

DPS PROGRAM (P4C)

REV 02 12/03/69

PURPOSE:

- (1) TO COMPLETE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR A LM DPS THRUSTING MANEUVER.
- (2) TO DO THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.
- (3) TO CONTROL THE PGNS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A PGNS CONTROLLED DPS MANEUVER.

ASSUMPTIONS:

- (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING DPS THRUSTING AND UNTIL THE CREW NOTIFIES THE LGC THAT RCS TRIM THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.

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+02
+EDIT
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FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3.3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (UT).

(3) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(4) THE EVENT TIMER 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 STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME.

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+EDIT
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(6) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (7)) FOR DISPLAY ON THE FDI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

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+EDIT
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+02
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IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER, IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION; WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC. IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION, VELOCITY, THE DESIRED THRUST VECTOR, AND THE DESIRED ATTITUDE ERRORS. HOWEVER, THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(7) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDI:

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MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.

MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS INDICATED

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+O2
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IN ASSUMPTION (6) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY.
FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6

(8) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNC'S ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNC'S DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE. THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60).

(9) WHEN THE THRUST/TRANSLATION CONTROLLER IS SET TO MINIMUM THRUST POSITION AND THE LGC THROTTLE COMMAND IS ZERO THE DPS WILL START AT 10 PER CENT THRUST.

(10) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM AND THE DPS ENGINE GIMBAL HAS BEEN PREVIOUSLY DRIVEN TO THE CORRECT TRIM POSITION. IF THIS BURN IS OF SUFFICIENT DURATION THAT VEHICLE TRANSIENTS AT IGNITION DUE TO CG/THRUST DOES NOT AFFECT ACCOMPLISHMENT OF MANEUVER AIM CONDITIONS, THEN GIMBAL DRIVE TO TRIM POSITION NEED NOT BE DONE BEFORE TIG. GIMBAL DRIVE TO TRIM POSITION IN WORST CASE COULD REQUIRE 2 MINUTES.

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+O2
+EDIT
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(11) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET AUTOPILOT (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY EXTENDED VERB AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT VIOLATIONS DURING CSM-DOCKED DPS BURNS (P40). THE CAPABILITY EXISTS DURING P63 AND P70 ALSO. PERFORMANCE OF FRESH START (V36E) WILL ALWAYS ENABLE THE PITCH-ROLL JETS.

(12) FOR EACH BURN AN IGNITION TOTAL ALLOWABLE TIME DELAY WILL BE SPECIFIED IN THE MISSION RULES. THIS DELAY TIME IS THE TOTAL TIME WHICH THE THRUSTING MANEUVER MAY BE DELAYED BEYOND THE LGC CALCULATED TIME OF IGNITION. IF ENGINE RESTARTS ARE INVOLVED, THE ACCOUNTING OF THIS TOTAL TIME DELAY IS UP TO THE CREW.

(13) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R4C). THIS ROUTINE IS CALLED AT DPS IGNITION BY THIS PROGRAM.

(14) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(15) THIS PROGRAM SHOULD BE SELECTED BY THE ASTRONAUT BY DSKY ENTRY AT LEAST 5 MIN. BEFORE THE ESTIMATED TIME OF IGNITION.

(16) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.

PROG
CNT

LGC

GROUND

CREW

. CREW
. PROGRAM
. SELECTION
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. .
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START DPS
PROGRAM (P40)
DISPLAY P40

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KEY IN DPS
PROGRAM (P40)
V37E 40E

#10

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22-1

MONITOR DSKY:
OBSERVE DISPLAY CF
P40

#20

IS THE APS FLAG SET?

.N .Y

POSS
HOLD
SNAP

FLASH VERB-NOUN
TO REQUEST RE-
SPONSE AND DIS-
PLAY ALARM CODE
C17C6 TO INDICA-
TE THAT APS FLAG
SHOWS THAT DPS
HAS BEEN STAGED;
V05M09
R1-XXXXX
R2-XXXXX
R3-XXXXX

DOES VERB-NOUN FLASH
TO REQUEST RESPONSE
AND DISPLAY OF ALARM
CODE INDICATE THAT
APS FLAG SHOWS
THAT DPS HAS BEEN
STAGED?

(NOTE:
THIS ALARM CODE
MAY BE DISPLAYED IN
EITHER R1, R2, OR
R3, DEPENDING ON
THE PRESENCE OR
ABSENCE OF OTHER
ALARM CODES.)

#30

.Y .N

#50

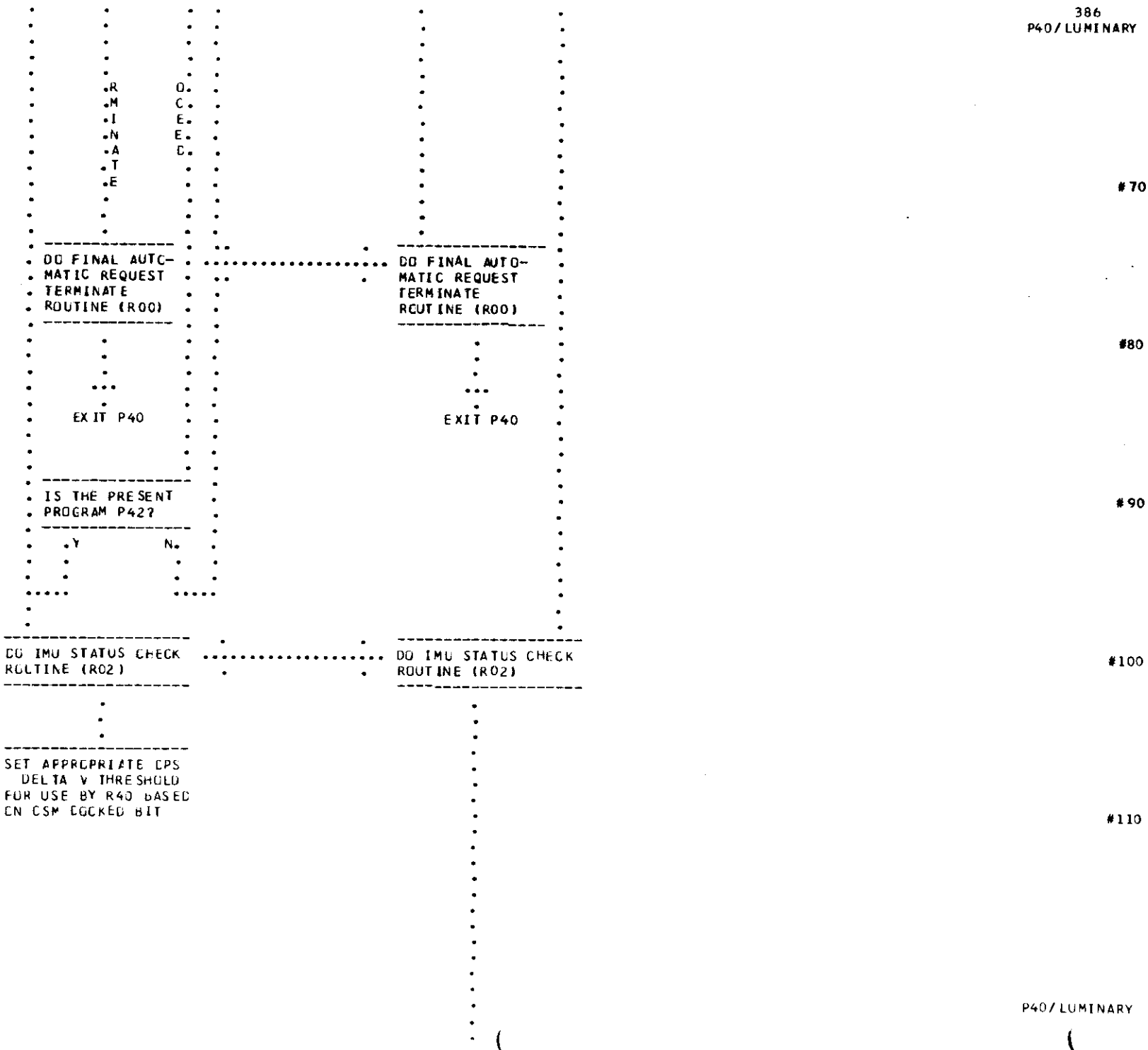
WAIT FOR KEY-
BOARD ENTRY

KEY IN TERMINATE
V34E

TERMINATE FLASH
UPON RECEIPT CF
TERMINATE OR
PRCCEED

#60

.T P.
.E R.



IN DAP.

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SET DELTA V
COUNTER=4 FOR USE
BY R40

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RESET NO THROTTLE
FLAG

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COMPUTE INITIAL
THRUST DIRECTION
AND INITIAL VALUE OF
VG VECTOR AND STORE
VG(LV) IN N81 AND
N86 FOR POSSIBLE
MANUAL SELECTION:

R1-VGX(LV)
R2-VGY(LV)
R3-VGZ(LV)

VGX(LV)-COMPONENT OF
VG AT TIG ALONG
(RXV)XR. IN FPS TO
NEAREST .1 FPS.

VGY(LV)-COMPONENT OF
VG AT TIG ALONG VXR.
IN FPS TO NEAREST
.1 FPS.

VGZ(LV)-COMPONENT OF
VG AT TIG ALONG -R.
IN FPS TO NEAREST
.1 FPS.

#120

#130

#140

#150

WHERE R IS GEO-
CENTRIC (EARTH
ORBIT) OR SELENC-
CENTRIC (LUNAR
ORBIT) RADIUS VECTOR
AND V IS VEHICLE
INERTIAL VELOCITY
VECTOR AT TIC.
(NOTE: N81 WILL NOW
DIFFER FROM N81 DIS-
PLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

#160

:

COMPUTE PREFERRED
IMU ORIENTATION:

#180

X = UNIT (T)
-SM -

Y = UNIT (T X R)
-SM - -

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

WHERE:

#190

T = THE INITIAL
- THRUST VECTOR
AT TIC

R = THE GEOCENTRIC
- (EARTH ORBIT)
OR SELENC-
CENTRIC (LUNAR
ORBIT) RADIUS
VECTOR AT TIC.

#200

(NOTE: IF T X R IS
SMALL (REFER SECTION

5.3.3.3 OF R567),

THEN Y =
- SM
UNIT (T X V)

WHERE V = VEHICLE

INERTIAL VELOCITY
VECTOR AT TIG.)

#210

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#220

STORE DESIRED ATTITUDE SPECIFICATION FOR USE BY ATTITUDE MANEUVER ROUTINE (R60). THE FINAL ATTITUDE WILL BE COMPUTED DURING R60 AND WILL POINT THE LM +X AXIS IN THE INITIAL THRUST DIRECTION. HOWEVER, IN ORDER TO CONSERVE RCS FUEL AND NOT CONSTRAIN THE NON-CRITICAL ATTITUDE ABOUT THE THRUST VECTOR, WINGS MAY NOT BE LEVEL IN THE COMPUTED FINAL ATTITUDE.

#230

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SET PREFERRED-ATTITUDE-COMPLETED FLAG

#240

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COMMAND ZERO ATTITUDE ERRORS

#250

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SET 1 DEGREE
DEADBAND.

#260

RESET 3-AXIS FLAG

#270

DO ATTITUDE MANEUVER
ROUTINE (R60)

DO ATTITUDE MANEUVER
ROUTINE (R60)

#280

HAVE PGNS CONTROL
AND AUTO ATTITUDE
CONTROL MODES BEEN
SELECTED?

#290

.Y N.

IS THE APS FLAG
SET?

#300

.Y N.

HAS THE AUTO
THROTTLE MODE
BEEN SELECTED?

.Y .N.

#310

POSS
HOLD
.....
SNAP

FLASH VERB-NOUN
TO REQUEST PLEASE
PERFORM PGNS
CONTROL, AUTC
ATTITUDE CONTROL,
AND AUTO THROTTLE
MODE SELECTION:
V50 N25
R1 - 00203
R2 - BLANK
R3 - BLANK

MONITOR DSKY:
GOES VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
PGNS CONTROL, AUTC
ATTITUDE CONTROL,
AND AUTO THROTTLE
MODE SELECTION?

.Y .N

#320

HAVE REQUESTED
MODES BEEN
SELECTED?

.N .Y

#330

DO I WISH TO
HAVE THESE
MODES SELECTED
DURING THE
THRUSTING
MANEUVER?

.Y .N

#340

#350

SET GUIDANCE
CONTROL SWITCH
TO PGNS, ATTITUDE CONTROL
SWITCH TO
AUTO, AND
THROTTLE SWITCH TO AUTO

#360

WAIT FOR KEY-
BCARD ENTRY

KEY IN PROCEED

#370

TERMINATE FLASH
UPON RECEIPT OF
PROCEED CR
ENTER

KEY IN ENTER

#380

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

#390

COMMAND CPS OFF

ZERO CPS AUTO
THRATTLE

#400

307

TEMP
HOLD

MON

DISPLAY ON DSKY:
VC6 N40
R1-TFI
R2-VG
R3-DELTA VM

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

TFI - TIME FROM
DPS IGNITION. IN
MIA, SEC TO NEAR-
EST SEC. MAX
READING IS 59B59.
SIGN IS - BEFORE
NOMINAL TIG, +
THEREAFTER.

UPDATE EVENT TIMER
IF DESIRED.

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

DELTA VM-MEASURED
DELTA V MAGNITUDE.
IN FPS TO NEAREST
.1 FPS. THIS DIS-
PLAY WILL BE 0000
UNTIL TIG-30 SEC
AND THEN SHOULD
CHANGE ONLY DUE TO
PIPA BIAS UNTIL
ULLAGE IS STARTED.

SET TDEC1 = TIG -30
SECCNCS

#410

#420

#430

#440

#450

DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41).
(NOTE: ENTER R41 AT
"A".)

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

#460

.NO TIG
.TIG SLIP
.SLIP

VERIFY/SET THRUST/
TRANSLATION CONTROL-
LER TO MINIMUM
THRUST POSITION.

#470

ARM DPS (AUTO
THROTTLE SIGNAL IS
ENABLED TO DPS AND
THRUST INDICATOR.)

#480

CHECK THRUST INDICA-
TOR (RIGHT SIDE) TO
ENSURE AUTO THROTTLE
COMMAND IS ZEROED (0
PERCENT INDICATION).

#490

.Y .N

GO TO
BACKUP
PROCED-
URES.

#500

CHECK STATUS OF
G/W LAMPS

#510

(NOTE: R41 WILL
DEFINE TIG TO BE
THE TIME TO WHICH
R41 DID INTEGRATE
THE LM STATE VEC-
TOR PLUS 30
SECONDS)

#520

WAIT UNTIL TIG - 35
SEC.

#530

BLANK THE DSKY DIS-
PLAY (V, N, R1, R2,
AND R3).

MONITOR DSKY:
AT TFI = -00835
OBSERVE DSKY DISPLAY
GO BLANK FOR 5
SECONDS.

#540

WAIT UNTIL TIG - 30
SEC.

RETURN VC6N4C
DISPLAYS

IS THE PRESENT
PROGRAM P42?

Y N

SET APS FLAG

START AVERAGE G
INTEGRATION

AT TFI =-7.5 SEC
SET ULLAGE
FLAG

MONITOR DSKY:
AT TFI = -00829
OBSERVE RETURN OF
VO6N40 DISPLAYS TO
INDICATE THAT
AVERAGE G INTEGRA-
TION HAS STARTED.
(NOTE: IF TIG HAS
BEEN SLIPPED BY R41,
THE TFI DISPLAY (R1)
AT THIS TIME WILL BE
REFERRED TO THE NEW
TIG).

MONITOR DSKY:
IN THE PERIOD FROM
TFI =-00830 UNTIL
TFI =-00815
DOES DELTA VM BECCME
GREATER THAN .5 FPS
INDICATING EXCESSIVE
PIPA BIAS ERROR?

N Y

GO TO BACKUP
PROCEDURES

AT TFI =-00807
MONITOR START OF +X
TRANSLATION.

#550

#560

#570

#580

#590

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+02
+EDIT
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.....

 WAIT UNTIL
 TIG -5 SEC.

.....

 RESET IGNITION FLAG

.....

 RESET ASTRONAUT FLAG

.....

 RESET IMPULSE FLAG

.....

 IS TIG LESS THAN 6
 SECONDS, BASED ON
 ASSUMED 10% CPS

397
 P40/LUMINARY

#600

#610

#620

#630

#640

P40/LUMINARY

THRST?

.N Y.

. .
. .

. SET IMPULSE FLAG

. .
. .
. .

IS TG LESS THAN
95 SECONDS, BASED
ON ASSUMED 10%
DPS THRST?

.N Y.

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. .
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. .
. .

. SET NO THROTT-
. LE FLAG TO
. INHIBIT THROT-
. TLE COMMAND TO
. MAXIMUM AT
. TIG +
. "ZOOMTIME"
. SEC.
. (NOTE: THE
. VALUE
. "ZOOMTIME" IS
. IN ERASABLE
. STORAGE HAVING
. BEEN LOADED
. PRIOR TO
. LAUNCH OR BY
. P27).

. .
. .
. .

CALL VERB 99 DISPLAY
(SEE "A" BELOW)

. .
. .

WAIT UNTIL TIG-C

. .
. .
. .
. .

#650

#660

#670

#680

#690

#700

SET IGNITION FLAG

IS ASTRONAUT FLAG
SET?

.Y N.
.
.
.....

GO TO EXIT
"B" (NOTE: THIS
BELOW IS NOT A P40
 EXIT. REFER
 DISPLAY RES-
 PONSE AT "A"
 BELOW.)

"A"
FROM
ABOVE

"F"
FROM
R40

CHANGE VERB BUT
RETAIN PRESENT NOUN
AND DISPLAYS IN R1,
R2, R3, FLASH VERB-
NOUN TO REQUEST
PLEASE PERFORM
ENGINE CN ENABLE:
V99N40

MONITOR DSKY:
AT TFI = -00BC5
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE CN ENABLE

MONITOR DSKY:
WAIT FOR INCREASE CF

#710

#720

#730

#740

#750

WAIT FOR KEYBOARD
ENTRY

DELTA VM INDICATING
SUFFICIENT ULLAGE.
REQUIRED ULLAGE
DELTA V IS A
FUNCTION OF VEHICLE
WEIGHT.

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·

#760

SHALL I ATTEMPT TO
COMPLETE THE
THRUSTING MANEUVER
WITH THE RCS?

· Y	· N
·	·
·	·

#770

..... KEY IN ENTER

KEY IN ENTER

#780

·
·
·
·
·
GO TO
"A"
BELOW

#790

SHALL I PERMIT
IGNITION?

· N	· Y
·	·
·	·

..... KEY IN PROCEED

KEY IN PROCEED

#800

TERMINATE FLASH UPON
RECEIPT OF ENTER,
PROCEED OR TERMINATE.

KEY IN
TERMINATE
V34E

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

RESET
ULLAGE
FLAG

GC TO
"C"
BELOW

CG FINAL AUTO-
MATIC REQUEST
TERMINATE ROU-
TINE (RCO).

DU FINAL AUTO-
MATIC REQUEST
TERMINATE RCU-
TINE (RCO).

#810

#820

#830

#840

#850

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. .
. . .
. . . .
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EXIT P40
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. . .
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EXIT P40
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SET ASTRGNAUT FLAG

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#860

IS IGNITION FLAG
SET?

.Y .N
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. . .
. . . .
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MONITOR DSKY:
IS R1 DISPLAY OF TFI
NEGATIVE AND
NON-ZERO?

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

#870

. RESUME STATIC
DISPLAY OF
V06N40



. MONITOR DSKY:
OBSERVE RE-
TURN OF STATIC
VERB-NOUN
(V06N40)

#880

.
. .
. . .
. . . .
EXIT
(NOTE: THIS IS
NOT A P40 EXIT.
REFER TIG-0
LOGIC ABOVE.)
.
.
"B"
FRM
ABOVE
.
.

STANDBY FOR
THRUST ON
WHEN TFI= -00800

.
.

#890

COMMAND CPS CN

. STANDBY FOR
THRUST ON
IMMEDIATELY

.
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#900

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376



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RESET PULSES FLAG

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TEMP
HOLD .

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

TFC - TIME FROM
ENGINE CUTOFF. IN
MIN AND SEC TO NEAR-
EST SEC. SIGN IS -
BEFORE, AND + AFTER
CUTOFF.

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MONITOR DSKY:
OBSERVE CHANGE OF
TFI DISPLAY TO TFC
IN R1. (NOTE: TFC IS
INITIALLY CALCULATED
ONCE AND DISPLAYED
BASED ON 10% DPS
THRUST. THIS DISPLAY
WILL COUNT DOWN WITH
ELAPSED TIME UNTIL
TVC STEERING IS IN-
ITIATED (WHEN STEER
FLAG IS SET BY R40.)
AT WHICH TIME TFC IS
RECALCULATED AND
DISPLAYED EVERY 2
SECCNDS BY THE GUID-
ANCE EQUATIONS.)

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IS TFC AT IGNITION
LESS THAN 6 SECONDS?

.N .Y.
.....
.....
.....
.....
GO TO
"E"
BELOW
.....

IS THE NO THROTTLE
FLAG SET?

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

CALL FOR MAXIMUM
THROTTLE COMMAND
.....
.....
.....
.....
.....

IS TFC AT IGNITION
LESS THAN 95
SECONDS?

.N .Y.
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.....
.....
.....
GC TC
.....
.....
.....
.....
.....

#910

#920

#930

#940

#950

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SEE "H" BELOW.)
.
.

RESET IGNITION FLAG

#1060

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.

RESET ASTRONAUT FLAG

#1070

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.
.

RE SET
IDLE FLAG

#1080

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.

CALL FOR RESET
OF ULLAGE FLAG IN
0.5 SECONDS.
(SEE "D"
BELOW.)

#1090

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.
.
.
.
EXIT
(NOTE: THIS IS
NOT A P40 EXIT.
SEE "D" BELOW).

#1100

"D"

FRM
ABOVE

AT ACTUAL TIG PLUS
"ZOOMTIME" SEC
COMMAND THROTTLE
TO MAXIMUM.

"ZOOMTIME" SECONDS
AFTER ACTUAL TIG
OBSERVE THRUST
INDICATOR TO INDI-
CATE XX PERCENT
AUTO THROTTLE COM-
MAND (RIGHT SIDE)
AND 100 PERCENT
CHAMBER PRESSURE
(LEFT SIDE).
(NOTE: THE VALUE
"ZOOMTIME" IS IN
ERASABLE STORAGE
HAVING BEEN LOADED
PRIOR TO LAUNCH
OR BY P27).

#1110

#1120

#1130

"G"
FROM
ABOVE

MAXIMUM THROTTLE
WILL NOT BE
COMMANDED.

#1140

"E"
FROM
ABOVE

#1150

THIS MANEUVER
IS AN IMPULSE
MANEUVER AND
WILL BE DONE
AT AN INERTI-
ALLY FIXED
VEHICLE
ATTITUDE.

#1160

MONITOR DPS
THRUSTING:

1. DSKY:
R1-TFC
SHOULD BE
DECREASING

R2-VG SHOULD BE
DECREASING

#1180

R3-DELTA VM
SHOULD INCREASE

2. FDI-ATT. ERRORS
SHOULD BE LESS THAN
OR EQUAL TO XX
DEGREE.

ATT RATES SHOULD BE
LESS THAN OR EQUAL
TO XX DEGREE/SEC.

#1190

3. THRUST INDICATOR
LEFT SIDE: XX PER-
CENT MAX CHAMBER

342

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(

322

PRESSURE RIGHT SIDE:
LGC THROTTLE COMMAND
XX PERCENT FULL
THRUST.

#1200

IDENTIFY EARLY,
NORMAL, OR LATE
ENGINE CUTOFF FROM
ASSESSMENT OF DSKY
DISPLAYS.

.E .N .L
.A .D .A
.R .R .T
.L .M .E
.Y . . .
. .C .C
.C .G .U
.U .T .T
.T .C .O
.D .F .F
.F .F .F
.F . . .
. . .
. . .

#1210

PUSH ENGINE
STOP PUSH-
BUTTON

#1220

GO TO
BACKUP
PROCEDURES.

#1230

IS TG LESS THAN 4
SECS?

#1240

.Y .N .

CONTINUE GUIDANCE
CONTROL

#1250

CALL ENGINE OFF COM-
MAND AT COMPUTED
REQUIRED TIME.

SEE DPS/APS
THRUST FAIL
ROUTINE
(R40) FOR
REQUIRED
RESPONSE

#1260

COMMAND ZERO ATTIT-
TUDE RATES

#1270

SET IDLE FLAG

#1280

WAIT UNTIL COMPUTED
TIME OF CUTOFF.

#1290

FRM
ABOVE

COMMAND ENGINE OFF

#1300

ZERO DPS AUTO
THRUSTLE

#1310

COMMAND ZERO ATTITUDE RATES

#1320

SET DEADBAND
TO PREVIOUS VALUE
DEFINED BY R03.

#1330

MAINTAIN VG
COMPUTATIONS AFTER
CUTOFF FOR POSSIBLE
NULLING BY RCS
TRIMMING MANEUVER
(NOTE: SEE ASSUMPTION (2) ABOVE).

DISARM DPS

#1340

"C"
FROM
ABOVE

"A"
FROM
ABOVE

#1350

COMMAND
ZERO
ATTITUDE
RATES

#1360

SET DEAD-
BAND
TO
PREVIOUS
VALUE
DEFINED
BY R03.

#1370

RESET
ULLAGE
FLAG

#1380

HOLD
MON
FLASH VERB-NDUN TO
REQUEST PROCEED.
HOLD DISPLAY OF TFC
AT ITS FINAL VALUE:
V16 N4C
R1 - TFC
R2 - VG
R3 - DELTA VM

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

#1390

NOTE: SEE ASSUMPTION (2) ABOVE).

#1400

RECORD THESE VALUES AS DESIRED.

#1410

WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE.

KEY IN PROCEED

#1420

.P .T .R
.R .E .E
.G .R .C
.C .M .Y
.E .I .C
.E .N .L
.D .A .E
. .T .
. .E

#1430

GC TO
"D"
BELOW

COMMAND ZERO ATTITUDE ERRORS

#1440

SET .3 DEGREE DEADBAND

#1450

HOLD
MGN
FLASH VERB-NCUN TO
REQUEST RESPONSE AND
DISPLAY COMPONENTS
OF VG(LM):
V16 N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)

MONITOR DSKY:
OBSERVE VERB-NCUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
COMPONENTS OF VG(LM)

#1460

COMPONENTS OF THE
PRESENT VG VECTOR
RESOLVED ALONG THE
LM X, Y, AND Z AXES.
THE VG VECTOR WILL
BE UPDATED BY THE
STEERING LOOPS
DURING EACH COMPUTA-
TION CYCLE. IN FPS
TO NEAREST .1 FPS.
(NOTE: SEE ASSUMP-
TION (2) ABOVE).

TO NULL OUT VG
COMPONENTS COMMAND
MANUAL TRANSLATIONS
AND ROTATIONS.
(NOTE: THIS MANEUVER
IS AT THE OPTION OF
THE CREW.)

#1470

THE ORBITAL PARA-
METER DISPLAY
ROUTINE (R30) MAY BE
SELECTED AT THIS
TIME (V82E) TO
MONITOR CONTINUOUSLY
UPDATED VALUES OF
APU ALT, PER ALT,
AND TFF.

#1480

WAIT FOR KEYBOARD
ENTRY
TERMINATE FLASH UPON
RECEIPT OF PROCEED,
RECYCLE, OR TERMIN-

KEY IN PROCEED

#1490

ATE.

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.P      .T      .R
.R      .E      .E
.G      .R      .C
.C      .M      .Y
.E      .I      .C
.E      .N      .L
.D      .A      .E
      .T
      .E

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      "D"
      FROM
      ABOVE

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ZERO RENDEZ VOUS
TRACKING MARK
COUNTER.
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SET DEADBAND
TO PREVIOUS VALUE
DEFINED BY RC3.
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DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00)
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DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00)
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#1500

#1510

#1520

#1530

#1540

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EXIT P40

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EXIT P40

#1550

CHANGE CONTROL NOTES

REV 00 PCR 30,31
REV 01 PCR 85,86,144,164,186,401,419,539,609,637
REV 00 (LUM 1A) PCR 647,648
REV 01 (LUM 1B) PCR 838,841,EDITORIAL
REV 02 ECITORIAL

330

RCS PROGRAM (P41)

REV 02 12/03/69

PURPOSE: (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR AN RCS THRUSTING MANEUVER.
 (2) TO PERFORM THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.
 (3) TO PROVIDE SUITABLE DISPLAYS FOR MANUAL EXECUTION OF THE THRUSTING MANEUVER IN THE ATTITUDE HOLD MODE.

ASSUMPTIONS: (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.
 (2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER UNTIL THE CREW NOTIFIES THE LGC THAT RCS THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
 FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3.3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (UT).

(3) WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (4)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER, IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION; WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(4) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;
 MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAPI'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
 MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.
 PGNS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
 MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS INDICATED IN ASSUMPTION (3) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R-567, PARA 3.2.6.

