

SPS PROGRAM (P40)

LOGIC REV 16 11/27/68

PURPOSE:

- (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A PREFERRED VEHICLE ATTITUDE FOR A SPS THRUSTING MANEUVER.
- (2) TO CALCULATE AND DISPLAY THE GIMBAL ANGLES WHICH WOULD RESULT WITH THE PRESENT IMU ORIENTATION IF THE VEHICLE WERE MANEUVERED TO THE PREFERRED VEHICLE ATTITUDE FOR A SPS THRUSTING MANEUVER. THE CREW IS THEREBY GIVEN AN OPPORTUNITY TO PERFORM THE MANEUVER WITH:
 - (A) THE PRESENT IMU ORIENTATION, IF THE MIDDLE GIMBAL ANGLE IS NOT GREATER THAN 45 DEGREES, AND THE IMU HAS BEEN ALIGNED WITHIN THE LAST 3 HRS.
 - (B) A NEW ORIENTATION ACHIEVED BY SELECTION OF P52.
- (3) TO DO THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.
- (4) TO CONTROL THE GNCS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A GNCS CONTROLLED SPS MANEUVER.

ASSUMPTIONS:

- (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE CMC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.
- (2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER SET OR RESET THE EXTERNAL DELTA V STEERING FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING THRUSTING AND UNTIL THE CREW NOTIFIES THE CMC TRIM THRUSTING HAS BEEN COMPLETED THE CMC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR LAMBERT STEERING VG IS CALCULATED AND UPDATED SIMILARLY, HOWEVER IT IS ALSO UPDATED PERIODICALLY BY LAMBERT SOLUTIONS TO CORRECT FOR CHANGES IN THE CSM STATE VECTOR.
- (3) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
- (4) THE TTE CLOCK IS SET TO COUNT TO ZERO AT TIG.
- (5) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW OR IF INTEGRATION CAN NOT BE COMPLETED ON TIME.
- (6) THE SPS THRUSTING PROGRAM DOES NOT MONITOR THE SC CONTROL DISCRETE (CHANNEL 31 BIT 15) DURING THRUSTING. THIS MEANS THAT THE CMC WILL CONTINUE TO GENERATE ENGINE ACTUATOR COMMANDS, SPS ENGINE ON DISCRETE, AND FOAI ATTITUDE ERROR NEEDLE COMMANDS UNTIL THE CMC SOLUTION INDICATES ENGINE OFF AT WHICH TIME THESE COMMANDS AND THE ENGINE ON DISCRETE ARE TERMINATED. HOWEVER, THIS PROGRAM IS NOT WRITTEN TO TAKE INTO ACCOUNT THE SITUATION WHERE CONTROL MAY BE TAKEN AWAY FROM THE GNCS AND THEN GIVEN BACK, AND IT IS NOT RECOMMENDED. IN EVENT CONTROL IS TAKEN AWAY FROM THE GNCS, THE CMC WILL ONLY BE RESPONSIBLE FOR COMPUTATION OF POSITION AND VELOCITY.
- (7) ROUTINE R03 HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. IN ORDER FOR THE GNCS TO PERFORM THE ATTITUDE MANEUVER AND CONTROL THE THRUSTING MANEUVER THE ASTRONAUT MUST KEY IN V46F AT SOME TIME PRIOR TO THE ATTITUDE MANEUVER.
- (8) THE VALUE OF DELTA V REQUIRED WILL BE STORED IN THE LOCAL VERTICAL COORDINATE SYSTEM AND IS AVAILABLE DURING THIS PROGRAM UNTIL AVERAGE G TURN ON BY KEYING IN V06N81.
- (9) THE ORBIT PARAMETER DISPLAY ROUTINE (R30) MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.
- (10) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
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.CREW PROG.
.SELECTION

.
.
.
.
.
.
.
.

#10

START SPS
PROGRAM (P40)
DISPLAY PROGRAM 40

.
.....
.

KEY IN SPS
PROGRAM (P40)
V37E 40E

.
.
.

#20

MONITOR DSKY:
OBSERVE DISPLAY OF
PROGRAM 40

.
.....
.

DO IMU STATUS CHECK
ROUTINE (R02)

.
.....
.

DO IMU STATUS CHECK
ROUTINE (R02)

#30

IS EXTERNAL DELTA V
FLAG SET?

.N .Y

. .

. .

SET CSTFER=
ECSTFER IN
STFER LAW

. .

. .

. .

. .

. .

. .

#40

P40/COLOSSUS

 SET PREFERRED
 ORIENTATION FLAG

#110

 STORE DESIRED ATTITUDE SPECIFICATION (TRIMMED ENGINE BELL CENTER LINE IN DIRECTION OF INITIAL THRUST) FOR USE BY ATTITUDE MANEUVER ROUTINE (R60). THE FINAL ATTITUDE WILL BE COMPUTED (VECT-POINT) DURING R60, AND WILL POINT THE TRIMMED ENGINE BELL IN THE INITIAL THRUST DIRECTION. IN ORDER TO CONSERVE RCS FUEL AND NOT CONSTRAIN THE NON-CRITICAL ROLL ATTITUDE, WINGS MAY NOT BE LEVEL IN THE COMPUTED FINAL ATTITUDE

#120

#130

 SET .5 DEGREE
 DEADBAND IN RCS DAP.

#140

 DO ATTITUDE MANEUVER
 ROUTINE (R60)

 DO ATTITUDE MANEUVER
 ROUTINE (R60)

#150

```

HOLD . FLASH VERB-NOUN TO
..... RFQUEST PLEASE PER-
SNAP . FORM ENGINE GIMBAL
      DRIVE TEST ENABLE
      V50 N25
      R1-00204
      R2-BLANK
      R3-BLANK

```

```

      .
    .....
      .
MONITOR DSKY
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE GIMBAL DRIVE
TEST ENABLE

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#160

SHALL I ENABLE
GIMBAL DRIVE TEST?

#170

WAIT FOR KEYBOARD
ENTRY

.N	.Y
:	:
:	:
-----	:
KEY IN ENTER	:

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR ENTER

KEY IN PROCEED

#180

.ENTER .PROCEED

