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RTCC REQUIREMENTS FOR APOLLO 10 (MISSION F) PREFLIGHT INFORMATION

Lunar Mission Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PROJECT APOLLO

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By Rocky D. Duncan
Lunar Mission Analysis Branch

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RTCC REQUIREMENTS FOR APOLLO 10 (MISSION F)

PREFLIGHT INFORMATION

By Rocky D. Duncan

SUMMARY AND INTRODUCTION

The purpose of this document is to present the preflight data requirements for direct support of the RTCC programs for Apollo 10 (Mission F). Also included in this document are the most current definitions of the data required for Missions F and G. Therefore, some of the preflight data requirements are not applicable to Apollo 10 (Mission F). The information applies only to those processors formulated by the LMAB. The processors for which preflight information has been defined are as follows.

1. TLI processor
2. MCC processor
3. Return-to-earth processor
4. LOI processor
5. Powered-flight processor

SYMBOLS

CSM	command and service modules
DPS	descent propulsion system
EMP	earth-moon plane
FCUA	fuel-critical unspecified area
LLS	lunar landing site

LM	lunar module
LMAB	Lunar Mission Analysis Branch
LOI	lunar orbit insertion
LOPC	lunar orbit plane change
LPO	lunar parking orbit
MCC	midcourse correction
MPT	mission planning table
n.d.	nondimensional
opp	opportunity
RTCC	Real-Time Computer Complex
SPS	service propulsion system
TEI	transearth injection
TLI	translunar injection
TLMC	translunar midcourse correction

TRANSLUNAR INJECTION AND MIDCOURSE CORRECTION PROCESSORS[a]

This section describes the parameters, coefficients, and constants associated with the TLI and MCC processors.[a] Most of the preflight data defined in this section is used by both processors; consequently, both processors are treated as a single entity. Definitions of the individual parameters and constants are presented in table I.

The TLI and MCC processors require the largest share of the preflight data requirements. Most of these requirements are the parameters which vary with launch azimuth, injection opportunity, and launch day across a monthly launch window. These numbers are dependent and independent variables which constitute all the first guesses and other numbers required to fly the mission. Because of the large number of parameters required, it has been decided to provide these data to IBM on tape.

[a]The formulation for the RTCC TLI and MCC processors is described in references 1 and 2.

The tape quantities were first punched on cards by the LMAB and then a card-to-tape process was used with IBM equipment. The purpose of this procedure is to avoid the difficulty of the differences in tapes generated by IBM and UNIVAC tape drives. The punched-card format and the order of the parameters are shown in table II. For each launch azimuth and injection opportunity, there is a data set on tape that consists of all the parameters required to fly that particular mission. The data sets will be ordered on the cards as follows.

1. Launch day

2. Launch azimuth

3. Second opportunity

4. First opportunity

The remainder of the preflight data (table III) which does not vary with launch day is provided by written transmittal.

RETURN TO EARTH PROCESSOR

The return to earth processor determines the maneuver required to produce trajectories which return to earth through use of state vectors in either moon or earth reference. The return to earth processor is described in references 3 and 4, and the constants, coefficients, and numbers associated with this processor are defined in table IV. These preflight data requirements can be functionally categorized as follows.

1. General constants

2. Generalized iterator constants

3. Guidance and targeting constants

4. Conic subprocessor constants

The preflight data for Apollo 10 (Mission F), alternate 1, are presented in tables V, VI, and VII.

LUNAR ORBIT INSERTION PROCESSOR

The LOI targeting processor computes several impulsive maneuvers to transfer from an approach hyperbola to a lunar parking orbit. A description of the lunar orbit insertion processor can be found in reference 5. The impulsive maneuvers transfer the spacecraft to different LPO's (such as an LPO with the minimum LOI ΔV or an LPO nearest the desired LPO). The flight controller selects the desired maneuver and transfers it to the MPT where the powered-burn targets are computed and the guidance is selected.

The preflight data requirements for the LOI processor are presented in table VIII. The actual values are presented in table IX. Note that most of the LOI processor data requirements are contained in the MCC data tables.

POWERED-FLIGHT PROCESSOR

The parameters and constants associated with the powered-flight processor (ref. 6) are described in this section. The powered-flight processor simulates thrusting maneuvers in the RTCC. The associated parameters and constants are principally the guidance constants and targeting parameters associated with the iterative guidance equations and the hypersurface, respectively.

