .001
DEGREE.

WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF
PROCEED OR RECYCLE

SHELL I PERMIT TORQUING? CONSIDER
MAGNITUDE OF TORQUING ANGLES.

N, Y,

KEY IN RECYCLE V32F

... EXIT R55

KEY IN PROCEED

... EXIT R55

R55/COLOSSUS
R55/SUNDANCE
R55/LUMINARY
PULSE IRIGS THROUGH DESIRED ANGLES

EXIT R55

CHANGE CONTROL NOTES

LOGIC REV 03 PCP MIT 66
PURPOSE: (1) To program sighting marks for the back-up alignment program 1092, etc.

ASSUMPTIONS: (1) The alignment knows the coordinates (orthostat) of the alternate type of sight he must use and this routine.
(2) When the alignment keys input in sequence to flashing yet the ad stores the three azimuths and two angles in memory in 1092.
(3) The routine is used to position the spacecraft so that the alternate for points toward the chosen star.
(4) This routine is automatically called by 1034 and 1094.

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>CUP</th>
<th>ORDER</th>
<th>COPY</th>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL TIME</th>
</tr>
</thead>
</table>

**NEW ROUTINE**

**HOLD**

**END**

FLASH VERB-NOUN TO REQUEST ORIENTATION AND DISPLAY ALTERNATE 1092 COORDINATES

**NEW ROUTINE**

**MONITOR ACK:**

VerNB-NOUN TO REQUEST ORIENTATION AND DISPLAY NEW ORIENTATION.

**NEW ROUTINE**

Flash to request orientation and display new orientation.

**NEW ROUTINE**

VerNB-NOUN TO REQUEST ORIENTATION AND DISPLAY NEW ORIENTATION.

**NEW ROUTINE**

Flash to request orientation and display new orientation.

**NEW ROUTINE**

Flash to request orientation and display new orientation.

**NEW ROUTINE**

Flash to request orientation and display new orientation.
HOUR
NAP
WATT FOR KEYBOARD
ENTRY:

TERMINATE FLASH
UPON RECEIPT OF NEW
DATA OR PROCEED

KEY IN V24F
AND LOAD
ANGLES,

NEW DATA
PROCEED

STORE
NEW DATA

HELP
SNAP

FLASH V24F
TO REQUEST ALTERNATE
LOS SIGHTING
MARK:

01-PLANK
02-PLANK
03-PLANK

MONITOR V24F:
"PROCESS V24F"
FLASH TO REQUEST
ALTERNATE LOS SIGHTING
MARK:

USING THE OPERATIONAL
HAND CONTROLLER ORI-
TATE THE SPACE-
CRAFT SO THAT THE
NAVIGATION STAR IS
PROPERLY ALIGNED THE

PREVIOUSLY
PURPOSE:

1. To measure the effect of solar radiation on the SXT trunnion angle.
2. To store the measured trunnion bias for use by the Cislunar Navigation Program (P23).

ASSUMPTIONS:

1. Trunnion bias is measurable only in space (vacuum).
2. Trunnion bias is a function of the angle between the landmark line of sight and the sun and is constant outside the cone from plus or minus 15 degrees from the landmark line of sight.
3. After the first time this routine is performed during a mission it should not be necessary to repeat it if the sun angle was outside the cone of assumption 2 and will be outside the cone during the navigation marks to be taken during P23. If the sun angle is within this cone this routine should be repeated each time through P23.
4. The optics should "soak" in an attitude within the region that will be used for P23 for at least a half hour prior to calibration and marking on the navigation targets of P23.
STORE TRU- 
NION BIAS ANGLE

--- EXIT ---

-- SNAP --

FLASH VERB-NOUN TO 
REQUEST RESPONSE AND 
DISPLAY TRUNNION 
BIAS ANGLE.
V06 N87
R1-BLANK
R2-XXX
R3-BLANK

R2-ANGLE IN DEGREES 
TO NEAREST .001 DEG

--- MONITOR OSKY: ---

DO I WISH TO INCORP- 
ORATE THE CALIBRA-
TION OR RECALIBRATE?

NOTE: THE SCALING OF 
THIS NOUN IS SUCH 
THAT A SMALL NEG-
ATIVE ANGLE WILL 
APPEAR AS A POSI-
TIVE ANGLE APPOA-
CHING 90°.