```

. INITIALIZE ENGINE
. GIMBALS TO 0
. DEGREES IN PITCH
. AND YAW AND PER-
. FORM GIMBAL DRIVE
. TEST SEQUENCE AT
. 2 SEC/STEP:
.   PITCH / YAW
. 1  2    /  0
. 2 -2    /  0
. 3  0    /  0
. 4  0    /  2
. 5  0    / -2
. 6  0    /  0
. IN DEGREES.

```

.....
 . MONITOR GIMBAL DRIVE
 SEQUENCE BY REFER-
 . ENCE TO ANALOG DIALS

#190

#200

#210

.....
 .
 .
 .
 .
 .

 WAIT 4 SECONDS

 .
 .
 .

 DRIVE SPS ENGINE
 BELL TO TRIM PO-
 SITION

 .
 .
 .

 OBSERVE DIAL INDICA-
 TION OF ENGINE BELL
 DRIVING TO TRIM
 POSITION

 .
 .
 .

#220

TEMP
 HOLD .

 MON .

 DISPLAY ON DSKY:
 V06 N40
 R1 - TFI
 R2 - VG
 R3 - DELTA VM

 MONITOR DSKY:
 OBSERVE DISPLAY OF
 TFI, VG, AND DELTA
 VM

#230

TFI - TIME FROM
 SPS IGNITION. IN
 MIN, SEC TO NEAR-
 EST SEC. MAX
 READING IS 59B59.
 (SIGN IS - BEFORE
 NOMINAL TIG, +
 THEREAFTER).

#240

VG - MAGNITUDE OF THE
 VELOCITY TO BE
 GAINED BY THRUSTING
 MANEUVER. IN FPS
 TO NEAREST .1 FPS

DELTA VM-MEASURED
 DELTA V MAGNITUDE
 IN FPS TO NEAREST
 .1 FPS. THIS DIS-
 PLAY SHOULD BE
 00000 UNTIL ULLAGE
 IS STARTED.

#250

 .
 .
 .

 SET TDEC = TIG
 -30 SEC

 .
 .
 .
 .
 .

#260

RESET TIG FLAG

#270

DO STATE VECTOR
INTEGRATION (MID TC
AVE) ROUTINE (R41).

NO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41).
OBSERVE THAT THE
COMPUTER ACTIVITY
LIGHT IS ON UNTIL
COMPLETION OF
ROUTINE 41

#280

WAIT UNTIL TFI =
-35 SEC

#290

BLANK DISPLAY OF
VERB-NOUN AND R1,
R2, R3 AT TFI > -35
SEC

MONITOR DSKY:
OBSERVE THAT DISPLAY
GOES BLANK
AT TFI = -35 SEC

第300

WAIT UNTIL TFI =
-30 SEC

REDISPLAY V06N40 NON-
FLASHING AND CALL
AVERAGE G ROUTINE.

MONITOR DSKY:
OBSERVE REDISPLAY OF
TFI, VG, DELTA VM,
AT TFI = -30 SEC.
TO INDICATE THAT THE
AVERAGE G ROUTINE IS
TURNED ON. OBSERVE
THAT THE COMPUTER
ACTIVITY LIGHT
BLINKS ON EVERY 2
SECONDS DURING

#310

#320

WAIT UNTIL
TFI =-5 SEC

"A"

IS THIS BURN TO BE
IMPULSIVE?

.N .Y
.
.
.
STORF
BURN
TIME

AVERAGE G.

MONITOR DSKY:
IN THE PERIOD FROM
TFI =-30 SEC UNTIL
TFI =-25 SEC
DOES DELTA VM BECOME
GREATER THAN 2.0 FPS
INDICATING EXCESSIVE
PIPA BIAS ERROR?

.N .Y
.
.
.
GO TO RACKUP
PROCEDURES

COMMAND +X ULLAGE
TRANSLATION USING
THC WHEN INDICATED
BY CHECKLIST

OBSERVE ULLAGE BUILD
UP IN R3.

"A"

#330

#340

#350

#360

#370

HOLD .
.....
MON .

CHANGE VERB BUT RE-
TAIN PRESENT NOUN
AND DISPLAYS IN R1,
R2, R3, FLASH VERB-
NOUN TO REQUEST
PLEASE PERFORM ENG-
INE ON ENABLE:
V99 N40
R1 - TFI
R2 - VG
R3 - DELTA VM

WAIT FOR KEYBOARD
ENTRY

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE

SHALL I PERMIT
IGNITION OR
RE-IGNITION?

.N .Y

KEY IN PROCEED

SHALL I ATTEMPT
TO COMPLETE THE
THRUSTING MANEU-
VER BY USE OF
THE RCS?

.N .Y

KEY IN ENTER

GO TO
"D"
BELOW

#380

#390

#400

#410

#420

RESUME NO FLASH
V06 N40 DISPLAY UPON
RECEIPT OF PROCEED.
TERMINATE FLASH UPON
RECEIPT OF ENTER OR
TERMINATE.

.P	.E	.T
.R	.N	.E
.D	.T	.R
.C	.F	.M
.E	.R	.I
.E	.	.N
.D	.	.A
.	.	.T
.	.	.E

COMMAND
ENGINE OFF.

GO TO
"D"
BELOW

COMMAND
ENGINE
OFF.

DO ROUTINE R00

EXIT

IS TFI MINUS?

.Y	.N
.	.
.	.
.	.
.	.
.	.

KEY IN
TERMINATE
V34E

DO ROUTINE R00

EXIT

#430

#440

#450

#460

#470

#480

.
 .
 .
 .
 .

 WAIT UNTIL
 TFI=0

 .
 .
 .

 COMMAND ENGINE ON

 .
 .
 .

 SHUT OFF RCS DAP

 .
 .
 .

 WAIT ABOUT .4
 SECONDS

 .
 .
 .

 TURN ON TVC DAP

 .
 .
 .

 WAIT ABOUT 1.6
 SECONDS

 .
 .
 .

 TURN OFF ALL RCS
 TRANSLATION

 .
 .
 .

 IS THIS AN IMPULSIVE
 BURN?

 .N .Y
 .
 .
 .
 .
 .
 .
 .
 .
 .

#490

#500

#510

#520

#530

"B"

#540

CALL CROSS PRO-
DUCT STEERING
ROUTINE AS DESCRIBED
IN SECTION 5.3.3.4
OF THIS DOCUMENT.

#550

NOTE: IF AT ANY
TIME DURING THE
THRUSTING PERIOD
THE ROUTINE DETECTS
A "THRUST FAILURE"
IT WILL CEASE
STEERING (RATE COM-
MAND SET TO ZERO),
WILL STOP CALCULAT-
ING TIME FROM CUTOFF
AND WILL DISABLE
C.G. TRACKING. IT
WILL TURN ON THE
SPS THRUST FAIL
ROUTINE (R40) AND
WILL SET THE TFC
REGISTER EQUAL TO
59859.

#560

IN THE EVENT THIS
ROUTINE DETECTS VC
INCREASING IT WILL
TURN ON PROGRAM
ALARM LIGHT AND
STORE ALARM CODE
1407.

#570

.THRUST . "THRUST
.OK . FAILURE"

#580

. DO THE SPS THRUST
. FAIL ROUTINE
. (R40).

DO THE SPS
THRUST FAIL
ROUTINE (R40)

"B"

"B"

#590

TEMP
HOLD . CHANGE TFI DISPLAY
..... TO TFC IN R1
MON . V06 N40
R1 - TFC
R2 - VG
R3 - DELTA VM

TFC - TIME FROM
ENGINE CUTOFF.
IN MIN AND SEC TO
NEAREST SEC.
MINUS BEFORE CUTOFF

MONITOR DSKY:
OBSERVE CHANGE OF
TFI DISPLAY TO TFC
IN R1

MONITOR SPS
THRUSTING:

1. DSKY:
R1-TFC
SHOULD BE
DECREASING

R2-VG SHOULD BE
DECREASING

R3-DELTA VM
SHOULD INCREASE

2. FDAI-ATT. ERROR
SHOULD BE LESS THAN
OR EQUAL TO --DEGREE
ATT RATES SHOULD BE
LESS THAN OR EQUAL
TO -- DEGREE/SEC.

3. SPS CHAMBER
PRESSURE (PC)
SHOULD BE NORMAL

Y. .N

#600

#610

#620

#630

#640

#650

MONITOR DSKY:
AS TFC AND VG GO
TO ZERO THRUST
SHOULD CUTOFF.

.N .L
.Q .A
.R .T
.M .E
.A .
.L .
. .
. .
. .

#660

GO TO BACK
UP PROCE-
DURES

#670

CMC COMMANDS ENGINE
OFF WHEN INDICATED
BY CROSS PRODUCT
STEERING ROUTINE OR
IMPULSIVE THRUST
TIMER (SET UP AT
IGNITION AS DEFINED
IN SECTION 5.3.3.3
OF R577)

#680

WAIT ABOUT 2.5
SECONDS

#690

TURN OFF TVC
DAP

#700

WAIT ABOUT
1.2 SEC.

SET WIDE DEADBAND
IN RCS DAP AND TURN
RCS DAP ON.

MAINTAIN VG
COMPUTATIONS AFTER
CUTOFF FOR POSSIBLE
NULLING BY RCS
TRIMMING MANEUVER

HOLD .

MON

FLASH VERB-NOUN TO
REQUEST PROCEED.
HOLD DISPLAY OF TFC
AT ITS VALUE WHEN
CMC COMMANDS ENGINE
CUTOFF

V16 N40
R1 - TFC
R2 - VG
R3 - DELTA VM

MOVE MAIN PANEL
SWITCH TO OFF.

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
PROCEED AND DISPLAY
OF TFC, VG AND DELTA
VM.

#710

#720

1730

#740

#750

#760

 WAIT FOR KEYBOARD
 ENTRY

#770

 KEY IN PROCEED

 TERMINATE FLASH UPON
 RECEIPT OF PROCEED.

#780

.P
 .R
 .Q
 .C
 .E
 .E
 .D

#790

 SET MINIMUM DFACBAND
 IN RCS DAP

#800

"D"

HOLD .
.....
MON .

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY:

V16 N85
R1-VGX(CSM)
R2-VGY(CSM)
R3-VGZ(CSM)

{COMPONENTS OF THE
VG VECTOR RESOLVED
ALONG THE PRESENT
CSM X,Y, AND Z CON-
TROL AXES. THE VG
VECTOR WILL BE UP-
DATED BY THE STEER-
ING LOOPS DURING
EACH COMPUTATION
CYCLE.

IN FPS TO THE
NEAREST .1 FPS).

++
+16
++
EDIT
PCR
206

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST RE-
SPONSE AND DISPLAY
OF VG COMPONENTS.

#810

TO NULL OUT VG COM-
PONENTS COMMAND MAN-
UAL TRANSLATIONS AND
ROTATIONS. (NOTE:
THIS MANEUVER IS AT
THE OPTION OF THE
CREW).

#820

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

#830

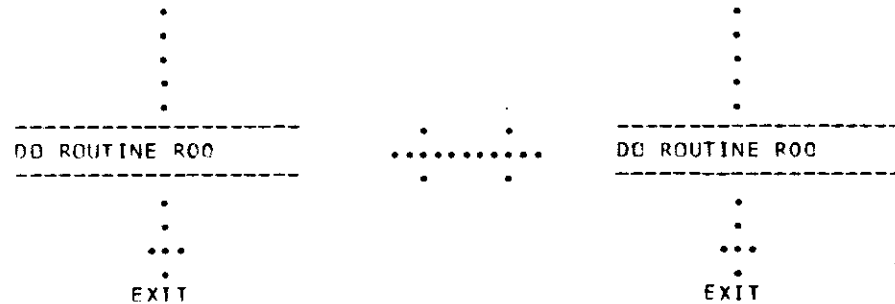
TERMINATE FLASH UPON
RECEIPT OF PROCEED

.P
.R
.O
.C
.E
.E
.C

#840

TRANSMIT ORBITAL.....RECEIVE ORBITAL DATA
DATA TO CREW . FROM GROUND

#850



#870

CHANGE CONTROL NOTES

REV 11 PCR MIT 32
REV 12 PCR MIT 32
REV 13 PCR MIT 66
PCR MIT 80 - 98
PCR NASA 151
REV 14 PCR 401.1
PCR 463
REV 15 PCR 206
REV 16 PCR 206 EDITORIAL

RCS PROGRAM (P41)

LCGIC REV 16 11/27/68

PURPOSE:

- (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A PREFERRED VEHICLE ATTITUDE FOR AN RCS THRUSTING MANEUVER.
- (2) TO CALCULATE THE GIMBAL ANGLES WHICH WOULD RESULT WITH THE PRESENT IMU ORIENTATION IF THE VEHICLE +X-AXIS WERE ALIGNED TO THE THRUST VECTOR. THE CREW IS THEREBY GIVEN AN OPPORTUNITY TO PERFORM THE MANEUVER WITH:
 - (A) THE PRESENT IMU ORIENTATION (NOT RECOMMENDED IF MIDDLE GIMBAL ANGLE IS GREATER THAN 45 DEGREES), IF THE IMU HAS NOT BEEN ALIGNED WITHIN THE LAST 3 HRS, REALIGNMENT IS DESIRABLE.
 - (B) A NEW ORIENTATION ACHIEVED BY SELECTION OF P52
- (3) TO DO THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.
- (4) TO PROVIDE SUITABLE DISPLAYS FOR MANUAL EXECUTION OF THE THRUSTING MANEUVER.

ASSUMPTIONS:

- (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE CMC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.
- (2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRETHRUST PROGRAM, WHICH EITHER SET OR RESET THE EXTERNAL DELTA V STEERING FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING THRUSTING AND UNTIL THE CREW NOTIFIES THE CMC TRIM THRUSTING HAS BEEN COMPLETED, THE CMC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR LAMBERT STEERING VG IS CALCULATED AND UPDATED SIMILARLY, HOWEVER IT IS ALSO UPDATED PERIODICALLY BY LAMBERT SOLUTIONS TO CORRECT FOR CHANGES IN THE CSM STATE VECTOR.
- (3) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
- (4) THE TTE CLOCK IS SET TO COUNT TO ZERO AT TIG.
- (5) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW OR IF INTEGRATION CAN NOT BE COMPLETED ON TIME.
- (6) ROUTINE R03 HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. IN ORDER FOR THE GNCS TO PERFORM THE ATTITUDE MANEUVER AND MAINTAIN ATTITUDE CONTROL THE ASTRONAUT MUST KEY IN V46E AT SOME TIME PRIOR TO THE ATTITUDE MANEUVER.
- (7) THE VALUE OF DELTA V REQUIRED AT TIG IN LOCAL VERTICAL COORDINATES IS STORED IN NOUN 81 AND MAY BE CALLED UNTIL AVERAGE G IS TURNED ON BY KEYING IN V06N81E.
- (8) THE ORBIT PARAMETER DISPLAY ROUTINE (R30) MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.
- (9) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

		.CREW PROG. .SELECTION	
-----		-----	
START RCS PROGRAM	.	KEY IN RCS PROGRAM	
DISPLAY PROGRAM 41	.....	(P41)	
	.	V37E 41E	#10

	.		
	.....	MONITOR DSKY:	
	.	OBSERVE DISPLAY OF	
-----		PROGRAM 41	#20

.			
.			
.			
-----		-----	
DO IMU STATUS CHECK	.	DO IMU STATUS CHECK	
ROUTINE (R02)	.....	ROUTINE (R02)	
	.		

.			
.			
.			#30

SET CSTEER =0.			

.			
.			
.			

COMPUTE INITIAL			
THRUST DIRECTION AND			
INITIAL VALUE OF VG			
VECTOR AND STORE IN			
NCUN 41 (VG LOCAL			
VERTICAL)			#40

.			
.			
.			
.			

COMPUTE PREFEPPED			
IMU ORIENTATION:			#50

P41/COLOSSUS

X = UNIT (X) =
-SM -CSM

UNIT (T)
-

Y = UNIT (Y) =
-SM -CSM

UNIT (X X R)
-CSM -

Z = UNIT (X X Y)
-SM -SM -SM

WHERE:

T = INITIAL THRUST
- VECTOR

R = THE CSM POSITION
- RADIUS VECTOR AT
TIG

X , Y = THE CSM
-CSM -CSM CONTROL
AXIS.

•
•
•

SET PREFERRED
ORIENTATION FLAG

•
•
•

STORE DESIRED ATTIT-
UDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60
AND WILL POINT THE
+X TRANSLATION AXIS
IN THE INITIAL
THRUST DIRECTION.
HOWEVER, IN ORDER TO
CONSERVE RCS FUEL
AND NOT CONSTRAIN
THE NONCRITICAL ROLL

#60

#70

#80

#90

#100

ATTITUDE, WINGS MAY
NOT BE LEVEL IN THE
COMPUTED FINAL
ATTITUDE.

#110

SFT MINIMUM
DEADBAND IN RCS DAP

#120

DO ATTITUDE MANEUVER
ROUTINE (R60)

DO ATTITUDE MANEUVER
ROUTINE (R60)

#130

TEMP
HOLD .
.....
MON .

DISPLAY (NO FLASH)
V06N85
R1 VGX(CSM)
R2 VGY(CSM)
R3 VGZ(CSM)

MONITOR DSKY:
OBSERVE NON-
FLASHING VERB-NOUN
DISPLAY OF VG COM-
PONENTS.

#140

(VGX(CSM), VGY(CSM)
VGZ(CSM) - COMPON-
ENTS OF THE VG
VECTOR AT TIG RE-
SOLVED ALONG PRESENT
CSM X, Y, AND Z CON-
TROL AXES RESPECT-
IVELY. UPDATED W.C.T.
VEHICLE ATTITUDE
EVERY 2 SECONDS IN
FPS TO NEAREST .1
FPS.

SELECT A/P AND MODE
CONTROL AS DESIRED.

#150

SET TDEC=TIG-30 SEC

#160

RESET TIG FLAG

DO STATE VECTOR IN-
TEGRATION (MID TO
AVE) ROUTINE (R41).

WAIT UNTIL TFI =
- 35 SEC

BLANK DISPLAY AT TFI
= - 35 SEC

WAIT UNTIL TFI =
-30 SEC

CALL AVERAGE G
INTEGRATION AND
VG UPDATE (IN-
STANTANEOUS VG
VECTOR).

DO STATE VECTOR IN-
TEGRATION (MID TO
AVE) ROUTINE (R41).
OBSERVE THAT THE
COMPUTER ACTIVITY
LIGHT IS ON UNTIL
COMPLETION OF
ROUTINE 41.

MONITOR DSKY:
OBSERVE THAT DISPLAY
GOES BLANK AT TFI =
- 35 SEC.

#170

#180

#190

#200

#210

++
+16
++
EDIT
PCR
206


```

+ 273
+
+
+
+
+
+16
++
EDIT

```

P41/COLOSSUS

#270

#280

#290

#300

CHANGE CONTROL NOTES

LOGIC REV 11 PCR MIT 32
LOGIC REV 12 PCR MIT 32
PCR MIT 34
LOGIC REV 13 PCP MIT 66
PCR NASA 151
LOGIC REV 14 PCP 401.1
LOGIC REV 15 PCR 206
LOGIC REV 16 PCR 206 EDITORIAL

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THRUST MONITOR PROGRAM (P47)

LCGIC REV 11 06/20/68

PURPOSE:

- (1) TO MONITOR VEHICLE ACCELERATION DURING A NON GNCS CONTROLLED THRUSTING MANEUVER.
 (2) TO DISPLAY THE DELTA V APPLIED TO THE VEHICLE BY THIS THRUSTING MANEUVER.

ASSUMPTIONS:

++

+11

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- (1) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
 (2) THE RESPONSIBILITY OF AVOIDING GIMBALE LOCK DURING EXECUTION OF THIS PROGRAM IS UPON THE ASTRONAUT.
 (3) THIS PROGRAM IS NORMALLY USED DURING RENDEZVOUS FINAL PHASE. IF THE CREW DESIRED TO DO ANY FINAL PHASE THRUSTING MANEUVERS AUTOMATICALLY UNDER GNCS CONTROL THEY MUST BE ACCOMPLISHED VIA SELECTION OF TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) AND THEN THE SPS THRUSTING PROGRAM (P40) OR THE RCS THRUSTING PROGRAM (P41).
 (4) RANGE, RANGE RATE, AND THETA MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE NO 1 (R31) WITH V83E.
 (5) RANGE, RANGE RATE, AND PHI MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE NO 2 (R34) WITH V85E.
 (6) VI, H AND H-DOT MAY BE CALLED BY KEYING IN V16N62E. THE DISPLAY OF H IN LUNAR ORBIT WILL BE INVALID.
 (7) THE ORBIT PARAMETER DISPLAY ROUTINE MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.
 (8) THIS PROGRAM SHOULD BE TURNED ON JUST PRIOR TO THE PLANNED THRUSTING MANEUVER AND TERMINATED AS SOON AS POSSIBLE FOLLOWING THE MANEUVER IN ORDER TO KEEP ERRORS OF BIAS AND AVERAGE G AT A MINIMUM.
 (9) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG
CONT

CMC

GROUND

CREW

CHECKLIST

TIME

TOTAL
TIME

 START THRUST
 MONITOR PROGRAM
 (P47).
 DISPLAY P47.

.

 .

 KEY IN THRUST
 MONITOR PROGRAM
 (P47)
 V37E47E

.CREW
 .
 .
 .PROGRAM
 .SELECTION
 .
 ...
 .

#10

. DELTA VX(CSM) - COM-
 . PONENT OF INTEGRATED
 . ACCELERATION ALONG
 . CSM CONTROL +X AXIS.
 . IN FPS TO NEAREST
 . .1 FPS.

#70

. DELTA VY(CSM) - COM-
 . PONENT OF INTEGRATED
 . ACCELERATION ALONG
 . CSM CONTROL +Y AXIS.
 . IN FPS TO NEAREST
 . .1 FPS.

. DELTA VZ(CSM) - COM-
 . PONENT OF INTEGRATED
 . ACCELERATION ALONG
 . CSM CONTROL +Z AXIS.
 . IN FPS TO NEAREST .1
 . FPS.

 PERFORM THRUSTING
 MANEUVER AS DESIRED
 MONITOR FDI BALL
 TO AVOID GIMBAL
 LOCK

#80

. NOTE1: R1,R2, AND R3
 . WILL READ 00000 IN-
 . ITIALLY AND WILL RE-
 . MAIN SO (EXCEPT FOR
 . ACCELEROMETER BIASES)
 . UNTIL A THRUSTING
 . MANEUVER IS STARTED.
 . THEY WILL BE UPATED
 . EVERY 2 SEC.

#90

. NOTE2: IN THE EVENT
 . THIS PROGRAM IS USED
 . TO MONITOR MANEUVERS
 . WITH A DELTA V
 . GREATER THAN 9999.9
 . FPS THIS DISPLAY
 . WILL ONLY LCSE THE
 . HIGH ORDER DIGIT. IT
 . WILL OTHERWISE READ
 . CORRECTLY.

#100

#110

#120