Because some of the powered-flight processor preflight data varies with launch azimuth, injection opportunity, and launch day, it was decided to provide these data on tape. This arrangement is convenient because these data are provided to MSC by MSFC in the launch vehicle PRESET tape.

LMAB will verify the numbers on the PRESET tape and generate cards for delivery to IBM. A card-to-tape process will be used to generate an IBM tape.

All of the parameters and constants used by the powered-flight processor are defined in table X. The format for the PRESET tape is presented in table A-I, and the format for the cards delivered to IBM is presented in table A-II. This card format allows for up to a 10-day monthly launch window.

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS

ASSOCIATED WITH THE TLI AND MCC PROCESSORS

No.	Parameter or constant	Processor utilizing parameter		Parameter or constant on tape	Definition
		TLI	MCC		
1	TLI_{ign}	X		Yes	Ground elapsed time of translunar injection ignition
2	δ	X		No	Declination of target vector for alternate missions
3	σ	X		No	Perigee ring half-angle for alternate missions
4	$T_{max\ sea}$		X	No	Maximum G.m.t. of pericynthion due to sun elevation constraints
5	$T_{min\ sea}$			No	Minimum G.m.t. of pericynthion due to sun elevation constraints
6	γ_{loi}		X	Yes	Flight-path angle at lunar orbit insertion initiation
7	$\Delta\psi_{loi}$		X	Yes	Change in azimuth at lunar orbit insertion
8	H_{pc}	X	X	Yes	Height of pericynthion
9	ϕ_{pc}	X	X	Yes	EMP latitude at pericynthion
10	λ_{pc}	X	X	Yes	EMP longitude at pericynthion
11	GMT_{pc}		X	Yes	G.m.t. time of pericynthion from epoch
12	ΔT_{lls}		X	Yes	Flight time from lunar orbit insertion to first pass over lunar landing site
13	T_{lo}		X	Yes	Total time spent in lunar orbit
14	ϕ_{lls}		X	Yes	Selenographic latitude of the lunar landing site
15	λ_{lls}		X	Yes	Selenographic longitude of lunar landing site
16	R_{lls}		X	Yes	Radius of the lunar landing site
17	ψ_{lls}		X	Yes	Selenographic azimuth over the lunar landing site
18	$I_{fr(max)C}$	X	X	No	Conic inclination of the free-return trajectory plus ΔI_{fr}
19	$I_{fr(max)I}$			No	Integrated inclination of the free-return trajectory plus ΔI_{fr}

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS

ASSOCIATED WITH THE TLI AND MCC PROCESSORS - Concluded

No.	Parameter or constant	Processor utilizing parameter		Parameter or constant on tape	Definition
		TLI	MCC		
20	ΔV_{tei}		X	Yes	Change in velocity at TEI (scalar)
21	$\Delta\psi_{tei}$		X	Yes	Change in azimuth at transearth injection
22	T_{te}		X	Yes	Time from transearth injection to entry
23	Rnty Rng		X	No	Earth relative entry range
24	Rnty Δt		X	No	Delta t from entry to landing
25	h_{rtny}	X	X	No	Height at entry for free return
26	γ_{rtny}	X	X	No	Flight-path angle at entry
27	I_{pr}		X	No	Maximum inclination for powered return
28	λ_{ip}		X	No	Longitude of earth impact point
29	$T_{tl\ min\ dps}$		X	No	Minimum translunar flight time for DPS abort
30	$T_{tl\ max\ dps}$		X	No	Maximum translunar flight time for DPS abort
31	m				Number required to compute the CSM plane change prior to LM ascent
32	n		X	No	
33	T_{biaseo}		X	No	Bias time for elliptical lunar parking orbit
34	V_{pcynlo}		X	No	Velocity at pericynthion of the elliptical lunar parking orbit
35	I_{fr}		X	Yes	Inclination of free return
36	Δt_{ndcir}		X	No	Delta t from the LPO node to circularization in the final LPO
37	H_{pc}		X	No	Height of pericynthion relative to the landing site of elliptical lunar parking orbit
38	H_{ac}		X	No	Height of pericynthion relative to the landing site of elliptical lunar parking orbit

