MEMORANDUM TO:  See attached list

FROM:  FM5/Chief, Lunar Mission Analysis Branch

SUBJECT:  Corrections to the flyby options of the RTCC Midcourse Correction Processor as specified in Internal Note No. 70-FM-11

The three flyby options use similar logic for the first five steps of each option. Option 8, the SPS lunar flyby, will be used as an example; but the changes indicated apply to each option. These changes have been coordinated with Flight Software Branch and IBM.

Ronald L. Berry

APPROVED BY:

John L. Mayer
Chief, Mission Planning and Analysis Division

The Flight Software Branch concurs with the above recommendation.

James C. Stokes, Jr., Chief
Flight Software Branch

Enclosure

Addressees:
(See attached list)
MPAD STANDARD INTERNAL NOTE DISTRIBUTION LIST
(Revised April 27, 1970)

AA2/Deputy Director
LM/G5/Technical Library (2)
LF/Chief
FA2/Assistant Director for Electronic Systems
FG/Deputy Chief
FG/Assistant Chief for Engineering and Development
FA/Chief, Office of Flight Operations
FA/Deputy Director
FA/Chief, Flight Support Division
LS/Chief, Flight Support Division
FA/Chief, Flight Software Branch (3)
FA/Chief, Advanced Planning Support Office
FC/Chief (5)
FL/Chief (2)
FA/Chief, Flight Software Branch (3)
FA/Manager for LM
FD/Acting Chief (2)
FF/Chief
FM/Chief
FM/Deputy Chief
FM/Technical Assistant
FM2/Chief
FM3/Chief
FM4/Chief
FM5/Chief
FM6/Chief
FM7/Chief
FM8/Chief
FM13/Chief
FM13/NR Representative (2)
FM13/GAC Representative (2)
FM13/Report Control File (25)
FM/Author(s)
Bellcomm/K. E. Martersteck
EM Library
TRW Library (4)
TRW/P. A. Evans (10)

ADDITIONS:
TRW/J. Boskins (5)
A. Mueller (12)
S. James (12)
S. Hofheinz
TRW/D. P. Johnson (3)
S. M. Gafford (4)
LPC/M. P. Frank
S. C. Bostick (2)

PS5/L. Dungan
E. Shinpaugh
K. Leach
FM/E. Schlessner (5)
FM5/J. D. Yencharis
P. A. Holmes
K. T. Zeiler
R. S. Davis
R. F. Wiley
R. H. Sanders
**Title or Subject:** RTCC REQUIREMENTS FOR APOLLO 14: LUNAR FLIGHT MODES OF THE TRANSLUNAR MIDCOURSE CORRECTION PROCESSOR

**Date of Paper:** May 25, 1970

**Authors:** Kenneth T. Zeiler and Quentin A. Holmes

**Distribution:**
- See attached memo

**Signature of Branch Head**
- Date

**Signature of Division Chief**
- Date

**Signature of Appropriate Assistant Director or Program Manager**
- Date

**Change or Addition made by**
- Date

**Location of Originals:**
MSC Form 199 (Rev Dec 63)
<table>
<thead>
<tr>
<th>Change no.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1         | 5/25/70  | Page 7: pen-and-ink change to correct typographical error. Pages 8 and 9, 14 and 15, 21 and 22: changed steps because of misordering.   
  a. Delete the call to integrated TLMC immediately preceding step 3.  
  b. Step 3 should be a conic instead of an integrated flyby.  
  c. First-guess values come from step 1 instead of TLMC in step 3.  
  d. Delete integrated maneuver storage immediately after step 3.  
  e. Insert a call to integrated TLMC immediately before step 4.  
  f. Step 4 should be an integrated instead of a conic flyby.  
  g. First-guess values in step 4 come from TLMC instead of step 2.  
  h. Store the integrated maneuver (deleted on pages 8, 14, and 21) immediately after step 4.  
  i. Step 5 executes a conic flyby to the same inclination of free return and height as step 4.  
  j. First guess values for step 5 come from step 3 not step 4.  
  k. Converged value of INCL OF FREE RETURN should read "CONV. VALUE FROM STEP 4 ± .01°".  