THE ACTUAL ANGLE 
WOULD THEN BE EQUAL 
THAT 90°.000 MINUS 
THE DISPLAYED VALUE.

--- KEY IN ---

PROCEED ---

--- R57/COLOSSUS ---

#70
--- #80
--- #90
--- #100
--- #110
--- #120
TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE.

RECYCLE PROCEED ERASE MARK DATA.

STORE CALIBRATION ANGLE.

EXIT.
PURPOSE:  
(1) TO MANEUVER THE LM/CSM OR CSM ALONE TO AN ATTITUDE SPECIFIED BY THE PROGRAM IN PROGRESS.

ASSUMPTIONS:  
(1) THE FINAL ATTITUDE DESIRED, DEFINED AS FOLLOWS, HAS BEEN STORED BY THE CALLING PROGRAM:
   (A) A SPECIFIC BODY FIXED VECTOR AND A DIRECTION IN SPACE TO WHICH THIS VECTOR IS TO BE AlIGNED (THE 3-AXIS
       FLAG IS SET).
   (B) A THREE AXIS (ORTHOGONAL) INERTIAL ORIENTATION TO WHICH THE THREE BODY AXES ARE TO BE AlIGNED (THE THREE
       AXIS FLAG IS SET).

(2) THE MANEUVER MAY BE PERFORMED AUTOMATICALLY BY THE GNCS OR PERFORMED MANUALLY WITH AN OPTIONAL FINAL AUTOMATIC
   GNCS CONTROLLED TRIM MANEUVER. THIS OPTIONAL TRIM MANEUVER SHOULD BE CONSIDERED ESSENTIAL FOR MANEUVERS TO SPS THRUST-
  ING ATTITUDES.

(3) THE DAP DATA LOAD ROUTINE (RO3) HAS BEEN PERFORMED PRIOR TO THIS ROUTINE.

(4) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE PROGRAM OR ROUTINE REQUIRING THE ATTITUDE MANEUVER.

(5) IF THIS ROUTINE WAS SELECTED BY THE TRACKING ATTITUDE ROUTINE (R61) THE VS0N18 AND THE VS0N18 IN THIS ROUTINE
   ARE PRIORITY DISPLAYS. THE VS0N18 DISPLAY WILL REMAIN UP A MINIMUM OF 2 SECONDS. RESPONSE AFTER 2 SECONDS WILL
   CAUSE THE PROGRAM TO CONTINUE AS DESCRIBED
IS THE PRIORITY DISPLAY IN R22 USING THE DSKY?

\[ \text{N} \rightarrow \text{Y} \]

\[ \text{WAIT} \]
\[ \text{UNTIL} \]
\[ \text{IT IS REMOVED} \]

IS THE 3 AXES FLAG SET?

\[ \text{N} \rightarrow \text{Y} \]

CALCULATE FINAL VEHICLE ATTITUDE TO MEET THE DESIRED ATTITUDE SPECIFICATION (VECPNT ROUTINE). THIS FINAL VEHICLE ATTITUDE WILL BE CALCULATED TO MEET THE ATTITUDE SPECIFICATION IN SUCH A WAY AS TO CONSERVE RCS FUEL AND NOT CONSTRAINT ANY UNSPECIFIED EDITED DEGREE OF FREEDOM.
SELECT GIMBAL ANGLES CORRESPONDING TO PREFERRED VEHICLE ATTITUDE AND PRESENT IMU ORIENTATION

FLASH VERB-NOUN TO REQUEST PLEASE PERFORM AUTO MANEUVER:
V50 NIB
R1-CG ROLL
R2-IG PITCH
R3-MG YAW

OG - FINAL DESIRED OUTER GIMBAL ANGLE IN DEGREES TO NEAREST .01 DEGREES.
IG - FINAL DESIRED INNER GIMBAL ANGLE IN DEGREES TO NEAREST .01 DEGREES
MG - FINAL DESIRED MIDDLE GIMBAL ANGLE IN DEGREES TO NEAREST .01 DEGREES.

REVIEW THE PRESENTLY DISPLAYED GIMBAL ANGLES AND THE PRESENT ATTITUDE. AM I WITHIN THE PRESENT RCS DAP DEADBAND LIMITS IN EACH AXIS?