(5) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

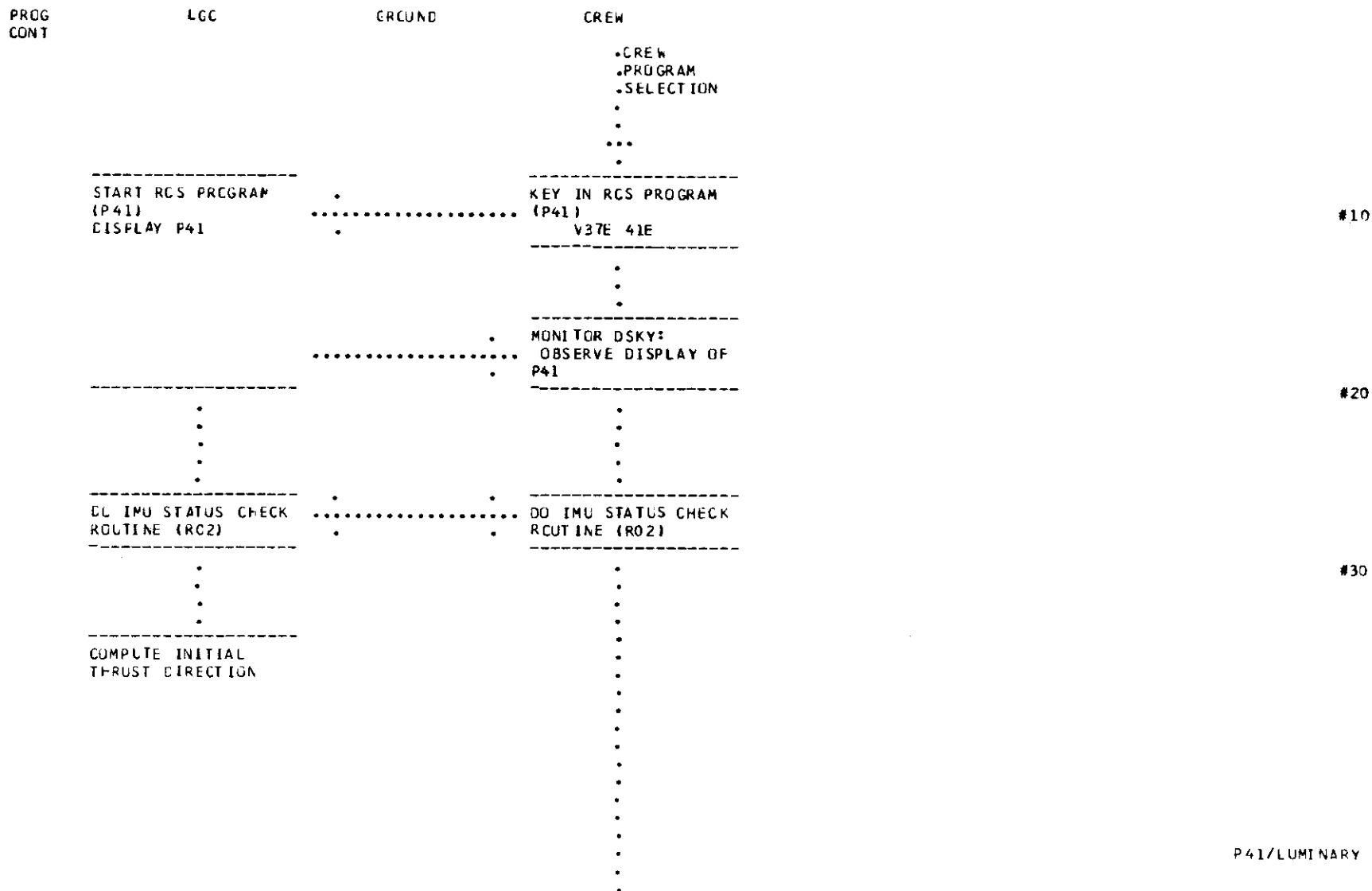
(6) THE EVENT TIMER IS SET TO COUNT TO ZERO AT TIG.

(7) RCS IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW, OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED ON TIME.

(8) THE X - AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.
 THE X - AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60).

- (9) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM.
- (10) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.
- (11) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.

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+02
+EDIT
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AND INITIAL VALUE
OF VG VECTOR AND
STORE VG(LV) IN N81
AND N86 FOR POSSIBLE
MANUAL SELECTION:

R1-VGX(LV)
R2-VGY(LV)
R3-VGZ(LV)

VGX(LV)-COMPONENT OF
VG AT TIG ALONG
(RXV)XR. IN FPS TO
NEAREST .1 FPS.

VGY(LV)-COMPONENT OF
VG AT TIG ALONG VXR.
IN FPS TO NEAREST
.1 FPS.

VGZ(LV)-COMPONENT OF
VG AT TIG ALONG -R.
IN FPS TO NEAREST
.1 FPS.

WHERE R IS GEOCENT-
RIC (EARTH ORBIT) OR
SELENOCENTRIC (LUNAR
ORBIT) RADIUS VECTOR
AND V IS VEHICLE
INERTIAL VELOCITY
VECTOR AT TIG.
(NOTE: N81 WILL NOW
DIFFER FROM N81 DIS-
PLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

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COMPUTE PREFERRED
IML ORIENTATION:

#40

#50

#60

#70

#80

X = UNIT T
-SM -

Y = UNIT (T X R)
-SM - -

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

WHERE:

T = THE INITIAL
-
THRUST VECTOR.

R = THE GECCENTRIC
-
(EARTH ORBIT) OR
SELENOCENTRIC
(LUNAR ORBIT)
RADIUS VECTOR AT
TIG.
(NOTE: IF T X R IS

SMALL (REFER SECTION
5.3.3.3.3 OF R567),
THEN Y =
-SM

UNIT (T X V)

WHERE V = VEHICLE

-
INERTIAL VELOCITY
VECTOR AT TIG.)

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STORE DESIRED ATTI-
TUDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60

#90

#100

#110

#120

#130

AND WILL POINT THE
 LM +X AXIS IN THE
 INITIAL THRUST DI-
 RECTION.
 HOWEVER, IN ORDER TO
 CONSERVE RCS FUEL
 AND NOT CONSTRAIN
 THE NON-CRITICAL
 ATTITUDE ABOUT THE
 THRUST VECTOR, WINGS
 MAY NOT BE LEVEL IN
 THE COMPUTED FINAL
 ATTITUDE.

#140

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 .

 SET PREFERRED-ATT-
 ITUDE-COMPUTED FLAG.

#150

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 .

 COMMAND ZERO ATTI-
 TUDE ERRORS

#160

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 .
 .

 SET 0.3 DEGREE
 DEADBAND

#170

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 .
 .

 RESET 3-AXIS FLAG

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 .

 DO ATTITUDE MANEUVER
 ROUTINE (R60)

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 .

 DO ATTITUDE MANEUVER
 ROUTINE (R60)

#180

TEMP
HOLD

MON DISPLAY ON DSKY:
V16 N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)

(VGX(LM), VGY(LM)
VGZ(LM) - COMPON-
ENTS OF THE VG
VECTOR AT TIG RESOL-
VED ALONG LM X, Y,
AND Z AXES RESPEC-
TIVELY. UPDATED
W.R.T. VEHICLE ATT I-
TUDE EVERY 1 SECCAD.
IN FPS TO NEAREST
.1 FPS. (NCTE: SEE
ASSUMPTION (2)
ABOVE.)

..... MONITOR DSKY:
OBSERVE DISPLAY OF
VG COMPONENTS.

#190

..... SET TDEC1=TIG-30
SEC.

#200

#210

..... DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41).
(NCTE: ENTER R41
AT "A".)

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

#220

.NC TIG.
.TIG SLIP.

336

SLIP

230

• DEFINE TIG TO BE
• THE TIME TO WHICH
• R41 DID INTEGRATE
• THE LM STATE VEC-
• TOR PLUS 30
• SECONDS.

#240

WAIT UNTIL TIG
-35 SEC.

250

BLANK THE DSKY DIS-
PLAY (V,N,R1,R2, AND
R3)

• MONITOR DSKY:
• AT TIG-35 SEC OB-
• SERVE DSKY DISPLAY
• TO GO BLANK FOR 5
• SECONDS

260

WAIT UNTIL TIG-30
SEC.

• MONITOR DSKY:
• AT TIG-30 SEC OB-
• SERVE RETURN OF
• V16N85 DISPLAYS
• TO INDICATE THAT

270

RETURN V16N85 DIS-
PLAYS

AVERAGE G INTEGRATION HAS STARTED.
OBSERVE COMPUTER ACTIVITY LIGHT BLINKS ON EVERY 2 SECONDS DURING AVERAGE G.

#280

START AVERAGE G INTEGRATION

#290

WAIT UNTIL TIG-5 SEC

#300

RESET IGNITION FLAG

#310

RESET ASTRONAUT FLAG

#320

WAIT UNTIL TIG-0 SEC

SET IGNITION FLAG

IS ASTRONAUT FLAG SET?

332

(NOTE: IN P41 THE ANSWER IS ALWAYS NO BECAUSE ASTRONAUT HAS NO V99 TO RE-SPCND TG).

N.

#330

RESET PULSES FLAG

COMMAND ZERO ATTITUDE ERRORS

#340

SET .3 DEGREE DEADBAND

#350

HOLD FLASH PRESENT VERB-
MON NOUN (V16N85) TO RE-
QUEST RESPONSE.
MAINTAIN DISPLAY OF
VG (LM) COMPONENTS.
(NOTE: SEE ASSUMPTION (2) ABOVE).

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AT LGC
ASSUMED TIG.

#360

COMMAND MANUAL
RGT AT IGNS AND

#370

TRANSLATIONS TO NULL
VG COMPONENTS

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THE ORBITAL PARAMET-
ER DISPLAY ROUTINE
(R30) MAY BE SELECT-
ED AT THIS TIME
(V82E) TO MONITOR
CONTINUOUSLY UPDATED
VALUES OF APD ALT,
PER ALT, AND TFF.

#380

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·

#390

WAIT FOR KEYBOARD
ENTRY

WHEN MANEUVER IS
COMPLETE KEY IN
PROCEED

TERMINATE VERB-NOUN
FLASH UPON RECEIPT
OF PROCEED, RECYCLE,
OR TERMINATE

#400

·P ·T ·R
·R ·E ·E
·O ·R ·C
·C ·M ·Y
·E ·I ·C
·E ·N ·L
·C ·A ·E

#410

ZERO RENDEZVOUS
TRACKING MARK
COUNTER

#420

SET DEADBAND
TO PREVIOUS VALUE

DEFINED BY R03.

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DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO).

EXIT P41

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DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO).

EXIT P41

#430

#440

CHANGE CONTRCL NOTES

REV 01 PCR 85,86,164,401,605,637
REV 00(LUM 1A) PCR 647
REV 01(LUM 1B) PCR 838,841,EDITORIAL
REV 02 EDITORIAL

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343

APS PROGRAM (P42)

REV 02 12/03/69

PURPOSE:

- (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR A LM APS THRUSTING MANEUVER.
- (2) TO DC THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.
- (3) TO CONTROL THE PGNS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A PGNS CONTROLLED APS MANEUVER.

ASSUMPTIONS:

- (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.
- (2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING APS THRUSTING AND UNTIL THE CREW NOTIFIES THE LGC THAT RCS TRIM THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS. FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3-3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (UT).
- (3) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
- (4) THE EVENT TIMER 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 STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME.

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+02
+EDIT
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- (6) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (7)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

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IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE DESIRED ATTITUDE ERRORS, HOWEVER THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

- (7) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI:

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

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+02
+EDIT
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PGNS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.

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+ 02
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MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS INDICATED IN ASSUMPTION (6) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6.

(8) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNC'S ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNC'S DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE. THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60).

(9) FOR EACH BURN AN IGNITION TOTAL ALLOWABLE TIME DELAY WILL BE SPECIFIED IN THE MISSION RULES. THIS DELAY TIME IS THE TOTAL TIME WHICH THE THRUSTING MANEUVER MAY BE DELAYED BEYOND THE LGC CALCULATED TIME OF IGNITION. IF ENGINE RESTARTS ARE INVOLVED, THE ACCOUNTING OF THIS TOTAL TIME DELAY IS UP TO THE CREW.

(10) THE LOAD DAP DATA ROUTINE (R03) MAY HAVE BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM.

(11) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS CALLED AT APS IGNITION BY THIS PROGRAM.

(12) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(13) THIS PROGRAM SHOULD BE SELECTED BY THE ASTRONAUT BY DSKY ENTRY AT LEAST 5 MINUTES BEFORE THE ESTIMATED TIME OF IGNITION.

(14) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.

PROG
CONT

LGC

GROUND

CREW

.CREW
.PROGRAM
.SELECTION
.
...
.

START APS PROGRAM
(P42) DISPLAY
P42

.....

KEY IN APS
PROGRAM (P42)
V37E 42E

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.
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.
.

#10

344

345

.....

MONITOR DSKY:
OBSERVE DISPLAY OF
P42

#20

IS THE APS FLAG
SET?

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

#30

POSS
HOLD .
.....
SNAP .

..FLASH VERB-NOUN
..TO REQUEST RES-
..PONSE AND DISPLAY
..ALARM CODE 01706
..TO INDICATE THAT
..APS FLAG SHOWS
..THAT THE DPS
..HAS NOT BEEN
..STAGED:
.. V05 N09
.. R1-XXXXX
.. R2-XXXXX
.. R3-XXXXX

.. DOES VERB-NOUN FLASH
.. TO REQUEST RESPONSE
.. AND DISPLAY OF ALARM
.. CODE INDICATE THAT
.. APS FLAG SHOWS
.. THAT THE DPS HAS NOT
.. BEEN STAGED?

#40

(NOTE:
THIS ALARM CODE
MAY BE DISPLAYED IN
EITHER R1, R2, OR
R3, DEPENDING ON THE
PRESENCE OR ABSENCE
OF OTHER ALARM
CODES.)

.Y .N
.
.
.....

#50

DO I WISH TO
CONTINUE WITH
P42 ALTHOUGH THE
DPS HAS NOT BEEN
STAGED?
(NOTE: IF CONTI-
NUATION IS

#60

SELECTED,
STAGING MUST BE
PERFORMED AFTER
TIG -30 SECONDS
AND BEFORE
IGNITION.)

.N .Y.

70

..WAIT FOR KEYBOARD
..ENTRY

KEY IN
TERMINATE
V34E

..TERMINATE FLASH
..UPON RECEIPT OF
..TERMINATE OR
..PROCEED

KEY IN
PROCEED

#80

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

#90

..IS THE PRESENT
..PROGRAM P42?

..A .Y.

#100

..DC FINAL AUTOMA-
..TIC REQUEST TER-
..MINATE ROUTINE
..(R00)

..DU FINAL AUTO-
..MATIC REQUEST
..TERMINATE
..ROUTINE (R00)

#110

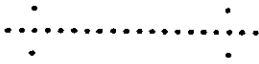
347

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.
EXIT P42
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.
.
EXIT P42
.
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.
.

DC IMU STATUS CHECK
ROUTINE (R02)

DO IMU STATUS CHECK
ROUTINE (R02)



#120

SET APS DELTA V
THRESHOLD FOR USE
BY R4C.

SET DELTA V
COUNTER = 4 FOR USE
BY R40

COMPUTE INITIAL
THRUST DIRECTION AND
INITIAL VALUE OF VG
VECTOR AND STORE
VG(LV) IN N81 AND
N86 FOR POSSIBLE
MANUAL SELECTION:

R1-VGX(LV)
R2-VGY(LV)
R3-VGZ(LV)

VGX(LV)-COMPONENT OF
VG AT TIG ALONG
{RXV}XR. IN FPS TO
NEAREST .1 FPS.

#130

#140

#150

#160

VGX(LV)-COMPONENT OF
VG AT TIG ALONG VXR.
IN FPS TO NEAREST
.1 FPS.

#170

VGZ(LV)-COMPONENT OF
VG AT TIG ALONG -R.
IN FPS TO NEAREST
.1 FPS.

WHERE R IS GECCENT-
RIC (EARTH ORBIT)
OR SELENOCENTRIC
(LUNAR ORBIT) RADIUS
VECTOR, AND V IS
VEHICLE INERTIAL
VELOCITY VECTOR AT
TIG.

#180

(NOTE: N81 WILL NOW
DIFFER FROM N81
DISPLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

#190

*
*
*

COMPLETE PREFERRED
IMU ORIENTATION:

X = UNIT(T)
-SM -

#200

Y = UNIT(T X R)
-SM - -

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

WHERE:

T = THE INITIAL
- THRUST VECTOR

#210

AT IGNITION

R = THE GEOCENTRIC
- (EARTH ORBIT)
OR SELENOCENTRIC
(LUNAR ORBIT) RADIUS
VECTOR AT TIG.

(NOTE: IF T X R IS

SMALL (REFER SECTION
5.3.3.3.3 OF R567),
THEN Y =

-SM
UNIT (T X V).

WHERE V = VEHICLE

INERTIAL VELOCITY AT
TIG.)

#220

.....
.
.
.
.

STORE DESIRED ATTITUDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60
AND WILL POINT THE
LM +X AXIS IN THE
INITIAL THRUST
DIRECTION. HOWEVER,
IN ORDER TO CONSERVE
RCS FUEL AND NOT
CONSTRAIN THE NON-
CRITICAL ATTITUDE
ABOUT THE THRUST
VECTOR, WINGS MAY
NOT BE LEVEL IN THE
COMPUTED FINAL
ATTITUDE.

#240

#250

.....
.
.
.
.

SET PREFERRED-
ATTITUDE-COMPUTED

#260

CONTROL MODES BEEN
SELECTED?

.Y N.
.
.

#320

IS THE APS FLAG
SET?

.Y N.
.
.

#330

HAS THE AUTO
THROTTLE MODE
BEEN SELECTED?

.Y N.
.
.

#340

POSS
HOLD .
.....
SNAP .

FLASH VERB-
NOUN TO RE-
QUEST PLEASE
PERFORM PGNS
CONTROL AND
AUTO ATTITUDE
CONTROL MODE
SELECTION:
V50N25
R1-OC203
R2-BLANK
R3-BLANK

MONITOR DSKY:
DOES VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM PGNS
CONTROL AND AUTO
ATTITUDE CONTROL
MODE SELECTION?

#350

.Y N.
.
.
.

HAVE REQUESTED
MODES BEEN
SELECTED?

#360

.N Y.
.
.
.

DO I WISH TO
HAVE THESE

#370

MODES SELECTED
DURING THE
THRUSTING
MANEUVER?

.Y .N

SET GUIDANCE
CONTROL SWITCH
TO PGNS AND
ATTITUDE CON-
TROL SWITCH TO
AUTO.

WAIT FOR KEY-
BOARD ENTRY

KEY IN PROCEED

TERMINATE
FLASH UPON RE-
CEIPT OF PRC-
CEED OR ENTER

KEY IN ENTER

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

COMMAND APS OFF

#380

#390

#400

#410

#420

352

TEMP
HOLD

..... DISPLAY ON DSKY:
MON . VC6 N40
R1 - TFI
R2 - VG
R3 - DELTA VM

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

#430

TFI - TIME FROM
APS IGNITION. IN
MIN, SEC TO NEAR-
EST SEC. MAX
READING IS 59859.
SIGN IS - BEFORE
NOMINAL TIG, +
THEREAFTER.

UPDATE EVENT TIMER
IF DESIRED

#440

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
DISPLAY WILL BE
0000 UNTIL TIG-30
SEC AND THEN
SHOULD CHANGE ONLY
DUE TO PIPA BIAS
UNTIL ULLAGE IS
STARTED.

#450

SET TDEC1 = TIG-30
SECCNCS

#460

#470

.....
DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41)
(NOTE: ENTER R41
AT "A".)

.NG TIG.
.TIG SLIP.
.SLIP
.
.
.
.

.....
(NOTE: R41 WILL
DEFINE TIG TO BE
THE TIME TO WHICH
R41 DID INTEGRATE
THE LM STATE VEC-
TOR PLUS 30
SECONDS.)
.....
.
.
.
.
.

.....
WAIT UNTIL TIG
-35 SEC
.....
.
.
.
.
.

.....
BLANK THE DSKY DIS-
PLAY (V,N,R1,R2, AND
R3).
.....
.
.
.

.....
WAIT UNTIL TIG
-30 SEC.
.....
.
.
.

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

.....
ARM APS
.....
.
.
.
.
.

.....
CHECK STATUS OF C/W
LAMPS
.....
.
.
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.
.

.....
MONITOR DSKY:
AT TIG -35 SEC OB-
SERVE DSKY DISPLAY
TO GO BLANK FOR 5
SECONDS.
.....
.
.
.
.
.

#480

#490

#500

#510

#520

355

RETURN VC6N40 DIS-
PLAYS

IS THE PRESENT
PROGRAM P42?

.N .Y.

. SET THE APS FLAG

START AVERAGE G
INTEGRATION.

CALL 1/ACCS AND
INITIALIZE THE DAP.
(NOTE: NORMALLY THE
DAP IS INITIALIZED
BY DATA SELECTED VIA
R03, WHERE THE APS
FLAG IS SET OR RESET.
FOR THIS PROGRAM,
THE APS FLAG IS SET,
CAUSING THE CORRECT
DAP INITIALIZATION
DATA TO BE SELECTED
WITHOUT RECOURSE TO
R03.)

MONITOR DSKY:
AT TFI = - 00B29
OBSERVE RETURN OF
V06N40 DISPLAYS TO
INDICATE THAT AVER-
AGE G INTEGRATION
HAS STARTED.
(NOTE: IF TIG HAS
BEEN SLIPPED BY R41,
THE TFI DISPLAY (R1)
AT THIS TIME WILL BE
REFERRED TO THE NEW
TIG.)

IS THE PRESENT
PROGRAM P42?

.Y .N.

PERFORM DPS
STAGING IF IT HAS
NOT ALREADY BEEN
DONE

#530

#540

#550

#560

#570

MONITOR DSKY:
IN THE PERIOD FROM
TFI --00830 UNTIL
TFI --00815
DOES DELTA VM BECOME
GREATER THAN .5 FPS
INDICATING EXCESSIVE
PIPA BIAS ERROR?

.N .Y

GO TO BACKUP
PROCEDURES

++
+02
+EDIT
++

WAIT UNTIL TIG
-5 SEC.

"F"
FROM
R40

RESET IGNITION FLAG

RESET ASTRONAUT FLAG

RESET IMPULSE FLAG

#580

#590

#600

#610

#620

#630

35¹¹

.....
WILL ACTIVE STEERING
BE ATTEMPTED DURING
THIS MANEUVER?
(REFER PARA. 5.3.3.-
3.3 OF SECTION 5 OF
R567)

#640

. Y . . N.
. . . .

. SET IMPULSE FLAG

#650

CALL VERB 99 DIS-
PLAYS (SEE "AM"
BELCW)

.....
CALL SET OF ULLAGE
FLAG AT TIG-3.5 SEC

#660

WAIT UNTIL TIG -0

#670

SET IGNITION FLAG

#680

IS ASTRONAUT FLAG
SET?

.Y .N
.
.
.....

GC TO
"B"
BELOW

EXIT
(NOTE: THIS
IS NOT A
P42 EXIT.
REFER DIS-
PLAY RE-
SPONSE AT
"A" BELOW)

#690

"A"
FROM
ABOVE

"B"
FROM
R40

#710

MONITOR DSKY:
AT TFI = - 00805
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE

#720

HELD .
.....
MUN .

CHANGE VERB BUT RE-
TAIN PRESENT NOUN
AND DISPLAYS IN R1,
R2, R3, FLASH VERB-
NOUN TO REQUEST
PLEASE PERFORM ENG-
INE ON ENABLE:
V99N40

#730

342

WAIT FOR KEYBOARD
ENTRY

.....
* AT TFI =-00803 MONI-
TOR START OF +X
* TRANSLATION.

#740

MONITOR DSKY:
WAIT FOR INCREASE OF
DELTA VM INDICATING
SUFFICIENT ULLAGE.
REQUIRED ULLAGE
DELTA V IS A
FUNCTION OF VEHICLE
WEIGHT.

#750

SHALL I ATTEMPT
TO COMPLETE THE
THRUSTING MANEU-
VER WITH THE RCS?

#770

.Y N.
* *
* *

.....
KEY IN ENTER

#780

GO TO

"A"
BELOW

SHALL I PERMIT
IGNITION?

.N .Y
.
.

KEY IN PROCEED

KEY IN
TERMINATE
V34E

TERMINATE FLASH UPON
RECEIPT OF ENTER,
PROCEED OR TERMINATE.

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

RESET
ULLAGE
FLAG

#790

#800

#810

#820

#830

300

SPLAY OF V06N40

EXIT
(NOTE: THIS
IS NOT A
P42 EXIT.
REFER TIG
-C LOGIC
ABOVE.)

"B"
FROM
ABOVE

COMMAND APS ON

RESET PULSES FLAG

OBSERVE RETURN
OF STATIC VERB-
NCUN DISPLAY
(V06N40)

STANDBY FOR
THRUST ON
WHEN TFI = -00B00

STANDBY FOR
THRUST ON
IMMEDIATELY

#890

#900

#910

#920

#930

#940

362

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. SIGN IS
 - BEFORE AND + AFTER
 CUTOFF.

MONITOR DSKY:
 OBSERVE CHANGE OF
 TFI DISPLAY TO TFC
 IN R1
 (NOTE: TFC IS IN-
 ITIALLY CALCULATED
 ONCE AND DISPLAYED.
 THIS DISPLAY WILL
 COUNT DOWN WITH
 ELAPSED TIME UNTIL
 TVC STEERING IS
 INITIATED (STEER
 FLAG IS SET BY R40)
 AT WHICH TIME TFC IS
 RECALCULATED AND
 DISPLAYED EVERY 2
 SECONDS BY THE
 GUIDANCE EQUATIONS.)

#950

#960

IS TFC AT IGNITION
 LESS THAN 6 SECONDS?

.N Y.

#970

#980

IS IMPULSE FLAG SET?

.N Y.

#990

CALL FOR ENGINE
 OFF COMMAND AT

```
.
.
.
.
.
. CALCULATED CUTOFF
. TIME. (SEE "D"
. BELOW)
. (NOTE: PGNS WILL
. COMMAND INERTIAL
. VEHICLE ATTITUDE
. HOLD THROUGHOUT
. THRUSTING MAN-
. EUVER.)
.-----
.
.
.
.-----
```

```
RESET IGNITION
FLAG
.-----
.
.
.
.-----
```

```
RESET ASTRONAUT
FLAG
.-----
.
.
.
.-----
```

```
RESET IMPULSE
FLAG
.-----
.
.
.
.-----
```

```
WAIT 0.5 SECONDS
.-----
.
.
.
.-----
```

```
RESET ULLAGE
FLAG
.-----
.
.
.
.-----
```

#1000

#1010

#1020

#1030

#1040

364

365

EXIT
(NOTE: THIS IS
NOT A P42 EXIT.
SEE "C" BELOW).

RESET IGNITION FLAG

RESET ASTRONAUT FLAG

RESET IDLE FLAG

CALL FOR RESET OF
ULLAGE FLAG IN 0.5
SEC.

THIS BURN IS A
MINIMUM IMPULSE
MANEUVER AND
WILL BE DONE AT
AN INERTIALLY
FIXED VEHICLE
ATTITUDE

#1050

#1060

#1070

#1080

#1090

MONITOR APS
THRUSTING:

1. DSKY:
R1-TFC
SHOULD BE
DECREASING.

#1100

R2-VG SHOULD BE
DECREASING.

R3-DELTA VM
SHOULD INCREASE.

2. FDAI-ATT. ERROR
SHOULD BE LESS THAN
OR EQUAL TO XX
DEGREE.

#1110

ATT RATES SHOULD BE
LESS THAN OR EQUAL
TO XX DEGREE/SEC.

3. APS CHAMBER PRES-
SURE (PC) SHOULD BE
NORMAL.

IDENTIFY EARLY,
NORMAL, OR LATE EN-
GINE CUTOFF FROM AS-
SESSMENT OF DSKY
DISPLAYS.

#1120

.E .N .L
.A .C .A
.R .R .T
.L .M .E
.Y . .
. .C .C
.C .U .U
.U .T .T
.T .D .D
.O .F .F
.F .F .F
.F . .

#1130

REQUIRED TIME

·
·
·

COMMAND ZERO ATTITUDE RATES

·
·
·

SET IDLE FLAG

·
·
·
·
·

WAIT UNTIL COMPLETED TIME OF CUTOFF

·
·
·
·
·
·
·
·
·

"D"
FROM
ABOVE

·
·
·
·
·

COMMAND ENGINE OFF

·
·
·

COMMAND ZERO ATTITUDE RATES

·
·
·
·

SET DEADBAND TO PREVIOUS VALUE

#1190

#1200

#1210

#1220

#1230

#1240

DEFINED BY R03.

.
.
.

MAINTAIN VG
COMPUTATIONS AFTER
CUTOFF FOR POSSIBLE
NULLING BY RCS
TRIMMING MANEUVER
(NOTE: SEE ASSUMP-
TION (2) ABOVE).

#1250

"C"
FROM
ABOVE

DISARM APS

#1260

COMMAND
ZERO ATT-
ITUDE
RATES

#1270

SET DEAD-
BAND TO
PREVIOUS
VALLE DE-
FINED BY
R03

#1280

RESET
CELLAGE

FLAG

#1290

TERMINATE
CALL FOR
SET CF
LLAGE
FLAG AT
TIG-3.5
SEC IF
CALL NOT
YET DONE

#1300

"A"
FROM
ABOVE

#1310

HOLD

MON

FLASH VERB-NOUN TO
REQUEST PROCEED.
HOLD DISPLAY OF TFC
AT ITS FINAL VALUE:
V16 N40
R1 - TFC
R2 - VG
R3 - DELTA VM

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

#1320

{NOTE: SEE ASSUMP-
TICK (2) ABOVE).

RECORD THESE VALUES
AS DESIRED.