Page 17: pen-and-ink change to correct error in step 6.  
Page 18: pen-and-ink change to show program modification to step 6.  
Pages 13 and 20: HEIGHT of PERILUNE in block that reads SCALE WEIGHT OF PERILUNE FOR TLMC.
CHANGE SHEET
FOR
MSC INTERNAL NOTE 70-FM-11 DATED FEBRUARY 6, 1970
RTCC REQUIREMENTS FOR APOLLO 14: LUNAR FLYBY MODES
OF THE TRANSLUNAR MIDCOURSE CORRECTION PROCESSOR
By Kenneth T. Zeiler and Quentin A. Holmes
Change 1
May 25, 1970

Ronald L. Berry, Chief
Lunar Mission Analysis Branch

John P. Mayer, Chief
Mission Planning and Analysis Division

NOTE: A black bar in the margin indicates the area of change.

After the attached enclosures, which are replacement pages, have
been inserted and after the following pen-and-ink changes have been
made, insert this CHANGE SHEET between the cover and the title page
and write on the cover, "CHANGE 1 inserted".

1. Page 7: change WEIGHT to HEIGHT in the block that reads
"SCALE WEIGHT OF PERILUNE FOR TIMC".

2. Page 17: Step 6 - The dependent variable HT OF PERILUNE
has no weight and is class 1.

3. Page 18: Step 8 - The dependent variable INCL OF FREE
RETURN should have a MIN of -1° and a MAX of +1° instead of ±0.01°.
ENTER WITH STATE VECTOR AND DELAY TIME TO MCC

STEP 1

COMPUTE MCC FIRST GUESSES WITH CONIC TLMC

SCALE WEIGHT OF PERILUNE FOR TLMC

STEP 2

EXECUTE CONIC FLYBY TO OBTAIN PERILUNE LATITUDE OF MINIMUM INCL NAV FLYBY

INDEPENDENT VARIABLES VALUE STEP SIZE WEIGHT
DELTA AZIMUTH MCC CONIC TLMC 0 1.544 1
DELTA GAMMA MCC CONIC TLMC 0 1.544 1
DELTA VELOCITY MCC CONIC TLMC 0 1.224 1

DEPENDENT VARIABLES MIN MAX WEIGHT CLASS DESIGNATOR
HT OF PERILUNE STEP 1 0.0 102.0 - 1
INCL OF PERILUNE 90° 102° 1 A
HT OF REENTRY 64.0 67.5665 1 0
INCL OF FREE RETURN -01° (DECL -00°42') +01° - 1

*AT THE EXPECTED TIME OF PERILUNE PASSAGE

STORE LATITUDE OF PERILUNE (φPLIT) OBTAINED IN STEP 2

FOR midcourse maneuvers performed from perilune min 3.5 hr to perilune arrival, the mean height of perilune for TLMC and the last three steps of each flyby option are scaled according to the time of the maneuver, between TLI and perilune minus 3.5 hr, the height of the normal TLI perilune is entered in TLMC. From perilune minus 3.5 hr to perilune arrival, the input height drops linearly from the TLI target value in 60 s. mm

Flow chart 1. - SPS lens flyby.
A

ASCENDING (POSITIVE) IS THE DESIRED INCLINATION OF RETURN ASCENDING OR DESCENDING?

ADD 2° (MED) TO 0 SPLIT FOR LATITUDE TARGET IN STEP 2

SUBTRACT 2° (MED) FROM 0 SPLIT LATITUDE TARGET IN STEP 2

STEP 3

EXECUTE CONIC FLYBY TO THE BASED LATITUDE OF PERILUNE

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLES</th>
<th>VALUE</th>
<th>STEP SIZE</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELTA AZIMUTH MOC</td>
<td>STEP 1</td>
<td>1 1.544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA GAMMA MOC</td>
<td>STEP 1</td>
<td>1 1.544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA VELOCITY MOC</td>
<td>STEP 1</td>
<td>1 1.544</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES</th>
<th>STEP 1</th>
<th>MAX</th>
<th>WEIGHT</th>
<th>CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT OF PERILUNE</td>
<td>90°</td>
<td>MAX 182°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>LAT OF PERILUNE (PRES 90°)</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>INCL OF FREE RETURN</td>
<td>90°</td>
<td>44 0665</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HT OF REENTRY</td>
<td>67.5665</td>
<td></td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

Flow chart 1 - SPS lunar flyby—Continued.
STEP 4

EXECUTE INTEGRATED FLYBY TO THE SAME LATITUDE OF PERILUNE AS STEP 3

INDEPENDENT VARIABLES | VALUE | STEP SIZE | WEIGHT |
-----------------------|-------|----------|--------|
DELTA AZIMUTH MCC     | TLMC  | $1.544   | 1      |
DELTA GAMMA MCC       | TLMC  | $1.544   | 1      |
DELTA VELOCITY MCC    | TLMC  | $1.524   | 1      |

