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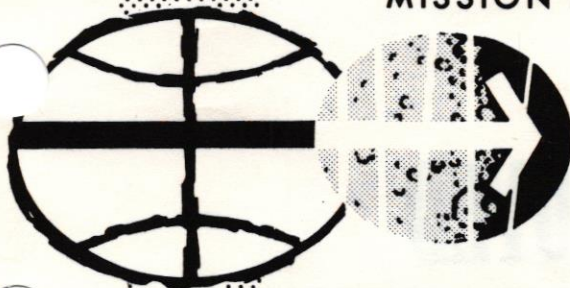
MSC INTERNAL NOTE NO. 69-FM-250

September 25, 1969

RTCC REQUIREMENTS FOR APOLLO 12 (MISSION H-1) TRANSLUNAR INJECTION PROCESSOR

**(This revision supersedes MSC Internal Note
No. 69-FM-132 dated June 5, 1969.)**

**Lunar Mission Analysis Branch
MISSION PLANNING AND ANALYSIS DIVISION**



**MANNED SPACECRAFT CENTER
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TO : See List Below

DATE: SEP 18 1969

FROM : FM5/Lunar Mission Analysis Branch

69-FM51-235

SUBJECT: RTCC requirements for H-1 mission - translunar injection targeting processor

The enclosed MSC Internal Note No. 69-FM-250, documents the detailed program logic for TLI retargeting capability. The changes reflected in the attached document resolve all known problems in this processor and as of this date, no further significant changes are anticipated.

This internal note supersedes MSC Internal Note No. 69-FM-132.

Ronald L. Berry

Ronald L. Berry, Chief
Lunar Mission Analysis Branch

APPROVED BY:

John P. Mayer

John P. Mayer
Chief, Mission Planning
and Analysis Division

The Flight Software Branch concurs with the above recommendations.

James C. Stokes, Jr.

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

Enclosure

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MSC INTERNAL NOTE NO. 69-FM-250

PROJECT APOLLO

RTCC REQUIREMENTS FOR APOLLO 12 (MISSION H-1):
TRANSLUNAR INJECTION PROCESSOR

By David S. Scheffman, Jerome D. Yencharis, and Kenneth T. Zeiler
Lunar Mission Analysis Branch

September 25, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved: Ronald L. Berry
Ronald L. Berry, Chief
Lunar Mission Analysis Branch

Approved: John P. Mayer
for John P. Mayer, Chief
Mission Planning and Analysis Division

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RTCC REQUIREMENTS FOR APOLLO 12 (MISSION H-1):

TRANSLUNAR INJECTION PROCESSOR

By David S. Scheffman, Jerome D. Yencharis,
and Kenneth T. Zeiler

SUMMARY

For the Apollo 12 (H-1) mission, the Real-Time Computer Complex must be able to simulate the nominal S-IVB hypersurface solutions for translunar injection and to do mission planning for a dispersed earth parking orbit.

This document describes the functional flow of the translunar injection processor and the detailed logic that allows the flight controllers to select and display one or more of the following options.

- a. S-IVB hypersurface solution
- b. Integrated free-return trajectory
- c. Hybrid ellipses
- d. Specified apogee altitude

INTRODUCTION

The translunar injection processor for the H-1 mission consists of two basic computation modules.

1. Hypersurface (i.e., subroutine HYPER)
2. Generalized iterator (i.e., forward iterator)

Both of these basic computational modules are documented. Reference 1 completely describes the logic and associated input and output for the hypersurface. The basic structure for the generalized iterator is documented in reference 2. Because the generalized iterator is already defined, this document need only describe the arrays for the dependent and independent variables and the computational sequences used by the generalized iterator.

The TLI processor also uses the subroutine LVTAR to generate targeting parameters. The function and detailed logic for this subroutine are described in the text.

In addition to defining the detailed flow of the computational modes for the generalized iterator, the text describes the functional flow of the processor. The functional flow illustrates the integration of the basic computational modules into a single unit that satisfies mission control requirements.

NOTATION

Abbreviations

EPO	earth parking orbit
FGL	first guess logic
TLI	translunar injection
MED	manual entry device
MPT	mission planning table
g.e.t.	ground elapsed time
G.m.t.	Greenwich mean time
RTCC	Real-Time Computer Complex
SC	spacecraft

Symbols

a	semimajor axis
C_3	energy
H	height
I	inclination
I_{OPP}	injection opportunity flag
M	mass
T	time
R	radius
$TU1$	target update flag
V	velocity
e	eccentricity
δ	declination of the target vector from the EPO plane measured positively toward the EPO axis of rotation
γ	flight-path angle
ψ	azimuth
σ	the perigee ring half angle
λ	longitude
ω_p	argument of perigee
Ω	right ascension
ϕ	latitude

Subscripts

b	burn
c	coast
fr	free return
ign	ignition
man	maneuver
nd	node
pl	perilune
rem	remaining
rtny	reentry
tli	translunar injection

FUNCTIONAL FLOW LOGIC

The TLI supervisory logic controls the computation procedures which simulate the S-IVB injection maneuver from the earth parking orbit. The options available enable the flight controller to simulate the nominal S-IVB burn from any injection opportunity or to generate alternate flight plans within the S-IVB ΔV capability. Flow chart 1 illustrates the functional flow for the translunar injection processor.

The output for the supervisory logic is the planning display which provides digital information for the flight controller. The format and the digital information displayed are defined in reference 3.

