T/DL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # SL030
ANOMALY # ________
ADR # ________

☐ COLOSSUS 3 ☐ LUMINARY 1E
☐ COLOSSUS __ ☐ LUMINARY __
☒ SKYLARK __

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

A. Coding

(✓) Begin coding immediately — Larry Berman

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

(✓) Prepare GSOP revisions for MDRB consideration — J. KLAWSNIK/E.OLSSON

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 Stephen L. Copps
Date 1/28/71

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD PROGRAM CHANGE REQUEST

NUMBER (Completed by FSB): SL030

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR	DATE	1.2 ORGANIZATION	APPROVAL	DATE
R. R. Regelbrugge	2-27-70	MPAD/OMAB	Carl R Huss	3/3/70

1.3 EFFECTIVITY

AAP COLOSSUS Program

1.4 TITLE OF CHANGE

Addition of NCC Maneuver Computation Capability

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

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: H W Tindall Jr

DATE: 3/4/70

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 IMPLEMENTATION ☐ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE: 1/13/71

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
DATA AMPLIFICATION SHEET

PROGRAM CHANGE REQUEST NO.	PREPARED BY	DATE	ORGANIZATION
SL030	R. R. Regelbrugge	2-27-70	OMAB/MPAD

CONTINUATION SECTION: *(Refer to Block Number and Title on Program Change Request form.)*

1.5 Reasons for Change - The nominal AAP rendezvous profile contains an NCC/NSR sequence instead of the CSI/CDH sequence used in Apollo. The NSR maneuver is equivalent to a CDH maneuver and can be computed by P-33. Computation capability for the NCC maneuver in the onboard computer will facilitate optimum use of rendezvous navigation by removing the dependency upon the RTCC for computation of this maneuver. This capability is also needed to allow an automated onboard rendezvous sequence which is desired for AAP.

1.6 Description of Change - Include in the onboard computer the NCC maneuver routine described in the attached discussion and flow charts.

REMARKS:

The NCC Maneuver Routine

The purpose of the NCC maneuver is to obtain desired height (Δh) and phase ($\Delta\phi$) offsets at the NSR maneuver point. The method used is to compute the desired active vehicle state vector at NSR and then obtain the NCC maneuver by passing a Lambert solution through the desired NSR point. The desired active vehicle state at NSR can either be obtained from input height and phase offsets at NSR or from the desired TPI conditions. In the latter case the procedure is to obtain the desired phase angle at TPI and then move the target vehicle state $\overline{R}_P, \overline{V}_P$ through this angle obtaining state $\overline{R}_j, \overline{V}_j$ which is at phase match with the desired TPI active vehicle state. Using $\overline{R}_j, \overline{V}_j$ and the desired coelliptic Δh the desired active vehicle state at TPI $\overline{R}'_A, \overline{V}'_A$ can be obtained. This state is then moved back to the time of NSR to give the desired NSR state.

