CONTENTS OF LUMINARY 1D

R.A. LARSON

8/26/70
7/8/70
To: Distribution
From: B. McCoy
Date: 11 May 1970
Subject: Call It LUMINARY 1D

Revision 163 of Luminary was released on 5/5/70 for manufacture. It contained a total of 39 PCRs, 6 PCNs, 15 ACBs and 6 Anomalies. On the following pages is a detailed description of each implementation or a reference made where appropriate.

The following is a list of the Fixed Memory changes showing the total number left of words in each bank.

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total 1C remaining 313
total 1D remaining 616
ANOMALY

L-1D-01 - SS
  02 - SS
  03 - Re-release
  04 - PCR 287
  05 - PCR 287
  06 - SS
  07 - SS
  08 - PCR-1028
  09
  10 - SS
  11 - PCR 986.2 Wb mis-scaled
  12 - ACB - L 15°
  13 - PCR-1028 LRWH = LRWH
  14 - SS
  15 - SS
  16
  17
  18
  19
  20 - SS
IMPLEMENTATION/COMMENTS

286

RLS and TLAND were placed in sequence for V71 uplink format. RLS begins at E4, 1420 and TLAND begins at E4, 1426. AGSK moved to E6, 1771 and VELBIAS is now at E5, 1400.

287/1038

The 526 alarm (Range to CSM > 400 N. M.) was deleted from P22. Instead V16N54 is displayed (range, range rate, \( \Theta \)) if the range rate is negative. If the range is greater than 400 N. M. and the range rate is positive in P22, a flashing Verb 37 results. In P20, if the range is greater than 400 N. M. the alarm light is turned on with code 526 stored. The range and range rate values for Noun 54 are computed and stored for possible monitoring by a V16N54 request from the crew. See memos #133, 133 rev 1, "Implementation of PCR 287" by P. Volante, V. Dunbar.

294

The quantity HIDESCENT was increased to 16,700 kg for the heavier LMs.

296

In P68, GSAVE (the 'G' vector saved for gravity measurements in P57) is the unit vector of RN (post landing navigated state vector) in Nav Base coordinates.

298

LR position change will now give a 523 alarm after 10 seconds if antenna did not reach position #2. Instruction change was simply CAF FOURTEEN to CAF FOUR. Also see Luminary Memo #146 "The New R12" by R. Covelli. (also PCR 1022)

306

DVTOTAL, the accumulated Delta Velocity during Average-G, was placed in word 78 of the Descent/Ascent Downlist.

307

TSIGHT, the AOT Marktime, was placed in word 99 of the Lunar Surface Align Downlist; CURSOR was placed in 100A and SPIRAL in 100B.
Coding was introduced to inhibit the 511 alarm until the antenna has been out of the desired position 5 consecutive passes through SERVICER (10 seconds). A counter (511CTR) is set to four when the antenna is first detected out of either position (or in both positions simultaneously) and it is decremented every succeeding pass the antenna remains out of position. Its location is E7, 1622. (See PCR 1022)

The Guidance Thrust Command is time associated with a particular PIPTIME. GTC and GTCTIME are in the same "snapshot" on the Descent/Ascent downlist and located in words 5a and 6a/6b respectively. GTCTIME is E7, 1752.

A new channel (77) was created to serve as a Hardware Restart indicator. It replaced CADRFLASH +1 in all Downlists. The first half of the word (channel 76) is a spare.

AZO is the angle between the x-axis of the Basic Reference Coordinate System and the x-axis of the Earth-Fixed Coordinate System at July 1, 1969. It was placed into fixed memory since it remains essentially the same for a given year.

A TIG countdown is started prior to the attitude maneuver in P41. It continues until TIG -35. A job, DYNMDISP, is scheduled immediately after P41 is called; it computes TFI and then calls itself every second. P41 proceeds on with DYNMDISP in the background, like CLOCKTASK in P40, 42. If V16N40E is used to monitor TFI, then V16N85E must be keyed if the VG display is desired again.

As in Colossus the astronaut does not have to key leading zeroes to a decimal load. For example a decimal load of +50 will reappear as +00050; +E will reappear as +00000E.
R29, the Ascent RR Designate Routine, was deleted from Luminary.

In an effort to save valuable time during the Powered Descent, the LR velocity readings are centered around PIPTIME. For details see Luminary Memo #146 "The New R12" by R. Covelli. The Radar Read routine used by the LR & RR was rewritten.

PCR 775 provided the capability to compensate for a Hardware failure in the Doppler Ranging Unit of the Landing Radar, a precautionary measure. This coding was removed.

In Luminary 1B the LR velocity readings were not taken until the S/C Inertial Velocity was 2000 fps. In Luminary 1C this limit was changed to 6000 fps, effectively removed. In Luminary 1D it was removed entirely, so that now LR velocity readings will start as soon as the velocity data good appears after R12 begins. Also see Luminary memo #146 "The New R12" by R. Covelli.

Erasable "TET" (N38) which is the time to which state vector is being integrated in each time step was put on the following downlists: Coast and Align, Lunar Surface Align and Rendezvous/Prethrust. It could aid the ground controllers to detect integration loops.

A value of 50 ft (scaled meters B-10) was placed into fixed memory; LR updates are inhibited below this altitude. This number (HLROFF - Single Precision) is loaded into the least significant half of a Double Precision word (HLROFF) at the start of P63 (FLAGORY); therefore, HLROFF can be externally changed to a different value after P63 is called. In routine MUNRETURN, HCALC (most significant half) is check to see if it is < 3000 ft (bit 1 = 0). If so,
HCALC +1 (least significant half) is subtracted from HLROFF. A plus result will reset LRINHFLG (flagword 11 bit 8). Later in the position update (NOREASON) and also in the velocity update (VUPDAT) this bit is checked. If it is reset, SERVICER continues without any LR updates (effectively a V58). HLROFF is E7, 1451.

LATVEL and FORVEL, the cross pointer lateral & forward velocity, are now on the Descent/ascent downlist in word 12, in that order.

In Flagword 11, bits 13 and 14 will now be set to indicate when at least one failure of the Altitude and Velocity Reasonability tests respectively have occurred. They are reset whenever their respective reasonability tests are passed.

Recently built gyros have a large bias shift that is dependent upon the polarity of the last torquing on the gyro. Coding was added to the IMU Pulse torquing routine to eliminate this bias shift. For details call R. Lones at MIT 864-6900 X821-529.

Program alarm 521 was a redundant indication of RR data good loss, so it was removed.

For Lunar Surface Alignments, Cursor/Spiral angles are now available for all celestial bodies, not just catalogued stars. Thus any body specified by N88 will be accompanied by a N79 display. The setting up of BESTI and the check for a catalog star were removed. Routine PLANET now interrogates N70 (R1).
N88 will now accept unit vectors instead of the half unit vector. Prior to unitizing, N88 (location STARAD) is divided by \((3)^{-1/2}\) to insure the unit operation will not overflow.

Fixed Memory Ephemeris constants were updated to 1970-1971 year.

P66 is essentially the same as it was in Luminary 1C (LM131 rev 1) which was done so as to keep changes only in one rope module for the re-release of Luminary 1C. Differences: a PRO to the V06N60 sets P66PROFL (Flagwrd 0, bit 1). This inhibits FINDCDU from sending RCS commands if the ENGARM switch is off.

PCN 1037 removes a "Stoprate" and the resetting of REDFLAG (Flagwrd 6 bit 6) from P66 initialization. It also adds a "Stoprate" when a 01466 alarm occurs. Therefore should the situation arise via high TLOSS etc, that P66 is having difficulty in emitting sufficient throttle commands, a 1466 alarm will occur preceded by RCS jet activity to stop any vehicle rates.

PCN 1035. The Terrain Model will be terminated when P66 is started; NOTERFLG (Flagwrd 1, bit 11) is set which causes Servicer to bypass Terrain Model computations.

Fixes Anomaly L-1C-04. A one second cycle was set up in V44 logic to wait for a Remode to be completed (checks bit 14 of RADMODES) before terminating a continuous designation of the RR.

The UPRUPT routine interrogates NODOP07BIT (Flag 3 bit 11) which is set by any V37EXXE after earth launch. If it is "0" the Uplink telemetry code (KEYTEMPl) is added to the previous summation of codes and forms a new sum (UPSUM). Next a counter (located at UPSUM +1) is
incremented to show the total number of uplink codes received. If NODOP07BIT is "1" no summing takes place.

UPSUM, UPSUM +1 share with ABDELV, location 1245.
GUILDENSTERN

Y

R13 (every 2 seconds)

(Servicer enters Descent Guidance here at Priority 20)

P66

N

ATT

HOLD

N

Y

GUILDRET

end of approach phase

Y

Continue P63, P64

STARTP66

N

Y

RODCOUNT

zero

MODE = 66

VDGVERT = HDOTDISP

P66PROFL = 1

CNTTHROT = TOOFEW

VHZC = WM x R

Compute ROD scaling

FCOLD, FWEIGHT = 0

WCHPHOLD, WCHPHASE = 2

SET RODFLAG

Clear XOVINFLG

Set NOTERFLG

Is It Too Late in the Servicer Cycle to do P66?

CRIT = 2LATE466 - (t - PIPTIME)

RODFLAG set indicates no restarts and no P66 omissions

Allow X axis override
Commanded Acceleration Vector for Horizontal Velocity Nulling:

\[ \text{AHZCX} = \text{GHZ} \]
\[ \text{AHZCY} = (\text{limit AHZLIM}) \left( -\frac{\text{QHZ UNFC}}{2} (y_{1-1} Y - \text{VHZCY}) / \text{TAUHZ} \right) \]
\[ \text{AHZCZ} = (\text{limit AHZLIM}) \left( -\frac{\text{QHZ UNFC}}{2} (z_{1-1} Z - \text{VHZCZ}) / \text{TAUHZ} \right) \]

ALARM 01410
Call STOPRATE
Reset OVERFLOW
ind

Clear = RODFLAG
CRIT = CNTTHROT
CNTTHROT = -TOOFEW

ALARM 01466
Call STOPRATE

--- Has Proceed been keyed in response to Flashing V06 N60 ?

*GHZ is lunar gravity; QHZ and 1/TAUHZ are gain constants; VY and VZ are the Y and Z components of velocity, platform coordinates. VHZCY and VHZCZ are the Y and Z components of commanded velocity, platform coordinates. I-1 indicates the previous pass, and on the first P66 pass this indicates the final P64 pass. (LIMIT AHZLIM) indicates the content of the subsequent parentheses is magnitude limited to AHZLIM.
RODTASK
Establish job RODCOMP at Priority 22

Tasks for RODCOMP:

- Priority = 22
- Causes one RODCOMP per second
- Prevents Priority 22 RODCOMP starting if RODCOMP is in progress

- Compute new desired Altitude Rate

VDGVERT = VDGVERT + RODCOUN * RODSCALE
RODCOUNT = 0

Y

AUTO THROT
N

Set desired altitude rate equal to the present altitude rate

Commanded thrust acceleration

Measured thrust acceleration

- Throttle Inputs
- Compute |AFC|
- Compute |AF|

Call THROTTLE
CNTTHROT = CNTTHROT + 1

- Key PROCEED
- Set flagwrd 0 bit 1

Display V06 N60 FLASH

END OF JOB

END OF JOB
The selection of P07 (V92) is now contingent on NODOP07BIT (Flag 3 bit 11) being "0". If it is "1" the Operator Error light is illuminated. A Fresh Start will not disturb this bit so that V36 can be used to terminate P07; therefore, P07 can be called again without manually resetting NODOP07BIT. However, if V37 is used, e.g. Sim Flights before launch, the bit must be reset before P07 can be called.

was implemented into LUMINARY 1D essentially the same as for LUMINARY 1C. It assures against stacking of jobs when TLOSS is present by omitting one horizontal and two vertical P66 commands. If there are too few vertical commands for proper ROD control, alarm 01466 is given. See Luminary Memo #146 "Automatic P66" by Allan Klumpp.

Immediately on keying V90E, V37FLBIT bit is checked to see if Average G is on. If so, the Operator Error light is illuminated.

now has precomputed LR position transformation matrices in Fixed Memory (VZBEAMNB) eliminating the computation time and to facilitate coding of PCR 1022. Routine POSINDEX sets the Interpreter Index Register X1 in accordance with the LR Position (location LRPOS):

Position 1 - LRPOS = 2 , X1 = -24D , X2 = 0
Position 2 - LRPOS = 1 , X1 = 0 , X2 = 0

Thus, when POSUPDAT and VELUPDAT routines use the LR measurement data, it is transformed in accordance with X1 from NB to SM coordinates. Four padloads were deleted: LRALPHA, LRALPHA2, LRBETA1, LRBETA2. Also see Luminary Memo #146 "The New R12" by R. Covelli.
The handling of the LR position alarm has been made very simple. In R12 channel 33 bits 6 and 7 are checked to see if there had been a change in position from the previous Servicer pass. If both or neither position discrete are present Servicer continues without any LR updates (Terrain model also bypassed). If this situation exists for 5 passes (10 seconds) 511 alarm is given and will be given once, every 10 seconds until the situation is corrected. LR updates will continue to be processed.

If either position 1 or 2 discrete are present it is checked against the present position (indicated by LRPOS). If they are different, Servicer continues with no updates. If they are the same, updates may be performed. Routine HIGATJOB is called to reposition the LR to position #2 at the beginning of the approach phase (P64). After the antenna has reached position #2 or after 10 seconds, "LRPOS" is set equal to 1 to indicate (reverse logic) that the new position is to be 2. If the antenna did not reach position #2 the 511 alarm will be given as described above. If the position is #2, normal updating continues. Note: the 523 alarm has been eliminated from R12 although it still exists for V59.

The LM navigated state vector was updated for any gravity effects on altitude after the LR updates. This was deemed to be insignificant and was removed. A call to MUNGRAV was removed from routine RVBOTH.

An a priori Terrain Model was implemented into Luminary to smooth the trajectory over rugged lunar terrain and to reduce the LPD errors and fuel consumption. It uses 5 segments, a slope and a range-to-landing site (abscissae), for each. The terrain not falling into the segmented region
(the model covers a region from some specified abscissae (range) to the landing site) will be modelled by a constant altitude, equal to the altitude at the last abscissae. The slopes and abscissae are specified in E memory by SLOPE0, 1, 2, 3, 4 and ABSC0, 1, 2, 3, 4. SLOPE1* and ABSC1* correspond to the segment nearest the landing site (loc E5, 1527 and E5, 1522 respectively, scaled B-6 and B-18 respectively). For more details see Luminary Memo # by Allan Klumpp, Don Eyles, and Bruce McCoy.

A new padload (LRWH1, E7, 1756) was created to allow for a two-segmented altitude weighting function. The present scheme is as shown below.

\[
\begin{align*}
\text{LRWH} \text{MAX} & \quad - \quad 1
\end{align*}
\]

\[
\begin{align*}
P63 & \quad - \quad P64
\end{align*}
\]

\[
\begin{align*}
LRWH & \quad 0
\end{align*}
\]

\[
\begin{align*}
\text{altitude (HCALC)} & \quad 7k
\end{align*}
\]

given by equation \( W_H = LRWH \frac{1 - HCALC/LRHMAX}{LRWH} \). 
LRWH is set equal to LRWH1 in P64. 
\( W_H \) is altitude weighting function. 
LRWH, LRWH1, and LRHMAX are erasable to set the slope. 
HCALC estimated altitude.

Due to the extensive analysis done prior to Apollo 13 on TLOSS it was found that the ground controllers could possibly determine what percentage of the computer duty cycle was not being used or what percentage was not available.
due to TLOSS. It was also thought possible that the post flight data could be used to calibrate LMS configuration time (presently it runs faster than the actual AGC). Two erasables were defined and are on all downlists (specified on PCR). SERVDURN (loc 1355) is loaded with the present LGC time (least significant half) just prior to the Average G Exit point (after navigation, prior to guidance). DUMLOOPS (loc 1356) is a counter which is incremented each time DUMMYJOB finds no job to be serviced - idle time. It will quit counting when a job is called, starting again when it is finished. Data will be published at a later date specifying the time between DUMLOOP increments.
R.E.G = (R_p - RLS_p + RLR_p) e

Landing site position vector in platform coordinates

Radar altitude beam vector in platform coordinates

\( z \) component

\( R.E.G \)

\( \text{Absc} \)

\( \text{Absc}1 \)

\( \text{Absc}2 \)

\( \text{Absc}3 \)

\( \text{A priori terrain} \)

\( \text{Actual terrain} \)

\( \text{Landing site} \)

\( \text{Smooth moon} \)

\( R_p \)

\( RLS_p \)

\( RLR_p \)
Range is a negative number equal to the z component in platform coord of the vector from the landing site to the point of intersection of the LR altitude beam with the lunar surface.

\[ \text{Range} = \sqrt{r_2^2 + y_2^2} - \Delta H \]

\[ \Delta H^* = \Delta H \]

Range < 262 km

Range = 262 km

\[ \text{NOTE FLAG SET} \]

\[ N = N - 1 \]

\[ \text{ABSC}(N+1) = \text{ABSC}(N) \]

\[ \text{ENGLIM} = \text{ABSC}(N) \]

\[ \Delta H = \Delta H^* \left( \text{ENGLIM} - \text{ABSC}(N) \right) / \text{SLOPE}(N) \]

\[ \text{ABSC}(N+1) = \text{ABSC}(N) \]

\[ \text{ENGLIM} = \text{ABSC}(N) \]

\[ N = N - 1 \]

\[ N = \emptyset \]

\[ \text{As long as Range is outside the last segment (\( N = \emptyset \)) \Delta H \text{ is the altitude of the model at the last ABSC} \]

\[ \Delta H = \Delta H^* \]
**Anomaly**

**Implementation/Comments**

L-1C-01  
It was found that a Restart during an EXTERNAL ΔV burn by P40 or P42 could cause a ΔV increment to be subtracted from VG again after the Restart recalled the steering routine S40. A Restart point was placed after the subtraction had been made.

L-1C-03  
A coding error in V59 leadin caused the DAP estimated attitude errors to be placed on the FDAI needles as well as moving the LR antenna to position #2. It was rewritten as shown below:

```
V59
  LRPOS2K
  average on
  No
  Flag 7 bit 5
  Yes
  R12 on
  No
  Flag 11 bit 15
  Yes
  V59GP63
  LRPOS2K1
  Exit
```

Now, V59 can be used in P64 if desirable.

L-1C-04  
See PCR 990.
The computation of HCALC (a Double Precision word), the estimated altitude in a Descent or Ascent, did not assure sign agreement to both halves of the word. It caused the x-axis-override inhibit to occur at an altitude somewhat less (~ 26 kft) than the desired altitude (30 kft). A call to the SIGNAGREE was added in routine RVBOTH where HCALC is calculated for the altitude check.

It was possible to not navigate some ΔV in P40, 42 or P63 if a V37 was used to terminate ullage or a DPS/APS guided burn because average G was turned off prior to allowing V37 to turn off ullage/the engine. In Luminary 1D a V37 turns off ullage/the engine immediately on finding Average-G on.

A Restart while the DAP was in the manual rate command mode may cause 1) Temporary nulling of a Q or R axis manually commanded rate while the rotational hand controller is out of the detent position, or 2) Yaw to another attitude if the Restart occurs during rate command initialization.

To correct this, the desired CDU's are set equal to the actual CDU's each pass through Q/R axis in manual rate command mode and OURRCFLG is set after initialization of manual rate command mode is completed.

When PCR 882 was implemented into Luminary 1C the Forward Velocity displayed in NOUN 60 was not computed when the MODE SELECT SW was in a position other than PGNCS. The check for the switch position was moved to a place in SPEEDRUN after Lateral and Forward Velocity are computed, thus, if the switch is in AGS or LDR, LATVEL and FORVEL will be computed for display and return is made to ALT/ALT RATE computations without sending LATVEL/FORVEL to the cross pointers.
The capability of a service routine (LONGCALL) was expanded to allow a call for a task located in a high super-bank (40-43). This was first implemented into COLOSSUS.

In the Ascent and Descent Programs, an interrupted display (such as V06N63) would cause an extra VAC area to be tied up when it is not really needed. If it was interrupted by an Extended Verb with display it would use 4 VAC areas. A routine (VACRLEAS) was written to change the next display job from one requiring a VAC area to one needing only a Core Set (12 registers instead of 42). The displays involved were the V06N63 displays in P12 and P63, the V06N64 displays in P64 and the N60 display in P66. This reduces the chance of receiving Executive storage overflow (31201, 31202) alarms.

Three fixed words were needed in bank 1 to implement PCR 872.2. It involved equating GENADR tags to fixed-fixed memory location equivalents.

Three fixed words were needed in bank 43 to implement PCR 990. Routine CLRADMOD was used to reset bits 14 and 10 of RADMODES which was done previously by 4 instructions. Redundant coding of resetting these bits in RRDESEND was deleted (same 4 instructions above to reset bits 14 and 10 had been followed by a TC CLRADMOD).

It was found in Luminary 1C a possible indeterminate transfer could occur if the TLOSS was high enough in P64 to cause a 1201 or 1202 alarm immediately prior to P66 entrance, occurring during the throttle routine. The problem had been caused by two programs using BANKCALL, the former destroying the return of the latter. A POSTJUMP and associated return interface replaced P66's BANKCALL to the throttle routine.
A Restart during a DPS throttle recovery caused the throttle commands to the DECA to be terminated because the Restart logic in STARTSUB2 "zeroed" bit 4 of channel 14 (Thrust Drive Enable). STARTSUB2 was changed to prevent the zeroing of this bit. Also, if a Restart occurred after the throttle pulses had been started but before the next phase change (after FINDCDUW) these pulses could be sent twice. A phase change (TC FASTCHNG) was added just after the return from throttle and just prior to FINDCDUW. A PCN 1043 was written to supercede this ACB since it was found after release that GSOP Section 2 was affected in a minute way. A statement was made that a Restart zeros all but bit 6 of channel 14.

Late changes were made to the Luminary 1C rope which were implemented at the same time AUTOP66 was crowned. One involved improving the logic on overflow checks in Lunar Landing in the Guidance Equations. It was found to be better to skip guidance commands if overflow occurred, regardless of the STEERSW. Another was a logic change in the same area (STEER?): remove the Attitude Hold Check for a decision to do a STOPRATE (tell the DAP to stop all attitude rates). There could be a situation of just switching PGNCS control mode from AUTO to Att Hold between FINDCDUW and the next pass through STEER?. The stoprate would then be bypassed unintentionally.

Don Eyles thought of an ingenious way of reducing duty cycle time (by us) in the very busy P66. By adding a few instructions prior to \texttt{QUICKTRIG (CDUSPOT = CDU)}, he used \texttt{QUICKTRIG} and \texttt{*NBSM*} in the P66 VERTICAL computations instead of the CDU*NBSM routine. Both methods are the same, transforming UNITX vector from NB to SM coordinates.
Spelling of NEGTORKP (an unreferenced erasable) and an insignificant card punch error for NOUN 60 were corrected.

The setting and resetting of the R04 flag in R65 was deleted; it had prevented the 521 alarm which was eliminated by PCR 979.

EBANKS 2 and 4 contained some erasable assignments that were not being used. Their tags were removed so that the locations may be available for assignment. They were W. IND1 (loc 1257), VACX, Y, Z (locs E4, 1537, 41, 43).

EBANK 7 also contained some erasable assignments that shared unnecessarily with RTARG. ZERLINA, ELVIRA, AZINCR1 and ELINCR1 were moved from E7, 1443-46 to E7, 1644-47 replacing their dummy erasables. Other erasables VDGVERT, NIGNLOOP, and NGUIDSUB (E7, 1644-47) used to share with the above dummies, now share with ZERLINA, ELVIRA, AZINCR1 and ELINCR1.

R. Covelli found that the Master Ignition Routine (BURN BABY, BURN) could be used by an erasable program (e.g. LM DEORBIT Erasable Program) if some instructions addressing fixed memory were changed to be able to address erasable memory also. For example

INDEX WHICH
TCF 12

is used to transfer control to a location specified by the 12th location of a table (each program has its own table specified by WHICH). If the TCF (Transfer Control to Fixed memory) were to be changed to TC (Transfer Control to either Fixed or erasable) a table such as that used for P40, 41 or 42 could be placed into erasable memory and program flow could
transfer between an erasable memory program and the Master Ignition Routine.
<table>
<thead>
<tr>
<th>TAG</th>
<th>Location Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAPFG7</td>
<td>0C2420 0C4000 0372</td>
</tr>
<tr>
<td>APPFGX</td>
<td>0C2424 0C4002 14522</td>
</tr>
<tr>
<td>APPFGZ</td>
<td>0C2430 77774 71233</td>
</tr>
<tr>
<td>VAPFG*</td>
<td>0C2434 00000 01062</td>
</tr>
<tr>
<td>APPFG*</td>
<td>0C2440 77754 67646</td>
</tr>
<tr>
<td>JAPFG*</td>
<td>0C2444 0612 30716</td>
</tr>
<tr>
<td>RODSCALE</td>
<td>+2</td>
</tr>
<tr>
<td>TAUROD</td>
<td>+2</td>
</tr>
<tr>
<td>LGF/TAU</td>
<td>+2</td>
</tr>
<tr>
<td>MINFORCE</td>
<td>+2</td>
</tr>
<tr>
<td>MAXFORCE</td>
<td>+2</td>
</tr>
<tr>
<td>UTUHZ</td>
<td>0C2534 14370</td>
</tr>
<tr>
<td>OOH</td>
<td>0C2535 11300 00000</td>
</tr>
<tr>
<td>AHZLINE</td>
<td>0C2537 15164 01420</td>
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<tr>
<td>MIF0ET</td>
<td>0C2541 00001 27631</td>
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<td>TOPOET</td>
<td>0C2543 00013 06551</td>
</tr>
<tr>
<td>ZOLATE</td>
<td>0C2474 07640</td>
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<tr>
<td>ZOONTIME</td>
<td>+2</td>
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<tr>
<td>LEPANIE</td>
<td>0C2475 14632</td>
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<td>0C2476 00017</td>
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<td>+2</td>
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</tr>
<tr>
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<td>+2</td>
</tr>
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<td>+2</td>
</tr>
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<td>0C3372 03671 03672</td>
</tr>
<tr>
<td>AGSF</td>
<td>0C3372 21200</td>
</tr>
</tbody>
</table>
TO: Distribution
FROM: B. J. McCoy
DATE: 1 June 1970
SUBJECT: Luminary ID re-release

Due to the bugs that came out of the woodwork after the May 5 release of Luminary ID, the program was judged to be non-flight worthy. The following bugs were fixed and are listed below. The rope release date for these changes is 16 June 1970.

1. Implementation of ACB L 20-
   An error was made in reading assembly card numbers: 2234 vs 2334. By coincidence, they are concerned with the same noun (60) in the NOUN Tables (output and input scaling). The fix makes the output scaling 0.5571 fps/bit and the input scaling the way it was originally, though it is not intended for use.

2. Implementation of PCR 988-
   The Restart point in P66 was moved down four places to prevent the AstrPro flag from being set by a Restart if it had been reset to turn off RCS jets (2) prevent a possible 1466 alarm if a P66 omission occurred with a Restart.

3. Implementation of PCR 896-
   (LMS/KSC). The landing Radar Velocity Reasonableness test could fail erroneously due to service being too fast. It starts to process LR velocity data before the complete set of radar readings are taken for a particular velocity beam. The fix is flowed below.
RL2RBIT is flagword 11 bit 3. This was concurrently discovered by Robert Force, NASA (LMS/MSC) but has not to this date been seen on the FMES at GAEC. A special case, i.e. no alt data good and a V68 terminating the a priori terrain model computations, produced 9 failures at MIT/CSDL.

4. Elevation angle fake out—PCN 1046

the shortened Rendezvous being used on the LMS's for crew training showed that the elevation angle in P34 (ELEV) shares an erasable cell that could cause a problem. At the time it shared with YDOT, the cross axis velocity to which Ascent Guidance is steering. It usually is a very small number; thus, when P34 displays its DP number in NOUN 55, it could appear to the astronaut as 000000. If he wants to compute an Elevation Angle based on a TPI TIG, he probably would not load zeros himself (it looks zero to him, even though it could be a very small non-zero number). This results in a 611 alarm, no Elevation angle for given TIG. The fix put in was to 1) initialize ELEV to zero in P34 before it is displayed and 2) don't share it with YDOT, but where it used to be (in Luminary 1C). (Subsequently reported by R. Force)

5. Implementation of L-1C-01-

A restart point was inserted in a subroutine (S40.8) which returned to the caller via QPRET, which is in the VAC area. Since a particular VAC will not necessarily correspond to the same job after a restart has occurred, the expected return (QPRET) could be anything and, thus, a random transfer is probable following a restart during subroutine S40.8 of P4X. This was corrected by making a direct transfer back from S40.8 to the calling routine UPDATEVG (X product steering).

6. Implementation of PCR 1013-

TOO FEW, the erasable governing the occurrence of a 1466 alarm if P66 issues "too few" throttle commands for everyone omitted (by TLOSS) shares with a P30 erasable and also with a Descent thrust/guidance erasable. It could result in an erroneous 1466 alarm should TLOSS be high enough to cause a P66 omission (now >10%). It was moved to an unshared, unswitched erasable location (1354).

Attached are additional Level III and IV tests to be performed as a result of these changes.

The known problems existing in Luminary that will not be fixed until Luminary 1E are as follows:

1. Luminary anomalies L-1C-01 and L-1C-02
2. "LRPOS" initialization in P63 is reversed
3. a DDOUBL instead of a DOUBLE in Throttle Control logic—effect is 2.7 lbs thrust
4. a V37 following within 10 sec of a V40N20 (CDU zero) turns off DAP
5. Altitude Rate on tape meter glitches periodically: unresolved
6. Cross Pointer - P66 Auto inconsistency: unresolved
7. "LRWH" overlays "RM" of P20
8. DXCH instead of XCH in Throttle Control Logic - affects only Throttle recovery
9. Display conflict in P20's with extended verbs
10. Predesignate flag in P22 incorrectly used
11. "LRWH" is not updated for P63 - P66 interface: unresolved

Corrections to Memo #148

1. Landing Radar beam on Terrain Model Graphs should have opposite polarity
2. for PCR 1029 SERVDURN is loaded with the difference between TIME 1 and PIPTIME +1 (least significant halves) just prior to Average G exit.
3. for PCR 315.2, channel 76 is not really a spare as such. The channel is available for hardware assignment.
4. for PCR 897 should read "...to compensate for a hardware change in the Doppler Ranging Unit."
PCR 1052 was implemented into the re-release to account for the IMU sensing vertical acceleration in P66 when the PIPA's are read while Spacecraft attitude rate is present. The result before the PCR implementation was throttle oscillation commonly referred to as "throttle castellation." Now, when the present acceleration due to thrust is computed (i.e. the PIPA's are read in P66) the pitch rate as determined by the DAP (OMEGAQ) is multiplied by the offset distance the IMU is from the X axis in the Z direction. This quantity is a measure of the Delta Velocity sensed by the PIPA's due to the IMU rotating ("bobbing") around the center of gravity and is subtracted from the total Delta V measured by the PIPA's for that P66 one-second pass. Navigation is in no way affected by the bobbing or the correction.

\[ \Delta V_x = \Delta V_x - \omega \cdot R \]
Level III Addendum
Test Plan for Lummary 1D (rev 163+)

Prepared by: McCoy
Date: 5/28/70

1. Test scaling of NOUN 60 R1-ACBL20
   a. Dump FORVEL (during Descent, for edit) at VERTDISP
   b. Edit will print out value scaled at 0.5571
   c. Compare to DSKY at corresponding time

2. Test Restart point in P66 - PCR 988
   a. cause a Restart in P66 (with 10% TLOSS) after P66 omission having "PRO"ed on NOUN 60
   b. show that "P66 PROFL" remains reset and no 1466 alarm occurs

3. Test R12 velocity radar readings PCR 866
   a. w/o alt data good, w/v68 - show that R12 waits; note time margin and compare duty cycle to run before this fix
   b. w/ alt data good, w/o v68 - show that R12 doesn't wait; compare duty cycle to run before this fix
   c. do (a) above with 10% TLOSS
   d. do (b) above with 10% TLOSS

4. Test that ELEV (DP) is initialized to zero in P34-PCN 1048
   a. pad load posmax into ELEV - trace coding to show proper load and note R2 of NOUN 55 equals zero.
   b. use old level 4 test NEWROT (rollback) to show that Lambert computes good ELEV for TIG loaded.

5. Test P40 restart fix: L-1C-01
   a. Trace S40.8 to show direct transfer back to UPDATEVG which had called it.
   b. Cause a Restart during S40.8 and trace as in (a).

6. Test TOO FEW doesn't share, period: PCR 1013
   a. show that TOO FEW does not change during an entire landing
Positioned by: McCoy
Date: 5/28/70

Rerun previous Level IV with following additions:

4.1.1 Nominal Automatic Landing
   a. call P20 in no-update mode (V95E)
   b. call P30 to load any ΔV into NOUN 81 at TIG of PDI +1 minute
   c. Trace loading of LRWH into LRWH
   d. Rollback ANEWROT and load the proper value via V21N01E, XXXXXE in P64 prior to data good after antenna reposition

4.1.2 Nominal Landing w/ Redesignations
   a. Trace 1st Pass through R12 to show proper re-initialization.

4.4.0 Surface Operations
   a. call P22 when Range to CSM>400 n. mi.
   b. when V16N54 appears, call R47 via V47E
   c. note any discrepancy
LUMINARY Memo #167

To: Distribution
From: B. McCoy, P. Rye
Date: 17 August 1970
Subject: Luminary 1D: Which One, What Kind, How Many?

Luminary 1D will be released for the third time on 19 September 1970; its revision # is 178. The new changes incorporated are PCRs 322, 1056 and 1058. Herewith are the descriptions.

PCR 322: One of the major causes of the predatory "throttle castellations" was the response time of the DPS throttle (THROTLAG). The previous value was 0.2 seconds; the new value is 0.08 seconds.

PCR 1056: The required ullage time for a very light Ascent Stage burn using 2 jets is 14 seconds before ignition. The previous Luminary 1D had assumed 3.5 seconds of ullage before ignition causing 2-3 fps overburn. The Apollo 14 crew will be using 4 jet ullage and this would contribute another 2-3 fps to the overburn. Luminary 178 will turn on ullage at 6 seconds prior to ignition. For 4 jet ullage, the required ullage time is 30 seconds. Since, the LGC turns it on at TIG -6 seconds, the astronaut can release the ACA when V99 appears (at TIG -5 seconds). Specifically, "P42TABLE +6" was changed to 2390 (-29.9 +6 seconds) and S40.13 uses "FRCS4" instead of "FRCS2" to assume 4 jet ullage, and also it uses "6.5 SECS" to assume 6.5 seconds of ullage (ullage is turned off at TIG +0.5 seconds). The value of K1VAL (total APS impulse in one second) was 2800 lbf·sec which is based on a "dry" (not yet fired) APS engine. The TPI impulsive burn and most conceivable burns on the APS (except lunar ascent) will be done on a "wet" engine. The value of 2800 lb/sec caused an overburn of roughly 2 fps. This value was changed to 3150 lbf·sec (extrapolation of data from LM Data Book).
PCR 1058: When it was found that the Landing Analog Displays Routine (R10) gave results with errors up to 3.5 fps in the cross pointer display, a new R10 was suggested to effectively eliminate these errors. In the process the altitude-rate glitch was eliminated. The word saving was 119 words; the new R10 takes 1% longer. The main cause of the errors was the single precision dot products; these were changed to double precision. Also, some computational simplifications were made to the dot products, knowing that the IMU is aligned to the landing site. A PIPA bias correction term is added to increase accuracy; computation of VBIAS formerly done in P66 is now done in SERVICER. Altitude is based on a simpler extrapolation than before. R10 now computes altitude and Alt-Rate every pass (every 1/4 second) outputting Alt-Rate before a 12 cs pause, Altitude immediately after the pause. Flag bit SWANDISP is now set immediately after SERVICER computes the parameters necessary for R10 so that R10 may start near TIG -30 rather than at ignition. The DIDFLAG definition remains the same; just DID the initialization. IMODES33 bit 7 is no longer used. ACB L-11 and Anomaly L-lB-04 were not incorporated into the new R10 as originally conceived, but they are in Luminary 178: The forward velocity for NOUN 60 will be computed if the MODE SELECT switch is not in PGNCS (and incidentally accurate to 0.1 fps); R10 will be initialized if the RR CDU ENABLE bit is removed by e.g. moving the RR MODE switch into and out of LGC.

The R10FLAG has been redefined. When it's set by P12, P70, P71, the inertial Y velocity will be displayed on the lateral velocity cross pointer while the forward velocity crosspointer is set to be zero. The lateral velocity is VVECT +2 minus VSURFACE +2; (inertial (Y)- SURFACE (Y) velocities).

Flow Charts for R10 and its interface parameter computation are attached. For more details see Luminary Memo #162 by Don Eyles. This memo supercedes Memo #162 where differences occur.
Changes to other areas due to R10 design:

1. downlist mnemonic changes
   LATVEL to LATVMETR
   FORVEL to FORVMETR

2. VBIAS calculation moved from STRTP66A into NORMLZE;
   parameter GHZ removed

3. For erasable overlay purposes ZAXIS computation moved to Ascent
   Guidance from P12 initialization.
R10 COMPUTATIONS in SERVICER

COPYCYC1

\[ \text{HCALCLAD} = \text{HCALC1} \]
\[ \text{DALTRATE} = \left( \frac{\text{UNIT/}r}{\text{XVJS}} \right)^2 \]
\[ \text{HDOTLAD} = \text{HDOTDISP} \]

\[ \text{G-VBIAS} = \text{GDTI/2} - \text{VBIAS} \]

\[ \text{RUNITX} = \left( \frac{\text{UNIT/}r}{1} + 1 \right) \times 2 \]
\[ \text{RUNITY} = \left( \frac{\text{UNIT/}r}{2} + 2, 3 \right) \times 2 \]
\[ \text{RUNITZ} = \left( \frac{\text{UNIT/}r}{3} + 3, 5 \right) \times 2 \]

SINGLE PRECISION, FULL SIZE

Set bit 11
FLAGWD 7

NORMALIZE

Define VBIAS equals VBIASX, Y, Z for one second

RVBOTH

VSURFACE = \left| \text{WM} \times \text{RIS} \right|

Interface parameters for R10 have been computed
LANADISP

\[
\text{PIPCTR} \leftarrow \text{PIPCTR1}
\]
\[
\text{TBASE2} \leftarrow (-L - \text{TIME1})
\]

\[\text{Bit 11} \quad \text{FLAG 7}\]

CLEAR: SERVICER completed

SET: SERVICER not completed

\[\text{VVECT} \leftarrow \text{V-SURFACE}\]

\[\text{DT} \leftarrow \text{TIME1} - \text{PIPTIME1}\]

\[\text{VVECT} \leftarrow \text{VVECT} + (\text{PIPA} + \text{PIPATMP}) \times \text{LANAKPIP}\]

\[\text{VVECT} \leftarrow \text{VVECT} + (G - \text{VBIAS}) \times \text{DT}\]

ALTSTUFF

continued on next sheet
ALTSTUFF

\[ \text{DALTRATE} = \text{RUNIT} \cdot \text{VVECT} \]
\[ \text{ALT RATE} = \text{DALTRATE} \times \text{DT} \]
\[ \text{ALTITUDE} = (\text{ALT RATE} + \text{HDOTLAB}) \times \text{DT} + \text{H CALC LAB} \]

MODE SELECT

AGS, LDR

CLEAR

DIDBIT

SET: initialization already performed

RR CDU
CDU ENABLE & BIT

SET: Crosspointers Enabled

DISPRSET page 10

ALTRROUT

Set bit 2
CHAN 14

Scale ALT RATE to 0.5 fps/bit & round to 0.5 fps

Set bit 3
CHAN 14

Signify Altitude Rate
Tape Meter Driven Below

continued on next sheet
from preceding sheet

**PAUSE 12 cs.**

**ALTROUT**

**Reset bit 2 CHAN 14**

**Scale ALTITUDE to 2.345 ft/bit!**

**Lower limit + ZERO**

**Set bit 3 CHAN 14**

**CROSVMETR**

**Page 9**

Limit FORVTEMP command to 198 fps. Scale in units of 0.5871 fps and round to nearest 0.5871 fps.

\[
\text{CDUSCMD = FORVTEMP - FORVMETR + (-ZERO) FORVMETR = FORVMETR + CDUSCMD}
\]

continued on next sheet
Limit LATVEL command to 194 fps. Scale in units of 0.5571 fps and round to nearest 0.5571 fps.