The TLI supervisor provides four mission options for the flight controller. These options are listed below in the order of increasing mission degradation.

- a. Option 1 - the S-IVB hypersurface solution

- b. Option 2 - integrated free-return trajectory
- c. Option 3 - the basic cislunar ellipse for the hybrid mission
- d. Option 4 - specified apogee altitude

The processor simulates the S-IVB injection maneuver for any injection opportunity for each of the above options.

For a nominal or mildly dispersed EPO, normally the hypersurface will target the TLI maneuver for the Apollo missions. The hypersurface, described in detail in reference 1, is an onboard S-IVB targeting scheme based on empirical data. No update capability is provided for the hypersurface.

For nonnominal situations the generalized iterator has the capability to generate the mission H-1 integrated free-return trajectory to the nominal mission preflight end condition or retarget to a high elliptical earth orbit.

The free-return logic computes a new trajectory to a nominal height and latitude at perilune by first generating an integrated trajectory to the nominal nodal position.

Options 3 and 4 compute alternate flight plans with an S-IVB burn into a high ellipse. The program logic computes the high ellipse either by maximizing apogee altitude for a given ΔV (option 3) or calculating a high ellipse with a specified apogee altitude (option 4). Option 3 provides the basic cislunar ellipse from which a circumlunar hybrid mission can be generated. [The corresponding SPS thrusting maneuver from the cislunar ellipse onto the translunar trajectory could be computed and associated parameters displayed by the midcourse processor (ref. 4).] As indicated above under option 4, a desired apogee altitude is input manually to the program and the corresponding high ellipse and the S-IVB thrusting maneuver computed and the appropriate quantities displayed. The logic is used to compute the mission E type of ellipse for the mission H-1 alternate mission capability.

In options 2, 3, and 4, one pass is made through the subroutine LVTAR to formulate S-IVB targeting parameters. LVTAR accepts as input several parameters from the generalized iterator output. The transfer of the TLI maneuver to the MPT (ref. 5) will cause the set of S-IVB targeting parameters to be transferred automatically for options 2, 3, and 4.

INPUT - OUTPUT

Inputs for all TLI processor options fall into two categories: quantities from a Data Table, and quantities manually entered during the mission via MED. The Data Table contains variables which are needed to execute the different options. These variables may be target parameters used in one of the alternate missions or first guesses for certain independent variables used in the integrated free return. This table also contains parameters which change according to the nominal mission design and launch day. Each time an option is to be computed, the appropriate independent and dependent variables and their desired values are called from the Data Table. The MED quantities and Data Table are defined in tables I and II, respectively.

Output from the TLI processor will be of three types: that displayed, that sent to the MPT, and that which updates the Data Table. Display parameters are shown in table III and defined in reference 3.

Two sets of parameters are defined for the TLI processor and MPT interface. The information sent to the MPT for the nominal hypersurface burn (option 1) is defined as follows.

- a. Injection opportunity flag
- b. Target flag indicating no update

For the mission design options (options 2, 3, and 4), the parameters transferred to the MPT include the following.

- a. Guidance mode flag
- b. Target flag indicating update
- c. Updated S-IVB targeting parameters

As stated in the functional flow description, the appropriate parameters will be automatically transferred to the MPT from the TLI processor.

INTEGRATED FREE-RETURN TRAJECTORY

The generalized iterator (ref. 2) will be used in the RTCC in conjunction with the following procedure to compute an integrated free-return-type mission.

Step 1.- The first step is to integrate the earth parking orbit from the current vector to the nominal TLI ignition time. The state vector obtained at the nominal TLI ignition time will be used as the base state for both the first guess logic and the generalized iterator.

Step 2.- The second step is to compute first guesses for C_3 , T_c , and σ by the use of CIST (ref. 6). To eliminate the tangency surface problem (ref. 6), CIST should be solved so that ϕ_{pl} is zero. [The inaccessible node logic (flow chart 2) is also found in ref. 6]. To avoid departure from the range of validity for the TLI polynomials, the first guess used for δ is one-fourth the value obtained from CIST.

Step 3.- The third step is to compute a conic free-return trajectory to the nominal perilune altitude and latitude.

Step 3

Independent variables	First guess	Trigger	Weight	Step size
C_3	CIST	On	1	$\begin{matrix} -21 \\ 2 \end{matrix}$
T_c	CIST	On	1	$\begin{matrix} -22 \\ 2 \end{matrix}$
δ	CIST/4	On	1	$\begin{matrix} -21 \\ 2 \end{matrix}$
σ	CIST	Off	--	--

Dependent variable	Minimum	Maximum	Class designator	Weight
H_{pl}	Nominal - 0.5 n. mi.	Nominal + 0.5 n. mi.	1	--
ϕ_{pl}	Nominal - 0.01°	Nominal + 0.01°	1	--
I_{pl}	90°	182°	0	64
$H_{fr\ rtn}$	64.1 n. mi.	67.6 n. mi.	1	--
$I_{fr\ rtn}$	0°	90°	0	8

Step 4.- The fourth step uses conic followed by integrated TLMC, combined with the state vector at perilune from TLMC step 3, to refine the value of C_3 . The translunar flight time from step 3 is offset by ΔT_{MED} . The independent and dependent variable array is as follows.