TABLE II.- FORMAT FOR TLI AND MCC TAPE

Card no.	Column 1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
1	341	1	0.108E+03	P	693411108P1
	(Day)	(Opportunity)	(Launch ψ)	(Window)	(Identification[a])
2	0.351723E+01	0.18003591E+03	0.8015632E+02	0.2183654	693411108P2
	(ϕ_{pc})	(λ_{pc})	(H_{pc})	(g.e.t. of TLI_{ign})	(Identification[a])
3					693411108P3
					(Identification[a])
4	0.418563E+01	-0.113801956E+01	0.685321E+02	0.2631562E+02	693411108P4
	($\Delta\psi_{loi}$)	(γ_{loi})	(T_{lo})	(ΔT_{lls})	(Identification[a])
5	0.7253621E+02	0.10300852E+01	0.45056623E+02	0.938E+02	693411108P5
	(ψ_{lls})	(ϕ_{lls})	(λ_{lls})	(R_{lls})	(Identification[a])
6	-0.31044682E+01	0.276191422E+04	0.103856155E+02	0.173E+02	693411108P6
	($\Delta\gamma_{tei}$)	(ΔV_{tei})	(T_{te})	(I_{fr})	(Identification[a])
7	108.3E + 03	RESERVED FOR EXPANSION			
	(G.m.t. of pc)				
8		RESERVED FOR EXPANSION			

[a]The identification number has the following parts: 693411108P1

Year	Card number
Day	Injection window
Opportunity	Launch azimuth

TABLE III.- VALUES FOR VARIABLES NOT FOUND ON TAPE[a]

Variable	Value
δ	0.0°
σ	7.5°
$T_{max\ sea}$	N A
$T_{min\ sea}$	N A
$I_{fr(max)C}$	75°
$I_{fr(max)I}$	90°
H_{rnty}	400 000 ft
Rnty Rng	1285 n. mi.
Rnty Δt	492 sec
γ_{rtny}	-6.52°
I_{pr}	40°
λ_{ip}	165° W
$T_{tl\ min\ dps}$	N A
$T_{tl\ max\ dps}$	N A
m	0
n	0
T_{biaseo}	.332 hr
V_{pcynlo}	5480.0 fps
Δt_{ndcir}	4.3 hr
H_{pc}	60 n. mi.
H_{ac}	170 n. mi.

[a]N A = not applicable to F.

TABLE IV.- RETURN TO EARTH ABORT PROCESSOR CONSTANTS TAPE LIST

Variable symbol	Variable definition
(a) General constants	
e_{LIM}	Eccentricity limit for EFCUA
MD_{MAX}	Maximum miss distance used in the trade-off displays
ΔMD	Miss distance increment used in the trade-off displays
$R_{A\ MAX}$	Abort radius limit for the EFCUA solution in the FCUA mode of the earth phase logic
T_{ARMIN}	Absolute minimum acceptable flight time from abort to entry
(b) Generalized iterator constants	
Tol_j $j = 1, 6$	Dependent variable tolerances
AVO, BVO	Two constants used to determine the minimum and maximum value for $\lvert\overline{\Delta V}\rvert$ in the optimise mode: Minimum = Maximum = MAX [AVO, (conic value) - BVO]
$STPZ_j$ $j = 1, 10$	Step sizes for the independent variables
$IWGT_j$ $j = 1, 11$	Independent variable weights
$DWGT_j$ $j = 1, 2$	Dependent variable weights

TABLE IV.- RETURN-TO-EARTH ABORT PROCESSOR

CONSTANTS TAPE LIST - Continued

Variable symbol	Variable definition
(c) Guidance and targeting constants	
C_{NOMC}	Nominal value of CM computer guidance parameter C
C_{NOML}	Nominal value of LM computer guidance parameter C
R_{TSPH}	Radius of the MSI used by the onboard guidance computer
TB_{SPS}	Maximum burn time for the SPS engine with no iteration in RTED
TB_{DPS}	Maximum full thrust level burn time for the DPS engine with no iteration in RTED
β_{LTST}	Limiting value of flight-path angle between $\overline{R}$ and $\overline{V}$ for solutions from Lambert's problem subroutine with the Lambert's guidance
ΔT_{LTG}	Time increment used in lunar reference to generate Lambert target vectors
ε_{TG}	Lambert's guidance target vector bias angle
η_{ATG}	Alternate transfer angle to Lambert's guidance target vector in earth reference
η_{MTG}	Transfer angle to Lambert's guidance target vector in moon reference
(d) Earth-centered subprocessor	
δT_z	Landing time tolerance for input landing time in the AST discrete solution option
a, b, c	Coefficients for the landing time limit function

