MISSION ANALYSIS PROGRAM FOR SOLAR ELECTRIC PROPULSION (MAPSEP)

CONTRACT NAS8-29666

(Revised) April, 1975

(NASA-CR-120407) MISSION ANALYSIS PROGRAM FOR SOLAR ELECTRIC PROPULSION (MAPSEP). VOLUME 2: USER'S MANUAL FOR EARTH ORBITAL MAPSEP (Martin Marietta Corp.) 225 p HC $7.00 CSCL 22A G3/13

N75-22351

Unclas 20452

VOLUME II - USER's MANUAL

FOR EARTH ORBITAL MAPSEP

Prepared by:

Planetary Systems Mission Analysis and Operations Section
Denver Division
Martin Marietta Corporation

For

National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama

FOREWORD

MAPSEP (Mission Anslysis Program for Solar Electric Propulsion) is a computer program developed by Martin Marietta Aerospace, Denver Division, for the NASA Marshall Space Flight Center under Contract NAS8-29666. MAPSEP contains the basic modes: TOPSEP (trajectory generation), GODSEP (linear error analysis) and SIMSEP (simulation). These modes and their various options give the user sufficient flexibility to analyze any low thrust mission with respect to trajectory performance, guidance and navigation, and to provide meaningful system related requirements for the purpose of vehicle design.

This volume is the second of three and contains the input/output description of MAPSEP and other user related information. Other volumes relate to analytical program descriptions and to program logical flow.

TABLE OF CONTENTS

1. INTRODUCTION

This manual provides the user of MAPSEP (Mission Analysis Program for Solar Electric Propulsion) with all the information necessary to input the program and to obtain meaningful output. In addition to listing all the input variables, their definitions, units, etc., there are chapters discussing recommended usage and limitations, and sample runs.

MAPSEP is composed of three primary modes, each of which performs a given function in a trajectory analysis. TOPSEP (Targeting and Optimization for SEP) evaluates performance by generating realistic integrated trajectories which meet whatever mission and system constraints are imposed by the user. GODSEP (Guidance and Orbit Determination for SEP) evaluates trajectory dispersions, using linear error analysis techniques, in the presence of dynamic and navigation uncertainties. SIMSEP (Simulation for SEP) deterministically simulates single or multiple trajectories in the presence of discrete system errors.

For the user who is unfamiliar with MAPSEP, it is recommended that he first study, briefly, Chapters 2 and 3 on Input and Output, respectively, to familiarize himself with some of the nomenclature and options. Next, a careful study of Chapter 4 on Operating Guidelines will yield considerable insight on MAPSEP Usage. The user can then return to Chapters 2 and 3 for specific information on his particular application. Finally, as additional background information, it is recommended that the Analytic Manual (Reference 1) and Program Manual (Reference 2) be referred to extensively.

2.0 INPUT

The basic input to MAPSEP is in the form of namelist data, fixed field cards and magnetic tape. This chapter describes all available input. Chapter 4 will discuss the organization of this input for specific analysis functions.

All MAPSEP modes require the namelist $TRAJ which contains reference trajectory and spacecraft characteristics. If desired, this namelist can be written on a disc file (STM) and eventually stored on magnetic tape to facilitate later runs or stacked cases in the same run. Following $TRAJ is mode peculiar input.

The reference trajectory generation mode (TOPSEP) requires the namelist $TØPSEP to follow $TRAJ. $TØPSEP contains parameters that determine the strategy for generating a trajectory which meets desired target conditions and mission constraints. The reference trajectory defined in $TRAJ is used as the initial guess.

The linear error analysis mode (GODSEP) requires the namelist $GØDSEP immediately after $TRAJ. $GØDSEP contains system uncertainties and navigation and guidance related data to perform a covariance analysis about the reference trajectory. Following $GØDSEP, fixed field cards are input to describe measurement and propagation schedules. Two disc files or tapes are often used: STM and GAIN. These files contain trajectory and transition matrix data (STM) and a-priori covariances and orbit determination filter gains (GAIN) to improve computational speed and to provide additional flexibility. Another namelist $GEVENT is optional and contains guidance event information.