CDUTCMD = LATVEL - LATVMETR + (-ZERO)
LATVMETR = LATVMETR + CDUTCMD

Set bits 11 and 12 of CHAN 14

Drive Cross Pointers

TASKOVER
CRSCMP

R10BIT

SET: Ascent
CLEAR: Descent

VHZ = RUNITZ (VVECT) + RUNITX (VVECT2, 1)
VHY = VVECTY

FOVTEMP = (VHZ + 1) M32 - (VHY + 1) M22
LATVEL = (VHY + 1) M32 + (VHZ + 1) M22

FORVELJ + 1 = FORTEMP + 1

FORTEMPJ + 1 = ZERO

LATVEL = (VVECTY, +1) + VSURFACE + 2, + 3

for DSKY

Return to Caller
**DISPRSET**

**CROSCOMP**

*page 9*

**DISPRSET +1**

**RESET**

**DIDBIT**

- **Bit 8**
  - **IMODE33**
    - **CLEAR**
      - **SET**
        - **Reset bit 2**
          - **CHAN 12**

- **Reset bit 8**
  - **CHAN 12**

**TASKOVER**

---

**DISPINIT**

**CROSCOMP**

*page 9*

**Set**

**DIDBIT**

**Set bit 8**

**CHAN 12**

**LATVMETR, FORVMETR = ZERO**

**INTLZE**

*3 SECOND*

**TASKOVER**

---

**INTLZE**

**Set bit 2**

**CHAN 12**

**Enable R2**

**END ENTER**

**Set bit 8**

**IMODE33**

**Indicate Tape Meters Enabled**

**TASKOVER**
LGYRD is direction for dedication of which gyro axis is being torqued. It is prepended normal (good) exit of PULSE. If not good, exit (e.g. course align before normal exit) LGYRD is left nonsense, other jobs coming up to do pulsating. See LGYRD is nonsense & go to sleep.

04 PL5 2 words

05 P20/22 E BANK

06 DTOTAL 5 words + 2 gradable

07 NEEDLER 6 words

08 MAXIS OVRD 2 6 words

10 PACE 9 words
EXISTING ANOMALIES IN LUMINARY 1D AS OF 9/29/70

LNY 31: Don't use V30 or V31 (or LoadN26) during any of the programs or routines mentioned.

LNY 51: When P20 is excited by means of V56, and no other program is running, the major mode display on the DSKY goes blank.

L-10-01 NEEDLE Initialization never takes place following DAP turn-on.

L-10-02 Core set overflow (3120w) alarm from bad return from pulse tagwyn.

L-10-04 P25 Without control spacecraft attitude if range to CSM is greater than 566NH.

L-10-05 Certain Verb routines should not be requested if P20 or P22 is running. READY to GO

L-10-06 DV TOTAL increment twice in one service cycle.

L-10-07 Manual rate control mode improperly terminated.
L-10-08  Payload LRWH1 after erasable detection with RM of P20.

L-10-10  There are a number of windows during which a charge in major modes would wipe out a waiting 1/ACS job, leaving the DAP with improper data.

L-10-11  WB off by x2

12 VHI during remode
MIT/IL SOFTWARE ANOMALY REPORT

1.1 ORIGINATOR: J. KERNAN
1.2 ORGANIZATION: MIT/IL
1.3 DATE: 1/20/69
1.4 ORIGINATOR CONTROL NO.

1.5 DESCRIPTION OF ANOMALY:
Request Executive (V30) and Request Waitlist (V31), which require loading Noun 26, should not be used with programs which share the N26 erasables DSPEEM 1, +1, and +2.

The other nouns which use these erasables are 4, 5, 25, 34, 41, and 97.

CONTINUED ON PAGE 2

1.6 DESCRIPTION OF RUN:
Use V30 or V31 while running a program or routine which uses one of the above nouns; e.g., P21.

CONTINUED ON PAGE

-MIT ANALYSIS-

2.1 CAUSE:
Erasable conflict.

2.2 RECOGNITION:
Abnormal program behavior.

2.3 MISSION EFFECT:
Indeterminate.

2.4 AVOIDANCE PROCEDURE:
Don't use V30 or V31 (or load N26) during any of the programs or routines mentioned in 1.5.

2.5 RECOVERY PROCEDURE:
Terminate the program or routine and reselect it.

2.6 PROGRAM CORRECTION:
Use unshared erasables for Noun 26.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc)
Program note.

2.8 RECOMMENDED RE-TESTING:
None.

CONTINUED ON PAGE

3.1 NASA DIRECTION:

CONTINUED ON PAGE

3.2 MIT/IL SIGNATURE: 2.10 DATE: 1/21/69

3.3 ORGANIZATION 3.4 DATE: 4.2 SIGNATURE: 4.3 ORGANIZATION 4.4 DATE:

NASA MSC SIGNATURE: 4.1 CLOSING ACTION TAKEN:
Program note in LUMINARY

CONTINUED ON PAGE

NASA MSC FORM 1409 (Rev May 68)
1.5 Description of Anomaly, cont'd.

The programs and routines which use the nouns in question are:

- R04 (N25)
- P07 (N41, N97) ground test
- P20 (N05, N25)
- P22 (N05, N25)
- P40 (N25)
- P51 (N05, N25)
- P57 (N04, N05, N25, N34)
- P70 (N25)
- P78 (N34)
- P06 (N25)
- P12 (N25)
- P21 (N34)
- P38 (N34)
- P42 (N25)
- P52 (N05, N25, N34)
- P63 (N25)
- P71 (N25)
### MIT/IL SOFTWARE ANOMALY REPORT

**1.1 ORIGINATOR:** D. A. Pettit

**1.2 ORGANIZATION:** GAEC

**1.3 DATE:** 3/26/69

**1.4 ORIGINATOR CONTROL NO.:** IM-1UM-14

**1.5 ANOMALY REPORT NUMBER:** LNY-51

**1.6 DESCRIPTION OF ANOMALY:**

When P20 is exited by means of V56, and no other program is running concurrently, the major mode display on the DSKY goes blank. V37 flashes requesting a new program. The major mode on the DSKY remains blank until a new program is selected via the DSKY. The integration in P20 is completed before exiting P20, but while in program blank there is no integration performed, i.e., the downlink state vectors will remain static until a new major mode is selected.

**1.6 DESCRIPTION OF RUN:**

FMES/FCI

### MIT ANALYSIS

2.1 CAUSE:

The program is designed to operate as described.

**2.2 RECOGNITION:**

N/A

**2.3 MISSION EFFECT:**

None

**2.4 AVOIDANCE PROCEDURE:**

Answer the Flashing V37 as soon as practical.

**2.5 RECOVERY PROCEDURE:**

N/A

**2.6 PROGRAM CORRECTION:**

None. This is not an anomaly.

**2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):**

None

**2.8 RECOMMENDED RE-TESTING:**

None

**3.1 NASA DIRECTION:**

**3.2 NASA/MSC SIGNATURE:**

**3.3 ORGANIZATION:**

**3.4 DATE:**

**3.5 SIGNATURE:**

**3.6 ORGANIZATION:**

**3.7 DATE:**

**4.1 CLOSING ACTION TAKEN:**

**4.2 SIGNATURE:**

**4.3 ORGANIZATION:**

**4.4 DATE:**
"NEEDLER" initialization never takes place following DAP turn-on if IMU error counters (CH 12 B 06) are enabled. This causes cells EDRIVE to be improperly loaded and cause a bias (constant except where changed due to DAC overflow) in the ATTITUDE ERROR NEEDLES.

Apollo 13: Crew turned on LGC with DAP OFF. They did a P52 option 1 which included a coarse align. This left CH 12 B 06 set so that "NEEDLER" did not properly initialize when DAP was subsequently turned on.

- MIT ANALYSIS -

2.1 CAUSE:
Proper initialization of the FDAI needle display only occurs when
1. The LGC is on,
2. The PGNCS mode select switch is not "Off".

2.2 RECOGNITION:
Constant bias in the needles; needles not nulled at the attitude reached by the DAP.

2.3 MISSION EFFECT:
Crew has an incorrect indication of the attitude error.

2.4 AVOIDANCE PROCEDURE:
1. Do not coarse align with the PGNCS mode select switch "Off".
2. After LGC power up (or a verb 43) do coarse align or CDU zero with PGNCS not "Off".

2.5 RECOVERY PROCEDURE:
Do a CDU zero (V40N20) with the PGNCS attitude mode select switch not turned to "Off".

2.6 PROGRAM CORRECTION:
Set RCSFLAGS/bit3 to call for NEEDLER initialization whenever the mode select switch is found "Off" (in addition to the present logic).

2.7 RECOMMENDED DISPOSITION: Fix, Work-around, etc:
Ensure that Apollo 14 checklists follow "avoidance procedure".
Fix in LUMINAR3 Y 1E.

2.8 RECOMMENDED RE-TESTING:
Limited testing on hybrid to show that various sequences all give valid needles.
2.1 continued

3. Either IMODES 33/bit 6 is set (DAP disabled by IMU routines) or channel 12/bit 6 is reset (IMU error counters disabled).

This initialization should be done whenever the NEEDLER routine may not have proper knowledge of the voltages to the FDAI needles; thus, it should be done after any IMU coarse align (which uses those same voltages to drive the IMU), a V43 (test of the FDAI needles), or a power-down of the needles' digital-to-analog converter.

As noted in block 1.6, in Apollo 13, P52 was done while the DAP was still "Off". Consequently, the setting and resetting of the two bits mentioned above did not serve to trigger the needed initialization.
A. Coding

☑ Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

☑ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: 

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 7-8-70
1.5 DESCRIPTION OF ANOMALY:

It is possible that a core set overflow (31202 Abort) will result from a "bad" return from pulse torquing due to IMU cage or coarse align.

1.6 DESCRIPTION OF RUN:

Satanche Level 3 test

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MIT ANALYSIS---

2.1 CAUSE:

"LGYRO" not zeroed if pulse torquing ends due to cage or coarse align; subsequent jobs attempting torquing will stack up via JOBSLEEP.

2.2 RECOGNITION:

31202 Abort

2.3 MISSION EFFECT:

Software restart caused by 31202 abort cleans up the problem, but further calls (by gyro compensation during average G) will refill the core sets, causing repeated overflows.

2.4 AVOIDANCE PROCEDURE:

Do not coarse align during Average G; or else set GCOMPSW negative. Zero LGYRO whenever cage is pushed.

2.5 RECOVERY PROCEDURE:

Set GCOMPSW negative (terminates compensation).

2.6 PROGRAM CORRECTION:

Clear LGYRO and wake possible sleeping jobs before exiting pulse torquing routine.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

Fix for Luminary 1E

2.8 RECOMMENDED RE-TESTING:

Level 2 test.

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NASADIRECTION:

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4.1 CLOSING ACTION TAKEN:

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A. Coding

☐ MIT Approved PCN  ☒ NASA Approved PCR
☐ MIT Approved ADR  ☐ NASA Approved PCR
☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

Begin coding immediately

ACTION:  
Pat White

Program Supervisor's Approval:  
Margaret Anderson

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager:  
[Signature]

Date:  7-8-70
P25 will not control spacecraft attitude if range to CSM is greater than 566 N. M.

2.1 CAUSE:
Coding error - P20/P22 logic is also being applied to P25.

2.2 RECOGNITION:
After selection of P25, no attitude changes occur; possible alarm light (code 526)

2.3 MISSION EFFECT:

2.4 AVOIDANCE PROCEDURE:
R63 can be used to position Z-axis along line-of-sight

2.5 RECOVERY PROCEDURE:
None

2.6 PROGRAM CORRECTION:
Restore RNDVZFLG check to LPS20.1 subroutine.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):
Fix for 1E; work-around for 1D

2.8 RECOMMENDED RE-TESTING:
P25 with range > 400 N. M.

2.9 MIT/LL SIGNATURE:

2.10 DATE: 7-6-70

3.1 NASA DIRECTION:

4.1 CLOSING ACTION TAKEN:

4.2 SIGNATURE: [Signature]

4.3 ORGANIZATION: [Organization]

4.4 DATE: [Date]
A. Coding
- Begin coding immediately

ACTION:
Program Supervisor's Approval: 

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
- Prepare GSOP revisions for MDRB consideration

ACTION:

- Technical Committee Meeting not required.

- Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout
- Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
- Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: 
Date: 7-8-70
The following extended verb routines should not be requested if P20 or P22 is running and the range to the CSM is greater than 400 N.M.

- R04 (V63) LR/RR self-test
- R05 (V64) S-band antenna
- R30 (V82) Apogee/Perigee display
- R31 (V83) Range/Range rate display
- R47 (V47) AGS initialization

**2.1 CAUSE:**

Erasable conflict

**2.2 RECOGNITION:**

Incorrect computations by these routines also noun 54 display in P20/P22 incorrect.

**2.3 MISSION EFFECT:**

Bad AGS update if V47 requested.

**2.4 AVOIDANCE PROCEDURE:**

Do not select extended verbs while in P20/P22 with range > 400 N.M.

**2.5 RECOVERY PROCEDURE:**

Terminate extended verb

**2.6 PROGRAM CORRECTION:**

Change erasable assignments to avoid conflict.

**2.7 RECOMMENDED DISPOSITION** (Fix, Work-around, etc.):

Work-around for 1D fix in 1E

**2.8 RECOMMENDED RE-TESTING:**

Select above extended verbs in P22 while N54 is being displayed
A. Coding
☑ Begin coding immediately

ACTION:

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION:

C. Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager:

Date 7-8-70
"DVTOTAL", the accumulated measured Delta Velocity from SERVICER, incremented twice in one SERVICER cycle after Restart occurred.

1.6 DESCRIPTION OF RUN:

FMES P40 simulation at GAC

2.1 CAUSE:

DAS instruction to DVTOTAL performed twice - no Phase change immediately following.

2.2 RECOGNITION:

R3 of N40 at end of burn ≠ R2 of N40 at start of burn

2.3 MISSION EFFECT:

None - downlist quantity may show extra ΔV (~10 fps) if Restart occurred during Powered Flight

2.4 AVOIDANCE PROCEDURE:

None

2.5 RECOVERY PROCEDURE:

None

2.6 PROGRAM CORRECTION:

Add TC QUICKFAZ5 after DAS instruction

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

None for 1D; fix for 1E

2.8 RECOMMENDED RE-TESTING:

Trace DAS instruction after Restart

3.1 NASA DIRECTION:

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3.2 NASA/MSC SIGNATURE:

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3.3 ORGANIZATION

4.1 CLOSING ACTION TAKEN:

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4.2 SIGNATURE

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</table>

A. Coding

- Begin coding immediately

**ACTION:**

George, Karon

Program Supervisor's Approval:

Margaret Hamilton

- Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

- Prepare GSOP revisions for MDRB consideration

**ACTION:**

C. KSC Testing and Checkout

- Review for possible impact on KSC testing and checkout

**ACTION:**

D. Other Programs Affected

- Review for corresponding changes in

**ACTION:**

Special Instructions

Project Manager:

Date: 7-8-70
If the mode control switch is moved from the ATT. HOLD to the AUTO position before the manual rate command mode has been properly terminated and while X-axis override is inhibited:

1) A short RCS jet firing (.15 sec. maximum) may occur about the yaw axis if the mode control switch is later returned to the ATT. HOLD position or if the X-axis override inhibition is removed.

**MIT Analysis**

2.1 Cause: 1) When the manual rate command mode is improperly terminated by switching to the AUTO mode control switch position while

2.2 Recognition: 1) A short yaw RCS firing at switch to ATT. HOLD or automatic removal of X-axis override inhibition.

2.3 Mission Effect: Possible unexpected RCS firing or yaw maneuver at switch to ATT. HOLD or automatic removal of X-axis override inhibition.

2.4 Avoidance Procedure: Wait at least 5 sec before switching mode control switch to AUTO position after returning ACA to detent following manual rate command maneuvers.

2.5 Recovery Procedure: 1) No recovery procedure necessary
2) Move ACA rapidly out of detent and back in yaw axis (a natural reaction)

2.6 Program Correction: Reset OURRCBIT whenever mode control switch is in AUTO position while X-axis override is inhibited.

2.7 Recommended Disposition: (Fix, Work around, etc):
Work around in Luminary 1D
Fix in Luminary 1E

2.8 Recommended Re-testing: Verify that anomaly has been properly fixed in Luminary 1E before release.
1.5 Cont.

2) The LM may yaw to a different attitude (180° max) when the X-axis override inhibition is removed if the direct rate damping phase of the manual rate command mode is active for the Q or R axis at the time of the switch to AUTO. During P64, for example, if:

1. The Mode Control Switch is moved to the ATT. HOLD position.

2. A 10°/sec pitch rate is commanded with the ACA.

3. The ACA is snapped back into detent position.

4. The Mode Control Switch is moved back to the AUTO position within 1 sec of the return to detent.

5. The yaw attitude is changed due to lateral redesignations.

When P66 is subsequently entered, the X-axis override inhibition is automatically removed. The vehicle will then yaw to the yaw reference attitude that existed when the Mode Control Switch was in the ATT. HOLD position.

2.1 Cont.

X-axis override is inhibited, OURRCBIT remains set. Consequently if the X-axis override inhibition is removed or if the mode control switch is moved back to the ATT. HOLD position, the P-axis manual rate command mode coding is entered immediately without the proper initialization. Thus, the manual P-axis attitude error, DXERROR, remains equal to the change in P-axis attitude since the improper termination of the manual rate command mode. If DXERROR is greater than the deadband, RCS jets may fire for up to 0.150 sec to reduce DXERROR. On the next DAP pass the manual rate command mode will be terminated properly, and the attitude hold mode will be entered.

2) If the direct rate damping phase of the manual rate command mode is active for the Q or R axis at the time of the switch from the ATT. HOLD to the AUTO mode control switch position while X-axis override is inhibited, QRBIT as well as OURRCBIT remains set and JUSTIN bit remains reset. When the X-axis override inhibition is removed, the P-axis manual rate command coding is immediately entered without initializing DXERROR. As in case 1, the RCS jets will fire to reduce DXERROR. Because JUSTIN is reset and QRBIT is set, however, the manual rate command mode cannot be terminated unless the mode control switch is moved back to the ATT. HOLD position (so that the QR axis manual coding will be exercised and QRBIT will be reset). Consequently, the DAP will yaw the vehicle until DXERROR is reduced to zero, then hold the new yaw attitude in the pseudo auto manual rate command mode.

2.2 Cont.

2) Yaw to new attitude at automatic removal of X-axis override inhibition.

2.6 Cont.

Reset QRBIT during rate damping in X-axis override mode.
INITIAL PROGRAM CHANGE ROUTING SLIP

A. Coding

☑ Begin coding immediately

ACTION:

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
 Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: [Signature]

Date: 7-8-70
Padload "LRWHl" shares erasable memory location with RM of P20.

1.6 DESCRIPTION OF RUN:

Eyeball

2.1 CAUSE:

see 1.5 above

2.2 RECOGNITION:

eyeball

2.3 MISSION EFFECT:

If P20 is selected before PDI to track CSM, the LR weighting function in P64 and P66 may affect navigation.

2.4 AVOIDANCE PROCEDURE:

Load LRWHl prior to PDI: V2lNOIE3756EXXXXXXE

2.5. RECOVERY PROCEDURE:

Load LRWHl: V2lNOIE3756EXXXXXXE

2.6 PROGRAM CORRECTION:

Move LRWHl to unshared memory.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

Program note for 1D; fix for 1E.

2.8 RECOMMENDED RE-TESTING:

Simulate landing sequence and show no change in LRWHI

2.9 MITIL SIGNATURE:

2.10 DATE: 7-6-70

3.1 NASA DIRECTION:

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3.2 NASA/MSC SIGNATURE:

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A. There are a number of windows during which a change in major mode would wipe out a waiting 1/ACCS job, leaving the DAP with improper data.

In this context, a "change in major mode" means a V37, V96, V56 or a V34 response to various displays in P20, P22 and P25. Each of these wipes out all waiting jobs.

1/ACCS is a routine which computes the control authorities of the RCS jets and the trim gimbals on the basis of vehicle mass and configuration.

Inspection of coding.

--- MIT ANALYSIS ---

2.1 CAUSE:

See Description of Anomaly.

2.2 RECOGNITION:

See page 3

2.3 MISSION EFFECT:

See Recognition. The only case that might be serious is case A3.

2.4 AVOIDANCE PROCEDURE:

See page 3

2.5 RECOVERY PROCEDURE:

Any procedure that causes 1/ACCS to be done. The simplest is V48E, Pro, V34E.

2.6 PROGRAM CORRECTION:

Have the subroutine that wipes out the queue of waiting jobs set up a job to do 1/ACCS. Any change in major mode will thus cause a 1/ACCS job to be done.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix in LUMINARY IE; work around in Apollo 14. (See PCN 1059)

2.8 RECOMMENDED RE-TESTING:

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3.1 NASA DIRECTION:

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3.2 NASA/[MSC] SIGNATURE: 4.2 SIGNATURE:

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It also computes various quantities which effectively determine the placement and curvature of the switch curves in the RCS phase plane on the basis of jet control authorities, the current attitude deadband, the vehicle configuration, whether it is powered or coasting flight, and jet failures. 1/ACCS should be executed whenever any of its inputs change. Hence, it is done in SERVICER after the mass is decremented and a job to do it is set up by the routines which change the deadband and the various discrete inputs.

If one of these jobs is wiped out by a change in major mode, some change in data may not have been effectively assimilated into the autopilot. Specifically,

1) abnormal exits from a powered flight program (including a V34 response to a flashing V97 or V99) could leave an improper deadband and/or the powered flight configuration of the RCS control law;

2) termination of P20 or P25 could leave a 0.3 degree deadband if R23 or R60 were in progress;

3) termination of routine 03 at the second display (N47) by change in major mode would prevent any desired changes to the deadband or the vehicle configuration from being incorporated into the phase plane and the rate estimator;

4) a change in major mode immediately after an RCS isolation valve was opened or closed would prevent the proper modification to the RCS phase plane logic. (The window for this is extremely small.)

B. Another problem could arise if a restart occurred in a certain part of the Lunar Surface Navigation Program, P22, with the range greater than 400 nautical miles and a positive range rate. Immediately following such a restart, coding would be entered via the phase table which would terminate P22 and, in the process, wipe out waiting jobs. Since a restart calls for a 1/ACCS job and clears the ACCSOKAY bit (DAPBOOLS/bit 3,) the DAP will idle until the 1/ACCS is done. If the P22 exit comes in while that 1/ACCS is in the queue of waiting jobs, it will wipe it out (together with the rest of the queue). Thus, the DAP will be left idling, waiting for a job which has gotten "lost". It will idle until 1/ACCS is done by some other routine - e.g. RO3 or the initiation of AVERAGEG. Since P22 is only done on the lunar surface, when the DAP is not needed, it seems quite certain that the occurrence of this case would have no effect at all on the mission.
2.2 Recognition

The various cases given in the Description will be treated separately.

A1) The crew or the ground might notice the discrepancy in the deadband because either the DAP was allowing the attitude error to grow larger than expected or the DAP was firing to correct attitude errors that were smaller than the expected deadband.

A2) Same as A1 except that the expected deadband would always be larger or equal to the deadband in effect.

A3) Same as A1 for deadband changes. Errors in configuration could result in extremely sloppy control or even instability.

A4) Some extra chattering of the RCS jets.

B) Console light(s) in the Mission Control Center would be lit. Also, if such a lock-out were accomplished and some activity which required the DAP were then carried out without first doing Routine 3 or in some other way causing 1/ACCS to be done, then it would be found that the DAP was not performing its function. One possible lunar surface activity that uses the DAP is an RCS test.

2.4 Avoidance Procedures

The crew can avoid the particular procedures that lead to the difficulties of case A. Specifically, the following should be avoided:

1) exits from powered flight programs after the pre-burn attitude is calculated that do not go through the final displays of that program;

2) termination of P20 or P25 during the execution of R23 or R60;

3) termination of R03 by a change in major mode;

4) change in major mode within a second of operating an RCS isolation valve.

There is no avoidance procedure for case B.
1.5 DESCRIPTION OF ANOMALY:
The value of $W_B$ is mis-scaled in Luminary 1D by a factor of 2 (See Luminary MEMO #169)

1.6 DESCRIPTION OF RUN:
Eyeball (Reported in comments to MIT from MSC)

2.1 CAUSE:
Error in preparation of PCR to change the LOSSEM Ephemers Number.

2.2 RECOGNITION:
Error when an approximate position vector of the moon is computed in LSPOS

2.3 MISSION EFFECT:
Bad alignment if the sun and moon are used.

2.4 AVOIDANCE PROCEDURE:
See 2.5

2.5 RECOVERY PROCEDURE:
The ground can transmit a very accurate Moon position vector if that body should be desired for alignment.

2.6 PROGRAM CORRECTION:
Correct scaling of $W_B$

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):
Fix for Luminary 1E. These numbers have to be changed for a new year for Apr 10 15.

2.8 RECOMMENDED RE-TESTING:

3.1 NASA DIRECTION:

3.2 NASA/MSC SIGNATURE:

4.1 CLOSING ACTION TAKEN:

4.2 SIGNATURE:

4.3 ORGANIZATION:

4.4 DATE:

MSC Form 1409 (Rev May 68)
A. Coding

☑ Begin coding immediately

ACTION: ____________________

Program Supervisor's Approval: ____________________

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: ____________________

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on ____________________

Attendees: ____________________

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: ____________________

D. Other Programs Affected

☐ Review for corresponding changes in ____________________

ACTION: ____________________

Special Instructions

Project Manager: ____________________

Date: 9-18-70

ATTORNEY-GENERAL
Selection of V4IN72 (RR Coarse align) while an RR reposition or remode is in progress results in incorrect operation of V4IN72. Also keying in V44 while a reposition is in progress will cause erroneous operation of a subsequent V4IN72.

**1.6 DESCRIPTION OF RUN:**

N A.

**-MIT ANALYSIS-**

**2.1 CAUSE:**

V4IN72 disables the RR error counter enable outbit, which stops the antenna drive, but the remode(or reposition) flags are not cleared.

**2.2 RECOGNITION:**

Following the loading of desired angles in N73, N72 will show actual angles not converging to desired angles.

**2.3 MISSION EFFECT:**

None.

**2.4 AVOIDANCE PROCEDURE:**

Do not key in V4IN72 while a reposition or remode is in progress, or V44 while a reposition is in progress.

**2.5 RECOVERY PROCEDURE:**

Cycle RR MODE SELECT switch from LGC to SLEW and then back to LGC. (Wait at least one second before returning to LGC).

**2.6 PROGRAM CORRECTION:**

Add checks to V41 and V44.

**2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):**

Fix for Luminary 1E, workaround for Luminary 1D.

**2.8 RECOMMENDED RE-TESTING:**

V4IN72 and V44 tested during RR repositioning.

**3.1 NASA DIRECTION:**

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**3.2 NASA/MSC SIGNATURE:**

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**4.1 CLOSING ACTION TAKEN:**

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**4.2 SIGNATURE:**

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1.5 DESCRIPTION OF ANOMALY: PCR 1028 provided a separate erasable load for LRWH in the programs following P63. P63 uses LRWH, post P63 uses LRWH. IF P66 is entered directly from P63, the P63 value of LRWH will be used.

1.6 DESCRIPTION OF RUN:

eye ball (TRW A-201 dated 23 May 1970)

2.1 CAUSE:

LRWH1 is initiated in the transition to P64 only.

2.2 RECOGNITION:

none

2.3 MISSION EFFECT: For Apollo 14 LRWH1 = LRWH
For subsequent missions - negligible effect

2.4 AVOIDANCE PROCEDURE:

none

2.5 RECOVERY PROCEDURE:

For Apollo 14, none; load LRWH with LRWH1 after P66

2.6 PROGRAM CORRECTION:

set LRWH = LRWH1 at manual entrance point to P66

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.)
do not fix - ground note

2.8 RECOMMENDED RE-TESTING:

none

2.9 MIT/IL SIGNATURE: Larson

2.10 DATE: 10/8/70
At TIG-5 in P40, TGO is computed. If TGO is computed to be less than 6 seconds, NO THROTTLE FLG (FW5 B12) should be set as shown on P. 398, line 680 of GSOP Section 4 (Lum Rev 131) to inhibit throttle command to max at TIG+ZOOMTIME. However, this bit is not set in LUMINARY Rev 178 causing the LGC to command max throttle at TIG+ZOOMTIME (although the engine would of course be off).

**MIT ANALYSIS**

### 2.1 CAUSE:

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### 2.2 RECOGNITION:

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### 2.3 MISSION EFFECT:

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### 2.4 AVOIDANCE PROCEDURE:

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### 2.5 RECOVERY PROCEDURE:

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### 2.6 PROGRAM CORRECTION:

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### 2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

CONTINUED ON PAGE

### 2.8 RECOMMENDED RE-TESTING:

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### 3.1 NASA DIRECTION:

CONTINUED ON PAGE

### 3.2 NASA/MSC SIGNATURE:

CONTINUED ON PAGE

### 4.1 CLOSING ACTION TAKEN:

CONTINUED ON PAGE
### MIT/IL SOFTWARE ANOMALY REPORT

**1.1 ORIGINATOR:**
N. Barnert

**1.2 ORGANIZATION:**
MIT/CSDL

**1.3 DATE:**
11/12/70

**1.4 ORIGINATOR CONTROL NO.:**

**1.5 PROGRAM ID:**
510-3

**1.6 DESCRIPTION OF ANOMALY:**

P00D00 Abort while P20 (P25) is running in the background will kill P20 (P25) and prevent its re-establishment unless RNDVZFLG (P25FLAG) is subsequently cleared.

### 1.6 DESCRIPTION OF RUN:

Eyeball

### -MIT ANALYSIS-

#### 2.1 CAUSE:

P20 (P25) restart groups are cleared, but RNDVZFLG (P25FLAG) is not reset.

#### 2.2 RECOGNITION:

Selection of P20 (P25) will put P20 (P25) in MODE lights but will not cause any computation, tracking, or mark processing to be performed. P20(P25) will not automatically be re-established in the background of targetting programs.

#### 2.3 MISSION EFFECT:

No P20(P25)

#### 2.4 AVOIDANCE PROCEDURE:

None

#### 2.5 RECOVERY PROCEDURE:

Select POO at P00D00 V37 request

#### 2.6 PROGRAM CORRECTION:

Reset RNDVZFLG (P25 FLAG) in P00D00 sequence.

#### 2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

Fix for Luminary 1E. (See PCN 11/24)

#### 2.8 RECOMMENDED RE-TESTING:

CONTINUED ON PAGE

#### 3.1 NASA DIRECTION:

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#### 4.1 CLOSING ACTION TAKEN:

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#### 3.2 NASA/MSC SIGNATURE:

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#### 4.3 ORGANIZATION:

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#### 4.4 DATE:

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**MSC Form 1409 (Rev May 68)**
PROGRAM CHANGE 1

A. Coding

☐ MIT Approved PCN
☐ NASA Approved PCR
☐ NASA Approved Software Anomaly
☐ MIT Approved ADR
☐ NASA Approved PCN
☐ MIT Approved Software Anomaly

☑ Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

☑ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: 

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 12-10-70
Fixed Memory constant VINJNOM (Nominal Injection Velocity) is 5509.3 fps instead of 5509.5 fps as specified in GSOP.

None - found by examining listing.

- MIT ANALYSIS -

2.1 CAUSE:
Loss of accuracy in converting from FPS to M./C.S.

2.2 RECOGNITION:
None

2.3 MISSION EFFECT:
None

2.4 AVOIDANCE PROCEDURE:
None

2.5 RECOVERY PROCEDURE:
None

2.6 PROGRAM CORRECTION:
Correct Constant

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):
Fix for Apollo 15 (LUM 1E)
No action necessary for Apollo 14 (LUM 1D)

2.8 RECOMMENDED RE-TESTING:
Nominal 12 ascent run

3.1 NASA DIRECTION:
CONTINUED ON PAGE

3.2 NAS/MS Signature:
CONTINUED ON PAGE

3.3 ORGANIZATION
CONTINUED ON PAGE

4.1 CLOSING ACTION TAKEN:
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4.2 SIGNATURE:
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4.4 DATE:
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PAGE 1 OF
Mit/IL Program Change Routing Slip

PCR/PCN #       ANOMALY # 1-1D-17

Online 2C  LUMINARY 1B
Online 2D  LUMINARY 1C
Online 2E  LUMINARY 1D
Online 2F  LUMINARY 1E

- MIT Approved PCN
- NASA Approved PCR
- NASA Approved PCN
- NASA Approved Software Anomaly
- MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION: 

Program Supervisor’s Approval: 

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: 

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

Special Instructions

Project Manager: 

Date: 12-10-70
1.1 ORIGINATOR: P. Volante
1.2 ORGANIZATION: MIT
1.3 DATE: 12/10/70
1.4 ORIGINATOR CONTROL NO.

| 2.1 CAUSE: | Flagword bit is shared between RR pre-designate routing of R21 and V16 N54 display computations or P22. |
| 2.2 RECOGNITION: | After RR tracks CSM into mode limits and no track light goes on, the V37 flash does not appear, but N54 is computed. |
| 2.3 MISSION EFFECT: | None |
| 2.4 AVOIDANCE PROCEDURE: | None |
| 2.5 RECOVERY PROCEDURE: | Select desired program when 530 alarm appears in P22. |
| 2.6 PROGRAM CORRECTION: | Unshare flagword bits in P22. |
| 2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.): | Fix for 1E. |
| 2.8 RECOMMENDED RE-TESTING: | P22 nominal run |

3.1 NASA DIRECTION: |
3.2 NASAMS C SIGNATURE: |

4.1 CLOSING ACTION TAKEN: |

Page 1 of
MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN #
ANOMALY # 1-10-18

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 2F  ✓ LUMINARY 1E

☐ MIT Approved PCN  ☐ NASA Approved PCR
☐ NASA Approved PCN  ☐ MIT Approved Software Anomaly
☐ NASA Approved Software Anomaly

A. Coding
☐ Begin coding immediately

ACTION:
Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: [Signature]
Date: 12-10-70
In P22, if the R21 routine (RR designate) drives the antenna close to the RR Mode II limits as the CSM is moving away from the landing site, the RR antenna may oscillate between the mode limits and the mode center several times.

**1.6 DESCRIPTION OF RUN:** System test lab run of P22 without allowing RR lockon.

**MIT ANALYSIS**

**2.1 CAUSE:** R21 and R24 do not clear designate flag when it finds the LOS outside Mode II limits in P22, so R25 calls for a designate after a reposition.

**2.2 RECOGNITION:** Oscillation of antenna trunnion and shaft angles varying between mode limits and mode center.

**2.3 MISSION EFFECT:** None - if this situation occurs, no tracking of the CSM could be obtained.

**2.4 AVOIDANCE PROCEDURE:** Select P22 while CSM is approaching landing site and not yet within RR mode limits.

**2.5 RECOVERY PROCEDURE:** None

**2.6 PROGRAM CORRECTION:** Fix coding to clear designate flag.

**2.7 RECOMMENDED DISPOSITION:** Fix for Apollo 15 (Lum 1E), work-around for Apollo 14 - (Lum 1D)

**2.8 RECOMMENDED RE-TESTING:** P22 with designate (R21) attempted as CSM is leaving mode limits.

**3.1 NASA DIRECTION:**

**3.2 NASA/MSC SIGNATURE:**

**4.1 CLOSING ACTION TAKEN:**

**4.2 SIGNATURE:**

**4.3 ORGANIZATION:**

**4.4 DATE:**
MIT/DL PROGRAM CHANGE ROUTING SLIP

PCR/PCN #

ANOMALY # L-1D-19

ADR #

☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 3  ☐ LUMINARY 1E
☐ COLOSSUS 3A ☐ LUMINARY 1F
☐ COLOSSUS 3A ☐ LUMINARY 1F

☐ MIT Approved PCN  ☐ NASA Approved PCR
☐ MIT Approved ADR  ☐ NASA Approved PCN

☐ MIT Approved Software Anomaly  ☐ NASA Approved Software Anomaly

A. Coding

☐ Begin coding immediately

ACTION:

Program Supervisor's Approval: __________________________

☐ Do not code until new GSOP material has been approved by the MIT
Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: __________________________

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC
testing and checkout

ACTION: __________________________

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: __________________________

Special Instructions

Project Manager: ________________
Date: 12-30-70
1.1 ORIGINATOR: B. McCoy
1.2 ORGANIZATION: MIT/CSDL
1.3 DATE: 12/30/70
1.4 ORIGINATOR CONTROL NO.

1.5 DESCRIPTION OF ANOMALY: Restarts in P20/25 may erroneously display V50N18 on DSKY.

1.6 DESCRIPTION OF RUN: Simulation at GAC - Restart testing for PCR324

- MIT ANALYSIS -

2.1 CAUSE: The Restart Point in R65 is after routine LPS20, 1 call which computes RRTARGET. This shares erasable cells with radar read data. A Restart occurring after the radar read but before LPS20, 1 restarts R65 with bad data in RRTARGET. The 15 degree check then fails and R60 is subsequently called.