Subroutine QRDTPI

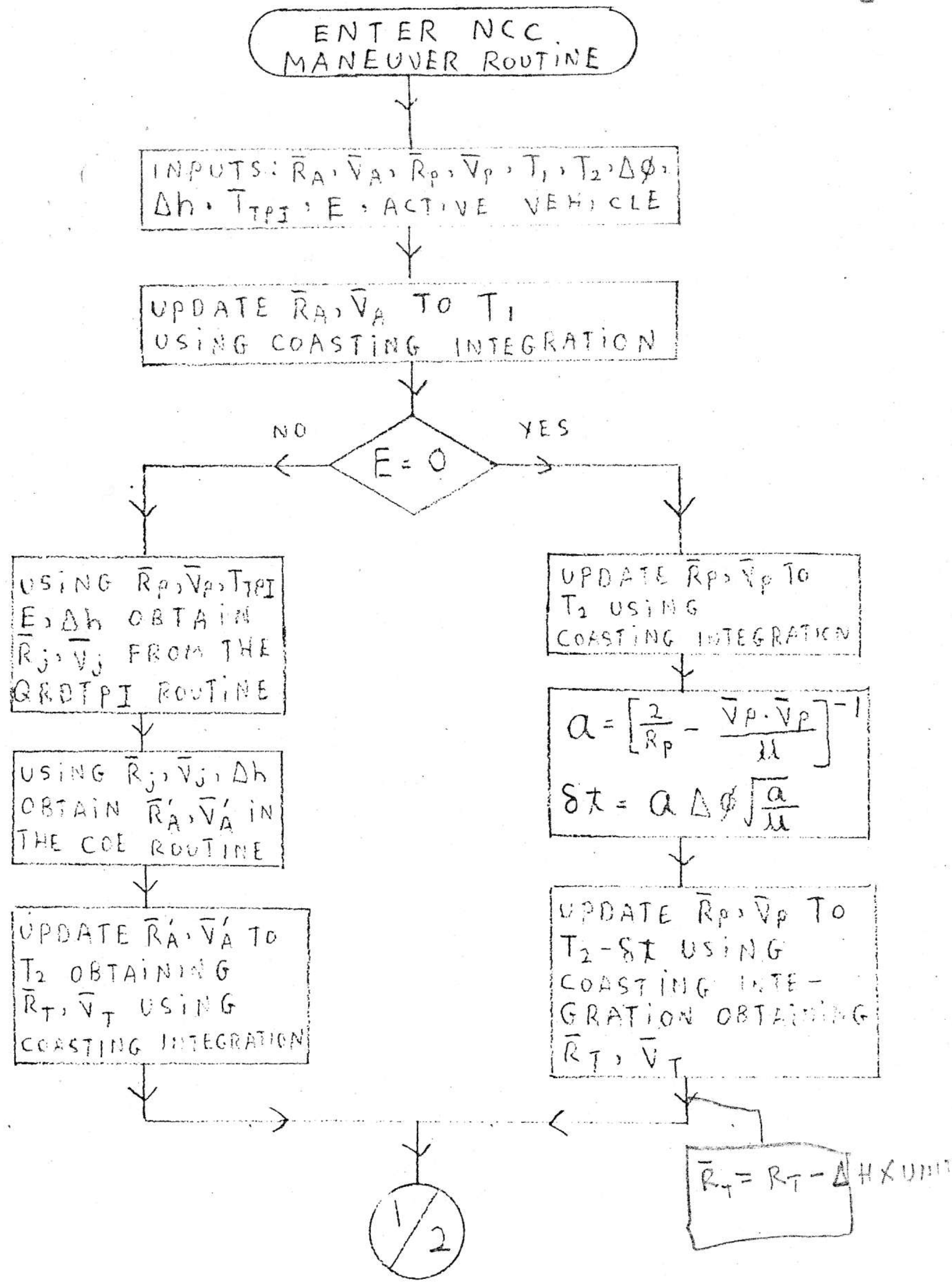
Subroutine QRDTPI is used to compute the desired phase angle at TPI and also the state vector $\overline{R}_j, \overline{V}_j$.

Subroutine COE

Subroutine COE computes an orbit coelliptic to a given orbit with a specified differential height.

Inputs to the NCC Maneuver Routine

$\overline{R}_A, \overline{V}_A$	Active vehicle state vector
$\overline{R}_P, \overline{V}_P$	Passive vehicle state vector
T_1	Time of NCC
T_2	Time of NSR
$\Delta\phi$	Desired phase offset at NSR (not input if $E \neq 0$)
Δh	Desired differential height at NSR
T_{TPI}	Time of TPI
E	Desired line-of-sight angle at TPI. (If E is input $\Delta\phi$ is computed based on the desired TPI conditions, otherwise $\Delta\phi$ is input.)