Step 4

Independent variables	First guess	Trigger	Weight	Step size
Longitude _{pl}	Step 3	On	1	2^{-19}
Velocity _{pl}	Step 3	On	1	2^{-19}
Azimuth _{pl}	Step 3	On	1	2^{-19}
ΔT_{TLI-pl}	Step 3 - ΔT_{MED}	Off	--	--

Dependent variable	Minimum	Maximum	Class Designator	Weight
X (post-TLI point)	Step 3 -.0657 n. mi.	Step 3 +.0657 n. mi.	1	--
Y (post-TLI point)	Step 3 -.0657 n. mi.	Step 3 +.0657 n. mi.	1	--
Z (post-TLI point)	Step 3 -.0657 n. mi.	Step 3 +.0657 n. mi.	1	--
γ (TLI point)	0°	90°	0	1

Step 5.- The fifth step is to compute an integrated trajectory to the nominal perilune position by use of the offset flight time from step 4.

Step 5

Independent variables	First guess	Trigger	Weight	Step size
C_3	Step 4	On	1	2^{-21}
T_c	Step 3	On	1	2^{-22}
δ	Step 3	On	1	2^{-21}
σ	CIST	Off	--	--
ΔT_{nd}	Step 3 - ΔT_{MED}	Off	--	--

Dependent variable	Minimum	Maximum	Class	Weight
H_{nd}	Nominal - 1.0 n. mi.	Nominal + 1.0 n. mi.	1	--
ϕ_{nd}	Nominal - 0.1°	Nominal + 0.1°	1	--
λ_{nd}	Nominal - 0.1°	Nominal + 0.1°	1	--
I_{nd}	90°	182°	0	64

Step 6.- The final step uses the converged answers determined from step 5 as first guesses to initiate the integrated free-return trajectory.

Step 6

Independent variables	First guess	Trigger	Weight	Step size
C_3	Step 5	On	1	2^{-21}
T_c	Step 5	On	1	2^{-22}
δ	Step 5	On	1	2^{-21}
σ	Step 5	Off	--	--

Dependent variable	Minimum	Maximum	Class	Weight
H_{pl}	Nominal - 0.5 n. mi.	Nominal + 0.5 n. mi.	1	--
ϕ_{pl}	Nominal - 0.01°	Nominal + 0.01°	1	--
$H_{fr\ rtn}$	60.85 n. mi.	70.85 n. mi.	1	--
I_{pl}	90°	182°	0	64
$I_{fr\ rtn}$	0°	90°	0	8

Hybrid Alternate Missions

If a nominal second S-IVB burn is not available, the generalized iterator computes a burn into a cislunar elliptical earth orbit. This ellipse is the initial trajectory from which a hybrid circumlunar alternate mission can be generated. (For a description of this alternate mission, see ref. 4.) The computational procedure, defined below, maximizes apogee altitude for a specified ΔV available for TLI. The value of C_3 is calculated internally for a $\delta = 0$. However, this value of C_3 will be close enough for a first guess when δ is not zero. The first guess for C_3 is shown in the appendix. To compute this ellipse from earth orbit, use the following array:

Independent variable	First guess	Weight	Step size
C_3	first guess is a function of ΔV available for TLI	4	2^{-23}
δ	Data Table	Not triggered	--
σ	Data Table	Not triggered	--
T_{ign}	MED	Not triggered	--

Dependent variable	Minimum	Maximum	Class designator	Weight
M_{tli}	Desired - 5 lb	Desired + 5 lb	1	--

After the above array has been converged in the conic mode, the terminal value of C_3 along with the constant values of δ , σ , and T_{ign} are used as first guesses for the integration of the ellipse. The variable array for the integration will be the same as for the conic.

MISSION E-TYPE ELLIPSES

If the S-IVB is not capable of injecting the SC on a translunar trajectory or into a hybrid ellipse, the only alternative is to perform an E-type mission. With the apogee (specified altitude) of the ellipse known, the energy (C_3) is predetermined. Energy is a function (see the appendix) of apogee and is determined by the relation $C_3 = \mu/a$. Apogee altitude is measured from the earth's surface. Because apogee is an MED quantity, the generalized iterator will be used to integrate the resulting ellipse and generate the display. The independent and dependent variable array is as follows.

Independent variable	First guesses	Weight	Step size
δ	Predetermined	Not triggered	--
σ	Predetermined	Not triggered	--
T_{ign}	MED	Not triggered	--
C_3	For first guess, see appendix	4	2^{-23}

Dependent variable	Minimum	Maximum	Class designator	Weight
Apogee	MED - 1 n. mi.	MED + 1 n. mi.	1	--

As in the hybrid mission, the internal calculation of C_3 will again be sufficient as a first guess if δ is not zero.

The detailed flow chart for the mission E type of ellipse is presented in flow chart 4.

SIMULATION OF SECOND S-IVB BURN

All S-IVB second burns are simulated by use of the polynomials from reference 8. For options 2, 3, and 4 of this precessor, the use of the polynomials is straightforward; but for option 1 (the hypersurface solution), the polynomials will be used somewhat differently. Table IV lists the inputs needed to evaluate the polynomials for option 1. Note from the table that several of the inputs are obtained from subroutine HYPER. The equations necessary for the evaluation of the polynomials for option 1 are contained in flow chart 5.

The TLI polynomials usually are used (options 2, 3, and 4) when no target vector is present for the TLI simulation. However, in option 1, a definite target vector is used and the ignition geometry is fixed. The equations in flow chart 5 illustrate the method of using the TLI polynomials to provide the ΔV and burn time for the maneuver.