2.2 RECOGNITION: Restart followed by V50N18 display

2.3 MISSION EFFECT: None

2.4 AVOIDANCE PROCEDURE: None

2.5 RECOVERY PROCEDURE: Depress ENTER pushbutton on DSKY; ignore request to perform maneuver.

2.6 PROGRAM CORRECTION: Place Restart Point before LPS20, 1

2.7 RECOMMENDED DISPOSITION: Fix, Work-around, etc.

2.8 RECOMMENDED RE-TESTING: Digital Simulation with Restart before and after Restart Point.

3.1 NASA DIRECTION: Fix for 1E; prog note for 1D

3.2 NASA/AMSC SIGNATURE: 3.3 ORGANIZATION 3.4 DATE: 4.1 CLOSING ACTION TAKEN:

4.0 DATE: 12/30/70
MIT/IDL PROGRAM CHANGE ROUTING SLIP

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A. Coding

☐ Begin coding immediately

Program Supervisor's Approval: [Signature]

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☑ Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: [Signature]

Date: 1-6-70+1
MIT/IL SOFTWARE ANOMALY REPORT

1. ORIGINATOR: P. Rye
   2. ORGANIZATION: MIT/DL
   3. DATE: 12/31/70
   4. ORIGINATOR CONTROL NO.

1.5 DESCRIPTION OF ANOMALY: 1. If a BAILOUT occurs during permanent integration in P00, R22, or R21 and is followed by any other restart before another restart point has been established in the program, and if a second integration process has begun, it is possible that normal program flow will be interrupted or that state vector will be invalidated.
   2. If a BAILOUT occurs during permanent integration in P00, followed by selection of V82, V89, or V90 before the integration is completed, the same effect as 1 can take place.

1.6 DESCRIPTION OF RUN:

Eyeball

-MIT ANALYSIS-

2.1 CAUSE: Erroneous clearing of REINTFLG by BAILOUT logic

2.2 RECOGNITION: BAILOUT followed by another restart during times specified in 1.5 followed by anomalous program behavior.

2.3 MISSION EFFECT: May need uplink of state vector and reselection of program.

2.4 AVOIDANCE PROCEDURE: 1. Do not select V37 after BAILOUT in P20 until integration is completed.
   2. Do not select V82, V89, or V90 until P00 integration is finished if a BAILOUT occurred.

2.5 RECOVERY PROCEDURE: Correct state vector and reselect program if necessary.

2.6 PROGRAM CORRECTION: Do not clear REINTFLG in BAILOUT

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):

Fix for LUM 1E

2.8 RECOMMENDED RE-TESTING:

Restart and BAILOUT tests P20 and P00

2.9 MITAL SIGNATURE: [Signature]

2.10 DATE: 1-6-70

3.1 NASA DIRECTION:

CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE:

CONTINUED ON PAGE

3.3 ORGANIZATION

CONTINUED ON PAGE

3.4 DATE:

4.1 CLOSING ACTION TAKEN:

CONTINUED ON PAGE

4.2 SIGNATURE:

CONTINUED ON PAGE

4.3 ORGANIZATION

CONTINUED ON PAGE

4.4 DATE:

MSC Form 1409 (Rev May 68)
A. Coding

- Begin coding immediately

ACTION:

Program Supervisor's Approval:

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

- Prepare GSOP revisions for MDRB consideration

ACTION:

- Technical Committee Meeting not required.

C. KSC Testing and Checkout

- Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

- Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: 

Date: 1-2-1-71
An RR antenna reposition initiated by R25 just after starting P20 or P22 can cause P20/P22 to loop and thus never get RR lock-on.

P22 with RR antenna reposition initiated just after P22 begins - program continued to run without locking on or issuing an alarm.

-MIT ANALYSIS-

2.1 CAUSE: P20/P22 initialization removes RR error counter enable (BIT 2 Chan 12).

2.2 RECOGNITION: P20/P22 continues to run after selection without issuing alarm 503 or V50N72 display within approximately 1 minute of selection.

2.3 MISSION EFFECT: Possible loss of marks in P20 and loss of entire P22 for that Rev.

2.4 AVOIDANCE PROCEDURE: None

2.5 RECOVERY PROCEDURE: Select another program via verb 37, then reselect P20/22.

2.6 PROGRAM CORRECTION: Do not remove RR error counter enable in P20/22 initialization.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix for 1E

2.8 RECOMMENDED RE-TESTING:

System Test Lab

3.1 NASA DIRECTION:

\[ \text{Fix} \quad 1-21-71 \]
A hardware or software restart during a RR TURNOFF sequence may result in an incorrect setting of the mode flag (ANTENFLG) in the RR status word, RADMODES (flagword 12).

1.6 DESCRIPTION OF RUN: P22 with RR turned on just prior to V37 selection of P22; software restart killed TURNON task and left RADMODES indicating Mode I, when antenna was really in Mode II.

2.1 CAUSE: TURNON task killed by restart before setting mode flag (ANTENFLG) in RADMODES.

2.2 RECOGNITION: RADMODES mode flag setting not agreeing with actual RR position; erratic behavior of RR since a reposition will be requested erroneously.

2.3 MISSION EFFECT:

2.4 AVOIDANCE PROCEDURE: Do not key in a V37 request within 10 seconds of RR TURNON; if a hardware restart or BAILOUT/P00D00 occurs during this time, repeat TURNON.

2.5 RECOVERY PROCEDURE: Cycle RR mode switch from LGC to SLEW and back, to force a TURNON sequence. (Hold in slew position for at least one second).

2.6 PROGRAM CORRECTION: Have restarts set RR not-in-auto bit in RADMODES if RR TURNON bit is set; this will cause a new TURNON sequence to be initiated after restart.

2.7 RECOMMENDED DISPOSITION: Do not fix, write program note.

2.8 RECOMMENDED RE-TESTING: Level 3 with restart during RR TURNON-

3.1 NASA DIRECTION:

Do not fix 1-21-71

3.2 NASA/MSC SIGNATURE: 3.3 ORGANIZATION 3.4 DATE:

4.1 CLOSING ACTION TAKEN:

4.2 SIGNATURE: 4.3 ORGANIZATION 4.4 DATE:
A. Coding
- Begin coding immediately

Program Supervisor's Approval: [Signature]

ACTION: [Signature]

B. GSOP Preparation
- Prepare GSOP revisions for MDRB consideration

ACTION: [Signature]

C. KSC Testing and Checkout
- Review for possible impact on KSC testing and checkout

ACTION: [Signature]

D. Other Programs Affected
- Review for corresponding changes in

ACTION: [Signature]

Special Instructions

Project Manager: [Signature]
Date: 1-25-71
In the erection of the guidance coordinate frame (CGCALC)

1. WCHPHASE instead of WCHPHOLD is used to select the index for selecting the criteria (TCGFBRAK or TCGFAPPR) for whether the frame is erected. On the final pass of P63 and P64, WCHPHASE is incremented before this use, therefore points to the succeeding phase. Consequently,

Apollo 14 shakedown tests. (The problem also existed on Apollos 11 and 12)

2.1 CAUSE:
see 1.5

2.2 RECOGNITION:
Tracked down a peculiarity in the orientation of the guidance coordinate frame.

2.3 MISSION EFFECT:
A yaw transient of about 5 degrees at the end of P64 can occur, particularly if JAPFG*+1 has a large magnitude and if azimuth redesignations have been made.

2.4 AVOIDANCE PROCEDURE:
Switch to P66 manually. Do not let P64 finish. In Apollo 14 JAPFG*+1 contains 07700 small enough so yaw transient is insufficient to require avoidance.

2.5 RECOVERY PROCEDURE:
Use X axis override in P66 to reorient the window

2.6 PROGRAM CORRECTION:
Use WCHPHOLD instead of WCHPHASE to select index registers in CGCALC.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):
Fix program (LUMINARY 12)

2.8 RECOMMENDED RE-TESTING:
See sheet

3.1 NASA DIRECTION:

3.2 NASA/MSC SIGNATURE: [signature]

3.3 ORGANIZATION: [organization]

3.4 DATE: [date]

4.1 CLOSING ACTION TAKEN:

4.2 SIGNATURE: [signature]

4.3 ORGANIZATION: [organization]

4.4 DATE: [date]
1.5 continued.

on the final pass of the braking phase, the approach phase index is selected with the result that TCGIAPPR and TCGFAPPR are used as criteria instead of TCGIBRAK and TCGFBRAK. On the final pass of the approach phase an index is selected one location beyond the index table (the constant happens to be 77776, equivalent to -1) with the result that criteria are picked up one location before TCGFBRAK. This location happens to contain the lower half of GAINAPPR; consequently on the last pass of the approach phase the lower half of GAINAPPR is used for TCGFAPPR, and TCGFBRAK is used for TCGIAPPR.

2. Similarly, on the last pass of the braking phase INTPRETX loads -2 instead of 0 into the index register X1 causing CGCALC to use GAINAPPR instead of GAINBRAK, and on the last pass of the approach phase INTPRETX loads +1 instead of -2 into the index register X1 causing CGCALC to use the lower half of JAPFG* and the upper half of GAINBRAK instead of the upper and lower halves of GAINAPPR respectively.

2.8 1. Select criteria providing time windows for guidance frame erection in the braking and approach phases. Run a complete landing observing that the frame is erected only during the windows.

2. Select criteria providing for guidance frame erection always. Observe that the correct index is always selected and that the frame is always correctly erected using the correct gain.

3. Introduce restarts causing VAC areas to be switched after the indices have been selected and observe that correct indices are re-selected and the frame is correctly erected using the correct gain.
1.5 DESCRIPTION OF ANOMALY: P70 or P71 selection prior to P12 leaves P12 with at least 3 flags abnormally set: FW9B13 (P7071FLG) set 1, FW9B08 (FLAP) set 1, FW9B06 (ROT FLAG) set 1. The first causes abort-type variable targeting during P12. The second causes some abnormal logic paths during P1D initialization. The third seems to cause no problems. Total effect has not been investigated by author.

1.6 DESCRIPTION OF RUN: LMS descent abort simulation, 1/14/71, Apollo 14 back-up crew, noted at MCC. An abort out of P66 was attempted (P71) without engine ignition. Subsequently P68, P00, and P12 were selected to do a T2 abort. Noted Flags are on AGC console event lites.

2.1 CAUSE:
See 1.5

2.2 RECOGNITION:
See 1.6

2.3 MISSION EFFECT: The first would cause abort type targeting during P12; the second is set by P70 only so that P12 call would not occur afterwards; the third would cause no effect on mission.

2.4 AVOIDANCE PROCEDURE:
Set flags prior to P12

2.5 RECOVERY PROCEDURE:
None

2.6 PROGRAM CORRECTION:
Initialize flags at beginning of P12 to reset configuration.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.)
Program note for 1D and 1E; fix for subsequent ropes.

2.8 RECOMMENDED RE-TESTING:
Preset these flags and call P12.

3.1 NASA DIRECTION:
Do not fix for 1E 1-21-71
MIT/DL PROGRAM CHANGE ROUTING SLIP

PCR/PCN #

ANOMALY # L-1D-25

ADR #

[ ] COLOSSUS 2E  [ ] LUMINARY 1D
[ ] COLOSSUS 3  [ ] LUMINARY 1E
[ ] COLOSSUS 3A  [ ] LUMINARY 1F
[ ] COLOSSUS 3B  [ ] LUMINARY

[ ] MIT Approved PCN  [ ] NASA Approved PCR
[ ] MIT Approved ADR  [ ] NASA Approved PCN
[ ] NASA Approved Software Anomaly
[ ] MIT Approved Software Anomaly

A. Coding

Begin coding immediately

ACTION: [Signature]

Program Supervisor's Approval: [Signature] Margaret Hamilton

[ ] Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

[ ] Prepare GSOP revisions for MDRB consideration

ACTION: [Signature]

[ ] Technical Committee Meeting not required.

[ ] Technical Committee Meeting(s) held on [Date]

Attendees:

C. KSC Testing and Checkout

[ ] Review for possible impact on KSC testing and checkout

ACTION: [Signature]

D. Other Programs Affected

[ ] Review for corresponding changes in

ACTION: [Signature]

Special Instructions

Project Manager: [Signature]

Date: 1-24-71
MIT/IL SOFTWARE ANOMALY REPORT

1.5 DESCRIPTION OF ANOMALY: Exiting P63, P40, or P42 with a V37 between average-G on and time of auto-ullage initiate may not kill the waitlist call to initiate ullage. The result is a continuous LGC ullage command with no way to terminate it except (1) V36, (2) AGS, (3) entering average-G and exiting. The problem is that V37 doesn't kill waitlist tasks until after AVETOMID integration (even though ullage is terminated at the start of V37).

1.6 DESCRIPTION OF RUN: LMS descent abort simulation, 1/14/71, Apollo 14 back-up crew, noted at MCC. A wave-off of PDI occurred and the crew did not exit P63 until after AVG-G on. He selected P00 via V37, during MIDTOAVE ullage came on, P00 then appeared and ullage continued. He selected P47 to see if he was ullaging, saw he was, went back to P00 which killed the ullage.

- MIT ANALYSIS -

2.1 CAUSE:
See 1.5

2.2 RECOGNITION:
See 1.6

2.3 MISSION EFFECT:
Orbit perturbed by ullage

2.4 AVOIDANCE PROCEDURE: If V37 is desired to terminate P63, P40, or P42 prior to ullage, do it before TIG-25 seconds.

2.5 RECOVERY PROCEDURE:
See 1.5

2.6 PROGRAM CORRECTION: Put a KILLTASK for ULLGTASK in V37 logic before AVETOMID integration.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):
Fix for 1E; program note for 1D.

2.8 RECOMMENDED RE-TESTING: P40: V37 at TIG-8 seconds

3.1 NASA DIRECTION:
Fix 1-21-71.

- MIT ANALYSIS -

2.9 MIT/IL SIGNATURE:

3.2 NASA/MSC SIGNATURE:

4.1 CLOSING ACTION TAKEN:

CONTINUED ON PAGE
MIT/IL SOFTWARE DEVELOPMENT PLAN

FOR

LUMINARY 1D LGC PROGRAM

Date 27 July 1970

This plan consists of 34 pages.
The LUMINARY 1D LGC Program is being prepared to support a manned Lunar or Earth Orbital LM Flight of a Block II G&N system.
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SECTION I

PROGRAM DEVELOPMENT SUMMARY
<table>
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<tr>
<th>Item No.</th>
<th>DESCRIPTION</th>
<th>Required Date</th>
<th>Predicted Date</th>
<th>Actual Date</th>
<th>COMMENTS</th>
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<tr>
<td>1</td>
<td>Establishment of Luminary 1D Assy.</td>
<td>11/6/69</td>
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<td>Rev. 163</td>
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<td>GSOP Publication (All PCR/PCNs approved at SCB Meetings #32 and 33).</td>
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**NOTE:** No Level 5 Testing is presently planned, as Level 4 testing is to be conducted on the planned release revision.
SECTION II

PROGRAM CHANGE REQUEST/NOTICE STATUS

PCR's/PCN's
<table>
<thead>
<tr>
<th>PCR No.</th>
<th>DESCRIPTION</th>
<th>Originator/ Date</th>
<th>MIT IMPACT Schedule</th>
<th>Storage</th>
<th>NASA/SCB DIRECTION</th>
<th>GSOP Section Affected</th>
<th>COMMENTS</th>
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<tr>
<td>286</td>
<td>Format Change to Landing Site Update.</td>
<td>MSC 10/1/69</td>
<td>No Slip. 0</td>
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<td>Implement &amp; provide detailed evaluation.</td>
<td>2</td>
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<tr>
<td>287</td>
<td>Removal of 526 Alarm in P22.</td>
<td>MSC 9/25/69</td>
<td>No Slip. 0</td>
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<td>Implement &amp; provide detailed evaluation.</td>
<td>4, 5</td>
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<td>291.2</td>
<td>Fourth Order Potential Model.</td>
<td>MSC 10/15/69</td>
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<td>Disapproved.</td>
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<td>293.2</td>
<td>Update Fixed Constants for 1970-1971 Ephemeris Year.</td>
<td>MSC 10/15/69</td>
<td>No Slip. 0</td>
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<td>Withdrawn.</td>
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<td>Update Fixed Memory Mass Properties.</td>
<td>MSC 11/12/69</td>
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<td>Implement &amp; provide detailed evaluation.</td>
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<td>Set &quot;G&quot; Vector Parallel to Landing Site for Radius Vector.</td>
<td>MSC 12/10/69</td>
<td>No Slip. 0</td>
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<td>Implement &amp; provide detailed evaluation.</td>
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<td>P66 Change.</td>
<td>MSC 10/1/69</td>
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<td>G&amp;C 1/16/70</td>
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<td>Implement &amp; provide detailed evaluation.</td>
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<td>Change Setting of NOLRREAD Flag.</td>
<td>G&amp;C 1/16/70</td>
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<td>GAC 1/19/70</td>
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<td>Eliminate Taking Marks in Pairs.</td>
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<td>Rewrite for Apollo 15</td>
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<td>NASA/SCB DIRECTION</td>
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<td>Implement apriori Terrain Profile.</td>
<td>MPAD 2/12/70</td>
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<td>306</td>
<td>Add ΔVM to Descent/Ascent Downlist.</td>
<td>FM2 1/30/70</td>
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<td>MPB 2/25/70</td>
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<td>Downlist Changes for Powered Descent.</td>
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<td>PIP Time in P57</td>
<td>G&amp;CD 3/13/70</td>
<td>1 Week</td>
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<td>Time to call 511 Alarms</td>
<td>G&amp;CD 3/17/70</td>
<td>3 Days</td>
<td>+4 F +1 E</td>
<td>Implement &amp; provide detailed evaluation</td>
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<td>312</td>
<td>Disapprove PCR 306</td>
<td>FSB 4/9/70</td>
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<td>Move AZO to Fixed Ephemera Constants.</td>
<td>Stoppelman 6/5/69</td>
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<td>Initiate TFI in P40s.</td>
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<td>Delete FLV50N25, R1 = 00500 from P63.</td>
<td>Cherry 8/20/69</td>
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<td>LR Velocity Read Centered at PIPTIME.</td>
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<td>Read X-pointer Input from CDUs.</td>
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<td>Lones 10/14/69</td>
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<td>976</td>
<td>Erasable Program for LM Deorbit.</td>
<td>McCoy 11/6/69</td>
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<td>979</td>
<td>Delete 521 Alarm.</td>
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<td>Robertson 12/9/69</td>
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<td>982</td>
<td>Extend Capability of Lunar Surface Star Acquisition Routine R59.</td>
<td>Millard 12/9/69</td>
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<td>983</td>
<td>Unit Vector Capability for N88.</td>
<td>Millard 12/9/69</td>
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<td>Originator/Date</td>
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<td>COMMENTS</td>
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<td>No Slip.</td>
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<td>Implement &amp; provide detailed evaluation.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>990*</td>
<td>V44 RR Remode Check.</td>
<td>Volante 12/19/69</td>
<td>No Slip.</td>
<td>+6 fixed</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>4, 5</td>
<td></td>
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<tr>
<td>391.2</td>
<td>Sum Uplink Data.</td>
<td>Edmonds 12/17/69</td>
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<td>+6 fixed</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>2, 4</td>
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<tr>
<td>996</td>
<td>Liftoff Check in P07.</td>
<td>Rye 1/26/70</td>
<td>No Slip.</td>
<td>+8 fixed memory.</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>998</td>
<td>Non-repeating 511 Alarm.</td>
<td>Covelli 1/23/70</td>
<td>No Slip.</td>
<td>+8 fixed +1 flagbit</td>
<td>Disapproved</td>
<td>—</td>
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<tr>
<td>999</td>
<td>Reset POSTORK, NEGTORK in P12 Initialization.</td>
<td>McCoy 1/28/70</td>
<td>No Slip.</td>
<td>+5 fixed</td>
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<td>—</td>
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<tr>
<td>1012</td>
<td>Multiple Servicers Avoidance.</td>
<td>Klumpp 1/30/70</td>
<td>No Slip.</td>
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<td>—</td>
<td></td>
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<tr>
<td>1014</td>
<td>V32E Check</td>
<td>Larson 2/2/70</td>
<td>No Slip.</td>
<td>+4</td>
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<td>—</td>
<td></td>
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<tr>
<td>1015</td>
<td>Check for AVEGON at Start of R 36.</td>
<td>Larson 2/2/70</td>
<td>No Slip.</td>
<td>+3 fixed</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PCR No.</td>
<td>DESCRIPTION</td>
<td>Originator/Date</td>
<td>MIT IMPACT</td>
<td>NASA/SCB DIRECTION</td>
<td>GSOP Section Affected</td>
<td>COMMENTS</td>
<td></td>
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<tr>
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<tr>
<td>1016</td>
<td>Prevent DAP from Maneuvering the Vehicle to Follow Platform during Gyro Torquing.</td>
<td>Larson 2/2/70</td>
<td>No Slip. +4 fixed</td>
<td>Withdrawn.</td>
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<tr>
<td>1017</td>
<td>To Preclude P3X Computations being Overwritten by P47.</td>
<td>Larson 2/2/70</td>
<td>No Slip. +7 fixed</td>
<td>Withdrawn.</td>
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<tr>
<td>1021</td>
<td>Fixed Memory Landing Radar Transformation Matrices.</td>
<td>Covelli 2/10/70</td>
<td>No Slip. +10 fixed</td>
<td>Implement &amp; provide Detailed evaluation.</td>
<td>5</td>
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<tr>
<td>1022</td>
<td>Landing Radar Position Alarms.</td>
<td>Covelli 2/10/70</td>
<td>No Slip. -25 words</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>2, 4, 5</td>
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<td>1025</td>
<td>Remove Gravity Computation after Landing Radar Attitude Update.</td>
<td>Covelli 2/27/70</td>
<td>No Slip. -1 Fixed</td>
<td>Implement &amp; provide detailed evaluation.</td>
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<tr>
<td>1027</td>
<td>A priori Terrain Models.</td>
<td>Kriegsman 3/3/70</td>
<td>No Slip. +10 unshar. Eras. +2 shared Eras. +30 wds. fixed</td>
<td>Implement &amp; provide detailed evaluation.</td>
<td>4, 5</td>
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<td>1028</td>
<td>Two-segment Altitude Weighting Functions for Landing Maneuver</td>
<td>Kriegsman 3/3/70</td>
<td>No Slip. +1 unshared eras. +2 fixed words.</td>
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<td>1029</td>
<td>Timing-indicators.</td>
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<td>PCR No.</td>
<td>DESCRIPTION</td>
<td>Originator/Date</td>
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<td>NASA/SCB DIRECTION</td>
<td>GSOP Section Affected</td>
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<td>1035*</td>
<td>V68 &amp; P66 terminate the terrain model</td>
<td>McCoy 4/14/70</td>
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<td>Implement &amp; provide detailed evaluation</td>
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<td>1036*</td>
<td>PCR 996 (Liftoff check in P07) Improvements</td>
<td>McCoy 4/21/70</td>
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<td>1037*</td>
<td>P66 corrections</td>
<td>Klumpp 4/22/70</td>
<td>No Slip</td>
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<td>3, 4</td>
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<td>1038*</td>
<td>Keep 526 Alarm in P20 (PCR 287)</td>
<td>McCoy 4/27/70</td>
<td>No Slip</td>
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<td>Implement &amp; provide detailed evaluation</td>
<td>4, 5</td>
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<td>1039*</td>
<td>Terrain Model Improvements (PCR 1027)</td>
<td>Klumpp 4/28/70</td>
<td>No Slip</td>
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<td>Implement &amp; provide detailed evaluation</td>
<td>4, 5</td>
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<td>1040*</td>
<td>Only P40 has Early TFI Countdown (PCR 872.2)</td>
<td>McCoy 4/29/70</td>
<td>No Slip</td>
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<td>Implement &amp; provide detailed evaluation</td>
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<td>1042*</td>
<td>Sec. 3; Rev. 4 GSOP Fix for L-1C-08</td>
<td>Klawensk 5/8/70</td>
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<td>Implement &amp; provide detailed evaluation</td>
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<td>Remove Zeroing of Bit 4 of Channel 14 on restart or V37</td>
<td>McCoy 5/12/70</td>
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<td>H. Maher 5/11/70</td>
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<td>Initialize Elev. angle in P34</td>
<td>McCoy 5/28/70</td>
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<td>P66/IMU Offset Compensation</td>
<td>McCoy 5/28/70</td>
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<td>PCR No.</td>
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<td>Originator/Date</td>
<td>MIT IMPACT</td>
<td>NASA/SCB DIRECTION</td>
<td>GSOP Section Affected</td>
<td>COMMENTS</td>
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<tr>
<td>*1056</td>
<td>P42 Improvements for Impulse and Ullage Logic</td>
<td>MIT/DL 7/20/70</td>
<td>1 Fixed</td>
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<td>To be accomplished in 9/18/70 re-release of Luminary 1D.</td>
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<tr>
<td>*1058</td>
<td>New Landing Analog Display (R10)</td>
<td>MIT/DL 7/6/70</td>
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<td>To be accomplished in 9/18/70 re-release of Luminary 1D.</td>
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<td>*XXX</td>
<td>Throttle Constant</td>
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<td>To be written by MSC and accomplished in 9/18/70 re-release of Luminary 1D.</td>
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SECTION III

PRE-LEVEL 4 TESTING

AND

LEVEL 3 SYSTEM TEST LAB TESTS
# PROGRAM DEVELOPMENT STATUS FOR LUMINARY 1D

<table>
<thead>
<tr>
<th>PCR/ ANOM/ ACB</th>
<th>DESCRIPTION</th>
<th>Responsible Engineer</th>
<th>PRE-LEVEL 4 TESTING</th>
<th>FIXED IN REV</th>
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<tbody>
<tr>
<td>PCR 286</td>
<td>Format Change to Landing Site Update.</td>
<td>McCoy</td>
<td>12/22</td>
<td>12/22</td>
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<tr>
<td>PCR 287</td>
<td>Removal of 526 Alarm in P22. (PCR 1038)</td>
<td>Dunbar/Volante</td>
<td>1/7</td>
<td>1/12</td>
</tr>
<tr>
<td>PCR 294</td>
<td>Update Fixed Memory Mass Properties.</td>
<td>Kirven</td>
<td>1/7</td>
<td>1/12</td>
</tr>
<tr>
<td>PCR 315.2</td>
<td>Channel 77 Modification.</td>
<td>Densmore</td>
<td>TESTED WITH PCR 302.2.</td>
<td></td>
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<tr>
<td>PCR 310</td>
<td>Time to call 511 alarms</td>
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*PCN*
<table>
<thead>
<tr>
<th>PCR/ANOM/ACB</th>
<th>DESCRIPTION</th>
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<th>PRE-LEVEL 4 TESTING</th>
<th>FIXED IN REV</th>
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<tr>
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<td>START</td>
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<td>Req</td>
<td>Pred</td>
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<td>PCR 821.2</td>
<td>Move AZO to Fixed Memory Constants.</td>
<td>Millard</td>
<td>12/22</td>
<td>12/22</td>
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<tr>
<td>PCR 872.2</td>
<td>Initiate TFI in P40s. (PCN 1040)</td>
<td>Kirven</td>
<td>1/7</td>
<td>1/12</td>
</tr>
<tr>
<td>PCR 874.2</td>
<td>Change Decimal Load Technique.</td>
<td>Rosenberg</td>
<td>12/23</td>
<td>12/22</td>
</tr>
<tr>
<td>PCR 896</td>
<td>LR Velocity Read Centered at PIPTIME.</td>
<td>Covelli</td>
<td>1/7</td>
<td>3/27</td>
</tr>
<tr>
<td>PCR 897</td>
<td>Delete PCR 775.</td>
<td>Covelli</td>
<td>12/22</td>
<td>3/27</td>
</tr>
<tr>
<td>PCR 898</td>
<td>LR Velocity Read.</td>
<td>Covelli</td>
<td>1/7</td>
<td>3/27</td>
</tr>
<tr>
<td>PCR 944</td>
<td>Read X-pointer Input from CDUs.</td>
<td>Albert</td>
<td>12/22</td>
<td>3/27</td>
</tr>
<tr>
<td>PCR/ANOM/ACB</td>
<td>DESCRIPTION</td>
<td>Responsible Engineer</td>
<td>PRE-LEVEL 4 TESTING</td>
<td>FIXED IN REV</td>
</tr>
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<td>START</td>
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<tr>
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<td>Pred</td>
</tr>
<tr>
<td>PCN 990*</td>
<td>V44 RR Remode Check</td>
<td>Volante</td>
<td>1/7</td>
<td>3/27</td>
</tr>
<tr>
<td>PCR 991.2</td>
<td>Sum Uplink Data.</td>
<td>Rosenberg</td>
<td>1/7</td>
<td>3/27</td>
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<tr>
<td>PCR 1029</td>
<td>Timing Indicators</td>
<td>Albert</td>
<td>4/5</td>
<td>4/5</td>
</tr>
<tr>
<td>PCN 1035*</td>
<td>V68 &amp; P66 terminate the terrain model</td>
<td>Klumpp</td>
<td>Tested with PCR 1027</td>
<td></td>
</tr>
<tr>
<td>PCN 1036*</td>
<td>PCR 996 (Liftoff check in P07) Improvements</td>
<td>Rosenberg</td>
<td>Tested with PCR 996</td>
<td></td>
</tr>
<tr>
<td>PCN 1037*</td>
<td>P66 corrections</td>
<td>Moore</td>
<td>Tested with PCR 988</td>
<td></td>
</tr>
<tr>
<td>PCR 1038</td>
<td>Keep 526 Alarm in P20 (PCR 287)</td>
<td>Volante</td>
<td>Tested with PCR 287</td>
<td></td>
</tr>
<tr>
<td>PCN1039</td>
<td>Terrain model improvements (PCR 1027)</td>
<td>Klumpp</td>
<td>Tested with PCR 1027</td>
<td></td>
</tr>
<tr>
<td>PCN 1040</td>
<td>Only P41 has Early TFI Countdown (PRC 872.2)</td>
<td>Kirren</td>
<td>Tested with PCR 872.2</td>
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</table>

*PCN
## Program Development Status for Luminary 1D

**PCR/ANOM/ACB**

<table>
<thead>
<tr>
<th>PCR/ANOM/ACB</th>
<th>Description</th>
<th>Responsible Engineer</th>
<th>Pre-Level 4 Testing</th>
<th>Fixed In REV</th>
</tr>
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<tbody>
<tr>
<td>PCR 1043</td>
<td>Remove Zeroing of Bit 4 of Channel 14 on restart or V37</td>
<td>Densmore</td>
<td>Fixed by ACB L-17</td>
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**Date:** 7/27/70
<table>
<thead>
<tr>
<th>PCR/ANOM/ACB</th>
<th>DESCRIPTION</th>
<th>Responsible Engineer</th>
<th>Pre-Level 4 Testing</th>
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<tbody>
<tr>
<td>L-1B-11</td>
<td>Terminal Mass Error in Descent and Ascent due to Inaccurate Mass Computation in SERVICER.</td>
<td>Kirven</td>
<td>Disposition: Change: Program note &amp; close out.</td>
<td>143</td>
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<tr>
<td>L-1C-01</td>
<td>Delta-V Increment may be Subtracted from VG Twice following a Restart.</td>
<td>Kirven</td>
<td>12/22 12/22 12/22</td>
<td>1/16 1/16 1/16</td>
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<tr>
<td>L-1C-03</td>
<td>Inspection of Coding V59 in P00.</td>
<td>Moore</td>
<td>12/22 3/27 12/22</td>
<td>1/16 4/16 4/20</td>
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<tr>
<td>L-1C-05</td>
<td>Correct for Sign Agreement when HCalcul is Calculated in RVBOTH.</td>
<td>Moore</td>
<td>1/12 3/27 3/27</td>
<td>1/16 4/27 4/27</td>
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<tr>
<td>L-11</td>
<td>Change Coding in SPEEDRUN to Compute LATVEL and FORVEL.</td>
<td>Bernikowich</td>
<td>12/22 12/22 12/22</td>
<td>1/16 5/24 5/18</td>
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<tr>
<td>L-12</td>
<td>Change Exit from LONGCALL.</td>
<td>Densmore</td>
<td>12/22 12/22 12/22</td>
<td>1/16 2/23 2/25</td>
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<tr>
<td>L-14</td>
<td>Save 3 Words in Bank 1 to Add Restart Table Entry.</td>
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<tr>
<td>PCR/ANOM/ACB</td>
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<tr>
<td>L-16</td>
<td>Present Coding can produce random branching if a restart in P64 leaves a job request for the restart point in the throttle routine unsatisfied at the time P66 is entered.</td>
<td>Moore</td>
<td>3/27 3/27 3/27 4/20 4/20 4/20</td>
<td>154</td>
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<tr>
<td>L-21</td>
<td>Addition of ECADRs to listing.</td>
<td>Densmore</td>
<td>—— —— —— —— —— ——</td>
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<tr>
<td>L-1C-07</td>
<td>Erroneous state vector and W-matrix in P00</td>
<td>—— Not an Anomaly</td>
<td>—— —— —— —— —— ——</td>
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<tr>
<td>L-23</td>
<td>Delete definitions of W.IND1, VACX, VACY and VACZ from the erasable assignment log section</td>
<td>—— No Test</td>
<td>—— —— —— —— —— ——</td>
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<tr>
<td>L-24</td>
<td>Move ZERLINA, ELVIRA, AZIMCR1 and ELINCR1 from E7 1443-1446 to E7 1644-1647</td>
<td>Moore</td>
<td>4/12 4/12 4/12 4/20 4/20 4/20</td>
<td>158</td>
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L-1B-XX = Anomalies reported on Luminary 1B; Fixed in 1D.  
L-1C-XX = Anomalies reported on Luminary 1C; Fixed in 1D.  
L-XX = ACBs.
PROGRAM DEVELOPMENT STATUS FOR LUMINARY ID

<table>
<thead>
<tr>
<th>PCR/ANOM/ACB</th>
<th>DESCRIPTION</th>
<th>Responsible Engineer</th>
<th>PRE-LEVEL 4 TESTING</th>
<th>FIXED IN REV</th>
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<tr>
<td>L-1C-08</td>
<td>DAP performance after a restart in Manual Rate Control Mode.</td>
<td>Kalan</td>
<td>4/1 4/1 4/1 4/20 4/20 4/16</td>
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<td>PRE-LEVEL 4 TESTING</td>
<td>FIXED IN REV</td>
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<td>Req</td>
<td>Pred</td>
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<tr>
<td>L-20</td>
<td>Test Scaling of Noun 60 R1</td>
<td>Albert</td>
<td>6/4</td>
<td>6/4</td>
</tr>
<tr>
<td>L-1D-03</td>
<td>Test R04 Rend. Radar Reading</td>
<td>White</td>
<td>6/9</td>
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<tr>
<td>PCN 1048</td>
<td>Test that ELEV is Initialized to Zero in P34</td>
<td>White</td>
<td>6/4</td>
<td>6/4</td>
</tr>
<tr>
<td>PCN 1052</td>
<td>Test IMU/CG Offset Acceleration Comp.</td>
<td>Klumpp</td>
<td>6/6</td>
<td>6/6</td>
</tr>
<tr>
<td>L27</td>
<td>Save 3 words in Bank 5 to make room for clearing of R12RDFLG in Fresh Start fix to PCR 896</td>
<td>Densmore</td>
<td>6/6</td>
<td>6/9</td>
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NOTE: For a complete description of tests see Luminary Memo #155.
<table>
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<tr>
<th>PCR/ANOM/ACB</th>
<th>DESCRIPTION</th>
<th>Responsible Engineer</th>
<th>PRE-LEVEL 4 TESTING</th>
<th>FIXED IN REV</th>
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<tr>
<td>PCN 1056</td>
<td>P42 Improvements for Impulse and Ullage Logic</td>
<td>Adler/Albert</td>
<td>7/27 7/27 8/17 8/17</td>
<td>174</td>
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<tr>
<td>PCN 1058</td>
<td>New Landing Analog Display (R10)</td>
<td>Eyles</td>
<td>7/27 7/27 8/17 8/17</td>
<td>174</td>
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<tr>
<td>PCN XXX</td>
<td>Throttle Constant</td>
<td>Eyles</td>
<td>8/17 8/17</td>
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<td>TITLE</td>
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<td>TEST COMPLETE</td>
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<td></td>
<td></td>
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<td>Pred</td>
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SECTION IV

LEVEL 4 AND 5 TESTING

AND

LEVEL 5 SYSTEM TEST LAB TESTS
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<tr>
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<tbody>
<tr>
<td>4.1.0</td>
<td>LANDINGS</td>
<td>Albert/Moore</td>
</tr>
<tr>
<td></td>
<td>Assumptions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) No Instrument/S.V. Errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Latest Terrain Model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c) Restarts/extended Verbs/monitors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(d) Apollo 13 Datafile</td>
<td></td>
</tr>
<tr>
<td>4.1.2</td>
<td>Redesignations. P63 (N69), P64 (ACA), P66 (ATT HOLD), P68, 10% T-LOSS.</td>
<td></td>
</tr>
<tr>
<td>4.2.0</td>
<td>RENDEZVOUS</td>
<td>P. White</td>
</tr>
<tr>
<td></td>
<td>Assumptions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) No Instrument/S.V. Errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Restart (P20, P40), Extended Verbs (V90)</td>
<td></td>
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<tr>
<td></td>
<td>(c) Apollo 13 Datafile</td>
<td></td>
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<tr>
<td>4.2.1</td>
<td>Nominal Rendezvous, P52 Planet Option (10% T-LOSS during Average-G).</td>
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<tr>
<td>4.3.0</td>
<td>ABORTS</td>
<td>W. Bernikovich</td>
</tr>
<tr>
<td></td>
<td>Assumptions: Same as Landing Tests.</td>
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</table>
# LEVEL 4 AND 5 TESTING FOR LUMINARY 1D

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<th>TEST NO.</th>
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<tbody>
<tr>
<td>4.3.1</td>
<td>Abort/Abort-Stage w/J1K1 Targets, 10% T-LOSS; &quot;MODE SELECT SW&quot; - AGS, V16N85, N77, N76.</td>
<td></td>
</tr>
<tr>
<td>4.3.2</td>
<td>Abort/Abort-Stage w/J2K2 Targets, 10% T-LOSS, V16N85, N77, N76.</td>
<td></td>
</tr>
</tbody>
</table>
| 4.4.0    | LUNAR SURFACE  
(a) No Instrument/S.V. Errors  
(b) Restarts/extended Verbs/monitor  
(c) Apollo 13 Datafile | D. Millard |
| 4.4.1    | P68, P00, P12-P57 (Star/planet), P06, P57 (Gravity/star), P57 (Gravity/REFSMMAT), -P22 (R > 500 mi.) P12, P20, P32. |                      |

Date: 7/27/70
<table>
<thead>
<tr>
<th>TEST No.</th>
<th>REV No.</th>
<th>LEVEL 4 TESTING</th>
<th>LEVEL 5 TESTING</th>
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<td>5/4</td>
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<td>4.1.2</td>
<td></td>
<td>4/13</td>
<td>5/5</td>
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|         |         |         |         |         |         |         |         |
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|         |         |         |         |         |         |         |         |

NOTE: Level 5 testing of Rev. 133 was not conducted due to the re-release of Luminary.
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<td>LANDINGS</td>
<td>ALBERT/MOORE</td>
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<td>Assumptions:</td>
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</tr>
<tr>
<td></td>
<td>(a) No instrument/S. V. errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Latest terrain model</td>
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</tr>
<tr>
<td></td>
<td>(c) Restarts/extended verbs/monitors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(d) Apollo 13 datafile</td>
<td></td>
</tr>
<tr>
<td>4.1.1</td>
<td>Nominal Automatic Landing. P63, P64, P66, P68, 10% T-loss</td>
<td></td>
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<tr>
<td></td>
<td>(a) Call P20 in no-update mode (V95E)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Call P30 to load any ΔV into noun 81 at TIG of PDI + 1 minute.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c) Trace loading of LRWH1 into LRWH</td>
<td></td>
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<tr>
<td></td>
<td>(d) Rollback ANEWROT and load the proper value via V21NOIE, XXXXXE in P64 prior to data good after antenna reposition.</td>
<td></td>
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<tr>
<td>4.1.2</td>
<td>Redesignations. P63(N69), P64(ACA), P66(ATT.HOLD), P68, 10% T-loss</td>
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</tr>
<tr>
<td></td>
<td>(a) Trace 1st pass through Rl2 to show proper reinitialization.</td>
<td></td>
</tr>
<tr>
<td>TEST NO.</td>
<td>DESCRIPTION</td>
<td>RESPONSIBLE ENGINEER</td>
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<tr>
<td>4.2.0</td>
<td>RENDEZVOUS</td>
<td>P. WHITE</td>
</tr>
<tr>
<td></td>
<td>Assumptions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) No instrument/S. V. errors</td>
<td></td>
</tr>
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<td>(b) Restart (P20, P40), extended verbs (V90)</td>
<td></td>
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<td></td>
<td>(c) Apollo 13 datafile</td>
<td></td>
</tr>
<tr>
<td>4.2.1</td>
<td>Nominal rendezvous, P52 planet option (10% T-loss during ave - G)</td>
<td></td>
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<tr>
<td>4.2.2</td>
<td>Do short rendezvous profile (P20, P34, P42, P35, P41, P35, P41)</td>
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<tr>
<td>4.2.3</td>
<td>Do CSM - active rendezvous</td>
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<td>ABORTS</td>
<td>W. BERNIKOVICH</td>
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<td>4.3.1</td>
<td>Abort/abort - stage W/J1K1 targets, 10% T-loss; &quot;MODE SELECT SW&quot; AGS, VL6N85, N77, N76</td>
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<td>Abort/abort - stage W/J2K2 targets, 10% T-loss, VL6N85, N77, N76</td>
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<td>4.4.0</td>
<td>LUNAR SURFACE</td>
<td>D. MILLARD</td>
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<td>(b) Restarts/extended verbs/monitors</td>
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<td></td>
<td>(c) Apollo 13 datafile</td>
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<td>4.4.1</td>
<td>P68, P00, P12-P57 (star/planet), P06, P57 (gravity/star), P57 (gravity/REFSMAT), - P22, P12, P20, P32</td>
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</tr>
<tr>
<td></td>
<td>(a) Call P22 when range to CSM &gt; 400 N. Mi.</td>
<td></td>
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<td>(b) When V16N54 appears, call R47 via V47E</td>
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<td></td>
<td>(c) Note any discrepancies</td>
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<td>REV No.</td>
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LEVEL 4 AND 5 TESTING FOR LUMINARY 1D RE-RELEASE (REV. 173)
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<td>Extended Verbs</td>
<td>Grace</td>
<td>7/1</td>
<td>6/18</td>
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<td>IOP</td>
<td>IMU Operational Programs</td>
<td>Grace</td>
<td>7/1</td>
<td>6/22</td>
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<td>STP2</td>
<td>IMU Performance test</td>
<td>Grace</td>
<td>7/21</td>
<td>7/21</td>
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<tr>
<td>STP3</td>
<td>IRIG Scale Factor</td>
<td>Grace</td>
<td>7/21</td>
<td>7/21</td>
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<td>AAR6</td>
<td>Test P57-PCR982 Change</td>
<td>St. Amand</td>
<td>7/11</td>
<td>7/10</td>
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<tr>
<td>RP</td>
<td>Radar Changes</td>
<td>Goodwin</td>
<td>7/11</td>
<td>7/10</td>
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<td>PT</td>
<td>IRIG Torque</td>
<td>Sheridan</td>
<td>7/8</td>
<td>6/17</td>
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<tr>
<td>SU</td>
<td>Sum Uplink</td>
<td>Sheridan</td>
<td>7/8</td>
<td>6/18</td>
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<td>C77</td>
<td>Channel 77 Restart Monitor</td>
<td>Sheridan</td>
<td>7/8</td>
<td>6/18</td>
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<td>Miscellaneous Changes -</td>
<td>Sheridan</td>
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<td>included in Radar Change</td>
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MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 287

ANOMALY #

[ ] COLOSSUS 2C [ ] LUMINARY 1B
[ ] COLOSSUS 2D [ ] LUMINARY 1C
[ ] COLOSSUS 2E [ ] LUMINARY 1D
[ ] COLOSSUS 2F [ ] LUMINARY 1E

[ ] MIT Approved PCN [ ] NASA Approved PCR
[ ] NASA Approved PCN

A. Coding

[ ] MIT Approved Software Anomaly
[ ] NASA Approved Software Anomaly

[ ] Begin coding immediately

ACTION: Virginia Graham

Program Supervisor's Approval: Margaret Zamsa

[ ] Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

[ ] Prepare GSOP revisions for MDRB consideration

ACTION: Lecie P. F. Cain

[ ] Technical Committee Meeting not required.

[ ] Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

[ ] Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

[ ] Review for corresponding changes in

ACTION:

Special Instructions

This change should also be made to P20

Project Manager: R. [Signature]

Date: 11/17/69

(Rev 10/69)
1.0 COMPLETED BY

1.1 ORIGINATOR: CTH-EG7
DATE: 9-25-69

1.2 ORGANIZATION: EG/Guidance & Control
APPROVAL: NPC DATE: 9/25

1.3 EFFECTIVITY: LUM 10

1.4 TITLE OF CHANGE: Removal of 526 Alarm in P22 & P2a

1.5 REASON(S) FOR CHANGE: Current P22 calls priority alarm 526 if range to CSM > 400 nm.
This alarm only confirms what the crew already knows.

1.6 DESCRIPTION OF CHANGE:

Replace the alarm code with contents of N54 (R, R) until range < 400 nm and then let program proceed normally.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 □ APPROVED □ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF: __________________________
DATE: __________________________

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT:

3.2 IMPACT OF PROVIDING DETAILED EVALUATION:

3.3 STORAGE IMPACT:

3.4 REMARKS:

3.5 MIT COORDINATOR:
DATE: __________________________

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

4.2 REMARKS:

4.3 SOFTWARE CONTROL BOARD SIGN OFF: __________________________
DATE: __________________________

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR:
DATE: __________________________

5.2 MIT EVALUATION:

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 START OR CONTINUE IMPLEMENTATION □ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF: __________________________
DATE: __________________________
A. Coding

- Begin coding immediately

Program Supervisor's Approval: [Signature]

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

- Prepare GSOP revisions for MDRB consideration

Action: [Signature]

- Technical Committee Meeting not required.

- Technical Committee Meeting(s) held on [Date]

C. KSC Testing and Checkout

- Review for possible impact on KSC testing and checkout

Action: [Signature]

D. Other Programs Affected

- Review for corresponding changes in [Programs]

Action: [Signature]

Special Instructions

Project Manager: [Signature]

Date: 12-29-69
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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<thead>
<tr>
<th>1.0 COMPLETED BY ORIGINATOR</th>
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<tr>
<td>J. W. Jurgensen</td>
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<tr>
<th>1.4 TITLE OF CHANGE</th>
</tr>
</thead>
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<tr>
<td>Update Fixed Memory Mass Properties</td>
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</table>

**Apollo 14 LUMINARY**

To reflect changes in IM weights, etc., for example, HI DESCENT, the maximum value in the reasonableness test for LEMMASS is almost 200 lbs. less than the actual weight of the Apollo 12 lunar module.

**CHANGE HI DESCENT TO**

16,700 kg

<table>
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<tr>
<th>2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT</th>
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<td>□ APPROVED</td>
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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**
| 11/13/69 |

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.4 REMARKS:**

**3.6 MIT DECISION:**

**3.7 MIT IMPLEMENTATION DATE:**

**4.0 SOFTWARE CONTROL BOARD ACTION**

| □ PROVIDE DETAILED CHANGE EVAL. | □ DIS-APPROVED |

**4.2 REMARKS**

**4.3 SOFTWARE CONTROL BOARD SIGN OFF**
| SDB on 12/18/69 |

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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<thead>
<tr>
<th>5.4 MIT EVALUATION</th>
</tr>
</thead>
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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

| □ START OR CONTINUE IMPLEMENTATION | □ DISAPPROVED OR STOP IMPLEMENTATION |

<table>
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<th>6.2 REMARKS</th>
<th>6.3 SOFTWARE CONTROL BOARD SIGN OFF</th>
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MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 296
ANOMALY #

REISSUE 2/26/70

COLOSSUS 2C  LUMINARY 1B
COLOSSUS 2D  LUMINARY 1C
COLOSSUS 2E  LUMINARY 1D
COLOSSUS 2F  LUMINARY 1E

MIT Approved PCN  NASA Approved PCR  NASA Approved Software Anomaly
NASA Approved PCN  MIT Approved Software Anomaly

A. Coding

☐ Begin coding immediately

ACTION: D. Moore

Program Supervisor's Approval: Margaret Hamilton

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: Section 4 & 5

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Detailed evaluation before coding & documentation

Project Manager: Russell H. Larson
Date: 2-15-70

(Rev 10/69)
REASON(S) FOR CHANGE: P-68 sets the gravity vector parallel to the 1M X body axis. Thus, the first gravity measurement in P-57 (options 1 or 3) gives a gravity error angle equal to the displacement of the 1M X body axis from the local vertical. This information is of little interest, since the IM body attitude is (cont.)

DESCRIPTION OF CHANGE:
In P-68, set "G" vector parallel to the LGC landing site radius vector instead of parallel to the 1M X body axis.

SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF:

3.5 MIT COORDINATOR: 

DATE: 

5.1 MIT COORDINATOR: 

DATE: 

6.1 START OR CONTINUE DETAILED PROGRAM CHANGE EVALUATION

6.3 SOFTWARE CONTROL BOARD SIGN OFF:

DATE: 

DISAPPROVED OR STOP IMPLEMENTATION

DISAPPROVED
1.5(cont.) well defined by attitudes at landing. A more pertinent quantity to display at this time would be the angle between the IGC navigated landing site radius vector and the measured gravity vector, since this is an immediate indication of how much the landing site coordinates may be expected to change if a subsequent P-57 option 2 is exercised.

Also, it is possible, although very unlikely, that a procedural error could result in destroying the IGC estimate of the landing site coordinates. (If a P-57 option 2 were performed prior to a gravity measurement, and the resultant landing site coordinates were accepted.)
REISSUED - 2/26/70

* G&CO has verified that there are no ICD's that will conflict with landing salam exterior of 11 seconds.

A. Coding
   - Begin coding immediately

   Action: [Signature]

   Program Supervisor's Approval: [Signature]

   Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
   - Prepare GSOP revisions for MDRB consideration

   Action: [Signature]

   Technical Committee Meeting(s) held on:

   Attendees:

C. KSC Testing and Checkout
   - Review for possible impact on KSC testing and checkout

   Action: [Signature]

D. Other Programs Affected
   - Review for corresponding changes in

   Action: [Signature]

Special Instructions

Implementation subject to date if not approved.
Project Manager: [Signature]
Date: 3-5-70

* Info taken from SCB Meeting of 2/17/70. (HMS#70-FA-15)

P&I spec says 10 sec. MAX.
NASA spec Oth says 10 sec. MAX.

(Rev 10/69)
### APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
- **Program Change Request**

1. **Completed by Originator:**
   - 1.0
   - Originator: C. T. Hackler
   - Date: January 16, 1970

2. **Organization:**
   - 1.2
   - Guidance & Control Div
   - Approval: [Stamp]
   - Date: [Stamp]

3. **Effectivity:**
   - 1.3
   - LUM 10

4. **Reason(s) for Change:**
   - 1.5
   - Landing radar antenna in Apollo 11 and 12 switched positions in less than 7 seconds.
   - If the antenna has not changed in 10 seconds, there is no reason to believe it will change with additional time.

5. **Description of Change:**
   - 1.6
   - Change constant C=14 in LR antenna reposition routine to C=4.

2.0 **Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT**

2.1 **Remarks:**

2.2 **Remarks:**

2.3 **Software Control Board or Flight Software Branch Sign Off:**

3.0 **MIT Visibility Impact Evaluation:**

3.1 **Schedule Impact:**

3.2 **Impact of Providing Detailed Evaluation:**

3.3 **Storage Impact:**

3.4 **Remarks:**

3.5 **MIT Coordinator:**

4.0 **Software Control Board Action**

4.1 **Implement and Provide Detailed Change Eval.**

4.2 **Remarks:**

4.3 **Software Control Board Sign Off:**

5.0 **MIT Detailed Program Change Evaluation**

5.1 **MIT Coordinator:**

5.2 **MIT Evaluation:**

6.0 **Software Control Board Decision on MIT Detailed Program Change Evaluation**

6.1 **Start or Continue Implementation**

6.2 **Remarks:**

6.3 **Software Control Board Sign Off:**

---

**Title of Change:**
- Decrease time to call alarm code 523

**Reason(s) for Change:**
- Landing radar antenna in Apollo 11 and 12 switched positions in less than 7 seconds. If the antenna has not changed in 10 seconds, there is no reason to believe it will change with additional time.

**Description of Change:**
- Change constant C=14 in LR antenna reposition routine to C=4.
MIT/IIL PROGRAM CHANGE ROUTING SLIP

PCR/PCR # 302.2
ANOMALY #

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☑ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ☑ NASA Approved PCR  ☐ NASA Approved PCN
☐ MIT Approved Software Anomaly  ☐ NASA Approved Software Anomaly

A. Coding

☐ Begin coding immediately

ACTION: _____________________________

Program Supervisor's Approval: _____________________________

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: _____________________________

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: _____________________________

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: _____________________________

Special Instructions

Project Manager: _____________________________
Date: 2-5-70

(Rev 10/69)
A hardware module is being added to both the CMC and LGC starting with Apollo 14 that enables the software, and hence crew or ground, to determine the exact cause of any hardware restart. (Continued)

The following software changes should be made to make channel 77 an effective device: (Continued)

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 [ ] APPROVED [ ] DISAPPROVED

2.2 REMARKS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

3.4 REMARKS:

3.5 MIT COORDINATOR

DATE

4.0 SOFTWARE CONTROL BOARD ACTION

[ ] IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL

[ ] PROVIDE DETAILED CHANGE EVALUATION

[ ] DISAPPROVED

4.1 REMARKS:

4.2 REMARKS:

a) Verify that all hardware channels in part added. The implementation of this PER will occur without problem.

b) Item B of 16 shall not be implemented.

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

DATE

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT-DETAILED PROGRAM CHANGE EVALUATION

[ ] START OR CONTINUE IMPLEMENTATION

[ ] DISAPPROVED OR STOP IMPLEMENTATION

6.1 REMARKS:

6.2 REMARKS:

[ ] SOFTWARE CONTROL BOARD SIGN OFF

DATE

[ ] SOFTWARE CONTROL BOARD SIGN OFF

DATE
1.5 Reasons for Change (Cont'd)

This is being done by the addition of another I/O channel (channel 77) that is read only with the exception of a WRITE with all zeroes which will clear the channel. Should a hardware restart occur, one of the bits in the channel would be set (to binary 1) indicating the source. The bit definitions are:

<table>
<thead>
<tr>
<th>BIT</th>
<th>RESTART (and/or AGC warning) CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-10</td>
<td>Spare</td>
</tr>
<tr>
<td>9</td>
<td>Scalar double freq.</td>
</tr>
<tr>
<td>8</td>
<td>Scalar fail</td>
</tr>
<tr>
<td>7</td>
<td>Counter fail</td>
</tr>
<tr>
<td>6</td>
<td>Voltage fail</td>
</tr>
<tr>
<td>5</td>
<td>Nightwatchman</td>
</tr>
<tr>
<td>4</td>
<td>Ruptlock</td>
</tr>
<tr>
<td>3</td>
<td>TC Trap</td>
</tr>
<tr>
<td>2</td>
<td>E-memory parity fail</td>
</tr>
<tr>
<td>1</td>
<td>E or F-memory parity fail</td>
</tr>
</tbody>
</table>

If multiple restarts occur, more than one bit could possibly be left set afterwards (i.e., if they were different types). Many restarts of the same type would leave just one bit set with the software REDOCNTR indicating the number.

1.6 Description of Change (Cont'd)

A. Fresh Start should initialize the channel to 0. This should be V36E ("SIAP1") only, not the 1107 alarm type of fresh start.

B. The channel should be added to a NOUN for ease in crew readout should restarts occur. R3 or R08 is suggested.

C. The channel should be added to the telemetry in place of the parameter CADRF I ASH+0 in all downlists. CADRF I ASH+1 may become spare if necessary.

D. The final V33E on a P27 state vector uplink should zero the channel.

Note that the only place the channel will be zeroed is in case of V36E (done nominally prelaunch) or state vector uplink. The ground or crew could input a V21N10E77EE which will also zero the channel. It should be noted that NO7 will not work with channel 77 (although N10 will, as previously implied). The purpose of the state vector uplink zeroing the channel is to provide a simple means for initializing the channel after (Continued)
1.6 Description of Change (Cont'd)

nominal restarts (e.g. power-up) at a point in time after which the ground has examined the channel. Since state vector uplinks are a part of all power-up (or serious recovery) procedures and since uplinking is always preceded by ground data acquisition, such a scheme should prove most satisfactory.

It should be noted that there is emphasis to zero the channel as little as possible under software control to preserve as much information as possible. That is, should multiple restarts of different types occur, it would be most desirable to not have the second type erase all record of the first having occurred. This is true no matter what type of scheme is considered (such as buffering or push-down into two or more erasable memory cells), given that enough restarts occur (e.g. a single parity fail followed by a TC trap restart loop).

In summary, simply putting the channel on the telemetry along with the already present counter gives the maximum information for all the most probable restart conditions (single or loop of one type, etc.); and only very specialized cases would not be covered as completely as with other more complex and expensive software changes.
MIT/DL PROGRAM CHANGE ROUTING SLIP

PCR/Pen # 306
ANOMALY #

☐ COLOSSUS 2D   ☐ LUMINARY 1C
☐ COLOSSUS 2E   ☑ LUMINARY 1D
☐ COLOSSUS 3    ☐ LUMINARY 1E
☐ COLOSSUS      ☐ LUMINARY

☐ MIT Approved PCN  ☑ NASA Approved PCR  ☐ NASA Approved PCN
☐ NASA Approved Software Anomaly  ☐ MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately
ACTION: 
Program Supervisor's Approval: 

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration
ACTION: 
Technical Committee Meeting not required

Technical Committee Meeting(s) held on 
Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout
ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in 

Special Instructions

ACTION: 

Project Manager: 
Date: 3-6-70
Apollo Spacecraft Software Configuration Control Board
Program Change Request

1.0 Completed by Originator

| J. H. Alphin | 1/30/70 | FM2 | Approval | 2/1/71 |

1.1 ORIGINATOR
1.2 DATE
1.3 ORGANIZATION
1.4 TITLE OF CHANGE

Apollo 14
Add $\Delta V_M$ to descent/ascent downlist

1.5 REASONS FOR CHANGE
Aid in postflight analysis for trajectory $\Delta V$/propellant usage. This is not a mandatory change and should only be considered if (a) $\Delta V_M$ is presently computed onboard and (b) space is presently available on the downlink.

1.6 DESCRIPTION OF CHANGE
Add $\Delta V_M$ to descent/ascent downlist. Word 18 should be added to PCR # 2.14.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

<table>
<thead>
<tr>
<th>APPROVED</th>
<th>DISAPPROVED</th>
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<tr>
<td>☐</td>
<td>☐</td>
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2.1 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

2.2 REMARKS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

<table>
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<th>SCHEDULE IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHEDULE IMPACT</td>
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3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.4 REMARKS:

<table>
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<th>SCB WORK ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCB WORK ON</td>
</tr>
</tbody>
</table>

3.5 MIT EVALUATOR

3.6 DATE
3-6-70

4.0 SOFTWARE CONTROL BOARD ACTION

| IMPLEMENT AND PROVIDE DETAILED CHANGE EVALUATION |
| DISAPPROVED |
| DISAPPROVED |

4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVALUATION

4.3 SOFTWARE CONTROL BOARD SIGN OFF

4.4 DATE
3/4/71

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

| START OR CONTINUE IMPLEMENTATION |
| DISAPPROVED OR STOP IMPLEMENTATION |
| DISAPPROVED OR STOP IMPLEMENTATION |

6.1 START OR CONTINUE IMPLEMENTATION

6.3 SOFTWARE CONTROL BOARD SIGN OFF

6.4 DATE
PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2D    ☐ LUMINARY 1C
☐ COLOSSUS 2E    ☐ LUMINARY 1D
☐ COLOSSUS 3    ☐ LUMINARY 1E
☐ COLOSSUS    ☐ LUMINARY

☐ MIT Approved PCN  ☑ NASA Approved PCR  ☐ NASA Approved Software Anomaly
☐ NASA Approved PCN  ☐ MIT Approved Software Anomaly

A. Coding
☑ Begin coding immediately

ACTION: [Signature]

Program Supervisor's Approval: [Signature]

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☑ Prepare GSOP revisions for MDRB consideration

ACTION: [Signature]

Technical Committee Meeting not required

Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION: [Signature]

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION: [Signature]

Special Instructions

Project Manager: [Signature]
Date: 3-6-70
### 1.0 Completed By Originator

<table>
<thead>
<tr>
<th>Originator</th>
<th>Date</th>
<th>Organization</th>
<th>Approval</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>T. J. Elucker</td>
<td>2/25/70</td>
<td>MPAD/MPB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 1.4 Title of Change

Apollo 14 and Subsequent Lunar Surface Align Downlist Change

#### 1.5 Reasons For Change

- The AOT mark data in P-57 is needed for the AOT + G RTCC processor to determine the LM lunar position. This data will permit a more accurate estimate of the LM position by the processor than the measured star unit vectors which are currently on the downlist due to not having to rotate the sighting data through the gimbal angle.

- Change word no. 90 which is currently POSTORK P and NESTORK P to the AOT detent code used for the star sighting. Place the AOT cursor and spiral angles in word no. 100 and place the AOT mark time in word no. 99.

#### 2.0 Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT

- **2.1** [ ] Approved [ ] Disapproved
- **2.2** Remarks:

#### 3.0 MIT Visibility Impact Evaluation:

- **3.1** Schedule Impact
- **3.2** Impact of Providing Detailed Evaluation
- **3.3** Storage Impact
- **3.4** Remarks:
  
  SCB work-on

- **3.5** MIT Coordinator
  
  R. T. Larson
  
  Date: 3-6-70

#### 4.0 Software Control Board Action

- **4.1** [ ] Implement and Provide Detailed Change Evaluation [ ] Disapproved
- **4.2** Remarks

#### 5.0 MIT Detailed Program Change Evaluation

- **5.1** MIT Coordinator
- **5.2** MIT Evaluation

#### 6.0 Software Control Board Decision On MIT Detailed Program Change Evaluation

- **6.1** [ ] Start or Continue Implementation [ ] Disapproved or Stop Implementation
- **6.2** Remarks

#### 6.3 Software Control Board Sign Off

<table>
<thead>
<tr>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start or Continue Implementation</td>
</tr>
</tbody>
</table>

**MSC Form 288 (Jul 68)**
1.5 Reason(s) for Change (cont'd)

matrix. The observations will be computed from the spiral and cursor angles in IM body coordinates and processed likewise.
**MT/DL PROGRAM CHANGE ROUTING SLIP**

- [ ] COLOSSUS 2D
- [X] LUMINARY 1C
- [X] COLOSSUS 2E
- [ ] LUMINARY ID
- [ ] COLOSSUS 3
- [ ] LUMINARY 1E
- [ ] LUMINARY
- [ ] MIT Approved PCN
- [X] NASA Approved PCR
- [ ] NASA Approved PCN
- [ ] NASA Approved Software Anomaly
- [ ] MIT Approved Software Anomaly

**A. Coding**

- [X] Begin coding immediately

**ACTION:**

Program Supervisor's Approval: [Signature]

**Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.**

**B. GSOP Preparation**

- [X] Prepare GSOP revisions for MDRB consideration

**ACTION:**

Technical Committee Meeting not required

Technical Committee Meeting(s) held on [Date]

Attendees:

**C. KSC Testing and Checkout**

- [ ] Review for possible impact on KSC testing and checkout

**ACTION:**

**D. Other Programs Affected**

- [ ] Review for corresponding changes in

**ACTION:**

**Special Instructions**

Project Manager: [Signature]

Date: 4/16/70
Crew request.

Change time to call 511 alarms from two to ten seconds.

MIT VISIBILITY IMPACT EVALUATION:

4.0 SOFTWARE CONTROL BOARD ACTION

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION
A. Coding
- Begin coding immediately

ACTION: 
Program Supervisor's Approval:  

Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
- Prepare GSOP revisions for MDRB consideration

ACTION:  
Technical Committee Meeting not required

C. KSC Testing and Checkout
- Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected
- Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager:  
Date: 3-6-70
OLLO: SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
PROGRAM CHANGE REQUEST

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR
S. G. Bales

1.2 ORGANIZATION
Flight Control

1.3 EFFECTIVITY
2/26/70

1.4 TITLE OF CHANGE
LUMINARY ID (Apollo 14)

1.5 REASON(S) FOR CHANGE
Downlist changes for powered descent

1.6 DESCRIPTION OF CHANGE
The change will provide the ground with an accurately timetagged value of Guidance Thrust Command. This data is necessary if the ground becomes involved in a throttle modulation procedure.

Move Guidance Thrust Command (currently word 78a) to word 5a, place piptime into words 6a and 6b, and place a downlink "snapshot" buffer on words 5 through 12.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 [ ] APPROVED [ ] DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

3.4 REMARKS:

3.5 MIT COORDINATOR
K. E. Larson

3.6 DATE
3-6-70

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 [ ] IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.
[ ] PROVIDE DETAILED CHANGE EVALUATION
[ ] DISAPPROVED

4.2 REMARKS:

4.3 SOFTWARE CONTROL BOARD SIGN OFF

4.4 DATE
3/4/70

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

5.3 DATE

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 [ ] START OR CONTINUE [ ] DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

6.4 DATE

MSC Form 288 (Jul 68)
A. Coding

☐ Begin coding immediately

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

ACTION: 

Program Supervisor's Approval: 

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: 

Technical Committee Meeting not required

Technical Committee Meeting(s) held on 

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 3-6-70
1.3 EFFECTIVITY
LUMINARY JD

1.5 REASON(S) FOR CHANGE
See initial issue of PCR 302.2.

1.6 DESCRIPTION OF CHANGE
Revised paragraph 1.6, item "C" on page 2 of the original PCR to read as follows:
C. The channel should be added to the telemetry in place of the parameter
CADRFLASH+1 in all downlists. CADRFLASH+0 will become a spare.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH
DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.2 REMARKS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.4 REMARKS:

4.0 SOFTWARE CONTROL BOARD ACTION

4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT
DETAILED PROGRAM CHANGE EVALUATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE
MIT/DL PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 3   ☐ LUMINARY 1E
☐ COLOSSUS 3A  ☐ LUMINARY 1F
☐ COLOSSUS 3A  ☐ LUMINARY__

☐ MIT Approved PCN  ☐ NASA Approved PCR
☐ MIT Approved ADR  ☐ NASA Approved PCN
☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding

☐ Begin coding immediately

ACTION:

Program Supervisor's Approval: __________________________

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: __________________________

Date: _______8-18-70____

[Signature]
## Apollo Spacecraft Software Configuration Control Board Program Change Request

### 1.0 Completed by Originator

<table>
<thead>
<tr>
<th>Originator</th>
<th>Date</th>
<th>Organization</th>
<th>Approval</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. H. Alphin</td>
<td>7/27/70</td>
<td>MPAD/LAB</td>
<td>P. Hodsman</td>
<td>8/30/70</td>
</tr>
</tbody>
</table>

### 1.3 Description of Change

The onboard computer uses a constant to simulate the DPS engine response. The actual response is smaller than predicted.

**Change**

The fixed memory constant "Throtlag" from 0.2 to 0.08.

### 2.0 Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT

<table>
<thead>
<tr>
<th>Option</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved</td>
<td>8/13/70</td>
</tr>
</tbody>
</table>

### 3.0 MIT Visibility Impact Evaluation:

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule Impact</td>
<td>8/13/70</td>
</tr>
<tr>
<td>Storage Impact</td>
<td>8/13/70</td>
</tr>
<tr>
<td>MIT Coordinator</td>
<td>8/13/70</td>
</tr>
</tbody>
</table>

### 4.0 Software Control Board Action

- Provide Detailed Change Evaluation
- MIT Detailed Program Change Evaluation

### 5.0 MIT Detailed Program Change Evaluation

<table>
<thead>
<tr>
<th>MIT Coordinator</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT Evaluation</td>
<td>8/13/70</td>
</tr>
</tbody>
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### 6.0 Software Control Board Decision on MIT Detailed Program Change Evaluation

<table>
<thead>
<tr>
<th>MIT Coordinator</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT Decision</td>
<td>8/13/70</td>
</tr>
</tbody>
</table>
MIT/IL PROGRAM CHANGE ROUTING SLIP

COLOSSUS 2C  LUMINARY 1B
COLOSSUS 2D  LUMINARY 1C
COLOSSUS 2E  LUMINARY 1D
COLOSSUS 2F  LUMINARY 1E

☐ MIT Approved PCN  ☑ NASA Approved PCR
☐ NASA Approved PCN

A. Coding
☐ Begin coding immediately

☑ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

D. Other Programs Affected

☐ Review for corresponding changes in

Special Instructions

ACTION: Charlotte Johnson
Program Supervisor's Approval: Margaret Hamilton

☑ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: ____________________________

Project Manager: Russell H. Turpin
Date: 10-31-69

(Rev 10/69)
1.0 COMPLETED BY ORIGINATOR

J. STOPPELMAN 6/5/69

1.3 EFFECTIVITY 1.4 TITLE OF CHANGE

LUMINARY Move AZO to Fixed Memory.

1.5 REASON(S) FOR CHANGE

AZO is for all effective purposes, constant for a given year and this change would yield two unshared erasables.

1.6 DESCRIPTION OF CHANGE

Delete AZO in erasable.
Define AZO in fixed.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 □ APPROVED □ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

DATE

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT 3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

+2 FIXED -2 ERASABLE

3.5 MIT COORDINATOR

DATE 10-7-69

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 □ PROVIDE DETAILED CHANG EVAL. □ PROVIDE DETAILED CHANGE EVALUATION □ DISAPPROVED

4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

APPROVED 50.8

DATE 10/9/69

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

DATE

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 □ START OR CONTINUE IMPLEMENTATION □ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE
MIT IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 872.2
ANOMALY #

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☑ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ☑ NASA Approved PCR  ☐ NASA Approved Software Anomaly
☐ NASA Approved PCN  ☐ MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION:

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: Russell H. Carson
Date: 10-31-69

(Rev. 10/69)
1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR
S. COPPS

1.2 ORGANIZATION
MIT/IL

1.3 EFFECTIVITY
LUMINARY

1.4 TITLE OF CHANGE
Initiate TFI in P30s.

1.5 REASON(S) FOR CHANGE
To provide astronaut with useful display.

1.6 DESCRIPTION OF CHANGE
Initiate TFI clockjob in P30s so that N35 and N40 are available anytime after N45.

2.0 SOFTWARE CONFIGURATION CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 □ APPROVED □ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONFIGURATION CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT
0

3.4 REMARKS:

3.5 MIT COORDINATOR

3.6 DATE

4.0 SOFTWARE CONFIGURATION CONTROL BOARD ACTION

☐ IMPLEMENT AND PROVIDE DETAILED CHANGE EVALUATION

☐ PROVIDE DETAILED CHANGE EVALUATION

☐ DISAPPROVED AND PROVIDE DETAILED CHANGE EVALUATION

☐ APPROVED AND PROVIDE DETAILED CHANGE EVALUATION

4.2 REMARKS:

April 14

4.3 SOFTWARE CONFIGURATION CONTROL BOARD SIGN OFF

DATE

10-9-69

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

5.3 SOFTWARE CONFIGURATION CONTROL BOARD SIGN OFF

DATE

6.0 SOFTWARE CONFIGURATION CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

☐ START OR CONTINUE IMPLEMENTATION

☐ DISAPPROVED OR STOP IMPLEMENTATION

☐ CONTINUE OR STOP IMPLEMENTATION

6.2 REMARKS:

DATE
MIT/IL PROGRAM CHANGE ROUTING SLIP

**ANOMALY #:**

- COLOSSUS 2C
- COLOSSUS 2D
- COLOSSUS 2E
- COLOSSUS 2F

- [ ] LUMINARY 1B
- [ ] LUMINARY 1C
- [ ] LUMINARY 1D
- [ ] LUMINARY 1E

- [ ] MIT Approved PCN
- [ ] NASA Approved PCR
- [ ] NASA Approved PCN
- [ ] NASA Approved Software Anomaly
- [ ] MIT Approved Software Anomaly

**A. Coding**

- [ ] Begin coding immediately

**ACTION:**

- [ ] Program Supervisor's Approval:

**B. GSOP Preparation**

- [ ] Prepare GSOP revisions for MDRB consideration

**ACTION:**

- [ ] Technical Committee Meeting not required.

- [ ] Technical Committee Meeting(s) held on

**Attendees:**

**C. KSC Testing and Checkout**

- [ ] Review for possible impact on KSC testing and checkout

**ACTION:**

**D. Other Programs Affected**

- [ ] Review for corresponding changes in

**ACTION:**

**Special Instructions**

*Summer Rosenberg will have this coding prepared for Colossus*

**Project Manager:**

*F. DeCain*

**Date:**

*10-31-69*
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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<thead>
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<tr>
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<table>
<thead>
<tr>
<th>1.4 TITLE OF CHANGE</th>
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<tbody>
<tr>
<td>Change Decimal Load Technique.</td>
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<tr>
<th>1.5 REASON(S) FOR CHANGE</th>
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<tr>
<td>Saves keystrokes.</td>
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<tr>
<th>1.6 DESCRIPTION OF CHANGE</th>
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<tbody>
<tr>
<td>Change decimal load logic to not require 5 digits. For example, if all zeros are desired simply load sign and enter, or if +50 is desired, simply load +50 ENTR.</td>
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<tr>
<th>2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT</th>
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<tr>
<th>3.0 MIT VISIBILITY IMPACT EVALUATION:</th>
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<td>3.1 SCHEDULE IMPACT</td>
</tr>
<tr>
<td>3.2 IMPACT OF PROVIDING DETAILED EVALUATION</td>
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<tr>
<td>3.3 STORAGE IMPACT</td>
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<tr>
<td>20 Words.</td>
</tr>
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<td>3.4 REMARKS:</td>
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<tr>
<td>3.5 MIT COORDINATOR</td>
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<td>□ PROVIDE DETAILED CHANGE EVALUATION</td>
</tr>
<tr>
<td>□ DISAPPROVED DETAILED CHANGE EVALUATION</td>
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<tr>
<td>□ Apollo 14</td>
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<td>5.2 MIT EVALUATION</td>
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<tr>
<th>6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION</th>
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<tr>
<td>□ START OR CONTINUE IMPLEMENTATION  □ DISAPPROVED OR STOP IMPLEMENTATION</td>
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<td>DATE</td>
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*MSC Form 288 (Jul 68)*
MIT/IL PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ✔ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ✔ NASA Approved PCR
☐ NASA Approved PCN  ☐ MIT Approved Software Anomaly
☐ NASA Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: 

Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on 

Attendees: 

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: 

Special Instructions

Craig has some of the done.

Project Manager: 

Date: 10-31-69
It is believed that the 390+ word cost is not worth the output of the routine.

Remove R29 from the LUMINARY program.

It is believed that the 390+ word cost is not worth the output of the routine.

Remove R29 from the LUMINARY program.
A. Coding

Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

Prepare GSOP revisions for MDRB consideration

ACTION: 

C. KSC Testing and Checkout

Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 10-31-69

(Rev 10/69)
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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<thead>
<tr>
<th>1.0 COMPLETED BY ORIGINATOR</th>
<th>896</th>
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</thead>
<tbody>
<tr>
<td>R. COVELLI</td>
<td>8/19/69</td>
</tr>
</tbody>
</table>

**LUMINARY**

LR Velocity Read Centered at PIP TIME.

**REASONS FOR CHANGE**

By centering the LR Velocity Reads about PIPTIME, the velocity extrapolation in R12 can be removed. Saves about 150 ms execution time.

**DESCRIPTION OF CHANGE**

Center LR Velocity read about PIPTIME.

**SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

<table>
<thead>
<tr>
<th>2.1 APPROVED</th>
<th>2.2 DISAPPROVED</th>
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**SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**MIT VISIBILITY IMPACT EVALUATION:**

<table>
<thead>
<tr>
<th>3.1 SCHEDULE IMPACT</th>
<th>3.2 IMPACT OF PROVIDING DETAILED EVALUATION</th>
</tr>
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**50 words.**

<table>
<thead>
<tr>
<th>3.3 SUBMISSION</th>
<th>3.4 REMARKS</th>
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**SOFTWARE CONTROL BOARD ACTION**

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<th>4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL</th>
<th>4.2 REMARKS</th>
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**APPROVED**

SCB

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<th>4.3 SOFTWARE CONTROL BOARD SIGN OFF</th>
<th>4.4 REMARKS</th>
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**MIT DETAILED PROGRAM CHANGE EVALUATION**

<table>
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<th>5.2 MIT EVALUATION</th>
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<thead>
<tr>
<th>6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION</th>
<th>6.2 REMARKS</th>
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<tr>
<th>6.3 SOFTWARE CONTROL BOARD SIGN OFF</th>
<th>6.4 REMARKS</th>
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</table>
PROGRAM CHANGE ROUTING SLIP

A. Coding

☐ MIT Approved PCN ☑ NASA Approved PCR ☐ NASA Approved Software Anomaly
☐ MIT Approved PCR ☐ NASA Approved PCN ☐ MIT Approved Software Anomaly

☐ LUMINARY 1B ☐ LUMINARY 1C ☐ LUMINARY 1D ☐ LUMINARY 1E
☐ COLOSSUS 2C ☐ COLOSSUS 2D ☐ COLOSSUS 2E ☐ COLOSSUS 2F

☐ Begin coding immediately

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

ACTION: Don Egler
Program Supervisor's Approval: Margaret Armstrong

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

ACTION: J. Glendenning

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: Russell H. Turner
Date: 10-31-69
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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<tr>
<td>R. COVELLI 8/19/69 MIT/IL</td>
</tr>
</tbody>
</table>

**1.1 ORIGINATOR**

R. COVELLI 8/19/69 MIT/IL

**1.3 EFFECTIVITY**

LUMINARY

**1.5 REASON(S) FOR CHANGE**

Delete PCR 775.