TABLE IV.- RETURN-TO-EARTH ABORT PROCESSOR

CONSTANTS TAPE LIST - Concluded

Variable symbol	Variable definition
(d) Earth-centered subprocessor - Concluded	
T_{RZAVE}	Average flight time from entry to landing
η_{RZAVE}	Average down-range angle from entry to landing
(e) Moon-center subprocessor	
ΔT_z	Value of the maximum trip time whenever the maximum landing time is not input for the FCUA option of the AST

TABLE V.- VALUES FOR GENERAL CONSTANTS AND GUIDANCE AND TARGETING CONSTANTS

Variable	Value
e_{LIM}	0.85
MD_{MAX}	400 n. mi.
ΔMD	100 n. mi.
R_{AMAX}	140 000 n. mi.
T_{ARMIN}	20 min
C_{NOMC}	0.5
C_{NOML}	0.0
R_{TSPH}	64 373 760 m
TB_{SPS}	15 sec
TB_{DPS}	15 sec
β_{LTST}	2°
ΔT_{LTG}	2 hr
ε_{TG}	15°
η_{ATG}	215°
η_{MTG}	160°

TABLE VI.- VALUES FOR GENERALIZED ITERATOR CONSTANTS

Constant tape symbol	Associated iterator variable	Value
Tol_1	h_R	0.03 n. mi.
Tol_2	Ψ_R	2°
Tol_3	ϕ_Z	0.10°
Tol_4	λ_Z	0.01°
Tol_5	γ_R	0.001°
Tol_6	T_{AZ}	12 hr
AVO	$\lvert\overline{\Delta V}\rvert$	-10 000 fps
BVO	$\lvert\overline{\Delta V}\rvert$	10 000 fps
$STPZ_1$	$\Delta\Psi_A$	1×10^{-6} rad
$STPZ_2$	$\Delta\gamma_A$	1×10^{-6} rad
$STPZ_3$	ΔV_A	2×10^{-7} er/hr
$STPZ_4$	T_A	1×10^{-7} hr
$STPZ_5$	T_R	1×10^{-6} hr
$STPZ_6$	ΔV_X	1×10^{-7} er/hr
$STPZ_7$	ΔV_Y	1×10^{-7} er/hr
$STPZ_8$	ΔV_Z	1×10^{-7} er/hr
$STPZ_9$	$\Delta\gamma_A$ (optimise setup)	1×10^{-6} rad
$STPZ_{10}$	ΔV_A (optimise setup)	2×10^{-7} er/hr
$IWGT_1$	$\Delta\Psi_A$	1
$IWGT_2$	$\Delta\gamma_A$	1

TABLE VI.- VALUES FOR GENERALIZED ITERATOR CONSTANTS - Concluded

Constant tape symbol	Associated iterator variable	Value
$IWGT_3$	$\Delta\gamma_A$ (optimise setup only)	1
$IWGT_4$	ΔV_A	16
$IWGT_5$	ΔV_A (optimise setup only)	1
$IWGT_6$	T_A (standard setup)	64
$IWGT_7$	T_A (RTED)	1
$IWGT_8$	T_R	1
$IWGT_9$	ΔV_X	1
$IWGT_{10}$	ΔV_Y	1
$IWGT_{11}$	ΔV_Z	1
$DWGT_1$	T_{AZ}	1
$DWGT_2$	$\lvert\overline{\Delta V}\rvert$	200

TABLE VII.- CONIC SUBPROCESSOR

Symbol	Value
(a) Earth-centered subprocessor	
δT	2 hr
a	77.0 hr
b	+6.2 hr/er
c	-0.103333 hr/er^2
T_{RZAVE}	0.17 hr
η_{RZAVE}	0.5 rad
(b) Moon-centered subprocessor	
ΔT_Z	120 hr