LAUNCH VEHICLE TARGETING SUBROUTINE

The subroutine LVTAR will generate the targeting parameters needed by the subroutine HYPER to provide targeting input the IGM in the MPT for options 2, 3, and 4. LVTAR uses the input provided by one of the three real-time mission design options and transforms the reference for three of the parameters.

Flow chart 6 presents the detailed flow for LVTAR, and table V described the input/output for the subroutine.

TABLE I.- MED INPUT

Input	Option 1	Option 2	Option 3	Option 4
Display option code	X	X	X	X
IØPP	X	X		
TU1	X			
T _{ign}			X	X
ΔV available for TLI			X	
H _a				X

TABLE II.- DATA TABLE^a

Parameter	Option 2	Option 3	Option 4
ϕ_{ign}	X		
λ_{ign}	X		
ψ_{ign}	X		
T_{ign}	X	X	X
R_{ign}	X		
$\bar{\phi}_{pc}$	X		
λ_{pc}	X		
δ	X	X	X
σ	X	X	X
I_{fr}	X		
H_{pc}	X		
H_{rtny}	X		
Rtny Rng	X		
i_{co}	X	X	X
RAN	X	X	X
e	X	X	X
C_3	X	X	X
ω_p	X	X	X
f_{co}	X	X	X

^aINPUT/OUTPUT for option 1; the nominal hypersurface solution is defined in reference 1.

TABLE III.- DISPLAY PARAMETERS

Parameter	Option 1	Option 2	Option 3	Option 4
STAI ^a	X	X	X	X
GMTV ^a	X	X	X	X
GETV ^a	X	X	X	X
WEIGHT ^a	X	X	X	X
TD REV ^a	X	X		
VENT ^a	X	X	X	X
CODE ^a	X	X	X	X
GETTH ^a	X	X	X	X
GETTB ^{a,b}	X	X	X	X
GETIG ^b	X	X	X	X
T _b ^b	X	X	X	X
ΔV_{man} ^b	X	X	X	X
ΔV_{rem} ^c	X	X	X	X
H _a ^d			X	X
ϕ_{ign} ^d	X	X	X	X
λ_{ign} ^d	X	X	X	X

^aParameters external to this processor are defined in reference 5.

^bParameters computed directly in TLI processor.

^cParameter computed by use of the standard rocket equation.

^dParameters computed by use of existing IBM subroutines.

TABLE IV.- INPUT/OUTPUT FOR POLYNOMIAL
SIMULATION OF TLI (HYPERSURFACE SOLUTION)

INPUT

[From subroutine HYPER]

C_3	twice vis viva energy desired at cutoff
σ	the perigee ring half angle
$(\bar{R}, \bar{V}, t)_{\text{IGN}}$	state vector at ignition

[From subroutine S-IVB]

F	thrust magnitude at nominal mixture ratio
F_1	thrust magnitude at adjusted mixture ratio
\dot{W}	weight flow rate at nominal mixture ratio (positive)

[Other Input]

W_{IGN}	weight at ignition
------------------	--------------------

OUTPUT

ΔV	characteristic velocity
t_B	burn time

TABLE V.- INPUT/OUTPUT FOR SUBROUTINE LVTAR

INPUT

Constant (premission)

λ_{PAD}	longitude of launch
Δt_6	constant delta time from restart preparation initiation to engine ignition