PCR 775 (LGC Doppler compensation) is not used. It uses storage and execution times.

**1.6 DESCRIPTION OF CHANGE**

Delete coding.

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

<table>
<thead>
<tr>
<th>2.1 APPROVED</th>
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**3.0 MIT VISIBILITY IMPACT EVALUATION:**

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-15 words.

**3.3 MIT COORDINATOR**

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<th>DATE</th>
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**3.4 REMARKS**

**4.0 SOFTWARE CONTROL BOARD ACTION**

| 4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL |

- [ ] PROVIDE DETAILED CHANGE EVALUATION

| 4.3 SOFTWARE CONTROL BOARD SIGN OFF |

**APPROVED 5/8**

<table>
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**4.2 REMARKS**

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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<thead>
<tr>
<th>5.2 MIT EVALUATION</th>
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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

| 6.1 START OR CONTINUE IMPLEMENTATION |

- [ ] DISAPPROVED OR STOP IMPLEMENTATION

<table>
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<tr>
<th>6.3 SOFTWARE CONTROL BOARD SIGN OFF</th>
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<tbody>
<tr>
<td>COLOSSUS 2C</td>
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<tr>
<td>------------</td>
</tr>
<tr>
<td>COLOSSUS 2D</td>
</tr>
<tr>
<td>COLOSSUS 2E</td>
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<td>COLOSSUS 2F</td>
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<table>
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<tr>
<th>MIT Approved PCN</th>
<th>NASA Approved PCR</th>
<th>NASA Approved Software Anomaly</th>
<th>MIT Approved Software Anomaly</th>
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<td>☑</td>
<td>☑</td>
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<td>☑</td>
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</table>

### A. Coding
- Begin coding immediately

**ACTION:**

**Program Supervisor's Approval:**

- **Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.**

### B. GSOP Preparation
- Prepare GSOP revisions for MDRB consideration

**ACTION:**

**F. DECHIN**

**J. GLENDENNING**

- Technical Committee Meeting not required.

- Technical Committee Meeting(s) held on:

### C. KSC Testing and Checkout
- Review for possible impact on KSC testing and checkout

**ACTION:**

### D. Other Programs Affected
- Review for corresponding changes in:

**ACTION:**

**Special Instructions**

**Project Manager:**

**Date:** 10-31-69

(Rev 10/69)
Begin LR velocity reading at start of P63 SERVICER.

Remove IVI < VUP test.
MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PPN: 899
ANOMALY #: 

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ☑ NASA Approved PCR  ☐ NASA Approved Software Anomaly
☐ MIT Approved PCN  ☐ NASA Approved PCN  ☑ Software Anomaly

A. Coding
☑ Begin coding immediately

ACTION: (Signature)
Program Supervisor's Approval: (Signature)

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☑ Prepare GSOP revisions for MDRB consideration

ACTION: (Signature)

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: (Signature) Russell H. Turner
Date: 10-31-69

(Rev 10/69)
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

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<td>J. Garman</td>
</tr>
<tr>
<td><strong>DATE</strong></td>
<td>8/18</td>
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<tr>
<td><strong>1.2 ORGANIZATION</strong></td>
<td>FSB</td>
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<tr>
<td><strong>APPROVAL</strong></td>
<td>George W. Cherry</td>
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<tr>
<td><strong>DATE</strong></td>
<td>8/20/69</td>
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**1.3 EFFECTIVITY**

**1.4 TITLE OF CHANGE**

N38 in C/A, LS, and R/P lists

**1.5 REASON(S) FOR CHANGE**

N38 would allow the ground to follow the progress of integration and detect integration loops.

**1.6 DESCRIPTION OF CHANGE**

Remove: LR VELZ and LR RANGE from word 76 in C/A; DELTA THETA from word 28 in LSA; OFFSET PT from word 95 in R/P; replace above with TET.

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

<table>
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<th></th>
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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

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**4.0 SOFTWARE CONTROL BOARD ACTION**

**4.1**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

**6.1**

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<th>Start or continue implementation</th>
<th>DISAPPROVED OR STOP IMPLEMENTATION</th>
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MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 970.2
ANOMALY # ______

☐ COLOSSUS 2C □ LUMINARY 1B
☐ COLOSSUS 2D □ LUMINARY 1C
☐ COLOSSUS 2E □ LUMINARY 1D
☐ COLOSSUS 2F □ LUMINARY 1E

☐ MIT Approved PCN □ NASA Approved PCR
☐ NASA Approved PCN
☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION:
R. Lousch

Program Supervisor's Approval: 

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: K. L. Larson
Date: 2-8-70
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

**NUMBER (Completed by RS0)**

**1.0 COMPLETED BY ORIGINATOR**

<table>
<thead>
<tr>
<th>1.1 ORIGINATOR</th>
<th>1.2 ORGANIZATION</th>
<th>1.4 TITLE OF CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. LONES</td>
<td>MIT/IL</td>
<td>Modify Gyro Torquing Routine.</td>
</tr>
</tbody>
</table>

**1.5 REASON(S) FOR CHANGE**

To minimize Gyro Bias Shifts as a result of pulse torquing. See Data Amplification Sheet.

**1.6 DESCRIPTION OF CHANGE**

Modify Gyro Torquing Routine so that pulse torquing will always finish with the same polarity pulses.

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

<table>
<thead>
<tr>
<th>2.1</th>
<th>APPROVED</th>
<th>DISAPPROVED</th>
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</thead>
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2.2 REMARKS:

**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT:**

<table>
<thead>
<tr>
<th>STORAGE IMPACT</th>
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<tbody>
<tr>
<td>10.25 weeks</td>
</tr>
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</table>

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

<table>
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<tr>
<th>3.4 REMARKS</th>
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**3.5 MIT COORDINATOR**

<table>
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<tr>
<td>12-11-69</td>
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**4.0 SOFTWARE CONTROL BOARD ACTION**

**4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.**

**4.2 REMARKS**

Ore approval received from T. Price 11/11/69

**4.3 SOFTWARE CONTROL BOARD SIGN OFF**

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<td>2/30/70</td>
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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

**5.1 MIT COORDINATOR**

<table>
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</thead>
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**5.2 MIT EVALUATION**

**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

**6.1 START OR CONTINUE IMPLEMENTATION**

**6.2 REMARKS**

<table>
<thead>
<tr>
<th>DATE</th>
</tr>
</thead>
</table>
1.5 Reason for Change, cont'd.

Recently built gyros have a large bias shift that is dependent on the polarity of the last torquing done on the gyro. (The Apollo 11 cm x & y gyros had an in-flight NBD shift of -2.1 and -1.6 meru respectively when drift compensation was changed from minus to plus.) The proposed change will eliminate this type of shift due to any polarity pulse torquing.
MITT PROGRAM CHANGE ROUTING SLIP

A. Coding

☑ Begin coding immediately

ACTION: (Signature)

Program Supervisor's Approval: (Signature)

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: (Signature)

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: (Signature)

Date: 12-29-69
1.0 COMPLETED BY ORIGINATOR

<table>
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<tr>
<td>R. Covelli</td>
<td>12/1/69</td>
<td>MIT/IL</td>
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1.3 EFFECTIVITY

<table>
<thead>
<tr>
<th>LUMINARY 1D</th>
<th>TITLE OF CHANGE</th>
</tr>
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<tbody>
<tr>
<td>Delete 521 Alarm</td>
<td></td>
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1.5 REASON(S) FOR CHANGE
Currently Program Alarm 521 is issued during a radar read whenever the data good signal is not present, provided that the radar read request was not made by H04, R12, R29 or R77. Cont. on page 2

1.6 DESCRIPTION OF CHANGE
Delete the coding that issues the 521 alarm.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH ACTION

2.1 [ ] APPROVED [ ] DISAPPROVED

2.2 REMARKS

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT
0

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT
-10 words fixed

3.4 REMARKS

3.5 MIT COORDINATOR

3.6 MIT SIGN OFF

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 [X] IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 [ ] START OR CONTINUE IMPLEMENTATION

6.2 REMARKS

6.3 SOFTWARE CONTROL BOARD SIGN OFF
This means that the alarm can only occur during P23 or P22 radar reads. However, when the data good signal is not present in these cases, the software lights the tracker fail light on the DSKY, and the hardware lights the No Track light on IM panel 3. Because of these two indications, the program alarm is not necessary and is probably undesirable. Removing the alarm would also save 10 words of fixed memory.
A. Coding

☐ Begin coding immediately

ACTION: [Signatures]

Program Supervisor's Approval: [Signatures]

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: [Signatures]

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on [Dates]

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: [Signatures]

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: [Signatures]

Special Instructions

Project Manager: [Signature]

Date: [Date]
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

**1.0 COMPLETED BY ORIGINATOR**

<table>
<thead>
<tr>
<th>ORIGINATOR</th>
<th>DATE</th>
<th>ORGANIZATION</th>
<th>APPROVAL</th>
</tr>
</thead>
</table>

**1.3 EFFECTIVITY**

LUMINARY 1D

**1.5 REASON(S) FOR CHANGE**

Provide R59 with the capability of locating, via cursor, spiral (N79) any celestial body specified by N88.

Provide N88 display any time non-catalog stars are selected by V01N70.

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

<table>
<thead>
<tr>
<th>APPROVED</th>
<th>DISAPPROVED</th>
<th>REMARKS</th>
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</table>

**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

DATE

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

**3.3 STORAGE IMPACT**

+10 WORDS

**3.5 MIT COORDINATOR**

DATE

12-15-69

**4.0 SOFTWARE CONTROL BOARD ACTION**

**4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.**

<table>
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</table>

**4.3 SOFTWARE CONTROL BOARD SIGN OFF**

DATE

SCB on 1/18/69

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

**5.1 MIT COORDINATOR**

DATE

**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

**6.3 SOFTWARE CONTROL BOARD SIGN OFF**

DATE
MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 983
ANOMALY #

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ☐ NASA Approved PCR
☐ NASA Approved PCN  ☐ MIT Approved Software Anomaly
☐ NASA Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION:

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

Action:

D. Other Programs Affected

☐ Review for corresponding changes in

Action:

Special Instructions

Project Manager: R. H. Lander
Date: 12-29-69
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

<table>
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<tbody>
<tr>
<td>D. MILLARD</td>
</tr>
<tr>
<td>12/9/69</td>
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<td>12-15-69</td>
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<tr>
<th>1.3 EFFECTIVITY</th>
<th>1.4 TITLE OF CHANGE</th>
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<tr>
<td>LUMINARY 1D</td>
<td>Unit Vector Capability for N88.</td>
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<table>
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<th>1.5 REASON(S) FOR CHANGE</th>
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<tbody>
<tr>
<td>Compatibility with CSM N88.</td>
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<table>
<thead>
<tr>
<th>1.6 DESCRIPTION OF CHANGE</th>
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<tbody>
<tr>
<td>Change N88 to accept a unit vector.</td>
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<table>
<thead>
<tr>
<th>2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT</th>
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<tbody>
<tr>
<td>2.1 APPROVED □ DISAPPROVED □ DISAPPROVED □ APPROVED</td>
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<tr>
<td>2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF</td>
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<tr>
<td>2.4 REMARKS:</td>
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<table>
<thead>
<tr>
<th>3.0 MIT VISIBILITY IMPACT EVALUATION:</th>
</tr>
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<tbody>
<tr>
<td>3.1 SCHEDULE IMPACT</td>
</tr>
<tr>
<td>3.2 IMPACT OF PROVIDING DETAILED EVALUATION</td>
</tr>
<tr>
<td>3.3 STORAGE IMPACT + 5 WORDS</td>
</tr>
<tr>
<td>3.4 REMARKS:</td>
</tr>
<tr>
<td>3.5 MIT COORDINATOR</td>
</tr>
<tr>
<td>3.6 MIT SIGN OFF</td>
</tr>
<tr>
<td>3.7 MIT SIGN OFF</td>
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<td>3.8 MIT SIGN OFF</td>
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<table>
<thead>
<tr>
<th>4.0 SOFTWARE CONTROL BOARD ACTION</th>
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<tbody>
<tr>
<td>4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVALUATION</td>
</tr>
<tr>
<td>4.2 REMARKS:</td>
</tr>
<tr>
<td>4.3 SOFTWARE CONTROL BOARD SIGN OFF</td>
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<tr>
<td>4.4 SOFTWARE CONTROL BOARD SIGN OFF</td>
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<table>
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<th>5.0 MIT DETAILED PROGRAM CHANGE EVALUATION</th>
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<tbody>
<tr>
<td>5.1 MIT COORDINATOR</td>
</tr>
<tr>
<td>5.2 MIT EVALUATION</td>
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<table>
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<tr>
<th>6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION</th>
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<tbody>
<tr>
<td>6.1 START OR CONTINUE IMPLEMENTATION □ DISAPPROVED OR STOP IMPLEMENTATION</td>
</tr>
<tr>
<td>6.2 REMARKS:</td>
</tr>
<tr>
<td>6.3 SOFTWARE CONTROL BOARD SIGN OFF</td>
</tr>
</tbody>
</table>

**MSC Form 280 (Jul 60) TPf21812**
A. Coding

☑ Begin coding immediately

ACTION:

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION:

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: [Signature]

Date: 12-29-69
This program will be used after July 1, 1970.

Update PIOs Ephemeris data, LOSSEM Ephemeris, and Star Table.

4.0 SOFTWARE CONTROL BOARD ACTION

- [X] PROVIDE DETAILED CHANGE EVALUATION
- [ ] PROVIDE DETAILED CHANGE EVALUATION
- [ ] DISAPPROVED CHANGE EVALUATION

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION
PIOS EPHEMERIS CONSTANTS:

GSOP UNITS

\[ \begin{align*}
A_{Z_0} & = 4.86315127049 \times 10^0 \quad \text{rad} \\
\omega_E & = 7.29211514667 \times 10^{-5} \quad \text{rad/\text{U-sec}} \\
B_0 & = 4.09159633164 \times 10^{-1} \quad \text{rad} \\
\dot{B} & = -7.19757979072 \times 10^{-14} \quad \text{rad/\text{U-sec}} \\
A_{10} & = 5.85919688671 \times 10^0 \quad \text{rad} \\
A_1 & = -1.07047015062 \times 10^{-8} \quad \text{rad/\text{U-sec}} \\
F_0 & = +1.52167495975 \times 10^0 \quad \text{rad} \\
\dot{F} & = +2.67240425515 \times 10^{-6} \quad \text{rad/\text{U-sec}} \\
\end{align*} \]

Calculated using \( \Delta T \) (1.0 July 1970) = 40.6 sec.

and \( \Delta T \) (1971.0) = 41.1 sec.

Source: J. Marshall Reber: MIT
PIOS EPHEMERIS CONSTANTS:

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<th>Units</th>
<th>Origin</th>
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<td>7.739945637 E-1 B 0</td>
<td>revs.</td>
</tr>
<tr>
<td>WEARTH</td>
<td>1.160576171 E-7 B23</td>
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<tr>
<td>BSUBO</td>
<td>6.511977813 E-2 B 0</td>
<td>rev</td>
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<tr>
<td>BDOT</td>
<td>-1.145530402 E-16 B28</td>
<td>rev/cs.</td>
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<td>-1.703706159 E-11 B28</td>
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<td>FDOT</td>
<td>4.253263471 E-9 B27</td>
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Source: J. M. Reber: MIT
**LOSSEM EPHEMERIS NUMBERS**

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<th>Equation</th>
<th>Value</th>
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<td>KONMAT</td>
<td>$K_1 \cos(OBL)$</td>
<td>$0.91746$</td>
</tr>
<tr>
<td></td>
<td>$K_2 \sin(OBL) \sin(IM)$</td>
<td>$-0.03\bar{5}711$</td>
</tr>
<tr>
<td></td>
<td>$K_3 \sin(OBL)$</td>
<td>$0.39784$</td>
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<td></td>
<td>$K_4 \cos(OBL) \sin(IM)$</td>
<td>$0.08\bar{2}354$</td>
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<td>RATESP</td>
<td>$B + 1$</td>
<td>$0.03660000$</td>
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<td></td>
<td>$LOMR$</td>
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<td></td>
<td>$LOSR$</td>
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Source: H. McOuat: MIT

SEE LUMINARY MEMO #119.
<table>
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<tr>
<th>Catalogue No. (octal)</th>
<th>Star Name</th>
<th>Vis. Mag.</th>
<th>X Coordinate</th>
<th>Y Coordinate</th>
<th>Z Coordinate</th>
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<tbody>
<tr>
<td>1</td>
<td>α Andromedae (Alpheratz)</td>
<td>2.1</td>
<td>+0.8746133997</td>
<td>+0.0262841262</td>
<td>-0.4837464836</td>
</tr>
<tr>
<td>2</td>
<td>β Ceti (Dipha)</td>
<td>2.2</td>
<td>+0.9342553544</td>
<td>+0.1737172460</td>
<td>-0.3114307320</td>
</tr>
<tr>
<td>3</td>
<td>γ Cassiopeiae (Navi)</td>
<td>2.2</td>
<td>+0.4774532337</td>
<td>+0.1167072881</td>
<td>+0.8708718726</td>
</tr>
<tr>
<td>4</td>
<td>α Eridani (Achernar)</td>
<td>0.6</td>
<td>+0.4918006361</td>
<td>+0.2205989850</td>
<td>-0.8422979006</td>
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<tr>
<td>5</td>
<td>α Ursae Minoris (Polaris)</td>
<td>2.1</td>
<td>+0.0129882160</td>
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<tr>
<td>6</td>
<td>θ Eridani (Acamar)</td>
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<td>+0.5449551668</td>
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<td>-0.0615513667</td>
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<td>α Canis Majoris (Sirius)</td>
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A. Coding

- Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

- Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

- Prepare GSOP revisions for MDRB consideration

ACTION: 

- Technical Committee Meeting not required.

- Technical Committee Meeting(s) held on Attendees: 

C. KSC Testing and Checkout

- Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

- Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 12-22-69
### 1.0 Completed by Originator

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<td>P. Volante</td>
<td>12/19/69</td>
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### 1.3 Effectivity

**Luminary 1D**

### 1.4 Title of Change

V44 RR Remode Check.

### 1.5 Reason(s) for Change

- Fix Anomaly L-1C-04. See Data Amplification Sheet.

### 1.6 Description of Change

Have V44 check for RR antenna Remode in progress and not disable RR error counters until remode complete.

### 2.0 Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT

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<th>2.2 Remarks</th>
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### 3.0 MIT Visibility Impact Evaluation:

- **3.1 Schedule Impact:** None
- **3.3 Storage Impact:** 6 Fixed

### 3.5 Mit Coordinator

K. H. Larson

**Date:** 12-25-69

**Approved for Implementation**

### 4.0 Software Control Board Action

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### 5.0 MIT Detailed Program Change Evaluation

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### 6.0 Software Control Board Decision on MIT Detailed Program Change Evaluation

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<th>Disapproved or Stop Implementation</th>
<th>6.2 Remarks</th>
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1.5 Reason(s) for Change, cont'd.

If V44 (Terminate RR Continuous Designate) is keyed in while an antenna remode is in progress, the RR error counters are disabled which stops the antenna drive. However, the remode task keeps running and the remode flag (Bit 14 or RADMODES) remains set, until a hardware or software restart occurs. A RR coarse align request (V41N72) during this time can cause erratic antenna behavior because the presence of the remode flag causes the designate routine to start a second remode task, which conflicts with the one still in progress. Recovery from this situation is effected by any V37 request (to cause a software restart) and cycling the RR mode control switch.
PURPOSE:
(1) To terminate the Continuous Designate Option V41N72.
(2) To disable the RA CDU FPCR counters.
(3) To enable R25.

ASSUMPTIONS:
(1) The process is crew selected by DSKY entry.
(2) V44E is effective only if RA Continuous Designation (V41N72, coarse align RA CDUS, Option 2) is in progress.
(3) The process may be selected at any time.

PROG CONT LCS GROUND CREW CREW SELECTION
START CREW INITIATED TERMINATE RR CONTINUOUS DESIGNATE

\[\text{WAIT } 2 \text{ SEC.} \]

\[\text{IS THE CONTINUOUS DESIGNATE FLAG SET?} \]
\[\text{Y} \quad \text{N} \]
\[\text{YES} \quad \text{EXIT} \]
\[\text{NO} \]

RESET CONTINUOUS DESIGNATE AND

\[\text{KEY IN V44E} \]

\[\text{V44/LUMINARY} \]

Page 3 of 3
Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

C. KSC Testing and Checkout

D. Other Programs Affected

Special Instructions

Project Manager: [Signature]
Date: 2-5-70
1.5 REASON(S) FOR CHANGE

Make UPRUPT Program the same as COLOSSUS and allow more efficient summing of K-start tape loads.

1.6 DESCRIPTION OF CHANGE

Modify UPRUPT so that during ground testing the number of uplink key codes is counted and each key code is summed and stored. See attached GSOP page.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 □ APPROVED □ DISAPPROVED

2.2 REMARKS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

6 fixed.

3.4 REMARKS:

Initiation approval key T. Price on 12-29-69

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 □ IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL. □ PROVIDE DETAILED CHANGE EVALUATION □ DISAPPROVED □ APPROVED

4.2 REMARKS:

If NODOPOT flag is set, disable the sum uplink data. Do not allow erasables with any cell loaded by Re-launch Erasable Load or any uplink loads.

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 □ START OR CONTINUE IMPLEMENTATION □ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:


2.1 Digital Uplink to LGC (P27)

By means of the LGC UPLINK, ground control can insert data or issue instructions to the LGC in the same manner that these functions are normally performed by the spacecraft crew in using the DSKY keyboard. The LGC is programmed to accept the following UPLINK inputs:

1. **LIFTOFF TIME INCREMENT**: Provides ground capability via VERB 70 to increment or decrement the LGC clock, LM and CSM state vector times and TEPHREM time with a double precision octal time value, scaled centiseconds $/2^{28}$.

2. **CONTIGUOUS BLOCK UPDATE**: Provides ground capability via VERB 71 to update from 1 to 18 consecutive E memory registers in the same EBANK.

3. **SCATTER UPDATE**: Provides ground capability via VERB 72 to update from 1 to 9 nonconsecutive E memory registers in the same or different EBANK's.

4. **OCTAL CLOCK INCREMENT**: Provides ground capability via VERB 73 to increment or decrement the LGC clock with a double precision octal time value, scaled centiseconds $/2^{28}$.

All information received by the LGC from the uplink is in the form of keyboard characters. Each character is assigned an identifying code number called its character code. Each character code transmitted to the LGC is sent as a triply redundant uplink word preceded by a leading "1" bit. Thus, if C is the 5-bit character code, then the 16 bit uplink word has the form:

$$1 \overline{C} C$$

where $\overline{C}$ denotes the bit-by-bit complement of C. (Table 2-1 defines all the legal input keycodes.) To these 16 bits of information the ground adds a 3-bit code specifying the system aboard the spacecraft which is to be the final recipient of the data and a 3-bit code indicating the spacecraft which should receive the information. The 22 total bits are sub-bit encoded (replacing each bit with a 5-bit code for transmission). If the message is received and successfully decoded, the onboard receiver will send back an 8-bit "message accepted pulse" to the ground and shift the original 16 bits of the uplink word to the LGC ($1 \overline{C} C$). The leading "1" bit causes an interrupt within the LGC after all 16 bits have been shifted from the uplink receiver.

Any ground command sequence normally transmitted via the uplink may be duplicated by the astronaut via the keyboard. All reference to uplink words used in this section are in the form transmitted from the uplink receiver to the LGC. Therefore, they do not contain the vehicle or subsystem addresses added by the ground facilities.

During ground testing the count of UPRUPTS and the sum of the $\overline{C} C$ codes entering the LGC are accumulated in erasable registers, permitting a count and sum-check on data transmitted UPLINK to the LGC.
COLOSSUS 2C  [ ] LUMINARY 1B
COLOSSUS 2D  [ ] LUMINARY 1C
COLOSSUS 2E  [ ] LUMINARY 1D
COLOSSUS 2F  [ ] LUMINARY 1E

[ ] MIT Approved PCN  [ ] NASA Approved PCR  [ ] NASA Approved Software Anomaly
[ ] NASA Approved PCN  [ ] MIT Approved Software Anomaly

A. Coding
[ ] Begin coding immediately

ACTION:  

Program Supervisor's Approval:  

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
[ ] Prepare GSOP revisions for MDRB consideration

ACTION:  

[ ] Technical Committee Meeting not required.
[ ] Technical Committee Meeting(s) held on Attendees:  

C. KSC Testing and Checkout
[ ] Review for possible impact on KSC testing and checkout

ACTION:  

D. Other Programs Affected
[ ] Review for corresponding changes in  

ACTION:  

Special Instructions  

Project Manager:  

Date: 2-5-70  

(Rev 10/69)
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

1. **ORIGINATOR**: P. RYE  
   **DATE**: 1/26/70  
   **ORGANIZATION**: MIT/IL

2. **EFFECTIVITY**: LUMINARY 1D

3. **REASON(S) FOR CHANGE**: Prevent selection of P07 during flight in order to avoid overwriting shared erasable memory.

4. **DESCRIPTION OF CHANGE**: Set bit by uplink at liftoff called NODO P07 (this bit is not cleared in FRESH START). Check NODO P07 at beginning of P07. If this bit is set, send out 21521 ALARM (POODOO). Request for V37 will result from POODOO.

5. **SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**:  
   **DATE**: 2/4/70

6. **MIT VISIBILITY IMPACT EVALUATION**:  
   **SCHEDULE IMPACT**: None
   **STORAGE IMPACT**: 8 Words of fixed memory

7. **SOFTWARE CONTROL BOARD ACTION**:  
   **IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL**:  
   **DATE**: SCB or 2/4/70

8. **MIT DETAILED PROGRAM CHANGE EVALUATION**:  
   **COORDINATOR**:  
   **EVALUATION**:  

9. **SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**:  
   **START OR CONTINUE IMPLEMENTATION**:  
   **DATE**:  
   **DISAPPROVED OR STOP IMPLEMENTATION**:  
   **DATE**:  
   **SOFTWARE CONTROL BOARD SIGN OFF**:  
   **DATE**: 
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<td>(Cont'd)</td>
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<tr>
<td>39-44</td>
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<table>
<thead>
<tr>
<th>Flagword</th>
<th>Bit</th>
<th>Meaning</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>12</td>
<td>LUNAFLAG. Used in lat-long subroutine. A 1 means lunar lat-long. A 0 means earth lat-long. Set to 0 or 1 by routines that call lat-long subroutine.</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>NODO P07 BIT is set to 1 by ground uplink at liftoff. Tested by V92 which performs POODOO (alarm 21521) if the bit is set. Tested in UPRUPT which maintains erasable sum of key codes if the bit is 0. (NOTE: this bit is not cleared by FRESH START.)</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>VFLAG. Used in automatic star selection routine (R56) during IMU alignment program (P52). Set to 1 to indicate that a pair of stars are not in the AOT field-of-view. Set to 0 if pair of stars found. Initially set to 1 at beginning of R56 and is used temporarily for program control purposes. Bit used for two distinct functions, hence assigned two separate mnemonics.</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>R04FLAG. Set to 1 by Verb 63 entry to indicate R04 is running and set to 0 at the end of R04. Set to 0 by Verb 78 entry to indicate R77 is running, rather than R04, since the two routines use much of the same coding. Set to 0 in R00 (V37). Set to 0 in the beginning of P20/P22 in order that alarm 521 be sent if the radar cannot be read. Set to 1 by R65 before reading RR and set to 0 by R65 after reading RR. The bit is checked in the RADAREAD routine (which is used by R04 and P20/P22) if the radar cannot be read; if the bit is 1 (R04 is running), alarm 521 will not be sent.</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>READRFLG. Bit is set to 1 by R29 when RR lock-on has been achieved and the RR read cycle is starting. A 1 indicates that R29 is reading RR data. Bit is reset to 0 by R29 when exiting the RR read cycle because of a bad reading or the RR not in LGC mode. Bit is reset to 0 by software restart (V37), FRESH START, and hardware restart. A 0 indicates that R29 is not reading RR data. Bit is tested by the RR read cycle of R29 to determine if radar read is allowed.</td>
</tr>
</tbody>
</table>
REQUEST FRESH START

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

ASSUMPTION: (1) THIS PROCESS MAY BE SELECTED AT ANY TIME.

(2) FRESH START CAN BE INITIATED IN ANY OF THE FOLLOWING WAYS:

(A) VIA PROGRAM IF PHASE TABLE CISA GREEPMENT IS DETECTED FOLLOWING A RESTART (ALARM CODE 01107).
(B) VIA PROGRAM IF SELF CHECK IS INTERRUPTED BY A RESTART DURING ITS ERASABLE MEMORY CHECK AND ERASABLE MEMORY IS SUSPECT.
(C) BY SIMULTANEOUS DEPRESSING OF THE MARK REJECT AND ERROR RESET BUTTONS DURING A RESTART.
(D) DSKY ENTRY OF V36E.

NOTE: A COMMANDED FRESH START (V36E) WILL TURN OFF THE ENGINE; AS WILL PRESSING "MARK REJECT" AND "ERROR RESET" DURING A RESTART.

THUS: "A" AND "B" DO NOT SHUT OFF THE DPS OR APS. "C" AND "D" WILL SHUT OFF THE DPS OR APS.

(3) IF FRESH START INTERRUPTS STATE VECTOR INTEGRATION, THE STATE VECTOR MAY BE INVALIDATED.

NOTE: LGC FRESH START INITIALIZES ALL FLAGWORDS (SEE EXCEPTIONS BELOW), CLEAR S ALL JOB CORE SET AND VAC AREAS, SETS WAITLIST TASKS TO END TASK, INITIALIZES ALL OUTPUT CHANNELS, INITIALIZES DAP IDLING PROGRAM, INITIALIZES DOWNTM TO COAST-AND-ALIGN DOWNTM, BLANKS THE DSKY, AND EXITS TO AN IDLING STATE (DUMMY JOB).

LGC FRESH START DOES NOT ALTER THE STATE OF THE FOLLOWING FLAG BITS:

(1) APSFLAG, WHICH INDICATES IF THE DESCENT STAGE IS ATTACHED.
(2) SURFACE FLAG, WHICH INDICATES IF THE LM STATE IS ON THE LUNAR SURFACE.
(3) LMOONFLG, WHICH INDICATES IF THE LM STATE IS EARTH OR LUNAR CENTERED.
(4) CHOONFLG, WHICH INDICATES IF THE CSM STATE IS EARTH OR LUNAR CENTERED.
(5) REF3SMAT FLAG, WHICH INDICATES IF REF3SMAT IS VALID.
(6) NODOP07 FLAG, WHICH INDICATES LIFTOFF has OCCURED.

PROG CONT LGC GROUND CREW

CREW SELECTION

START CREW INITIATED FRESH START KEY IN V36E
### MIT-DL Program Change Routing Slip

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<tr>
<th>Option</th>
<th>Code</th>
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<td>LUMINARY 1D</td>
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<tr>
<td>COLOSSUS 3</td>
<td>LUMINARY 1E</td>
<td></td>
</tr>
<tr>
<td>COLOSSUS 3A</td>
<td>LUMINARY 1F</td>
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<tr>
<td>COLOSSUS 3</td>
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<td>LUMINARY</td>
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- **MIT Approved PCN**
- **NASA Approved PCR**
- **NASA Approved PCN**
- **MIT Approved Software Anomaly**
- **Software Anomaly**

**A. Coding**
- [ ] Begin coding immediately
- [ ] Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

**B. GSOP Preparation**
- [ ] Prepare GSOP revisions for MDRB consideration
- [ ] Technical Committee Meeting not required.
- [ ] Technical Committee Meeting(s) held on

**C. KSC Testing and Checkout**
- [ ] Review for possible impact on KSC testing and checkout

**D. Other Programs Affected**
- [ ] Review for corresponding changes in

**Special Instructions**

**Project Manager**

**Date** 6-5-74
# MIT-PCN

## APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD

### PROGRAM CHANGE REQUEST

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<th>1.1 ORIGINATOR</th>
<th>DATE</th>
<th>1.2 ORGANIZATION</th>
<th>1.3 EFFECTIVITY</th>
<th>1.4 TITLE OF CHANGE</th>
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<td>H. Maher</td>
<td>5/11/70</td>
<td>MIT</td>
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<td>GSOP Section 2 Rev 9</td>
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### REASONS FOR CHANGE

To Improve Quality of Document

### DESCRIPTION OF CHANGE

See Data Amplification Sheets

### SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH

#### DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

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#### 2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

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### MIT VISIBILITY IMPACT EVALUATION:

#### 3.1 SCHEDULE IMPACT

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#### 3.3 STORAGE IMPACT

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<th>3.4 REMARKS</th>
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#### 3.5 MIT COORDINATOR

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### SOFTWARE CONTROL BOARD ACTION

#### 4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

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#### 4.3 SOFTWARE CONTROL BOARD SIGN OFF

| DATE |

### MIT DETAILED PROGRAM CHANGE EVALUATION

#### 5.1 MIT COORDINATOR

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</table>

### SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

#### 6.2 REMARKS

| DATE |

---

MIT Form 200 (Jul 80)
1.6 Description of change (cont)

Note: PCR 818 was complied with in Revision 5 but was inadvertently not so indicated in the list above.

2.1.6 Absolute Addresses for UPDATE Program

2.2 LGC Digital Downlink

2.1.1.2.1.1 Verb 70 Double Precision Time Verification

Program 27 verifies that the double precision octal time can be subtracted from the LGC clock without causing overflow. (For this operation two of the UPBUFF registers, UPBUFF +18D and 19D, are used as temporary buffers for TIME2 and TIME1.) If the double precision input time can be subtracted from the LGC clock without causing overflow, P27 proceeds to increment TEPHEM and decrement the LGC clock, the CSM State Vector time, and the LM State Vector time. Program 27 will then turn the uplink activity light "OFF", replace the downlink list code in DNLSTCOD with the code for the Coast and Align downlist, release the State Vector data for other routines, and reinstate the previous program.

2-7

* Refer to Paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.
1.6 Description of change (cont)

* Refer to Paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

2.1.6 Absolute Addresses for UPDATE Program

ASSEMBLE REVISION 2.15 OF AGC PROGRAM: LUMINARY BY NASA 2.7.11.2-13

ABSOULTE ADDRESSES FOR UPDATE PROGRAM

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<th>MENCONEIC</th>
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<td>01801</td>
<td></td>
<td></td>
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<tr>
<td>03606</td>
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<td>ECADR.UPSVFLAG</td>
</tr>
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NEW NUMBER

01731

03433

NEW NUMBER

02020

UPDATE ECADRS FOR LUMINARY REV 163

D. The Descent and Ascent List is transmitted during:

P12 Powered Ascent Guidance
P63 Braking Phase Guidance
P64 Approach Phase Guidance
P66 Terminal Descent Phase Guidance
Word Number

39-44

(Cont'd)

Flagword  Bit

2   8

"Set 1 by P72
AND P73"

DELETED

Meaning

XDELVFLG. Set to 1 if an External Delta V burn is to be performed. Set to 0 if a Lambert burn is required. Set to 1 in P30 before N42 display. For P34, P35, F74, and P75 - set to 0 in subroutine S34/35. For P32/P72 and P33/P73 set to 1 in subroutine ADVANCE.

R04FLAG. Set to 1 by Verb 63 entry to indicate R04 is running and set to 0 at the end of R04. Set to 0 by Verb 78 entry to indicate R77 is running, rather than R04, since the two routines use much of the same coding. Set to 0 in R00 (V37).

There were two functions for this flagword. Bit 9 and two mnemonics. Now there is only one.

These bits are used together to indicate astronaut-chosen KALCMANU maneuver rates.

CHANNEL 11. Output channel. Bits are used to control engine on/off and for display parameter quantities. Set 20000 by a fresh start. A restart zeroes all output channels by hardware means.
PIPTIME1. The time at which the accelerometers were read (associated with words 96-98, but since the group is not a snapshot quantity, their values as transmitted may not be valid simultaneously). When the PIPAs are read, the time is stored in PIPTIME1 (except during gravity determination in P57); when the state vector is updated, the contents of PIPTIME1 is stored in PIPTIME. Scaled centiseconds/2^28, referenced to computer clock.

Spare. The first half of each spare contains 000008. The second half is ARUPT (the contents of the accumulator when the telemetry interrupt was recognized).

Repeat of word 29 on the Rendezvous/Prethrust List.

30-66 Same as words 30-66 on Orbital Maneuvers List.

67 Same as words 68-75 on Orbital Maneuvers List.

68-75 Same as word 13 on Orbital Maneuvers List.

76 Same as words 77-94 on Coast and Align List.

77-94 Same as word 76 of Coast and Align List.

100 Spare. See page 2-87 for definition.
Description of change (cont)

1. Same as words 30-67 on Orbital Maneuvers List. See page 2-87 for definition.

2. Garbage. Same erased location as word 99 on this list.

3. Same as words 80-89 on Orbital Maneuvers List.

4. Garbage. Same erased location as word 99 on this list.

5. Same as word 26 on Rendezvous/Pre thrust List.

6. Same as word 27 on Rendezvous and Pre thrust List.

7. Same as words 30-67 on Orbital Maneuvers List. See page 2-87 for definition.

8. Garbage. Same erased location as word 99 on this list.

9. Same as words 30-67 on Orbital Maneuvers List.

10. Garbage. Same erased location as word 99 on this list.

11. Same as words 30-67 on Orbital Maneuvers List.

12. Garbage. Same erased location as word 99 on this list.

13. Same as words 80-89 on Orbital Maneuvers List.

14. Garbage. Same erased location as word 99 on this list.

15. Same as word 26 on Rendezvous/Pre thrust List.

16. Same as word 27 on Rendezvous and Pre thrust List.

17. LM STATE VELOCITY Error. Scaled (meters/centisecond)/2. Calculated once every 2 sec.


PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 1008
ANOMALY #_____

☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 3  ☐ LUMINARY 1E
☐ COLOSSUS 3A ☐ LUMINARY 1F
☐ COLOSSUS 3A ☐ LUMINARY 1F

☐ MIT Approved PCN
☐ NASA Approved PCR
☐ NASA Approved PCN
☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding

☐ Begin coding immediately (GSOP ONLY)

Program Supervisor's Approval:

☐ Do not code until new GSOP material has been approved by the MIT
Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB
consideration

ACTION: J. KLAWSNICK

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC
testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager:

Date 6-5-70
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

**1.0 COMPLETED BY ORIGINATOR**

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<td>J. Klawsnik</td>
<td>5/15/70</td>
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**1.3 EFFECTIVITY**

- LUMINARY ID

**1.5 REASON(S) FOR CHANGE**

- To Improve Quality of Document

**1.6 DESCRIPTION OF CHANGE**

- See Data Amplification Sheet

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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2.2 REMARKS

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

**3.3 STORAGE IMPACT**

**3.4 REMARKS**

**3.5 MIT COORDINATOR**

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**4.0 SOFTWARE CONTROL BOARD ACTION**

**4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVALUATION**

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**4.2 REMARKS**

**4.3 SOFTWARE CONTROL BOARD SIGN OFF**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

**5.1 MIT COORDINATOR**

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**5.2 MIT EVALUATION**

**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

**6.1 START OR CONTINUE IMPLEMENTATION**

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**6.2 REMARKS**

**6.3 SOFTWARE CONTROL BOARD SIGN OFF**

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</table>
1. 6 Description of change cont.