TABLE VIII.- PREFLIGHT PARAMETERS FOR LOI PROCESSOR

Symbol	Definition
H_{lo}	Nominal LPO circular orbit altitude referenced to the LLS
H_{ac}	Nominal LPO elliptical orbit apocynthion altitude referenced to the LLS
T_{biaseo}	Time bias to compensate for elliptical LPO
ϕ_{lls}[a]	Latitude of LLS
λ_{lls}[a]	Longitude of LLS
R_{lls}[a]	Radius of LLS
$\left.\begin{matrix} m \\ n \end{matrix}\right\}$	Numbers used to compute CSM plane change
$\Delta V_{loi\ cal}$	Calibration of conic LOI ΔV
$\Delta V_{tei\ cal}$	Calibration of conic TEI ΔV
c	First guess on Lambert guidance constant
Transfer angle	Transfer angle from LOI impulsive point to Lambert target vector
H_{rnty}	Nominal value for height of reentry
I_{pr}[a]	Nominal value for inclination of powered return
T_{te}[a]	Nominal transearth flight time
T_{lo}[a]	Time in lunar parking orbit
ΔT_{lls}[a]	Delta time to first pass over LLS
ΔV_{tei}[a]	Delta velocity at TEI

[a]The parameters are on the MCC preflight data tape.

TABLE VIII.- PREFLIGHT PARAMETERS FOR LOI PROCESSOR - Concluded

Symbol	Definition
$\Delta\psi_{tei}$ [a]	Delta azimuth at TEI
GMT_{pc} [a]	Greenwich mean time of pericynthion measured from epoch

[a]The parameters are on the MCC preflight data tape.

TABLE IX.- LOI PREFLIGHT DATA NOT CONTAINED IN MCC PROCESSOR DATA TABLES

Symbol	Value
H_{lo}	60 n. mi.
H_{ac}	170 n. mi.
T_{bias}	.332 hr
o	1
n	0
$\Delta V_{loi\ cal}$	10 fps
$\Delta V_{tei\ cal}$	0 fps
c	.5
Transfer angle	270°
H_{rnty}	400 000 ft

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM)

Parameter	Definition	Value
$K_{\alpha 1}$, $K_{\alpha 2}$	coefficients of α_{TS} polynomial	0, 0
DTGM	time from TB_6 to time at which IGM guidance is initiated	584.0 sec
DTIG	time from TB_6 to time at which ignition occurs	578.0 sec
K_{po}, K_{yo}	coefficients in pitch, yaw polynomials	90.0, 0.0 deg
K_{T3}	coefficient in T_3 polynomial	0.0
T_2	second guidance stage burn time	120.0 sec (first opp) 0.0 sec (second opp)
t_{b2}	transition time for mixture ratio shift	5.0 sec (first opp) 1.0 sec (second opp)
K_{pc}	constant used to force MRS in IGM	0.0 sec
ϵ_1	remaining burn time for which alternate method of computing range angle is used	1000. sec
ϵ_2	remaining burn time for which guidance enforces only terminal velocity conditions	30. sec
ϵ_3	remaining burn time for which terminal r, v, γ are frozen	30. sec
ϵ_4	remaining burn time at which cutoff equations are entered	3. sec
RφT	flag which indicates rotation of end conditions	1.0
RφV	constant used for biasing terminal range angle prediction	-0.4
$\dot{X}_{YL}$	maximum allowable pitch rate	1.0 deg/sec
$\dot{X}_{ZL}$	maximum allowable yaw rate	1.0 deg/sec
$\dot{X}_{XL}$	maximum allowable roll rate	1.0 deg/sec
C_o'	time artificial tau mode is used, measured from time IGM is initiated	10.0 sec
ΔT_{4M}	limited value for difference between actual and nominal burn times for first S-IVB burn	100.0 sec
V_{EX3}	exhaust velocity, third IGM stage	4201.6192 m/sec (first opp) 4198.6915 m/sec (second opp)
τ_{2N}	estimated time to deplete vehicle mass, second IGM stage	685.0 sec (first opp) 610.0 sec (second opp)