Variable Inputs

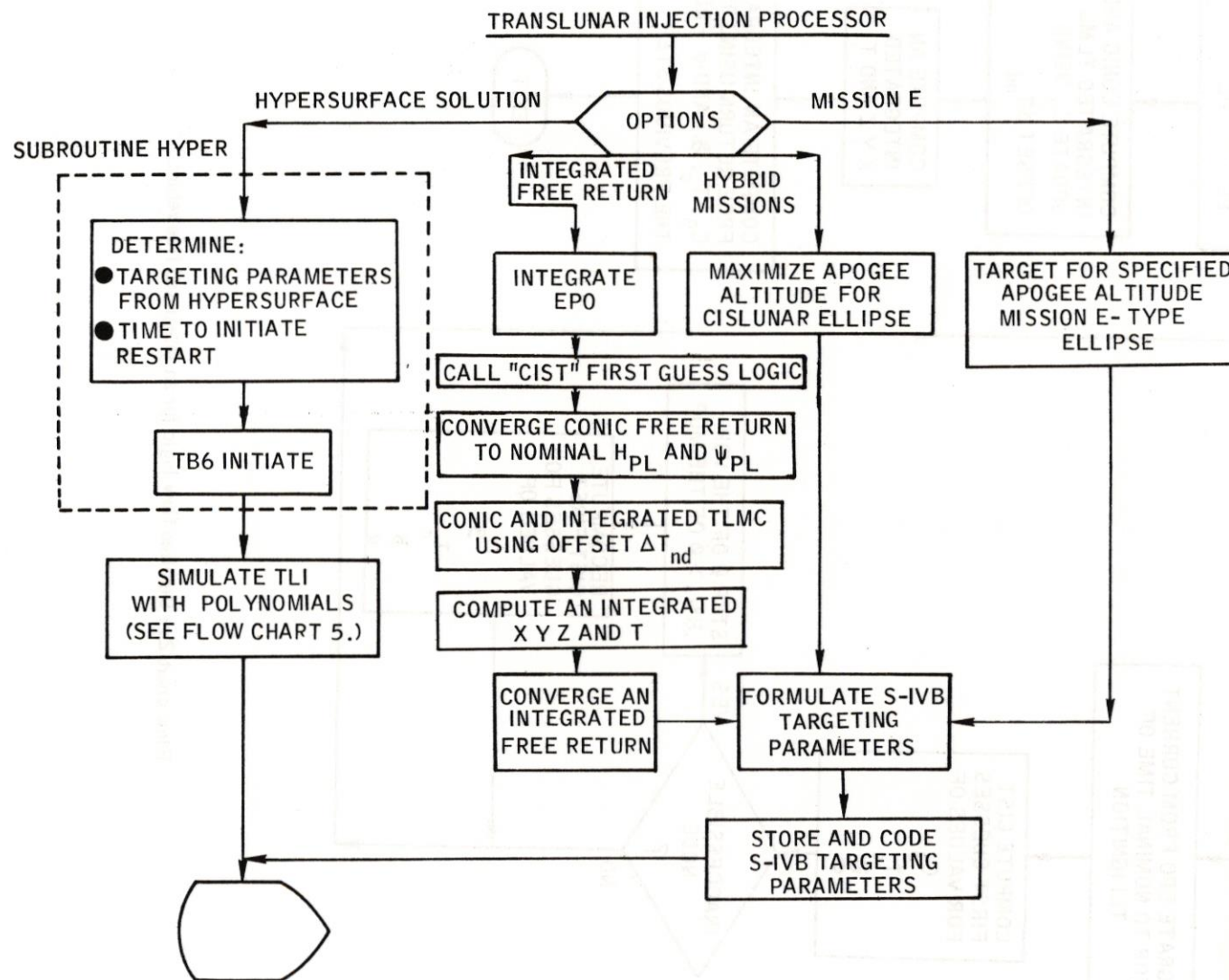
i_{co}	inclination of desired cutoff plane
e_{co}	eccentricity of desired cutoff ellipse
C_{3co}	twice vis viva energy desired at cutoff
ω_p	argument of perigee of desired cutoff ellipse
f_{co}	estimate true anomaly at cutoff
t_{ign}	time of ignition
T_l	actual time of launch
RAN	right ascension of ascending node of desired cutoff ellipse
RAGL	right ascension of Greenwich at time of launch

OUTPUT

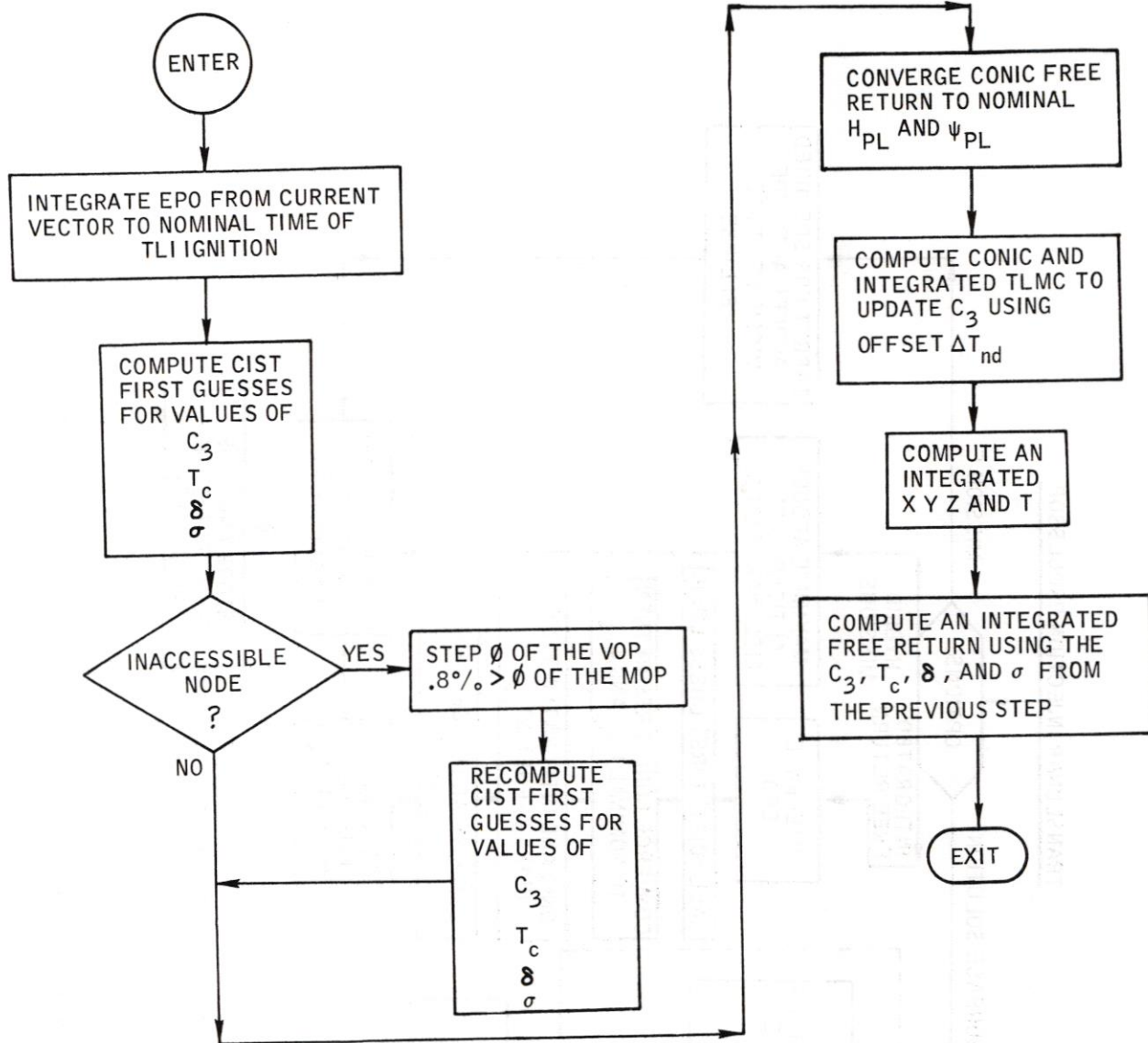
TB6	time of restart preparation initiation
-----	--