In addition to changes of a purely editorial or format nature, perform the following: Refer to "Attitude mode control Switch" as "PGNCS Attitude mode control Switch"; combine tables 3. 6-1 and 3. 6-3; indicate on page 3. 2-17 that SNUFFBIT affects both automatic and manual axis control; on page 3. 3-13 FLR/I should read FL6/I; clarify assumptions on page 3. 3-17; mention R61 as one of the preferred Axis Tracking Routines on page 3. 7-10 and 3. 7-16; speak specifically of the Attitude maneuver routine on page 3. 2-5; on page 3. 6-16 U', V' should replace U, V; in figure on page 3. 7-2, $\theta$ should be $\phi$. Also make the following changes on the pages indicated:

3. 2. 2. 2 Automatic Maneuvers

Automatic attitude maneuvers are implemented with exactly the same logic as that used in attitude hold, except for the additional inputs shown in Fig. 3. 2-2.

One important difference is that the reference angles, $\theta_d$, will, in general, be functions of time. These angles are generated by the steering routines, such as the attitude-maneuver routine, R60, shown schematically in Fig. 3. 2-2. The attitude-maneuver routine also generates the following quantities to provide smooth and efficient control:

1. $\Delta \theta_{do}$, $\Delta \theta_{di}$, $\Delta \theta_{dm}$ — reference CDU angle increments
2. $\omega_{dp}$, $\omega_{dq}$, $\omega_{dr}$ — desired spacecraft rates
3. $\beta_{R}$, $\beta_{Q}$, $\beta_{P}$ — attitude lag angles

The preferred tracking attitude routines, R61 and R65, maneuver the vehicle by sending the final desired CDU angles directly to the DAP whenever the desired attitude is less than 15 degrees from the current attitude (for angles greater than 15 degrees they call R60).
1.6 Description of change (cont)

\[ \beta_{Q} \text{ would be of the order of 250 deg. This would produce unpredictable results,} \]

\[ \text{therefore, the high rate should not be selected for the CSM-docked configuration,} \]

\[ \text{(Even with a different algorithm, such a maneuver would be undesirable because} \]

\[ \text{of the exorbitant RCS fuel consumption.)} \]

\[ \text{Note that when steering is completed, } \omega_{d} \text{ and } \Delta \theta_{d}, \text{ as well as } \beta, \text{ are reset to} \]

\[ \text{zero and, in effect, the LM DAP reverts to attitude hold about the desired gimbal} \]

\[ \text{angles.} \]

\[ \text{3.2-6} \]

modes of operation.

X-axis override is available only when the PGNCS attitude mode control switch

\[ \text{is placed in the AUTO position. Its use is further restricted by an internal program} \]

\[ \text{discrete as described in Subsection 3.2.4.} \]

3.2.2.5 Minimum Impulse Mode

Figure 3.2-4 shows the functional elements associated with the minimum imp-

\[ \text{ulse mode. In this mode, the LM DAP responds only to hand-controller commands.} \]

\[ \text{Each time the ACA is moved from the center (detent) position past the pulse/direct} \]

\[ \text{switches of the ACA, a single 14-millisecond firing of the RCS jets results about the} \]

\[ \text{axes commanded. The ACA must be returned to detent before another firing will be} \]

\[ \text{made. If no ACA commands are present, the spacecraft will drift freely.} \]

\[ \text{In the CSM-docked configuration, the duration of the firings is 14 millisecond for} \]

\[ \text{commands about the } \mathbf{P} \text{ axis and is 60 millisecond for commands about the } \mathbf{Q} \text{ and } \mathbf{R} \text{ axes.} \]

\[ \text{In all other respects, the minimum impulse mode is identical for the CSM-docked} \]

\[ \text{and LM-alone configurations.} \]

\[ \text{Although the DAP does not utilize the state estimate in this mode, the rate} \]

\[ \text{estimate is maintained, consequently the V60 rate display on the FDAI needles is} \]

\[ \text{valid.} \]

\[ \text{3.2-8} \]
3. XOVINHIB bit must not be set. XOVINHIB is set automatically in:
   a) The P12 powered ascent program between the time of ignition and 12 sec after the radial velocity equals +40 ft/sec.
   b) The P70 DPS abort program and the P71 APS abort program (if the LGC-estimated altitude at initiation is less than 25,000 ft) between the time of ignition and 12 sec after the radial velocity equals +40 ft/sec.
   c) The P63 braking phase program and P64 approach phase program when the LGC-estimated altitude is less than 30,000 ft.

3.2-15

in the PGNCS mode of operation is supplied by the resolvers mounted on the IMU gimbals. The attitude-rate meters are driven from signals generated by the rate-gyro assembly via the control electronics section of the stabilization and control system. The attitude-error meters, (which interface with the LGC via the digital-to-analog converters of the IMU CDU's), display one of the following three DAP-computed parameters:

1. Mode 1 attitude errors (autopilot following errors) - selected via the DSKY by V61E.
2. Mode 2 attitude errors (total attitude errors with respect to the angles in Noun 22) - selected by V62E.
3. Estimated vehicle rates - selected by V60E.
These quantities are displayed in the pilot axes. They are available in all operational modes of the autopilot and are updated every 200 milliseconds.

Mode 1 is provided as a monitor of the LM DAP and of its ability to track steering commands.

Mode 2 is provided to assist the crew in manually maneuvering the spacecraft to the attitude (gimbal angles) specified in N22 and in monitoring automatic maneuvers. These errors represent the difference between the N22 angles and the current CDU angles, resolved into pilot axes. The crew may preset an attitude reference (desired gimbal angles) into N22, but caution is advised since this may interfere with data generated under program control. It is therefore recommended that N22 be loaded for this purpose in P00 only. Note that N22 represents desired gimbal angles, not ball angles.

Since the conversion from gimbal angles to FDAI ball angles is somewhat complicated, routine 60 will automatically convert the desired gimbal angles in N22 to the required ball angles in N18 to assist the crew in monitoring and performing large spacecraft attitude maneuvers.

DAP-estimated vehicle rates may be selected by the crew with the DSKY by means of V60E. The rate-display mode provides a much finer scaling and better accuracy than that available on the attitude-rate needles driven by the rate-gyro assembly and can also be used as a backup to the rate-needle drive by the analog autopilot if the rate-gyro assembly fails.

Routine 60 automatically selects the Mode 2 attitude-error display (an equivalent of V62E). Consequently, DAP-estimated rates or Mode 1 errors will be displayed during and after automatic maneuvers only if selected by the crew after the initiation of R60.

In the PGNCS minimum impulse mode, the LM DAP will zero the Mode 1 error displays. If AGS control is selected the DAP will continue to generate the displays, provided that the PGNCS attitude mode control switch is left in either the AUTO position or the ATT HOLD position. However, the rate display is meaningless. If the PGNCS attitude mode control switch is in the OFF position, the needles are not maintained at all.
1.6 Description of change (cont)

where

\[ F = \text{the computed descent-engine thrust} \]

\[ L = \text{the distance from the hinge pin of the descent-engine bell to} \]
\[ \text{the center of gravity of the LM} \]

\[ I = \text{the pitch or roll moment of inertia of the LM} \]

\[ \delta = \text{the component about the pitch or roll axis of the angle between} \]
\[ \text{the descent-engine thrust vector and the vector } L \text{ from the descent-} \]
\[ \text{engine hinge pin to the LM center of gravity} \]

\[ 3.3-7 \]

The proper choice for the rate gain constants \( N_{\omega_L} \) and \( N_{\omega_C} \) and the acceleration gain constants \( N_{\alpha_L} \) and \( N_{\alpha_C} \) is best understood by an analysis of the state estimator as a frequency-domain filter. To simplify the analysis, assume that the unexplained attitude \( \theta \) will exceed the threshold \( \theta_{\text{max}} \) every control-sample period. The computed rate gain \( K_{\omega} \) and acceleration gain \( K_{\alpha} \) take on constant values.

\[ 3.3-26 \]

Alterations in the autopilot gains would produce unpredictable performance. If, on the other hand, the acceleration-estimate time constant was too great, there would be a prolonged transient in powered flight characterized by inefficient jet firings while the bias-acceleration estimate reached steady-state.

The values of filter gains selected appear to satisfy the various requirements. Figure 3.3-10 shows that, for a sinusoidal disturbance of 1-deg amplitude, the error in the bias-acceleration estimate for the LM-alone case will not exceed 3.3 deg/sec, and for the CSM-docked case will not exceed 0.13 deg/sec. Propellant slosh modes, with frequencies usually of the order of 0.5 cycles per second, will induce errors well below these maxima. Testing of the ascent powered flight indicates an acceptable start transient with an offset center of gravity. Testing of descent powered flight with initial gimbal mistrim indicates that an insignificant amount of RCS fuel is consumed in opposing the torque due to the lagging trim gimbal.

\[ 3.3-29 \]
1.6 Description of change (cont)

is executed every two seconds during powered flight, and at certain other times when one of its inputs is changed by another subprogram. The routine computes the functions of acceleration and deadband required by TJETLAW.

Table 3.4-3 shows the quantities computed in the 1/ACCS routine. These quantities are computed for the P, U', and V' axes. For the P axis, all quantities that are

the LM-alone autopilot). Rather, jets are turned on or off only at the control-sample instants and are left on or off for the full sampling period.

By George R. Kalan and Edgar M. Oshika.

**For the CSM-docked case, the U' and V' axes are set coincident with the U and V axes, respectively. This is a consequence of the assumption (see Subsection 3.3.1.3) that an average moment of inertia can be used for the Q and R axes. When the Q and R inertias are equal, the U'-V' system is equivalent to the U-V system.

rate has been reached, the DAP returns to the logical path that is followed when the jets are not firing, to re-evaluate the torquing policy.

In the re-evaluation of the torquing policy, a check is first made to determine if the error-rate magnitude, \( |EDOT| \), exceeds the outer rate limit of 1.73 deg/sec. If the outer rate limit is exceeded, the jet firing time is set to a convenient large number (±5.12 sec) signed so as to reduce the error rate, and the jet-inhibition logic is entered. When the outer rate limit is not exceeded, the control policy represented by Fig. 3.4-12 is used to determine the jet firing time. If the state lies

3.4-27
1.6 Description of change (cont)

By Richard D. Goss and Lowell Hull.

**The two-position selector on the controller must be in the JETS position to obtain control of translation by means of the RCS jets. With the selector in the THROTTLE position, up-and-down motion of the controller along the X axis results in varying the thrust magnitude of the descent engine, and the other motions of the hand controller are prevented mechanically.

3.4-4

pitch axis and one for the roll axis — are always set at 0.3 sec each time the GTS attitude control law is executed. Thus, if the use of the trim gimbals is disallowed, and execution of the GTS attitude control law is bypassed, the drives will stop within 0.3 sec.

3.5-4

attitude errors or DAP-estimated rates on the FDAI needles. This is done whenever the IMU CDU's are usable and the PGNCS mode select switch is not in the OFF position. It should be noted, however, that the attitude error displays are meaningless if the last computed "desired attitude" or the outputs of the IMU CDU's are

3.6-5

The following points will aid in reading Figs. 3.6-2 through 3.6-4:

1. The trapezoidal blocks indicate the LM DAP outputs to the hardware.

2. The symbols \( \theta \), \( \omega \) and \( \alpha \) denote estimated attitude, angular rate, and bias angular acceleration, respectively.

*Most of these functions are described in Subsection 3.4.2.*

3.6-5
each DAP pass, the timers are decremented by 0.1 sec. When one of the timers is zero, the appropriate gimbal drive is stopped. This mechanism also serves to guard against a run-away of the gimbals that could otherwise occur when trim-gimbal control is suddenly locked out by the USEQRJTS bit being restored to 1 (as part of the engine-off routine, for example). The timers are set up in each pass of the GTS attitude control law to a value such that they will not be counted down to zero before the next trim-gimbal-system pass; the drives therefore continue.
MIT/DL PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2D  ☑ LUMINARY 1C
☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 3  ☐ LUMINARY 1E
☐ COLOSSUS 4  ☐ LUMINARY 1F

☐ MIT Approved PCN  ☑ NASA Approved PCR
☐ NASA Approved PCN  ☐ NASA Approved Software Anomaly
☐ NASA Approved Software Anomaly

A. Coding
☐ Begin coding immediately

ACTION: Dave Moore
Program Supervisor's Approval: Margaret Hamilton

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration

ACTION: Section 5
Technical Committee Meeting not required
Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: 
Date: 3-6-70
Multiple Servicers Avoidance in P66.

If there is an unexpected amount of time loss, or an excessive computation load, several servicer jobs can run simultaneously with the possibility of producing out-of-order and erroneous guidance commands.

See Data Amplification Sheet.
1. Description of Change:

(1) At the beginning of P66, check the elapsed time since reading the PIPAs for the current state vector (TIME2 - PIPTIME). If the elapsed time is within the padloaded erasable margin 2LATE466, continue the P66 guidance. Otherwise, omit P66 and exit to the vertical displays.

(2) If the number of throttling between any omission is not greater than the padloaded erasable TOOFEW, issue the alarm 01466. This avoids locking out P66 completely without notice.

(3) Raise the priority of the servicer job to 21 shortly after the preceding checks. This prevents a subsequent servicer job from starting until P66 finishes.

(4) Request the independent ROD job at priority 22. This allows the independent ROD job to bump the servicer job at any point except in the ROD equations.

(5) Raise the priority of the servicer job and the independent ROD job to 23 at the start of the ROD equations. This locks all subsequent jobs out of the ROD equations until the current job finishes.

This method of responding to computer overloads remains a fixed (as opposed to a variable) servicer period.
MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 1015
ANOMALY #

☐ COLOSSUS 2C  ☐ LUMINARY 1B
☒ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☒ LUMINARY 1D
☐ COLOSSUS 2F  ☐ LUMINARY 1E

☐ MIT Approved PCN  ☒ NASA Approved PCR
☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding
☐ Begin coding immediately

ACTION: Zed Crocker

Program Supervisor's Approval: Margaret Lincoln

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration

ACTION: Fred De Cair

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: Russell Jones
Date: 2-5-70

(Rev 10/69)
### APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
#### PROGRAM CHANGE REQUEST

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| 2/2/70 |

### TITLE OF CHANGE
Check for AVEGON at Start of R36.

### 1.5 REASON(S) FOR CHANGE
R36 (rendezvous out of plane display, V80E) uses the permanent state (which during P12 would be the R and V on the lunar surface) and since that state was not an orbital state, an acceleration overflow in integration will occur, causing a 20430 POODOO alarm.

### 1.6 DESCRIPTION OF CHANGE
Check for "AVEGON" at start of R36. Turn on OPP ERR light if on.

### 2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH
#### DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

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### 6.0 SOFTWARE CONTROL BOARD DECISION ON HIT DETAILED PROGRAM CHANGE EVALUATION

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**MSC Form 288 (Jul 66) TP#21812**
MIT/DL PROGRAM CHANGE ROUTING SLIP

□ COLOSSUS 2D □ LUMINARY 1C
□ COLOSSUS 2E □ LUMINARY 1D
□ COLOSSUS 3 □ LUMINARY 1E
□ COLOSSUS □ LUMINARY

□ MIT Approved PCN □ NASA Approved PCR
□ NASA Approved PCN

A. Coding

☑ Begin coding immediately

ACTION: __________

Program Supervisor's Approval: __________

☑ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: __________

Technical Committee Meeting(s) held on __________ Attendees: __________

C. KSC Testing and Checkout

☑ Review for possible impact on KSC testing and checkout

ACTION: __________

D. Other Programs Affected

☑ Review for corresponding changes in __________

ACTION: __________

Special Instructions

Project Manager __________
Date 3-6-70
LUMINARY ID

Fixed Memory Landing Radar Transformation Matrices.

To permit the program to use the transformation matrix for either landing radar position without additional computation.

Replace the routines SETPOS1 and SETPOS2 with the landing radar transformation matrices.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

☐ APPROVED ☐ DISAPPROVED

2.2 REMARKS.

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

DATE

3.0 MIT VISIBILITY IMPACT EVALUATION:

☐ SCHEDULE IMPACT ☐ IMPACT OF PROVIDING DETAILED EVALUATION

☐ STORAGE IMPACT ☐ DISAPPROVED

3.4 REMARKS.

4.0 SOFTWARE CONTROL BOARD ACTION

☐ IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL. ☐ DISAPPROVED

☐ PROVIDE DETAILED CHANGE EVALUATION

4.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

3/4/70

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

DATE

5.2 MIT EVALUATION

6.0 MIT IMPLEMENTATION

☐ START OR CONTINUE ☐ DISAPPROVED OR STOP IMPLEMENTATION

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

MSS Form 264 (Jul 88)
MIT/DL PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E ☐ LUMINARY 1D
☐ COLOSSUS 3 ☐ LUMINARY 1E
☐ COLOSSUS ☐ LUMINARY

☐ MIT Approved PCN ☐ NASA Approved PCR
☐ NASA Approved PCN ☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding
☐ Begin coding immediately
ACTION: Dave Moore
Program Supervisor's Approval: Margaret Hamilton

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration
ACTION: License 2
License 4, 5

Technical Committee Meeting not required

Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout
ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in
ACTION:

Special Instructions

Project Manager: [Signature]
Date: 3-6-70
APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
PROGRAM CHANGE REQUEST

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR
R. COVELLI

1.2 ORGANIZATION
DATE
2/10/70
MIT/Draper Lab

1.3 EFFECTIVITY
LUMINARY 1D

1.4 TITLE OF CHANGE
Landing Radar Position Alarms

1.5 REASON(S) FOR CHANGE
See Data Amplification Sheet.

1.6 DESCRIPTION OF CHANGE
See Data Amplification Sheet.

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH
DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 □ APPROVED □ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE
BRANCH SIGN OFF

DATE

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

3.4 REMARKS:

3.5 MIT COORDINATOR

DATE

2/23/70

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 □ IMPLEMENT AND PROVIDE DETAILED
CHANGE EVAL. □ PROVIDE DETAILED
CHANGE EVALUATION □ DISAPPROVED

4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

3/4/70

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

DATE

5.2 MIT EVALUATION

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT
DETAILED PROGRAM CHANGE EVALUATION

6.1 □ START OR CONTINUE
IMPLEMENTATION □ DISAPPROVED OR STOP
IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

HSC Form 288 (Jul 68)
1.5 Reason(s) for Change:

Changing the landing radar position alarm logic will simplify the astronaut procedures if the landing radar fails to reposition when it should, or if it repositions when it should not. The change also permits landing radar data incorporation any time that the data good signal is present, regardless of antenna position.

1.6 Description of Change:

The key to this change is the removal of the concept of "desired landing radar position." The program will accept landing radar data in either position as long as the data good discrete is present. If neither position discrete is present, or if both are present, program alarm 511 is issued. The 511 alarm will not be repeated on subsequent cycles if the same conditions persist, so that the alarm system will not be locked out by the 511 alarm.

If the landing radar position changes unexpectedly, program alarm 522 will be issued. The data will not be used the first time because the antenna may have been moving during the data reading.

The 523 alarm will no longer be issued if the antenna fails to achieve Position #2. If the antenna remains in Position #1, a 522 alarm will be issued and on the following cycles the data will be used as long as the data good signal is present. If the antenna leaves Position #1 but fails to achieve Position #2, a 511 alarm will be issued.

Remarks:

(1) It is expected that PCR #1024, "Fixed Memory Landing Radar Transformation Matrices," will also be approved. This would reduce execution time for computing the matrix each time the position changes.

(2) The crew can manually reposition the landing radar antenna at any time. Program alarms 511 and 522 will appear, but the data will then be used until the antenna reaches the desired position.
A. Coding

- Begin coding immediately

- Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

- Prepare GSOP revisions for MDRB consideration

- Technical Committee Meeting not required

- Technical Committee Meeting(s) held on
  Attendees:

C. KSC Testing and Checkout

- Review for possible impact on KSC testing and checkout

- ACTION:

D. Other Programs Affected

- Review for corresponding changes in

- ACTION:

Special Instructions

Project Manager: [Signature]
Date: 3-6-70
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**1.5 REASON(S) FOR CHANGE**
Reduce execution time during R12. The gravity vector is now recomputed after the landing radar altitude update, although its change is insignificant.

**1.6 DESCRIPTION OF CHANGE**
Remove to call to MUNGRAV after LR altitude update

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**4.0 SOFTWARE CONTROL BOARD ACTION**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

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A. Coding

☐ Begin coding immediately

ACTION: C. Elyea

Program Supervisor's Approval: Margaret Hamilton

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: L. E. 4&5

Technical Committee Meeting not required

Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: [Signature]

Date: 3-6-70
**LO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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1.5 Reason for Change

The present powered landing-maneuver navigation system essentially assumes a smooth lunar terrain. As a result, significant errors can occur in the estimates of vehicle altitude w.r.t. the site when the approach terrain to the site is rough and contains large slopes, hills, or craters. These errors can adversely effect the required landing-maneuver ΔV, LPD operational characteristics, and the terminal-phase altitude vs. range-to-go characteristics. This has been observed in simulated landings to Censorinus-B, Censorinus-C, and Fra Mauro (Refs. 1 and 2) and also to Littrow-2 (Ref. 3).

1.6 Description of Change

A significant improvement in performance is obtained by storing in the LGC an a-priori model of the approach terrain to the site of interest. The basic idea is to store the deviations in terrain altitude w.r.t. the site altitude (TEREST) as a function of the computed range-to-go from the landing site (RZG). It is recommended that this be done by a series of linear segments or slopes, as shown in Fig. 1 for Littrow-2.

Important considerations in implementing the change are the following:

(1.) Based on studies to date (Refs. 1 - 3) it is felt that a minimum of five segments are required to give satisfactory performance for the sites of interest.

(2.) In order to obtain the desired flexibility over a wide range of terrain profiles (Censorinus, Littrow, and Copernicus), the two parameters defining each linear segment, e.g. the slope and starting range-to-go, should be in erasable memory.

(3.) The range-to-go (RZG) used in the storing of the a-priori terrain should be computed as the difference between the down-range components of the estimated LM and landing site position vectors.

SM coordinates, i.e.:
1.6 Description of Change (cont.)

(3.)

\[ RZG = r_{P,2} - r_{SP,2} \]

where \( r_{P} \) and \( r_{SP} \) are the computed LM and site position vectors.

It should be noted that \( r_{SP,2} \) will be changed by N69 updates and by landing-site redesignations.

(4.) The terrain profile to be stored will be the one seen by the range beam on a nominal trajectory. It is felt that this is a better choice than the local terrain below the vehicle.

(5.) The a-priori terrain (TEREST) will be used to modify the altitude measurement (\( \hat{h} \)) as indicated in the navigation relations below:

\[
\begin{align*}
\hat{h} &= r_{P} - r_{SP} \\
\delta h &= \hat{h} - \hat{h} + \text{TEREST} \\
r_{P} &= r_{P} + w_{H} \delta h u_{HP}
\end{align*}
\]

The quantity \( \hat{h} \) is the a-priori altitude estimate, \( w_{H} \) is the LR altitude weighting function, and \( u_{HP} \) is a unit vector along the local vertical. It is assumed in the \( \delta h \) relation that the sign of TEREST is positive when a terrain point higher than the site is being modeled.
Fig. 1: Initial A-Priori Target Model for LIDAR

Relations Used to Simulate A-priori Model

IF RZG, HEG, TÉREST = \( \frac{333}{14300} \) RZG

IF RZG+14300 HEG, TÉREST = 333+700 (RZG+14300)

IF RZG+21200 HEG, TÉREST = 1033+2470 (RZG+21200)

IF RZG+38300 HEG, TÉREST = -1440+0

IF RZG+380000 HEG, TÉREST = 8000
REFERENCES


MI~ .PROGRAM CHANGE ROUTING SLIP

☐ COLOSSUS 2D ☐ LUMINARY 1C
☐ COLOSSUS 2E ☐ LUMINARY 1D
☐ COLOSSUS 3 ☐ LUMINARY 1E
☐ COLOSSUS ☐ LUMINARY

☐ MIT Approved PCN ☐ NASA Approved PCR ☐ NASA Approved PCN
☐ NASA Approved Software Anomaly ☐ MIT Approved Software Anomaly

A. Coding
☐ Begin coding immediately

ACTION: 
Program Supervisor's Approval: 

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration

ACTION: 
Technical Committee Meeting not required

Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager:

Date 3-6-70
## OLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST

### 1.0 COMPLETED BY ORIGINATOR

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<th>1.1 ORIGINATOR</th>
<th>1.2 ORGANIZATION</th>
<th>APPROVAL</th>
<th>1.3 EFFECTIVITY</th>
<th>1.4 TITLE OF CHANGE</th>
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<tr>
<td>B. KRIEGSMAN</td>
<td>MIT/CSD Lab.</td>
<td></td>
<td>LUMINARY 1D</td>
<td>Two-segment Altitude Weighting Functions for Landing Maneuver.</td>
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</tbody>
</table>

### 1.5 REASON(S) FOR CHANGE

See Data Amplification Sheet.

### 1.6 DESCRIPTION OF CHANGE

See Data Amplification Sheet.

### 2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

#### 2.1
- [ ] APPROVED
- [ ] DISAPPROVED

### 2.2 REMARKS:

#### 2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

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### 3.0 MIT VISIBILITY IMPACT EVALUATION:

#### 3.1 SCHEDULE IMPACT

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#### 3.2 IMPACT OF PROVIDING DETAILED EVALUATION

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### 3.3 MIT COORDINATOR

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### 4.0 SOFTWARE CONTROL BOARD ACTION

#### 4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

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#### 4.3 SOFTWARE CONTROL BOARD SIGN OFF

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### 5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

#### 5.1 MIT COORDINATOR

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#### 5.2 MIT EVALUATION

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### 6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

#### 6.1 START OR CONTINUE IMPLEMENTATION

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#### 6.2 REMARKS:

#### 6.3 SOFTWARE CONTROL BOARD SIGN OFF

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Landing maneuvers over rough terrains with large hills and craters require relatively low weighting functions in the braking phase. This is desirable to avoid following the local terrain variations at long ranges, and introducing excessive pitch-angle oscillations (Refs. 1-3). In the approach phase, on the other hand, higher weighting functions are desired in order to keep the altitude estimation errors small close to the site. The present weighting-function scheme has limited flexibility.

1.6 Description of Change:

The present LR weighting function is given by:

\[ W_H = LRWH \left(1 - \frac{h'}{LRH_{\text{MAX}}} \right) \]

where \( h' \) is the estimated vehicle altitude, and \( LRWH \) and \( LRH_{\text{MAX}} \) are erasable quantities used to set the slope of the weighting function. To provide flexibility in the choice of \( W_H \), it is desired that a separate erasable load be provided for \( LRWH \) in the programs following P63.

REFERENCES:
MIT/DL PROGRAM CHANGE ROUTING SLIP

[ ] COLOSSUS 2D [ ] LUMINARY IC
[ ] COLOSSUS 2E [ ] LUMINARY 1D
[ ] COLOSSUS 3 [ ] LUMINARY 1E
[ ] COLOSSUS [ ] LUMINARY

[ ] MIT Approved PCN [ ] NASA Approved PCR
[ ] NASA Approved PCN

A. Coding

[ ] Begin coding immediately

ACTION: [Signature]

Program Supervisor's Approval: [Signature]

[ ] Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

[ ] Prepare GSOP revisions for MDRB consideration

ACTION: [Signature]

Technical Committee Meeting not required

Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

[ ] Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

[ ] Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager [Signature]

Date [Date]
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<td>3/18/70</td>
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<td>Organization</td>
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<td>Reason(s) for Change</td>
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<td>1.6</td>
<td>Description of Change</td>
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<td>See Data Amplification Sheet</td>
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<td>Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT</td>
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<td>Remarks</td>
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<td>Software Control Board or Flight Software Branch Sign Off</td>
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<td>L. Larson</td>
<td>7/7/70</td>
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<td>6.3</td>
<td>Software Control Board Sign Off</td>
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1.6 Description of Change

Put on downlink the following indicators:

(1) DUMMY JOB CNTR (DUM LOOPS).

(2) DURATION OF SERVICER

\[ \text{SURVdurN} = \text{TIME 1} - (\text{PIP TIME} + 1) \]

These indicators are to be put on the following downlist in the format:

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<tr>
<th>FIRST REG</th>
<th>SECOND REG</th>
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<tr>
<td>SURVdurN</td>
<td>DUMLOOPS</td>
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<td>DESCENT and ASCENT</td>
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<td>AGS INITIALIZATION and UPDATE</td>
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<td>ORBITAL MANEUVERS</td>
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### MIT-PCN

**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

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<th>1.2 ORGANIZATION</th>
<th>1.4 TITLE OF CHANGE</th>
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<tbody>
<tr>
<td>McCoy</td>
<td>MIT</td>
<td>V68 and P66 terminate the terrain model</td>
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1.5 DESCRIPTION OF CHANGE

See amplification sheet

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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<th>2.2 REMARKS</th>
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2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

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3.0 MIT VISIBILITY IMPACT EVALUATION:

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<th>3.1 SCHEDULE IMPACT</th>
<th>3.2 IMPACT OF PROVIDING DETAILED EVALUATION</th>
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<th>3.4 REMARKS</th>
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**4.0 SOFTWARE CONTROL BOARD ACTION**

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<th>4.2 REMARKS</th>
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4.2 SOFTWARE CONTROL BOARD SIGN OFF

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5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

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<th>6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION</th>
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6.3 SOFTWARE CONTROL BOARD SIGN OFF

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</table>
1.5  (a) An extended verb shall allow the astronaut to bypass the terrain model computations if the model causes adverse effects.

(b) P66 need not use the terrain model because the program is not guiding toward a specific altitude. Also, the astronaut should have on his displays the true present altitude, rather than that relative to the landing site.

1.6  V68 and entrance to P66 set a flag to bypass the terrain model computations.
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

<table>
<thead>
<tr>
<th>1.0 COMPLETED BY ORIGINATOR</th>
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<tbody>
<tr>
<td>McCoy</td>
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<th>1.3 EFFECTIVITY</th>
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<th>1.4 TITLE OF CHANGE</th>
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<tr>
<td>PCR 096 (Liftoff check in P07) Improvements</td>
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<th>1.5 REASONS FOR CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To keep astronaut from having to set bit in flight.</td>
</tr>
<tr>
<td>2. Astronaut will not get a POD00 for keystroke error.</td>
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<table>
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<tr>
<th>1.6 DESCRIPTION OF CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set POD07FG in V37 logic</td>
</tr>
<tr>
<td>2. If V92E with flag set, display operator error, not alarm 21521.</td>
</tr>
</tbody>
</table>

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

<table>
<thead>
<tr>
<th>2.1 IMPLEMENT AND PROVIDE DETAILED EVALUATION</th>
<th>2.2 REMARKS</th>
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<td>[ ] APPROVED</td>
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**3.0 MIT VISIBILITY IMPACT EVALUATION:**

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<td>[ ] APRV</td>
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**4.0 SOFTWARE CONTROL BOARD ACTION**

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| 5/14/70 |

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

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**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

<table>
<thead>
<tr>
<th>NUMBER (Completed by POE)</th>
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<tbody>
<tr>
<td>1036</td>
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**MSC Form 286 (Jul 68)**

**TP#21812**
APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
PROGRAM CHANGE REQUEST

1.0 COMPLETED BY ORIGINATOR

<table>
<thead>
<tr>
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<tr>
<td>Klumpp</td>
<td>4/22/70</td>
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</table>

1.4 TITLE OF CHANGE

LUMINARY ID

1.6 REASON(S) FOR CHANGE

See Data Amplification Sheet

1.6 DESCRIPTION OF CHANGE

See Data Amplification Sheet

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

<table>
<thead>
<tr>
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</table>

2.2 REMARKS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 COST IMPACT

2 words

3.4 REMARKS:

Vert., approved from 1/1/70

Price on 4/23/70

3.5 MIT ORIGINATOR

DATE

4/27/70

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

5/14/70

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

DATE

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 START OR CONTINUE IMP.

6.2 REMARKS

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE
1. a. remove "stoprate" from P66 initialization
   b. remove the resetting of REDFLAG from P66 initialization
   c. provide a "stoprate" when a 01466 alarm occurs

2. a. it interrupts any attitude control of spacecraft when ROD's are skipped;
   b. not necessary to reset it since redesignation monitor is terminated when P66 begins;
   c. attitude rates should be terminated when the PGNS is having difficulty controlling the spacecraft as with the 01466 alarm situation.
Due to the difficulty in providing a display in P20 while it is running in background of another program. (Also see Luminary Memo #133)
The terrain Model should correspond to the path followed by the intersection of the altitude radar beam with the Lunar Surface. PCR 1027 did not account for the downrange displacement introduced by the non-vertical orientation of the altitude beam.

See Data Amplification Sheet

---

### 2.0 SOFTWARE CONTROL BOARD ACTION

- **4.7 REMARKS**: Re-evaluate to make sure that this is really a good thing to do.
  - i.e.: Accuracy gain, T-loss etc.

---

### 5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

---

### 6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION
1.6  \[ R_{ZG} = \mathbf{r}_{P,2} + \mathbf{r}_{LRP,2} - \mathbf{r}_{SP,2} \]

where \( \mathbf{r}_{P,2} \) is the downrange position vector of the LM

\( \mathbf{r}_{LRP,2} \) is the altitude beam vector Z component, and

\( \mathbf{r}_{SP,2} \) is the Landing Site position vector Z component, all in platform coordinates.
LUMINARY 1D

Due to Complexity in changing the very neat Master Ignition Routine and the fact that P40 and P42 already have a TFI countdown and P41 has none.

Do not incorporate PCR 872.2 into P3X, P40 or P42. TFI will begin counting down immediately after calling P41 and terminates at TIG - 35.
A. Coding

- Begin coding immediately

ACTION: 

Program Supervisor’s Approval: 

- Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: J. Klawski

Technical Committee Meeting not required

Technical Committee Meeting(s) held on:

Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager: 

Date: 5-11-70
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST**

### 1.0 COMPLETED BY ORIGINATOR

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<thead>
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<th>J. Klawnsik</th>
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<tr>
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<td>1.3 EFFECTIVITY</td>
<td>LUMINARIES 1D</td>
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<td>1.4 TITLE OF CHANGE</td>
<td>Sect. 3 Rev. 4 GSOP</td>
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<tr>
<td>1.5 REASON(S) FOR CHANGE</td>
<td>Fix for L-1 C-08.</td>
</tr>
<tr>
<td>1.6 DESCRIPTION OF CHANGE</td>
<td>Change Sect. 3 GSOP to conform with Data Amplification Sheet.</td>
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### 2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

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### 3.0 MIT VISIBILITY IMPACT EVALUATION:

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<th>SCHEDULE IMPACT</th>
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<tr>
<td>3.2</td>
<td>IMPACT OF PROVIDING DETAILED EVALUATION</td>
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<tr>
<td>3.3</td>
<td>STORAGE IMPACT</td>
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<tr>
<td>3.4</td>
<td>REMARKS:</td>
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### 4.0 SOFTWARE CONTROL BOARD ACTION

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<th>□ PROVIDE DETAILED CHANGE EVALUATION</th>
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### 5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

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### 6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

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<th>SOFTWARE CONTROL BOARD SIGN OFF</th>
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APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
DATA AMPLIFICATION SHEET

PROGRAM CHANGE REQUEST NO. PREPARED BY DATE ORGANIZATION
1042 J. Klawsnik 5/8/70

CONTINUATION SECTION (Refer to Block Number and Title on Program Change Request Form.)
1.6  Continued
Change Pg. 3.4 - 38 as shown

U', V' axes, these rate errors are then resolved into U', V' components (ω_eU', ω_eV').
At this point, the automatic steering inputs are zeroed; that is,

\[
\begin{align*}
\omega_dP &= 0 & \Delta \theta_dP &= 0 & \beta_dP &= 0 \\
\omega_dQ &= 0 & \Delta \theta_dQ &= 0 & \beta_dQ &= 0 \\
\omega_dR &= 0 & \Delta \theta_dR &= 0 & \beta_dR &= 0
\end{align*}
\]

The desired CDU's are also set equal to the current CDU's; that is,

\[
\begin{align*}
\text{CDUXD} &= \text{CDUX} & \theta_do &= \theta_o \\
\text{CDUYD} &= \text{CDUY} & \theta_di &= \theta_i \\
\text{CDUZD} &= \text{CDUZ} & \theta_dm &= \theta_m
\end{align*}
\]

A check is then made to determine if either \(|\Delta \omega_{cQ}| > \omega_{BL}| or \(|\Delta \omega_{cR}| > \omega_{BL}|. If so, the Q, R-axes direct rate control law is selected. Before entering the direct rate control law, however, the Q, R-axes time counter, \(T_{cQR}'\), is set to 4 seconds. This counter has the same function as \(T_{cP}'\).

At the beginning of the direct rate control law, the Q, R manual errors, \(\theta_{emQ}\) and \(\theta_{emR}'\), are zeroed.
MIT/DL PROGRAM CHANGE ROUTING SLIP

☐ COLLOSSUS 2D    ☐ LUMINARY 1C
☐ COLLOSSUS 2E    ☑ LUMINARY 1D
☐ COLLOSSUS 3    ☐ LUMINARY 1E
☐ COLLOSSUS      ☐ LUMINARY

☐ MIT Approved PCN    ☐ NASA Approved PCR
☑ NASA Approved PCN    ☐ NASA Approved Software Anomaly
☐ MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately

Program Supervisor’s Approval:

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: H. MAHER

Technical Committee Meeting not required

Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager:

Date: 5-19-70

NASA Approved PCN

NASA Approved PCR

MIT Approved PCN

NASA Approved Software Anomaly

MIT Approved Software Anomaly

FIXED BY ACB L-17

ACTION: [Signature]

Program Supervisor’s Approval: [Signature]

[Signature]

[Signature]
**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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<td>5/12/70</td>
<td>MIT</td>
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</table>

**1.3 EFFECTIVITY**

LUM 1D

**1.4 TITLE OF CHANGE**

Remove zeroing of bit 4 of channel 14 on restart or V37.