#1330

WAIT FOR KEYBOARD
ENTRY
TERMINATE FLASH UPON
RECEIPT OF PROCEED.

KEY IN PROCEED

RECYCLE, OR
TERMINATE

.P	.T	.K
.R	.E	.E
.O	.R	.C
.C	.M	.Y
.E	.I	.C
.E	.N	.L
.D	.A	.E
.	.T	.
.	.E

#1340

GO TO
"EM"
BELOW

#1350

COMMAND ZERO ATT-
ITUDE ERRORS

#1360

SET 0.3 DEGREES
DEADBAND

#1370

HOLD FLASH VERB-NGUN TO
 MON REQUEST RESPONSE AND
 DISPLAY COMPONENTS
 OF VG(LM):
 V16 N85
 R1-VGX(LM)
 R2-VGY(LM)
 R3-VGZ(LM)

MONITOR DSKY:
 OBSERVE VERB-NGUN
 FLASH TO REQUEST
 RESPONSE AND DISPLAY
 OF VG(LM) COMPONENTS

#1380

COMPONENTS OF THE
PRESENT VG VECTOR
RESOLVED ALONG THE
LM X, Y, AND Z AXES.
THE VG VECTOR WILL
BE UPDATED BY THE
STEERING LOOPS
DURING EACH COMPUTA-
TION CYCLE. IN FPS
TO NEAREST .1 FPS.
(NOTE: SEE ASSUMP-
TION (2) ABOVE).

TO NULL OUT VG
COMPONENTS COMMAND
MANUAL TRANSLATIONS
AND ROTATIONS.
(NOTE: THIS MANEUVER
IS AT THE OPTION OF
THE CREW.)

#1390

#1400

THE ORBITAL PARAME-
TER DISPLAY ROUTINE
(R30) MAY BE SELECT-
ED AT THIS TIME
(V82E) TO MONITOR
CONTINUOUSLY UPDATED
VALUES OF APD ALT,
PER ALT, AND TFF.

#1410

WAIT FOR KEYBOARD
ENTRY
TERMINATE FLASH UPON
RECEIPT OF PROCEED,
RECYCLE, OR
TERMINATE

KEY IN PROCEED

#1420

.P .T .R
.R .E .E
.O .R .C
.C .M .Y
.E .I .C
.E .N .L
.D .A .E
. .T .
. .E

#1430

#1440

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.
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.
.
.
.
.

```

"E"
FROM
ABOVE

```

-----
ZERO RENDEZVUS
TRACKING MARK
CCOUNTER
-----

```

#1450

```

-----
SET DEADBAND
TO PREVIOUS VALUE
DEFINED BY R03.
-----

```

#1460

```

-----
DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00)
-----

```

```

-----
DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00)
-----

```

#1470

EXIT P42

EXIT P42

#1480

CHANGE CONTRCL NOTES

REV 00 PCR 31
 REV 01 PCR 85,86,114,144,164,186,401,419,609,637
 REV 00(LUM 1A) PCR 647,648
 REV 01(LUM 1B) PCR 833,841, EDITCRIAL
 REV C2 EDITORIAL

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374

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(

THRUST MONITOR PROGRAM (P47)

REV 02 08/07/69

- PURPOSE: (1) TO MONITOR VEHICLE ACCELERATION DURING A NON-PGNC CONTROLLED THRUSTING MANEUVER.
 (2) TO DISPLAY THE DELTA V APPLIED TO THE VEHICLE BY THIS THRUSTING MANEUVER.
- ASSUMPTIONS: (1) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
 (2) THE RESPONSIBILITY OF AVOIDING GIMBAL LOCK DURING EXECUTION OF THIS PROGRAM IS UPON THE ASTRONAUT.
 (3) THIS PROGRAM IS NORMALLY USED DURING RENDEZVOUS FINAL PHASE. IF THE CREW DESIRES TO DO ANY FINAL PHASE THRUSTING MANEUVERS AUTOMATICALLY UNDER PGNC CONTROL THEY MUST BE ACCOMPLISHED VIA SELECTION OF TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) AND THEN THE DPS THRUSTING PROGRAM (P40) OR THE APS THRUSTING PROGRAM (P42).
 (4) RANGE, RANGE RATE, AND THETA MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE (R31).
 (5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. THE PROGRAM SHOULD BE TURNED ON JUST PRIOR TO THE PLANNED THRUSTING MANEUVER AND TERMINATED AS SOON AS POSSIBLE AFTER THE MANEUVER IN ORDER TO KEEP ERRORS ASSOCIATED WITH AVERAGE G INTEGRATION AT A MINIMUM.

++
+02
+EDIT
++

PROG
CONT

LGC

GROUND

CREW

.CREW
.PROGRAM
.SELECTION
.
...

START THRUST
MONITOR PROGRAM
(P47).
DISPLAY P47.

.
.....
.

KEY IN THRUST
MONITOR PROGRAM
(P47)
V37E47E

#10

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MONITOR DSKY:
OBSERVE DISPLAY
OF P47.

#0

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.....

 DO IMU STATUS
 CHECK ROUTINE
 (RC2)

.....

 DO IMU STATUS
 CHECK ROUTINE
 (RO2)

.....

 DO STATE VECTOR INT-
 EGRATION (MIDTCAVE)
 RCUTINE (R41)
 (NOTE: ENTER R41 AT
 "B")

.....

 DO STATE VECTOR INT-
 EGRATION (MIDTCAVE)
 ROUTINE (R41). OB-
 SERVE THAT THE COM-
 PUTER ACTIVITY LIGHT
 IS ON UNTIL COMPLE-
 TION OF R41.

.....

 START AVERAGE G
 INTEGRATION

.....

 FLASH VERB-NOUN TO
 REQUEST RESPONSE AND
 DISPLAY DELTA V
 (LM):
 V16A83
 R1-DELTA VX(LM)
 R2-DELTA VY(LM)
 R3-DELTA VZ(LM)

.....

 MONITOR DSKY:
 OBSERVE FLASHING
 VERB-NOUN TO REQUEST
 RESPONSE AND DISPLAY
 OF EACH COMPONENT OF
 DELTA V(LM).

.....

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

HOLD ..

 MON ..

#30

#40

#50

#60

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

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

NOTE: R1,2, AND 3
 WILL READ 0000 IN-
 ITIALLY AND WILL RE-
 MAIN SC EXCEPT FOR
 PIPA BIAS ACCUMLLAT-
 IONS UNTIL A THRUST-
 ING MANEUVER IS
 STARTED. THEY WILL
 BE UPDATED EVERY
 2 SEC.

WAIT FOR KEYBOARD
 ENTRY

PERFORM THRUSTING
 MANEUVER(S) AS
 DESIRED.
 MONITOR FDAI BALL
 TO AVOID GIMBAL
 LOCK

THE ORBITAL PARAMET-
 ER DISPLAY ROUTINE
 (R30) MAY BE SELECT-
 ED AT THIS TIME
 (V82E) TO MONITOR
 CONTINUOUSLY UPDATED
 VALUES OF APO ALT,
 PER ALT AND TFF.

SHALL I TERMINATE
 THIS PROGRAM?

.Y .N

SHALL I ZERO
 THE DISPLAY IN
 ORDER TO MONIT-
 OR ANOTHER
 BURN?

.Y .N

KEY IN RECY-
 CLE (V32E)

#70

#80

#90

#100

#110

#120

TERMINATE FLASH UPON
RECEIPT OF PROCEED,
TERMINATE OR RECYCLE.

KEY IN PROCEED OR
TERMINATE (V34E)

#130

.R
.E
.C
.Y
.C
.L
.E

P.
R.
G.
C.
E.
E.
D.
/
T.
E.
R.
M.
I.
N.
A.
T.
E.

#140

REINITIALIZE
ACCELEROMETER
INTEGRATION

#150

DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO)

DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO)

#160

EXIT P47

EXIT P47

#170

CHANGE CONTRCL NOTES

LOGIC REV 01 PCK 401,437
REV 02 EDITCRIAL

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IMU ORIENTATION DETERMINATION PROGRAM (P51)

REV 02 08/07/69

PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE AOT OR A BACKUP OPTICAL SYSTEM.

ASSUMPTIONS: (1) THIS PROGRAM MAY ONLY BE PERFORMED WHILE THE LM IS IN FLIGHT.

(2) THE ISS 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.

(3) THERE ARE NO RESTRAINTS UPON THE LM ATTITUDE CONTROL MODES UNTIL THE CREW WISHES TO MANUALLY MANEUVER THE VEHICLE.

(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 LGC PROGRAMS.

(5) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.

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

PROG
CONT

LGC

GROUND

CREW

.CREW
.PROGRAM
.SELECTION
.
.
.
.

START IMU ORIENTATION
DETERMINATION
PROGRAM (P51)
DISPLAY P51

.
.....
.

KEY IN IMU
ORIENTATION DETERMI-
NATION PROGRAM (P51)
V37E 51E

.
.
.
.
.
.
.
.

#10

MONITOR DSKY:
OBSERVE DISPLAY OF
P51

#20

IS THE ISS ON?

.Y .N

#30

SET IMUSE FLAG

++
+02
+EDIT
++

TURN ON PROGRAM
ALARM LIGHT AND
STORE ALARM CODE.
(NOTE: IF CALLED,
ALARM CODE WILL
BE 00210.)

MONITOR DSKY:
DOES PROGRAM ALARM
LIGHT COME ON INDIC-
ATING THAT THE IMU
IS NOT ON?

#40

.Y .N

TURN ON IMU
AND RESELECT
P51 VIA ROD

#50

DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO).

DO FINAL
AUTOMATIC
REQUEST TER-
MINATE ROU-
TINE (ROO).

#60

EXIT
P51

EXIT
P51

#70

HOLD . FLASH VERB-NOUN TO
..... REQUEST PLEASE PER-
SNAP . FORM CELESTIAL BCDY
ACQUISITION:
V50 A25
R1-CCC15
R2-BLANK
R3-BLANK

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TC REQUEST
PLEASE PERFORM
CELESTIAL BODY
ACQUISITION

#80

SHALL I MANEUVER (OR
CONTINUE TO MANEU-
VER) THE LM TO POSI-
TION THE IMU INNER
GIMBAL AXIS IN A
PREFERRED DIRECTION?

#90

.N .Y
.
.

WITH THE ROTATION
CONTRCL RCTATE
THE LM UNTIL THE
PITCH AXIS IS IN
THE PREFERRED
DIRECTION

#100

ARE 2 CELESTIAL
BODIES VISIBLE IN

#110

THE OPTICAL SYS-
TEM FIELD OF
VIEW ?

.Y .N

#120

WITH THE ROTATION CONTROL
ORIENT THE LM
UNTIL 2 CELESTIAL BODIES
ARE VISIBLE IN THE OPTICAL
SYSTEM

#130

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

#140

N. .Y

MONITOR FDAI BALL
IS GIMBAL LOCK
IMPENDING?

#150

.Y .N

WAIT FOR KEYBOARD
ENTRY

KEY IN ENTER

#160

TERMINATE FLASH UPON
RECEIPT OF PROCEED
CR ENTER

KEY IN PROCEED

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

#170

TEMP
HGLD .
.....
SNAP .

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

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

#180

WHERE R1, R2,
AND R3 REPRESENT
ICDO/GIMBAL ANG-
LES TO BE COARSE
ALIGNED TO (OG,
IG, MG, RESPEC-
TIVELY).
IN DEGREES TO
NEAREST .01 DE-
GREE

#190

COMMAND ISS TO
COARSE ALIGN
MODE

#200

TURN ON "NO ATT"
LIGHT

OBSERVE "NO ATT"
LIGHT TO INDICATE
THAT IMU IS IN
COARSE ALIGN MODE

#210

DISABLE CAP

#220

RESET TRACK FLAG

RESET DRIFT FLAG

RESET REFSMMAT
FLAG

COARSE ALIGN ISS

(NOTE: IF, AT THE END OF COARSE ALIGNMENT, THE GIMBALS ARE NOT WITHIN 2 DEGREES OF 0,0,0, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT AND STORE ALARM CODES 00211 AND 00217.)

TERMINATE COARSE
ALIGN MODE IN

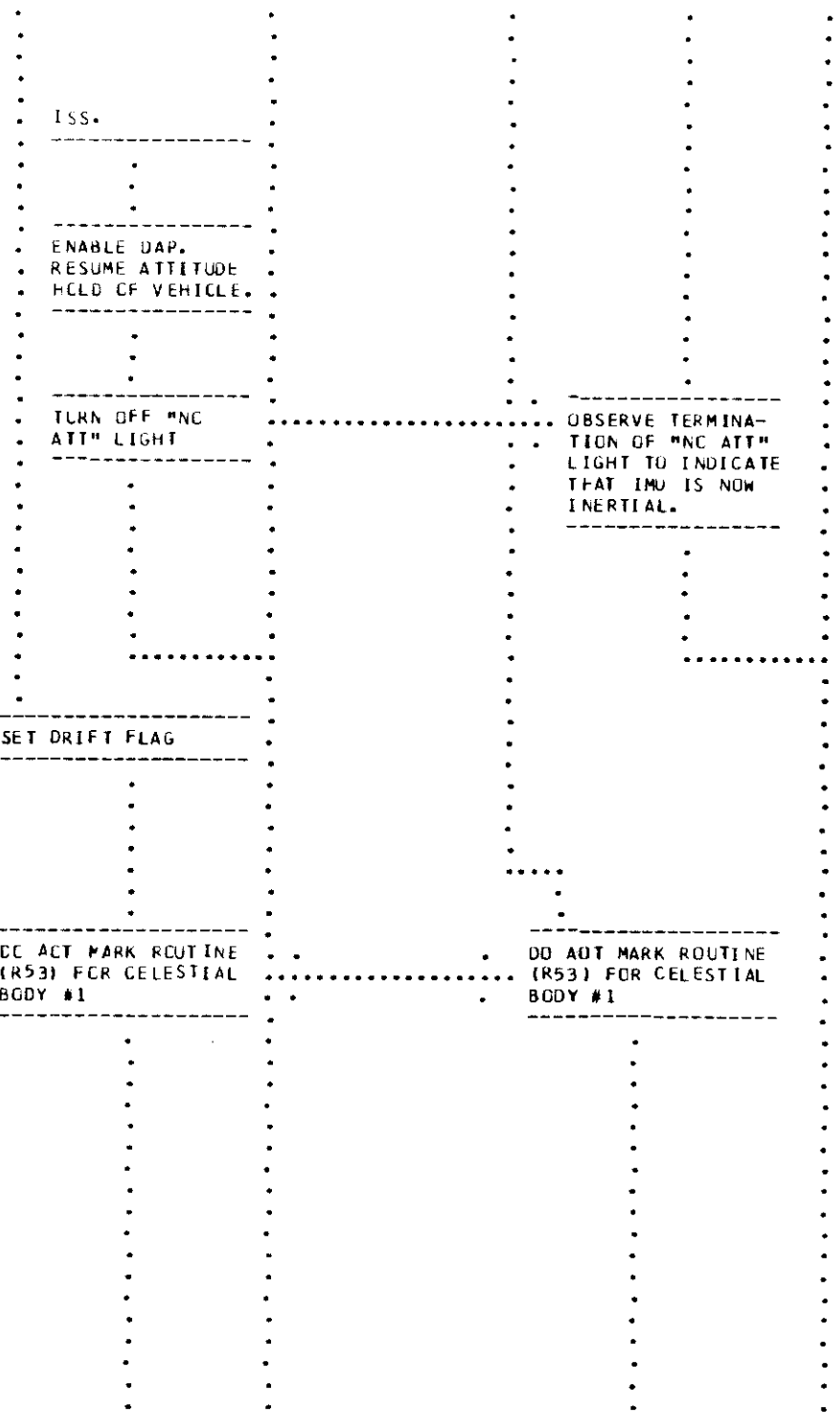
(NOTE: IF, AT THE END OF COARSE ALIGNMENT, THE GIMBALS ARE NOT WITHIN 2 DEGREES OF 0,0,0, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT AND STORE ALARM CODES 00211 AND 00217.)

#230

#240

#250

#260



270

#280

#290

#300

310

DO CELESTIAL BODY
DEFINITION ROUTINE
(R58) FOR CELESTIAL
BODY USED.

DO CELESTIAL BODY
DEFINITION ROUTINE
(R58) FOR CELESTIAL
BODY USED.

320

DO ADT MARK ROUTINE
(R53) FOR CELESTIAL
BODY #2

DO ADT MARK ROUTINE
(R53) FOR CELESTIAL
BODY #2

#330

DO CELESTIAL BODY
DEFINITION ROUTINE
(R58) FOR CELESTIAL
BODY USED.

DO CELESTIAL BODY
DEFINITION ROUTINE
(R58) FOR CELESTIAL
BODY USED.

#340

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

350

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

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

CALCLLATE IMC INERTIAL
ORIENTATION W.R.T.
CELESTIAL COORDIN-
ATES AS DEFINED BY
CELESTIAL BODIES # 1

#360

37
AND # 2 . STORE AS
PRESENT PLATFORM
ORIENTATION
(REFSMAT)

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

SET REFSMAT FLAG

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

DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (RCO).

.....
.
.....
.
EXIT P51

.....
.
.....
.
DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (ROO).

.....
.
.....
.
EXIT P51



#370

#380

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 7
REV 01 EDITORIAL
REV 02 EDITORIAL

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IMU REALIGN PROGRAM (P52)

REV 02 12/03/69

PURPOSE:

(1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 5) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE AOT OR A BACKUP OPTICAL SYSTEM.

(A) PREFERRED ORIENTATION (OPTION 00001)

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

(B) LANDING SITE ORIENTATION (OPTION 00004)

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

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

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

WHERE:

THE ORIGIN IS THE CENTER OF THE MOON.

R = THE POSITION VECTOR OF THE LM ON THE LUNAR SURFACE AT A LANDING SITE AND A TIME
-LS
T(ALIGN) SELECTED BY THE CREW.

H = THE ANGULAR MOMENTUM VECTOR OF THE CSM (R x V).
-CSM \quad -CSM \quad -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 OCCURS ONLY IF T(LAND) HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE CREW, AND THE CREW HAS THEN DEFINED T(ALIGN) TO BE T(LAND) IN THIS PROGRAM.

(C) NOMINAL ORIENTATION (OPTION 00002)

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

$$Y = \text{UNIT}(V \times R) \\ -SM \quad - \quad -$$

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

WHERE:

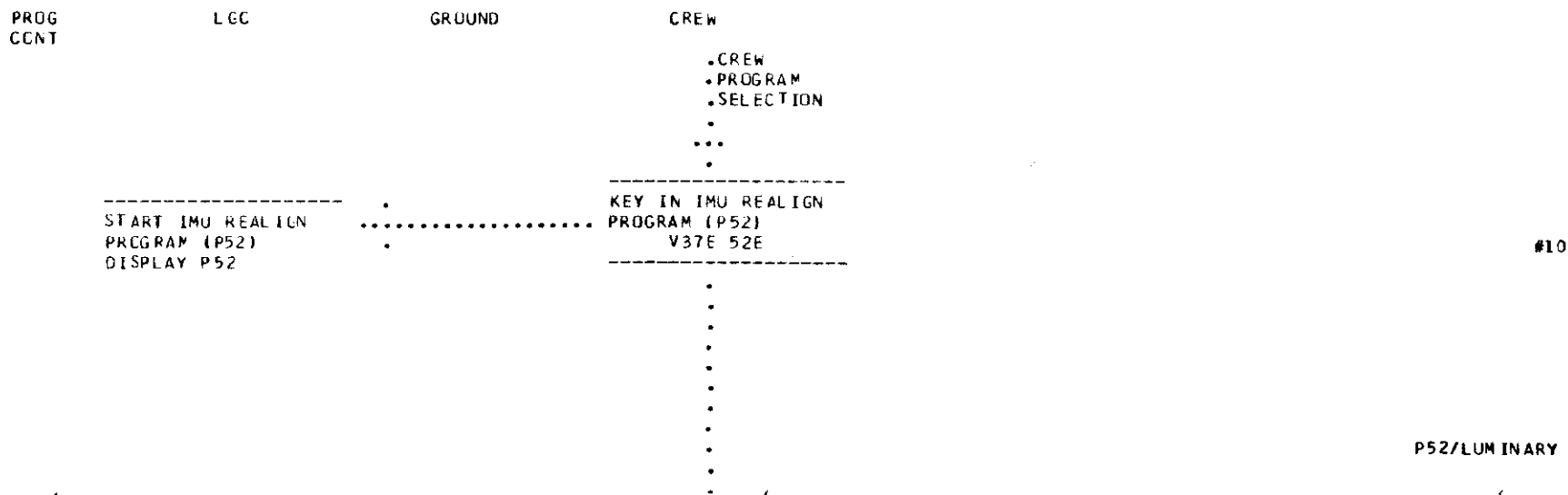
R = THE GECCENTRIC (EARTH ORBIT) OR SELENCENTRIC (LUNAR ORBIT) RADIUS VECTOR AT TIME T(ALIGN)
-
SELECTED BY THE ASTRONAUT.

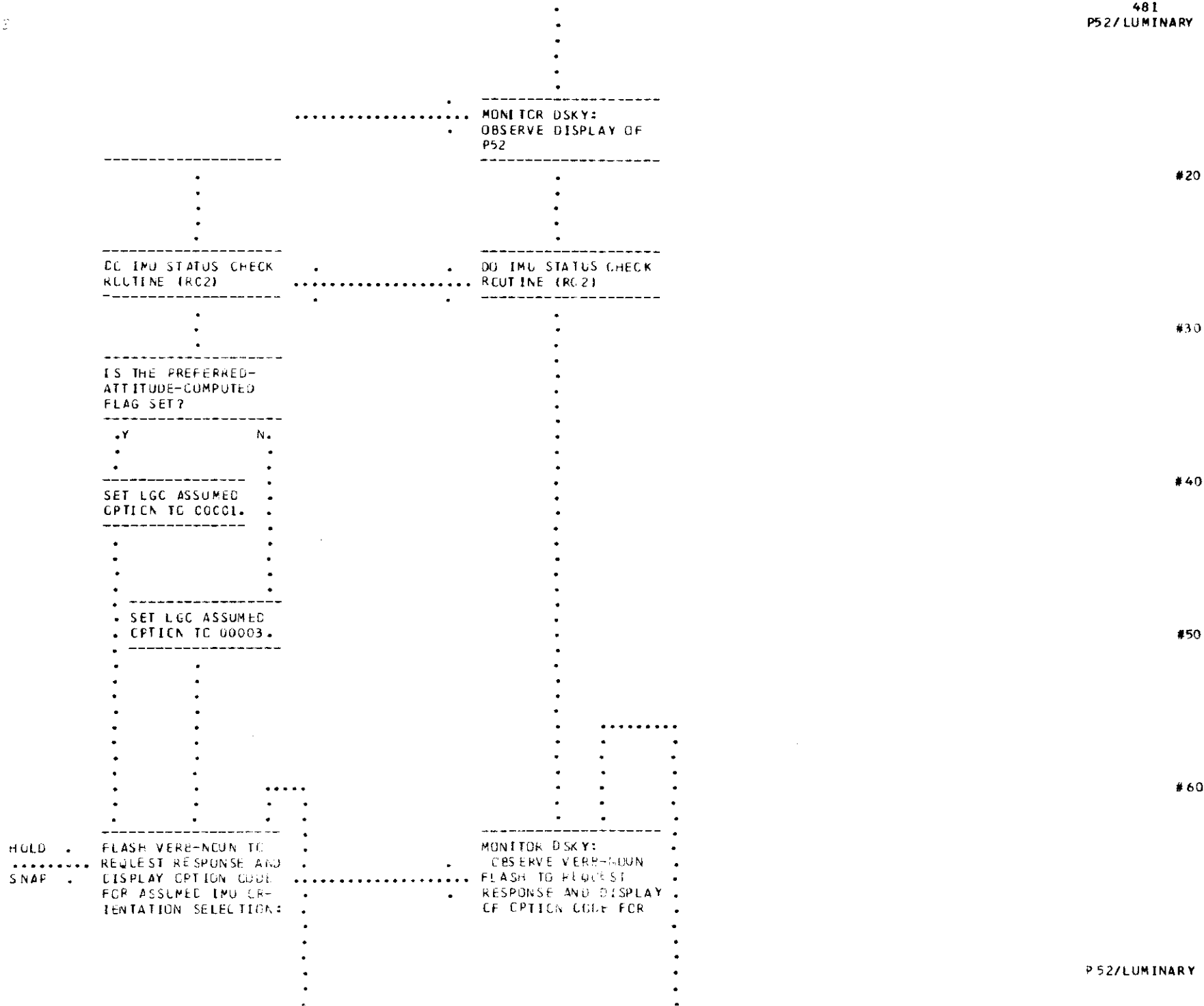
\underline{V} = THE INERTIAL VELOCITY VECTOR AT TIME T(ALIGN) SELECTED BY THE ASTRONAUT.

(E) REFSMMAT (OPTION 0003)

SEE ASSUMPTION (5)

- ASSUMPTIONS: (1) THIS PROGRAM MAY ONLY BE PERFORMED WHILE THE LM IS IN FLIGHT.
- (2) THE CONFIGURATION MAY BE DOCKED (LM/CSM) OR UNDOCKED (LM ALONE). THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE LGC BY COMPLETION OF THE CAP DATA LOAD ROUTINE (R03).
- (3) THERE ARE NO RESTRAINTS UPON THE LM ATTITUDE CONTROL MODES UNTIL A PGNS CONTROLLED MANEUVER IS CALLED BY A PROGRAM OR THE CREW WISHES TO MANUALLY MANEUVER THE VEHICLE. THE GUIDANCE CONTROL SWITCH MAY BE AT PGNS OR AGS AND IF AT PGNS, THE MODE MAY BE AUTO OR ATTITUDE HOLD. PRIOR TO PGNS CONTROLLED MANEUVERS THE LGC WILL REQUEST THE CORRECT MODE IF IT IS NOT IN EFFECT. FOR MANUALLY CONTROLLED MANEUVERS THE CREW MUST SELECT THE CORRECT MODES.
- (4) 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 ALLOW POINTING OF THE AOT AT ASTRONAUT OR LGC SELECTED STARS EITHER MANUALLY BY THE CREW OR AUTOMATICALLY BY AN LGC CONTROLLED ATTITUDE MANEUVER.
- (5) THE ISS IS ON AND HAS BEEN ALIGNED TO A "KNOWN" ORIENTATION WHICH IS STORED IN THE LGC (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).
- (6) AN OPTION IS PROVIDED TO REALIGN THE IMU TO THE PREFERRED, NOMINAL, OR LANDING SITE ORIENTATIONS WITHOUT MAKING CELESTIAL BODY SIGHTINGS (SEE LOGIC FLOW).
- (7) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.
- (8) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.





VC4 NO6
R1-00001
R2-0000X
R3-BLANK

ASSUMED IMU ORIEN-
TIGN SELECTION

#70

R1 IS THE
OPTION CODE
FOR ASSUMED
IMU ORIENTATION
SELECTION.

IS THIS THE IMU ORI-
ENTATION I DESIRE?

#80

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

.Y .N

WAIT FOR KEYBOARD
ENTRY

KEY IN
PROCEED

#90

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V22E
AND LOAD THE
DESIRED ORIEN-
TATION CODE IN
R2

#100

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

#110

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

CHECK STORED OPTION
CODE

.0 .0 .0 .0
.0 .C .0 .0
.0 .0 .0 .0
.0 .0 .0 .0
.2 .C .1 .3

. .C . .
. .C . .
. .0 . .
. .0 . .
. .4 . .

. . GO TO GO TO
. . "A" "B"
. . BELCH BELCH

. STORE T(LAND) IN
. T(ALIGN)

STORE 0000,
0000,0000 FOR
DISPLAY AS
T(ALIGN)

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

WAS NOMINAL OR LAN-
DING SITE ORIENTA-
TION SELECTED?
(NOTE: AN ORIENTA-
TION CODE OF 00000
WILL BE INTERPRETED
AS LANDING SITE
OPTION BY THE LCC).

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

. WAS THE PREFERRED
. ORIENTATION SELE-
. CTED?

.Y N.
. .
. .
. .
. .
. .
. GO TO GO TO
. "A" "B"
. BELOW BELOW

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#120

#130

#140

#150

#150

HOLD FLASH VERB-NCUN TO
..... REQUEST RESPONSE AND
SNAP DISPLAY T(ALIGN);
 VOEN34
 R1- T(ALIGN)-HRS
 R2- T(ALIGN)-MINS
 R3- T(ALIGN)-SECS

T(ALIGN)- TIME(GET)
AT WHICH LM POSITION
AND VELOCITY VECTORS
ARE TO BE DEFINED
FOR A NOMINAL OR
LANDING SITE IMU
ORIENTATION. IN
HRS, MINS, SECS, TO
NEAREST .01 SEC.

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

#170

#180

#190

FOR OPTION 2
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) AUTCMAT-
ICALLY SELECTED AS
THE PRESENT TIME.
FOR OPTION 4,
T(ALIGN) WILL BE
DEFINED AS T(LAND).

#200

DO I WISH TO ALIGN
THE IML TO AN

#210

ORIENTATION DEFINED
BY THE T(ALIGN)
PRESENTLY DISPLAYED?

.Y .N

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

#220

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V25E AND
LOAD THE DESIRED
T(ALIGN) IN R1,
R2, AND R3.

#230

.PROCEED .NEW
 .DATA

STORE DATA

#240

IS T(ALIGN) DEFINED
TO BE ZERO OR NEGA-
TIVE?

.Y .N

#250

DEFINE T(ALIGN)
= T PRESENT

+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+

+
+
+
+
+
+EDIT
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+C2
++

IS STORED ORIENTATION
CODE CCCC2?

.N .Y
(L.S.) (NOM)

STORE THE
VALLE OF
T(ALIGN) IN
THE T(LAND)
LOCATIGN.

. COMPUTE NOMINAL
. ORIENTATION FOR
. THE PREVIOUSLY
. DEFINED T(ALIGN).
. SELECT THIS ORI-
. ENTATION FOR
. GIMBAL ANGLE
. COMPUTATIONS.
. (NOTE: AT THIS
. TIME ANY PREFERR-
. ED ORIENTATION
. STORED IN THE LGC
. IS LCST).

GO TO
"A"
BELOW

COMPUTE LAT, LONG/2,
AND ALT FROM

WAS NOMINAL IMU
ORIENTATION SELEC-
TED?

.N .Y
(L.S.)

GO TO
"A"
BELOW

#260

#270

#280

#290

#300

STORED LANDING SITE VECTOR (IN "PRIMARY" STORAGE) AND SPECIFIED T(ALIGN). (NOTE: THE "PRIMARY" STORAGE OF THE LANDING SITE CAN BE MODIFIED ONLY BY PRELAUNCH ERASABLE LOAD, P27, P57, OR P68. SHOULD THE CREW WRITE OVER THE FOLLOWING DISPLAY, THE NEWLY DEFINED LANDING SITE IS EFFECTIVE ONLY TO DEFINE A LANDING SITE ORIENTATION FOR THE IMU.)

++
+OZ
+EDIT
++

#310

#320

#330

HOLD

SNAP

FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY THE LGC-STORED OR THE NEWLY-DEFINED LANDING SITE COORDINATES.
V06N89
R1-LAT
R2-LONG/2
R3-ALT

LAT-SELENGGRAPHIC LATITUDE OF THE DESIGNATED LANDING SITE. POLARITY INDICATES NORTH(+) OR SOUTH(-). IN DEGREES TO NEAREST .001 DEGREES.

MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF THE LGC-STORED OR THE NEWLY-DEFINED LANDING SITE COORDINATES.

#340

ARE THESE THE DESIRED LANDING SITE COORDINATES?

#350

.Y N.

LCAG/2-SELENGGRAPHIC
LONGITUDE DIVIDED BY
TWO OF THE LGC-STO-
RED OR THE NEWLY-
DEFINED LANDING SITE.
POLARITY INDICATES
EAST(+) OR WEST(-).
IN DEGREES TO NEAR-
EST .001 DEGREE.

#360

ALT-THE ALTITUDE OF
THE LGC-STORED OR
THE NEWLY-DEFINED
LANDING SITE ABOVE
THE RADIUS AT THE
DESIGNATED
LANDING SITE. IN
NAUTICAL MILES TO
NEAREST .01 NM.

#370

:
:

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

#380

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V25E AND
LOAD THE CORRECT
COORDINATES.

#390

.PROCEED .NEW
 .DATA

STORE DATA

#400

COMPUTE LANDING SITE
ORIENTATION FOR THE

400

LGC-STORED OR THE
 NEWLY-DEFINED
 LANDING SITE COOR-
 DINATES AND T(ALIGN).
 SELECT THIS ORIENTA-
 TION FOR GIMBAL
 ANGLE COMPUTATION.
 (NOTE: AT THIS TIME
 ANY PREFERRED ORIENT-
 ATION PREVIOUSLY
 STORED IN THE LGC
 IS LOST)

#410

.....
 "A"
 FROM
 ABOVE
 .
 .
 .
 .
 .

#420

.....
 . READ PRESENT VEHICLE
 . ATTITUDE FROM THE
 . PRESENT GIMBAL
 . ANGLES

#430

.....
 . COMPUTE GIMBAL
 . ANGLES AT DESIRED
 . IMU ORIENTATION AND
 . PRESENT VEHICLE
 . ATTITUDE

#440

.....
 "A"
 FROM
 ABOVE
 .
 .
 .
 .
 .
 .
 .

#450

HOLD . . . FLASH VERB-NOUN TO
 . . . REQUEST RESPONSE AND
 . . . DISPLAY THE RESULT-
 SNAP . . . ING ICDU/GIMBAL
 . . . ANGLES:

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

#460

V06 N22
R1-CG
R2-IG
R3-MG

ANGLES AFTER PRO-
POSED LM/IMU ALIGN-
MENT

ALL GIMBAL ANGLES IN
DEGREES TO NEAREST
01 DEGREE

#470

#480

WAIT FOR KEYBOARD
ENTRY

#490

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

N Y

#500

MANEUVER VEH-
ICLE WITH
ROTATION
CONTRCLER

#510

UPDATE THE
DISPLAY OF

402