The trajectory simulation mode (SIMSEP) requires the namelist \$SIMSEP to follow \$TRAJ. \$SIMSEP contains parameters which describe the scope of the simulation, expected dynamic errors, and cumulative statistics from previous SIMSEP runs. Following \$SIMSEP are a set of \$GUID namelists, one for each guidance correction maneuver. \$GUID describes the strategy, knowledge or estimation uncertainties and cumulative statistics for that particular maneuver.

The trajectory display mode (REFSEP) requires only the namelist \$TRAJ followed by scheduling cards, similar to those used in GODSEP. The fixed field schedule cards define: types of data displayed, span of interest, and frequency of printout.

For those users who can vary the amount of blank common storage in their runs, a guideline to estimate the total MAPSEP core requirements is given below. Blank common length is related directly to the dimension of the dynamic state (NDIM) used in transition matrix (STM) computation, and, the total augmented (knowledge) state (NAUG). The values of "program" and "blank common" must be added to compute the total decimal core for a CDC 6500. Other operating systems must scale these requirements appropriately.

TOPSEP:	program	$= 23400$	(N = number of control parameters)
	blank common	$= 800 + 68(N)+(N)^2$	
GODSEP:	program	$= 23900$	
	blank common	$= 100 + 9\ (NDIM)^2$	(if STM created)
		$= 100 + 9\ (NDIM)^2 + 5\ (NAUG)^2$	(if STM used)
		$= 100 + 13\ (NAUG)^2$	(if PDOT used)
SIMSEP:	program	$= 39100$	(N = number of guidance events)
	blank common	$= 900 + N(NAUG)^2$	
REFSEP:	program + blank common	$= 21000$	

2.1 Trajectory - $TRAJ Input Description

The namelist $TRAJ, which is read in by DATAM, contains reference trajectory and spacecraft related information for ballistic or low thrust missions. Many of the variables have adequate default values such that the user only has to input those which are different. The variables are grouped as either trajectory, spacecraft or miscellaneous parameters.

Namelist $TRAJ:

a) Trajectory Parameters:

Variable	Dim	Default	Units	Definition
STEP	1	.5	-	Scaling factor of the integration step size.
BØDYIN	16x1			This array allows the user to input ephemeris data for a body that is not already included in MAPSEP (Planet Code is 10). The default values are those of the comet Encke. Orbital elements are of the form $X(t) = X_o + \alpha t$ where X_o is a constant, α is the rate of change and t is the time in Julian Centuries.
BØDYIN(1)		2444580.0	days	Julian date of ephemeris epoch.
BØDYIN(2)		500.0	km	Mean equational radius.
BØDYIN(3)		1000.0	km	Radius of the sphere of influence.
BØDYIN(4)		10^{-9}	km^3/sec^2	Gravitational constant.

Variable	Dim	Default	Units	Definition
BØDYIN(5)		33180812.67	km	Semi-major axis (a).
BØDYIN(6)		0.0	Km/J.C.*	Time derivative of the semi-major axis.
BØDYIN(7)		0.847		Eccentricity (e).
BØDYIN(8)		0.0	1/J.C.	Time derivative of the eccentricity.
BØDYIN(9)		11.95	deg	Inclination of the orbit plane (i).
BØDYIN(10)		0.0	deg/J.C.	Time derivative of the inclination.
BØDYIN(11)		334.2	deg	Longitude of the ascending node (Ω).
BØDYIN(12)		0.0	deg/J.C.	Time derivative of Ω.
BØDYIN(13)		160.2	deg	Longitude of periapsis ($\tilde{\omega}$).
BØDYIN(14)		0.0	deg/J.C.	Time derivative of $\tilde{\omega}$.
BØDYIN(15)		0.0	deg	Mean Anomaly (M) at ephemeris epoch.
BØDYIN(16)		0.0	deg/J.C.	Mean motion (n); computed internally if input is zero.
DRMAX	1	50.	km	Maximum deviation from the reference conic before rectification.
FRCA	1	0.4	-	Scale factor of the target planet semi-major axis used as the maximum S/C-target distance below which the closest approach test begins; this avoids local minima, or "false" closest approaches, especially for inner planet missions.