```

      .
      .
      .
      .
      .
      .
      .
      . . .
      .
EXIT

```

```

      .
      .
      .
      .
      .
      .
      .
    ...
      .
EXIT

```

#180

REV 07 PCR MIT 32
REV 08 PCR MIT 32
REV 09 PCR NASA 64
REV 10 PCR MIT 66
REV 11 PCR 401.1

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IMU ORIENTATION DETERMINATION PROGRAM (P51)

LOGIC REV 06 04/02/68

PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING SIGHTINGS ON TWO CELESTIAL BODIES USING THE SCANNING TELESCOPE OR THE SEXTANT.

ASSUMPTIONS: (1) THE IMU MAY BE:

(A) OFF (STANDBY)

(B) ON, AND ALIGNED OR NOT ALIGNED SINCE TURN ON.

++
+06 IF (A) IS TRUE, THE IMU MUST BE TURNED ON BEFORE THIS PROGRAM CAN BE PERFORMED.
+ IF (B) IS TRUE THIS PROGRAM CAN BE COMPLETED.
+06
++

(2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.

(3) TIME AND RCS FUEL MAY BE SAVED, AND SUBSEQUENT IMU ALIGNMENT DECISIONS GREATLY SIMPLIFIED IF THIS PROGRAM IS PERFORMED IN SUCH A WAY AS TO LEAVE THE IMU INERTIALLY STABILIZED AT AN ORIENTATION AS CLOSE AS POSSIBLE TO THE OPTIMUM ORIENTATION REQUIRED BY FUTURE CMC PROGRAMS.

(4) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

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

			.CREW PROG .SELECTION			
----- START IMU ORIENTA- TION DETERMINATION PROGRAM (P51) DISPLAY PROGRAM 51 -----	.	.....	KEY IN IMU ORIENTATION DETERMI- NATION PROGRAM (P51) V37E 51E -----			#10

	 MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 51 -----			#20
--	--	-------	--	--	--	-----

.....

SHALL I MANEUVER THE
CSM TO POSITION THE
IMU INNER GIMBAL
AXIS IN A PREFERRED
DIRECTION?

.N .Y

WITH THE ROTATION
CONTROL ROTATE
THE CSM UNTIL THE
PITCH AXIS IS IN
THE PREFERRED
DIRECTION

ARE 2 CELESTIAL
BODIES VISIBLE IN
THE SCT FIELD OF
VIEW?

.Y .N

WITH THE ROTA-
TION CONTROL
ORIENT THE CSM
UNTIL 2 CELES-
TIAL BODIES
ARE VISIBLE IN
THE SCT

MONITOR FDI BALL
IS GIMBAL LOCK
IMPENDING?

.Y .N

#80

#90

#100

#110

#120

#130

SHALL I
COARSE
ALIGN IMU
TO 0,0,0
GIMBAL
ANGLES?

.N .Y

#140

WAIT FOR KEYBOARD
ENTRY

KEY IN ENTER

#150

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR ENTER

KEY IN PROCEED

.P .E
.R .N
.O .T
.C .E
.E .R
.E .
.D .

#160

TEMP
HOLD .
.....
SNAP .

DISPLAY ON DSKY:
V41 N22
R1-00000
R2-00000
R3-00000

MONITOR DSKY:
OBSERVE DISPLAY
OF COARSE ALIGN
VERR AND ICDU
ANGLES (ALL
00000) FOR COARSE
ALIGNMENT

#170

WHERE R1, R2,
AND R3 REPRESENT

CDU/ISS ANGLES
TO BE COARSE
ALIGNED TO (CG,
IG, MG, RESPEC-
TIVELY).

#180

RESET REFSMMAT
FLAG

COMMAND ISS TO
COARSE ALIGN
MODE

#190

TURN ON "NO ATT"
LIGHT

OBSERVE "NO ATT"
LIGHT ON

#200

COARSE ALIGN ISS

TERMINATE COARSE
ALIGN MODE IN
ISS. RESUME ATT-
ITUDE HOLD OF
VEHICLE

#210

TURN OFF "NO
ATT" LIGHT

WAIT FOR "NO-ATT"
LIGHT OFF

#220

SET TARGET FLAG TO
STAR FOR USE BY
SIGHTING MARK ROUTINE.
(P53)

#230

#240

```

.
.
.
-----
SET MARK INDEX TO 1
FOR USE BY THE
SIGHTING MARK
ROUTINE (R53)
-----
.
.
.

```

```

-----
DO SIGHTING MARK
ROUTINE (R53) FOR
CELESTIAL BODY =1
-----
.
.
.

```

```

-----
CALCULATE CELESTIAL
BODY #1 VECTOR
W.R.T. IMU
-----
.
.
.

```

```

-----
DO SIGHTING MARK
ROUTINE (R53) FOR
CELESTIAL BODY =2
-----
.
.
.

```

```

-----
CALCULATE CELESTIAL
BODY #2 VECTOR
W.R.T. IMU
-----
.
.
.

```

```

-----
DO SIGHTING DATA
DISPLAY ROUTINE
(R54)
-----

```

```

. F . E
. X . X
. I . I
. T . T
. "A" . "B"
.
.
.
.
.
.

```

```

-----
DO SIGHTING MARK
ROUTINE (R53) FOR
CELESTIAL BODY =1.
IF POSSIBLE USE SXT,
OTHERWISE SCT.
-----
.
.
.

```

```

-----
DO SIGHTING MARK
ROUTINE (R53) FOR
CELESTIAL BODY =2.
IF POSSIBLE USE SXT,
OTHERWISE SCT.
-----
.
.
.

```

```

-----
DO SIGHTING DATA
DISPLAY ROUTINE
(R54)
-----

```

```

. E . F
. X . X
. I . I
. T . T
. "B" . "A"
.
.
.
.
.
.

```

#250

#260

#270

#280

#290

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PURPOSE:

(1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 4) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE SCANNING TELESCOPE OR THE SEXTANT:

(A) PREFERRED ORIENTATION

AN OPTIMUM ORIENTATION FOR A PREVIOUSLY CALCULATED MANEUVER. THIS ORIENTATION MUST BE CALCULATED AND STOPPED BY A PREVIOUSLY SELECTED PROGRAM.

(B) LANDING SITE ORIENTATION

$$\begin{matrix} X & = & \text{UNIT}(R &) \\ -SM & & -LS \end{matrix}$$

$$\begin{matrix} Y & = & \text{UNIT}(Z & X & X &) \\ -SM & & -SM & -SM \end{matrix}$$

$$\begin{matrix} Z & = & \text{UNIT}(H & X & X &) \\ -SM & & -CSM & -SM \end{matrix}$$

WHERE: THE ORIGIN IS THE CENTER OF THE MOON.

R = THE POSITION OF THE MOST RECENTLY DEFINED LANDING SITE AT TIME, T (ALIGN) SELECTED BY THE ASTRONAUT.
-LS

H = THE ANGULAR MOMENTUM VECTOR OF THE CSM (R X V) AT TIME T (ALIGN) SELECTED BY THE ASTRONAUT.
-CSM -CSM -CSM

A SPECIAL CASE OF THE LANDING SITE ORIENTATION OCCURS WHEN T (ALIGN) IS DEFINED AS THE TIME OF LUNAR LANDING T (LAND). THIS CASE MAY OCCUR ONLY IF T (LAND) HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE ASTRONAUT AND THE ASTRONAUT HAS THEN DEFINED T (ALIGN) TO BE T (LAND) IN THIS PROGRAM.

(C) NOMINAL ORIENTATION

$$\begin{matrix} X & = & \text{UNIT}(V & X & Z &) \\ -SM & & -SM & -SM \end{matrix}$$

$$\begin{matrix} Y & = & \text{UNIT}(V & X & P &) \\ -SM & & - & - \end{matrix}$$

$$\begin{matrix} Z & = & \text{UNIT}(-P) \\ -SM & & - \end{matrix}$$

WHERE:

P = THE GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADII VECTOR AT TIME T (ALIGN)
- SELECTED BY THE ASTRONAUT

V = THE INERTIAL VELOCITY VECTOR AT TIME T (ALIGN) SELECTED BY THE ASTRONAUT.
-

(0) REFSMMAT

SEE ASSUMPTION (4)

ASSUMPTIONS: (1) THE DOCKED CONFIGURATION MAY BE SIVB/CSM, LM/CSM, OR CSM. THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE CMC BY COMPLETION OF THE DAP DATA LOAD ROUTINE R03.

(2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.

++ (3) THIS PROGRAM MAKES NO PROVISION FOR AN ATTITUDE MANUEVER TO RETURN THE VEHICLE TO A SPECIFIC ATTITUDE. SUCH A
+15 MANUEVER IF DESIRED MUST BE DONE MANUALLY AN OPTION IS PROVIDED HOWEVER TO POINT THE SXT AT ASTRONAUT OR CMC
++ SELECTED STARS EITHER MANUALLY BY CREW INPUT OR AUTOMATICALLY UNDER CMC CONTROL.
EDIT

(4) THE ISS IS ON AND HAS BEEN ALIGNED TO A KNOWN ORIENTATION WHICH IS STORED IN THE CMC (REFSMMAT). THE PRESENT IMU ORIENTATION DIFFERS FROM THAT TO WHICH IT WAS LAST ALIGNED ONLY DUE TO GYRO DRIFT (I.E. NEITHER GIMBAL LOCK NOR IMU POWER INTERRUPTION HAS OCCURRED SINCE THE LAST ALIGNMENT).

(5) THE LANDING SITE ORIENTATION IS USED FOR:

(A) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM/CSM SEPARATION

(B) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM ASCENT FROM THE LUNAR SURFACE.

(6) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG
CONT

CMC

GROUND

CREW

CHECKLIST

TIME

TOTAL
TIME

START IMU REALIGN
PROGRAM (P52)
DISPLAY PROGRAM 52

CREW PROG
SELECTION
.....

KEY IN IMU REALIGN
PROGRAM (P52)
V37F 52F

#10

P52/COLOSSUS

MONITOR DSKY:
OBSERVE DISPLAY OF
PROGRAM 52

#20

DO IMU STATUS CHECK
ROUTINE (R02)

DO IMU STATUS CHECK
ROUTINE (R02)

#30

++
+15
++
EDIT

SET MARK INDEX TO 1
FOR USE BY THE
SIGHTING MARK
ROUTINE R53.

#40

IS THE PREFERRED
ORIENTATION FLAG SET?

.Y .N

SET OPTION CODE
IN P2 BELOW
=00001

#50

SET OPTION CODE
IN P2 BELOW=00002.

#60

#70

#80

#90

#100

#110

#120

HOLD .
.....
SNAP .

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY OPTION CODE
FOR ASSUMED IMU
ORIENTATION
SELECTION:
V04 N06
R1-00001
R2-0000X
R3-BLANK

R1 IS THE OPTION
CODE FOR ASSUMED
IMU ORIENTATION
SELECTION

R2 IS THE CMC
ASSUMED OPTION:
00001-PREFERRED
00002-NOMINAL
00003-REFSMAT
00004-LANDING SITE

WAIT FOR KEYBOARD
ENTRY

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

.D .NEW
.R .CODE
.C .
.C .
.E .
.E .
.D .
STORE CODE

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF OPTION CODE FOR
ASSUMED IMU
ORIENTATION
SELECTION

IS THIS THE IMU ORI-
ENTATION I DESIRE?

.Y .N
. .
. .

KEY IN PROCEED

KEY IN V22F
AND LOAD THE
DESIRED ORIEN-
TATION CODE IN
R2

#180

HOLD .
.....
SNAP .
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY T(ALIGN):
V06N34
R1- T(ALIGN)-HRS
R2- T(ALIGN)-MINS
R3- T(ALIGN)-SECS

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST RE-
SPONSE AND DISPLAY
OF T(ALIGN).

#190

T(ALIGN- TIME (GET)
AT WHICH VEHICLE
POSITION AND VELO-
CITY VECTORS ARE SE-
LECTED TO DEFINE IMU
AND CSM NOMINAL OR
LANDING SITE ORIEN-
TATION. IN HRS, MINS
AND SECS TO NEAREST
.01 SEC.

T(ALIGN) WILL APPEAR
HERE AS 00000,
00000, 00000, WHICH
IF ACCEPTED WILL
INDICATE THAT THE
NOMINAL OR LANDING
SITE ORIENTATION
WILL BE DEFINED FOR
A T(ALIGN) AUTOMAT-
ICALLY SELECTED AS
THE PRESENT TIME

#200

DO I WISH TO ALIGN
THE IMU TO AN ORIEN-
TATION DEFINED BY
THE T(ALIGN) PRE-
SENTLY DISPLAYED?

#210

WAIT FOR KEYBOARD
ENTRY

KEY IN
PROCEED

#220

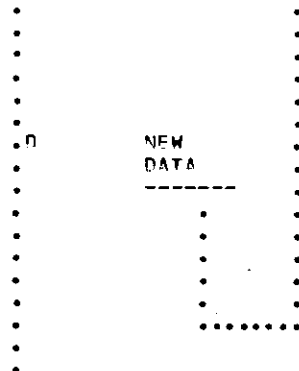
TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V25F
AND LOAD
THE DESIRED
T(ALIGN) IN
R1, R2, AND
R3.

#230

.P .NEW
.P .DATA
.Q
.C
.F
.F
STORE

57



P52/COLLOSSUS

#240

IS T(ALIGN) DEFINED
TO BE= 0?



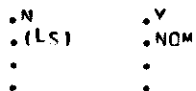
#250

DEFINE T(ALIGN)
= T PRESENT.



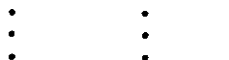
#260

IS STORED ORIENTAT-
ION CODE 00002?



++
+15
+
+15
++
EDIT

FIND CSM
STATE AT T(A-
LIGN) USING
CONIC INTEG-
RATION MODE



COMPUTE NOMINAL
ORIENTATION FOR
THE PREVIOUSLY
DEFINED
T(ALIGN). SEL-
ECT THIS ORIE-
TATION FOR
GENERAL ANGLES
COMPUTATION.
(NOTE: AT THIS

WAS NOMINAL IMU
ORIENTATION
SELECTED?



#270

GO TO
"A"
BELOW

#280

P52/COLLOSSUS

#290

TIME ANY PREF-
ERRED ORIENTA-
TION STORED IN
THE CMC. IS
LOST).

GO TO
NEXT
BELOW

#300

HOLD .
.....
SNAP .

FLASH VFOB-NOUN TO
REQUEST RESPONSE AND
DISPLAY STORED LAND-
ING SITE COORDINATES

V06NR9
R1- LAT
R2- LONG/2
R3- ALT

R1- LAT IS LATITUDE
OF LANDING SITE IN
DEG TO NEAREST .001
DEG.

PLUS IS NORTH.

++
+15
++
EDIT

R2- LONG/2 IS LONG-
ITUDE OF LANDING
SITE DIVIDED BY 2 IN
DEGREES TO NEAREST
.001 DEG. PLUS IS
EAST.

++
+15
++
PCN
595

R3-ALTITUDE ABOVE
MEAN LUNAR RADIUS IN
NAUTICAL MILES TO
NEAREST .01 NM

WAIT FOR KEYBOARD
ENTRY

MONITOR DSKY:
OBSERVE VFOB NOUN
FLASH TO REQUEST
RESPONSE AND DIS-
PLAY OF STORED LAND-
ING SITE COORDIN-
ATES.

#310

ARE THESE THE COR-
RECT LANDING SITE
COORDINATES?

#320

#330

KEY IN
PROCEED

#340

++
+15
++
EDIT