```

. RESULTING
. GIMBAL
. ANGLES:
. KEY IN
. RECYCLE
. V32E

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#520

```

. TERMINATE FLASH UPON
. RECEIPT OF PROCEED
. OR RECYCLE

```

```

-----
KEY IN PROCEED
-----

```

#530

```

. R . P
. E . R
. C . D
. Y . C
. C . E
. L . E
. E . D

```

#540

HOLD

SNAP

```

-----
FLASH VERB NOUN TO
REQUEST PLEASE PER-
FORM NORMAL OR GYRO
TORQUE COARSE ALIGN;
V5CN25
R1-00013
R2-BLANK
R3-BLANK
-----

```

```

-----
MONITOR DSKY:
OBSERVE VERB NOUN
FLASH TO REQUEST
PLEASE PERFORM
NORMAL OR GYRO TOR-
QUE COARSE ALIGN
-----

```

#550

```

-----
THE NORMAL METHOD
OF ACHIEVING IMU
REALIGNMENT IS TO
ACCEPT THIS REQUEST
BY KEYING IN PROCEED

```

#560

405

..... KEY IN PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR ENTER

..... KEY IN ENTER

.P .ENTER
.R .
.C .
.C .
.E .
.E .
.D .
. .
. .

.....
COMPUTE TORQUING
ANGLES REQUIRED
TO ACHIEVE NEW
ORIENTATION.

. .
. .
. .

.....
RESET REFSMMAT
FLAG

. .
. .
. .

.....
RESET DRIFT FLAG

. .
. .
. .

.....
PULSE IRIGS
THROUGH TORQUING
ANGLES AND DIS-
PLAY PRESENT ICCL
ANGLES UNTIL

.....
MONITOR DSKY:
OBSERVE VERB-NOUN
DISPLAY OF PRE-
SENT GIMBAL
ANGLES UNTIL CCM-

#620

#630

#640

#650

407

SET REFSMMAT FLAG

#710

SET DRIFT FLAG

#720

POSS
HOLD
.....
SNAP

FLASH VERB-NOUN
TC REQUEST PLEASE
PERFORM FINE
ALIGN:
V50 N25
R1-CC014
R2-BLANK
R3-BLANK

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

#730

WAIT FOR KEYBOARD
ENTRY

DO I WISH TO AT-
TEMPT TO FINE
ALIGN THE IMU?
.Y N.

KEY IN PROCEED

#740

TERMINATE FLASH
UPON RECEIPT OF
PROCEED OR ENTER

KEY IN ENTER

.P .E
.R .N
.C .T
.C .E
.E .R

GO TO GC TO

#750

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LUNAR SURFACE ALIGN PROGRAM (P57)

REV 03 12/03/69

++
+03
PURPOSE:
+EDIT
++

(1) WHILE ON THE SURFACE OF THE MOON TO ALIGN OR REALIGN THE IMU TO ONE OF THREE TYPES OF ORIENTATIONS:

(A) LANDING SITE ORIENTATION

X = UNIT (R)
-SM -LS

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

Z = UNIT (H X X)
-SM -CSM -SM

WHERE:

- (1) THE ORIGIN IS THE CENTER OF THE MOON
- (2) R = THE POSITION VECTOR OF THE LM ON THE LUNAR SURFACE AT THE MOST RECENTLY DESIGNATED LANDING SITE AND A TIME T(ALIGN) SELECTED BY THE CREW.
-LS
- (3) H = THE ANGULAR MOMENTUM VECTOR OF THE CSM (R X V).
-CSM -CSM -CSM

(B) PREFERRED ORIENTATION

AN IMU ORIENTATION SPECIFIED BY THE GROUND AND LOADED INTO THE LGC BY THE LGC UPDATE PROGRAM (P27).

(C) PRESENT REFSMMAT

++
+03
+EDIT
++

- ASSUMPTIONS:
- (1) THERE ARE SEVERAL TECHNIQUES AVAILABLE TO THE CREW FOR COMPLETING AN IMU ALIGNMENT. THE RESULTANT ACCURACY OF THE IMU TO THE SPECIFIED DESIRED ORIENTATION (I.E. THAT ORIENTATION DEFINED BY THE FINAL REFSMMAT) IS DEPENDENT UPON THE ALIGNMENT TECHNIQUE WHICH THE CREW SELECTS. THIS SELECTION WILL BE DICTATED BY THE CIRCUMSTANCES AT THE TIME OF ALIGNMENT.
 - (2) THE LM HAS LANDED ON THE LUNAR SURFACE. THE LM YAW ANGLE WITH RESPECT TO THE INERTIAL ORIENTATION OF THE IMU AT LANDING WAS NOT CONSTRAINED DURING LANDING.
 - (3) ALL POSSIBLE EFFORTS HAVE BEEN MADE BY THE CREW TO ENSURE THAT THE LM WILL NOT SHIFT ITS POSITION WITH RESPECT TO THE LUNAR SURFACE. NO PROVISION HAS BEEN MADE TO INCORPORATE IN THE LGC ANY MEASUREMENT OF LM SETTLING ON THE LUNAR SURFACE. HOWEVER A SHIFTING OF THE LM WILL RESULT IN A MISALIGNED IMU ONLY IN THE CASE WHERE AN ALIGNMENT IS MADE FROM A STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE (OPTION CODES 0000 AND 0001; SEE LOGIC BELOW), AND THE IMU IS NOT SUBSEQUENTLY ALIGNED BY REFERENCE TO CELESTIAL BODIES AND/OR LUNAR GRAVITY.
 - (4) THE ISS IS ON AND MAY BE:
 - (A) AT AN INERTIAL ORIENTATION "UNKNOWN" TO THE LGC; I.E.: IT MAY HAVE BEEN SHUT DOWN AND RESTARTED SINCE

LANDING WITHCLT SUBSEQUENT ORIENTATION DETERMINATION.

- (B) AT AN INERTIAL ORIENTATION "KNOWN" BY THE LGC; I.E.: NEITHER GIMBAL LOCK NOR IMU POWER INTERRUPTION HAS OCCURRED SINCE THE LAST IMU ALIGNMENT OR ORIENTATION DETERMINATION. THEREFORE THE PRESENT ORIENTATION DIFFERS FROM THAT STORED IN REFSMMAT ONLY BECAUSE OF GYRO DRIFT AND/OR THE INITIAL MISALIGNMENT OF THE IMU TO THE STORED REFSMMAT.
- (5) NO MONITOR OR CONTROL OF THE RENDEZVOUS RADAR (RR) WILL BE EXERCISED BY THE LGC DURING THIS PROGRAM EXCEPT AS DEFINED BY THE RR MONITOR ROUTINE (R25).
- (6) THE LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE IS AVAILABLE IN LGC STORAGE, I.E.: IT WILL HAVE BEEN STORED BY THE LANDING CONFIRMATION PROGRAM (P68). ONCE THIS ATTITUDE HAS BEEN STORED IT WILL BE PRESERVED BY THE LGC UNTIL IT IS REPLACED BY A MORE RECENT VALUE.
- (7) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THE R59 PORTION OF THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.
- (8) THE DAP SHOULD BE OFF OR IN ATT HOLD ("MODE CONTROL-PGNS" SWITCH TO "OFF" OR "ATT HCLD") DURING GYRO TORQUING BY THIS PROGRAM TO PRECLUDE RCS JET FIRINGS DUE TO REALIGNMENT OF THE IMU CAUSING ATTITUDE ERRORS EXCEEDING THE MAXIMUM DEADBAND.
- (9) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT WILL NORMALLY BE SELECTED TO PERFORM AN ALIGNMENT OF THE IMU IMMEDIATELY AFTER LANDING ON THE LUNAR SURFACE, PRIOR TO SELECTION OF THE RR LUNAR SURFACE NAVIGATION PROGRAM (P22), PRIOR TO AGS INITIALIZATION AND APPROXIMATELY 15 MINUTES PRIOR TO ASCENT. THIS PROGRAM MAY ALSO BE USED TO PROVIDE AN IMU ALIGNMENT IN TIME-CRITICAL EMERGENCIES PRIOR TO ASCENT.
- (10) A DETERMINATION OF THE LM POSITION VECTOR WHILE ON THE LUNAR SURFACE (R) CAN BE ACCOMPLISHED ONLY IN
-LS
CONJUNCTION WITH IMU ALIGNMENT TECHNIQUE OPTION #2 (USING ADT SIGHTINGS TO TWO CELESTIAL BODIES). IT IS VALID ONLY IF THE LUNAR GRAVITY VECTOR HAS BEEN PREVIOUSLY DEFINED, DURING P57, USING IMU ALIGNMENT TECHNIQUE OPTION #1 (USING REFSMMAT OR STORED LM ATTITUDE AND DETERMINATION OF LUNAR GRAVITY VECTOR) OR OPTION #3 (USING SINGLE CELESTIAL BODY SIGHTING AND DETERMINATION OF LUNAR GRAVITY VECTOR).

++
+03
+EDIT
++

PROG
CONT

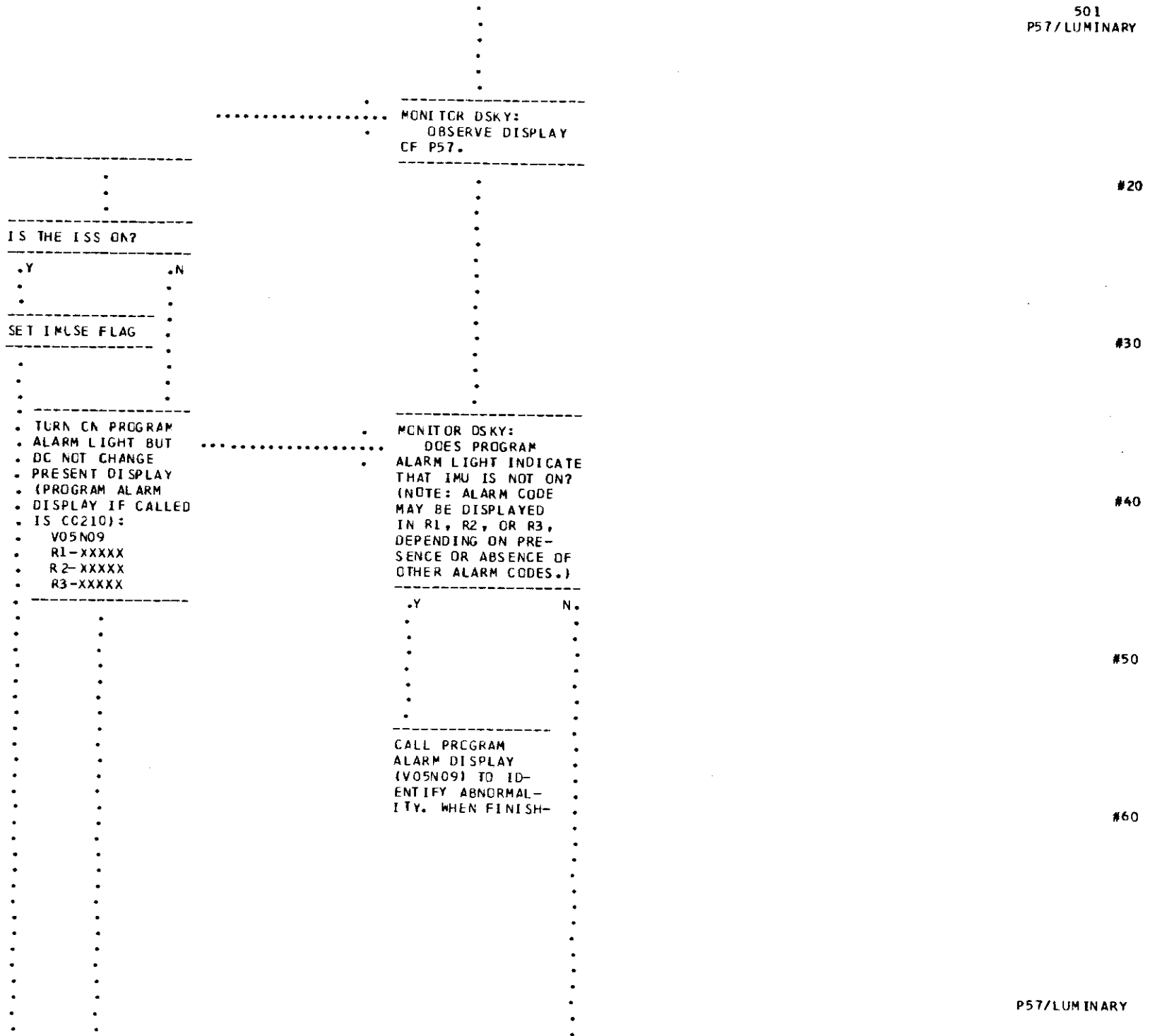
LGC GROUND CREW

.CREW
 .PROGRAM
 .SELECTION
 .
 .
 .

START LUNAR SURFACE ALIGN PROGRAM (P57). DISPLAY P57	KEY IN LUNAR SURFACE ALIGN PROGRAM (P57) V37E 57E
--	-----------------	---

4.2

(



#20

#30

#40

#50

#60

ED PUSH KEY
RELEASE.

PRESS ALARM RESET
TO RESET PROGRAM
ALARM.

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(R00)

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(R00)

EXIT P57

EXIT P57

SET LGC ASSUMED
OPTIC CODE FOR
IMU ORIENTATION
TO = C0003
(REFSMAT)

HOLD FLASH VERB-NOUN TO
SNAP REQUEST RESPONSE AND
DISPLAY OPTIC CODE
FOR ASSUMED IMU OR-

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

#70

#80

#90

#100

414

(

(

ORIENTATION SELECTION
V04N06
R1-CCCC1
R2-0000X
R3-BLANK

OF OPTION CODE FOR
ASSUMED IMU ORIENTA-
TION SELECTION

#110

R1 IS THE OPTION
CODE FOR ASSUMED
IMU ORIENTATION
SELECTION.

IS THIS THE DESIRED
IMU ORIENTATION?

#120

R2 IS THE LGC
ASSUMED IMU ORIENTA-
TION SELECTION
OPTION:
00001-PREFERRED
00002-NOMINAL
00003-REFSMAT
00004-LANDING SITE

. Y . N .

#130

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

#140

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN V22E
AND LOAD THE
DESIRED ORIENTA-
TION OPTION IN
R2

#150

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

WAS THE NOMINAL
OPTION SELECTED?

#160

.N . Y .

IS THE LGC ASSUMED
OPTIGN = 00002?

.N Y.

IS THE LGC ASSUMED
OPTIGN = 00003?

.Y N.

DEFINE THE DESIR-
ED IMU ORIENTA-
TION TO BE
REFSMMAT.

GO TO
"E"
BELOW

IS THE LGC ASSUMED
OPTIGN = 00001?

.Y N.

GO TO
"E"

WAS THE REFSMMAT
OPTIGN SELECTED?

.Y N.

GO TO
"E"
BELOW

WAS THE PREFERRED
OPTIGN SELECTED?

.Y N.

NOTE: IF CREW
SELECTS ALIGNMENT
TO A PREFERRED

#170

#180

#190

#200

417

BELOW

ORIENTATION
(00001), AND NONE
HAS BEEN DEFINED,
NO ALARM WILL
RESULT, BUT THE
RESULTING ALIGN-
MENT WILL BE
WORTHLESS.

#210

GC TO
"E"
BELOW

#220

OBTAIN CONTENTS OF
TIG REGISTER FROM
STORAGE FOR DISPLAY
AS T(ALIGN)
(NOTE: IF P12 WAS
PARTIALLY PERFORMED
IMMEDIATELY AFTER
THE LUNAR LANDING,
TIG WILL CONTAIN
TIG(AS)).

#230

#240

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

MONITOR DSKY:
OBSERVE VERB-NGUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF T(ALIGN) WHICH IS
EQUAL TO THE PRES-

#250

R3-T(ALIGN)-SECS
T(ALIGN)-TIME(GET)
AT WHICH LM POSITION
VECTOR IS DEFINED
FOR A LANDING SITE
ORIENTATION. IN HRS
MINS AND SECS TO
NEAREST .01 SEC.

ENTLY DEFINED TIG
(AS).
(NOTE: IT IS ASSUMED
THAT P12 WAS PAR-
TIALLY PERFORMED
IMMEDIATELY AFTER
THE LUNAR LANDING.
AT THAT TIME TIG(AS)
WAS DEFINED.)

#260

#270

#280

#290

#300

WAIT FOR KEYBOARD
ENTRY

IF T(ALIGN) IS
DEFINED TO BE
00000, 00000,
00000, THE LAND-
ING SITE
ORIENTATION
WILL BE DE-
FINED FOR A

418

(

(

T(ALIGN)
AUTOMATICALLY
SELECTED BY
THE LGC AS THE
PRESENT TIME.

#310

DO I WISH TO
ALIGN THE IMU TO
A LANDING SITE
ORIENTATION DE-
FINED BY THE T
(ALIGN) PRESENTLY
DISPLAYED?

#320

.Y .N

KEY IN V25E
AND LOAD THE
DESIRED T
(ALIGN) IN R1,
R2 AND R3

#330

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

KEY IN PROCEED

#340

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

#350

#360

IS T(ALIGN) DE-
FINED TO BE = 0?

#370

.N Y.
.

• DEFINE T
• T(ALIGN) = PRE-
• SENT TIME

#380

IS T(ALIGN)
DEFINED TO BE
GREATER THAN
THE PRESENT
TIME?

#390

.N Y.
.

• STORE
• T(ALIGN)
• IN TIG
• REGISTER
• FOR POSSI-

420

#21

BLE USE BY
P12 AS
TIG(AS).

#400

COMPUTE LANDING
SITE ORIENTATION
FOR DEFINED T
(ALIGN).
(NOTE: AT THIS
TIME ANY PRE-
FERRED ORIENTA-
TION PREVIOUSLY
STORED IN THE LGC
IS LOST.)

#410

"E"
FRM
ABOVE

#420

SET LGC ASSUMED
ALIGNMENT TECHNIQUE
OPTICN CODE TO
0000 (SEE BELOW).

#430

"E"
FRM
ABOVE

#440

HOLD . FLASH VERB-NOUN TO
..... REQUEST RESPONSE AND
SNAP . DISPLAY OPTICN CODE
FOR ASSUMED ALIGN-

MONITOR DSKY:
OBSERVE FLASHING
VERB-NOUN TO REQUEST
RESPGSE AND DISPLAY

MENT TECHNIQUE TO BE EMPLOYED, AND STORED DATCODE:

- V05N06
- R1-00010
- R2-C000X
- R3-00000

R1 IS THE OPTION CODE FOR ASSUMED ALIGNMENT TECHNIQUE TO BE EMPLOYED.

R2 IS THE LGC-ASSUMED ALIGNMENT TECHNIQUE OPTION CODE:

00000: TIME CRITICAL ANYTIME ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SELECTED USING STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE OR PRESENT REFSMMAT.

++
+03
+EDIT
++

00001-ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SELECTED USING PRESENT REFSMMAT (OR A STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE) AND DETERMINATION OF THE LUNAR GRAVITY VECTOR.

++
+03
+EDIT
++

00002-ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SEL-

++
+03
+EDIT

+
+
+
+
+
+
+
+
+
+
+
+
+
+

CF OPTION CODE FOR ASSUMED ALIGNMENT TECHNIQUE TO BE EMPLOYED, AND STORED DATCODE.

#450

THE PREREQUISITES FOR SELECTION OF AN ALIGNMENT TECHNIQUE OPTION CODE (R2) ARE AS FOLLOWS:

- 00000-(A)
- 00001-(A)
- 00002-(B)
- 00003-(C)

WHERE:

(A) A LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE OR REFSMMAT IS DEFINED. (REFER TO ASSUMPTION (4) (B) ABOVE.)

#470

(B) TWO CELESTIAL BODIES ARE VISIBLE FOR SIGHTING (TWO NAV STARS/PLANETS, OR ONE NAV STAR/ PLANET AND THE SUN).

#480

(C) ONE CELESTIAL BODY IS VISIBLE FOR SIGHTING (NAV STAR/PLANET OR SUN).

#490

422

423 +
+
+
+
++

ECTED USING AGT
SIGHTINGS TO TWO
CELESTIAL BODIES.

++
+03
+EDIT
++

CCCC3-ALIGN TO
THE DESIRED
ORIENTATION
PREVIOUSLY SEL-
ECTED USING AGT
SIGHTINGS TO ONE
CELESTIAL BODY AND
DETERMINATION OF
THE LUNAR GRAVITY
VECTOR.

R3 IS DATCODE-A
TWO DIGIT CODE. R3
WILL CONTAIN A "1"
IN THE "C" DIGIT IF
A REFSMMAT IS
DEFINED, OR
A "0" IF NO REFSMMAT
IS DEFINED.

R3 WILL CONTAIN A
"1" IN THE "D"
DIGIT TO INDICATE
THAT A STORED LM
ATTITUDE IS AVAIL-
ABLE, OR A "0" IF IT
IS NOT AVAILABLE.

OPTIMALLY DATCODE
SHOULD THEREFORE
READ 00110.

#500

#510

#520

#530

IS THE LGC-ASSUMED
ALIGNMENT TECHNIQUE
OPTICN CODE CORRECT
(R2)?

Y. N.
.

#540

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

KEY IN V2ZE AND
LOAD THE DESIRED
LGC-ASSUMED ALI-
GNMENT TECHNIQUE
OPTION CODE IN
R2.

#550

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR NEW DATA

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

STORE DATA

#560

#570

IS REFSMMAT FLAG
SET?

.Y .N

IS ATTITUDE FLAG
SET?

.Y N.

IS REFSMMAT FLAG
SET?

Y. .N

IS ATTITUDE FLAG
SET?

Y. .N

#580

#590

424

#25

GO TO
"B"
BELGW

IS ALIGNMENT
TECHNIQUE OPTION
CODE = 0002
OR 0003?

.Y .N

GO TO
"B"
BELGW

IS ALIGNMENT
TECHNIQUE OPTION
CODE = 0002
OR 0003?

.Y .N

POSS

HOLD

SNAP

FLASH VERB-NGUN
TO REQUEST RE-
SPONSE AND DIS-
PLAY ALARM CODE
00701:
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
(NOTE: ALARM CODE
MAY BE DISPLAYED
IN R1, R2, OR R3,
DEPENDING ON PRE-
SENCE OR ABSENCE
OF OTHER ALARM
CODES.)

MONITOR DSKY:
DISPLAY OF
ALARM CODE INDIC-
ATES THAT OPTION
00000 OR 00001
HAS BEEN SELECTED
BUT THE LGC CAN-
NOT CONTINUE
BECAUSE NEITHER
PRESENT REFSMMAT
NOR A STORED LM
ATTITUDE ARE
AVAILABLE.
DO I WISH TO SEL-
ECT ANOTHER
OPTION?

.N .Y

WAIT FOR KEYBOARD
ENTRY

KEY IN
RECYCLE
V32E

#600

#610

#620

#630

#640

#650

TERMINATE FLASH
UPON RECEIPT OF
RECYCLE OR
TERMINATE

KEY IN TERMINATE
V34E

T. .R
E. .E
R. .C
M. .Y
I. .C
N. .L
A. .E
T.
E.

#660

#670

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(ROO)

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(ROO)

#680

EXIT P57

EXIT P57

#690

COMPUTE AND STORE
LM ATTITUDE IN HGON-
FIXED COORDINATES
USING REFSMMAT

426

#27

SET ATTITUDE FLAG

#700

"B"
FROM
ABOVE

#710

SET INITIAL ALIGN
FLAG

#720

IS ALIGNMENT TECH-
NIQUE OPTION CODE =
00001 OR 00003?

IS ALIGNMENT TECH-
NIQUE OPTION CODE =
00001 OR 00003?

.N .Y
GO TO
"C"
BELOW

.Y .N
GO TO
"C"
BELOW

#730

SET DESIRED GIMBAL
ANGLES AS FOLLOWS:

#740

OG = +42 DEG
IG = -42 DEG
MG = +35.25 DEG

COMMAND ISS TO
COARSE ALIGN MODE.

TURN ON "NO ATT"
LIGHT

RESET TRACK FLAG

RESET DRIFT FLAG

RESET REFSMMAT FLAG

COARSE ALIGN ISS.

(NOTE: IF AT THE END
OF COARSE ALIGNMENT,
THE GIMBALS ARE NOT
WITHIN 2 DEGREES OF

OBSERVE "NO ATT"
LIGHT TO INDICATE
THAT IMU IS IN
COARSE ALIGN MODE
FOR ALIGNMENT TO THE
FIRST POSITION FOR
LUNAR GRAVITY DETER-
MINATION

(NOTE: IF AT THE END
OF COARSE ALIGNMENT,
THE GIMBALS ARE NOT
WITHIN 2 DEGREES OF

#750

#760

#770

#780

#790

428

429

THE DESIRED VALUES,
THE LGC WILL TURN ON
THE PROGRAM ALARM
LIGHT AND STORE
ALARM CODES 00211
AND 00217).