ENTER NCC MANEUVER ROUTINE
INPUTS: $\bar{R}_A$, $\bar{V}_A$, $\bar{R}_p$, $\bar{V}_p$, T_1, T_2, $\Delta\phi$, Δh, T_{TPI}, E, ACTIVE VEHICLE
UPDATE $\bar{R}_A$, $\bar{V}_A$ TO T_1 USING COASTING INTEGRATION
NO
E = 0
YES
USING $\bar{R}_p$, $\bar{V}_p$, T_{TPI} E, Δh OBTAIN $\bar{R}_J$, $\bar{V}_J$ FROM THE QRDTPI ROUTINE
USING $\bar{R}_J$, $\bar{V}_J$, Δh OBTAIN $\bar{R}_A'$, $\bar{V}_A'$ IN THE COE ROUTINE
UPDATE $\bar{R}_A'$, $\bar{V}_A'$ TO T_2 OBTAINING $\bar{R}_T$, $\bar{V}_T$ USING COASTING INTEGRATION
UPDATE $\bar{R}_p$, $\bar{V}_p$ TO T_2 USING COASTING INTEGRATION
$a = \left[\frac{2}{R_p} - \frac{\bar{V}_p \cdot \bar{V}_p}{\mu}\right]^{-1}$
$\delta t = a\,\Delta\phi\sqrt{\frac{a}{\mu}}$
UPDATE $\bar{R}_p$, $\bar{V}_p$ TO $T_2 - \delta t$ USING COASTING INTE-GRATION OBTAINING $\bar{R}_T$, $\bar{V}_T$
$\bar{R}_T = R_T - \Delta H \times$ UNIT
1/2

(1)

↓

OBTAIN $\bar{V}_A'$, F_2, $\bar{V}_T'$ USING $\bar{R}_A$, $\bar{V}_A$, $\bar{R}_T$, T_1, $T_F = T_2 - T_1$, $\varepsilon = 15°$, $N_1 = 2$ IN THE INITVEL ROUTINE

↓

$$\overline{\Delta V}_1 = \bar{V}_A' - \bar{V}_A$$
$$\overline{\Delta V}_2 = \bar{V}_T - \bar{V}_T'$$
$$\bar{Z} = -\,\text{UNIT}(\bar{R}_A)$$
$$\bar{Y} = \text{UNIT}(\bar{V}_A \times \bar{R}_A)$$
$$\bar{X} = \bar{Y} \times \bar{Z}$$
$$\overline{\Delta V}_1(LV) = [\bar{X}\ \bar{Y}\ \bar{Z}]^T\, \overline{\Delta V}_1$$

↓

AT THIS POINT THE ASTRONAUT MAY OVERWRITE $\Delta V_1(LV)$

↓

EXIT TO P-30

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ENTER COE

INPUTS: $\bar{R}_j$, $\bar{V}_j$, Δh

$$V_{VJ} = \bar{V}_j \cdot \bar{R}_j / R_j$$

$$a_j = \left[\frac{2}{R_j} - \frac{\bar{V}_j \cdot \bar{V}_j}{\mu}\right]^{-1}$$