```

P          .NEW
R          .DATA
Q          .
C          .
F          -----
F          STOP
D          NEW
.          DATA

```

KEY IN V25E AND
LOAD THE COR-
RECT COORDIN-
ATES.

COMPUTE LANDING SITE
ORIENTATION FOR THE
PREVIOUSLY DEFINED
LANDING SITE COOR-
DINATES AND (ALIGN).
SELECT THIS ORIENT-
ATION FOR GYMRAL
ANGLE COMPUTATION.
(NOTE: AT THIS TIME
ANY PREFERRED ORIENT-
ATION PREVIOUSLY
STORED IN THE CMC
IS LOST.)

"A"
FROM
ABOVE

#360

#370

#380

#390

READ VEHICLE ATTITUDE FROM GIMBAL ANGLES

#400

COMPUTE GIMBAL ANGLES AT SELECTED IMU ORIENTATION AND PRESENT VEHICLE ATTITUDE

#410

MAN FROM ABOVE

#420

HOLD SNAP
FLASH VERB-NOUIN TO REQUEST RESPONSE AND DISPLAY THE RESULTING GIMBAL ANGLES:
V06 N22
R1-06
R2-16
R3-40

MONITOR DSKY:
OBSERVE VERB-NOUIN FLASH TO REQUEST RESPONSE AND DISPLAY OF GIMBAL ANGLES AFTER PROPOSED CSM/ IMU ALIGNMENT

#430

ALL GIMBAL ANGLES IN DEGREES TO NEAREST .01 DEGREE

IS MIDDLE GIMBAL ANGLE SATISFACTORY?

#440

BY SUITABLE MODE
SELECTION ENSURE
THAT VEHICLE IS
AS INERTIALLY
STABLE AS
POSSIBLE TO EN-
SURE ACCURACY OF
IMU COARSE
ALIGNMENT.

.Y

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

DO I WISH TO
MANEUVER VEHICLE
TO AN ATTITUDE
WHICH WILL PRO-
VIDE A MORE
SUITABLE MGA?

.N

.Y

MANEUVER VEH-
ICLE WITH
ROTATION
CONTROLLER

UPDATE THE
DISPLAY OF
RESULTING
GIMBAL ANGLES
KEY IN DECY-
CLE

V32F

#450

#460

#470

#480

#490

TERMINATE FLASH UPON
RECEIPT OF PROCEED
RECYCLE OR NEW PRO-
GRAM

.R
.P
.C
.Y
.C
.L
....F

.D NEW
.P PROG
.C
.C
.F
.E GO TO
.D PROGRAM
SELECTED

EXIT P52

SELECT FINAL DESIRED
IMU ORIENTATION FROM
STORAGE FOR USE BY
THE COARSE ALIGN
ROUTINE (P50)

DO COARSE ALIGN
ROUTINE (P50)

"RR"

SELECT NEW PRO-
GRAM AS DESIRED
KEY IN V37E--F

GO TO PROGRAM
SELECTED

EXIT P52

DO COARSE ALIGN
ROUTINE (P50)

#500

#510

#520

#530

#540

#550

#560

#570

#580

#590

STORE THE
PRESENT
IMU OR-
IENTAT-
TION IN
REFSMAT
AND SET
REFSMAT
FLAG

"RR"

HOLD

SNAP

FLASH VERR-NOIN TO
REQUEST PLEASE PER-
FORM CELESTIAL BODY
ACQUISITION
V50 N25
R1-00015
R2-BLANK
R3-BLANK

MONITOR DSKY:
OBSERVE VERR-NOIN
FLASH TO REQUEST
PLEASE PERFORM
CELESTIAL BODY
ACQUISITION:

DO I WISH ASSISTANCE
FROM THE CMC IN
SELECTING TWO STARS
SUITABLE FOR
ALIGNMENT?

N Y

WAIT FOR KEYBOARD
ENTRY

KEY IN ENTER

MANEUVER VEHICLE UN-
TIL SUITABLE STARS
MAY BE ACQUIRED.
MONITOR FDI1 BALL
TO AVOID GIMPAL
LOCK. (NOTE: ASTRO-
NAUT MAY USE OPTICS
TO ASSIST ATTITUDE
CHOICE OR MAY MANEU-

#600

VER AT RANDOM.)

TERMINATE FLASH UPON
RECEIPT OF ENTER OR
PROCEED

KEY IN PROCEED

.ENTER .PROCEED

#610

NO STAR SELECTION
ROUTINE (REFER TO
SECTION 5.6.4 OF
R577)

#620

.TWO .TWO
.STARS .STARS
.AVAILABLE .NOT
.AVAILABLE

POSS
HOLD .
.....
SNAP .

FLASH VERR-NOUN
TO REQUEST RES-
PONSE AND DIS-
PLAY ALARM CODE:

V05N00

R1-

R2-

R3-

EXPECTED ALARM
CODE AT THIS
TIME IS 405

MONITOR DSKY:
DOES ALARM
CODE DISPLAY
INDICATE THAT TWO
STARS ARE NOT AVAIL-
ABLE IN THE SXT
FIELD OF VIEW?

#630

.Y .N

#640

SHALL I BYPASS
STAR SELECTION
ROUTINE AND
SELECT MY OWN
CELESTIAL
BODY?

.Y .N

#650

#660

#670

#680

#690

#700

++
+15
+
+
+
+
+
+
+
+15
++
EDIT

SFT TARGET
FLAG TO STAR
FOR USE BY
THE AUTO OP-
TICS POSI-
TIONING
ROUTINE
(R52) AND THE
SIGHTING
MARK ROUTINE
(R53).

#710

++
+
+15
HOLD
SNAP
+15
++
EDIT

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY CELESTIAL

BODY CODE
VOIN70
R1-000XX
R2-BLANK
R3-BLANK

R1 - CELESTIAL BODY
CODE

WAIT FOR KEYBOARD
ENTRY

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
CELESTIAL BODY CODE

#720

#730

DO I WISH TO SIGHT
ON THIS CELESTIAL
BODY?

.Y

.N

KEY IN V21^E
AND CHANGE
CELESTIAL BODY
CODE

#740

#750

#760

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN
PROCEED

NEW DATA
STORE NEW DATA

P
R
D
C
F
F
D

#770

IS CELESTIAL BODY
CODE 00?

N Y

#780

IS THE CELESTIAL
BODY CODE 46, 47
OR 50?

N Y

#790

OBTAIN STAR
VECTOR FROM
STORED
EPHEMERIS

#800

CALCULATE CEL-
ESTIAL BODY
VECTOR FOR THE
BODY DEFINED
BY THE CELEST-
IAL BODY CODE.

#810

♦♦
♦15
♦♦
EDIT

2 PL - SAME AS
X PL FOR 2
COMPONENT.

TERMINATE
FLASH UPON
RECEIPT OF
PROCEED OR NEW
DATA.