THE DESIRED VALUES,
THE LGC WILL TURN ON
THE PROGRAM ALARM
LIGHT AND STORE
ALARM CODES 00211
AND 00217).

#800

TERMINATE COARSE
ALIGN MODE IN ISS.

#810

TURN OFF "NO ATT"
LIGHT

OBSERVE TERMINATION
OF "NO ATT" LIGHT TO
INDICATE THAT IMU IS
NOW INERTIAL.

#820

DETERMINE GRAVITY
VECTOR, G, BY READ-
ING ACCELEROMETER
OUTPUTS

#830

STORE 1/2 UNIT (G)
IN NAV BASE
COORDINATES AS G1

#840

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

CALCULATE DESIRED
ICDL/GIMBAL ANGLES
TO ROTATE IMU STABLE
MEMBER 180 DEGREES
ABOUT G

#850

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

COMMAND ISS TO
COARSE ALIGN MODE.

#860

.....

TURN ON "NO ATT"
LIGHT

OBSERVE "NO ATT"
LIGHT TO INDICATE
THAT IMU IS IN
COARSE ALIGN MODE,
FOR ALIGNMENT TO THE
SECOND POSITION FOR
LUNAR GRAVITY DETER-
MINATION.

#870

RESET TRACK FLAG

.....

RESET DRIFT FLAG

#880

RESET REFSMAT FLAG

.....

COARSE ALIGN ISS.

#890

113

IN NAV BASE
COORDINATES AS G2

#940

:
:

DEFINE THE 1/2 UNIT
LUNAR GRAVITY VECTOR
TO BE THE UNITIZED
SUM OF G1 AND G2

#950

POSS
HOLD . FLASH VERB-NOUN TO
..... REQUEST RESPONSE
SNAP . AND DISPLAY GRAV ERR
ANGLE:
V06 N04
R1-GRAV ERR ANGLE
R2-BLANK
R3-BLANK

GRAV ERR ANGLE - THE
ANGULAR DIFFERENCE
BETWEEN PRESENT AND
ANY PREVIOUSLY DE-
FINED GRAVITY VECTOR.
POLARITY IS ALWAYS +.
IN DEGREES TO NEAR-
EST .01 DEGREES
(NOTE: UNTIL THIS
PROGRAM IS PERFORMED
THE FIRST TIME THE
LGC WILL ASSUME THE
LUNAR GRAVITY VECTOR
TO BE PARALLEL TO
THE LM X AXIS IF P68
WAS PREVIOUSLY COM-
PLETED. IF P68 WAS
NOT PREVIOUSLY COM-
PLETED, THIS DISPLAY
IS MEANINGLESS ON

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF GRAV ERR ANGLE.
(NOTE: UNTIL THIS
PROGRAM IS PERFORMED
THE FIRST TIME THE
LGC WILL ASSUME THE
LUNAR GRAVITY VECTOR
TO BE PARALLEL TO
THE LM X AXIS.)

#960

#970

#980

THE FIRST PASS).
 (NOTE: A PREVIOUSLY
 DEFINED GRAVITY
 VECTOR HAS ONLY BEEN
 RETAINED FOR COMPA-
 RISON IF THIS DIS-
 PLAY WAS NOT TERMI-
 NATED AT THAT TIME
 BY V34E).

#990

DO I WISH TO COM-
 PLETE ALIGNMENT NOW?

#1000

.N .Y

DO I WISH TO
 REMEASURE THE
 LUNAR GRAVITY
 VECTOR?

#1010

.Y N.

WAIT FOR KEYBOARD
 ENTRY

KEY IN
 RECYCLE
 V32E

#1020

KEY IN
 TERMINATE
 V34E

#1030

TERMINATE FLASH UPON
RECEIPT OF PROCEED,
RECYCLE, OR
TERMINATE

KEY IN PROCEED

```

.P      .T      .R
.R      .E      .E
.O      .R      .C
.C      .M      .Y
.E      .I      .C
.E      .N      .L
.D      .A      .E
      .T
      .E
      .....
  
```

#1040

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(ROO)

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(ROO)

#1050

EXIT P57

```

"CM"
FROM
ABOVE ...
EXIT P57
  
```

#1060

"CM"
FROM ABOVE

CONSIDER THIS TO BE
THE FIRST PASS
THROUGH THE ALIGN-
MENT PROGRAM.
WAS A STORED LM
ATTITUDE OR REFSMMAT
AVAILABLE AT THE
START OF THIS
PROGRAM?