$$\bar{R}'_A = \bar{R}_j - \Delta h \, \text{UNIT}(\bar{R}_j)$$

$$a_A = a_j - \Delta h$$

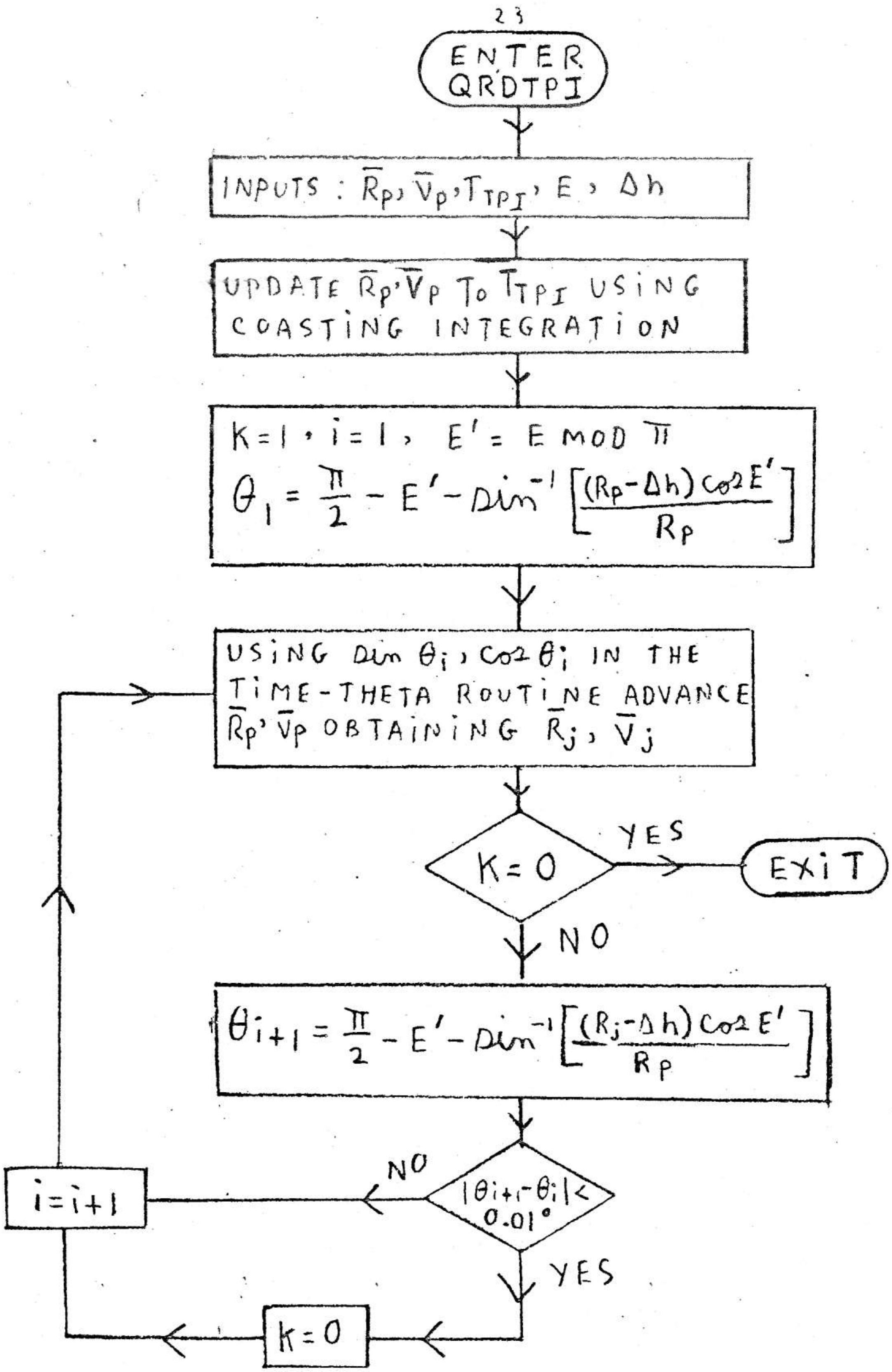
$$V_{VA} = V_{VJ} \left(\frac{a_j}{a_A}\right)^{3/2}$$

$$V_{HA} = \sqrt{\mu\left(\frac{2}{R'_A} - \frac{1}{a_A}\right) - V_{VA}^2}$$

$$\bar{U} = \text{UNIT}(\bar{R}_j \times \bar{V}_j)$$

$$\bar{V}'_A = V_{HA} \, \text{UNIT}(\bar{U} \times \bar{R}'_A) + V_{VA} \, \text{UNIT}(\bar{R}'_A)$$

EXIT


23
ENTER QRDTPI
INPUTS : $\bar{R}_p, \bar{V}_p, T_{TPI}, E, \Delta h$
UPDATE $\bar{R}_p, \bar{V}_p$ TO T_{TPI} USING COASTING INTEGRATION
$K = 1, i = 1, E' = E \text{ MOD } \pi$
$\theta_1 = \frac{\pi}{2} - E' - \sin^{-1}\left[\frac{(R_p - \Delta h)\cos E'}{R_p}\right]$
USING $\sin\theta_i, \cos\theta_i$ IN THE TIME-THETA ROUTINE ADVANCE $\bar{R}_p, \bar{V}_p$ OBTAINING $\bar{R}_j, \bar{V}_j$
$K = 0$
YES
EXIT
NO
$\theta_{i+1} = \frac{\pi}{2} - E' - \sin^{-1}\left[\frac{(R_j - \Delta h)\cos E'}{R_p}\right]$
$|\theta_{i+1} - \theta_i| < 0.01°$
NO
$i = i + 1$
YES
$K = 0$