WAIT FOR KEYBOARD ENTRY

MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM AUTO MANEUVER AND DISPLAY OF DESIRED GIMBAL ANGLES.

REVIEW THE PRESENTLY DISPLAYED GIMBAL ANGLES AND THE PRESENT ATTITUDE. AM I WITHIN THE PRESENT RCS DAP DEADBAND LIMITS IN EACH AXIS?

Y
N

DO I WISH TO FURTHER ADJUST THE VEHICLE ATTITUDE ABOUT THE

R60/COLOSSUS
R60/LUMINARY
TERMINATE FLASH UPON RECEIPT OF ENTER CR PROCEED

RESET 3-AXIS FLAG.

IS THE 3-AXIS FLAG SET?

DESIRABLE VECTOR? (NOT POSSIBLE FOR ALL CASES. SEE ASSUMPTION 1)

SHALL I HAVE THE GNCS PERFORM THE MANEUVER AUTOMATICALLY?

SELECT CMG CONTROL AND SELECT THE AUTO MODE.
CALCULATE FINAL VEHICLE ATTITUDE TO MEET THE DESIRED ATTITUDE SPECIFICATION (VECPOINT ROUTINE). THIS FINAL VEHICLE ATTITUDE WILL BE CALCULATED TO MEET THE ATTITUDE SPECIFICATION IN SUCH A WAY AS TO CON- SERVE RCS FUEL AND NOT CONSTRAIN ANY UNSPECIFIED DEGREE OF FREEDOM. NOTE: GNCS CAPABILITY TO PERFORM MANEUVER AUTOMATICALLY WILL BE COMPROMISED IF THE ATTITUDE IS CHANGED BY MANUAL INPUTS AFTER THIS TIME.

SAY: HAVE THE GNCS RECOMPLTE THE DESIRED ATTITUDE WITHOUT PERFORMING THE AUTOMATIC MANEUVER? (NOT POSSIBLE FOR ALL CASES. SEE ASSUMPTION 1)

---

EITHER SELECT SCS CONTROL OR PLACE MODE SWITCH NOT IN AUTO.

---

KEY IN PROCEED

---

SELECT GIMBAL ANGLES CORRESPONDING TO PREFERRED VEHICLE ATTITUDE AND PRESENT IMH ORIEN- TATION.
PERFORM MANEUVER MANUALLY USING RHCP AND ATTITUDE READOUTS.
AND/OR THE FDAI ROLL AND EPPRO TO NEEDLES.

IS SAC CONTROL CW?

CD DIRECT THE CMC TO PERFORM THE MANEUVER AUTOMATICALLY?
TEMP HOLD SNAP

DISPLAY FINAL GIMBAL ANGLES
- V06418
- R1-CC ROLL
- R2-IC PITCH
- R3-WG YAW
- ALL ANGLES IN DEGREES TO THE NEAREST .01 DEGREES

- DC MANEUVER CALCULATION (KALCHAI) AND ICUD DRIVE ROUTINE TO ACHIEVE FINAL GIMBAL ANGLES. THE MANEUVER RATE WILL BE THAT LAST DEFINED TO THE CMC BY DSKY ENTRY. THIS PROCESS WILL INCLUDE A MONITOR OF THE RHC INPUTS TO THE CMC. ANY INPUT FROM THE RHC WILL BE INTERPRETED AS A MANUAL OVERRIDE AND WILL CAUSE IMMEDIATE TERMINATION OF THIS MANEUVER CALCULATION AND ICUD DRIVE ROUTINE.

- MONITOR DSKY:
  - OBSERVE NON-FLASHING VERB-NOUN DISPLAY OF FINAL GIMBAL ANGLES UNTIL COMPLETION OF THE AUTOMATIC MANEUVER.

- MONITOR ATTITUDE MANEUVER BY REFERENCE TO FDAI BALL AND ATTITUDE ERROR NEEDLES TO AVOID GIMBAL LOCK.