#1070

IS THE ATTITUDE FLAG
SET?

```

.Y      .N.
      .
      .
      .
      .
      .
      .
      .
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#1080

434

#1090

RE SET THE INITIAL
ALIGN FLAG.

#1100

CHECK THE TECHNI-
QUE OPTION CODE

CHECK THE TECHNI-
QUE OPTION CODE

.00000 .0 .0
.00001 .0 .0
(NOTE: .C .C
ON THE .0 .0
.FIRST .2 .3
.PASS . .
.THIS . .
.LGGIC . .
.PATH . .
.EXISTS . .
IN THE . .
.PROGRAM . .
.AS SHO-
WN. . .
IT IS . .
NEVER . .
USED . .
HOWEVER . .
AS IT . .
HAS BEEN . .
.PRECLU-
DED BY . .
.PREVIOUS . .
.LGGIC. . .
SEE . .
.ABCVE). . .

.00002 00000.
.00003 00001.
(NOTE: ON
THE FIRST
PASS THIS
LOGIC PATH
EXISTS IN
THE PROGRAM
AS SHOWN.
IT IS NEVER
USED HOWEVER.
AS IT HAS
BEEN PRE-
CLUDED BY
PREVIOUS
LOGIC. SEE
ABCVE).

#1110

#1120

#1130

DEFINE UNIT
LOS VECTORS AS
DESCRIBED IN
SECTION
5.6.2.2 OF
R567.

#1140

SET STAR INDI-
CATOR = 0.

#1150

SET STAR INDI-
CATOR = 1

#1160

DO LUNAR SURFACE
SIGHTING MARK
ROUTINE (R59)

DO LUNAR SURFACE
SIGHTING MARK
ROUTINE (R59) FOR
CELESTIAL BODY #1

#1170

DO CELESTIAL BCDY
DEFINITION ROU-
TINE (R58) FOR
CELESTIAL BCDY

DO CELESTIAL BODY
DEFINITION ROUTINE
(R58) FOR CELES-
TIAL BODY ACTUALLY

#1180

ACTUALLY USED

IS STAR INDICATOR
GREATER THAN
ZERO?

.Y .N

DEFINE UNIT LOS
VECTOR AS DESCRIBED
IN SECTION
5.6.2.2 OF R567

TRANSFORM LOS VEC-
TORS IN REFERENCE
COORDINATES TO DE-
SIRED IMU COOR-
DINATES

IS INITIAL ALIGN
FLAG SET?

.Y .N

USED.

IS TECHNIQUE OP-
TION CODE
= 00002?

.Y .N

DO R59 FOR
CELESTIAL BODY
#2

DO R58 FOR CELE-
STIAL BODY #2
ACTUALLY USED.

IS THIS THE FIRST
PASS THROUGH THE
ALIGNMENT PROGRAM?

.N .Y

#1190

#1200

#1210

#1220

#1230

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

DO SIGHTING DATA
DISPLAY ROUTINE
(R54)

#1240

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

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

#1250

GO TO
"D"
BELOW

GO TO
"D"
BELOW

#1260

++
+03
+EDIT

COMPUTE DESIRED GYRO
TORQUING ANGLES.

#1270

IS INITIAL ALIGN
FLAG SET?

IS THIS THE FIRST
PASS THROUGH THE
ALIGNMENT PROGRAM?

#1280

.Y N.

.N Y.

POSS
HOLD

SNAP

FLASH VERB-NOUN
TO REQUEST RESPO-
NSE AND DISPLAY
GYRO TORQUING

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DIS-

#38

439

ANGLES:
V06N93
R1-X GYRO
R2-Y GYRC
R3-Z GYRC
IN DEGREES TO
NEAREST .001 DEG-
REE.

PLAY OF GYRO TOR-
QUING ANGLES.
THESE ANGLES WILL
BE APPLIED TO THE
IMU UNLESS I RECY-
CLE. DO I WISH TO
PERMIT GYRO TOR-
QUING?

#1290

-Y N.

#1300

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

KEY IN RECYCLE,
V32E

#1310

TERMINATE FLASH
UPON RECEIPT OF
PROCEED OR RE-
CYCLE

.P .R
.R .E
.D .C
.C .Y
.E .L
.D .E

GO TO
"D"
BELOW

#1320

GO TO
"D"
BELOW

#1330

IS ANY GYRC TORQUING
ANGLE GREATER THAN

WAS ANY GYRO TORQU-
ING ANGLE GREATER

5 DEGREES?

.N Y.

CALCULATE DESIRED
ICDU/GIMBAL ANG-
LES TO ALIGN THE
IMU TO THE DESI-
RED ORIENTATION

IS THE INITIAL
ALIGN FLAG SET?

.N Y.

FLASH VERB-NOUN
TO REQUEST RE-
SPONSE AND DIS-
PLAY THE RESULT-
ING ICDU GIMB-
AL ANGLES:
V06 N22
R1 - OG
R2 - IG
R3 - MG

ALL GIMBAL AN-
GLES IN DEGREES
TO NEAREST .01

THAN 5 DEGREES?

.Y .N

IS THIS THE FIRST
PASS THROUGH THE
ALIGNMENT PRO-
GRAM?

.Y N.

MONITOR DSKY:
OBSERVE VERB-
NOUN FLASH TO
REQUEST RESPONSE
AND DISPLAY OF
ICDU GIMBAL AN-
GLES AFTER PRO-
POSED LM IMU
ALIGNMENT

#1340

#1350

#1360

#1370

#1380

HOLD .

SNAP .

440

44

DEGREE

WAIT FOR KEY-
BOARD ENTRY

KEY IN PROCEED

TERMINATE FLASH
UPON RECEIPT OF
PROCEED

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

COMMAND ISS TO
COARSE ALIGN MODE

TURN ON "NO ATT"
LIGHT

OBSERVE "NO ATT"
LIGHT TO INDICATE
THAT IMU IS IN
COARSE ALIGN MODE

RESET TRACK FLAG.

RESET DRIFT FLAG.

#1390

#1400

#1410

#1420

#1430

• RESET REFSMMAT
• FLAG.

• COARSE ALIGN ISS

• (NOTE: IF AT END
• OF COARSE ALIGN-
• MENT THE GIMBALS
• ARE NOT WITHIN 2
• DEGREES OF THE
• DESIRED VALUES,
• THE LGC WILL TURN
• ON THE PROGRAM
• ALARM LIGHT AND
• STORE ALARM CODES
• 00211 AND 00217).

• TERMINATE COARSE
• ALIGN MODE IN ISS

• TURN OFF "NO ATT"
• LIGHT

• SET DRIFT FLAG.

• (NOTE: IF AT END
• OF COARSE ALIGN-
• MENT THE GIMBALS
• ARE NOT WITHIN 2
• DEGREES OF THE
• DESIRED VALUES,
• THE LGC WILL TURN
• ON THE PROGRAM
• ALARM LIGHT AND
• STORE ALARM CODES
• 00211 AND 00217).

• OBSERVE TERMINA-
• TION OF "NO ATT"
• LIGHT TO INDICATE
• THAT IMU IS NOW
• INERTIAL

#1440

#1450

#1460

#1470

#1480

442

"D"
BELOW

"C"
BELOW

#1530

IS INITIAL ALIGN
FLAG SET?

WAS THIS THE FIRST
PASS THROUGH THE
ALIGNMENT PROGRAM?

.N Y.

.Y N.

#1540

THE NEXT PASS IS
THE SECOND PASS.

COMPUTE AND STORE
PRESENT LM ATTITUDE
IN MOON FIXED COOR-
DINATES.

#1550

SET ATTITUDE FLAG.

#1560

"D"
FROM
ABOVE

"C"
FROM ABOVE

#1570

HOLD . FLASH VERB-NCUN TO
..... REQUEST PLEASE PER-
SNAP . FORM FINE ALIGNMENT:
 V5CN25

MONITOR DSKY:
OBSERVE VERB-NCUN
FLASH TO REQUEST
PLEASE PERFORM FINE

444

44E

R1 - 00014
R2 - BLANK
R3 - BLANK

ALIGNMENT

.
.
.
.

#1580

DO I WANT TO TRY THE
ALIGNMENT AGAIN OR
CHECK THE FINE
ALIGNMENT?

.Y .N.

#1590

WAIT FOR KEY BOARD
ENTRY

KEY IN PROCEED

.
.
.

#1600

DO I WISH TO DETER-
MINE THE LM LUNAR
SURFACE POSITION
VECTOR?
(NOTE: THIS IS ONLY
APPLICABLE IF IN
OPTION #2, AND THIS
PROGRAM (P57) HAS
BEEN PREVIOUSLY COM-
PLETED USING EITHER
OPTION #1 OR OPTION
#3.)

.N .Y.

#1610

KEY IN ENTER

#1620

TERMINATE FLASH UPON
RECEIPT OF PROCEED,
ENTER, OR TERMINATE.

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

KEY IN TERM-
INATE, V34 E

#1630

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROUTINE
(ROO)

EXIT P57

DO FINAL AUTO-
MATIC REQUEST
TERMINATE
ROUTINE (ROO)

EXIT P57

#1640

#1650

IS TECHNIQUE OPTION
CODE = 00002?

.N Y.
. .
. .
. .
. .
GO TO
"A"
BELOW
. .
. .

IS TECHNIQUE OPTICN
CODE = 00002?

.N Y.
. .
. .
. .
. .
GO TO
"A"
BELOW
. .
. .

#1660

#1670

CALCULATE THE PRES-
ENT LM LUNAR SURFACE

446

447

POSITION VECTOR IN
REFERENCE CCCRODI-
NATES FROM THE
STORED LUNAR GRAVITY
VECTOR, LATEST R
-LS
MAGNITUDE, AND THE
JUST-COMPUTED
REFSMAT

#1680

#1690

#1700

#1710

#1720

HOLD
SNAP

FLASH VERB-NOUN
TO REQUEST RES-
PONSE AND DIS-
PLAY STORED
LANDING SITE
COORDINATES.
VO6N89
R1 - LAT
R2 - LONG/2
R3 - ALT

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF COMPUTED LANDING
SITE COORDINATES.

LAT-SELENOGRA-
PHIC LATITUDE
OF THE LM LUNAR
SURFACE POSI-
TION VECTOR.
POLARITY INDIC-
ATES NORTH (+)
OR SOUTH (-).
IN DEGREES TO
NEAREST .001
DEGREE.

MONITOR LGC
DOWNLINK
TELEMETRY OF
LAT, LONG/2,
AND ALT. CO-
ORDINATE
EVALUATIONS
OF LGC-COM-
PUTED PARA-
METERS WITH
THE CREW.

COORDINATE EVALU-
ATION OF THE LGC-
COMPUTED PARAMETERS
WITH THE GROUND.

LONG/2-SELENO-
GRAPHIC LONGI-
TUDINE (DIVIDED
BY TWO) OF THE
LM LUNAR SUR-
FACE POSITION

IS THE DISPLAYED
DATA ACCEPTABLE?

.Y .N
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VECTOR.
POLARITY INDIC-
ATES EAST (+),
OR WEST (-). IN
DEGREES TO
NEAREST .001
DEGREE.

DO I HAVE BETTER
DATA FROM ANOTHER
SOURCE?

. N Y.

#1730

ALT-THE ALTI-
TUDE OF THE LM
LUNAR SURFACE
POSITION VECTOR
ABOVE THE RAD-
IUS AT THE MOST
RECENTLY DEFIN-
ED LANDING
SITE. IN NAUT-
ICAL MILES TO
NEAREST .01 NM.

#1740

WAIT FOR KEY-
BOARD ENTRY

KEY IN V25E
AND LOAD THE
CORRECT CO-
ORDINATES

#1750

TERMINATE FLASH
UPON RECEIPT OF
PROCEED, TERM-
INATE, OR NEW
DATA

KEY IN TERMINATE,
V34E

#1760

KEY IN PROCEED

#1770

. P . T NEW
. R . E DATA.

448

BRAKING PHASE PROGRAM (P63)

REV 03 12/03/69

PURPOSE:

- (1) TO CALCULATE THE REQUIRED TIME OF DPS IGNITION (TIG) AND OTHER INITIAL CONDITIONS REQUIRED BY THE LGC FOR A PGNCS-CONTROLLED, DPS-EXECUTED, BRAKING PHASE OF THE POWERED LANDING MANEUVER.
- (2) TO PROVIDE OPTION TO FINE ALIGN THE IMU TO AN EXISTING REFSMMAT.
- (3) TO ALIGN THE LM TO THE THRUSTING IGNITION ATTITUDE.
- (4) TO CONTROL THE PGNCS DURING COUNTDOWN, IGNITION, AND THRUSTING OF THE POWERED LANDING MANEUVER UNTIL HI GATE.
- (5) TO INDICATE THAT HI GATE HAS BEEN REACHED (TGO LESS THAN TENDBRAK) BY AUTOMATIC SELECTION OF THE APPROACH PHASE PROGRAM (P64).

ASSUMPTIONS:

- (1) THE LM IS ON A DESCENT COAST ORBIT (HOCHMANN TRANSFER) APPROACHING THE BRAKING IGNITION POINT WHICH IS NOMINALLY 50,000 FT. ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. THE DESCENT COAST ORBIT IS APPROXIMATELY COPLANAR WITH THE CSM ORBITAL PLANE. IF THE DESIGNATED LANDING SITE IS NOT IN THE DESCENT COAST PLANE AT THE NOMINAL TIME OF LANDING THE PLANE CHANGE WILL BE ACCOMPLISHED BY THE POWERED LANDING MANEUVER (BRAKING PROGRAM (P63) AND APPROACH PROGRAM (P64)).
- (2) THE CSM IS IN A NEAR-CIRCULAR ORBIT AROUND THE MOON AT A NOMINAL ALTITUDE OF 60 NAUTICAL MILES. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.
- (3) THE IMU IS ON AND ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING (T(LAND)), BUT SHOULD BE FINE ALIGNED TO THIS ORIENTATION AS CLOSELY AS POSSIBLE PRIOR TO DPS IGNITION. THE LM HAS NOT YET BEEN ALIGNED TO THE CORRECT ATTITUDE FOR IGNITION FOR THE POWERED LANDING MANEUVER.
- (4) THE LANDING RADAR (LR) WAS ENERGIZED AND CHECKED OUT, AND MADE READY AT LR POSITION #1 PRIOR TO SELECTION OF THIS PROGRAM. RADAR DATA WILL NOT BE INCORPORATED INTO THE LM STATE VECTOR UNTIL THE ASTRONAUT SETS THE LR PERMIT FLAG VIA V57E INDICATING HE IS SATISFIED WITH THE QUALITY OF THE DATA (THE LR PERMIT FLAG IS RESET BY RCC, OR BY EXTENDED VERBS V57 GR V58).
- (5) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.
- (6) THE LANDING ANALOG DISPLAYS ROUTINE (R10) IS ENABLED AT DPS IGNITION AND IS TERMINATED UPON TERMINATION OF AVERAGE G. THE POWERED FLIGHT DESIGNATE ROUTINE (R29) IS NOT ENABLED DURING THE LUNAR DESCENT.
- (7) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH, AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.
- (8) THE AIM CONDITIONS FOR THE BRAKING PHASE ARE STORED IN THE LGC.
- (9) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED BY THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.
 - (A) THE LM AND CSM STATE VECTORS. THE LGC HAS UPDATED THESE AS REQUIRED. NO FURTHER STATE VECTOR UPDATES FROM ANY EXTERNAL SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.
 - (B) THE NOMINAL LANDING TIME AT THE DESIGNATED LANDING SITE (T(LAND)) AND THE POSITION (RLS)
- (10) THE DPS IS NOT THROTTLEABLE OVER THE WHOLE RANGE FROM 0 TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS ABOUT 10 PERCENT) AND

THE PGNC'S COMMANDED SETTING.

THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN "AUTO" (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGNC'S COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT MINIMUM FOR "ZOOMTIME" SECONDS OF THRUSTING, AND THEREAFTER AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC. THE VALUE "ZOOMTIME" IS IN ERASABLE STORAGE, HAVING BEEN LOADED PRIOR TO LAUNCH OR BY P27.

++
+03
+EDIT
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DUE TO THE REGION OF FORBIDDEN THROTTLING, THRUST COMMAND LOGIC IN CONJUNCTION WITH THE INTERIM TERMINAL CONDITIONS (SEE ASSUMPTION (8)) ASSURE THAT THE COMMANDED THROTTLE REMAINS AT MAXIMUM UNTIL THE GUIDANCE EQUATIONS FIRST REQUIRE IT TO BE WITHIN THE ALLOWABLE THROTTLE RANGE. THEREAFTER IT SHOULD REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE. THIS PRINCIPLE IS DESCRIBED IN MORE DETAIL IN SECTION 5.3.4 OF R567. THE RESULT IS A SMOOTH AND EFFICIENT THRUST ATTITUDE PROFILE THROUGHOUT THE BRAKING PHASE.

FURTHERMORE THE DPS MUST BE STARTED IN THE FOLLOWING SEQUENCE: +X AXIS 2 JET ULLAGE FOR 7.5 SEC; IGNITION AT MINIMUM THROTTLE; ULLAGE OFF 0.5 SECONDS AFTER IGNITION; MINIMUM THRUST UNTIL TIG (AS DEFINED BY R41) + "ZOOMTIME"; AND THEN MAXIMUM THROTTLE. THE THROTTLE SETTING THEN BECOMES CONTROLLED BY THE GUIDANCE EQUATIONS.

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+03
+285
+03
++
(11) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION.

SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE MANEUVER.

THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH WILL BE CALLED BY THIS PROGRAM.

(12) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNC'S ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNC'S DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X-AXIS OVERRIDE OPTION IS AVAILABLE TO THE CREW (UNTIL THE ESTIMATED ALTITUDE IS BELOW 30,000 FEET), HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60). THE OPTION IS INHIBITED BY THIS PROGRAM FROM MIDWAY IN THE PROGRAM (SEE ASSUMPTION (13) BELOW) TO THE END.

(13) THE LGC SPECIFIES LM ATTITUDE DURING THE POWERED LANDING MANEUVER BASED UPON THE REQUIREMENTS OF THRUST VECTOR CONTROL, LANDING SITE VISIBILITY, AND LR ORIENTATION. AFTER DPS IGNITION, THRUST VECTOR CONTROL IS REQUIRED THROUGH THE REMAINDER OF THIS PROGRAM. THE LANDING SITE BECOMES VISIBLE AT THE BEGINNING OF THE APPROACH PHASE.

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+03
+EDIT
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THRUST VECTOR CONTROL DOES NOT CONSTRAIN THE LM ORIENTATION ABOUT THE THRUST AXIS (YAW ATTITUDE). ROTATION ABOUT THE LM Y AND LM Z AXES IS USED TO POINT THE MEASURED THRUST VECTOR ALONG THE DESIRED THRUST VECTOR.

THE FIRST RESTRAINT UPON THE LM YAW ATTITUDE TO OCCUR IS THAT OF LR ORIENTATION. THE LGC WILL NOT ATTEMPT TO USE LR DATA UNTIL THE LGC ESTIMATION OF ALTITUDE IS 30,000 FT., AUTOMATIC X-AXIS OVERRIDE LOCKOUT (DONE BY R12) AND YAW ATTITUDE SPECIFICATION BY THE LGC WILL NOT OCCUR UNTIL THE LGC ESTIMATED ALTITUDE IS 30,000 FT.. BEFORE THIS TIME, THE ASTRONAUT MUST MANEUVER TO A ROUGHLY-WINDOW-UP YAW ORIENTATION TO PREVENT SUBSEQUENT LOSS OF S-BAND LOCK-ON. THE LGC WILL THEN COMMAND THE VEHICLE TO THE LGC-SPECIFIED YAW ATTITUDE.

SUBSEQUENT TO X-AXIS OVERRIDE LOCKOUT, CONTROL OF THE VEHICLE ABOUT THE LM X AXIS IS GOVERNED BY LR ORIENTATION REQUIREMENTS DURING THIS PROGRAM. THE LANDING SITE BECOMES VISIBLE TO THE COMMAND PILOT IF THE LOOK ANGLE (THE ANGLE BETWEEN THE LM -X AXIS AND THE LOS TO THE LANDING SITE) IS GREATER THAN 25 DEGREES AND THE LOS IS IN OR NEAR THE LM X/Z PLANE.

AT ANY TIME DURING P63, P64 OR P65, THE MAGNITUDE OF THE LOOK ANGLE AND THE ORIENTATION OF THE LOOK ANGLE PLANE (THAT PLANE CONTAINING THE LOS AND THE LM X AXIS) ARE DEFINED BY THE INERTIAL ORIENTATION OF THE LM X AXIS AND THE POSITION OF THE LM WITH RESPECT TO THE LANDING SITE.

(14) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R10) WHICH IS ENABLED AT DPS IGNITION.

(15) THE RATE OF DESCENT (ROD) MODE IS NOT ENABLED DURING THIS PROGRAM (SEE LANDING (ROD) PROGRAM (P66), ASSUMPTION 12 FOR DEFINITION OF ROD MODE).

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+03
452 +
+
+
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(16) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE DESCENT ORBIT INJECTION, THE DESCENT CCAST, OR THE POWERED DESCENT (P63), (P64), (P65), OR (P66).

453
+
+
+
+
+285
++
FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS NOMINALLY COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTCN) OR THE ASCENT STAGE (ABORT STAGE BUTCN). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTCN).

DURING THE POWERED LANDING MANEUVER THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4.3 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH WILL BE ENABLED BY THIS PROGRAM.

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+03
+EDIT
+
+
+
+
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+
+
+03
++
(17) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (19)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. THIS FLAG IS RESET BY P12, P40, P41, P42, P63, P70, P71 AND R40 AT MAIN ENGINE IGNITION. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS ALSO SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE ASTRONAUT IS RESPONSIBLE FOR MAINTAINING SMALL ENOUGH ATTITUDE ERRORS TO ACHIEVE GUIDANCE OBJECTIVES.

(18) CONTROL OF THE LM DPS, RCS AND APS IS TRANSFERRED FROM THE PGNS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PULLING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R471). IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE DESIRED ATTITUDE ERRORS. HOWEVER THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(19) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

- MODE I - SELECTED BY EXTENDED VERB 61. AUTCPILCT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
- MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

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+03
+EDIT
+
+03
++
PGNS - DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60. MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS INDICATED IN ASSUMPTION (17) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6

(20) THE EVENT TIMER WAS SET PRIOR TO SELECTION OF THIS PROGRAM TO COUNT TO ZERO AT T BRAK BASED ON A TIME FROM IGNITION PROVIDED BY THE GROUND.

(21) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. AT THAT TIME THE DPS ENGINE GIMBAL SHOULD HAVE BEEN DRIVEN TO THE CORRECT TRIM POSITION.

(22) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET AUTOPILOT (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY EXTENDED VERB AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT VIOLATIONS DURING CSM-DOCKED DPS BURNS (P40). THE CAPABILITY EXISTS DURING P63 AND P70 ALSO. PERFORMANCE OF FRESH START (V36E) WILL ALWAYS ENABLE THE PITCH-ROLL JETS.

++
+03
+EDIT
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(23) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM (AFTER COMPLETION OF THE IGNITION ALGORITHM) BY KEYING IN V57E (SEE LOGIC DESCRIPTION OF V57);

- (A) V06 N68
 - R1-RANGE
 - R2-TG
 - R3-DELTA H

RANGE - SLANT RANGE FROM THE LM TO THE DESIGNATED LANDING SITE. IN NAUTICAL MILES TO NEAREST .1 NM.

TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE CURRENT AIM CONDITIONS. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859. SIGN IS -.

DELTA H - THE PRESENT LR INDICATED ALTITUDE MINUS THE LGC CALCULATED ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. IN FEET TO THE NEAREST FOOT.

(NOTE: DELTA H IS INITIALLY SET TO 99999 WHERE IT WILL REMAIN UNTIL R12 CALCULATES A VALUE BASED ON LR DATA)

(24) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE OPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS ENABLED AT OPS IGNITION BY THIS PROGRAM.

(25) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT SHOULD BE SELECTED AT LEAST 20 MINUTES BEFORE THE NOMINAL TIME OF IGNITION FOR THE POWERED LANDING MANEUVER (T BRAK).

(26) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(27) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME. FOR A SUCCESSFUL LANDING, NO SLIP SHOULD BE PERMITTED.

(28) TWO ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNC'S POWERED LANDING EQUATIONS:

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+03
+EDIT
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(A) IF SUBROUTINE ROOTPSRS IN THE RG/VG CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 1406, STOP ALL VEHICLE ATTITUDE RATES, AND CONTINUE. THIS ALARM COULD ONLY OCCUR IN P63 OR P64. (NOTE: IF THIS CONDITION OCCURS BEFORE IGNITION DURING THE IGNITION ALGORITHM, THE RESULT WILL BE A P0000 ALARM, 21406).

(B) IF AN OVERFLOW OCCURS ANYWHERE IN THE LANDING EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 1410, STOP ALL VEHICLE ATTITUDE RATES AND CONTINUE. THIS ALARM COULD ONLY OCCUR IN P63, P64, P65.

(29) THIS PROGRAM ALLOWS MANUAL CONTROL OF LM ATTITUDE AND THE SELECTION OF P66. DURING P63 (AND P64 AND P65) THE ASTRONAUT CAN DISPLAY THE PGNC'S TOTAL GUIDANCE ERROR ON THE FDAI ERROR NEEDLES (ATTITUDE MON SWITCH IN PGNC'S) BY HAVING KEYED IN V62 THRU THE DSKY. HE CAN THEN STEER OUT THE PGNC'S P63 ATTITUDE ERRORS WITH THE AGS MANUALLY (GUID CNT IN AGS AND AGS MODE CONTROL IN ATT HOLD); OR WITH THE PGNC'S MANUALLY (GUID CNT IN PGNC'S AND PGNC'S MODE CONTROL IN ATT HOLD) OR AUTOMATICALLY (PGNC'S MODE CONTROL IN AUTO). THUS THERE ARE THREE ATTITUDE CONTROL SUBMODES IN P63 (AND P64 AND P65): AGS MANUAL; PGNC'S MANUAL; OR PGNC'S AUTO. A CAUTIONARY NOTE: IF THE ASTRONAUT HITS THE ROD (RATE-OF-DESCENT) SWITCH WHILE HE IS IN PGNC'S ATT HOLD, THE LGC WILL IRREVOCABLY TRANSFER HIM OUT OF THE AUTO GUIDANCE PROGRAM MODES INTO THE ROD PROGRAM MODE, P66.

(30) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

- (A) V16 N92
 - R1- THRCMD
 - R2- HCOT
 - R3- H

THRCMD- THE PERCENT THROTTLE DESIRED BY THE LGC, BASED ON THE OPS RATED THRUST OF 10,500 POUNDS. IN PERCENT

++
+03
+285
+
+
+
+
+
+
+54
+
+
+

455

+
+
+
+
+
+
+
+
+
+
+
+
+03
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TO NEAREST PERCENT. (NOTE: IN P63 MORE THRUST IS DESIRED THAN CAN BE DELIVERED BY THE DPS; THEREFORE, R1 MAY SHOW MORE THAN 100 PERCENT (WHILE THROTTLE IS AT 100 PERCENT DELIVERED). AT THROTTLE RECOVERY (THROTTLE DOWN) R1 WILL DISPLAY +00055; AT HALF-THROTTLE, R1 WILL DISPLAY +00050).

HDOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE INITIALLY DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

PROG
CONT

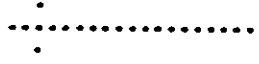
LGC

GROUND

CREW

.CREW
.PROGRAM
.SELECTION
...
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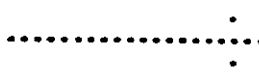
START BRAKING PHASE
PROGRAM (P63)
DISPLAY P63



KEY IN BRAKING PHASE
PROGRAM (P63)
V37E 63E

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#10

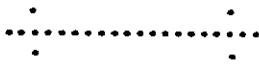


MONITOR DSKY:
OBSERVE DISPLAY OF
P63

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#20

DO IMU STATUS
CHECK ROUTINE (R02)



DO IMU STATUS
CHECK ROUTINE (R02)

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#30

SET OPS DELTA V
THRESHOLD FOR USE BY



R40

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SET DELTA V COUNTER
= 4 FOR USE BY R40

#40

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REMOVE RR TRACK
ENABLE DISCRETE FROM
THE RR.

#50

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RESET NC THROTTLE
FLAG

#60

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RESET REDESIGNATION
FLAG

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RESET LR BYPASS FLAG

#70

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SET MUNFLAG

#80

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RESET P25 FLAG

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RESET RENDEZVOUS
FLAG

#90

456

CALL IGNITION ALGO-
RITHM TO DEFINE
NOMINAL TIME OF
IGNITION (TIG) FOR
THE POWERED LANDING
MANEUVER, TIME TO GO
(TG) FROM DPS FULL
THRUST (NOMINAL TIG
+ "ZOOMTIME" SEC) TO
THE AIM CONDITIONS
(HI GATE), AND THE
THRUST VECTOR ALIGN-
MENT AT TIG.
(REFER SECTION
5.3.4 OF R567)
(NOTE: IF THE IGNI-
TION ALGORITHM DOES
NOT CONVERGE, A PRO-
GRAM ALARM (01412)
WILL RESULT.)

.GOOD ALARM.
.EXIT EXIT.

TURN ON PROGRAM
ALARM LIGHT AND
STORE ALARM
CODE 01412

N69 PROVIDES THREE-
COMPONENT CORREC-
TIONS TO THE LANDING
SITE VECTOR IN
STABLE MEMBER COOR-
DINATES. IF THE NCUN
IS LOADED BEFORE THE
IGNITION ALGORITHM,
THE CHANGE WILL BE
INCORPORATED IN THE
IGNITION ALGORITHM,
THIS INFLUENCING
LIGHT-UP TIME; IF
THE NCUN IS LOADED
BETWEEN THE IGNITION
ALGORITHM AND THE
START OF GUIDANCE,
THE CORRECTION WILL
BE INCORPORATED AT
THE START OF GUI-
DANCE; IF THE NCUN
IS LOADED AFTER THE
START OF GUIDANCE
(AT THROTTLE-UP),
THE CORRECTION WILL
BE INCORPORATED
IMMEDIATELY.
(NOTE: SINCE RLS IS
NOT CHANGED, RESEL-
ECTION OF P63 WILL
DESTROY ANY CHANGES
MADE USING THIS
TECHNIQUE.)

DOES PROGRAM ALARM
LIGHT INDICATE PRO-
GRAM ABNORMALITY?

.Y N.

#100

#110

#120

#130

#140

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STORE THE DESIRED
ATTITUDE SPECIFI-
CATION FOR USE
BY THE ATTITUDE
MANEUVER ROUTINE
(R6C).
THE FINAL ATTITUDE
WILL BE COMPUTED TO
POINT THE LM +X AXIS
IN THE INITIAL
THRUST DIRECTION.
HOWEVER, IN ORDER TO
CONSERVE RCS FUEL
AND NOT CONSTRAIN
THE NON-CRITICAL
ATTITUDE ABOUT THE
THRUST VECTOR, WINGS
MAY NOT BE LEVEL
IN THE COMPUTED
FINAL ATTITUDE.

KEY IN V05N09
AND IDENTIFY
ALARM CODE. CODE
01412 INDICATES
THAT THE IGNI-
TION ALGORITHM
WILL NOT CON-
VERGE. CREW MUST
RESPOND WITH
V96E OR NEW PRO-
GRAM SELECTION
(V37EXXE). CON-
SULT BACKUP PRO-
CEDURES.

#150

#160

#170

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HOLD FLASH VERB-NOUN TO
REQUEST RESPONSE AND
MGN DISPLAY MANEUVER
PARAMETERS COMPUTED
FOR IGNITION TIME:
V06N61
R1-TG
R2-TFI
R3-CROSSRANGE

TG-THE ESTIMATED

MONITOR DSKY:
OBSERVE VERB-
NOUN FLASH TO
REQUEST RESPONSE
AND DISPLAY OF
TG, TFI, AND CROSS-
RANGE.

#180

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458

TIME OF FLIGHT TO
THE ACCOMPLISHMENT
OF THE AIM CONDI-
TIONS (HI GATE). IN
MINS AND SECS TO
NEAREST SEC. MAX
READING IS 59859.

RESET EVENT TIMER
WITH TFI.

#190

SIGN -.
THIS VALUE WILL INI-
TIALY BE THE TIME
FROM FULL THRUST TO
HI GATE, AND WILL
REMAIN UNCHANGED
UNTIL FULL THRUST
IS COMMANDED.

#200

TFI-TIME FROM
NOMINAL OPS IGNITION
(TIG). IN MINS AND
SECS TO
NEAREST SEC. MAX
READING IS 59859.
SIGN IS - BEFORE
NOMINAL TIG, +
THEREAFTER.

#210

CROSSRANGE-
THE OUT-OF-PLANE
DISTANCE BETWEEN THE
INITIAL LM ORBITAL
PLANE AND THE PRE-
SENTLY DESIGNATED
LANDING SITE. POLAR-
ITY INDICATES THE
DESIGNATED SITE
IS NORTH (+)
OR SOUTH (-) OF THE
ORBITAL PLANE. IN
NAUTICAL MILES TO
THE NEAREST .1 NM.

#220

WAIT FOR KEY BOARD
ENTRY

KEY IN PROCEED

#230

TERMINATE FLASH UPON
RECEIPT OF PROCEED.

#240

HOLD

SNAP

FLASH VERB-NOUN TO
REQUEST PLEASE PER-
FORM IMU FINE ALIGN-
MENT:
V50 N25
R1-00014
R2-BLANK
R3-BLANK

MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM IMU
FINE ALIGNMENT.

#250

DO I WISH TO BYPASS
THE ALIGNMENT?

#260

.N .Y.

WAIT FOR KEYBOARD
ENTRY

KEY IN PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED
OR ENTER

KEY IN
ENTER

#270

.ENTER .PROCEED

SELECT PRESENT
REFSMAT (LAND-
ING SITE OR-
IENTATION DE-
FINED FOR THE

#280

460

DESIGNATED LAND-
ING SITE AND THE
NOMINAL TIME OF
LANDING(T(LAND))
AS FINAL DESIRED
IML ORIENTATION.

DO INFLIGHT FINE
ALIGN ROUTINE
(R51)

DO INFLIGHT FINE
ALIGN ROUTINE
(R51)

(NOTE: THERE ARE
A LIMITED NUMBER
OF STARS WHICH
MAY BE USED AT
THIS TIME WHEN
THE FOLLOWING
CONSTRAINTS ARE
CONSIDERED:

(A) THE SUN
ANGLE OF INCI-
DENCE (FROM
SUN/MOON LINE
TO LUNAR SUR-
FACE) BELOW
THIS POINT IN
THE TRAJECTORY
IS NEARLY 90
DEGREES.

(B) THE EDGE
OF THE AOT
FIELD OF VIEW
MUST BE AT
LEAST 15 DEG-
REES FROM THE
SUNLIT SURFACE
OF THE MOON TO
ELIMINATE
LIGHT REFLEC-
TIONS FOR SAT-
ISFACTORY STAR

#290

#300

#310

#320

#330

SIGHTING.

(C) THE MOON
SUBTENDS AN
ANGLE GREATER
THAN 140 DEG
AT THE PRESENT
ALTITUDE OF
THE LM.

#340

(D) THE EARTH
SUBTENDS AN
ANGLE OF ABOUT
2 DEG AT THE
PRESENT RANGE
OF THE LM.

(E) THE SUN
ANGLE OF INCI-
DENCE (FROM
SUN/AOT LINE
TO EXTERNAL
AOT PRISM
FACE) UPON
THE AOT MUST
BE LESS THAN
0 DEGREES
UNLESS THE AOT
IS SHADED BY
THE LM STRUCT-