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM) - Continued

Parameter	Definition	Value
$\dot{M}_3$	mass flow rate, third IGM stage	474.234 lb/sec (first opp) 473.948 lb/sec (second opp)
	S-IVB engine model	
T_0	time from TB_6 to start of first thrusting phase (vent and ullage)	0.0 sec
T_1	time from TB_6 to start of second thrusting phase (chilldown)	570.0 sec
T_2	time from TB_6 to start of third thrusting phase (buildup)	578 sec
T_3	time from TB_6 to start of fourth thrusting (main burn)	580.5 sec
T_{MRS}	time from TB_6 to mixture ratio shift (first opp only)	705.0 sec
DTT	delta time from cutoff for J2 tailoff phase	1.919 sec
DTV	delta time for LH2 vent	574 sec
TH0	thrust level in first phase	45 lb
TH1	thrust level in second phase	725 lb
TH2	thrust level in third phase	96 936 lb
TH3L	thrust level in fourth phase (first opp pre-MRS)	182 550 lb
TH3H	thrust level in fourth phase (first opp post-MRS)	203 086 lb
TH3	thrust level in fourth phase (second opp)	202 760 lb
THTO	thrust level in tailoff phase	25 871 lb
THV	thrust level in tailoff vent phase	12.0 lb
MF0	mass flow rate, first phase	.114 lb/sec
MF1	mass flow rate, second phase	2.5 lb/sec

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM) - Concluded

Parameter	Definition	Value
MF2	mass flow rate, third phase	149.6 lb/sec
MF3L	mass flow rate, fourth phase (first opp, pre-MRS	424.45 lb/sec
MF3H	mass flow rate, fourth phase (first opp, post-MRS)	474.38 lb/sec
MF3	mass flow rate, fourth phase (second opp)	473.54 lb/sec
MFTO	mass flow rate, tailoff phase	70 lb/sec
MFV	mass flow rate, tailoff vent phase	.31 lb/sec

APPENDIX

TAPE FORMAT FOR THE POWERED-FLIGHT PROCESSOR

TABLE A-I.- MSFC PRESENT TAPE FORMAT

Tape position	Symbol	Units	Definition (reference)
1		days	Launch day
2		months	Launch month
3		years	Launch year
4	TLO	sec	Reference launch time (midnight)
5	RAO (θ_{EO})	deg	Reference launch site right ascension (positive east of vernal equinox)
6			Blank
7			Blank
8 - 60	A_z	deg	Table of values for launch azimuth from analytic launch azimuth model
61 - 113	t_D	sec	Table of values for t_D corresponding to values of A_z
114 - 128	RAS_1	deg	15-place table of target vector right ascension, first TLI opportunity
129 - 143	DEC_1	deg	15-place table of target vector declination, first TLI opportunity
144 - 158	$C3_1$	km^2/sec^2	15-place table of target $C3_1$ (twice specific energy at TLI), first TLI opportunity

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
159 - 173	$\cos \sigma_1$		15-place table of values of $\cos \sigma_1$, first TLI opportunity
174 - 188	e_{N_1}		15-place table of values of e_{N_1}, first TLI opportunity
189 - 190			Blank
191 - 205	RAS_2	deg	Table of values of target vector right ascension, second TLI opportunity
206 - 220	DEC_2	deg	Table of values of target vector declination, second TLI opportunity
221 - 235	$C3_2$	km^2/sec^2	Table of values of $C3_2$ (twice specific energy at TLI), second TLI opportunity
236 - 250	$\cos \sigma_2$		Table of values of $\cos \sigma_2$, second TLI opportunity
251 - 265	e_{N_2}		Table of values of e_{N_2}, second TLI opportunity
266			Number of azimuths
267			Blank

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
268 - 282	t_D	sec	Table of values of t_D, independent variable for all out-of-orbit targeting tables, both TLI opportunities
283	αTS_1	deg	Angle between $\hat{S}$ and $\hat{T}$ at S-IVB reignition, first opportunity
284	β_1	deg	Angle between $\hat{S}$ and $\hat{R}_i$ at initiation of S-IVB restart preparations, first opportunity
285	R_{N_1}	ft	Nominal reignition radius, first opportunity
286	T_{ST_1}	sec	Constant used to initiate the $\bar{S} \cdot \bar{T}_p$ test, first opportunity
287	f_1	deg	True anomaly of the predicted cutoff radius vector, first opportunity
288	$T'_{3R\ 1}$	sec	Initial prediction of fifth stage (IGM) burn time, first opportunity
289	$\tau_{3R\ 1}$	sec	Estimated time to deplete vehicle mass from assumed MRS, first opportunity
290	ΔV_{BR1}	m/sec	Velocity cutoff bias for translunar injection, first opportunity