- SHALL I OVERRIDE THE GNCS AND COMPLETE THE MANEUVER MANUALLY?
  - Y/N

- WAIT FOR AUTOMATIC COMPLETION.
PERFORM ATTITUDE MANEUVER MANUALLY USING RHC AND RY REFERENCE TO THE OUT-THE-WINDOW VIEW AND/OR THE FDOA BALL AND ATTITUDE ERROR NEEDLES.

CHANGE CONTROL NOTES

REV 00 FOR NASA 00
REV 11 FOR J06 EDITORIAL
PURPOSE:
1. To compute the preferred tracking attitude of the CSM which enables optimal tracking of the LM and LM tracking of the CSM radar transponder and to compute the 4x-axis tracking attitude of the CSM which enables CCM tracking of the LM.
2. To perform the maneuver to the selected tracking attitude if the maneuver is less than 10 degrees but to call READ if the maneuver is greater than 10 degrees.

ASSUMPTIONS:
1. The preferred tracking attitude is computed as follows:
   a. The track axis (1) is aligned along the LOS to the LM. The track axis (1) is defined as:
      \[ \cos \theta \cos \phi \hat{i} + \cos \theta \sin \phi \hat{j} + \sin \theta \hat{k} \]
   b. The CCM orientation about the track axis (1) is a function of the existing attitude at the time of the calculation and is calculated so as to yield a minimum attitude maneuver.
   c. The routine is automatically called by the rendezvous navigation program (P201).
   d. The gimbal angles required to point the preferred LOS at the LM are available by keying in V/NOSE.
   e. The gimbal angles required to point the 4x-axis LOS at the LM are available by keying in V/NOSE.
   f. If the surface flag has been set (V/AGE) this routine will assume the LM to be at the most recently defined landing site. The landing site can be placed into the CMC during the orbit navigation program (P22) or by uplink.

START PROGRAM
TRACKING ATTITUDE ROUTINE (P411)

...
IS THE S61 COUNTER EQUAL TO ZERO?

Y  N

IS S61 COUNTER NEGATIVE?

N  Y

DECREMENT S61 COUNTER BY ONE.

EXIT

IS THE SURFACE FLAG SET?

N  Y

EXTRAPOLATE CSM STATE VECTOR TO THE PRESENT TIME USING CONE EQUATIONS AND SET POSITION OF THE LM EQUAL TO THE LANDING SITE.
CALCULATE THE PRESCRIPTION TRACKING ATTITUDE FROM ESM TO LWM, (PREFERRED UNIT VECTOR ALIGNMENT WITH LPM FROM ESM TO LWM). THIS ATTITUDE WILL BE COMPUTED IN EQUATIONS TO POINT THE PRESCRIPTION AXIS AT LWM BUT WILL NOT CONSTRRAIN THE NON-CRITICAL ORIENTATION ABOUT THAT VECTOR.

COMPUTE REQUIRES ORIENTATION ANGLES, AT THE PREFERRED TRACKING ATTITUDE. IF THE PRESENT ATTITUDE ORIENTATION IS HELD AND STEERED IN NULL OR

CALCULATE AX-AXIS TRACK ANGULAR ATTITUDE FROM ESM TO LWM AXES, AXES ALIGNED WITH LPM FROM ESM TO LWM. THIS ATTITUDE WILL BE COMPUTED IN EQUATIONS TO POINT THE AX-AXES.
AT THE/im put will
not constain the
non-critical or-
entation about
that vector (roll)

---

Compute required
pitch angles at
the +Y axis track-
ing attitude if
the present imu
orientation is
held and
store in noun 94

---

Is the preferred
attitude flag
set (see p?01)?

\( N \) \( Y \)

---

Transfer con-
tents of noun
95 into noun 18

---

Transfer con-
tents of noun
96 into noun 18
SHUT-OFF UPLINK ACTIVITY

LIGHT FROM BATTERY FOR USE IN CASE OF MANUFACTURER MANNED ROUTINE MINING OR OUTAGE

PROTECT THE GIMBAL ANCHOR AND ANY PROPELLORS.必須保持飛機於穩定狀態，任何角度超出15°以上，必須立即停止作業，並進行機器相關检查。

REQUIRED GIMBAL ANGLE CHANGES

GIMBAL ANGLE CHANGES GREATER THAN 15° MUST BE MADE ONLY AFTER MAINTENANCE TIME.