URE.

#350

#360

THE ABOVE CONS-
TRAINTS, COUPLED
WITH THE DESIRA-
BILITY OF ALIGN-
ING THE IMU AS
SHORTLY BEFORE
DPS IGNITION AS
FEASIBLE, RESULT
IN A LIMITED NUM-
BER OF ACCEPTABLE
STARS. IT IS
ASSUMED THAT THE
CREW HAVE THE
IDENTIFICATION OF
TWO OR MORE OF

#370

462

THESE STARS. THE
 IDENTITY OF TWO
 OF THESE STARS
 MAY HAVE BEEN
 LOADED INTO THE
 LGC PRIOR TO
 LAUNCH BY P27,
 OR MAY BE
 LOADED DURING THE
 AUTO OPTICS POSI-
 TIONING ROUTINE
 (R52) (CALLED BY
 THE FINE ALIGN
 ROUTINE (R51)),
 OR DURING THE LGC
 UPDATE PROGRAM
 (P27).

#380

#390

#400

 COMMAND ZERO ATTITUDE ERRORS

 SET 1 DEGREE DEAD-
 BAND.

#410

#420

 DO ATTITUDE MANEUVER
 ROUTINE (R60)
 (NOTE: THE 3-AXIS
 FLAG WAS ASSUMED TO
 BE RESET BY RCC AND

 DO ATTITUDE MANEUVER
 ROUTINE (R60)

WILL NOT BE RESET
AGAIN AT THIS TIME
FOR THIS MANEUVER).

#430

IS THE LANDING RADAR
POSITION #1 DISCRETE
PRESENT?

#440

.Y .N

POSS
HOLD .
.....
SNAP .

FLASH VERB-NCUN
TO REQUEST
PLEASE PERFORM
LR DESCENT POS-
ITION SELEC-
TION:
V50N25
R1-00500
R2-BLANK
R3-BLANK

MONITOR DSKY:
DOES VERB-NCUN
FLASH TO REQUEST
PLEASE PERFORM LR
DESCENT POSITION
SELECTION?

#450

.Y .N

HAS LR BEEN
MANUALLY COMMAN-
DED TO DESCENT
POSITION?

#460

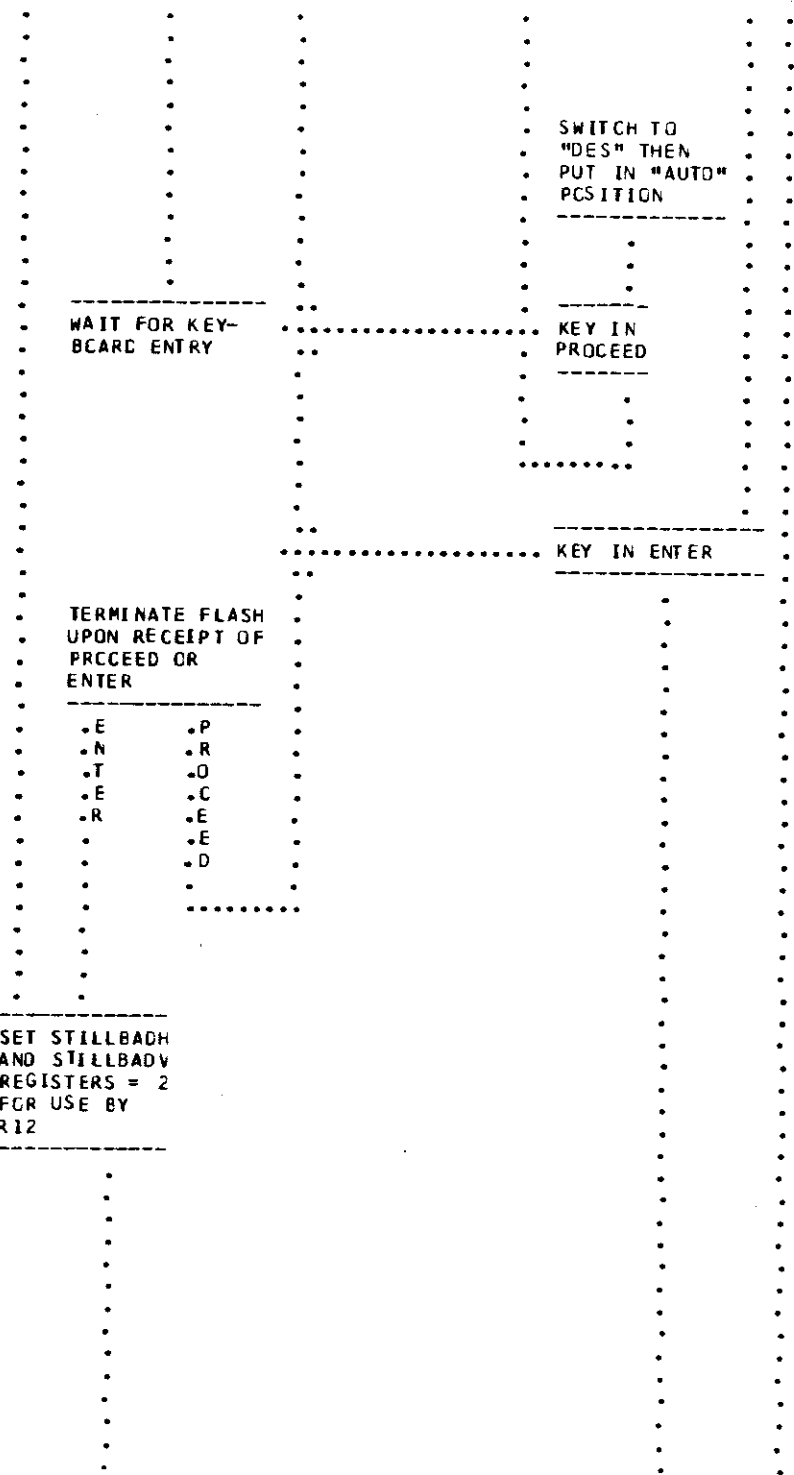
.N .Y

MOMENTARILY
PUT LDG ANT

#470

464

465



#480

#490

#500

#510

#520

SET L, M, R,
AND S COUNT-
ERS = C FOR
USE BY R12

#530

HAVE PGNS CONTROL
AND AUTO ATTITUDE
CONTROL MODES BEEN
SELECTED?

#540

.Y N.

#550

IS THE APS FLAG
SET?

.Y N.

#560

HAS THE AUTO
THROTTLE MODE
BEEN SELECTED?

.Y N.

#570

POSS
HOLD .

SNAP .

FLASH VERB-
NOUN TO RE-
QUEST PLEASE
PERFORM PGNS

MONITOR DSKY:
DOES VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM

466

467

CONTROL, AUTO
 ATTITUDE CON-
 TROL, AND AUTO
 THROTTLE MODE
 SELECTION:
 V50 N25
 R1-00203
 R2-BLANK
 R3-BLANK

PGNS CONTROL, AUTO
 ATTITUDE CONTROL,
 AND AUTO THROTTLE
 MODE SELECTION?

#580

.Y N.

HAVE REQUESTED
 MODES BEEN SELE-
 CTED?

#590

.N .Y

DO I WISH TO
 HAVE THESE
 MODES SELECTED
 DURING THE
 THRUSTING
 MANEUVER?

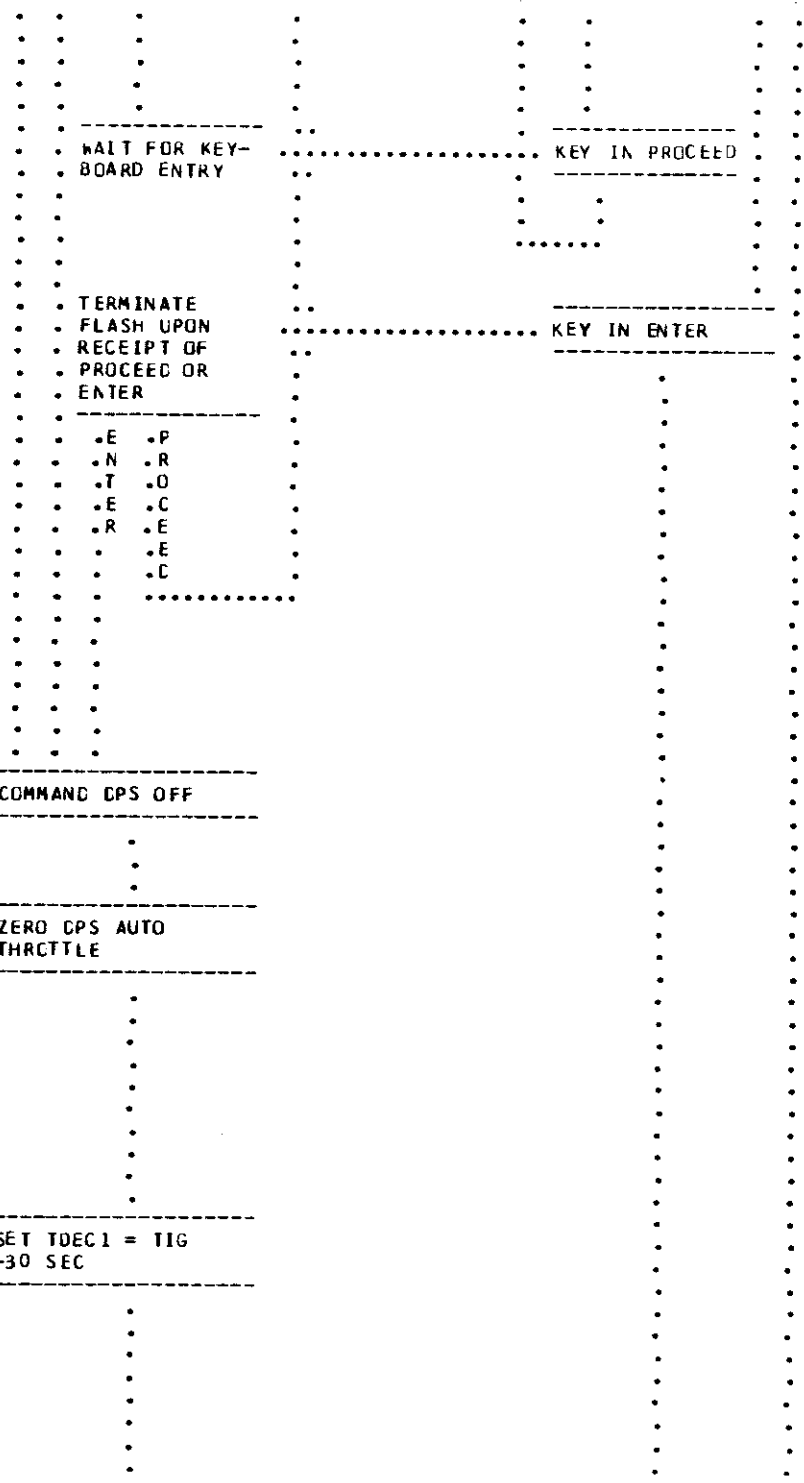
#600

.Y .N

SET GUIDANCE
 CONTROL SWITCH
 TO PGNS, ATT-
 ITUDE CONTROL
 SWITCH TO
 AUTO, AND
 THROTTLE
 SWITCH TO AUTO

#610

#620



#630

#640

#650

#660

#670

#680

468

46⁰

++
+03
+EDIT
++

INTEGRATE CSM STATE
VECTOR TO TDEC1

DO STATE VECTOR IN-
TEGRATION (MIDICAVE)
ROUTINE (R41)
(NOTE: ENTER R41 AT
"A")

.NC TIG.
.TIG SLIP.
.SLIP .
. .
. .
. .

. (NOTE: R41 WILL
. DEFINE TIG TO BE
. THE TIME TO WHICH
. R41 DID INTEGRATE
. THE LM STATE
. VECTOR PLUS 30
. SECONDS.)

CALL BLANKING OF
DSKY AT TIG-35
SEC. (SEE "A"
BELOW)

TEMP
HOLD

..... DISPLAY ON DSKY:
MON V06 N62
 R1 - VI
 R2 - TFI

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

MONITOR DSKY:
OBSERVE DISPLAY OF
VI, TFI, AND DELTA
VM.

#690

#700

#710

#720

#730

R3 - DELTA VM

VI - MAGNITUDE OF LM
INERTIAL VELOCITY
WITH RESPECT TO THE
REFERENCE COORDINATE
SYSTEM. IN FPS TO
NEAREST .1 FPS.
(NOTE: THIS DISPLAY
(R1) REMAINS CON-
STANT AT THE VALUE
APPROPRIATE TO AVER-
AGE-G INITIATION,
UNTIL TIG-30 THE
VALUE IS AN EXTRA-
POLATED VALUE GOOD
AT TIG-30.)

TFI- SEE DEFINITION
ABOVE

DELTA VM-MEASURED
DELTA V MAGNITUDE.
IN FPS TO NEAREST
.1 FPS. THIS DIS-
PLAY WILL BE 00000
UNTIL TIG-30 SEC AND
THEN SHOULD CHANGE
ONLY DUE TO PIPA
BIAS UNTIL ULLAGE IS
STARTED.

. . .
...
EXIT
(NOTE: THIS IS
NOT A P63 EXIT.
SEE "A" BELOW.)

(NOTE: IF TIG HAS
BEEN SLIPPED BY R41,
THE TFI DISPLAY (R2)
AT THIS TIME WILL BE
REFERRED TO THE NEW
TIG.)

. . .

UPDATE EVENT TIMER
IF DESIRED.

#740

#750

#760

#770

VERIFY/SET THRUST/
TRANSLATION CONTROL-
LER TO MINIMUM
THRUST POSITION.

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470

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ARM DPS. (AUTO
THROTTLE SIGNAL IS
ENABLED TO DPS AND
THRUST INDICATOR).

#780

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CHECK THRUST INDICA-
TOR (RIGHT SIDE) TO
ENSURE AUTO THROTTLE
COMMAND IS ZEROED
TO PERCENT INDICA-
TION.

#790

.Y .N

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•
•

GO TO
BACKUP
PROCED-
URES.

#800

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•

CHECK STATUS OF C/W
LAMPS

#810

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•

"A"
FROM
ABOVE

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•
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•
•

#820

BLANK THE DSKY DIS-
PLAY (V, N, R1, R2
AND R3).

.....
MONITOR DSKY:
AT TFI = -00B35
OBSERVE DSKY DISPLAY
TO GO BLANK FOR 5
SECONDS.

#830

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WAIT UNTIL TIG -30
SEC.

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#840

RETURN VC6N62
DISPLAYS

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MONITOR DSKY:
AT TFI = -00B29
OBSERVE RETURN OF
V06N62 DISPLAYS TO
INDICATE THAT
AVERAGE G INTEGRA-
TION HAS STARTED.

.....

#850

START AVERAGE G
INTEGRATION (NOTE:
THE R10/R11/R12
SERVICE ROUTINE
(RCS) AND THE DE-
SCENT STATE VECTOR
UPDATE ROUTINE (R12)
WILL BE CALLED ONCE
EVERY 2 SECONDS BY
AVERAGE G DURING
P63,P64,P65 AND
P66. HOWEVER THE
OPERATION OF R10
AND R11 IS NOT
ENABLED UNTIL
IGNITION.

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#860

++
+03
+285
++

#870

#880

472

CALL VERB 99 DISPLAY
(SEE "B" BELOW)

#940

WAIT UNTIL TIG - 0

#950

SET IGNITION FLAG

#960

IS ASTRONAUT FLAG
SET?

.Y
.
.
...
.
GO TO
"C"
BELOW

N.
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...
.
EXIT
(NOTE: THIS
IS NOT A
P63 EXIT.
REFER
DISPLAY
RESPONSE
AT "B"
BELOW).

#970

#980

"B"
FROM
ABOVE

"F"
FROM R40

474

475

HOLD .
.....
MON .

CHANGE VERB BUT MA-
INTAIN PRESENT NOUN
AND DISPLAY IN R1,
R2, AND R3, FLASH
VERB-NOUN TO REQUEST
PLEASE PERFORM ENG-
INE ON ENABLE:
V59N62

MONITOR DSKY:
AT TFI = -00805
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE

#990

#1000

MONITOR DSKY:
WAIT FOR INCREASE IN
DELTA VM INDICATING
SUFFICIENT ULLAGE.
REQUIRED ULLAGE
DELTA V IS A
FUNCTION OF VEHICLE
WEIGHT.

#1010

#1020

WAIT FOR KEYBOARD
ENTRY

SHALL I PERMIT
IGNITION?

.N .Y
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#1030

KEY IN PROCEED

TERMINATE FLASH UPON
RECEIPT OF PROCEED,
ENTER, CR TERMINATE

KEY IN
TERMINATE
V34E

#1040

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

#1050

RESET ULLAGE
FLAG

#1060

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROU-
TINE (ROO)

DO FINAL AUTO-
MATIC REQUEST
TERMINATE ROU-
TINE (ROO)

#1070

EXIT P63

EXIT P63

SET ASTRONAUT FLAG

#1080

476

IS IGNITION FLAG
SET?

.Y N.

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. RESUME STATIC
. DISPLAY OF
. VC6N62

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. EXIT
. (NOTE: THIS IS
. NOT A P63 EXIT.
. REFER TIG - 0
. LOGIC ABOVE.)

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MONITOR DSKY:
IS R2 DISPLAY OF
TFI NEGATIVE AND
NON-ZERO?

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MONITOR DSKY:
OBSERVE RE-
TURN OF STATIC
VERB-NOUN
(V06N62).

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STANDBY FOR
THRUST ON
WHEN TFI =
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#1090

#1100

#1110

#1120

#1130

RESET PULSES FLAG

#1140

TEMP
HOLD

..... CHANGE VERB-NCUN AND
MON CHANGE DISPLAY OF
TFI IN R2 TO H COT
AND DELTA VM IN R3
TO H;
V06N63
R1-VI
R2-H COT
R3-H

MONITOR DSKY:
OBSERVE VERB-NCUN
CHANGE AND CHANGE OF
TFI IN R2 TO H COT
AND DELTA VM IN R3
TO H.

#1150

VI - SEE DEFINITION
ABOVE.

#1160

H COT-THE PRESENT
RATE OF CHANGE OF
ALTITUDE (H). POL-
ARITY INDICATES DES-
CENT (-) OR ASCENT
(+). IN FPS TO NEAR-
EST .1 FPS.

H - THE PRESENT AL-
TITUDE OF THE LM
ABOVE THE LUNAR
RADIUS AT THE DESIG-
NATED LANDING SITE.
POLARITY IS + FOR
ALTITUDES GREATER
THAN THE ABOVE
RADIUS. IN FEET TO
NEAREST FOOT.

#1170

#1 180

470

.....

SET ABORT ENABLE
FLAG

#1190

.....

SET LANDING ANALOG
DISPLAYS FLAG

#1200

++
+03
+EDIT
++

.....

RESET IDLE FLAG

#1210

.....

IS IMPULSE FLAG SET?
(NOTE: ANSWER WILL
ALWAYS BE NO FOR
P63)

#1220

.N
.....

.....

RESET IGNITION FLAG

#1230

.....

RESET ASTRONAUT FLAG

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CALL FOR RESET OF
LUMINANCE FLAG

#1240

IN 0.5 SEC.

START MONITOR OF
BRAKING PHASE OF
POWERED LANDING
MANEUVER AS INCI-
CATED BY LM AND
DSKY DISPLAYS

#1250

START MONITOR OF THE
LGC/LR OPERATIGN AS
DESCRIBED IN THE
DESCENT STATE VECTOR
UPDATE ROUTINE (R12)

#1260

AT TIG (AS DEFINED
BY R41) + "ZOOMTIME"
SEC COMMAND THRATTLE
TO MAXIMUM.
(NOTE: THE VALUE
"ZOOMTIME" IS IN
ERASABLE STORAGE,
HAVING BEEN LOADED
PRIOR TO LAUNCH OR
BY P27.)

"ZOOMTIME" SECONDS
AFTER TIG (AS DEFIN-
ED BY R41) DE-
SERVE THRUST IN-
DICATOR TO INDICATE
XX PERCENT AUTO
THRATTLE COMMAND
(RIGHT SIDE) AND 100
PERCENT CHAMBER
PRESSURE (LEFT SIDE)
(NOTE: THE VALUE
"ZOOMTIME" IS IN
ERASABLE STORAGE
HAVING BEEN
LOADED PRIOR TO
LAUNCH OR BY P27).
(NOTE: IF IGNITION

#1270

#1280

CALL LANDING AUTO
MODES MONITOR

ROUTINE (R13)

HAS NOT BEEN AUTHOR-
IZED BY THE CREW
UNTIL AFTER TIG (AS
DEFINED BY R41)
+ "ZOOMTIME", THE
ENGINE WILL THROTTLE
UP AT IGNITION).

#1290

COMMENCE POWERED
LANDING GUIDANCE
TO ATTAIN BRAKING
PHASE AIM CON-
DITICNS.

SOMETIME BEFORE
ALTITUDE REACHES
30,000 FEET, YAW THE
LM TO A ROUGHLY
WINDOW-UP ORIENTA-
TION TAKING THE
ROUTE ABOUT THE
X-AXIS THAT DOES NOT
RESULT IN LOSS OF
S-BAND LOCK-ON

#1300

#1310

WHEN H IS EQUAL
TO + 30000 THE
X-AXIS OVERRIDE
OPTION IS REMOVED
BY R12. THE LGC WILL
AUTOMATICALLY COM-
MAND THE LM TO AN
ATTITUDE AROUND THE
LM X AXIS AS SPECIF-
IED BY THE GUIDANCE
EQUATIONS. THE CREW
NO LONGER HAS ANY
MANUAL ATTITUDE
CONTROL OF THE LM
WHILE IN THE AUTO
ATTITUDE CONTRL

#1320

#1330

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MODE.

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#1340

WAIT UNTIL TG
IS LESS THAN
"TENDBRAK".
(NOTE: THE VALUE
"TENDBRAK" IS IN
ERASABLE STORAGE
HAVING BEEN LOADED
PRIOR TO LAUNCH OR
BY P27).

WAIT UNTIL TG IS
LESS THAN "TENDBRAK"
(NOTE: THE VALUE
"TENDBRAK" IS IN ER-
ASABLE STORAGE HAV-
ING BEEN LOADED
PRIOR TO LAUNCH OR
BY P27).

#1350

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GO TO APPROACH PHASE
PROGRAM (P64)

GO TO APPROACH PHASE
PROGRAM (P64)

#1360

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EXIT P63

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EXIT P63

#1370

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 13,30,31
LOGIC REV 01 PCR 65,86,118,144,164,186,234,246,253,401,419,437,
497,529,542,568,637
LOGIC REV 00(ILLUM 1A) PCR 670, 737, 751
REVS 01,C2(LUM 1B) PCR 814,838,841,854, EDITORIAL
REV 03(LUM 1C) PCR 285, EDITORIAL

APPROACH PHASE PROGRAM (P64)

REV 02 12/03/69

PURPOSE :

- (1) TO CONTROL THE PGCS DURING THE THRUSTING OF THE POWERED LANDING MANEUVER BETWEEN HI GATE AND LO GATE.
- (2) TO CONTROL THE DPS THRUST AND ATTITUDE BETWEEN HI GATE AND LO GATE.
- (3) TO PROVIDE THE CREW WITH THE CAPABILITY OF REDESIGNATING THE LANDING SITE TO WHICH THE PGCS IS GUIDING THE LM.
- (4) TO SELECT P65 AUTOMATICALLY WHEN TC IS LESS THAN TENDAPPR (TIME-TO-END-APPROACH-PHASE).

ASSUMPTIONS :

- (1) THE LM IS ON THE POWERED LANDING DESCENT BETWEEN HI GATE AND LO GATE (SEE BRAKING PHASE PROGRAM (P53), AND SECTION 5.3.4 OF R567).
- (2) THE CSM IS IN A NEAR CIRCULAR ORBIT AROUND THE MOON AT A NOMINAL ALTITUDE OF 60 NAUTICAL MILES. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.
- (3) THE IMU IS ON AND ACCURATELY ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING (T(LAND)). THE MOST RECENT IMU ALIGNMENT TOOK PLACE DURING THE BRAKING PHASE PROGRAM (P63) PRIOR TO DPS IGNITION.
- (4) THE LANDING RADAR (LR) IS ON, CHECKED OUT, AND SHOULD HAVE BEEN PROVIDING TO THE LGC VELOCITY AND RANGE INFORMATION WITH RESPECT TO THE MOON. THIS INFORMATION SHOULD HAVE BEEN INCORPORATED INTO THE LM STATE VECTOR. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) WHICH IS ALREADY IN PROCESS.
- (5) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.
- (6) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.
- (7) THE AIM CONDITIONS (LO GATE) FOR THE APPROACH PHASE ARE STORED IN THE LGC.
- (8) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED IN THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.
 - (A) THE LM STATE VECTOR. THE LGC HAS UPDATED THIS AS REQUIRED DURING THRUSTING. NO FURTHER STATE VECTOR UPDATES FROM ANY SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.
- (9) THE DPS IS NOT THROTTLEABLE OVER THE WHOLE RANGE FROM 0 TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS ABOUT 10 PERCENT) AND THE PGCS COMMANDED SETTING.

THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN AUTO (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGCS COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC .

NOMINALLY, IF THE APPROACH PHASE PROGRAM IS COMPLETED WITHOUT ANY REDESIGNATION OF THE LANDING SITE (SEE ASSUMPTION (12)), THE THROTTLE WILL REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE THROUGHOUT THE PHASE. EXCESSIVE TARGET REDESIGNATIONS DURING THIS PROGRAM HOWEVER MAY RESULT IN REQUIRED THROTTLE EXCURSIONS OUTSIDE THE ALLOWABLE RANGE. IN SUCH CASES THE LGC WILL COMMAND MAXIMUM THROTTLE FOR AT LEAST 2 SEC, AND UNTIL THE REQUIRED THROTTLE SETTING RETURNS TO THE PERMITTED THROTTLE REGION.
- (10) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION. SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE MANEUVER.

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THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH IS ALREADY IN PROCESS.

(11) THE X-AXIS OVERRIDE OPTION IS NOT PROVIDED THE CREW WHENEVER THE LGC-ESTIMATED ALTITUDE IS LESS THAN 30,000 FT. (REFER R12 AND ASSUMPTION 13 OF P63).

(12) DURING MOST OF THE APPROACH PHASE, THE LGC PROVIDES THE CREW THE OPTION TO REDESIGNATE THE LANDING SITE TO WHICH THE PGNC'S IS GUIDING THE LM. THIS OPTION IS CALLED THE LANDING POINT DESIGNATOR (LPD) MODE. IT IS WORTH NOTING THAT THE PGNC'S MODE CONTROL SWITCH MUST BE IN AUTO FOR THE ACA TO FUNCTION AS A LANDING SITE RE-DESIGNATOR. IF THIS SWITCH IS IN ATT HOLD THE ACA FUNCTIONS AS A RATE COMMAND/ATTITUDE HOLD STICK.

THE LANDING POINT REDESIGNATION, IF EXERCISED, IS BASED UPON VISUAL ASSESSMENT OF THE LUNAR TERRAIN WITH RESPECT TO THE PRESENTLY DESIGNATED LANDING SITE. DURING THE LPD MODE THE PRESENT LANDING SITE IS DISPLAYED ON THE DSKY IN TERMS OF COORDINATES ON THE LPD SIGHTING GRID ON THE LEFT HAND LM WINDOW (LPD ANGLE). LANDING SITE REDESIGNATIONS ARE MANUALLY PUT INTO THE COMPUTER VIA THE ATTITUDE CONTROLLER ON AN INCREMENTAL BASIS, I.E.: A LIMIT SWITCH ACTUATION IN THE ATTITUDE CONTROLLER CAUSES THE LGC TO REDESIGNATE THE LANDING SITE A FIXED ANGULAR INCREMENT (1/2 DEGREE IN ELEVATION, 2 DEGREES IN AZIMUTH) FROM THE PRESENT LM/LANDING SITE LOS. THE APPLICABLE ATTITUDE CONTROLLER POLARITIES ARE:

- (A) - PITCH ROTATION GIVES - LPD ELEVATION (NEW SITE BEYOND PRESENT SITE)
- (B) + PITCH ROTATION GIVES + LPD ELEVATION (NEW SITE SHORT OF PRESENT SITE)
- (C) + ROLL ROTATION GIVES + LPD AZIMUTH (NEW SITE TO RIGHT OF PRESENT SITE)
- (D) - ROLL ROTATION GIVES - LPD AZIMUTH (NEW SITE TO LEFT OF PRESENT SITE)

THE LPD MODE IS MORE COMPLETELY DESCRIBED IN SECTION 5.3.4 OF R567.

(13) THE INITIAL MANEUVER OF THE APPROACH PHASE IS THE LM ATTITUDE TRANSITION FROM THE LM ATTITUDE AT THE START OF P64 TO A SATISFACTORY ATTITUDE FOR LANDING SITE VISIBILITY. AFTER THE COMPLETION OF THIS MANEUVER THE LM ATTITUDE IS CONSTRAINED BY THRUST POINTING REQUIREMENTS AND IS CONTROLLED ABOUT THE THRUST AXIS SO AS TO MAINTAIN THE CURRENT LANDING SITE IN THE LM X/Z PLANE. THE CONDITIONS ACHIEVED BY THE START OF P64 SHOULD BE SUCH THAT THE THRUST POINTING REQUIREMENTS OF THE APPROACH PHASE WILL YIELD SATISFACTORY VISIBILITY AND RADAR ORIENTATIONS.

THE LANDING SITE BECOMES VISIBLE TO THE COMMAND PILOT IF THE LOOK ANGLE (THE ANGLE BETWEEN THE LM -X AXIS AND THE LOS TO THE LANDING SITE) IS LESS THAN 65 DEGREES AND THE LOS IS IN OR NEAR THE LM X/Z PLANE.

AT ANYTIME DURING P63, P64 OR P65, THE MAGNITUDE OF THE LOOK ANGLE AND THE ORIENTATION OF THE LOOK ANGLE PLANE (THAT PLANE CONTAINING THE LOS AND THE LM X AXIS) ARE DEFINED BY THE INERTIAL ORIENTATION OF THE LM X AXIS AND THE POSITION OF THE LM WITH RESPECT TO THE LANDING SITE.

THE INERTIAL ORIENTATION OF THE LM X AXIS IS CONTROLLED BY REQUIREMENTS OF THRUST VECTOR CONTROL. THE ORIENTATION OF THE LM WINDOWS WITH RESPECT TO THE LOOK ANGLE PLANE IS CONTROLLED BY ROTATION OF THE VEHICLE ABOUT THE LM X AXIS. THIS CONTROL IS EXERCISED AS SHOWN IN SECTION 5.3.4 OF R567.

(14) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R10) WHICH IS ALREADY IN PROCESS.

(15) THE RATE OF DESCENT (ROD) MODE IS NOT ENABLED DURING THIS PROGRAM (SEE LANDING PHASE (RCD) PROGRAM (P66), ASSUMPTION (12) FOR DEFINITION OF RCD MODE).

(16) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE DESCENT ORBIT INJECTION, THE DESCENT COAST, OR THE POWERED DESCENT (P63), (P64), (P65), OR (P66).

FOR ABORTS FROM THE DESCENT ORBIT INJECTION OR THE DESCENT COAST IT IS ASSUMED THAT SUFFICIENT TIME EXISTS TO PERFORM A TPI MANEUVER (SEE TERMINAL PHASE INITIATION (TPI) PROGRAM (P34)) TO INTERCEPT THE CSM DIRECTLY.

FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS NOMINALLY COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).

DURING THE POWERED LANDING MANEUVER THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND THE ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT

PROGRAM (P70) OR APS ABORT PROGRAM (P71)). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4.3 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH IS ALREADY IN PROCESS.

++ (17) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN
+02 AUTC, THE PGNS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND
+EDIT VEHICLE ATTITUDE RATES (SEE ASSUMPTION (19)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW
+ AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS.
+ THIS MANUAL CONTROL WILL IN THE RATE COMMAND/ATTITUDE HOLD MODE.
+ IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN
+ ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS
+ FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER
+ THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED
+ THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS
+ 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12,P40,P41,P42,P63,P70,P71
+ AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST
+ ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNS WILL NOT BE RESPONSIBLE
+02 IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
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(18) CONTROL OF THE LM DPS, RCS, AND APS IS TRANSFERRED FROM THE PGNS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME DURING THIS PROGRAM BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).

IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR AND THE DESIRED ATTITUDE ERRORS, HOWEVER THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(19) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

++ MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S
+02 ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
+EDIT MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY
+ MANEUVERING THE VEHICLE.
+ PGNS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
+ MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS
+ INDICATED IN ASSUMPTION (17) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. FOR A
+ MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6.
+02
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(20) THE LOAD CAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THE START OF THE POWERED LANDING MANEUVER AND SHOULD NOT BE REQUIRED DURING THIS PROGRAM.

(21) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R4C). THIS ROUTINE IS IN EFFECT DURING THIS PROGRAM, HAVING BEEN ENABLED BY P63.

(22) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE BRAKING PHASE PROGRAM (P63) WHEN TG DURING THE PHASE BECOMES LESS THAN TENDBRAK (TIME-TO-END-BRAKING-PHASE).

(23) TWO ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNC'S POWERED LANDING EQUATIONS:

(A) IF SUBROUTINE ROOTPSRS IN THE TIME-TO-GO CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 1406, STOP ALL VEHICLE ATTITUDE RATES, AND CONTINUE. THIS ALARM COULD OCCUR ONLY IN P63 AND P64.

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+02
+EDIT
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(B) IF AN OVERFLOW OCCURS ANYWHERE IN THE LANDING EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 1410, STOP ALL VEHICLE ATTITUDE RATES AND CONTINUE. THIS ALARM COULD ONLY OCCUR IN P63, P64, OR P65.

(24) THIS PROGRAM ALLOWS MANUAL CONTROL OF THE LM ATTITUDE. IF MANUAL CONTROL IS DESIRED, PUT THE MODE CONTROL SWITCH IN ATT HOLD AND USE THE ACA TO CONTROL THE LM ATTITUDE.

IF P66 IS DESIRED, CLICK THE ROD SWITCH WHILE THE MODE CONTROL SWITCH IS IN ATT HOLD. THE ACA DOES NOT RE-DESIGNATE THE LANDING SITE WHILE THE MODE CONTROL SWITCH IS IN ATT HOLD. TO USE THE ACA TO RE-DESIGNATE THE LANDING SITE, PUT THE MODE CONTROL SWITCH IN AUTO AND ROTATE THE ACA IN THE DESIRED DIRECTION. ONCE CONTROL IS TRANSFERRED FROM P64 TO P66, P64 CANNOT BE RE-ENTERED.

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+02
+EDIT
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+02
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(25) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM (AFTER COMPLETION OF THE IGNITION ALGORITHM) BY KEYING IN V57E; (SEE LGC DESCRIPTION OF V57)

(A) V06 N68
R1-RANGE
R2-TG
R3-DELTA H

RANGE - SLANT RANGE FROM THE LM TO THE DESIGNATED LANDING SITE. IN NAUTICAL MILES TO NEAREST .1 NM.

TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE CURRENT AIM CONDITIONS. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859. SIGN IS -.

DELTA H - THE PRESENT LR INDICATED ALTITUDE MINUS THE LGC CALCULATED ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. IN FEET TO THE NEAREST FOOT.

(NOTE: DELTA H IS INITIALLY SET TO 99999 WHERE IT WILL REMAIN UNTIL R12 CALCULATES A VALUE BASED ON LK DATA).

(26) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

(A) V16 N92
R1 - THRCD
R2 - HCDT
R3 - H

THRCD - THE PERCENT THROTTLE DESIRED BY THE LGC, BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT.

HCDT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE INITIALLY DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

++
+02
+285
+
+
+
+
+
+02
++

PROG LGC GROUND CREW

130 SECONDS IS
DISPLAYED AS 99.
(NOTE: TR IS A
POSITIVE NUMBER
EQUAL TO:
-TG-(TCGFAPR+4),
WHERE TCGFAPR IS
THE TIME-TC-GC AT
WHICH ERECTION OF
THE GUIDANCE CO-
ORDINATE FRAME IS
SUSPENDED.)

#100

LPD-THE ANGLE BE-
LOW THE LM +Z
AXIS TO THE LOS
TO THE PRESENTLY
DESIGNATED LAND-
ING SITE. IN DE-
GREES TO NEAREST
DEGREE.

#110

(NOTE: THE DISPLAY
IN R1 APPEARS AS
XXYY WHERE: XX IS
TR AND YY IS LPD).

#120

H DOT - THE PRESENT
RATE OF CHANGE OF
ALTITUDE (H). POLAR-
ITY INDICATES DES-
CENT (-) OR ASCENT
(+). IN FT/SEC TO
NEAREST .1 FT/SEC.

#130

H - THE PRESENT
ALTITUDE OF THE LM
ABOVE THE LUNAR
RADIUS AT THE INIT-
IALLY DESIGNATED
LANDING SITE.
POLARITY IS + FOR
ALTITUDES GREATER
THAN THE ABOVE
RADIUS. IN FEET TO
NEAREST FOOT.

#140

#150

DO I WISH TO
EXERCISE THE LPD
CAPABILITY?

.Y .N

WAIT FOR KEYBOARD
ENTRY OR FOR TR=0

KEY IN
PROCEED

#160

TERMINATE FLASH
UPON RECEIPT OF
PROCEED OR CHANGE TO
NON-FLASHING DISPLAY
IF TR=0

#170

.P .TR=C
.R
.G
.C
.E
.E
.D

CONTINUE
POWERED
LANDING
GUIDANCE
USING P64
AIM
CONCITICNS
REFERRED
TO THE
PRESENTLY
DESIGNATED
LANDING

#180

#190

491

SITE.

CALCULATE
LPD FOR
THE PRE-
SENTLY DE-
SIGNATED
LANDING
SITE.

#200

TEMP
HOLD

MON

DISPLAY ON
DSKY:
V06N64
R1-TR/LPD
R2-H DOT
R3-F

NOTE: FOR
DEFINITIONS,
SEE ABOVE

USING LPD
(R1) AND THE LPD
SCALE ON THE COM-
MAND PILOT'S WIN-
DOW OBSERVE THE
PRESENTLY
DESIGNATED
LANDING SITE.

#210

USING THE ATT I-
TUDE CONTROLLER
REDESIGNATE THE
LANDING SITE.
THIS WILL INCRE-
MENT THE APPRO-
PRIATE REDESIGNA-
TION COUNTER IN
THE LGC.
OBSERVE THE
FOLLOWING GROUND
RULES:

#220

(A) SITE REDESIC-
NATION TOWARDS
THE LM (+ PITCH
ROTATION) WILL
REDUCE THIS SITE
VISIBILITY CLEAR-
ANCE WHICH IS

#230

ORIGINALLY ONLY
10 DEGREES.

#240

(B) LARGE REDESIGNATIONS SHOULD BE MADE AS EARLY IN THE APPROACH PHASE AS POSSIBLE TO CONSERVE FUEL AND MINIMIZE ATTITUDE TRANSIENTS.

#250

(C) WHEN TR IS EQUAL TO 0 SEC THE LGC WILL NO LONGER RESPOND TO LPD REDESIGNATIONS.

IS TR = 0?

.N .Y

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+02
+968
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+
+02
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(NOTE: DISPLAYED LPD ANGLES AND VEHICLE YAW MAY BE BIASED TO MAKE UP FOR ERRORS IN THE ALIGNMENT OF THE LPD RETICLE AND FOR WINDOW BENDING WHEN THE LM IS PRESSURIZED. THAT PART OF WINDOW ERROR WHICH CANNOT BE RESOLVED INTO ROTATIONS ABOUT THE BODY Y AND X AXES WILL REMAIN UNCOMPENSATED, EXCEPT AT A CHOSEN SPOT ALONG THE RETICLE- THE MEAN LPD ANGLE OF THE APPROACH PHASE).

#260

#270

#280

493

++
+02
+EDIT
+
+
+02
++

ZERO AZI-
MUTH AND
ELEVATION
RECESIG-
NATION REG-
ISTERS

#290

SET RECES-
IGNATION
FLAG

#300

HAVE ANY MANU-
AL LPD CCMANDS
BEEN ISSUED
SINCE THE LAST
PASS?

#310

.N Y.

WAIT 2 SEC

#320

USING PERTUR-
BATION EQA-
TIONS AND LPD
CCMANDS ACCU-
MLATED SINCE
LAST PASS,
CCMPUTE POSIT-

#330

ION OF NEW AIM
POINT. (REFER
TO SECTION
5.3.4 OF R567
FOR DETAILED
DESCRIPTION)

#340

TRANSFER AIM
CONDITIONS TO
NEW AIM POINT.

#350

ZERO THE
REDESIGNATION
COUNTER

#360

WAIT 2 SEC

#370

RESET REDESIGNATION
FLAG

#380

WAIT FOR TG TC BE
LESS THAN TENDAPPR

495

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GO TO LANDING PHASE
{ALTC} PROGRAM (P65).

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EXIT P64

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GO TO LANDING PHASE
{AUTO} PROGRAM (P65)

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EXIT P64

#390

#400

CHANGE CONTROL NOTES

REV 00 PCR 31
REV 01 PCR 85,164,246,542
REV 00(LUM 1A) PCR 670,737,751
REV 01(LUM 1B) PCR 838,840,841, EDITORIAL
REV 02(LUM 1C) PCR 285,968, EDITORIAL

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LANDING PHASE (AUTO) PROGRAM (P65)

REV 02 12/03/69

PURPOSE:

(1) TO CONTROL THE PGNC'S DURING THE THRUSTING OF THE POWERED LANDING MANEUVER FROM THE PERIOD IMMEDIATELY AFTER COMPLETION OF THE APPROACH PHASE AIM CONDITIONS (LO GATE) UNTIL TOUCHDOWN ON THE LUNAR SURFACE.

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+02

ASSUMPTIONS:

(1) THE LM IS ON THE POWERED LANDING DESCENT HAVING JUST ARRIVED AT THE LO GATE CONDITIONS (SEE APPROACH PHASE PROGRAM (P64) AND SECTION 5.3.4 OF R567).

+EDIT