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
291, 292			Blank
293	α_{TS_2}	deg	Angle between $\hat{S}$ and $\hat{T}$ at S-IVB reignition, second opportunity
294	β_2	deg	Angle between $\hat{S}$ and $\hat{R}_i$ at initiation of S-IVB restart preparations, second opportunity
295	R_{N2}	ft	Nominal reignition radius, second opportunity
296	T_{ST2}	sec	Constant used to initiate the $\bar{S} \cdot \bar{T}_p$ test, second opportunity
297	f_2	deg	True anomaly of the predicted cutoff radius vector, second opportunity
298	T'_{3R2}	sec	Initial prediction of fifth stage (IGM) burn time, second opportunity
299	τ_{3R2}	sec	Estimated time to deplete vehicle mass from assumed MRS, second opportunity
300	ΔV_{BR2}	m/sec	Velocity cutoff bias for translunar injection, first opportunity
301 - 303			Blank

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Defintion (reference)
[a]304	AZO	deg	Initial value of launch azimuth used as independent variable in forming the polynomials for i and θ_N
305	AZS	deg	Range of launch azimuth values used in forming the polynomials for i and θ_N
306 - 312	$f_0, f_1, \ldots f_6$	n.d.	Coefficients of polynomial for i
313 - 319	$g_0, g_1, \ldots g_6$	n.d.	Coefficients of polynomial for θ_N
320 - 324	$h_{10}, h_{11}, \ldots h_{14}$	n.d.	Coefficients of first launch azimuth polynomial segment
325 - 329	$h_{20}, h_{21}, \ldots h_{24}$	n.d.	Coefficients of second launch azimuth polynomial segment
330 - 334	$h_{30}, h_{31}, \ldots h_{34}$	n.d.	Coefficients of third launch azimuth polynomial segment

[a]Data in tape positions 304 through 346 are not used by the Powered-Flight Processor.

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Concluded

Tape position	Symbol	Units	Definition (reference)
335	t_{DS1}	sec	Time of closing of the first launch azimuth segment and opening of the second segment
336	t_{DS2}	sec	Time of closing of the second launch azimuth segment and opening of the third segment
337	t_{DS3}	sec	Time of the closing of the third launch azimuth segment
338	t_{D1}	sec	Actual time of launch minus referenced time of launch (TLO) opening of first azimuth polynomial segment
339	t_{D2}	sec	t_D at opening of second azimuth polynomial $t_{D2} = t_{DS1}$
340	t_{D3}	sec	Value of t_D at opening of third azimuth polynomial $t_{D3} = t_{DS2}$
341	t_{SD1}	sec	t_D increment over first azimuth polynomial segment = t_{DS1}
342	t_{SD2}	sec	t_D increment over second polynomial segment = $t_{DS2} - t_{DS1}$
343	t_{SD3}	sec	increment third segment = $t_{DS3} - t_{DS2}$
344 - 346			Blank

MSC CARD FORMAT

1. All numbers will be right justified in the field , except the ID which will be left justified.

2. All numbers except launch day and opportunity will be in a form such as X.XXXXXXXX or X.XXXXXXXX±XXX.

3. If there are no parameters for a launch day or opportunity, then all fields should be zero.

4. The values of t_D will be in ascending order.

5. Identification field:

XX	XXX	X	XXX
year	day of year	opportunity	card number

TABLE A-II.- CARD FORMAT

Card no	Column 1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
1	Launch day of year	Opportunity	t_D	COS σ	XXXXXXXX
			Hours		Identification
2	C_3	e_n	RA	DEC	XXXXXXXX
	Er^2/hr^2		Radians	Radians	Identification
3	t_D	COS σ	C_3	e_n	XXXXXXXX
	Hours		ER^2/hr^2		Identification
4	RA	DEC	t_D	COS σ	XXXXXXXX
	Radians	Radians	Hours		Identification
5	C_3	e_n	RA	DEC	XXXXXXXX
	Er^2/hr^2		Radians	Radians	Identification
6 - 23	The format of cards 3, 4, and 5 will be repeated in cards 6 - 23				
24 - 46	Same format as cards 1 - 23 except for the same launch day and second opportunity				
47 - 92	Same format as cards 1 - 46 except for second launch day				
93 - 138	Same format as cards 1 - 46 except for third launch day				