TABLE V.- INPUT/OUTPUT FOR SUBROUTINE LVTAR - Concluded

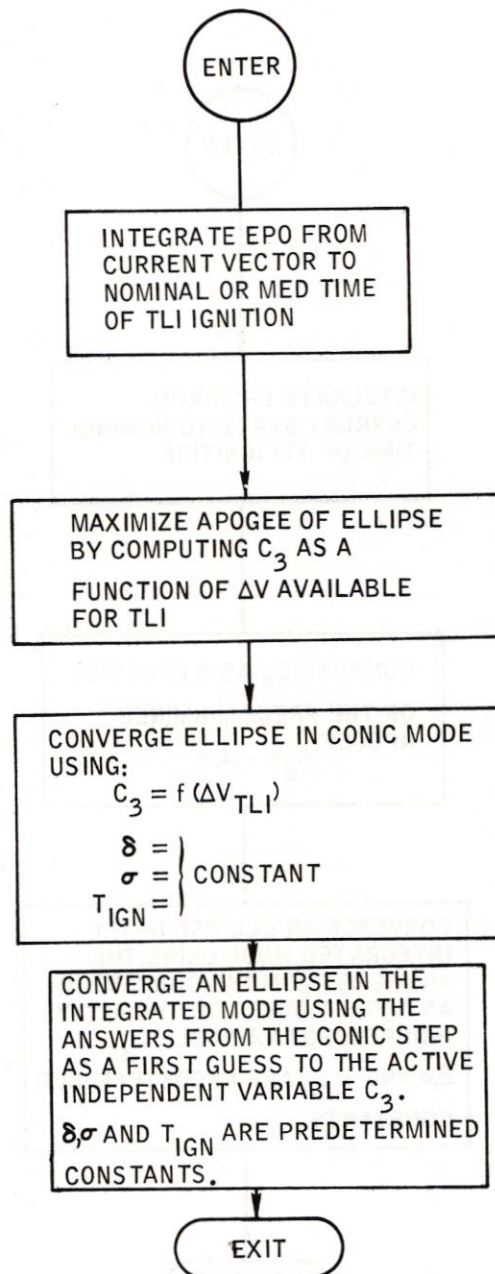
Output	
i	inclination of desired cutoff plane
θ_n	descending node of cutoff plane, referenced to launch meridian at time of launch
e	eccentricity at cutoff
C_3	twice vis viva energy
α_d	angle from desired perigee of cutoff ellipse to descending node of cutoff ellipse
f	estimated true anomaly at cutoff
TU1 = 1	indicates target update



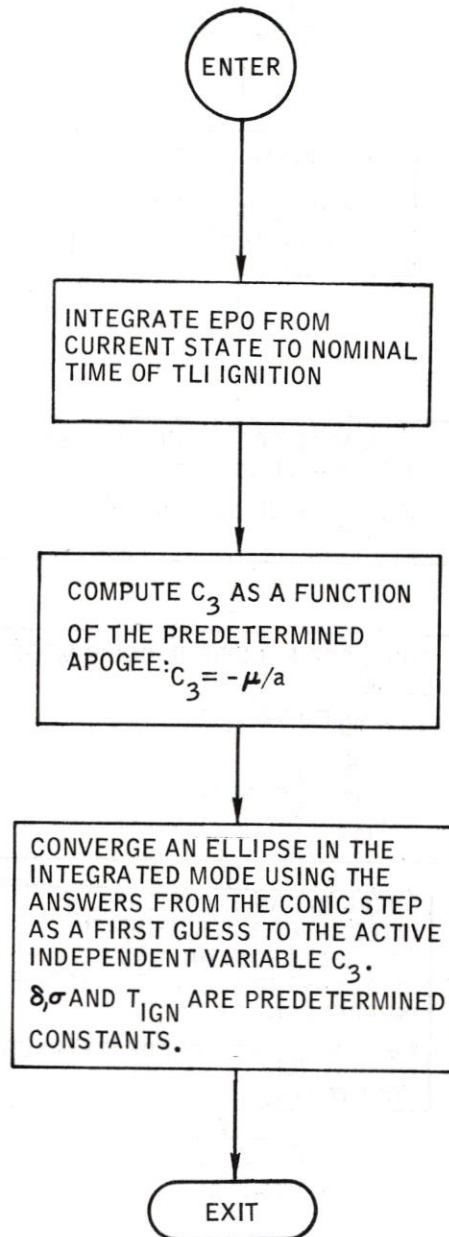
Flow chart 1.- Functional flow logic for the translunar injection processor.