**1.5 REASON(S) FOR CHANGE**

If a software restart occurs during the throttle down of the DPS engine, the pulses to the DECA are terminated.

**1.6 DESCRIPTION OF CHANGE**

Remove zeroing of bit 4 of channel 14 from STARTSB2.

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH**

**DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

- [ ] Approved
- [ ] Disapproved

**2.2 REMARKS:**

**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**DATE:**

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**SCHEDULE IMPACT**

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

**3.3 STORAGE IMPACT**

**3.4 REMARKS:**

**3.5 MIT COORDINATOR**

**DATE:** 5/12/70

**4.0 SOFTWARE CONTROL BOARD ACTION**

- [x] Implement and provide detailed change evaluation
- [ ] Provide detailed change evaluation
- [ ] Disapproved

**4.2 REMARKS:**

**4.3 SOFTWARE CONTROL BOARD SIGN OFF**

**DATE:** 5/14/70

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

**5.1 MIT COORDINATOR**

**DATE:**

**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

- [ ] Start or continue implementation
- [ ] Disapproved or stop implementation

**6.2 REMARKS:**
MIT/DL PROGRAM CHANGE ROUTING SLIP

COLOSSUS 2E
COLOSSUS 3
COLOSSUS 3A
COLOSSUS

LUMINARY 1D
LUMINARY 1E
LUMINARY 1F
LUMINARY

MIT Approved PCN
\[ NASA Approved PCN \]
\[ NASA Approved PCR \]
\[ NASA Approved Software Anomaly \]
\[ MIT Approved Software Anomaly \]

A. Coding

\[ \text{Begin coding immediately} \]

ACTION:

Program Supervisor's Approval:

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

\[ \text{Prepare GSOP revisions for MDRB consideration} \]

ACTION:

Technical Committee Meeting not required.

Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

\[ \text{Review for possible impact on KSC testing and checkout} \]

ACTION:

D. Other Programs Affected

\[ \text{Review for corresponding changes in} \]

ACTION:

Special Instructions

Project Manager:

Date: 6-5-70
### APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD

**PROGRAM CHANGE REQUEST**

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**1.3 EFFECTIVITY**

**LUMINARY ID**

**1.4 TITLE OF CHANGE**

Initialize Elevation Angle in P34

**1.5 REASONS FOR CHANGE**

1. The option to compute Elevation Angle from TPI-TIG is used more often (astronaut loads zero)
2. Eliminates possibility of 611 alarm: the erasable sharing with Elev. (cont'd)

**1.6 DESCRIPTION OF CHANGE**

Load zero into Elev dp prior to first NOUN 55 display in P34.

---

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH**

**DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**DATE**

---

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

None

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

- **3.3 STORAGE IMPACT**
  - 2 words

**3.4 REMARKS:**

Verbal approval by T. Price on 6-3-70

---

**4.0 SOFTWARE CONTROL BOARD ACTION**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

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**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD NUMBER**

1048

**NUMBER (Completed by F58)**

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**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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**1.3 EFFECTIVITY**

**LUMINARY ID**

**1.4 TITLE OF CHANGE**

Initialize Elevation Angle in P34

**1.5 REASONS FOR CHANGE**

1. The option to compute Elevation Angle from TPI-TIG is used more often (astronaut loads zero)
2. Eliminates possibility of 611 alarm: the erasable sharing with Elev. (cont'd)

**1.6 DESCRIPTION OF CHANGE**

Load zero into Elev dp prior to first NOUN 55 display in P34.

---

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH**

**DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**DATE**

---

**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

None

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

- **3.3 STORAGE IMPACT**
  - 2 words

**3.4 REMARKS:**

Verbal approval by T. Price on 6-3-70

---

**4.0 SOFTWARE CONTROL BOARD ACTION**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

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**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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**1.3 EFFECTIVITY**

**LUMINARY ID**

**1.4 TITLE OF CHANGE**

Initialize Elevation Angle in P34

**1.5 REASONS FOR CHANGE**

1. The option to compute Elevation Angle from TPI-TIG is used more often (astronaut loads zero)
2. Eliminates possibility of 611 alarm: the erasable sharing with Elev. (cont'd)

**1.6 DESCRIPTION OF CHANGE**

Load zero into Elev dp prior to first NOUN 55 display in P34.

---

**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH**

**DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**DATE**

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**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

None

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

- **3.3 STORAGE IMPACT**
  - 2 words

**3.4 REMARKS:**

Verbal approval by T. Price on 6-3-70

---

**4.0 SOFTWARE CONTROL BOARD ACTION**

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**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

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**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

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**APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD**

**PROGRAM CHANGE REQUEST**

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**1.3 EFFECTIVITY**

**LUMINARY ID**

**1.4 TITLE OF CHANGE**

Initialize Elevation Angle in P34

**1.5 REASONS FOR CHANGE**

1. The option to compute Elevation Angle from TPI-TIG is used more often (astronaut loads zero)
2. Eliminates possibility of 611 alarm: the erasable sharing with Elev. (cont'd)

**1.6 DESCRIPTION OF CHANGE**

Load zero into Elev dp prior to first NOUN 55 display in P34.

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**2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH**

**DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT**

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**2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF**

**DATE**

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**3.0 MIT VISIBILITY IMPACT EVALUATION:**

**3.1 SCHEDULE IMPACT**

None

**3.2 IMPACT OF PROVIDING DETAILED EVALUATION**

- **3.3 STORAGE IMPACT**
  - 2 words

**3.4 REMARKS:**

Verbal approval by T. Price on 6-3-70

---

**4.0 SOFTWARE CONTROL BOARD ACTION**

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<tr>
<td>4.3 SOFTWARE CONTROL BOARD SIGN OFF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATE**

---

**5.0 MIT DETAILED PROGRAM CHANGE EVALUATION**

<table>
<thead>
<tr>
<th>5.1 MIT COORDINATOR</th>
<th>5.2 MIT EVALUATION</th>
</tr>
</thead>
</table>

**DATE**

---

**6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION**

<table>
<thead>
<tr>
<th>□ START OR CONTINUE IMPLEMENTATION</th>
<th>□ DISAPPROVED OR STOP IMPLEMENTATION</th>
<th>6.2 REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3 SOFTWARE CONTROL BOARD SIGN OFF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATE**

---
## APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD DATA AMPLIFICATION SHEET

<table>
<thead>
<tr>
<th>PROGRAM CHANGE REQUEST NO.</th>
<th>PREPARED BY</th>
<th>DATE</th>
<th>ORGANIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1048</td>
<td>McCoy</td>
<td>5/28/70</td>
<td>MIT/DL</td>
</tr>
</tbody>
</table>

**CONTINUATION SECTION (Refer to Block Number and Title on Program Change Request Form.)**

1.5 **Cont'd**

is so small that pinball scaling causes display to appear to Astronaut as zero. The astronaut wanting this option would not reload zero, however, the Lambert targeting would see a non-zero Elevation Angle (unreasonably small) and attempt, unsuccessfully, to find a solution, hence a 611 alarm.
A. Coding

☐ Begin coding immediately

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

Program Supervisor's Approval: Margaret H. Hamilton

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on

Attendees:

J. Klawunik

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION:

Special Instructions

Project Manager [Signature]

Date 6-4-70
Due to the IMU being located approximately 1 1/2 meters from the center of gravity, translational acceleration is induced by any attitude vehicular rates by a factor of \( \frac{W}{R} \), where \( W \) is the rate and \( R \) is the moment arm. (cont. page 2)

When computing present acceleration due to thrust (reading the PIPAS) remove effects of this offset acceleration.

### 2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

<table>
<thead>
<tr>
<th>7.1</th>
<th>[ ] APPROVED</th>
<th>[ ] DISAPPROVED</th>
</tr>
</thead>
</table>

### 3.0 MIT VISIBILITY IMPACT EVALUATION:

#### 3.1 SCHEDULE IMPACT

#### 3.2 IMPACT OF PROVIDING DETAILED EVALUATION

#### 3.3 STORAGE IMPACT

11 words (fixed)

#### 3.5 MIT COORDINATION

**Russell H. Larson**

**Date:**

6-3-70

---

**T. Price on 6-3-70**

### 4.0 SOFTWARE CONTROL BOARD ACTION

#### 4.1 IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL.

#### 4.2 Software Control Board Sign Off

**Date:**

---

### 5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

#### 5.1 MIT COORDINATOR

**Date:**

### 6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

#### 6.1 START OR CONTINUE IMPLEMENTATION

#### 6.2 Software Control Board Sign Off

**Date:**

---

**McCoy 6/3/70 MIT/SDL**
1.5 Reason for change (cont.)

This acceleration sensed by the X PIPA affects the P66 vertical throttle control if the PIPA's are read while the vehicle rates are in progress.
**IT/DL PROGRAM CHANGE ROUTING SLIP**

**PCR/PCN # 1056 Rev.1**

<table>
<thead>
<tr>
<th>LUMINARY 1D</th>
<th>LUMINARY 1E</th>
<th>LUMINARY 1F</th>
</tr>
</thead>
</table>

**COLOSSUS 2E**

**REISSUE**

<table>
<thead>
<tr>
<th>MIT Approved PCN</th>
<th>NASA Approved PCR</th>
<th>NASA Approved Software Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT Approved ADR</td>
<td>NASA Approved PCN</td>
<td>MIT Approved Software Anomaly</td>
</tr>
</tbody>
</table>

**A. Coding**

- [ ] MIT Approved PCN
- [ ] NASA Approved PCR
- [ ] NASA Approved Software Anomaly
- [ ] MIT Approved ADR
- [ ] NASA Approved PCN
- [ ] MIT Approved Software Anomaly

- Begin coding immediately

**ACTION:**

Program Supervisor's Approval: Margaret Hamilton

- Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

**B. GSOP Preparation**

- [ ] Technical Committee Meeting not required.
- [ ] Technical Committee Meeting(s) held on Attendees:

**ACTION:**

J. Klawsnik / J. Smith

**C. KSC Testing and Checkout**

- [ ] Review for possible impact on KSC testing and checkout

**ACTION:**

**D. Other Programs Affected**

- [ ] Review for corresponding changes in

**ACTION:**

Special Instructions

Project Manager: [Signature]

Date: 9-16-70
**Title:** Improvements for Impulse and Ullage Logic

**LUMINARY ID**

1. Remove overburn possibilities when ullage time is required to be greater than 3.5 seconds in P42.
2. Correct APS Impulse Constant for "Wet" Engine (cont.)

**Description of Change**

1. Turn on ullage at TIG-6 sec. in P42; assume 6.5 sec. in Routine S40.13.
2. Charge K1VAL from 2800 to 3150 lb. sec. in Routine S40.13.
3. Change Thrust Ullage (F_L) from 200 to 400 lbs. in Routine S40.13.

**Software Control Board or Flight Software Branch Decision for Visibility Impact Estimate by MIT**

<table>
<thead>
<tr>
<th>2.1</th>
<th>Approved</th>
<th>Disapproved</th>
</tr>
</thead>
</table>

**Mit Visibility Impact Evaluation**

3.1 Schedule Impact

3.2 Impact of Providing Detailed Evaluation

3.3 Storage Impact

2 Words

3.4 Remarks

3.5 Mit Coordinator

9-16-70

**Software Control Board Action**

4.1 Implement and Provide Detailed Change Evaluation

4.2 Remarks

4.3 Software Control Board Sign Off

**Mit Detailed Program Change Evaluation**

5.1 Mit Coordinator

5.2 Mit Evaluation

**Software Control Board Decision on Mit Detailed Program Change Evaluation**

6.1 Start or Continue Implementation

6.2 Remarks

6.3 Software Control Board Sign Off
1. 5 Cont.

3. Prime Flight Crew will be using 4 jet x-translation for ullage in case (1) APS doesn't shutdown or (2) APS doesn't ignite at all, the ΔV will be easier to null than with 2 jets.
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 AXES WITH
THE ATTITUDE CONTROLLER EVEN THOUGH THE PONGS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT
THE PONGS 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 R50).

(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 THROTTLE.

(10) THE LOAD DAP DATA ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM AND THE LGC 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/THRLST DOES NOT AFFECT ACCOMPLISHMENT OF MANEUVER AIM CONDITIONS, THEN GIMBAL
DRIVE TO TRIM POSITION NEED NOT BE DONE BEFORE TIC. GIMBAL DRIVE TO TRIM POSITION IN WORST CASE COULD REQUIRE
2 MINUTES. JET X-TRANSLATION FOR UPLAGE OF 10.5 SECONDS IS ASSUMED.

(11) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET ATTITUDE (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY
EXTENDED VERS AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT
VIOLATIONS DURING CSW-LOCKED 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 IGNITION 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
(R40). THIS ROUTINE IS CALLED AT OP S IGNITION BY THIS PROGRAM.

(14) THE LGC WILL NEITHER DESIGNATE NON 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.
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 PONGS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO CEINT THE PONGS 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).

(10) 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.

(11) THE LOAD DAP DATA ROUTINE (R03) MAY HAVE BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. FOR 6.5 SECONDS UNTIL OFFSET IS ASSUMED.

(12) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (KR) 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.

---

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.

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(11) THE LOAD DAP DATA ROUTINE (R03) MAY HAVE BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. FOR 6.5 SECONDS UNTIL OFFSET IS ASSUMED.

(12) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (KR) 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.
WILL ACTIVE STEERING BE ATTEMPTED DURING THIS MANEUVER? (REFER PARA. 5.3.3.- 3.3 OF SECTION 5 OF R567)

SET IPPLUSE FLAG

CALL VERB 59 DISPLAYS (SEE "A"
BELCH)

CALL SET OF UJLAGE
FLAG AT TIG(3.5 SEC)

WAIT UNTIL TIG = 0

SET IGNITION FLAG
WAIT FOR KEYBOARD ENTRY

AT TFI = 00803 MONITOR START OF 4X JET TRANSLATION

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

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

KEY IN ENTER

GO TO
FLAG

TERMINATE CALL FOR SET CF LAG A1 TIG-3,5 SEC IF CALL NOT YET DNE

"A" FROM ABOVE

HOLD

FLASH VERB-NOLN TO REQUEST PROCEED.
HOLD DISPLAY OF TFC AT ITS FINAL VALUE:
V1 = 440
R1 = TFC
R2 = VG
R3 = DELTA VP
(NOTE: SEE ASSUMP-
TICK (2) ABOVE).

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

RECORD THESE VALUES AS DESIRED.

WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED,

KEY IN PROCEED
If either the DPS or APS were selected for the maneuver, the Time-to-Go Prediction Subroutine of Fig. 3.3-11 is then processed. With reference to Fig. 3.3-11:

\[ S_{TH} \]

- DPS throttle inhibit switch
  - 0 Allow DPS throttle up
  - 1 Inhibit DPS throttle up

\[ S_I \]

- Impulse Switch
  - 0 Allow steering at the proper time via ΔV Monitor Routine (Section 5.3.3.6)
  - 1 Indicates short maneuver and no steering is required

\[ F_L \]

- Ullage thrust (jet thrust)

\[ K_1 \]

- APS impulse velocity acquired in a one second maneuver for a unit mass vehicle

\[ K_2 \]

- APS minimum impulse constant

\[ K_3 \]

- APS minimum impulse constant equal to the slope of minimum impulse curve.

\[ K_4 \]

- 10% DPS engine thrust

\[ F_{APS} \]

- APS Thrust

The initial computation in Fig. 3.3-11 estimates the velocity-to-be-gained after \( t_{5} \) seconds of ullage. If the DPS were selected (P-40), the maneuver time, \( t_{go} \), is then computed on the basis of 10% thrust. If this time is less than 6 seconds no active guidance steering is attempted \( (S_1 = 1) \) and the vehicle attitude is maintained at the pre-thrust alignment throughout the maneuver. If the DPS \( t_{go} \) is greater than 85 seconds normal steering will
Figure 3.3-11 Time-to-go Predictor Routine
<table>
<thead>
<tr>
<th>Section No.</th>
<th>GSOP Name</th>
<th>LGC Name</th>
<th>Units</th>
<th>Value</th>
<th>Reference (Sec. 5.8.2)</th>
<th>Comments (Sec. 5.8.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2.4.2.2</td>
<td>( \text{varIMU} )</td>
<td></td>
<td>((\text{mr})^2)</td>
<td>1.0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>5.2.5.3</td>
<td>( \omega_M )</td>
<td></td>
<td>rad/sec</td>
<td>(2.661699\times10^{-6})</td>
<td>2, 3, 4</td>
<td></td>
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<tr>
<td>5.3.3.3.1</td>
<td>( \text{F}_{\text{DPS}} )</td>
<td></td>
<td>pounds</td>
<td>9817.5</td>
<td>29, 30</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>( \text{F}_{\text{APS}} )</td>
<td></td>
<td>pounds</td>
<td>3500</td>
<td>5, 17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \text{F}_{\text{RCS}} )</td>
<td></td>
<td>pounds</td>
<td>400 or 200</td>
<td>5, 17</td>
<td></td>
</tr>
<tr>
<td>5.3.3.3.3</td>
<td>( \Delta V_K(\text{DPS}) ) \footnote{LM only CSM docked}</td>
<td></td>
<td>cm/sec</td>
<td>36</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>( \Delta V_K(\text{APS}) )</td>
<td></td>
<td>cm/sec</td>
<td>12</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>( \dot{m}(\text{APS}) )</td>
<td></td>
<td>lb/sec</td>
<td>308</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>( K_1 )</td>
<td></td>
<td>kg-m/cs</td>
<td>31.138</td>
<td>18</td>
<td></td>
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<tr>
<td></td>
<td>( K_2 )</td>
<td></td>
<td>kg-m/cs</td>
<td>1.5569</td>
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<tr>
<td></td>
<td>( K_3 )</td>
<td></td>
<td>kg-m/cs(^2)</td>
<td>1050</td>
<td>5. 17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( K_4 )</td>
<td></td>
<td>pounds</td>
<td>17.377</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( V_e(\text{DPS}) )</td>
<td>\text{DPSVEX}</td>
<td>m/sec</td>
<td>2955.889</td>
<td>29, 30</td>
<td>24</td>
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<tr>
<td></td>
<td>( V_e(\text{APS}) )</td>
<td>\text{APSVEX}</td>
<td>fps</td>
<td>9942</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>( F_L )</td>
<td></td>
<td>pounds</td>
<td>(400)</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
SET UP RESTARTS TO SCHEDULE NEXT LOCATION AS A FINDVAC JOB WITH SAME PRIORITY

WHICH = P4Z ADDRESS (Determines branch program will take in master ignition routine)

Incorrect program selection for vehicle configuration

P4ZTABLE: VN 0640 (c)
TCF STARTUP (1)
TCF COMPFAIL (2)
TCF GEEPST (3)
TCF TAKEDOWN (4)
TCF P2G For (5)
DEC Z640 (6)
ECAS STEREO (7)
TCF P2DUPLICATE (11)
TCF P2HANAP (13)
TCF P2ZIGN (13)
TCF P2Z STAGE (14)

LOAD APS ENGINE PARAMETERS

FORCE OF ENGINE THRUST MASS CHANGE RATE AT TAILOFF

TRANSFER CONTROL TO COMMON PROGRAM ON P40 CHART

TABLES USED BY MASTER IGNITION TABLE

DEC 2390

NEXT SHEET
MIT/DL PROGRAM CHANGE ROUTING SLIP

COLOSSUS 2E  □ LUMINARY 1D
COLOSSUS 3  □ LUMINARY 1E
COLOSSUS 3A □ LUMINARY 1F
COLOSSUS □ LUMINARY

□ MIT Approved PCN  □ NASA Approved PCR
□ MIT Approved ADR  □ NASA Approved PCN
□ NASA Approved Software Anomaly
□ MIT Approved Software Anomaly

A. Coding

☑ Begin coding immediately

ACTION: Don Elyer

Program Supervisor's Approval: Margaret Hamilton

□ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: 

□ Technical Committee Meeting not required.

□ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☑ Review for possible impact on KSC testing and checkout

ACTION:

D. Other Programs Affected

☑ Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: K.H. Larson
Date: 8-18-76
APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
PROGRAM CHANGE REQUEST

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR
EYLES

1.2 ORGANIZATION
MIT

1.3 EFFECTIVITY

1.4 TITLE OF CHANGE
LUMINARY 1D (Apollo 14)
New Landing Analog Displays (R10)

1.5 REASON(S) FOR CHANGE
See attached sheet

1.6 DESCRIPTION OF CHANGE
See attached sheet

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 [ ] APPROVED [ ] DISAPPROVED

2.2 REASONS:

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT

3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT

3.4 REASONS:

3.5 MIT DETAILED

3.6 REASONS:

DATE
8-11-70

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 [ ] IMPLEMENT AND [ ] PROVIDE DETAILED CHARGE EVAL.

4.2 REASONS:

4.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE
8/13/70

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR

5.2 MIT EVALUATION

DATE

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 START OR CONTINUE [ ] DISAPPROVED OR STOP IMPLEMENTATION

6.2 REASONS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE
1.5 Reasons for Change:

1. Minimize errors in forward and lateral velocity displayed on the crosspointers.
2. Eliminate the periodic "lurch" in the altitude-rate displayed on the tape meter.
3. Correct error and excessive granularity of the forward velocity displayed in R1 of noun 60 (during P66).
4. Speed up display of altitude and altitude-rate (display each every 1/4 second instead of every 1/2 second as at present).
5. Begin displaying analog data when average-G is turned on instead of waiting for ignition.
6. During ascent and aborts, display stable-member Y-axis velocity as "lateral velocity" and zero forward velocity.

1.6 Description of Change:

Incorporate in LUMINARY a new Landing Analog Displays (LAD).

New features are (1) the addition of a PIPA bias correction term to the velocity computation which is the starting point of the LAD computations, and (2) a simpler altitude extrapolation:

\[ \text{ALTITUDE} = \left( \frac{\text{HDOTLAD} + \text{ALTRATE}}{2} \right) \text{DT} + \text{HCALCLAD} \]

where HDOTLAD and HCALCLAD are altitude-rate and altitude at PIPTIME, DT is time since PIPTIME, and ALTRATE is the current altitude-rate computed by LAD. GSOP change pages for this PCR are attached.

REMARKS
<table>
<thead>
<tr>
<th>Flagword</th>
<th>Bit</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREEFLAG</td>
<td>0</td>
<td>Used as a temporary flag to control the internal logic of the following subroutines:</td>
</tr>
<tr>
<td>R54</td>
<td>3</td>
<td>- Used as a counter to control two passes through CHKSBB which computes the star data check error. Set to 1 for first pass, set to 0 for second pass. Also used to indicate the response of the astronaut to the star data check display V06N05. Set to 1 if the astronaut performed PROCEED, V33E. Set to 0 if the astronaut performed RECYCLE, V32E.</td>
</tr>
<tr>
<td>R51</td>
<td>5</td>
<td>- Bit interrogated after R54 in P52. If bit is 1, gyro torquing (R55) is accomplished. If bit is 0, gyro torquing is bypassed and V50N25 R1 = 00014 is displayed.</td>
</tr>
<tr>
<td>P57</td>
<td>6</td>
<td>- GRAVITY VECTOR DETERMINATION routine is used to indicate astronaut response to error display. Bit is set to 0 if the astronaut performed PROCEED, and set to 1 if the astronaut performed RECYCLE.</td>
</tr>
<tr>
<td>P51</td>
<td>7</td>
<td>- Bit interrogated after R54. If bit is 1, the new REFSMMAT is computed and stored and the REFSMMAT flag is set. If bit is 0, P51 is started again and V50N25 R1 = 00015 is displayed.</td>
</tr>
<tr>
<td>LSPOS</td>
<td>8</td>
<td>- Used as a counter to control two passes through POSITB. Bit is 0 for first pass, 1 for second pass.</td>
</tr>
<tr>
<td>R10</td>
<td>10</td>
<td>- Bit set to 1 during ascent (in P12, P70, and P71) to indicate that R10 only outputs data to altitude and altitude-rate meters. Bit reset to 0 (initially and during descent) to indicate that R10 outputs data to the Forward and Lateral velocity cross-pointers, in addition to the altitude and altitude rate meters. Bit is checked in R10 (Landing Analog Displays) in order to determine the type of output to display on CROSS POINTERS.</td>
</tr>
<tr>
<td>P6PROFL</td>
<td>12</td>
<td>- Set to 1 when P66 is entered for the first time (in R13) as a directive to continue P66 horizontal nulling. It is reset to 0 when the astronaut proceeds on a flashing V06 N60 after touchdown, the 0 specifying a stop to P66 horizontal nulling. It is tested in P66 after horizontal commands have been calculated, but before commands are issued.</td>
</tr>
<tr>
<td>NJETSFLG</td>
<td>15</td>
<td>- Used for thrust determination in P41. Set in R03 (entered via V48) as follows: set to 1 if bit 11 of DAPDATR1 is 0, indicating that 2-jet X translation is specified; set to 0 if bit 11 of DAPDATR1 is 1, indicating 4-jet X translation.</td>
</tr>
<tr>
<td>Word Number</td>
<td>Contents</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>I.D. word for this list. Will contain 77773.</td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>Sync bits. Will contain 77340.</td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>SPARES. See page 2-70 for definition.</td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td>GUIDANCE THRUST COMMAND (FC). The magnitude of the desired DPS thrust computed by the Lunar Landing Guidance Equations. It does not apply to Ascents or Aborts. Calculated once every 2 seconds during landing. Scaled lbs/(2.5 x 10^14).</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>Garbage. This erasable location contains RDOTV and JTCTR, neither of which is calculated during Descent/Ascent.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>GTCTIME. The LM state vector time (PIPTIME) associated with guidance thrust command. Scaled centiseconds/10^8, referenced to the computer clock.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MARKTIME. Time of CDUs for LR Velocity Reading when R12 running. Scaled centiseconds/10^8, referenced to computer clock.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>LR RANGE (d.p.). Landing radar slant range. Scaled ft/(1.079 x 10^28). Always low scale. Calculated every 2 seconds during altitude updates.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>LR VELOCITY. Velocity along one of the antenna axes (as indicated by VSELECT). Each downlinked sample is the sum of five readings of one component. A different component is read every 2 seconds during LR velocity updates. Scaled (ft/sec)/[(K/5) x (10^28)] where K = -0.6440 for X, K = 1.212 for Y, and K = 0.8668 for Z. This is the scaling for the average of the five readings, i.e., if the telemetered double precision octal fraction is converted to a decimal fraction and multiplied by (K/5) x (10^28), the result is one component of the radar measured LM velocity relative to the surface, along the appropriate axis of the antenna coordinate frame as defined in the Lunar Landing Coordinate Systems section of Section 5 of the LUMINARY GSOP.</td>
<td></td>
</tr>
<tr>
<td>10, 11a</td>
<td>CDIVY, CDUZ, CDUX. The Y, Z and X CDUs for LR Range Reading for R12 at LR Range Time. 15-bit fractions scaled degrees/360.</td>
<td></td>
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<tr>
<td>11b</td>
<td>VSELECT. Indicates LR velocity (X, Y, or Z) which has been read. Changes after a different velocity component has been read. An integer. 2 indicates X, 1 indicates Y, 0 indicates Z. DURING DESCENT</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>LATVEL(12a)FORVEL(12b). Lateral and forward velocity. The orthogonal components of the horizontal velocity of the vehicle with respect to the moon, which are essentially parallel and perpendicular to the X-Z plane of the vehicle (for small pitch and roll angle displacements). It is scaled, (ft/sec)/(0.557 x 10^14) and is computed and displayed four times per second. DURING ASCENT AND ABORTS, LATERAL VELOCITY IS THE INERTIAL CRSS AXIS. VELOCITY AND FORWARD VELOCITY WILL BE SET EQUAL TO ZERO.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Same as word 67 on Orbital Maneuvers List.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Same as word 14 on Orbital Maneuvers List.</td>
<td></td>
</tr>
</tbody>
</table>
(7) 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 (9)) for display on the FDI. The crew may exercise control around the yaw axis only with the aca y-axis override if the y-axes override capability is permitted by the program in progress. 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 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 pulsing flag. However, it is strongly recommended that powered flight nut be attempted in the minimum impulse mode. The pulsing flag is set or reset by extended verb 76 (minimum impulses) and 77 (rate command) respectively. The pulsing flag is also reset by P12, P40, P41, P42, P71, P72, and 00 at main engine ignition; with the exception of these cases, mode selection is always based upon the last entry made in the sky. During a thrusting maneuver in the PGNs/attitude hold mode the PGNs will not be responsible if register overflows occur within the LGC.

(8) Control of the LM RCS and APS is transferred from the PGNs to the ASCENT 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 ascent, the AGS will GLID the LM to a safe credit. The AGS may be initialized by the LGC at any time by manual selection of the AGS initialization routine (R47) and should have been performed prior to selection of P12.

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.

(9) The PGNs can generate two types of attitude errors for display on the FDI:

Mode I - Selected by extended verb 61, autopilot following errors used as a monitor of the APS'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.

The 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 (7). Display selection is always based upon the last entry made in the sky. For a more detailed description of these displays refer to section 3 of R67, para. 3.2.5.

(10) The rendezvous radar (RR) was energized and checked out prior to selection of this program.

(11) The landing analog displays routine (R10) is enabled at R1G, however -10 use of the PR CDUs is inhibited by this program. The PGNs/autonomous-hovering routine (R10) is enabled after rate control R1 and R1G is terminated upon termination of average 6. During this mode altitude-rate and altitude are displayed as the time meters and inertial crossrange velocity on the case pointers.

(12) Either the lead CAP LTA routine (R93) or the landing confirmation program (P68) has been performed prior to selection of this program.

(13) For each run a 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.

(14) The astronaut may monitor the following additional parameters during this program by keying in V0777:

V1677
K1-TG
R2-V1Y1
B3-LANK

FIRE:
THE PGCN'S COMMANDED SETTING.

This program assumes the throttle control to be in "AUTO" (the DPS receives the sum of the manual and PGCN commanded settings) and the manual throttle to be set at minimum for *zoom time* seconds of thrusting, and thereafter at a level less than that required by the LGC. The value "zoom time" is in erasable storage, having been loaded prior to launch or by PC5.

Due to the region of permissible throttling, thrust command logic in conjunction with the interim terminal conditions (see assumption (10)) 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.

Flatline 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 THROTTLE IS DETERMINED TO BE IN THE MAXIMUM THRUST. The throttle setting then becomes controlled by the guidance equations.

(11) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. If this discrete is issued to the LGC when the attitude mode control switch is in the AUTO position, the LGC will then activate the powered landing maneuver, the LGC assumes that it no longer has complete automatic control of the maneuver.

The monitor and the associated 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 L/M X-AXIS with the attitude controller even though the PGCN attitude control mode is AUTO. When the controller is returned to the powered landing command, the PGCN 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 attitude is below 30,000 feet), however it should not be exercised during the attitude maneuver about the thrusting attitude (see R60). The option is inhibited by this program from mid-way in the program (see assumption (13) below) to the end.

(13) The LGC specifies L/M ATTITUDE during the powered landing maneuver based upon the requirements of thrust vector control, landing site visibility, and L/M 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. Thrust vector control does not constrain the L/M orientation about the thrust axis (yaw attitude). Rotation about the L/M Y and L/M Z axes is used to point the measured thrust vector along the desired thrust vector.

The first restraint upon the L/M yaw attitude to occur is that of L/M orientation. The LGC will not attempt to use L/M data until the LGC estimates L/M orientation. If automatic X-AXIS OVERRIDE LOCKOUT (done by R12) and L/M yaw attitude specification by the LGC will not occur until the LGC estimates L/M orientation is 30,000 ft. or greater. Before this time, the astronaut must maneuver to align the L/M yaw orientation to prevent subsequent loss of 5-BAND LOCK-ON. The LGC will then command the vehicle to the LGC-specified L/M yaw attitude.

Subsequent to X-AXIS OVERRIDE LOCKOUT control of the vehicle about the L/M X-AXIS is governed by L/M orientation requirements during this program. The landing site becomes visible to the command pilot if the look angle (the angle between the L/M X-AXIS and the LOS to the landing site) is greater than 25 degrees and the LOS is in or near the L/M 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 L/M X-AXIS) are defined by the inertial orientation of the L/M X-AXIS and the position of the L/M 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 L/M meters during this program. The calculation of these parameters is under the control of the landing analog displays routine (R10) which is enabled when G AVERAGE G IS TURNO-OFF.

(15) The rate of descent (ROD) mode is not enabled during this program (see landing (ROD) program (P55), assumption S2 for definition of ROD 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).
WAIT UNTIL TIG -30 SEC.

RETURN V06N62 DISPLAYS

MONITOR CSKY:
AT TPI = -00329
OBSERVE RETURN OF
V06N62 DISPLAYS TO
INDICATE THAT
AVERAGE G INTEGRATION HAS STARTED.

START AVERAGE G INTEGRATION (NOTE:
THE RIO/R11/R12
SERVICE ROUTINE
(RC9) 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.) NOVEVER THE
OPERATION OF Q3:
AND R11 IS NOT
ENABLED UNTIL
IGNITION.

R10 ALSO BEGINS
IMMEDIATELY.
SET ABORT ENABLE FLAG

SET LANGEN ANALOG DISPLAY FLAG

++ EDIT

RESET IDLE FLAG

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

RESET IGNITION FLAG

RESET ASTRONAUT FLAG

CALL FOR RESET OF LLAGE FLAG
DPS ABORT PROGRAM (PTC)  

**PURPOSE:**  
(1) TO CONTROL A PGACS CONTROLLED DPS ABORT FROM THE POWERED LANDING MANEUVER (P63, 64, 65, OR 66) WHEN REQUIRED.  
(SEE ASSUMPTION (1)).

**ASSUMPTIONS:**  
(1) THIS PROGRAM WILL CONTROL A DPS ABORT IN ONE OF THE WAYS:

(A) IF THE ALTITUDE IS GREATER THAN 25,000 FT, THIS PROGRAM WILL COMMAND MAXIMUM DPS THRUSTING, CONTINUE DPS THRUSTING, PERFORM AN ATTITUDE MANEUVER USING THE RCS TO THE CORRECT ATTITUDE TO CONTINUE THE ABORT ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(B) IF THE ALTITUDE IS LESS THAN 25,000 FT, THIS PROGRAM WILL COMMAND MAXIMUM DPS THRUST AND ENTER A VERTICAL RISE PHASE WHICH WILL TERMINATE EITHER WHEN THE LM ALTITUDE EXCEEDS 25,000 FT, OR WHEN THE LM VERTICAL VELOCITY IS GREATER THAN 40 FT/SEC.

DURING THE VERTICAL RISE PHASE, THE VEHICLE IS MANEUVERED TO ALIGN THE LM X AXIS WITH THE LOCAL VERTICAL USING THE RCS, AND THE LM Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE. THE PROGRAM WILL THEN PITCH THE LM TO THE CORRECT ATTITUDE FOR ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LP ON AN ABORT ORBIT.

(2) THE ABORT ORBIT IS DEFINED IN SECTION 5.4.3 OF R567.

(3) THE LM IS ON THE POWERED LANDING DESCENT SOMEWHERE BETWEEN DPS IGNITION FOR THE MANEUVER (P63) AND DPS SHUTDOWN ON THE LUNAR SURFACE (P65 OR P66).

(4) THE CSN IS IN A NEAR CIRCULAR CRIB AROUND THE MOON AT A NOMINAL ALTITUDE OF 60 NAUTICAL MILES. THE CSN IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE REE TRACKING BY THE LM.

(5) THE INL IS ON AND ACCURATELY ALIGNED TO THE LANDING ORIENTATION. THE MOST RECENT IMU ALIGNMENT (FINE) TOOK PLACE DURING THE BRAKING PHASE PROGRAM (P63) PRIOR TO DPS IGNITION.


(7) THE Rendezvous Radar (RR) WAS ENERGIZED AND CHECKED OUT PRIOR TO SELECTION OF THIS PROGRAM.

(8) THE LANDING ANALOG DISPLAY ROUTINE (R10) IS ENABLED UPON ENTRY TO THIS PROGRAM, HAVING BEEN ENABLED BY P63.

(9) USE OF RR COMMANDS IS LIMITED BY THIS PROGRAM. R10 IS TERMINATED UPON TERMINATION OF AVERAGE 6. DURING THIS MODE ATTITUDE RATE AND ALTITUDE ARE DISPLAYED ON THE TAPE METERS AND INERTIAL CROSS RANGE VELOCITY ON THE CROSS POINTERS.

(10) THE CRS IS NOT THRUSTABLE OVER THE WHOLE RANGE FROM ZERO TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THRUST OR OVER A SPECIFIC THRUST RANGE OF LOWER SETTINGS. THESE THRUST SETTINGS ARE SPECIFIED IN SECTION 5 OF R567 AND ARE TOTAL THRUST SETTINGS, I.E.: THE SUM OF THE MANUAL SETTINGS (WHOSE MINIMUM IS 10 PERCENT) AND THE PGCS COMPARED SETTING.

THIS PROGRAM ASSUMES THE THRUST CONTROL TO BE IN AUTO (THE CRS RECEIVES THE SUM OF THE MANUAL AND PGCS COMMANDER SETTING) AND THE MANUAL THRUST TO BE SET AT A LEVEL LESS THAN THAT REQUIRED BY THE LG. THE LG WILL COMMAND MAXIMUM THRUST FOR ALL CRS THRUST CONTROLLED BY THIS PROGRAM.


THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW EXCEPT WHEN THE LG IS SPECIFYING A DESIRED YAW.
PURPOSE:

(1) TO CONTROL A PGNCS CONTROLLED APS ABORT FROM THE POWERED LANDING MANEUVER (P63, 64, 65, OR 66) OR A DPS ABORT (P70) WHEN REQUIRED (SEE ASSUMPTION (1)).

ASSUMPTIONS:

(1) THE PROGRAM WILL CONTROL AN APS ABORT IN ONE OF TWO WAYS:

(A) IF THE ALTITUDE IS GREATER THAN 25,000 FT, THIS PROGRAM WILL IGNITE THE APS, CONTINUE APS THRUSTING, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(B) IF THE ALTITUDE IS LESS THAN 25,000 FT, THIS PROGRAM WILL IGNITE THE APS, CONTINUE APS THRUSTING, ENTER A VERTICAL RISE PHASE WHICH WILL TERMINATE EITHER WHEN THE LM ALTITUDE EXCEEDS 25,000 FT. OR WHEN THE LM VERTICAL VELOCITY IS GREATER THAN 40 FT/SEC. DURING THE VERTICAL RISE PHASE THE VEHICLE IS MANEUVERED IN ORDER TO ALIGN THE LM X AXIS WITH THE LOCAL VERTICAL USING THE RCS, AND THE LM Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE. THE PROGRAM WILL THEN PITCH THE LM TO THE CORRECT ATTITUDE FOR ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(2) THIS PROGRAM DOES NOT CHECK TO SEE IF THE DPS HAS BEEN STAGED. THUS IF P71 IS SELECTED VIA V37 AND THE DESCENT STAGE HAS NOT BEEN MANUALLY STAGED THIS PROGRAM MAY COMMAND ENGINE ON (ASSUMPTION 1A OR 1B ABOVE). IN SUCH CASES THE COMMAND WILL GO TO THE DPS.