TABLE A-II.- CARD FORMAT - Continued

Card no	Column				
139 - 184	Same format as cards 1 - 46 except for fourth launch day				
185 - 230	Same format as cards 1 - 46 except for fifth launch day				
231 - 276	Same format as cards 1 - 46 except for sixth launch day				
277 - 322	Same format as cards 1 - 46 except for seventh launch day				
323 - 368	Same format as cards 1 - 46 except for eighth launch day				
369 - 414	Same format as cards 1 - 46 except for ninth launch day				
415 - 460	Same format as cards 1 - 46 except for tenth launch day				
	1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
461	Launch day of year	Opportunity	T_{ST}	β	XXXXXXXX
			Hours	Radians	Identification
462	α^*_{TS}	f	R_N	T_3'	XXXXXXXX
	Radians	Radians	Er	Hours	Identification
463	τ_{3R}	T_2	V_{ex2}	$\dot{M}_2$	XXXXXXXX
	Hours	Hours	Er/hr	lb/hr	Identification
464	ΔV_{BR}	τ_{2N}	K_{p0}	K_{y0}	XXXXXXXX
	Er/hr	Hours	Radians	Radians	Identification

TABLE A-II.- CARD FORMAT - Continued

Card no	Column
465 - 468	Same format as cards 461 - 464 except for same launch day and second opportunity
469 - 476	Same format as cards 461 - 468 except for second launch day
477 - 484	Same format as cards 461 - 468 except for third launch day
485 - 492	Same format as cards 461 - 468 except for fourth launch day
493 - 500	Same format as cards 461 - 468 except for fifth launch day
501 - 508	Same format as cards 461 - 468 except for sixth launch day
509 - 516	Same format as cards 461 - 468 except for seventh launch day
517 - 524	Same format as cards 461 - 468 except for eighth launch day
525 - 532	Same format as cards 461 - 468 except for ninth launch day
533 - 540	Same format as cards 461 - 468 except for tenth launch day

Card no	1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
541	Launch day of year	T_{LO}	θ_{EO}	ω_e	XXXXXXXX
		Hours	Radians	rad/hr	Identification
542	$K_{\alpha 1}$	$K_{\alpha 2}$	K_{T3}	t_{DSO}	XXXXXXXX
	rad/hr	rad/hr^2		Hours	Identification

TABLE A-II.- CARD FORMAT - Continued

Card no	Column 1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
543	t_{DS1}	t_{DS2}	t_{DS3}	h_{10}	XXXXXXXXX
	Hours	Hours	Hours	Radians	Identification
544	h_{11}	h_{12}	h_{13}	h_{14}	XXXXXXXXX
	Radians	Radians	Radians	Radians	Identification
545	t_{D1}	t_{SD1}	h_{20}	h_{21}	XXXXXXXXX
	Hours	Hours	Radians	Radians	Identification
546	h_{22}	h_{23}	h_{24}	t_{D2}	XXXXXXXXX
	Radians	Radians	Radians	Hours	Identification
547	t_{SD2}	h_{30}	h_{31}	h_{32}	XXXXXXXXX
	Hours	Radians	Radians	Radians	Identification
548	h_{33}	h_{34}	t_{D3}	t_{SD3}	XXXXXXXXX
	Radians	Radians	Hours	Hours	Identification
549 - 556	Same format as cards 541 - 548 except for second launch day				
557 - 564	Same format as cards 541 - 548 except for third launch day				

TABLE A-II.- CARD FORMAT - Concluded

Card no	Column
565 - 572	Same format as cards 541 - 548 except for fourth launch day
573 - 580	Same format as cards 541 - 548 except for fifth launch day
581 - 588	Same format as cards 541 - 548 except for sixth launch day.
589 - 596	Same format as cards 541 - 548 except for seventh launch day
597 - 604	Same format as cards 541 - 548 except for eight launch day
605 - 612	Same format as cards 541 - 548 except for ninth launch day
613 - 620	Same format as cards 541 - 548 except for tenth launch day

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