PERFORMING GIMBAL ANCHOR FOR USE.

(ALL)
SET PACE COUNTER EQUAL TO 0.

EXIT

IS CNC AUTO MODE SELECTED?

Y

N

IS STICK FLAG SET?

Y

N

CALCULATE THE ANGULAR VELOCITY OF THE LOS AND RESOLVE INTO RCS DAD CONTROL AXES.

INPUT THE FOLLOWING QUANTITIES TO THE RCS DAD:

(1) DESIRED BODY ATTITUDE

1A
(2) First, copy to computer tape.

(3) Amounts by which the coil-activated registers should be incremented at 0.1 second intervals.

SET REG COUNTER COIAL TO A.

... EXIT P1.

CHANGE CONTROL NOTES

LOGIC REV 11 DIG # XIT 54
REV 12 DIG # XIT 48
REV 13 DIG # XIT 47
REV 14 DIG # XIT 46
REV 15 DIG # XIT 45
PRE 11 DIG # XIT 44
PRE 12 DIG # XIT 43
PURPOSE: (1) TO PROVIDE THE CREW WITH THE ABILITY TO SPECIFY A FINAL VEHICLE ATTITUDE FOR USE BY A CMC-CONTROLLED ATTITUDE MANEUVER.

ASSUMPTIONS: (1) THE ROUTINE IS MANUALLY SELECTED BY THE ASTRONAUT BY DSKY ENTRY.
(2) THE DAP DEADBAND DURING THIS ROUTINE IS AS DEFINED BY THE LOAD DAP DATA ROUTINE (R03).
(3) THIS ROUTINE CAN ONLY BE ENTERED FROM THE CMC IDLING PROGRAM (POO).

---

**PROG CONT** CMC GROUND CREW CHECKLIST TIME TOTAL TIME

---

START CREW-DEFINED MANEUVER ROUTINE (R62) ---

---

IS CURRENT PROGRAM POO? ---

---

IS ANOTHER EXTENDED VERB ACTIVE? ---

---

PCN ---

---

**#10**

---

**#20**

---

---
HOLD

SNAP

TURN ON OPERATOR ERROR LIGHT

REQUEST RESPONSE AND DISPLAY FINAL GIMBAL ANGLES:
- V06 N22
- R1- CG ROLL
- R2- IG PITCH
- R3- MG YAW

ALL GIMBAL ANGLES IN DEGREES TO NEAREST .01 DEGREE.

WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF PROCED OR NEW DATA

MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF FINAL GIMBAL ANGLES.

DO I WISH TO KEY IN NEW GIMBAL ANGLES TO BE USED BY ROUTINE R60?

KEY IN V2SE AND LOAD NEW GIMBAL ANGLES

KEY IN PROCEED

R62/COLOSSUS
GAI

SET 3 AXIS FLAG FOR USE BY ATTITUDE MANEUVER ROUTINE (R60)

DO ATTITUDE MANEUVER ROUTINE (R60)

EXIT R62

 CHANGE CONTROL NOTES

LOGIC REV 05 P/N 586
PURPOSE:

1. To calculate the final General Angles required to point the CSM +X axis at the LM and to calculate the final General Angles required to point the preferred tracking axis at the LM.

2. To display the General Angles corresponding to the attitude option selected by the Astronaut.

3. To call the Attitude Maneuver Routing (R40) for Automatic Maneuver Capability.

ASSUMPTIONS:

1. The preferred tracking attitude is defined as follows:
   - The track axis (1) is aligned along the LOS to the LM. The track axis (1) is defined as:
     - UNIT(1) = UNIT(2) COS 56 deg + UNIT (X) SIN 56 deg
     - UNIT (X)
   - The CSM Orientation about the track axes (1) is a function of the existing attitude at the time of the calculation so as to yield a minimum attitude maneuver.

2. To save time the CSM attitude control mode should be preselected (for automatic maneuvers R40 should have been done and the CMC auto mode selected).

3. This routine may be selected in R40 only.

4. This routine is selected by the Astronaut by DSKY entry.

PROC.

CONT  CMC  GROUND  CREW  

CHECKLIST  TIME  TOTAL

*CREW

*ROUTING

*SELECTION

**

START DIRECTIONS

FINAL ATTITUDE ROUTING CARD

**

IS THE CURRENT R40 OPEN?