```

.D      .NEW
.D      .DATA
.D      .
.C      .
.F      -----
.F      STORE NEW

```

ARE THE POSITION
VECTOR COMPONENTS
CORRECT?

KEY IN V25E AND
....LOAD CORRECT
POSITION VECTOR
COMPONENTS

#860

DO GYRO TORQUING
ROUTINE (R55).

DO GYRO TORQUING
ROUTINE (R55).

RESET PREFERRED
ORIENTATION FLAG

#930

HOLD . FLASH VFRB-NOUN TO
..... REQUEST PLEASE PER-
SNAP . FORM FINE ALIGN:
V50 N25
R1-00014
R2-BLANK
R3-BLANK

MONITOR DSKY:
OBSERVE VERR-NOUN
FLASH TO REQUEST
PLEASE PERFORM FINE
ALIGN.

#940

DO I WANT TO RECD
THE CELESTIAL BODY
SIGHTINGS, SIGHT-
ING DATA TEST, AND
GYRO TORQUING TO
VERIFY THE ACCURACY
OF ALIGNMENT?
NOTE: IF THE SIGHT-
ING DATA WAS BAD OR
THE TORQUING ANGLES
WERE LARGE THE
ASTRONAUT SHOULD
PROCEED AND RECD THE
ALIGNMENT.

#950

WAIT FOR KEYBOARD
ENTRY

KEY IN
ENTER

#960

#970

KEY IN
DOWN
GREEN

• F
• N
• T
• F
• P
•
•
•
•
•
•
•
•
•
•

•
•
•
•••
•
GO TO
"BN
ABOVE

#980

॥०००॥

NO ROUTINE R00

NO ROUTINE P00

EXIT
052

•
EXIT
P52

#1000

CHANGE CONTROL NOTES

REV 12	DCR	MIT	38
REV 13	DCR	MIT	66
	DCR	MIT	90
REV 14	DCR	430.1	
REV 15	DCN	505	

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BACK UP IMU ORIENTATION DETERMINATION PROGRAM (P53)

LOGIC

REV 07

11/27/68

PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING A BACK UP OPTICAL DEVICE.

ASSUMPTIONS: (1) THE IMU MAY BE:

(A) OFF (STANDBY)

(B) ON, AND ALIGNED OR NOT ALIGNED SINCE TURN ON.

IF (A) IS TRUE, THE IMU MUST BE TURNED ON BEFORE THIS PROGRAM CAN BE PERFORMED.
IF (B) IS TRUE THIS PROGRAM CAN BE COMPLETED.

(2) THIS PROGRAM IS IDENTICAL TO P51 EXCEPT THAT P56 IS CALLED IN PLACE OF P53

(3) THE CSM ATTITUDE CONTROL MODE SELECTED IS AT THE OPTION OF THE CREW.

(4) TIME AND RCS FUEL MAY BE SAVED, AND SUBSEQUENT IMU ALIGNMENT DECISIONS GREATLY SIMPLIFIED IF THIS PROGRAM IS PERFORMED IN SUCH A WAY AS TO LEAVE THE IMU INERTIALLY STABILIZED AT AN ORIENTATION AS CLOSE AS POSSIBLE TO THE OPTIMUM ORIENTATION REQUIRED BY FUTURE CMC PROGRAMS.

(5) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG
CONT

CMC

GROUND

CREW

CHECKLIST

TIME

TOTAL
TIME

.CREW PROG
.SELECTION

.
...
.

START BACK UP IMU
ORIENTATION DETERMI-
NATION PROGRAM (P53)
DISPLAY PROGRAM 53

.
.....
.

KEY IN BACK UP IMU
ORIENTATION DETERMI-
NATION PROGRAM (P53)
V37E 53E

#10

.
.....
.
MONITOR DSKY:
OBSERVE DISPLAY OF
PROGRAM 53

#20

.
.
.
.
.
.
.
.

IS ISS ON?

.Y

.N

TURN ON PROGRAM
ALARM AND STORE
ALARM CODE
00210

MONITOR DSKY:
DOES PROGRAM ALARM
LIGHT COME ON AND
DOES V37 FLASH INDICATING
THAT THE IMU
IS NOT ON?

.Y

.N

TURN ON THE
IMU AND RESE-
LECT P53 VIA
R00.

DO ROUTINE R00

DO ROUTINE R00

EXIT

EXIT

HOLD .
.....
SNAP .
FLASH VERR-NOUN TO
REQUEST PLEASE PER-
FORM CELESTIAL BODY
ACQUISITION:
V50 N25
P1-00015
P2 - BLANK
P3 - BLANK

MONITOR DSKY:
OBSERVE VERR-NOUN
FLASH TO REQUEST
PLEASE PERFORM CELE-
STIAL BODY ACQUISITION

#30

#40

#50

#60

#70

SHALL I MANEUVER THE
CSM TO POSITION THE
IMU INNER GIMBAL
AXIS IN A PREFERRED
DIRECTION?

.N .Y

WITH THE ROTATION
CONTROL ROTATE
THE CSM UNTIL THE
PITCH AXIS IS IN
THE PREFERRED
DIRECTION

SHALL I MANEUVER
THE CSM TO AC-
QUIRE A CELESTIAL
BODY?

.N .Y

WITH THE ROT-
ATIONAL HAND
CONTROLLER
ORIENT THE CSM

MONITOR FDI BALL
IS GIMBAL LOCK
IMPENDING?

.Y .N

#80

#90

#100

#110

#120

#130

SHALL I
COARSE
ALIGN IMU
TO 0,0,0
GIMBAL
ANGLES?

.N .Y

#140

WAIT FOR KEYBOARD
ENTRY

KEY IN
ENTER

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR ENTER

KEY IN PROCEED

#150

.P
.R
.O
.C
.E
.E
.D

.E
.N
.T
.F
.P

#160

POSS
TEMP
HOLD .
.....
SNAP .

DISPLAY ON DSKY:
V41 N22
R1-00000
R2-00000
R3-00000

WHERE R1, R2,
AND R3 REPRESENT
CDU/ISS ANGLES
TO BE COARSE
ALIGNED TO (OG,
IG, MG, RESPEC-
TIVELY).

MONITOR DSKY:
OBSERVE DISPLAY
OF COARSE ALIGN
VERR AND JCDU
ANGLES (ALL
00000) FOR COARSE
ALIGNMENT

#170

#180

RESET REFSMMAT
FLAG

COMMAND ISS TO
COARSE ALIGN
MODE

TURN ON "NO ATT"
LIGHT

COARSE ALIGN ISS

TERMINATE COARSE
ALIGN MODE IN
ISS. RESUME ATT-
TITUDE HOLD OF
VEHICLE.

TURN OFF "NO
ATT" LIGHT

OBSERVE "NO ATT"
LIGHT ON

WAIT FOR "NO-ATT"
LIGHT OFF

#190

#200

#210

#220

#230

316

#280

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)

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PURPOSE:

(1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 4) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH A BACK-UP OPTICAL DEVICE:

(A) PREFERRED ORIENTATION

AN OPTIMUM ORIENTATION FOR A PREVIOUSLY CALCULATED MANEUVER. THIS ORIENTATION MUST BE CALCULATED AND STOPPED BY A PREVIOUSLY SELECTED PROGRAM.

(B) LANDING SITE ORIENTATION

$X = \text{UNIT}(P)$
 $-SM \quad -LS$

$Y = \text{UNIT}(Z \times X)$
 $-SM \quad -SM \quad -SM$

$Z = \text{UNIT}(H \times X)$
 $-SM \quad -CSM \quad -SM$

WHERE: THE ORIGIN IS THE CENTER OF THE MOON.

P = THE POSITION OF THE MOST RECENTLY DEFINED LANDING SITE AT TIME, $T(\text{ALIGN})$ SELECTED BY THE ASTRONAUT
 $-LS$

H = THE ANGULAR MOMENTUM VECTOR OF THE CSM ($R \times V$) AT TIME $T(\text{ALIGN})$ SELECTED BY THE ASTRONAUT.
 $-CSM \quad -CSM \quad -CSM$

A SPECIAL CASE OF THE LANDING SITE ORIENTATION OCCURS WHEN $T(\text{ALIGN})$ IS DEFINED AS THE TIME OF LUNAR LANDING $T(\text{LAND})$. THIS CASE MAY OCCUR ONLY IF $T(\text{LAND})$ HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE ASTRONAUT, AND THE ASTRONAUT HAS THEN DEFINED $T(\text{ALIGN})$ TO BE $T(\text{LAND})$ IN THIS PROGRAM.

(C) NOMINAL ORIENTATION

$X = \text{UNIT}(V \times Z)$
 $-CSM \quad -SM \quad -SM$

$Y = \text{UNIT}(V \times P)$
 $-CSM \quad - \quad -$

$Z = \text{UNIT}(-R)$
 $-CSM \quad -$

WHERE:

R = THE GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AT TIME $T(\text{ALIGN})$
 $-$ SELECTED BY THE ASTRONAUT

V = THE INERTIAL VELOCITY VECTOR AT TIME $T(\text{ALIGN})$ SELECTED BY THE ASTRONAUT.
 $-$

(D) DEFSMAT

SEE ASSUMPTION (4)

- ASSUMPTIONS: (1) THE DOCKED CONFIGURATION MAY BE SIVB/CSM, LM/CSM, OR CSM. THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE CMC BY COMPLETION OF THE DAP DATA LOAD ROUTINE R03.
- (2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.
- (3) THIS PROGRAM MAKES NO PROVISION FOR AN ATTITUDE MANEUVER TO RETURN THE VEHICLE TO A SPECIFIC ATTITUDE. SUCH A MANEUVER, IF DESIRED, MUST BE DONE MANUALLY. AN OPTION IS PROVIDED HOWEVER TO POINT THE SXT AT ASTRONAUT OR CMC SELECTED STARS EITHER MANUALLY BY CREW INPUT OR AUTOMATICALLY UNDER CMC CONTROL.
- (4) THE ISS IS ON AND HAS BEEN ALIGNED TO A KNOWN ORIENTATION WHICH IS STORED IN THE CMC (REFSMAT). THE PRESENT IMU ORIENTATION DIFFERS FROM THAT TO WHICH IT WAS LAST ALIGNED ONLY DUE TO GYRO DRIFT (I.E. NEITHER GIMBAL LOCK NOR IMU POWER INTERRUPTION HAS OCCURRED SINCE THE LAST ALIGNMENT).
- (5) THE LANDING SITE ORIENTATION IS USED FOR:
- (A) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM/CSM SEPARATION
 - (B) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM ASCENT FROM THE LUNAR SURFACE.
- (6) THIS PROGRAM IS IDENTICAL TO P52 EXCEPT THAT R56 IS CALLED IN PLACE OF R52 AND R53.
- (7) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG
CONT

CMC

GROUND

CREW

CHECKLIST

TIME

TOTAL
TIME

START BACKUP IMU RE-
ALIGN PROGRAM (P54)
DISPLAY PROGRAM 54

START BACKUP IMU RE-
ALIGN PROGRAM (P54)
V37E 54F

CREW PROG
SELECTION

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

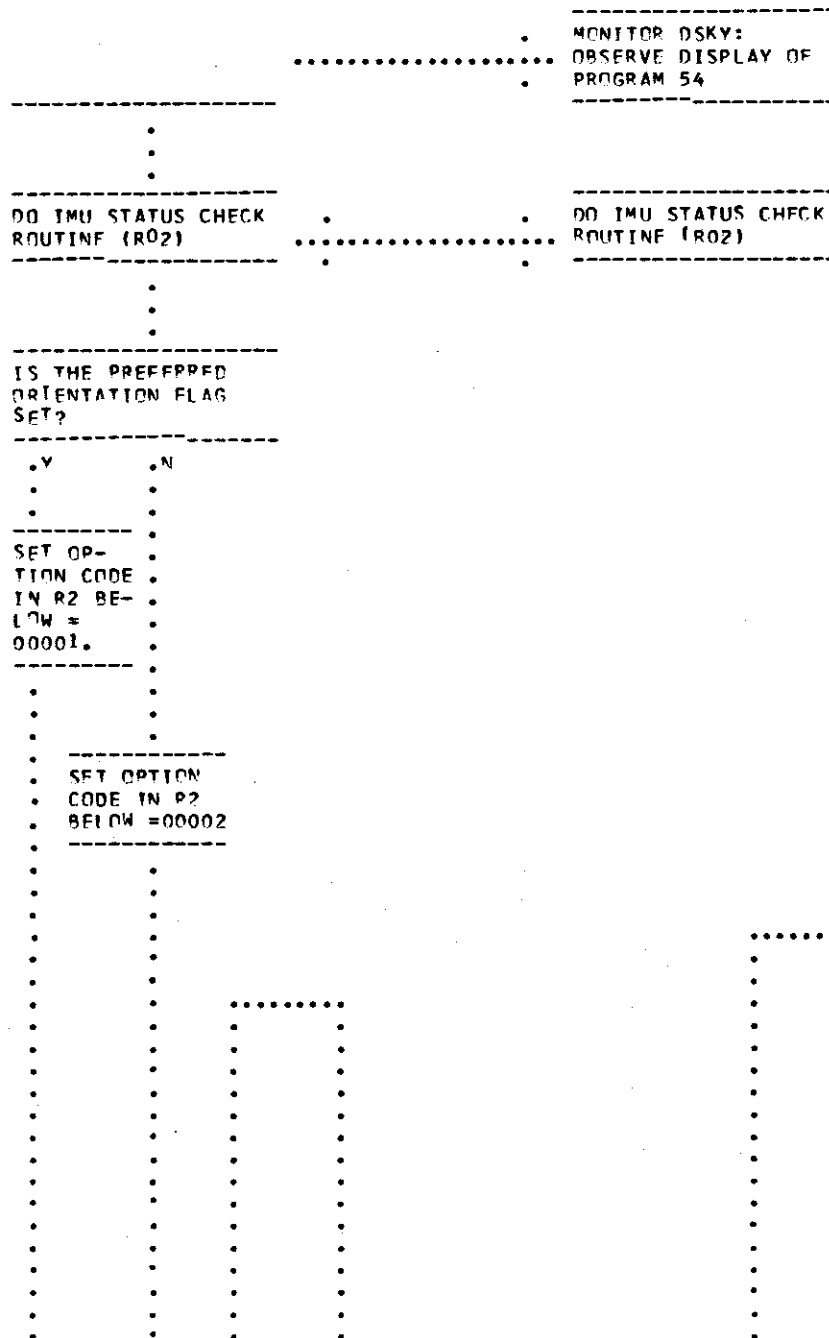
...

...

...

#10

P54/COLOSSUS



#20

#30

#40

#50

#60

HOLD .
.....
SNAP .

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY OPTION CODE
FOR ASSUMED IMU
ORIENTATION
SELECTION:
V04 N06
R1-00001
R2-0000X
R3-BLANK

R1 IS THE OPTION
CODE FOR ASSUMED
IMU ORIENTATION
SELECTION

R2 IS THE CMC
ASSUMED OPTION:
00001-PREFERRED
00002-NOMINAL
00003-REFSMAT
00004-LANDING SITE

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF OPTION CODE FOR
ASSUMED IMU
ORIENTATION
SELECTION

#70

IS THIS THE IMU ORI-
ENTATION I DESIRE?

Y

N

#90

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V22F
AND LOAD THE
DESIRED ORIEN-
TATION CODE IN
P2

#100

.P NEW
.Q CODE
.N
.C
.E
.F STORE CODE
.D

#110

IS STORED ORIENTA-
TION CODE 00001?

.N .Y
.
.

SELECT PRE-
FERRED IMU
ORIENTATION
FOR GIMBAL
ANGLE COMPU-
TATION

GO TO
"A"
BELOW

IS STORED ORIENTA-
TION CODE 00002 OR
00004?

.Y .N
.NOM .(PEF)
.LS

GO TO
"B"
BELOW

STORE 00000, 00000,
00000 FOR DISPLAY
AS, T (ALIGN.)

#120

#130

#140

#150

#160

T(ALIGN) - TIME (GET) AT WHICH VEHICLE POSITION AND VELOCITY VECTORS ARE SELECTED TO DEFINE IMU AND CSM NOMINAL OR LANDING SITE ORIENTATION. IN HRS, MINS, AND SECS TO NEAREST .01 SEC.

WAIT FOR KEYBOARD
ENTRY

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

```

.0      .NEW
.0      .DATA
.0      .
.0      -----
.0      STOP

```

MONITOR DSKY:
OBSERVE VERP-ALPHA
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF T (ALIGN).

T(ALIGN) WILL APPEAR
HERE AS 00000, 00000
00000, WHICH IF AC-
CEPTED WILL INDICATE
THAT THE NOMINAL OR
LANDING SITE ORIENTA-
TION WILL BE DEFINED
FOR A T(ALIGN)
AUTOMATICALLY SEL-
ECTED AS THE PRESENT
TIME

DO I WISH TO ALIGN
THE IMU TO AN ORIEN-
TATION DEFINED BY
THE T(ALIGN) PRE-
SENTLY DISPLAYED?

.Y
 :
 :

 KEY IN
 PROCEED

KEY IN V25F AND
LOAD THE DESIRED
TIALIGN1 IN R1,
R2, AND R3.

4229

IS Y(ALIGN) DEFINED
TO BE = 0?