* - J.C. is a Julian Century (36525 days exactly).

Variable	Dim	Default	Units	Definition
IAUGDC	10	10*0	-	Flags used to identify the augmented dynamic state for GODSEP in the STM file generation submode. Non-zero entries will activate a parameter.
IAUGDC(1)				S/C position and velocity vectors
IAUGDC(2)				Thrust bias: proportionality, pitch and a yaw.
IAUGDC(3)				Not used.
IAUGDC(4)				Gravitational constant of Earth.
IAUGDC(5)				Gravitational constant of sun.
IAUGDC(6)-(7)				Not used.
IAUGDC(8)				J2 zonal harmonic.
IAUGDC(9)-(10)				Not used.
ICØØRD	1	3	-	Planet code (see next page) of reference body of input state (STATE); positive values indicate 1950.0 ecliptic inertial coordinates; a value of -3 indicates geocentric equatorial coordinates.

CODE	PLANET
0	Sun
1	Mercury
2	Venus
3	Earth
4	Mars
5	Jupiter
6	Saturn
7	Uranus
8	Neptune
9	Pluto
10	User Specified
11	Moon

Variable	Dim	Default	Units	Definition
ISTØP	1	1	-	The trajectory termination flag. There are four possible criteria for terminating the trajectory. = 1, final time (TEND) = 2, closest approach = 3, sphere of influence = 4, stopping radius (RSTØP).
NB	11	11*0	-	This array is used to input the bodies to be considered in the trajectory propagation. The entries in NB, correspond to the non-zero values of the planet codes. The sun is automatically included.
MØRBIT	1	1000	REV'S	The number of orbital revolutions between the coarse shadow tests. o If $\|$MØRBIT$\| \geq$ 1000 or MØRBIT = 0 the shadow logic will not be executed. o If 1000 $>$ MØRBIT $>$ 0 shadow logic will be executed but shadow phase changes will not be printed. o If -1000 $<$ MØRBIT $<$ 0 shadow logic will be executed and shadow phase changes will be printed (IPRINT must not equal zero).
J2	1	1.082645×10^{-3}	-	J2 zonal harmonic.
J2FLG	1	0	-	J2 activation flag. = 0, no J2 effect. = 1, J2 on.
INØRB	1	0	-	FLAG indicating the type of components comprising the initial state vector (STATE) = 0, Cartesian state = 1, Orbital elements.

Variable	Dim	Default	Units	Definition
NTP	1	3	-	The planet code of the target body.
RSTØP	1	31096.5	km	The stopping radius must be specified when ISTØP is set to 4. The default value is set to a synchronous Earth orbit.
STATE	6	6*0.	km, km/sec, deg	Initial state vector; if INØRB = 0, then cartesian $(X, Y, Z, \dot{X}, \dot{Y}, \dot{Z})$; if INØRB = 1, $r_{periapsis}$, $r_{apoapsis}$, i, Ω, ω, f (true anomaly) (see also ICØØRD).
TEND	1	0.0	days	The trajectory termination time, t_{final}, relative to launch. The input may be full Julian Date or days from launch.
TLNCH	1	0.0	days	The Julian Date of the trajectory epoch (launch).
TSTART	1	0.0	days	The trajectory time associated with the input state. This can be a Julian Date or days from launch.
XBØDY	1	6HENCKE	-	Hollerith label for the input body (BØDYIN).

b) Spacecraft Parameters:

Variable	Dim	Default	Units	Definition
ENGINE	30			This array defines the spacecraft thrust subsystem (Section 4.1, Reference 1).
ENGINE(1)		21.65	KW	Useful power from the solar array at 1 AU (P_o).
ENGINE(2)		.65	KW	Housekeeping power (P_{HK}).
ENGINE(3)		21.65	KW	Maximum power when $r \leq r_{min}$ (P_{max}). See ENGINE(9).