YES  NO

**

#10

#20
IS ANOTHER EXTENDED VERSION ACTIVE?

MONITOR DSky:

DOES OPERATOR FROM LIGHT COME ON, INDICATING THAT THIS ROUTINE CAN NOT BE SELECTED AT THIS TIME?

IN ORDER TO TURN THIS ROUTINE ON SELECT PMC IDLING PROGRAM (P08) BY KEYING V37EOF AND RESPECT THIS ROUTINE

DO IMU STATUS CHECK ROUTINE (P07)

EXIT P63

EXIT P63

EXIT P63

EXIT P63

EXIT P63

EXIT P63

EXIT P63
IS THE OPTION = 1?

AND

YES

RESET THE PREFERRED ATTITUDE FLAG.

SET THE PREFERRED ATTITUDE FLAG.

EXTRAPOLATE LM AND CSM STATE VECTORS FORWARD TO THE PRESENT TIME +1 MIN USING CONIC EQUATIONS

CALCULATE THE PREFERRED TRACKING ATTITUDE FROM CSM TO LM, PREFERRED UNIT VECTOR ALIGNED WITH LOS FROM CSM TO LM. THIS ATTITUDE WILL BE COMPUTED (EXACTLY) TO POINT THE PREFERRED AXIS AT THE LM BUT WILL NOT CONSTRAINT THE NON-CRITICAL ORIENTATION ABOUT THAT VECTOR.
COMPUTE REQUIRED
GIMBAL ANGLES AT THE
PREFERRED TRACKING
ATTITUDE IF THE
PRESENT LM ORIENT-
ATION IS HELD AND
STATED IN NOIN 93.

---------------------

CALCULATE THE +Y-
AXIS TRACKING ATT-
ITUDE FROM CSM TO LM
(+X-AXIS ALIGNED
WITH LOS FROM CSM TO
LM). THIS ATTITUDE
WILL BE COMPUTED
(FRAMEPT) TO POINT
THE +X-AXIS AT THE
LM BUT WILL NOT CON-
STRAIN THE NON-CRIT-
ICAL ORIENTATION
ABOUT THAT VECTOR
(ROLL).

---------------------

COMPUTE REQUIRED
GIMBAL ANGLES AT
THE +X-AXIS TRACKING
ATTITUDE IF THE
PRESENT LM ORIENT-
ATION IS HELD AND
STATED IN NOIN 93.

---------------------

IS THE PREFERRED
ATTITUDE FLAG SET
(SEE O?93)?

-----------------------------------------------

NO  YES
CHANGE CONTROL NOTES

REV 10  PCR WIT/4
REV 11  PCR WIT 206
REV 12  PCM 531
REV 13  PCR 206 EDITORIAL
         PCM 594

630
PURPOSE:  
(1) TO INITIATE A COMPUTER FRESH START

ASSUMPTIONS:
(1) FRESH START IS CREW INITIATED BY DSKY ENTRY.
(2) ALTHOUGH THE REFSMMAT FLAG IS RESET BY A FRESH START INDICATING THAT THE REFSMMAT IS NOT GOOD, THE ACTUAL REFSMMAT IS NOT CHANGED.
(3) FRESH START RESETS THE CSM MOON FLAG AND THE LM MOON FLAG INDICATING EARTH ORBIT FOR STATE VECTOR INTEGRATION.
(4) IF A FRESH START INTERRUPTS STATE VECTOR INTEGRATION, THE STATE VECTOR MAY BE INVALIDATED.
(5) THIS PROCESS MAY BE SELECTED AT ANY TIME.

---

PROC CONT CMC GROUND CREW CHECKLIST TIME TOTAL TIME

---

CREW SELECTION

---

START CREW INITIATED -------------- KEY IN V36E
FRESH START                         --------------

---

ZERO OUTBIT CHANNELS
5 (RCS PITCH AND
YAW) AND 6 (RCS ROLL)

---

SET TIME 3 = 37777
TIME 4 = 37775
TIME 5 = 37774

---

#10

#20

#30

V36/COLOSSUS
ZERO OUTPUT CHANNELS: 11 (EXCEPT ENGINE ON, CFF AND ISS WARNING); 12 (EXCEPT COARSE ALIGN ENABLE, ZERO IMU CDF'S, ENABLE +94 IMU ERROR COUNTER; 13 (EXCEPT TELEMETRY BITS, RESET TRAP BITS AND INTERRUPT BIT); 14 (EXCEPT CYRO ENABLE).