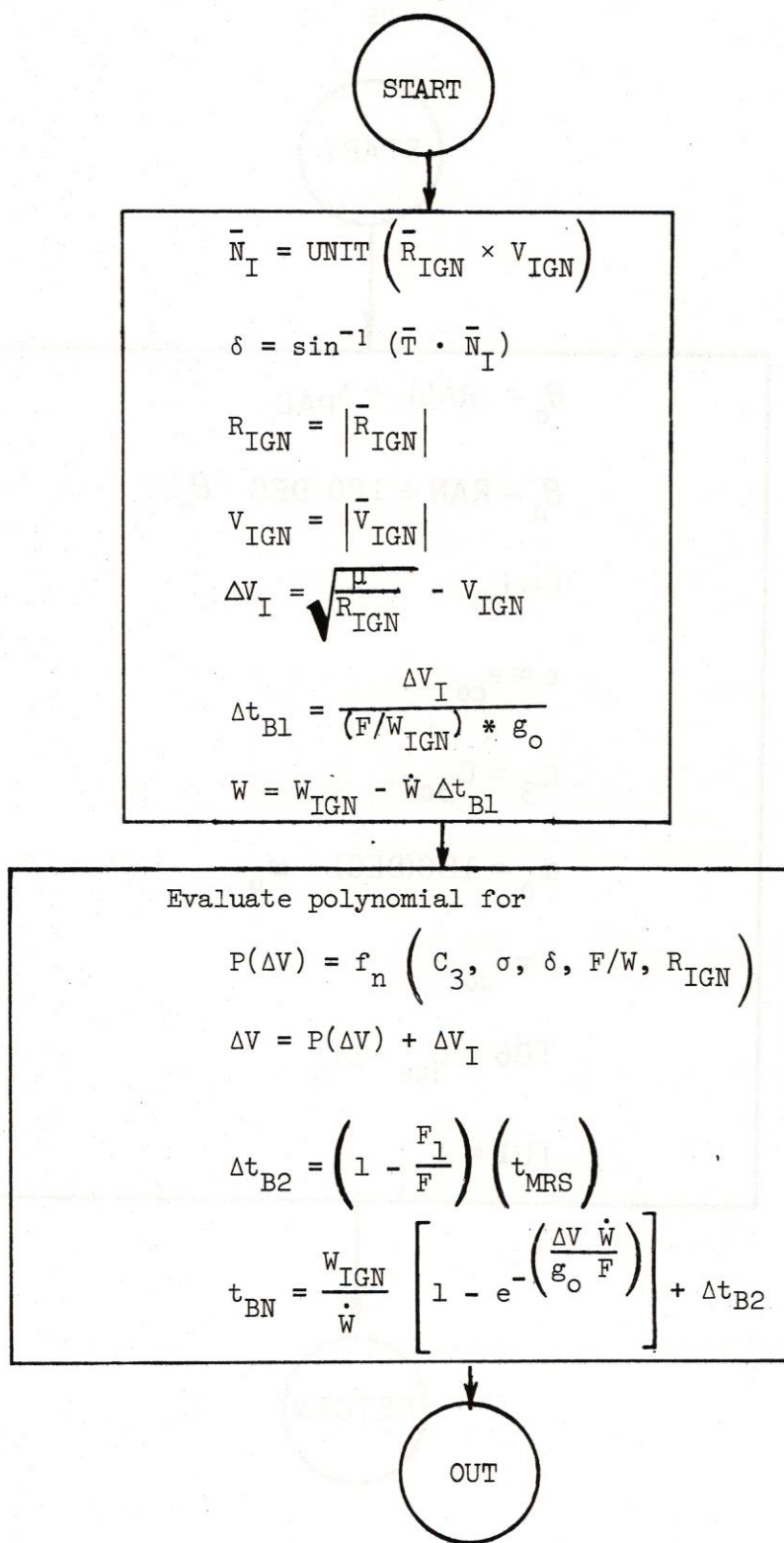
Flow chart 2.- Detailed flow logic for an integrated free return.