Variable	Dim	Default	Units	Definition
ENGINE(4)		1.4382	-	Power Constant (C_1).
ENGINE(5)		0.0	-	Power Constant (C_2).
ENGINE(6)		-0.2235	-	Power Constant (C_3).
ENGINE(7)		0.0	-	Power Constant (C_4).
ENGINE(8)		-0.2147	-	Power Constant (C_5).
ENGINE(9)		1.0	AU	Heliocentric distance for which the power is a maximum (r_{min}).
ENGINE(10)		29.418	km/sec	Ion exhaust velocity (c).
ENGINE(11)		1.0	-	Thruster efficiency (η).
ENGINE(12)		0.0	1/sec	Power loss (P_L).
ENGINE(13)		0.0	days	Time decay of power loss prior to start of the mission.
ENGINE(14)		-	-	Not used.
ENGINE(15)		-1.0	$(\text{meters})^2$	Radiation pressure coefficient times the effective cross-sectional area of the solar arrays (C_RA). If negative, no radiation pressure.
ENGINE(16)		1.0	-	Scale factor on ENGINE(15) when $r < r_{min}$.
ENGINE(17)		3	min.	Thruster startup delay time after end of a shadow period.
ENGINE(18)		9	min.	
ENGINE(19)		.464	min/sec	If shadow time $\leq$ ENGINE(17), then delay = 0., otherwise delay = ENGINE(18) + ENGINE(19) * shadow + ENGINE(20) * $(\text{shadow})^2$.
ENGINE(20)		0	min/sec^2	
FLX	1	0.	10^{14} part/cm^2	Cumulative particle flux (1 MEV equivalent)
FLXDØT	1	0.	10^{14} part/cm^2 sec	Flux rate.

Variable	Dim	Default	Units	Definition
IENRGY	1	1	-	This flag determines the type of power subsystem. 0 - Ballistic 1 - Solar Electric Power 2 - Nuclear Electric Power
ISCD	1	0	-	Solar cell (and power) degradation flag resulting from particle flux. = 0, no power degradation = 1, power degradation by flux
PHAS	4			Thrust control phasing parameters (See also THRUST).
PHAS(1)		0.	deg	Pitch (or in-plane) phase angle.
PHAS(2)		0.	deg	Yaw (or out-of-plane) phase angle.
PHAS(3)		0.	---	Not used.
PHAS(4)		0.	rad/sec	Mean motion used when "fast" variable is time dependent anomaly. $>$ 0., time dependent anomaly relative to phase start time, $\leq$ 0., eccentric anomaly.
SCMASS	1	2000.0	kg	Spacecraft mass at TSTART.
THRUST	10x40			This array defines the thrust control policy for the trajectory. Each column contains the controls for each segment of the trajectory for i = 1 to 40 segments.

For orbit plane system,

In-plane thrust = $a_0+a_1t+a_2 \sin (E+PHAS(1))$

Out-of-plane thrust = $a_3+a_4t+a_5 \sin (E+PHAS(2))$

For pitch/yaw Policy 1,

pitch = $a_o+a_1+a_2 \sin (E+PHAS(1))$

yaw = $a_3+a_4t+a_5 \sin (E+PHAS(2))$

For pitch/yaw Policy 2,

pitch = $a_o+a_1 \sin (E+a_2)$

yaw = $a_3+a_4 \sin (E+a_5)$

Variable	Dim	Default	Units	Definition
				where E = eccentric or time dependent anomaly (See PHAS(4)); See also Analytic Manual, P. 17). Note that the THRUST array allows for 40 control segments; however, this full capability is used only in the GODSEP mode (See P. 156) whereas TOPSEP and SIMSEP are restricted to 20 control segments.
THRUST(1,i)		9.,39*0.	-	= 0., last thrust phase = 2., orbit plane thrust policy = 3., pitch/yaw policy 1 = 4., pitch/yaw policy 2 = 9., coast
THRUST(2,i)		$40*10^{20}$	days	Days from launch for which the i^{th} phase ends.
THRUST(3,i)		40*1.0		Throttling level (T_L).