TERMINATE WAITLISTED TASKS

CLEAR ALL EXECUTIVE REGISTER SETS

INDICATE NO ACTIVE JOBS

MAKE ALL VAC AREAS AVAILABLE

BLANK DSKY REGISTERS ([PROGRAM, VERS, NOUN, Q1, P2, O3])
RESET DISPLAY/ASTRONAUT INTERFACE FLAGS

TURN OFF DSKY DISCRETE LIGHTS.

CLEAR FAIL REGISTERS, SELF CHECK ERROR COUNTER, AND RESTART COUNTER

CLEAR SELF-CHECK ERROR REGISTERS, MODE REGISTER.

INITIALIZE PIPA AND TELEMETRY FAIL FLAGS

ZERO OUT BIT CHANNELS: 114 (AM RELAYS); 12 (GNC); 13 (AGC); AND 14 (TSS)

INITIALIZE DOWNLINK WITH POD DOWMLIST
CLEAR PHASE TABLE

INITIALIZE IMU
(INHIBIT IMU FAIL
FOR 5 SECONDS)

INITIALIZE OPTICS

RESET EXTENDED VERB
ACTIVITY INTERLOCK

RESET ALL FLAGWORDS
(EXCEPT IDLEFLAG-
BIT 7 FLAGWORD 7
AND COMPUTER FLAG-
BIT 8 FLAGWORD 51)

RESET IDLEFLAG

EXIT
<table>
<thead>
<tr>
<th>Change Control Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Rev 04</td>
</tr>
</tbody>
</table>
PURPOSE:
1. To insure synchronization between the ISS CDU counters and the CDU counters in the computer.
2. To terminate the IMU coarse align mode and enter the fine align mode (inertial IMU).

ASSUMPTIONS:
1. The process is crew selected bysky entry.
2. The process may not be selected if the ISS is in the coarse align mode and in gimbal lock.
3. The process is intended primarily for use on the ground.

<table>
<thead>
<tr>
<th>PROC</th>
<th>CONT</th>
<th>GROUND</th>
<th>CREW</th>
<th>CHECKLIST</th>
<th>TIME</th>
<th>TOTAL TIME</th>
</tr>
</thead>
</table>

**CREW PROC. SELECTION**

```
START CREW INITIATED
CDU ZERO

IS ISS IN COARSE ALIGN MODE WITH GIMBAL LOCK?

Y
N

IS THE IMU BEING INITIATED?

Y
N
```

**KEY IN V40N20F**

<table>
<thead>
<tr>
<th>TIME</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#10</td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td></td>
</tr>
<tr>
<td>#30</td>
<td></td>
</tr>
</tbody>
</table>
PurposE:  
(1) To align the IMU to gimbAl Angles specified by the Astronaut.
(2) To coarse align to 0,0,0 when in gimbAl lock and coarse align.

AssumpTions:  
(1) The process is crew selected by dsky entry.
(2) The process may be selected only when no other extended verb is active.
(3) The accuracy of the alignment is tested to a tolerance of ±2 degrees. If this tolerance is exceeded, the Astronaut will be notifed via a program alarm.
(4) V41 may only be used with N20 or N01. Refer to optics coarse align extended verb (V41N01).
(5) The process should never be used during a program which requires that the IMU be on and aligned.

<table>
<thead>
<tr>
<th>Prog</th>
<th>Cmc</th>
<th>Ground</th>
<th>Crew</th>
<th>Checklist</th>
<th>Time</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>cont</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Start crew initiated
ICDU coarse align

---

Is another extended verb active?

---

Key in V41N20E

---

#10

V41N20/COL
IS THE IMU BEING INITIALIZED?

N  Y

TURN ON OPR ERR LIGHT

...