```

DEFINE T (ALIGN)
= T PRESENT.

```

IS STORED ORIENTA-
TION CODE 00002?

- FIND CSM STATE
- AT T(ALIGN)
- USING CONIC
- INTEGRATION

- COMPUTE NOMINAL
- ORIENTATION FOR
- THE PREVIOUSLY
- DEFINED (ALIGN).
- SELECT THIS OR-
- IENTATION FOR
- GIMBAL ANGLES
- COMPUTATION.
- (NOTE: AT THIS
- TIME ANY PREFER-
- RED ORIENTATION
- STORED IN THE CMC
- IS LOST).

#240

#250

#260

#270

#290

MONITOR DSKY:
OBSERVE VERR-NOUN
FLASH TO REQUEST RE-
SPONSE AND DISPLAY
OF STORED LANDING
SITE COORDINATES.

ARE THESE THE COR-
RECT LANDING SITE
COORDINATES? AND IS
R3 EQUAL TO +00000?

[illegible]

#310

KFV IN
PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

.P .NEW
.R .DATA
.Q
.C
.E
.F STORE
.D NEW
DATA
.....

KEY IN V25F AND
LOAD THE CORRECT
COORDINATES AND
SET R3 EQUAL TO
+00000.

#330

#340

COMPUTE LANDING SITE
ORIENTATION FOR THE
PREVIOUSLY DEFINED
LANDING SITE COOR-
DINATES AND T(ALIGN).
SELECT THIS ORIE-
NTATION FOR GIMBAL
ANGLE COMPUTATION.
(NOTE: AT THIS TIME
ANY PREFERRED ORIE-
NTATION PREVIOUSLY
STORED IN THE CMC IS
LOST.)

#350

#360

"A"
FROM
ABOVE

.....
.....
.....
.....

READ VEHICLE ATTIT-
TUD FROM GIMBAL
ANGLES

#370

#380

#390

COMPUTE GIMBAL
ANGLES AT SELECTED
IMU ORIENTATION AND
PRESENT VEHICLE
ATTITUDE

MAN
FROM
ABOVE

#400

HOLD
.....
SNAP

FLASH VERR-NOUN TO
REQUEST RESPONSE AND
DISPLAY THE RESULT-
ING GIMBAL ANGLES:
V06 N22
R1-06
R2-16
R3-M6

MONITOR DSKY:
OBSERVE VERR-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF GIMBAL ANGLES
AFTER PROPOSED CSM/
IMU ALIGNMENT

#410

ALL GIMBAL ANGLES IN
DEGREES TO NEAREST
.01 DEGREE

IS MIDDLE GIMBAL
ANGLE SATISFACTORY?

Y

N

#420

BY SUITABLE MODE
SELECTION ENSURE
THAT VEHICLE IS
AS INERTIALLY
STABLE AS
POSSIBLE TO EN-
SURE ACCURACY OF
IMU COARSE
ALIGNMENT.

#430

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

#440

DO I WISH TO
MANEUVER VEHICLE
TO AN ATTITUDE
WHICH WILL PRO-
VIDE A MORE
SUITABLE MGA?

.N .Y

#450

MANEUVER VEH-
ICLE WITH
ROTATION
CONTROLLER

#460

UPDATE THE
DISPLAY OF
RESULTING
GIMBAL ANGLES
KEY IN RECY-
CLE
V32F

#470

TERMINATE FLASH UPON
RECEIPT OF PROCEED
RECYCLE OR NEW PRO-
GRAM

SELECT NEW PRO-
GRAM AS DESIRED
KEY IN V37E--F

#480

.R .P .NEW
.E .R .PROG
.C .N .
.Y .C .
.C .E .
.L .E .GO TO
.F .C .PROGRAM
SELECTED

GO TO PROGRAM
SELECTED

#490

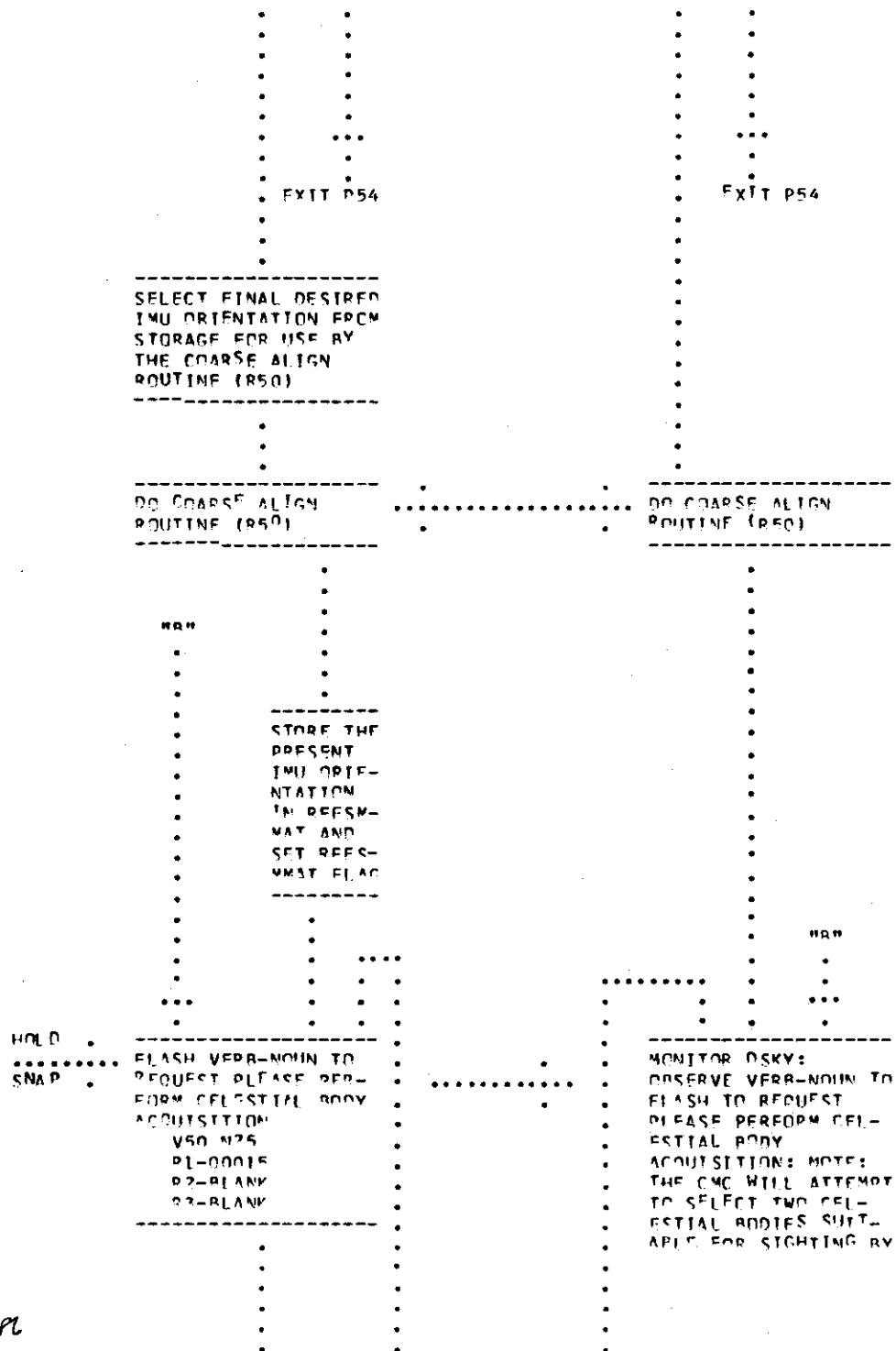
#500

#510

#520

#530

#540



WAIT FOR KEYBOARD
ENTRY

TERMINATE FLASH UPON
RECEIPT OF ENTER
OR PROCEED

• ENTER • PROCEED

USE OF THE OPTICS.
SINCE THE OPTICS ARE
NOT BEING USED THE
ROUTINE MAY HAVE NO
VALUE.

DO I WISH TO HAVE
THE CMC ASSIST ME IN
SELECTING TWO CEF-
ESTIAL BODIES SUIT-
ABLE FOR ALIGNMENT?

☐ NO ☐ YES

KEY IN ENTER

MANEUVER VEHICLE UN-
TIL SUITABLE CEN-
TRAL BODIES MAY BE
ACQUIRED. MONITOR
FRA! BALL TO AVOID
GIMBAL LOCK.
(NOTE: ASTRONAUT MAY
USE OPTICS TO ASSIST
ATTITUDE CHOICE OR
MAY MANEUVER AT
RANDOM.)

KEY IN PROCEED

#600

DO STAP SELECTION
ROUTINE (REFER TO
SECTION 5.6.4 OF
R577)

TWO TWO
STARS STARS
AVAILABLE NOT
AVAILABLE

POSS
HOLD
.....
SNAP

FLASH VEPB-NOUN
TO REQUEST RES-
PONSE AND DIS-
PLAY ALARM CODE:
V05N09
P1-
P2-
P3-
EXPECTED ALARM
CODE AT THIS
TIME IS 405

#610

MONITOR DSKY:
DOES ALARM
CODE DISPLAY
INDICATE THAT TWO
STARS ARE NOT AVAIL-
ABLE IN THE SC
FIELD OF VIEW?

Y N
.
.
.
.

#620

SHALL I BYPASS
STAR SELECTION
ROUTINE AND
SELECT MY OWN
CELESTIAL
BODY?

Y N
.
.

#630

MANEUVER
VEHICLE UN-
TIL A SUIT-
ABLE CEL-
ESTIAL BODY
IS ACQUIRED

#640

WAIT FOR KEY-
BOARD ENTRY

KEY IN PRO-
CEED

#650

#660

#670

#680

#690

#700

89

TERMINATE FLASH
UPON RECEIPT OF
PROCEED OR RE-
CYCLE.

KEY IN RE-
CYCLE
V32E

P R
R F
D C
C Y
E C
F L
D E

SELECT STAR #1

HOLD
SNAP

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY CELESTIAL
BODY CODE
V01N70
01-000XY
02-PLANX
03-BLANK

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
CELESTIAL BODY CODE

WAIT FOR KEYBOARD
ENTRY

DO I WISH TO SIGHT
ON THIS CELESTIAL
BODY?

.Y .N

IT IS NOT NECES-
SARY TO CHANGE
CODE AT THIS
TIME SINCE THIS
DISPLAY IS FOR
INFORMATION
ONLY. HOWEVER,
IF IT IS CHANGED
NOW IT WILL NOT
HAVE TO BE
CHANGED FOL-
LOWING THE
SIGHTING.

DO I WISH TO
CHANGE THE CELESTIAL BODY
CODE?

.N .Y

KEY IN V21F
AND CHANGE
CELESTIAL
BODY CODE.

#710

#720

#730

#740

#750

#760

#770

#780

#790

#800

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN
PROCEED

NEW DATA
STORE NEW DATA

IS CELESTIAL BODY
CODE 00?

N Y

IS THE CELESTIAL
BODY CODE 46, 47
OR 50?

N Y

OBTAIN STAR
VECTOR FROM
STORED
EPHEMERIS

CALCULATE CEL-
ESTIAL BODY
VECTOR FOR THE
BODY DEFINED
BY THE CELES-
TIAL BODY CODE

860

♦♦
+16
♦♦
EDIT