(3) THE ABORT CRITERIA IS DEFINED IN SECTION 5.4.3 OF RR67.

(4) 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 AND TRACER TRACKING BY THE LM.

(5) THE IMU IS ON AND ACCURATELY ALIGNED TO THE ALIGNED SITE ORIENTATION. THE MOST RECENT IMU ALIGNMENT (FINE) TOOK PLACE DURING THE BRAKING PHASE PROGRAM (P63) PRIOR TO DPS IGNITION.

(6) THE LANDING RACER (LR) IS ON AND WAS CHECKED OUT WHEN IN POSITION #1. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12).

(7) THE KNEEJOINT RACER (AR) WAS ENERGIZED AND CHECKED OUT PRIOR TO SELECTION OF THIS PROGRAM.

(8) THE LANDING ANALOG DISPLAYS ROUTINE (R10) IS ENABLED UPON ENTRY TO THIS PROGRAM, HAVING BEEN ENABLED BY P63.

(9) 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 PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

(10) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS.
PURPOSE:

1. To monitor the "DISPLAY INERTIAL DATA" discrete the absence of which indicates the crew has selected for display on the LM meters one or more of the LGC-calculated display parameters. These parameters are:
   
   (A) FORWARD VELOCITY - SEE SECTION 5 OF RS67 FOR DEFINITION.
   
   (B) LATERAL VELOCITY - SEE SECTION 5 OF RS67 FOR DEFINITION.
   
   (C) ALTITUDE - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE, AS MODIFIED BY THE TERRAIN MODEL.
   
   (D) ALTITUDE RATE - THE PRESENT RATE OF CHANGE OF ALTITUDE (C) ABOVE.

2. To calculate these display parameters and transmit them to the LM meters when the "DISPLAY INERTIAL DATA" discrete is act present.

ASSUMPTIONS:

1. This routine is automatically called every .25 seconds by the abort discretes monitor routine (R11), but only during P12, P3, P4, P6, P70, or P71. However, if the routine is inhibited from using the negative forward and lateral velocity crosspointers during P12, P70, or P71, then only altitude and altitude rate (LM meters) will be displayed. During P12, P70, or P71, forward velocity is set to zero and lateral velocity is inertial velocity in the crossrange axis.

<table>
<thead>
<tr>
<th>PROG</th>
<th>CAT</th>
<th>LGC</th>
<th>GROUND</th>
<th>CREW</th>
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<tbody>
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**START LANDING ANALOG DISPLAYS ROUTINE (R10)**********

**IS THE LANDING ANALOG DISPLAYS FLAG.**

---

RIO/LUMINARY.
SET?

UPDATE VELOCITY VECTOR TO CURRENT TIME

DO I WISH THE LGC TO COMPUTE THE LANDING ANALOG DISPLAYS?

CALCULATE ALTITUDE AND ALTITUDE RATE

IS THE "DISPLAY INERTIAL DATA" DISCRETE PRESENT?

SET THE "MODE SEL" SWITCH TO "PGNS"

IS DID FLAG SET?

SET DID FLAG.

SET THE "MODE SEL" SWITCH TO "AGS" OR "LOG RADAR"

EXIT R10

R10/LUMINARY
SET PARAMETER
CENTER TC
ALTERATE.

SEND DISPLAY
INERTIAL DATA
DISCRETE TO
THE RR COUS.

PERFORM INIT-
IALIZATION FOR
FIRST DISPLAY
OF DATA.

ENABLE RR ERRER
COUNTER

SET INERTIAL
DATA DISCRETE
CDUS.

WHICH WILL BE UPDATED 4 TIMES PER SECOND.

CHECK PARAMETER POINTER.

SET PARAME TERS TO ALT RATE.

CALCULATE ALTITUDE RATE.

SET PARAMETER POINTER TO ALT RATE.

CALCULATE ALTITUDE.

TRANSMIT ALTITUDE OR ALTITUDE RATE.

OBSERVE ALTITUDE AND ALTITUDE RATE ON TAPE METERS WHICH WILL BE UPDATED.
TIME PER SECOND

EXIT R10

IS R10 FLAG SET?

IS INERTIAL DATA DISCRETE FLAG SET?

N
Y

DISABLE RR ERROR COUNTER

REPLACE DISPLAY INERTIAL DATA DISCRETE FROM THE RR CDSL

RESET INERTIAL DATA DISCRETE FLAG
RESET DID FLAG

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 475, 499, 617
REV 02 EDITORIAL
REV 03 (LUM 1C) PCR 285
Analog Display Parameters

The LGC is required to drive four analog displays in all landing-maneuver phases, if selected to do so by the astronaut. The various analog-display quantities are the following:

1. \( h \):
   Altitude
   The estimated local altitude of the vehicle as derived from the difference between the current position vector \( r_p \) and the landing-site radius magnitude \( r_{LS} \). The LGC drives a digital tape meter with altitude scaled at 2,345 feet/bit over a range of 0–60,000 feet.

2. \( v_v \):
   Altitude Rate
   The component of the vehicle's velocity that lies along the local-vertical direction \( u_{HP} \). The LGC drives a digital tape meter with this parameter scaled at 0.5 ft/sec per bit over a range of ±500 ft/sec.

3. \( v_{HF} \) and \( v_{HL} \):
   Forward and Lateral Velocity
   Orthogonal components of the horizontal velocity of the vehicle with respect to the moon, which are essentially parallel and perpendicular to the X - Z plane of the vehicle (for small pitch and roll angle displacements). The coordinates and display requirements for these velocity components are defined in ICD L15-540-10001. The scaling of these components is for a range of ±200 ft/sec.

The altitude \( h \) and altitude rate \( v_v \) are computed and displayed two times/second, alternating them every 0.25 second, and forward and lateral velocity \( v_{HF} \) and \( v_{HL} \) are computed and displayed four times/second.
The displays are kept up-to-date by reading the PIPA-output data at certain special intermediate times \( (t_i) \). The vehicle's velocity with respect to the moon at these intermediate times \( (\mathbf{v}_{MP_i}) \) is computed from the relations:

\[
\mathbf{v}_{MP_i} = \mathbf{v}_{MP_{n-1}} - (\mathbf{g}_P_{n-1} (t_i - t_{n-1}) + (\Delta \mathbf{v}_P_{i} + \Delta \mathbf{h}_P_{n-1}) - \mathbf{v}_{SURF} (t_{n} \leq t_i < t_j)
\]

\[
\mathbf{v}_{MP_i} = \mathbf{v}_{MP_n} + (\mathbf{g}_P_{n} (t_i - t_n) + (\Delta \mathbf{v}_P_{i} - \mathbf{v}_{SURF}) (t_j \leq t_i < t_{n+1})
\]

where the subscript \( i \) refers to the display-computation time, the subscript \( n \) refers to the normal PIPA-output processing time, and the subscript \( j \) refers to the actual time that the cycle through the State-Vector-Update Routine is completed. \( \mathbf{v}_{SURF} \) is the velocity of the lunar surface computed in the State Vector-Update Routine.

Two different relations are required because the computations of velocity \( (\mathbf{v}_{MP}) \) and gravitational acceleration \( (\mathbf{g}_P) \) for time \( t_n \) are not completed until a later time \( t_j \) (greater than \( t_n \)). The PIPA-output registers, however, are read and then set to zero at the normal PIPA-output processing time \( (t_n) \). For this reason, it is necessary to save and use the preceding-cycle PIPA-output data \( \Delta \mathbf{v}_P_{n-1} \) until the cycle through the State-Vector-Update Routine is completed \( (t_j) \), as shown in the first of the preceding two relations.

The vertical velocity displayed at the intermediate time \( (t_i) \), i.e., \( \mathbf{v}_{V_i} \) is given by the relations *:

\[
\mathbf{v}_{V_i} = \mathbf{v}_{MP_i} \cdot \mathbf{u}_{hP_{n-1}} + \mathbf{v}_{HOR_{n-1}} (t_i - t_{n-1}) (t_n < t_i < t_j)
\]

\[
\mathbf{v}_{V_i} = \mathbf{v}_{MP_i} \cdot \mathbf{u}_{hP_{n}} + \mathbf{v}_{HOR_{n}} (t_i - t_n) (t_j \leq t_i < t_{n+1})
\]

where the subscripts \( i, j, \) and \( n \) refer to the times mentioned earlier in this section.

It should be noted here that the local-vertical unit vectors \( (\mathbf{u}_{hP_{n}} \) and \( \mathbf{u}_{hP_{n-1}}) \) correspond to the normal PIPA-processing times \( (t_n \) and \( t_{n-1}) \). For this reason, a correction term shown above is required to account for vehicle motion (and

\* \( \mathbf{v}_{HOR} \) is computed in the State-Vector-Update Routine.

5.3-110
rotation of $u_{hp}$) during the interval from the PIPA-processing time ($t_n$ or $t_{n-1}$) to the display time ($t_i$).

The vehicle altitude displayed at intermediate times is given by the relations:

$$h_i = h_{n-1} + \frac{v_{v_{n-1}}(t_i - t_{n-1})}{2} \quad (t_n \leq t_i < t_j)$$

$$h_i = h_n + \frac{v_{v_n}(t_i - t_n)}{2} \quad (t_j \leq t_i < t_{n+1})$$

where the altitude ($h_n$ or $h_{n-1}$) and vertical velocity ($v_{v_n}$ or $v_{v_{n-1}}$) are from the State-Vector-Update Routine.

The forward and lateral velocity components ($v_{HF}$ and $v_{HL}$) are computed from the same equations shown in the State-Vector-Update Routine, except that the intermediate time horizontal velocity ($v_{MP_i}$) is used in place of that for the normal PIPA-output processing time ($v_{MP}$ or $v_{MP_n}$). For convenience, these relations are repeated below.

$$v_{HZ_i} = v_{MP_i} \cdot u_{HZP}$$

$$v_{HY_i} = v_{MP_i} \cdot u_{HY}$$

$$v_{HF_i} = v_{HZ_i} \cos AOG_i - v_{HY_i} \sin AOG_i$$

$$v_{HL_i} = v_{HZ_i} \sin AOG_i + v_{HY_i} \cos AOG_i$$

where the subscript $i$ is used to indicate quantities determined for the display times ($t_i$). The unit vector $u_{HZP}$ is for the PIPA-processing time. The angle $AOG$ is the stable member outer gimbal angle.

**ANALOG DISPLAYS ARE POSTED DURING ASCENT (P12, P70, P71) AS WELL.** IN THIS CASE FORWARD VELOCITY IS ALWAYS DISPLAYED AS ZERO AND LATERAL VELOCITY IS $v_{MP_i}$—IN OTHER WORDS INERTIAL CROSS RANGE VELOCITY.
MIT/IL PROGRAM CHANGE ROUTING SLIP

COLOSSUS 2C  □ LUMINARY 1B
COLOSSUS 2D  □ LUMINARY 1C
COLOSSUS 2E  □ LUMINARY 1D
COLOSSUS 2F  □ LUMINARY 1E

□ MIT Approved PCN  □ NASA Approved PCR  □ NASA Approved PCN
□ NASA Approved Software Anomaly  □ MIT Approved Software Anomaly

A. Coding
☑ Begin coding immediately

ACTION: [Signature]

Program Supervisor's Approval: [Signature]

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☑ Prepare GSOP revisions for MDRB consideration

ACTION: [Signature]

□ Technical Committee Meeting not required.
□ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☑ Review for possible impact on KSC testing and checkout

ACTION: [Signature]

D. Other Programs Affected

☑ Review for corresponding changes in

ACTION: [Signature]

Special Instructions

Connect with

Peter Adler

Project Manager: [Signature]
Date: 11-7-69

(Rev 1/69)
Delta-V increment may be subtracted from $V_G$ twice following a restart.

**DOI Simulation at GAEC.**

**MIT ANALYSIS**

**2.1 CAUSE:**
Due to faulty restart protection, the code that subtracts DELVREF from $V_G$ may be executed twice.

**2.2 RECOGNITION:** Following a restart, $V_G$ (R2 of N40) may drop by twice the amount of $\Delta V$ accumulated in the past 2 seconds. This is not accompanied by a similar gain in DV total (R3, N40). At end of burn, DV total not equal to targeted $V_G$ (715, 5/63).

**MISSION EFFECT:**
Causes LGC to command underburn. State vector unaffected; DOI results in 15 nmi perilune instead of 9 nmi.

**2.4 AVOIDANCE PROCEDURE:**
None

**2.5 RECOVERY PROCEDURE:**
Add appropriate $\Delta V$ manually at end of burn, normally 8.7 fps at 40% throttle.

**2.6 PROGRAM CORRECTION:**
Insert phase change in S40.8.

**2.7 RECOMMENDED DISPOSITION** (Fix, Work-around, etc.):
Fix for 1D. Program note for 1B, 1C.

**2.8 RECOMMENDED RE-TESTING:**
Digital DOI with restarts.

**NASA DIRECTION**

**2.9 MIT/IL SIGNATURE:**

**2.10 DATE:**

---

**4.1 CLOSING ACTION TAKEN:**
ANOMALY # 7-18-03

A. Coding

☐ Begin coding immediately

ACTION: 

☐ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

☐ Prepare GSOP revisions for MDRB consideration

ACTION: 

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout

☐ Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

☐ Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 

Date: 12-4-69
If a V59E is used to reposition the Landing Radar antenna to position two at any time other than powered descent in P63, the return from the repositioning routine will be incorrect. As a result, V61 will also be executed, which will cause DAP attitude errors to be displayed on the FDAI. Furthermore, if the repositioning is not successful, the 523 alarm will not be given. Also, all subsequent radar operations using the RADSTALL routine as a buffer will return with the status of the previous radar operation. This will remain in effect until a V37 or a restart occurs.

---

### Description of Run

Inspection of coding

---

### MIT Analysis

#### 2.1 Cause:
Coding error. The routine LRPOS2 is called by a TC, but it returns via SWRETURN.

#### 2.2 Recognition:
None.

#### 2.3 Mission Effect:
Probably none, since there are no plans to use V59.

#### 2.4 Avoidance Procedure:
Do not use V59 other than during powered descent in P63.

#### 2.5 Recovery Procedure:
If in POO, reselect POO, or V69E.

#### 2.6 Program Correction:
Call routine LRPOS2 via BANKCALL.

#### 2.7 Recommended Disposition (Fix, Work-around, etc):
Fix for LUMINARY 1D.

#### 2.8 Recommended Re-testing:
Basic trace of V59 logic in a digital simulation.

---

### NASA Direction

---

### Closing Action Taken:

---
See Attached Sheet.

### 1.6 DESCRIPTION OF RUN:
System test lab run - V41N72 with V44 during remode - followed by V41N72.

---

### 2.1 CAUSE:
Two remode tasks operating simultaneously.

### 2.2 RECOGNITION:
Antenna won't designate properly in V41N72.

### 2.3 MISSION EFFECT:

### 2.4 AVOIDANCE PROCEDURE:
Do not key in V44E if RR is known to be remodling.

### 2.5 RECOVERY PROCEDURE:
V37 select of any program, followed by cycling RR mode switch.

### 2.6 PROGRAM CORRECTION:
Insert check for remode in progress in V44 coding.

### 2.7 RECOMMENDED DISPOSITION (Fix, work-around, etc.):
Fix for Luminary 1D (PCR 990) work-around for LUMINARY 1C.

### 2.8 RECOMMENDED RE-TESTING:
V41-V44-V41 Sequence as above.

---

### 2.9 MIT/IL SIGNATURE:

### 2.10 DATE:
12-23-73
1.5 Description of Anomaly:

If V44 (terminate RR continuous designate) is keyed in while an antenna remode is in progress, the RR error counters are disabled which stops the antenna drive. However, the remode task keeps running and the remode flag (Bit 14 or RADMODES) remains set, until a hardware or software restart occurs. A RR coarse align request (V41N72) during this time can cause erratic antenna behavior because the presence of the remode flag causes the designate routine to start a second remode task, which conflicts with the one still in progress. Recovery from this situation is effected by any V37 request (to cause a software restart) and cycling the RR mode control switch.
PROGRAM CHANGE ROUTING SLIP

[Checkboxes for COLOSSUS 2C, LUMINARY 1B, COLOSSUS 2D, LUMINARY 1C, COLOSSUS 2E, LUMINARY 1D, COLOSSUS 2F, LUMINARY 1E]

- MIT Approved PCN
- NASA Approved PCR
- NASA Approved PCN
- NASA Approved Software Anomaly
- MIT Approved Software Anomaly

A. Coding
- Begin coding immediately

 ACTION: B. McCoy

Program Supervisor's Approval: [Signature]

- Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
- Prepare GSOP revisions for MDRB consideration

 ACTION:

- Technical Committee Meeting not required.

- Technical Committee Meeting(s) held on
  Attendees:

C. KSC Testing and Checkout
- Review for possible impact on KSC testing and checkout

 ACTION:

D. Other Programs Affected
- Review for corresponding changes in

 ACTION:

Special Instructions

Project Manager: [Signature]
Date: 1-7-70
HCALC, the altitude estimate during a Descent or an Ascent, does not have sign agreement; it is a Double Precision word. When it is added to "1-30 kft" overflow could occur from the low order half into the high order half. The test on this sum can be incorrect at the 30 thousand foot check to inhibit X-axis override.

A Descent at GAEC; also occurred during Apollo 12.

2.1 CAUSE:
See 1.5.

2.2 RECOGNITION:
See 1.6.

2.3 MISSION EFFECT:
The windows may be brought up at an altitude of 26 kft rather than 30 kft.

2.4 AVOIDANCE PROCEDURE:
None

2.5 RECOVERY PROCEDURE:
None needed.

2.6 PROGRAM CORRECTION:
Correct for sign agreement when HCALC is calculated in RVBOTH.

2.7 RECOMMENDED DISPOSITION (fix, work-around, etc):
Fix for LUMINARY 1D and program note for 1C.

2.8 RECOMMENDED RE-TESTING:
Trace HCALC at 30 kft chk to insure no overflow.

3.1 NASA DIRECTION:
SEE 2.7
P40A or P63 commanding ullage, with average-g off.

This can occur if a V37EXXE is done after ullage initiation and prior to ignition (the point of ullage termination). For example, this can occur if, in response to a flashing V99, one goes to P00 via V37 rather than doing a PRO.

CONTINUED ON PAGE

1.6 DESCRIPTION OF RUN:

LMS descent aborts on February 5, 1970.

CONTINUED ON PAGE

- MIT ANALYSIS -

2.1 CAUSE:

See 1.5 and Amplification Sheet.

CONTINUED ON PAGE

2.2 RECOGNITION:

See 1.5.

CONTINUED ON PAGE

2.3 MISSION EFFECT: If in the unlikely event a burn would be terminated at this time, in this manner, the navigated state vector would not be correct to within 2-5 fps, depending on which program was used.

CONTINUED ON PAGE

2.4 AVOIDANCE PROCEDURE: In order to terminate a burn program use V34E in response to flashing V99; if engine is on, press Engine STOP pushbutton, then V37EXXE.

CONTINUED ON PAGE

2.5 RECOVERY PROCEDURE:

Correct state vector.

CONTINUED ON PAGE

2.6 PROGRAM CORRECTION:

Move engine off call from SEUDOP00 to a point after determining average G is on, but before resetting V37 flag.

CONTINUED ON PAGE

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix for LUMINARY 1D.

CONTINUED ON PAGE

2.8 RECOMMENDED RE-TESTING:

Trace V37 logic with engine on; ullage on.

CONTINUED ON PAGE

3.1 NASA DIRECTION:

SEE 2.7

CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE

3.3 ORGANIZATION: FSB

3.4 DATE: 3/18/70

CONTINUED ON PAGE

4.1 CLOSING ACTION TAKEN:

Write program note for Luminary 1C

CONTINUED ON PAGE

4.2 SIGNATURE:

4.3 ORGANIZATION: 4.4 DATE:
1.5 Description of Anomaly

The V37 logic stops average-g immediately but does not terminate ullage until "AVETOMID" integration is complete.

A V34E followed by a V37 is a workaround for this problem.

2.1 Cause:

A similar situation exists with the APS/DPS engine on during a burn. If a V37EXXE is attempted while one of these engines is on, they will remain on until AVGTOMID integration is completed. Any ΔV accumulated is not incorporated into the navigated state vector because Average G is immediately terminated by the V37.
ANOMALY # L-1C-07
RE ISSUE - 3/18/70
(SEE NOTE BELOW)

A. Coding
☐ Begin coding immediately

ACTION: [Signature]
Program Supervisor's Approval: [Signature]

☐ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation
☐ Prepare GSOP revisions for MDRB consideration

ACTION: ________________________
Technical Committee Meeting not required
Technical Committee Meeting(s) held on Attendees:

C. KSC Testing and Checkout
☐ Review for possible impact on KSC testing and checkout

ACTION: ________________________

D. Other Programs Affected
☐ Review for corresponding changes in

ACTION: ________________________

Special Instructions

NOTE: FURTHER ANALYSIS HAS SHOWN THAT THIS IS NOT AN ANOMALY IN LUMINARY

Project Manager: [Signature]
Date: 3-17-70
The result of extended verb precision integration while in P00 may be stored into permanent state vector storage, possibly resulting in erroneous state vectors and W-matrix. Extended verbs are: V82, V89, V90.

2.1 CAUSE:
STATEFLG is not cleared in P00 integration following determination that the CSM state vector need not be integrated. If a precision integration is waiting to be done at this time, the integration will be done and either SV may be updated.

2.2 RECOGNITION:
Difficult on board. Ground may detect using state vector times. P00 integration of CSM is done in full time steps which are truncated to 128 centi-seconds.

2.3 MISSION EFFECT:
May result in loss of LM state vector and W-matrix correlation.

2.4 AVOIDANCE PROCEDURE:
In P00, do V96 before V82, V89, V90.

2.5 RECOVERY PROCEDURE:
Uplink new state vectors.

2.6 PROGRAM CORRECTION:
Cause STATEFLG to be cleared when CSM is not integrated in P00.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc.):
Note for IC.
Fix for 1D.

2.8 RECOMMENDED RE-TESTING:

3.1 NASA DIRECTION:

4.1 CLOSING ACTION TAKEN:
FURTHER ANALYSIS AT MIT/IL HAS SHOWN THAT THIS IS NOT AN ANOMALY IN LUMINARY.

RC
2.2 Recognition, cont'd.

Thus legitimate permanent state vector updates in POO will result in the same number of centi-seconds in the CSM time as before the POO integration and the LM will always be integrated to CSM time.

If extended verb integration caused erroneous update, the state vector time will probably not show this relation.

2.3 Mission Effect, cont'd.

<table>
<thead>
<tr>
<th>SURFFLAG</th>
<th>Verb</th>
<th>State to be Integrated in Verb</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF, ON</td>
<td>V82</td>
<td>CM</td>
<td>Precision CM to CM, RLS to LM.</td>
</tr>
<tr>
<td>ON</td>
<td>V82</td>
<td>LM</td>
<td>Precision LM to LM, No Update, RLS to LM.</td>
</tr>
<tr>
<td>OFF</td>
<td>V82</td>
<td>LM, CM</td>
<td>No Update, Precision to LM, RLS to LM.</td>
</tr>
<tr>
<td>OFF</td>
<td>V89</td>
<td>LM</td>
<td>Precision CM to CM,</td>
</tr>
<tr>
<td>ON</td>
<td>V89</td>
<td>CM</td>
<td>Precision LM to LM, RLS to LM.</td>
</tr>
<tr>
<td>OFF</td>
<td>V90</td>
<td>LM</td>
<td>Precision CM to CM,</td>
</tr>
<tr>
<td>ON</td>
<td>V90</td>
<td>CM</td>
<td>Precision LM to LM, RLS to LM.</td>
</tr>
</tbody>
</table>

If RENDWFLG is set, an update of LM state vector results in W-matrix non-synchronization.
MIT/DL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # 1-12-08

ANOMALY # 1-12-08

☐ COLOSSUS 2D  ☐ LUMINARY 1C
☐ COLOSSUS 2E  ☐ LUMINARY 1D
☐ COLOSSUS 3  ☐ LUMINARY 1E
☐ COLOSSUS 4  ☐ LUMINARY

☐ MIT Approved PCN  ☐ NASA Approved PCR
☐ MIT Approved PCN  ☐ NASA Approved PCR

A. Coding

○ Begin coding immediately

ACTION: ________________________________

Program Supervisor's Approval: ________________________________

○ Do not code until new GSOP material has been approved by the Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

○ Prepare GSOP revisions for MDRB consideration

ACTION: ________________________________

Technical Committee Meeting not required

Technical Committee Meeting(s) held on

Attendees:

C. KSC Testing and Checkout

○ Review for possible impact on KSC testing and checkout

ACTION: ________________________________

D. Other Programs Affected

○ Review for corresponding changes in

ACTION: ________________________________

Special Instructions

Project Manager ________________________________
Date ________________________________
A hardware or software Restart while the DAP is in the manual rate command mode may cause:

1) Temporary nulling of a Q or R axis manually commanded rate while the rotational hand controller is out of the detent position.

2) Yaw to another attitude if the restart occurs during a 0.25 m.s. period of the manual rate command mode initialization pass (the first DAP pass after the rotational hand controller is moved out of the detent position).

1.6-1) Observed in digital and hybrid runs when restart occurred while rotational hand controller was out of detent in Q or R axes.

1.6-2) Discovered during inspection of coding.
DATE AMPLIFICATION SHEET

2.1 Cause:

1) After attaining a manually commanded rate, the DAP enters the pseudo-auto phase of the manual rate command mode. In the pseudo-auto phase, attitude is controlled using a set of special manual attitude errors, "DXERROR", "DYERROR", and "DZERROR", which are computed by integrating the rate errors. "DYERROR" and "DZERROR" use the same erasable locations as "QERROR" and "RERROR", the attitude errors computed in the non-manual modes from the difference between the actual CDU angles "CDUY" and "CDUZ", and the desired CDU angles "CDUVD" and "CDUZD". After a restart, the DAP idles for one or two passes, during which "QERROR" and "RERROR" are computed for the Mode 1 attitude error displays and overwrite "DYERROR" and "DZERROR". Since the DAP does not maintain "CDUVD" and "CDYZD" in the pseudo-auto phase, these quantities remain equal to the "CDUY" and "CDUZ" values at the entry of the pseudo-auto phase. Consequently the pseudo-auto control is resumed after the restart with a large attitude error bias which opposes the manually commanded rate. This causes jet firings which reduce or null the commanded rate. After several seconds (during which the state drifts across the RCS control law phase plane coast zone), the vehicle is again accelerated to the commanded rate.

2) During the initialization pass of the manual rate command mode, "OURRCFLG" is set to indicate that the manual rate command mode is active before zeroing "DXERROR", "DYERROR" and "DZERROR". If a restart occurs between the setting of "OURRCFLG" and the initialization, the DAP will enter the manual rate command mode after idling without any initialization.
Since they use the same erasable locations as "QERROR" and "RERROR" (which have not significantly exceeded the deadband size during the preceding attitude hold period), "DYERROR" and "DZERROR" will be nearly zero and should cause no problem. "DXERROR", however, is an unshared erasable which is initialized only in the manual rate command coding, but integrates the yaw changes whenever the DAP is not idling. Consequently, the vehicle could maneuver to any yaw attitude in this situation.

2.2 Recognition:

1) Vehicle rotation rate temporarily decreased or nulled to zero after restart during Q or R axis manual rate command maneuver.

2) Vehicle moves to a new yaw attitude after restart at beginning of Q, R or P axis manual rate command maneuver.

2.5 Recovery Procedure:

1) Move rotational hand controller to detent position for approximately 1 sec., then return to original position.

2) Move rotational hand controller quickly about P axis, then back to original position.

2.6 Program Correction:

1) Do "ZATTEROR" to set desired CDUs to actual CDUs on each Q and R axis pass in either phase of the manual rate command mode ("ZATTEROR" is currently done on each Q and R axis pass in the direct rate phase of the manual rate command mode).

2) Set "OURRCFLG" after completing initialization of manual rate command mode.
PROGRAM CHANGE ROUTING SLIP

COLOSSUS 2E  LUMINARY 1D
COLOSSUS 3  LUMINARY 1E
COLOSSUS 3A LUMINARY 1F
COLOSSUS   LUMINARY

MIT Approved PCN  NASA Approved PCR  NASA Approved Software Anomaly
NASA Approved PCN  MIT Approved Software Anomaly

A. Coding
Begin coding immediately

ACTION: 

Program Supervisor's Approval: 

Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

Prepare GSOP revisions for MDRB consideration

ACTION: 

Technical Committee Meeting not required.

Technical Committee Meeting(s) held on
Attendees:

C. KSC Testing and Checkout

Review for possible impact on KSC testing and checkout

ACTION: 

D. Other Programs Affected

Review for corresponding changes in

ACTION: 

Special Instructions

Project Manager: 
Date: 6-3-70
1.1 ORIGINATOR: R. L. Pearson
1.2 ORGANIZATION: FCOB
1.3 DATE: 5/22/70
1.4 ORIGINATOR CONTROL NO.

1.5 DESCRIPTION OF ANOMALY:
The velocity updates during descents (P-63 and P-64) fail the reasonableness test shortly after LR lock-on and continue to fail intermittently throughout the descent.

1.6 DESCRIPTION OF RUN:
Descent runs and crew training on LMS-2.

2.1 CAUSE:
Velocity updates to state vector are done before all of the 5 radar reads have been taken.

2.2 RECOGNITION:
Simulation at MIT showed that a Radar read was occurring after VELUPDAT.

2.3 MISSION EFFECT:
Loss of valid landing Radar Data - Possibly cause for abort.

2.4 AVOIDANCE PROCEDURE:
Possible increase computer duty cycle by calling extended verb, e.g. V82 and then monitor nominal display with V16N63, V16N64, V16N60.

2.5 RECOVERY PROCEDURE:
None.

2.6 PROGRAM CORRECTION:
Set flag in R12READ and reset it when exiting; check flag in VMEASCK and do CCS NEWJOB if flag is set and recycle, otherwise continue.

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etch):
Fix for re-release of ID.

2.8 RECOMMENDED RE-TESTING:
Digital Simulation to show logic paths.

3.1 NASA DIRECTION:

4.1. CLOSING ACTION TAKEN:

4.2 SIGNATURE:
4.3 ORGANIZATION:
4.4 DATE:

MISC Form 1409 (Rev May 68)
Assembly Control Board Request

Name of Program(s): Luminaro 10

Originator: W. Pierick

Organization: MIL/10

Date: 1/25/69

Description of Change:

Change the coding in SPECDRUN (during service) to compute forward and forward regardless of position of move sensor switch - addition 2 positions

Reason:

The forward velocity (module) is not computed for display on X-pointer in forward mode. The selection (which controls which system will display on the X-pointer or tapes) should be in any position but TAX PGNCS

Assigned to:

W. Pierick

Comments:

\[\text{SPECDRUN}\]

\[
\begin{array}{c}
\text{Valid?} \\
\text{Yes} \\
\text{NO} \\
\text{Set DIGITAL} \\
\text{Yes DIGITAL} \\
\text{NO DIGITAL} \\
\text{Complete FORWARD/REV} \\
\text{Reset DIGITAL} \\
\text{Yes DIGITAL} \\
\text{NO DIGITAL} \\
\text{Compute ALT, ALT RATE} \\
\text{EXIT}
\end{array}
\]

Approved by: M. Hamilton

Date: 12/3/69
Assembly Control Board Request

Name of Program(s): LUMINARY
Originator: J. Jaffe
Organization: MIT
Date: 12-10-69
Description of Change: Change exit from LONGCALL

Reason: Assembly is not possible to call a high superior void
LONGCALL change from DTCC 10 TO SUPPORT allow this.

Assigned to: DENSMORE

Comments:

Approved by: M. Hamilton
Date: 12-11-69
Name of Program(s): LUMINARY

Originator: P. Rye

Organization: MIT/IL

Date: 12/30/69

Description of Change:

Create subroutine RLEASVAC to release VAC area and change a FINDVAC to a NOVAC job. Perform this before putting up cyclic displays at end of guidance.

Reason:

To keep displays in landing and ascent from tying up a VAC area if DSKY is busy because of astronaut or extended verb.

Assigned to:

P. Rye

Comments: For LUMINARY 1D

Approved by: W. Hamilton

Date: 12/30/69
Name of Program(s): LUMINARY ID
Originator: Adler
Organization: MIT
Date: 9 JAN 70
Description of Change:
Save 8 words in bank 1 by equaling GENADR tags to fixed equivalents in order to add resort table entry (PCR 872-2).

Reason: PCR 872-2

Assigned to: D. [Signature]

Comments:

Approved by: M. Hamilton
Date: 11/3/70
Name of Program(s):  Lunar 1D
Originator:  McIlroy
Organization:  MIT/CSDL
Date:  1/16/70

Description of Change:

Instead of setting bits via "CS,INH,MASK,75," a "TC CLRDMOD" which does the same thing (reset bits 14/15 of RADMODES) + resetting RR/CD4 ERROR COUNTER ENABLE.

Reason:

Saves 2 words in Bank 4/3

Assigned to:  P. Oslin

Comments:

Approved by:  [Signature]
Date:  1/16/70
Assembly Control Board Request

Name of Program(s):  LUMINARY
Originator:  DON EYLES AND ALLAN KLUMPP
Organization:  MIT
Date:  70 02 06

Description of Change:
P66 should call the THRTHRT as follows:
TC  POSTJUMP
FCADA  THRO766

In BANK 31 the following should be added:
THRO766  TC  TIHTHRT +3
INCR  CNTTHRT  COUNT ONE THRO766 COMPLETION

In BANK 32, delete INCR CNTTHRT and the transfer to DISPEX66

Reason:
The present coding can produce random branching
if a restart in P66 leaves a job
request for the restart point in the throttle routine
unsatisfied at the time P66 is entered.
See Program Note 53 of this date by Allan Klump.

Assigned to:  D. Eyles

Comments:

Approved by:  Margaret Hamilton
Date:  2-9-70
Name of Program(s): Luminary 1D
Originator: B. McCoy
Organization: MIT/CSD
Date: 3/18/70

Description of Change:
Remove the zeroing of both G channel from SPACESUB.

Reason: If a software restart occurs during the throttle down of the DPS engine, the pulses to the DECA are terminated. On the next guidance pass they are resummed, however.

Assigned to: D. Somerville

Comments:

Approved by: M. Hamilton
Date: Feb 23, 1970
Assembly Control Board Request

Name of Program(s): Luminary D

Originator: Dave Moore

Organization: MIT/L

Date: Feb 25/1970

Description of Change: 1) Change order of card from Steer to check and then check for overflow to overflow check and then Steer check.
2) Omit all hold check and put instead a ratestop (even though it check the ratestop action an increment if an act hold)

Reason: 1) Order changed so that if an error occurs, commands will be skipped for one revolution (in matter of the Steer mode switch was changed to a table from static or vice versa. Then command will be issued in having steer after any question of overflow has been cleared.
2) Omit all hold check & place a ratestop instead.

Note: Rate in terms already.

Assigned to: D. Demme

Comments: 

Approved by: Margaret Hamlet

Date: 3-2-70
Name of Program(s): Luminary
Originator: EYCES
Organization: MIT
Date: 19 March, '70
Description of Change: Use QUICTRICA in P66R00 instead of CDUXNBSM to save memory.
Reason: To save memory.

Assigned to: EYCES

Comments:

Approved by: [Signature]
Date: [Signature]
Name of Program(s): Luminary 10
Originator: McCoy
Organization: M.I.T
Date: 18 MAR 70
Description of Change:
1) change "NEG.TORKP" to "NEG.TORKP"
2) change NOWN table 5.517 to 5.571

Reason:
1) incorrect spelling for dominant quantity; unimportant
2) correct card punch error; insignificant

Assigned to: McCoy

Comments:

Approved by: M. Hamilton
Date: 3-20-70
Name of Program(s): LUMINARY

Originator: Hamilton

Organization: MIT

Date: 3 March 70

Description of Change: Put in a list of ECADRs at the beginning of the listing for uplinked parameters to be put into Section 2 of the GSOP. This will be done with =ECADR op code and will be assembled with each revision but won't take up any room.

Reason: Avoid obsolete ECADRs in the GSOP.

Assigned to: Densmore

Comments: check to see if covers for same change

Approved by: Margaret Hamilton

Date: 3-25-70
Name of Program(s): Luminary 1D
Originator: Volante
Organization: MIT
Date: 23 March 70
Description of Change: Delete setting of ROY FLTAC. It formerly prevented the issuing of a 521 alarm which no longer exists.
Reason: Room to implement
PCR 979

Assigned to: Densmore

Comments:

Approved by: M. Hamilton
Date: 3-26-70
Assembly Control Board Request  

No. 423

Name of Program(s): Luminary ID

Originator: Denmore

Organization: MIT

Date: 5 April 70

Description of Change: Delete definitions of 4 unused shared variables from the variable assignments log section. W.IND1, VACX, VACY, and VACZ are deleted. NOSUPPP. Formerly

Reason: in E2 (undetermined)

Assigned to: Denmore

Comments:

Approved by: Margaret Hamilton

Date: 4-15-70
Name of Program(s): Luminary 1D
Originator: Eyles
Organization: MIT
Date: 7 April 70
Description of Change: Move ZERLINA, ELVIRA, AZINCRI1 and ELINCR1 from E7 1443-1446 (sharing with ARARG) to E7, 1644-1647 where they belong, replacing the definitions of dummy for them there. Other variables (VDCVRT (d.p.), NIGNLOOP) and NGUIDSOP, formerly equal to the actual locations, dummies were equal to to the actual locations.

Assigned to: Persmane

Comments: Done in REV 158

Approved by: Margaret Hamilton
Date: 4/15/70
Name of Program(s): LUMINARY

Originator: ME00Y

Organization: M17

Date: 4/21/70

Description of Change:

Modify 13 instructions in BURN-BABY-BURN so that smaller programs can utilize logic in the master ignition routine. Also, add 1 word to Bank 36.

Reason:

Specifically for the LM DECIBEL burn, but also perhaps for contingency procedures, real time programming during a mission.

Assigned to:

Comments:

Approved by: [Signature]

Date:
Name of Program(s): Luminary 1D
Originator: Densmore
Organization:
Date: 28 May 70
Description of Change: (1) Unused constant oct 77777 was deleted. (2) RESTARTS routine was called directly rather than by picking up a CADER for it. (3) A single constant for masking during FLAGWDRD8 SWINIT initialization replaced adding in bits individually.
Reason: Save 3 words in Bank 5 to make room for clearing of R12 RDFSQ in Fresh Start.
Fix to PCR 896.

Assigned to: Dana Densmore

Comments:

Approved by: Margaret A. Hamilo
Date: 6/10/70