EXIT

FLASH VERB-NOUN TO REQUEST LOAD OF DESIRED COUV ANGLES.
V21N??
R1-0G ROLL
R2-1G PITCH
R3-0G YAW

ALL REGISTERS INITIALLY BLANK

ALL ANGLES IN DEGREES TO NEAREST .01 DEGREE

MONITOR DSKY: OBSERVE VERB-NOUN FLASH REQUESTING LOAD OF COUV ANGLES

SHALL I LOAD COUV ANGLES?

Y  N

V41N20/COL
WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF DATA OR PROCEED

LOAD DESIRED ANGLES

DATA
PROC
CE
D

DISPLAY COARSE ALIGN VERB

MONITOR DSYV?

ENTER COARSE ALIGN MODE

TURN ON NO ATT LIGHT

COARSE ALIGN IMU TO STORED ANGLES (15 SECS MAX)
WAIT 1.5 SECONDS

READ PRESENT IMU ORIENTATION W.R.T. THE VEHICLE. (GIMBAL ANGLES)

ARE THE GIMBALS WITHIN 2 DEGREES OF THE DESIRED ANGLES?

Y: TURN ON PROGRAM ALARM AND STORE ALARM CODE (00211)

NO: MONITOR DSky.

DOES PROGRAM ALARM INDICATE THAT THE IMU GIMBALS DID NOT DRIVE TO WITHIN 2 DEGREES OF THE DESIRED ANGLES?

Y: CHECK STATUS OF CW PANEL. IS AN ISS MALFUNCTION INDICATED?

N: EXIT

EXIT
DO I DESIRE TO
REFLECT THE
COARSE ALIGN
PROCESS?
NOTE: THE
DEGREE OF
FAILURE MAY BE
EXIT CHECKED BY
COMPARING THE
SPECIFIED
GIMBAL ANGLES
(V16N22E) WITH
THE CURRENT
ANGLES
(V16N20E).
-------------
N  Y

-------------
RESELECT
COARSE
ALN MIN KEY
V41N20E

EXIT
EXIT

CHANGE CONTROL NOTES

REV 03  PCR 206
04  EDITORIAL
PURPOSE:  
(1) TO DRIVE THE OPTICS TO SHAFT AND TRUNNION ANGLES SPECIFIED BY THE ASTRONAUT

ASSUMPTIONS: 
(1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.
(2) THE PROCESS MAY BE SELECTED ONLY WHEN NO OTHER EXTENDED VERB IS ACTIVE.

<table>
<thead>
<tr>
<th>CREW PROG. SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>START CREW INITIATED OS CARGE ALIGN</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Key In V4IN91E</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Is Another Extended Verb Active?</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Y</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>TURN ON CPP ERR LIGHT</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Exit</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
</tbody>
</table>

V4IN91/COL
IS OPTICS MODE CMC?

Y   N

TURN ON OPR ERR LIGHT

TURN ON PROGRAM ALARM AND STORE ALARM CODE (00115)

ARE OPTICS AVAILABLE?

Y   N

TURN ON PROGRAM ALARM AND STORE ALARM CODE (00117)

MONITOR PROGRAM ALARM LIGHT: IF THE PROGRAM ALARM LIGHT COMES ON AT THIS TIME, THE ASTRONAUT SHOULD KEY V05N09E TO CHECK THE ALARM CODE:

00115-SET OPTICS MODE SW-CMC RSET

00117-OPTICS NOT AVAILABLE. THE PROCESS CANNOT BE DONE AT THIS TIME

TURN ON PROGRAM ALARM AND STORE ALARM CODE (00117)
HOLD

FLASH VERB-NOUN TO
REQUEST LOAD OF DE-
SIRE OPTICS ANGLES
V21 N92
R1 - SHAFT
R2 - TRUNNION
R3 - BLANK

ALL REGISTERS
INITIALLY BLANK

SHAFT ANGLE IN DE-
GREES TO NEAREST
.01 DEGREE

TRUNNION ANGLE IN
DEGREES TO NEAREST
.001 DEGREE

SHALL I LOAD OPTICS
ANGLES?

Y N

WAIT FOR KEYBOARD
ENTRY

LOAD DESIRED
ANGLES

TERMINATE FLASH UPON
RECEIPT OF DATA
OR PROCEED

KEY IN
PROCEED

DATA P R O C E D

USE ANGLES
IN SAC, PAC