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(2) THE CSM IS IN A NEAR CIRCULAR ORBIT AROUND THE MOON AT A NOMINAL ALTITUDE OF 60 NAUTICAL MILES. THE CSM'S POSITION WITH RESPECT TO THE LM IS APPROXIMATELY 0 DEGREES CENTRAL ANGLE ABOVE THE LM. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.

(3) THE IMU IS ON AND ACCURATELY ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING (T(LAND)). THE MOST RECENT IMU ALIGNMENT (FINE) TOOK PLACE DURING THE BRAKING PROGRAM (P63) PRIOR TO CPS IGNITION.

(4) THE LANDING RADAR (LR) IS ON, CHECKED OUT, AND SHOULD HAVE BEEN PROVIDING TO THE LGC VELOCITY AND RANGE INFORMATION WITH RESPECT TO THE MOON. THIS INFORMATION SHOULD HAVE BEEN INCORPORATED INTO THE LM STATE VECTOR. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) WHICH IS ALREADY IN PROCESS.

(5) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(6) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.

(7) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED IN THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.

(A) THE LM STATE VECTOR. THE LGC HAS UPDATED THIS AS REQUIRED DURING THRUSTING. NO FURTHER STATE VECTOR UPDATES FROM ANY SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.

(8) THE DPS IS NOT THROTTLEABLE OVER THE WHOLE RANGE FROM 0 PERCENT TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS. I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS ABOUT 10 PERCENT) AND THE PGNC'S COMMANDED SETTING.

THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN AUTO (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGNC'S COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC. NOMINALLY THE THROTTLE WILL REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE THROUGHOUT THIS PROGRAM.

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+02

+285

(9) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "AUTO STABILIZATION" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION.

SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE MANEUVER.

+02

THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH IS

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(10) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNC'S ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNC'S DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW EXCEPT WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE. THUS THE OPTION IS NOT INHIBITED BY THIS PROGRAM.

(11) THE LPD OPTION IS NOT PROVIDED THE CREW DURING THIS PROGRAM.

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+02
+EDIT
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(12) THE INITIAL MANEUVER OF THE AUTO LANDING PHASE IS THE LM ATTITUDE TRANSIENT FROM THE LM ATTITUDE AT LO GATE TO THE HOVER ATTITUDE (LM X AXIS ALONG THE LOCAL VERTICAL). THE FINAL DESIGNATED LANDING SITE REMAINS IN THE LM X/Z PLANE DURING THIS TRANSIENT.

THE LM ALTITUDE RATE IS MAINTAINED AT A CONSTANT RATE UNTIL TOUCHDOWN (NORMALLY 3 FT/SEC DOWNWARD).

(13) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R1C) WHICH IS ALREADY IN PROCESS.

(14) THE RATE OF DESCENT (ROD) MODE IS NOT ENABLED DURING THIS PROGRAM (SEE LANDING PHASE (ROD) PROGRAM (P66), FOR DEFINITION OF ROD MODE).

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+02
+285
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(15) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE DESCENT ORBIT INJECTION, THE DESCENT COAST, OR THE POWERED DESCENT (P63), (P64), (P65), OR (P66).

FOR ABORTS FROM THE DESCENT ORBIT INJECTION OR THE DESCENT COAST IT IS ASSUMED THAT SUFFICIENT TIME EXISTS TO PERFORM A TPI MANEUVER (SEE TERMINAL PHASE INITIATION (TPI) PROGRAM (P34)) TO INTERCEPT THE CSM DIRECTLY.

FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).

DURING THE POWERED LANDING MANEUVER, THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4.3 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH IS ALREADY IN PROCESS.

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+02
+EDIT

(16) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (18)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71 AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

+02
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(17) CONTROL OF THE LM DPS, RCS AND APS IS TRANSFERRED FROM THE PGNS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47). IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR AND THE DESIRED ATTITUDE ERRORS, HOWEVER THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(18) THE PGNS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

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+02
+EDIT
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+02
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MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60. MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. WITH THE EXCEPTIONS INDICATED IN ASSUMPTION (16) ABOVE, DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6.

(19) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THE START OF THE POWERED LANDING MANEUVER AND SHOULD NOT BE REQUIRED DURING THIS PROGRAM.

(20) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS IN EFFECT DURING THIS PROGRAM UNTIL P68 SELECTION (VIA R00), HAVING BEEN ENABLED BY P63.

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+02
+EDIT
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+02
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(21) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE APPROACH PHASE PROGRAM (P64) AT THE COMPLETION OF THE LO GATE AIM CONDITIONS-TG LESS THAN TENDAPPR (TIME-TO-END-APPROACH-PHASE).

(22) TWO ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNCS POWERED LANDING EQUATIONS:

(A) IF SUBROUTINE ROOTPSRS IN THE RG/VG CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 21406 AND GO IMMEDIATELY TO THE FINAL AUTOMATIC REQUEST TERMINATE ROUTINE (R00). THIS ALARM COULD ONLY OCCUR IN P63 DURING IGNITION COMPUTATIONS.

(B) IF AN OVERFLOW OCCURS ANYWHERE IN THE LANDING EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 1410, STOP ALL VEHICLE ATTITUDE RATES AND CONTINUE. THIS ALARM COULD OCCUR IN P63, P64, OR P65.

(23) THIS PROGRAM ALLOWS MANUAL CONTROL OF LM ATTITUDE AND THE SELECTION OF P66. DURING P65 (AND P63 AND P64) THE ASTRONAUT CAN DISPLAY THE PGNCS TOTAL GUIDANCE ERROR ON THE FDAI ERROR NEEDLES (ATTITUDE MON SWITCH IN PGNCS) BY HAVING KEYED IN V62 THRU THE DSKY. HE CAN THEN STEER OUT THE PGNCS P63 ATTITUDE ERRORS WITH THE AGS MANUALLY (GUID CONT IN AGS AND AGS MODE CONTROL IN ATT HOLD); OR WITH THE PGNCS MANUALLY (GLID CONT IN PGNCS AND PGNCS MODE CONTROL IN ATT HOLD) OR AUTOMATICALLY (PGNCS MODE CONTROL IN AUTO). THUS THERE ARE THREE ATTITUDE CONTROL SUBMODES IN P65 (AND P63 AND P64): AGS MANUAL; PGNCS MANUAL; OR PGNCS AUTO.

A CAUTIONARY NOTE: IF THE ASTRONAUT HITS THE ROD (RATE-OF-DESCENT) SWITCH WHILE HE IS IN PGNCS ATT HOLD, THE LGC WILL IRREVOCABLY TRANSFER HIM OUT OF THE AUTO GUIDANCE PROGRAM MODES INTO THE ROD PROGRAM MODE (P66).

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+02
+285
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+02
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(24) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

(A) V16 N92
R1-THRCMD
R2-HDOT
R3-H

THRCMD-THE PERCENT THROTTLE DESIRED BY THE LGC BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT.

HDOT-THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H-THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE INITIALLY DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

PROG

LGC

GROUND

CREW

CONT

	.LGC		
	.PROGRAM		
	.SELECTION		
	.		
	.		
	.		
	.---		
	START LANDING PHASE	. MONITOR DSKY:	
	(AUTC) PROGRAM OBSERVE DISPLAY	#10
	(P65). DISPLAY P65	. OF P65	
	.---	.---	
	.	.	
	.	.	
	.---	.---	
	RESET X-AXIS OVER-		
	RIDE INHIBIT FLAG		#20
	.	.	
	.	.	
	.	.	
	.---	.---	
HOLD			
.....	FLASH VERB-NOUN TO	. MONITOR DSKY:	
MON	REQUEST RESPONSE AND OBSERVE VERB-NOUN	
.	DISPLAY ON DSKY:	. FLASH TO REQUEST RE-	
++	VC6 N60	SPONSE AND DISPLAY	
+02	R1-FORVEL	OF FORVEL, H DOT	#30
+882	R2-H DOT	AND H.	
+	R3-H	(NOTE: THIS DISPLAY	
+		WILL CONTINUE FLASH-	
+		ING TO ALLOW THE	
+	FORVEL-THE FORWARD	ASTRONAUT TO ZERO	
+	COMPONENT OF THE	ATTITUDE ERRORS ON	
+	HORIZONTAL VELOCITY	THE LUNAR SURFACE	
+	OF THE VEHICLE WITH	AS OFTEN AS	
+	RESPECT TO THE MOON,	DESIRED).	
+	WHICH IS ESSENTIALLY	.---	
+	PARALLEL TO THE X-Z	.	#40
+	PLANE OF THE VEHICLE	.	
+	(FOR SMALL PITCH	.	
+02	DISPLACEMENTS).	.	
++	IN FPS TO NEAREST	.	
	.1 FPS.	.	
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501

H DOT-THE PRESENT
RATE OF CHANGE OF
ALTITUDE (H). POLA-
RITY INDICATES DES-
CENT (-) OR ASCENT
(+). POLARITY IS
NOMINALLY - DURING
THIS PROGRAM. IN FPS
TC NEAREST .1 FPS

#50

H-THE PRESENT ALTI-
TUDE OF THE LM ABOVE
THE LUNAR RADIUS AT
THE INITIALLY DESIG-
NATED LANDING SITE.
POLARITY IS + FOR
ALTITUDES GREATER
THAN THE ABOVE
RADIUS. IN FEET TO
NEAREST FOOT.

#60

MONITOR FDAI AND OUT
THE WINDOW:
OBSERVE ATTITUDE
TRANSIENT TO BRING
LM TO LOCAL VERTICAL
ATTITUDE WITH LM +Z
AXIS DOWNRANGE.

#70

START AUTOMATIC DES-
CENT. NULL THE HORI-
ZONTAL VELOCITY RE-
LATIVE TO THE
SURFACE AND MAINTAIN
RATE OF DESCENT AT 3
FEET PER SECOND.

MONITOR AUTOMATIC
DESCENT USING ALL
PGNCS AND LM DIS-
PLAYS AND OUT THE
WINDOW REFERENCES
AS DESIRED.
OBSERVE H DOT
TO BE -00030.
THIS PROGRAM DOES
NOT ALLOW MANUAL

#80

#90

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+02
+EDIT
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+
+02
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+02
+285
+02
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CONTROL OF LM ATTITUDE OR THROTTLE.

IF MANUAL ATTITUDE CONTROL IS DESIRED PUT ATTITUDE CONTROL MODE SWITCH IN ATTITUDE HOLD.

THE LGC WILL AUTOMATICALLY SELECT LANDING PHASE (ROD) PROGRAM (P66) AND MAINTAIN THE PRESENT RATE OF DESCENT AND PRESENT LM ATTITUDE. ATTITUDE AND RATE OF DESCENT MAY THEN BE MODIFIED BY MANUAL CONTROL. THE MODE II ATTITUDE ERROR NEEDLES WILL CONTINUE TO DISPLAY THE LAST ERROR WHEN EXIT WAS MADE FROM P65.

#100

#110

IF MANUAL THROTTLE CONTROL IS DESIRED, ADVANCE THRUST/TRANSLATION CONTROLLER UNTIL LGC CONTRIBUTION TO TOTAL THRUST IS ZERO (THRUST INDICATOR-RIGHT SIDE), AND PUT THROTTLE CONTROL IN MANUAL. THE LGC WILL MAINTAIN THE PRESENT LM INERTIAL ATTITUDE. THROTTLE CONTROL WILL REVERT TO THE LEVEL COMMANDED BY THE THRUST/TRANSLATION CONTROLLER.

#120

#130

RATE OF DESCENT MAY THEN BE MODIFIED BY MANUAL THROTTLE CONTROL. LM ATTITUDE

#140

503

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+02
+285
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WILL REMAIN INERTIA-
LLY FIXED UNLESS
MANUAL ATTITUDE
CONTROL IS EXERCISED
HOWEVER MANUAL ATT-
ITUDE CONTROL CAN-
NOT BE EXERCISED
UNLESS THE ATTITUDE
CONTROL MODE SWITCH
IS IN ATTITUDE
CONTROL.

#150

ONCE THIS PRO-
GRAM IS EXITED IT
MAY NOT BE RETURNED
TO FROM P66.

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#160

MONITOR DSKY:
WHEN H IS
APPROXIMATELY XX FT
OBSERVE TRACKER FAIL
LIGHT TO COME ON
INDICATING THAT LR
IS NO LONGER RETURN-
ING GOOD DATA.

#170

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MONITOR DSKY:
WHEN ACTUAL ALTI-
TUDE IS APPROXI-
MATELY 4.4 FT,
OBSERVE LUNAR
CONTACT LIGHT TO
COME ON INDICATING
THAT THE PROBE(S) ON
THE LM LANDING GEAR
HAVE MADE CONTACT

#180

WITH THE LUNAR SUR-
FACE.

#190

PUSH ENGINE STOP
SWITCH TO TERMINATE
DPS THRUST

#200

WITH MODE CONTRCL
SWITCH IN "ATT
HOLD", KEY IN PRO-
CEED OR V32E (TC
COMMAND ZERO ATTI-
TUDE ERRORS AND
RATES. THIS WILL
PREVENT RCS JET FIR-
INGS ON THE LUNAR
SURFACE UNTIL P68
PLACES THE DAP IN
THE MINIMUM IMPULSE
MODE)

#210

CHECK THRUST INDICA-
TOR (LEFT SIDE) TO
INDICATE 0 PERCENT
CHAMBER PRESSURE.

#220

STANDBY ABORT STAGE
PUSHBUTTON IN CASE
LM STARTS TO TIP
OVER WHILE LANDING.

#230

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+02
+EDIT
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+02
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524

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505

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+02
+EDIT

WAIT FOR KEYBOARD
ENTRY

AM I FINISHED WITH
THE DISPLAY?

.N .Y

KEY IN TERMINATE

TERMINATE FLASH UPON
RECEIPT OF V37E68E

WHEN LANDING HAS
BEEN SUCCESSFULLY
COMPLETED, KEY IN
V37E68E TO SELECT
THE LANDING CON-
FIRMATION PROGRAM
(P68).

.P .V .T .V
.R .3 .E .3
.O .2 .R .7
.C .E .M .E
.E . .I .6
.E . .N .8
.D . .A .E

COMMAND
ZERO AT-
TITUDE
ERRORS

COMMAND
ZERO

#240

#250

#260

#270

#280

LANDING PHASE (ROD) PROGRAM (P66)

REV 02 12/03/69

- PURPOSE:
- (1) TO MODIFY THE RATE OF DESCENT OF THE LM (WITH RESPECT TO THE LUNAR SURFACE) IN RESPONSE TO ASTRONAUT ORIGINATED INPUTS TO THE LGC VIA THE LM RATE OF DESCENT SWITCH.
 - (2) TO MODIFY THE INERTIAL ATTITUDE OF THE LM IN RESPONSE TO ASTRONAUT ORIGINATED INPUTS VIA THE ATTITUDE CONTROLLER ONLY IF THE ATTITUDE CONTROL SWITCH IS IN ATTITUDE HOLD.
 - (3) TO MAINTAIN A CONSTANT RATE OF DESCENT AND LM INERTIAL ATTITUDE IN THE ABSENCE OF MANUAL CONTROL INPUTS.
 - (4) TO UPDATE THE LM STATE VECTOR WITH VEHICLE ACCELERATION AND LANDING RADAR (LR) DATA.

- ASSUMPTIONS:
- (1) THE LM IS IN THE LATE STAGES OF LANDING, WITH A RELATIVELY LOW INERTIAL VELOCITY.
 - (2) THE IMU IS ON AND ACCURATELY ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING (T(LAND)).
 - (3) THE LANDING RADAR (LR) IS ON, CHECKED OUT, AND SHOULD HAVE BEEN PROVIDING TO THE LGC VELOCITY AND RANGE INFORMATION WITH RESPECT TO THE MOON. THIS INFORMATION SHOULD HAVE BEEN INCORPORATED INTO THE LM STATE VECTOR. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) WHICH IS ALREADY IN PROCESS.
 - (4) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.
 - (5) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.
 - (6) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED IN THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.
 - (A) THE LM STATE VECTOR. THE LGC HAS UPDATED THIS AS REQUIRED DURING THRUSTING. NO FURTHER STATE VECTOR UPDATES FROM ANY SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.
 - (7) THE DPS IS NOT THROTTLEABLE OVER THE WHOLE RANGE FROM 0 PERCENT TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS 10 PERCENT), AND THE PGNC'S COMMANDED SETTING.
 - THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN AUTO (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGNC'S COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC. NOMINALLY THE THROTTLE WILL REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE THROUGHOUT THIS PROGRAM.
 - (8) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION. SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE MANEUVER.
 - THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH IS ALREADY IN PROCESS.
 - (9) THE LPD OPTION IS NOT PROVIDED THE CREW DURING THIS PROGRAM.
 - (10) THE LGC ASSUMES ALL ATTITUDE CHANGES TO BE MANUAL THROUGHOUT THIS PROGRAM. THE LGC WILL HOLD INERTIAL ATTITUDE IN EITHER MODE, HOWEVER ONLY IN THE ATTITUDE HOLD MODE MAY THE ATTITUDE BE CHANGED BY MANUAL CONTROL VIA THE ATTITUDE CONTROLLER.

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 +285
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 +02
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(11) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R1C) WHICH IS ALREADY IN PROCESS.

(12) DURING THIS PROGRAM THE LGC MONITORS THE OUTPUT OF THE RATE OF DESCENT (ROD) SWITCH IN THE LM. THIS SWITCH IS OPERATED BY THE ASTRONAUT IN RESPONSE TO HIS ASSESSMENT OF THE PRESENT LM RATE OF DESCENT BASED ON OUT-THE-WINDOW REFERENCES AND LM/DSKY DISPLAYS.

SWITCH OPERATION IS ON AN INCREMENTAL BASIS, EITHER - (INCREASE ROD) OR + (DECREASE ROD). EACH COMMAND RESULTS IN AN LGC-COMMANDED CHANGE OF "RODSCALE" FT/SEC IN THE LM RATE OF DESCENT. ("RODSCALE" IS A VALUE LOADED INTO ERASABLE STORAGE PRIOR TO FLIGHT)

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(13) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE POWERED DESCENT (P63), (P64), (P65), OR (P66).

FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).

DURING THE POWERED LANDING MANEUVER, THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4.3 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH IS ALREADY IN PROCESS.

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+02
+EDIT
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+02
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(14) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH AT PGNS AND THE MODE CONTROL SWITCH AT ATTITUDE HOLD THE PGNS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12,P40,P41,P42,P63,P70,P71 AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE, THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(15) CONTROL OF THE LM DPS, RCS, AND APS IS TRANSFERRED FROM THE PGNS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47). IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE DESIRED ATTITUDE ERRORS; HOWEVER THE PGNS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC BECAUSE THE AGS IS NOT MAINTAINING REASCENABLE ATTITUDE CONTROL.

(16) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THE START OF THE POWERED LANDING MANEUVER AND SHOULD NOT BE REQUIRED DURING THIS PROGRAM.

(17) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS IN EFFECT DURING THIS PROGRAM UNTIL SELECTION (VIA ROD) OF THE LANDING CONFIRMATION PROGRAM (P66), HAVING BEEN ENABLED BY P63.

(18) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE LANDING AUTO MODES MONITOR ROUTINE (R13) DURING THE POWERED LANDING MANEUVER WHEN:

(A) ATTITUDE CONTROL IS FIRST TRANSFERRED TO MANUAL (ATTITUDE CONTROL SWITCH TO ATTITUDE HOLD) IF THE THROTTLE CONTROL REMAINS AUTO (THROTTLE SWITCH IN AUTO) AND THE ASTRONAUT COMMANDS A NET CHANGE IN THE RATE OF DESCENT BY MEANS OF THE ROD SWITCH.

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+02
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(19) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

- (A) V16 N52
- R1-THRCMD
- R2-HDOT
- R3-H

THRCMD-THE PERCENT THROTTLE DESIRED BY THE LGC BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT.

HDOT-THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H-THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE INITIALLY DESIGNATED LANDING SITE. IN FEET TO NEAREST FCCT.

PROG
CONT

LGC

GROUND

CREW

.LGC
.PROGRAM
.SELECTION
.
.
.
.
.
.

START LANDING PHASE
(ROD) PROGRAM (P66).
DISPLAY P66

SET DESIRED H DOT
EQUAL TO ACTUAL
H DOT

. MONITOR DSKY:
. OBSERVE DISPLAY
. OF P66

#10

#20

#30

.....

DO STOPRATE TO TER-
MINATE MANEUVER (IF
ANY) IN PROCESS

.....

#40

.....

RESET X-AXIS OVER-
RIDE INHIBIT FLAG.
(NOTE: DEPENDING UP-
ON THE TIME OF SELE-
CTION OF THIS PRG-
RAM THE X-AXIS OVER-
RIDE OPTION MAY NOT
BE INHIBITED AND
THIS FUNCTION IS RE-
DUNDANT.)

.....

#50

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+02
+285
+882

#60

.....
.....

COMPUTE FOR VEL,
H DGT, AND H

.....

#70

+02

510

511

+
+
+
+
++

HOLD

..... FLASH VERB-NOUN TO MONITOR DSKY: #80
 MON .. REQUEST RESPONSE AND OBSERVE VERB-NOUN
 .. DISPLAY ON DSKY: .. FLASH TO REQUEST RE-
 ++ .. V06 N60 .. SPONSE AND DISPLAY
 +02 .. R1-FORVEL .. OF FORVEL, H DOT
 +882 .. R2-H DOT .. AND H.
 + .. R3-H .. (NOTE: THIS DISPLAY
 + .. FORVEL-THE FORWARD .. WILL CONTINUE FLASH-
 + .. COMPONENT OF THE .. ING TO ALLOW THE
 + .. HORIZONTAL VELOCITY .. ASTRONAUT TO ZERO
 + .. OF THE VEHICLE WITH .. ATTITUDE ERRORS ON
 + .. RESPECT TO THE MOON .. THE LUNAR SURFACE AS
 + .. WHICH IS ESSENTIALLY .. OFTEN AS DESIRED).
 + .. PARALLEL TO THE X-Z ..
 + .. PLANE OF THE VEHICLE ..
 +02 .. (FOR SMALL PITCH ..
 ++ .. DISPLACEMENTS). ..
 .. IN FPS TO NEAREST .1 ..
 .. FPS .. #100
 .. H DOT-THE PRESENT ..
 .. RATE OF CHANGE OF ..
 .. ALTITUDE (H). POLA- ..
 .. RITY INDICATES DES- ..
 .. CENT (-), OR ASCENT ..
 .. (+). POLARITY IS ..
 .. NOMINALLY - DURING ..
 .. THIS PROGRAM. IN FPS ..
 .. TO NEAREST .1 FPS .. #110
 .. H-THE PRESENT RADAR ..
 .. UPDATED ALTITUDE OF ..
 .. THE LM ABOVE THE ..
 .. LUNAR SURFACE. ..
 .. POLARITY IS + ..
 .. FOR ALTITUDES ..
 .. GREATER THAN THE ..
 .. ABOVE RADIUS. IN ..
 .. FEET TO NEAREST ..

FCCT.

#120

MONITOR RATE OF
DESCENT INPUTS TO
THE LGC

MONITOR PROGRESS OF
POWERED LANDING
MANEUVER USING LM
DISPLAYS, DSKY DIS-
PLAYS AND WINDOW.
USING RATE OF
DESCENT SWITCH,
COMMAND DESIRED RATE
OF DESCENT.

#130

COMPUTE REQUIRED
CHANGE IN THROTTLE
SETTING FOR PRESENT-
LY DESIRED ROD.

IF MANUAL ATTIT-
UDE CONTROL IS DE-
SIRED USE ATTITUDE
CONTROLLER.

#140

COMMAND REQUIRED
THROTTLE SETTING

MONITOR THRUST
INDICATOR (RIGHT
SIDE) TO ENSURE THAT
LGC THROTTLE COMMAND
DOES NOT EXCEED XX
PERCENT. (NOTE: THE
LGC WILL NOT INTEN-
TIONALLY COMMAND A
THRUST LEVEL LARGER
THAN THAT SPECIFIED
BY A PAD-LOADED
LIMIT (NOMINALLY 60
PERCENT) NO MATTER
WHAT THE CIRCUM-
STANCES ARE.

#150

WAIT ONE
SECOND

IF MANUAL THROTT-
LE CONTROL IS DESIR-
ED, ADVANCE THRUST/
TRANSLATION CONTROL-
LER UNTIL LGC CON-
TRIBUTION TO TOTAL
THRUST IS ZERO
(THRUST INDICATOR-
RIGHT SIDE), AND PUT
THROTTLE SWITCH TO
MANUAL. THE LGC WILL

#160

513
+
+
+
+
+
+02
+285
+02
++

MAINTAIN THE PRESENT
LM INERTIAL ATTITUDE.
THROTTLE CONTROL WILL REVERT TO
THE LEVEL COMMANDED
BY THE THRUST/TRANSLATION
CONTROLLER.

#170

RATE OF DESCENT
MAY THEN BE MODIFIED
BY MANUAL THROTTLE
CONTROL. LM ATTITUDE
WILL REMAIN INERTIALLY
FIXED UNLESS MANUAL
ATTITUDE CONTROL IS
EXERCISED, HOWEVER
MANUAL ATTITUDE CONTROL
CANNOT BE EXERCISED
UNLESS THE ATTITUDE
CONTROL MODE SWITCH IS
IN ATTITUDE HOLD.

#180

ONCE THIS PROGRAM IS
EXITED IT MAY BE RETURNED
TO BY PLACING THE
THROTTLE SWITCH IN
AUTO.

#190

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MONITOR DSKY:
WHEN H IS APPROXIMATELY
XX FT OBSERVE TRACKER
FAIL LIGHT TO COME ON
INDICATING THAT LR IS
NO LONGER RETURNING
GOOD DATA.

#200

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MONITOR DSKY:
WHEN ACTUAL ALTI-

#210

515

LM STARTS TO TIP
OVER WHILE LANDING.

.

AM I FINISHED WITH
THE DISPLAY?

#270

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+02
+EDIT

WAIT FOR KEY BOARD
ENTRY

.N .Y

KEY IN TERMINATE

#280

TERMINATE FLASH UPON
RECEIPT OF V37E68E

WHEN LANDING HAS
BEEN SUCCESSFULLY
COMPLETED, KEY IN
V37E68E TO SELECT
THE LANDING CON-
FIRMATION PROGRAM
(P68).

#290

.P .V .T .V
.R .3 .E .3
.D .2 .R .7
.C .E .M .E
.E .I .6
.E .N .8
.D .A .E
. .T .
. .E .
. . . .

COMMAND
ZERO AT-
TITUDE
ERRORS

#300

517

LANDING CONFIRMATION PROGRAM (P68)

REV 03 12/03/69

- PURPOSE:
- (1) TO TERMINATE LANDING PROGRAM AND CAP FUNCTIONS.
 - (2) TO INITIALIZE THE LGC FOR LUNAR SURFACE OPERATION.
 - (3) TO PERMIT THE ASTRONAUT TO PREVENT RCS JET FIRINGS ON THE LUNAR SURFACE.

ASSUMPTIONS: (1) THE FOLLOWING DISPLAY IS AVAILABLE DURING THE PROGRAM BY KEYING IN V85E (SEE EXTENDED VERBS).

V16N56
 R1 - RR LOS AZIMUTH
 R2 - RR LOS ELEVATION
 R3 - BLANK

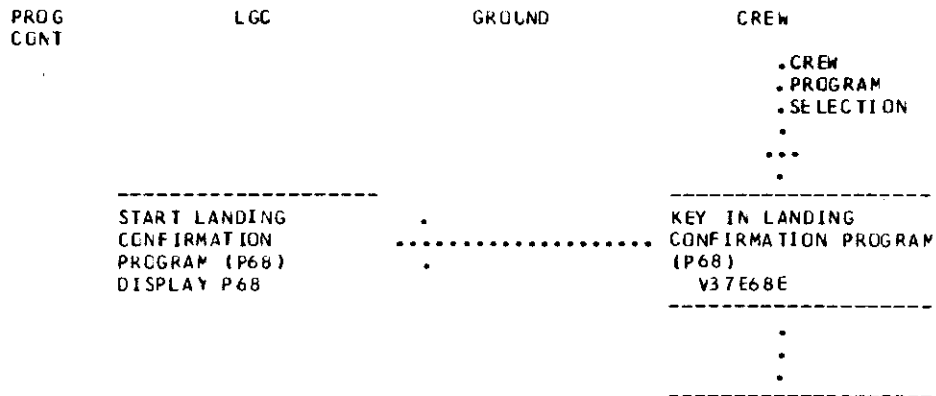
WHERE: RR LOS AZIMUTH - THE ANGLE BETWEEN THE LM X/Z PLANE AND THE RR LOS VECTOR. POSITIVE ROTATION IS FROM THE LM +Z AXIS TO THE LM +Y AXIS. IN DEGREES TO THE NEAREST .01 DEGREE.

RR LOS ELEVATION - THE ANGLE BETWEEN THE LM +Z AXIS AND THE PROJECTION OF THE RR LOS VECTOR ON THE LM X/Z PLANE. POSITIVE ROTATION IS POSITIVE ROTATION ABOUT THE LM +Y AXIS.

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 +03
 +285
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- (2) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT IS TO BE SELECTED ONLY AFTER THE LM HAS LANDED ON THE LUNAR SURFACE (P65 OR P66).
- (3) V37E68E SELECTION OF P68 WILL TERMINATE AVERAGE G AND COMMAND THE ENGINE OFF (REFER TO R00).
- (4) THE SELECTION OF THIS PROGRAM PLACES THE DAP IN THE MINIMUM IMPULSE COMMAND MODE. AS LONG AS THE ASTRONAUT KEEPS THE MODE CONT SWITCH IN ATT HCLD, RCS JET FIRINGS WILL NOT OCCUR, EVEN WHILE THE PLATFORM IS BEING GYRO TORQUED (IN P57).

++
 +C3
 +EDIT
 ++



#10

MONITOR DSKY
DISPLAY OF P68

. . .

COMMAND ZERO
ATTITUDE ERRORS

. . .

SET PULSES
FLAG

. . .

SET SURFACE FLAG

. . .

RESET ABRCT ENABLE
FLAG

. . .

(AT THIS TIME THE
DAP IS PLACED IN THE
MINIMUM IMPULSE
COMMAND MODE).
PLACE THE MODE CONT
SWITCH IN ATT HOLD
AND THE DAP WILL NOT
FIRE RCS JETS. P12
WILL AUTOMATICALLY
PLACE THE DAP BACK
INTO RATE COMMAND/
ATTITUDE HOLD MODE
AT MAIN ENGINE
IGNITION.

++
+03
+EDIT
++

#20

#30

#40

#50

#60

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(

517

SET APS FLAG

RESET LANDING ANALOG
DISPLAYS FLAG

SET LR BYPASS FLAG

STORE PRESENT POSI-
TION VECTOR AS LAND-
ING SITE IN LUNAR
FIXED COORDINATES
(REFER TO SECTION
5.3.4 OF R567).

HOLD .
..... SNAP .

FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY LGC CALCUL-
ATED LANDING SITE
COORDINATES:
VC6N43
R1-LAT
R2-LONG
R3-ALT

LAT-SELENOGRAPHIC
LATITUDE OF THE LGC-
ASSUMED PRESENT
LANDING SITE. CLAR-
ITY INDICATES NORTH
(+) OR SOUTH (-).

OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF LGC CALCULATED
LANDING SITE COORDI-
NATES.

RECORD THESE VALUES.

#70

#80

#90

#100

#110

IN DEGREES TO NEAR-
EST .01 DEGREES .

LONG-SELENOGRAPHIC
LONGITUDE OF THE
LGC-ASSUMED PRESENT
LANDING SITE. POLA-
RITY INDICATES EAST
(+) OR WEST (-). IN
DEGREES TO NEAREST
.01 DEGREES .

#120

ALT-THE PRESENT
ALTITUDE OF THE LM
ABOVE THE LUNAR
RADIUS AT THE
INITIALLY DESIGNATED
LANDING SITE (IF RE-
START OCCURS-ABOVE
THE LUNAR RADIUS AT
THE LGC-ASSUMED
PRESENT LANDING
SITE, I.E. = 0).
THIS VALUE SHOULD
NOMINALLY BE 0000
EXCEPT FOR ACCRUED
ERRORS FROM THE LR
IN THE LAST PHASES
OF THE LANDING. IN
NAUTICAL MILES TO
NEAREST .1 NM.

#130

#140

ENSURE THAT THE LM
IS STABILIZED UPON
THE SURFACE OF THE
MOON AS WELL AS
POSSIBLE.

#150

WAIT FOR KEYBOARD
ENTRY

..... KEY IN PROCEED

#160

TERMINATE FLASH UPON

520

521

RECEIPT OF PROCEED

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

#170

FROM LGC CALCULATED
LANDING SITE COORDI-
NATES AND THE PRE-
SENT ICCU/GIMBAL
ANGLES COMPLETE AND
STORE THE PRESENT
LM ATTITUDE WITH RE-
SPECT TO THE LUNAR
SURFACE.
DEFINE LUNAR GRAVITY
VECTOR TO BE
PARALLEL TO THE
LM X AXIS FOR USE
BY P57.

#180

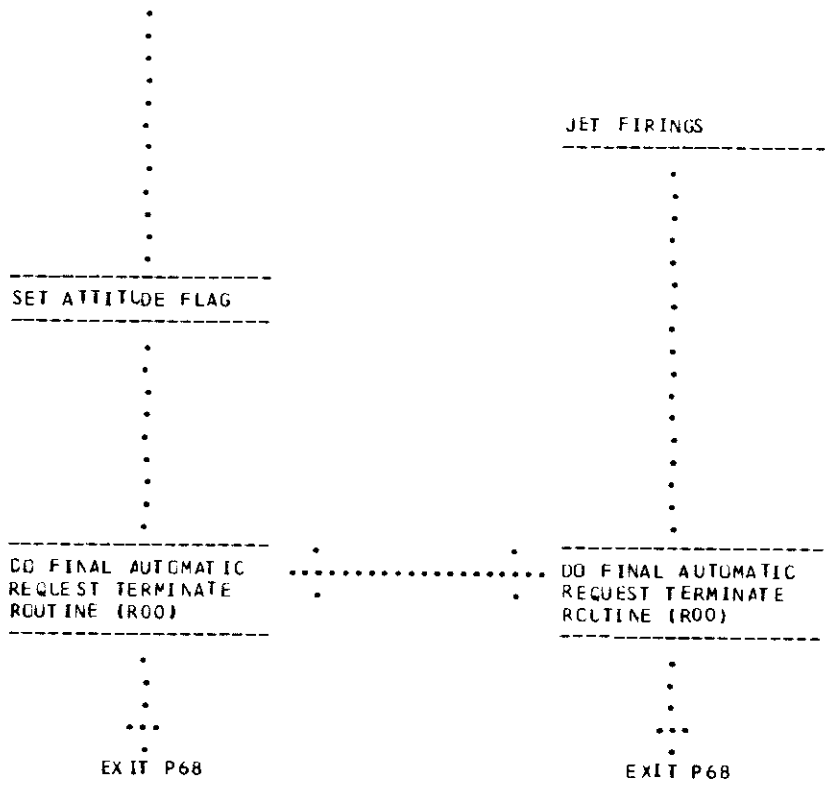
#190

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#200

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+03
+EDIT
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NOTE: THE ASTRONAUT
MUST SWITCH ATTITUDE
CONTROL FROM AUTO
TO ATT HOLD TO TURN
OFF THE DAP IN ORDER
TO PREVENT SPURIOUS



#210

#220

#230

#240

CHANGE CONTROL NOTES

LOGIC REV 0C PCR 470
 REV 01 PCR 99, 419, 546, 547, 623
 REV 02 (LUM 1B) PCR 838, EDITORIAL
 REV 03 (LUM 1C) PCR 285, EDITORIAL

522