DEPENDENT VARIABLES   | MIN. | MAX. | WEIGHT | CLASS |
-----------------------|------|------|--------|-------|
HT OF PERILUNE         | STEP 1 ±0.5 N, M, /MED | - | 1 |
INC. OF PERILUNE       | 90°  | 182° | 1      | 0     |
LAT OF PERILUNE        | (SAME AS STEP 3)         | - | 1 |
INC. OF FREE RETURN    | 0°   | 90°  | 1      | 0     |
HT OF REENTRY          | 64.0965 | 67.5665 | - | 1 |

STORE INTEGRATED MANEUVER
($\Delta x_1, \Delta y_1, \Delta z_1$)

STEP 5

EXECUTE CONIC FLYBY TO SAME INC. OF FREE RETURN AND HEIGHT AS STEP 4

INDEPENDENT VARIABLES | VALUE | STEP SIZE | WEIGHT |
-----------------------|-------|----------|--------|
DELTA AZIMUTH MCC     | STEP 3 | $1.544   | 1      |
DELTA GAMMA MCC       | STEP 3 | $1.544   | 1      |
DELTA VELOCITY MCC    | STEP 5 | $1.524   | 1      |

DEPENDENT VARIABLES   | MIN. | MAX. | WEIGHT | CLASS |
-----------------------|------|------|--------|-------|
HT OF PERILUNE         | STEP 1 ±0.5 N, M, /MED | - | 1 |
INC. OF PERILUNE       | 90°  | 182° | 1      | 0     |
INC. OF FREE RETURN    | (CONV VALUE FROM STEP 4 ± .01) | - | 1 |
HT OF REENTRY          | 64.0965 | 67.5665 | - | 1 |

STORE PREMIDCOURSE STATE (S1) AND POSTMIDCOURSE STATE (S2C)
Flow chart 1. - SPS lunar flyby - Continued.
STEP 2.
EXECUTE CONIC FLYBY TO OBTAIN PERILUNE LATITUDE OF MINIMUM INCL. FLYBY

INDEPENDENT VARIABLES

<table>
<thead>
<tr>
<th>Delta Azimuth MCC</th>
<th>CONIC TLMC</th>
<th>1.544</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta Gamma MCC</td>
<td>CONIC TLMC</td>
<td>1.544</td>
<td>1</td>
</tr>
<tr>
<td>Delta Velocity MCC</td>
<td>CONIC TLMC</td>
<td>1.524</td>
<td>1</td>
</tr>
</tbody>
</table>

DEPENDENT VARIABLES

<table>
<thead>
<tr>
<th>Ht of Perilune</th>
<th>Min 405 N, W/MRD</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incl of Perilune</td>
<td>90°</td>
<td>1</td>
</tr>
<tr>
<td>Ht of Reentry</td>
<td>16.0965</td>
<td>0</td>
</tr>
<tr>
<td>Incl of Free Ref</td>
<td>-0.01° DeclMoon +2° + 0.1°</td>
<td>1</td>
</tr>
</tbody>
</table>

*AT THE EXPECTED TIME OF PERILUNE PASSAGE

STORE LATITUDE OF PERILUNE \( \alpha_{SPLIT} \) OBTAINED IN STEP 2

*Per midcourse maneuvers performed from perilune minus 1.5 hr to perilune interval, the input height of perilune for TLMC and the first three lines of each flyby table are scaled according to the time of the maneuver. Between TLI and perilune minus 1.5 hr, the height of the nominal TLI perilune is entered in TLMC. From perilune minus 1.5 hr to perilune minus the input height drops linearly from the TLI target value to 60 n. mi.

Flow chart 2 - Optimized lunar flyby.