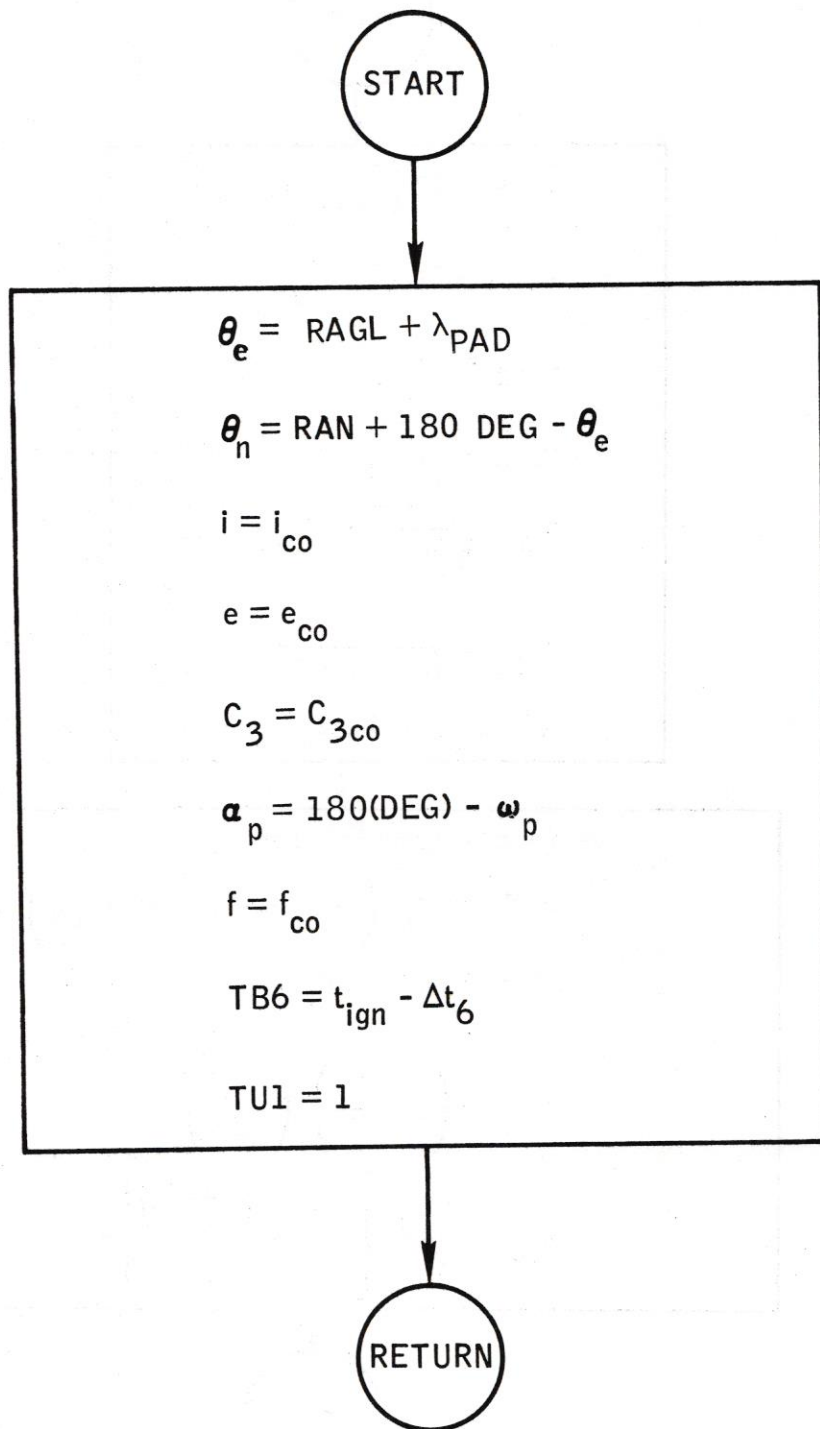
Flow chart 3.- Detailed flow logic for computing a hybrid ellipse.



Flow chart 4.- Detailed flow logic for computing a mission E-type ellipse.



Flow chart 5. - Simulation of second S-IVB burn
(hypersurface solution - option 1)



Flow chart 6. - Detailed flow logic for subroutine LVTAR.

APPENDIX

HYBRID, ALTERNATE MISSIONS

First guess for C_3 Assume $|\Delta \bar{V}| = \Delta \bar{V}$ for $\delta + 0$:

$$|\Delta \bar{V}| = g * Isp * \ln (M_{EPO}/M_{TLI})$$

$$C_3 = |\Delta \bar{V}|^2 - \frac{\mu}{R_I} + 2|\Delta \bar{V}| \sqrt{\frac{\mu}{R_I}}$$

 R_I = radius at ign

MISSION E-TYPE ELLIPSES

First guess for C_3

$$H_{Ap} = a(1 + e) - 1 \text{ e.r.}$$

height of apogee.

$$H_p = a(1 - e) - 1 \text{ e.r.}$$

height of perigee

$$H_{Ap} + H_p = 2a - 2 \text{ e.r.}$$

$$a = \frac{H_{Ap} + H_p}{2} + 1 \text{ e.r.}$$

 H_p assumed to be 105 n. mi.

$$C_3 = - \mu/a$$

REFERENCES

1. Yencharis, J. D.; and Fridge, Ernest M.: AS-504A Requirements for the RTCC: Powered-Flight Simulation. MSC IN 67-FM-82, June 28, 1967.
2. Moore, William E.: AS-503A/504A Requirements for the RTCC: Generalized Iterator. MSC IN 66-FM-131, November 4, 1966.
3. Flight Control Division/J. D. Hodge: RTCC Requirements: AS-504 Translunar Injection (TLI) Planning Display. March 9, 1967.
4. Morrey, B. F.; and Sellers, Donald R.: AS-504 Requirements for the RTCC: Translunar Midcourse Correction Processor. MSC IN 67-FM-80, June 19, 1967.
5. Fridge, Ernest M.; and Cary, Thomas M.: Logic for the Real-Time Computation of the Mission Planning Table. MSC IN 66-FM-68, June 30, 1966.
6. Johnson, Francis, Jr.; and Linbeck, Thomas J.: Logic to Provide the Generalized Iterator with First Guesses for the RTCC TLI Processor. MSC IN 68-FM-32, February 1, 1968.
7. Moore, William E.: User's Guide for the Generalized Forward Iterator. MSC IN 66-FM-58, June 17, 1966.
8. Yencharis, J. D.: RTCC Requirements for Missions F and G: Empirical Equations for Simulating the Translunar Injection Maneuver. MSC IN 68-FM-154, June 25, 1968.