```

.D      .NEW
.D      .DATA
.D      .
.D      .
.F      -----
.F      STORE NEW
.D      DATA

```

KEY IN V2⁵F AND
LOAD CORRECT
POSITION VECTOR
COMPONENTS

#870

DO ALTERNATE LOS
SIGHTING MARK
ROUTINE (R56).

DO ALTERNATE LOS
SIGHTING MARK
ROUTINE (R56).

HAVE TWO CEL-
ESTIAL BODIES
BEEN MARKED?

HAVE I MARKED TWO
CELESTIAL BODIES?

#880

.N

.Y

.Y

.N

SELECT STAR
#2 IF STAR
SELECTION
ROUTINE WAS
DONE.

#890

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

#900

.EXIT
"RM"

.EXIT
"AM"

#910

DO GYRO TORQUING
ROUTINE (R55).

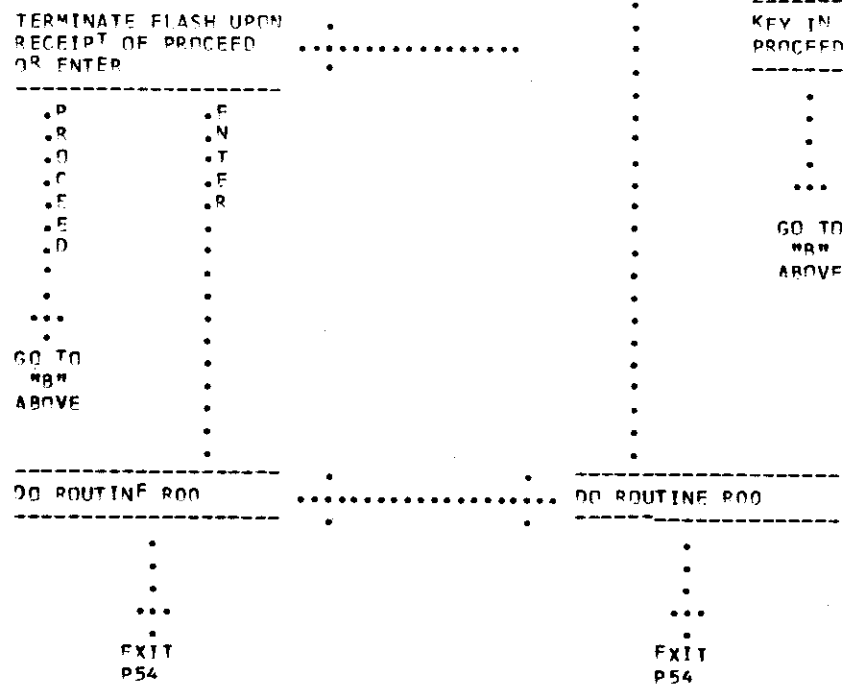
DO GYRO TORQUING
ROUTINE (R55).

#930

#940

#950

4960



#970

#980

#990

CHANGE CONTROL NOTES

REV 12 PCR MIT 38
 REV 13 PCR MIT 66
 PCR MIT 90
 REV 14 PCR 430.1
 REV 15 PCR 206 EDITORIAL
 REV 16 EDITORIAL

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ENTRY-PREPARATION PROGRAM (P61)

LOGIC REV 13 11/27/68

PURPOSE: (1) TO START NAVIGATION, CHECK IMU ALIGNMENT, AND PROVIDE ENTRY MONITOR SYSTEM INITIALIZATION DATA.

ASSUMPTIONS: (1) THE PROGRAM IS ENTERED WITH ADEQUATE FREE FALL TIME TO COMPLETE THE MANEUVERS FROM A WORST CASE STARTING ATTITUDE.

(2) THE ISS IS ON AND PRECISELY ALIGNED TO A SATISFACTORY ORIENTATION.

(3) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG .SELECTION			
----- START ENTRY-PREPAR- ATION PROGRAM (P61) DISPLAY PROGRAM 61 -----	----- KEY IN ENTRY PREPAR- ATION PROGRAM (P61) V37E 61E -----			#10
----- . . . -----	----- MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 61 -----			#20
----- DO IMU STATUS CHECK ROUTINE (R02) ----- . . -----	----- DO IMU STATUS CHECK ROUTINE (R02) -----			
----- SET TIG FLAG -----					#30

DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41)

CALL AVERAGE G
ROUTINE

IS UNIT (V X R)

WITHIN 30 DEG OF

+Y
-SM

.Y .N

IS UNIT (V X R)

WITHIN 30 DEG OF

-Y ?
-SM

.Y .N

COMMAND PROGRAM

ALARM AND

DISPLAY

V05 N09

R1-

R2-

R3-

EXPECTED ALARM

CODE AT THIS

TIME IS 01427

DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41)
OBSERVE THAT THE
COMPUTER ACTIVITY
LIGHT IS ON UNTIL
COMPLETION OF ROU-
TINE 41.

OBSERVE PROGRAM
ALARM LIGHT ON DSKY
AND DISPLAY OF ERROR
CODE (IMU RE-
VERSED. ZERO ROLL
ON FDI BALL WILL
MEAN LIFT DOWN)

#40

#50

#60

#70

#80

++
POSS
TEMP
HOLD .
.....
SNAP .
+
+
+
+
+13
++
EDIT
PCR
206

 WAIT FOR KEYBOARD
 ENTRY

 KEY IN PROCEED

 TERMINATE FLASH
 UPON RECEIPT OF
 PROCEED OR NEW DATA

 KEY IN
 V25E
 AND LOAD
 DESIRED
 PARAMETERS

P. .NEW
 R. .DATA
 C. .
 C. .
 E. -----
 E. STORE DATA
 D. -----

#150

#160

 HOLD . FLASH VERB-NOUN TO
 REQUEST RESPONSE AND
 SNAP . DISPLAY:
 V06 N60
 R1 - G MAX
 R2 - VPRED
 R3 - GAMMA EI

 MONITOR DSKY:
 OBSERVE VERB-NOUN
 FLASH TO REQUEST
 RESPONSE AND DISPLAY
 OF G MAX, VPRED AND
 GAMMA EI

#170

G MAX - MAX PREDICTED
 G FOR FREE FALL AND
 ENTRY AT NOMINAL
 BANK ANGLE (L/D =
 .18) IN GS TO
 NEAREST .01 G.

#180

VPRED- PREDICTED
 INERTIAL VELOCITY
 AT 400,000 FT
 ALTITUDE ABOVE
 THE FISCHER
 ELLIPSOID.
 IN FPS TO NEAREST
 FPS.

#190

GAMMA EI - FLIGHT
PATH ANGLE. ANGLE
BETWEEN INERTIAL
VELOCITY AND THE
LOCAL HORIZONTAL
AT THE ENTRY INTER-
FACE ALTITUDE AT
400,000 FT ALTIT-
UDE ABOVE THE
FISCHER ELLIPSOID.
IN DEGREES TO
NEAREST .01 DEG.

#200

MINUS INDICATES
FLIGHT PATH IS BELOW
THE HORIZONTAL PLANE.

RECORD DATA IF
NECESSARY

#210

WAIT FOR KEYBOARD
ENTRY

TERMINATE FLASH UPON
RECEIPT OF PROCEED

KEY IN PROCEED

#220

#230

HOLD .
 FLASH VERB-NOUN
 SNAP . TO REQUEST RESPONSE
 AND DISPLAY:
 V06 N63
 R1 - RTOGO
 R2 - VIO
 R3 - TFE

RTOGO - RANGE TO GO
 FROM A PRELOADED
 ALTITUDE (SEE NOTE)
 ABOVE THE FISCHER
 ELLIPSOID TO THE
 SPLASH POINT. IN
 NAUTICAL MILES TO
 NEAREST .1 NM.

VIO - PREDICTED
 INERTIAL VELOCITY
 AT A PRELOADED AL-
 TITUDE (SEE NOTE)
 ABOVE THE FISCHER
 ELLIPSOID IN FPS TO
 NEAREST FPS.

TFE - TIME FROM NOW
 TO A PRELOADED ALT-
 ITUDE (SEE NOTE)
 ABOVE THE FISCHER
 ELLIPSOID IN MIN
 AND SEC TO NEAREST
 SEC. MAX READING IS
 59859. -ABOVE +
 BELOW ALTITUDE.

NOTE: THE ALTITUDE
 IS PRELOADED IN
 ERASABLE.
 FOR EARTH
 ORBIT = 284,643
 FOR LUNAR
 MISSION = 297,431

WAIT FOR KEYBOARD
 ENTRY

TERMINATE FLASH UPON
 RECEIPT OF PROCEED

MONITOR DSKY:
 OBSERVE VERB-NOUN
 FLASH TO REQUEST
 RESPONSE AND DISPLAY
 OF EMS INITIALIZATION
 PARAMETERS

RECORD DATA FOR
 EMS INITIALIZATION

KEY IN PROCEED

#240

#250

#260

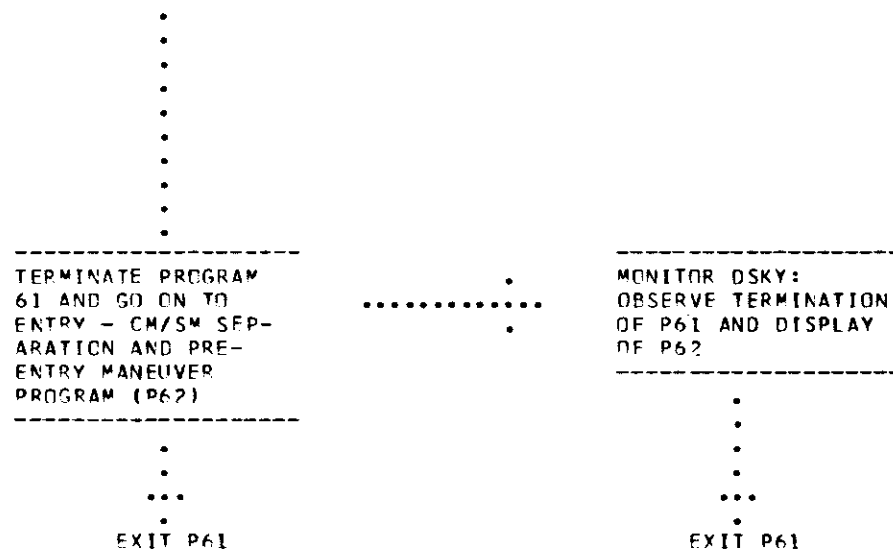
#270

#280

#290

347

P61/COLOSSUS



#300

#310

CHANGE CONTROL NOTES

REV 09 PCR MIT 32
 REV 10 DELETE ASSUMPTION 5
 REV 11 PCR MIT 42
 REV 12 PCR 50
 REV 13 PCR MIT 149
 REV 13 PCR 206 EDITORIAL

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ENTRY - CM/SM SEPARATION AND PRE-ENTRY MANEUVER
PROGRAM (P62)

LOGIC REV 11 11/27/68

PURPOSE: (1) TO NOTIFY CREW WHEN THE GNCS IS PREPARED FOR CM/SM SEPARATION.

(2) TO ORIENT THE CM TO THE CORRECT ATTITUDE FOR ATMOSPHERIC ENTRY.

ASSUMPTIONS: (1) THE PROGRAM IS ENTERED WITH ADEQUATE FREE FALL TIME TO ACCOMPLISH CM/SM SEPARATION AND TO COMPLETE THE MANEUVER FROM A WORST CASE STARTING ATTITUDE.

(2) THE IMU IS SATISFACTORILY ALIGNED FOR ENTRY.

(3) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY-PREPARATION PROGRAM (P61) OR IT MAY BE SELECTED MANUALLY.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PRG .SELECTION.....		.CREW PRG .SELECTION			
	----- START ENTRY- CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62). DISPLAY PROGRAM 62	. ..... .	----- KEY IN ENTRY: CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62) V37E 62E -----			#10
		. ..... .	----- MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 62 -----			#20
	----- . . .					
	----- DO IMU STATUS CHECK ROUTINE R02. -----	. ..... .	----- DO IMU STATUS CHECK ROUTINE R02. -----			
	. . . . .					#30

.....
 WAIT FOR KEYBOARD
 ENTRY
 TERMINATE FLASH UPON
 RECEIPT OF PROCEED.

.P
 .R
 .O
 .C
 .E
 .E
 .D

 TURN OFF CSM
 RCS DAP

 TURN ON ENTRY DAP
 AND MAINTAIN ATTITUDE HOLD.

HOLD
 SNAP
 ++
 +11
 ++
 EDIT
 PCR
 206

FLASH VERB-NOUN TO
 REQUEST RESPONSE AND
 DISPLAY STORED DATA
 V06 N61
 R1-IMPACT LAT
 R2-IMPACT LONG
 R3-HEADS UP/DOWN

IMPACT LAT - LATITUDE OF DESIRED IMPACT POINT. IN DEGREES TO NEAREST .01 DEG. + IS NORTH

.....
 WHEN SATISFIED THAT
 CM/SM SEPARATION
 HAS SATISFACTORILY
 OCCURRED WAIT -- SEC
 FOR ADEQUATE SEPARATION DISTANCE AND
 KEY IN PROCEED.

.....
 MONITOR DSKY:
 OBSERVE VERB-NOUN
 FLASH TO REQUEST
 RESPONSE AND DISPLAY
 OF S/C ENTRY DATA
 NOTE: LAT AND
 LONG SHOULD HAVE
 BEEN LOADED BEFORE
 ENTERING THIS PROGRAM

#190

#200

#210

#220

#230

IMPACT LONG - LONG-
ITUDE OF DESIRED IM-
PACT POINT. IN
DEGREES TO NEAREST
.01 DEG. + IS EAST

HEADS UP/DOWN - DE-
FINES ENTRY ROLL
ATTITUDE
+00001 FOR HEADS UP/
LIFT DOWN
-00001 FOR HEADS
DOWN/LIFT UP

#240

AM I SATISFIED WITH
THESE VALUES?

#250

.Y .N

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

#260

KEY IN V25E AND
LOAD DESIRED
PARAMETERS

P. .NEW
R. .DATA
O. .
C. .
E. .
E. STORE DATA
D. .

#270

ESTABLISH ATTITUDE
COMMANDS FOR ENTRY
DAP NECESSARY TO
GIVE CORRECT ANGLE
OF ATTACK INTO ATM-
SPHERE:

#280

ROLL COMMAND -
BASED ON PREVIOUS
DEFINITION OF HEADS
UP/DOWN

ALPHA COMMAND -
TRIM ANGLE OF ATTACK
(TRIM ALPHA)
BETA COMMAND - ZERO

FOR LIFT DOWN
THIS ATTITUDE WILL
BE OBTAINED AFTER A
SIMPLE PITCH DOWN
MANEUVER FROM THE
SEPARATION ATTITUDE.
FOR LIFT UP AN ADDI-
TIONAL 180 DEGREES
OF ROLL IS REQUIRED.

#290

-
-
-

#300

TURN ON ENTRY DAP

•
•
•
•

```

TEMP      -----
HOLD      .  DISPLAY ON DSKY DE-
.....    SIRED FINAL GIMBAL
MON       .  ANGLES:

```

V06 N22
R1- OG ROLL
R2- IG PITCH
R3- MG YAW

IN DEGREES TO
NEAREST .01 DEG.

•

IS THE ANGLE ALPHA
ALREADY WITHIN 45
DEGREES?

• Y	• N
•	•
•	•

. WAIT UNTIL CM
 . ANGLE OF ATTACK
 . (ALPHA) IS WITH-
 . IN 45 DEGREES
 . AND THEN WAIT
 . AN ADDITIONAL
 . 21 SECCNDS.

• • • • •

MONITOR DSKY:
OBSERVE DISPLAY
OF FINAL GIMBAL
ANGLES.

.....

#310

#320

#330

#340

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.
.
-----
TERMINATE PROGRAM
62 AND GO TO ENTRY-
INITIALIZATION
PROGRAM (P 63)
-----

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.
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.
.
.
EXIT P62

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.....
.

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-----
MONITOR DSKY:
OBSERVE TERMINATION
OF P 62 AND DISPLAY
OF P 63
-----

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.
.
.
EXIT P62

```

#350

CHANGE CONTROL NOTES

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REV 07  PCR MIT 32
REV 08  PCR MIT 41
REV 09  PCR MIT 66
REV 10  PCR MIT 152
REV 11  PCR 206 EDITORIAL

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ENTRY-INITIALIZATION PROGRAM (P63)

LOGIC REV 06 04/09/68

PURPOSE:

- (1) TO INITIALIZE THE ENTRY EQUATIONS.
- (2) TO CONTINUE TO HOLD THE CM TO THE CORRECT ATTITUDE WITH RESPECT TO THE ATMOSPHERE FOR THE ONSET OF ENTRY DECELERATION.
- (3) TO ESTABLISH ENTRY DSKY DISPLAYS.
- (4) TO SENSE .05G AND DISPLAY THIS EVENT TO THE CREW BY SELECTING THE ENTRY-POST 0.05G PROGRAM (P64).

ASSUMPTIONS:

- (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY-CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62).
- (2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TO TARC) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HCOT) BY KEYING IN V16N68E.

PROG
CONT

CMC

GROUND

CREW

CHECKLIST

TIME

TOTAL
TIME

	.CMC PROG .SELECTION				
START ENTRY - INITIALIZATION PROGRAM (63) DISPLAY PROGRAM 63	.....	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 63			#10
PERFORM ENTRY INITIALIZATION ROUTINE WHICH INCLUDES:					#20

A-CONTINUE CALCULATION OF INITIAL ROLL ANGLE BASED ON THE LATERAL RANGE OF THE LANDING TARGET AND HEADS UP/HEADS DOWN AS SPECIFIED.

#30

B-CONTINUE CALCULATION OF DESIRED CM PITCH AND YAW ATTITUDE AS DETERMINED BY THE VEHICLES POSITION AND VELOCITY W.R.T. THE ATMOSPHERE. PRIOR TO .05G THIS ATTITUDE IS ZERO SIDESLIP AND ANGLE OF ATTACK NEAR TRIM VALUE.

#40

MAINTAIN CM ATTITUDE FOR LIFT VECTOR UP/DOWN, AS SELECTED, ZERO SIDESLIP, AND TRIM ANGLE OF ATTACK

#50

TEMP
HOLD .
.....
MON .

DISPLAY ON DSKY:
V06 N64
R1-G
R2-VI
R3-R TO GO

MONITOR DSKY:
OBSERVE DISPLAY OF
G, VI AND R TO GO

#60

#70

G-ACCELERATION IN G
TC NEAREST .01G

VI-INERTIAL VELOCITY
IN FPS TO NEAREST
FPS

R TO GO - RANGE TC
GO TO THE DESIRED
SPLASH POINT
ASSUMING SPLASH
POINT LOCATED AT
CALCULATED IMPACT
TIME. IN NAUTICAL
MILES TO NEAREST
.1 NM. NEGATIVE AND
COUNTING DOWN WHEN
APPROACHING TARGET,
POSITIVE AND COUNT-
ING UP WHEN LEAVING
TARGET.

WAIT FOR .05G
INDICATION

ENTRY LOGIC DETECTS
.05G

CHANGE ENTRY DAP
FROM ATTITUDE HOLD
IN ALPHA AND BETA TO
RATE DAMPING IN
PITCH AND YAW, ROLL
UNCHANGED.

MONITOR GNCS CONTROL
OF PRE - .05G CM
ATTITUDE:

(1) DSKY:

R1-G-INCREASING

R2-VI-NOMINAL

R3-R TO GO
NEGATIVE AND
COUNTING DOWN
WHEN APPROACHING
TARGET, POSITIVE
AND COUNTING UP
WHEN LEAVING
TARGET.

(2) FDAI:

ATTITUDE RATES
LESS THAN--DEG./
SEC.

ATTITUDE ERRORS
LESS THAN --DEG.

#80

#90

#100

#110

#120

361

CHANGE CONTROL NOTES

REV 06

PCR MIT 66

00240000

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PURPOSE:

- (1) TO START ENTRY GUIDANCE AT .05G SELECTING ROLL ATTITUDE, CONSTANT DRAG LEVEL, AND DRAG THRESHOLD, KA, WHICH ARE KEYED TO THE .05G POINT.
- (2) SELECT FINAL PHASE (P67) IF $V < 27000$ FPS WHEN .2G OCCURS.
- (3) ITERATE FOR UPCCNTROL SOLUTION (P65) IF $V > 27000$ FPS AND IF ALTITUDE RATE AND DRAG LEVEL CONDITIONS ARE SATISFIED
- (4) SELECT FINAL PHASE (P67) IF NO UPCCNTROL SOLUTION EXISTS WITH $V_L > 18000$ FPS.
- (5) TO ESTABLISH THE 0.05 G MODE IN SCS.
- (6) TO CONTINUE ENTRY ESKY DISPLAYS.