Change 1, May 29, 1970
**STEP 3**

**EXECUTE COMIC FLYBY TO THE BIASED LATITUDE OF PERILUNE**

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLES</th>
<th>VALUE</th>
<th>STEP SIZE</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELTA AZIMUTH MCC</td>
<td>STEP 1</td>
<td>$\phi$ 1544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA GAMMA MCC</td>
<td>STEP 1</td>
<td>$\phi$ 1544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA VELOCITY MCC</td>
<td>STEP 1</td>
<td>$\phi$ 1544</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES</th>
<th>MIN</th>
<th>MAX</th>
<th>WEIGHT</th>
<th>CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT OF PERILUNE</td>
<td>STEP 1</td>
<td>$\pm$0.5 N. MI/MIED</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>INCL OF PERILUNE</td>
<td>90°</td>
<td>182°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>LAT OF PERILUNE</td>
<td>(PRESET = 01°)</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>INCL OF FREE RETURN</td>
<td>0°</td>
<td>90°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>HT OF REENTRY</td>
<td>64.0985</td>
<td>67.5685</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

Flow chart 2 - Option 2nd house flyby - Continued.
COMPUTE MCC FIRST GUESSES WITH INTEGRATED TLMC USING BIASED LATITUDE OF PERILUNE

STEP 4
EXECUTE INTEGRATED FLYBY TO THE SAME LATITUDE OF PERILUNE AS STEP 3

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLES</th>
<th>VALUE</th>
<th>STEP SIZE</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELTA AZIMUTH MCC</td>
<td>TLMC</td>
<td>1 1 544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA GAMMA MCC</td>
<td>TLMC</td>
<td>1 1 544</td>
<td>1</td>
</tr>
<tr>
<td>DELTA VELOCITY MCC</td>
<td>TLMC</td>
<td>1 1 524</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES</th>
<th>MIN</th>
<th>MAX</th>
<th>WEIGHT</th>
<th>CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT OF PERILUNE</td>
<td>STEP 1 ± 0.5 N. MI/MED</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>INCL OF PERILUNE</td>
<td>90°</td>
<td>102°</td>
<td>1</td>
<td>D</td>
</tr>
<tr>
<td>LAT OF PERILUNE</td>
<td>PRESET ± 0.1°</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>INCL OF FREE RETURN</td>
<td>D°</td>
<td>90°</td>
<td>1</td>
<td>D</td>
</tr>
<tr>
<td>HT OF REENTRY</td>
<td>66.0965</td>
<td>67.5665</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

STORE INTEGRATED STATE OVER \( \Omega, \varphi, \chi, \xi, \eta \)

STEP 5
EXECUTE CONIC FLYBY TO SAME INCL OF FREE RETURN AND HEIGHT AS STEP 4

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLES</th>
<th>VALUE</th>
<th>STEP SIZE</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELTA AZIMUTH MCC</td>
<td>STEP 3</td>
<td>( \delta 1 544 )</td>
<td>1</td>
</tr>
<tr>
<td>DELTA GAMMA MCC</td>
<td>STEP 3</td>
<td>( \delta 1 544 )</td>
<td>1</td>
</tr>
<tr>
<td>DELTA VELOCITY MCC</td>
<td>STEP 3</td>
<td>( \delta 1 524 )</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES</th>
<th>MIN</th>
<th>MAX</th>
<th>WEIGHT</th>
<th>CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT OF PERILUNE</td>
<td>STEP 1 ± 0.5 N. MI/MED</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>INCL OF PERILUNE</td>
<td>90°</td>
<td>102°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>INCL OF FREE RETURN</td>
<td>CDNV VALUE FROM STEP 4 ± 0.1°</td>
<td>1</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>HT OF REENTRY</td>
<td>64.0965</td>
<td>67.5665</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

STORE PREMIDOCCOURSE STATE (S1) AND POSTMIDOCCOURSE STATE (S2)

Flow chart 2 - Optimized Lunar Flyby - Continued, Change 1 May 25, 1970
STATE VECTOR OFFSET

PROGRAM NEEDS
S1 - PREMIDCOURSE STATE
S2C - CONIC MIDCOURSE STATE
$\Delta X, \Delta Y, \Delta Z$ - INTEGRATED MIDCOURSE CORRECTION

COMPUTE STATE $S'$
$S' = S2C - \Delta X, \Delta Y, \Delta Z$

S2C (POLARFORM) - $S'$ (POLARFORM) = $\Delta V, \Delta \gamma, \Delta \phi$
$\Delta V, \Delta \gamma, \Delta \phi$ ARE FIRST GUESSES FOR STEP 5 OR STEP 7

Flow chart 2 - Optimized lunar flyby - Continued.
Flow chart 2 - Optimized lunar flyby - Concluded.
**Flow chart 3 - Optimized ACS flyby to a desired inclination at free return.**
Flow chart 3. - Optimized RCS flyby to a desired inclination of free return - Continued.
Flow chart 2. - Optimized RCS firing to a desired inclination
of free return - Continued.