ASSUMPTIONS:

- (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY INITIALIZATION PROGRAM (P 63).
- (2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TC TARG) DURING THIS PROGRAM BY KEYING IN V16N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.

[illegible]

SFT 0.05 G ENTRY
SWITCH ON SCS
CONTROL PANEL TO ON

TEMP
HOLD .
.....
MON .

DISPLAY ON DSKY:

V06 N68
R1-BETA
R2-VI
R3-H DOT

BETA-COMMANDED BANK
ANGLE. IN DEGREES
TO NEAREST .01
DEGREE

VI - INERTIAL
VELOCITY. IN FPS TO
NEAREST FPS

H DOT - RATE
OF CHANGE OF
ALTITUDE ABOVE PAD
RADIUS. IN FPS TO
NEAREST FPS.
PLUS FOR INCREASING
ALTITUDE, MINUS FOR
DECREASING ALTITUDE.

MONITOR G+N CONTROL
OF ENTRY:
(A) FDAI:
ATT ERRORS LESS
THAN --DEG

ATT RATES LESS
THAN --DEG/SEC

BALL INDICATES
LIFT VECTOR
DIRECTION COR-
RELATION WITH
BETA

(B) DSKY:
R1-BETA VARIES
TO LIMIT G AND
CONTROL LIFT
VECTOR

R2 - VI
DECREASING
R3-H DOT

COMMAND CM ATTITUDE
IN ACCORDANCE WITH
CMC ENTRY LOGIC

#30

#40

#50

#60

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ENTRY - UP CONTROL PROGRAM (P65)

LOGIC REV 08 11/27/68

- PURPOSE:
- (1) TO EXECUTE ENTRY - UP CONTROL GUIDANCE WHICH STEERS THE CM TO A CONTROLLED EXIT (SKIP OUT) CONDITION.
 - (2) TO ESTABLISH ENTRY - UP CONTROL DISPLAYS WHICH ARE USED IN CONJUNCTION WITH THE EMS TO DETERMINE FOR THE ASTRO-NAUT IF THE BACKUP PROCEDURES SHOULD BE IMPLEMENTED.
 - (3) TO SENSE EXIT (DRAG ACCELERATION LESS THAN $Q7 \text{ FPS}^2$) AND THEREUPON TO SELECT THE ENTRY - BALLISTIC PHASE PROGRAM (P66).
 - (4) WHERE RDOT IS NEGATIVE AND THE V IS SUFFICIENTLY LOW (V-VL-C18 NEG), PROGRAM WILL EXIT DIRECTLY TO P67 (FINAL PHASE).
- ASSUMPTIONS:
- (1) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY - POST 0.05G PROGRAM (P64) WHEN CONSTANT DRAG CONTROL HAS BROUGHT RANGE PREDICTION TO WITHIN 25 N.M. OF THE DESIRED RANGE. IT IS SKIPPED IN EARTH ORBIT MISSIONS.
 - (2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TO TARG) DURING THIS PROGRAM BY KEYING IN V16N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.
 - (3) MANUAL RESPONSE TO N69 IS NOT NECESSARY TO TERMINATE P65. SELECTION OF EITHER P66 OR P67 BY ENTRY GUIDANCE PROVIDES AUTOMATIC TERMINATION.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PRG .SELECTION					
	----- START ENTRY - UP CONTROL PHASE PROGRAM (65) -----					#10
					

	DISPLAY PROGRAM 65			MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 65		
	-----			-----		
	. . . . .					#20

HOLD . FLASH VERB-NOUN TO
 REQUEST RESPONSE AND
 MON . DISPLAY PRE-COMPUTED
 EXIT CONDITIONS
 V16 N69
 R1 - BETA
 R2 - DL
 R3 - VL

BETA - COMMANDED
 BANK ANGLE. IN DEG-
 REES TO NEAREST 0.01
 DEGREE

DL - DRAG ACCELE-
 RATION AT SKIP OUT IN
 GS TO NEAREST
 0.01 G (Q7)

VL - SKIP OUT
 VELOCITY. IN FPS TO
 NEAREST FPS.

MONITOR DSKY:
 OBSERVE VERB-NOUN
 FLASH TO REQUEST RE-
 SPONSE AND DISPLAY
 OF BETA, DL, AND VL

#30

#40

RECORD CONTENTS OF
 R1, R2, AND R3 FOR
 LATER USE WITH EMS

#50

++
 +08 DO EITHER:
 + WAIT FOR KEYBOARD
 + ENTRY
 + TERMINATE FLASH UPON
 + RECEIPT OF PROCEED
 + OR FLASH IS AUTO-
 + MATICALLY TERMINATED
 + UPON RECEIPT BY
 + ENTRY GUIDANCE OF
 +08 P66 OR P67.
 ++

KEY IN PROCEED

#60

.P
 .R
 .C
 .C
 .E
 .F
 .D

#70

ENTRY - BALLISTIC PROGRAM (P66)

LOGIC REV 07 05/07/68

- PURPOSE: (1) TO MAINTAIN CM ATTITUDE DURING BALLISTIC (SKIP OUT) PHASE FOR ATMOSPHERIC RE-ENTRY.
 (2) TO SENSE RE-ENTRY (DRAG ACCELERATION BUILDS UP TO $Q7 + 0.5 \text{ FPS}^2$ OR APPROX. 0.2G) AND THEREUPON TO SELECT THE ENTRY - FINAL PHASE PROGRAM (P67).
- ASSUMPTIONS: (1) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY - UP CONTROL PROGRAM (P65) WHEN DRAG ACCELERATION BECOMES LESS THAN $C7 \text{ FPS}^2$.
 (2) THE ASTRONAUT MAY MONITOR N64 (G, VI, R TC TARG) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG .SELECTION ...					
	----- START ENTRY - BAL- LISTIC PROGRAM (P66) -----					#10
					
	----- DISPLAY PROGRAM 66 -----	.....		MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 66 -----		
					
	----- ESTABLISH ATTITUDE COMMANDS FOR ENTRY DAP NECESSARY TO GIVE CORRECT ANGLE OF ATTACK INTO THE ATMOSPHERE: ROLL COMMAND- MAINTAIN LAST COMPUTED VALUE					#20
++ +07 + + +						#30
					P66/COLOSSUS	

FROM ENTRY
 GUIDANCE UNLESS
 ACCELERATION GOES
 BELOW .05 G IN
 WHICH CASE MAIN-
 TAIN ZERO DEGREES
 UNTIL TERMINATION
 OF P66.
 ALPHA COMMAND-
 TRIM ANGLE OF
 ATTACK (TRIM
 ALPHA)
 BETA COMMAND-
 ZERO.

#40

CALCULATE FINAL
 GIMBAL ANGLES RE-
 QUIRED BASED ON PRE-
 SENT STATE VECTOR.
 REPEAT CALCULATION
 EVERY TWO SECONDS
 UNTIL TERMINATION OF
 P66.

#50

TEMP
 HOLD .

 MON .
 DISPLAY ON DSKY:
 THE DESIRED GIMBAL
 ANGLES TO WHICH THE
 ENTRY DAP WILL ORI-
 ENT THE CM
 V06 N22
 R1-CG ROLL
 R2-IG PITCH
 R3-MG YAW

ALL COMMANDED GIMBAL
 ANGLES IN DEGREES TO
 NEAREST 0.01 DEGREE.

MONITOR GNCS CONTROL
 OF ENTRY:

F0A1: ATTITUDE
 ERROR NEEDLES -
 DIFFERENCE BETW-
 EEN THE TOTAL DE-
 SIRED ATTITUDE
 AND THE ACTUAL
 ATTITUDE (FLY TO
 POLARITY).

#60

#70

BALL: ACTUAL GIMBAL
 ANGLES READ ON BALL
 SHOULD AGREE WITH
 COMMANDED GIMBAL
 ANGLES READ ON DSKY.

#80

.....

 COMMAND CM ATTITUDE
 IN ACCORDANCE WITH
 CMC ENTRY - BALLIS-
 TIC PHASE LOGIC

RCLL ANGLE IS HELD
 AT EXIT RCLL ATTITU-
 TUDE, PITCH AND YAW
 ATTITUDE IS DETER-
 MINED BY THE VEHICLE
 POSITION AND VELO-
 CITY W.R.T. THE
 ATMOSPHERE. THIS
 ATTITUDE IS ZERO
 SIDESLIP AND ANGLE
 OF ATTACK NEAR THE
 TRIM VALUE.

NOTE: THREE AXIS DAP
 CONTROL WAS REGAINED
 WHEN LESS THAN 0.05
 G WAS SENSED AND
 WILL BE RELINQUISHED
 WHEN 0.05 G IS AGAIN
 SENSED.

.....

 TERMINATE P66 AND GO
 TO ENTRY-FINAL PHASE
 PROGRAM (P67) WHEN
 DRAG ACCELERATION
 BUILDS UP 2
 TO Q7 + 0.5 FPS

.....
 EXIT P66

.....

 MONITOR DSKY:
 OBSERVE TERMINATION
 OF P66 AND DISPLAY
 OF P67

.....
 EXIT P66

#90

#100

#110

#120

CHANGE CONTROL NOTES

REV 06 PCR MIT 66
REV 07 PCR NASA 155

00176000
00177000

APOLLO COMPUTER LOGIC CHECKLIST INTERFACE

ENTRY - FINAL PHASE PROGRAM (P67)

 LOGIC REV 09 11/29/68
 CHECKLIST REV 10 04/27/68

PURPOSE: (1) TO CONTINUE ENTRY GUIDANCE AFTER $Q7 + 0.5 \text{ FPS}^2$ (OR APPROX. 0.2G) UNTIL TERMINATION OF STEERING WHEN THE CM VELOCITY WRT EARTH = 1000 FT/SEC (ALTITUDE IS APPROXIMATELY 65,000 FT.).

(2) TO CONTINUE ENTRY DSKY DISPLAYS.

ASSUMPTIONS: (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY:

(A) P65 WHEN ADOT IS NEGATIVE AND THE V IS SUFFICIENTLY LOW ($V - V_L - C18$ NEG)

(B) P66 WHEN DRAG ACCELERATION BUILDS UP TO $Q7 + 0.5 \text{ FPS}^2$ (OR APPROX. 0.2G)

(C) P64 IF NO UPCONTROL SOLUTION EXISTS WITH $V_L > 18000 \text{ FPS}$

(2) THE ASTRONAUT MAY MONITOR N64 (G, VI, R TO GO) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HOOT) BY KEYING IN V16N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG. .SELECTION					
	----- START ENTRY-FINAL PHASE PROGRAM (P 67) -----					#10
	. . .					
	----- DISPLAY PROGRAM 67 -----	.....	. . .	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 67 -----		#20
					

TEMP
HOLD .
.....
MON .

DISPLAY ON DSKY:
V06 N66
R1-BETA
R2-X RNG ERR
R3-DWN RNG ERR

MONITOR G+N CONTROL
OF ENTRY:
(A)FDAI:

ATT ERRORS LESS
THAN --DEG
ATT RATES LESS
THAN --DEG/SEC.

#30

BETA-COMMANDED
BANK ANGLE. IN
DEGREES TO NEAREST
.01 DEGREE

BALL INDICATES
LIFT VECTOR
DIRECTION COR-
RELATION WITH
BETA
(R) DSKY:
R1-BETA VARIES
TO LIMIT G AND
CONTROL LIFT
VECTOR.

#40

X RNG ERR - CMC
SOLUTION FOR CROSS
RANGE ERROR. POS-
ITIVE IF ON THE
SOUTH OF THE
TARGET PLANE. NEG-
ATIVE IF ON THE
NORTH OF THE TARGET
PLANE. IN NAUTICAL
MILES TO THE NEAR-
EST .1 NM.

DWN RNG ERR - CMC
SOLUTION FOR DOWN
RANGE ERROR (DEC-
REASING) POSITIVE
FOR OVERSHOOT,
NEGATIVE FOR UN-
DERSHOOT. IN NAUT-
ICAL MILES TO
NEAREST .1 NM.
(PREDANGLE-THETA)

#50

R3- DWN RNG ERR
- DECREASING

++
+09
++
PCR
528

NOTE: THE DWN RNG
ERR DISPLAY WILL
BE 9999.9 NM ONCE
THE TARGET HAS
BEEN OVERSHOT.

#60

COMMAND CM ATTITUDE
IN ACCORDANCE WITH
CMC ENTRY LOGIC

#70

.....

 WAIT UNTIL CM
 VELOCITY WRT EARTH =
 1000 FPS

#80

HOLD.

 MON .

 FLASH VERB-NOUN TO
 REQUEST RESPONSE AND
 DISPLAY:
 V16 N67
 R1-RTGO
 R2-LAT
 R3- LONG

 MONITOR DSKY:
 OBSERVE VERR-NOUN
 FLASH TO REQUEST RE-
 SPONSE AND DISPLAY
 PRESENT POSITION AND
 RANGE TO GO

#90

RTGO-RANGE TO GO TO
 TARGET. IN NAUTICAL
 MILES TO NEAREST .1
 NM. NEGATIVE AND
 DECREASING WHEN AP-
 PROACHING TARGET,
 POSITIVE AND IN-
 CREASING WHEN LEAV-
 ING TARGET.
 LAT - LATITUDE OF
 PRESENT POSITION. IN
 DEGREES TO NEAREST
 .01 DEG.

(+ IS NORTH)

LONG - LONGITUDE OF
 PRESENT POSITION. IN
 DEGREES TO NEAREST
 .01 DEG.

(+ IS EAST)

 HOLD CONSTANT ATTIT-
 UDE MANUALLY (FULL
 LIFT UP OR DOWN, DE-
 PENDING ON RTGO)
 UNTIL CHUTE DEPLOY-
 MENT.

#100

#110

 MONITOR ALTIMETER
 AND STANDBY TO BACK-
 UP MESC FOR CHUTE
 DEPLOYMENT

#120

.....

WAIT FOR KEYBOARD
ENTRY

.....

WHEN CM IS ON THE
CHUTES KEY IN
PROCEED

.....

TERMINATE FLASH UPON
RECEIPT OF PROCEED

#130

.....

TURN OFF ENTRY DAP

#140

.....

DO ROUTINE R00

.....

DO ROUTINE R00

.....
EXIT P67

.....
EXIT P67

#150

CHANGE CONTROL NOTES

REV 07 PCR MIT 66
REV 08 PCR 206
REV 09 PCR 528