Variable	Dim	Default	Units	Definition
THRUST(4,i)		40*0.0	deg	In-plane or pitch angle (a_0).
THRUST(5,i)		40*0.0	deg or deg/sec	Thrust policy coefficient (a_1).
THRUST(6,i)		40*0.0	deg	Thrust policy coefficient (a_2)
THRUST(7,i)		40*0.0	deg	Out of plane or yaw angle (a_3).
THRUST(8,i)		40*0.0	-	The number of thrusters. This is required only for GØDSEP and SIMSEP.
THRUST(9,i)		40*0.0	deg or deg/sec	Thrust policy coefficient (a_4)
THRUST(10,i)		40*0.0	deg	Thrust policy coefficient (a_5)

c) Miscellaneous Parameters

Variable	Dim	Default	Units	Definition
EDIT IEDIT LEDIT	200 20 20	200*0.0 20*0 20*.F.	- - -	These arrays are used for storage related to temporary program modifications.
IØPT	4	2,1,0,1	-	Optional trajectory control flags.
IØPT(1),(2),(3)				Not used.
IØPT(4)				Primary body change test = 0, check for body changes = 1, no check
IPRINT	1	0	-	This flag controls trajectory print. > 0, Print every IPRINT integration steps. = 0, No print. = -1, Print every XPRINT days. = -2, Print every event. IPRINT = -1 should rarely be used, especially in the GØDSEP mode. It is suggested to set IPRINT = 20000. The result will be prints, at

Variable	Dim	Default	Units	Definition
				every primary body and thrust control phase change and at termination.
NEQPRT	1	0	-	Flag to turn on equatorial trajectory print (if = 1).
ISTMF	1	1	-	This flag is used in conjunction with the STM file and the namelist $TRAJ. = 0, Ignore. = 1, Write the namelist $TRAJ onto disc; create the STM file if the mode is GODSEP. = 2, Read $TRAJ from disc; read the STM file if the mode is GODSEP. = 3, The same as 2, but also read the a-priori covariances from the GAIN file if the mode is GODSEP. = 4, Read $TRAJ from disc and update with a <u>second</u> input $TRAJ namelist.
MØDE	1	2	-	This flag indicates the operating mode of MAPSEP. Positive values will recycle back to MAPSEP main, while negative numbers will return to the main of the mode. This feature allows the user to run stacked cases. = ± 1, Targeting and Optimization (TØPSEP). = ± 2, Error Analysis (GØDSEP). = ± 3, Simulation (SIMSEP).
PRNML	1	F	-	Do (T), do not (F) print input namelist $TRAJ
XPRINT	1	10^{20}	days	Trajectory print frequency. Must be specified when IPRINT = -1 (MPRNT = -1 in $TØPSEP)

d) REFSEP Parameters

Variable	Dim	Default	Units	Definition
ELVMIN	1	0.	deg	Minimum elevation angle for tracking S/C or target body.
KARDS	1	0	-	Number of formatted print schedule cards to be read in after the $TRAJ namelist
NPUNCH	1	0	-	= 1, punch THRUST array to include shadow periods as coast phases. = 0, no punch cards.
PITCHI	1	16700.	$kg-m^2$	Moment of inertia about pitch axis.
RØLLI	1	123000.	$kg-m^2$	Moment of inertia about roll axis.
SPHLØC	1	.T.	-	= .T., station locations in spherical coordinates = .F., station locations in cylindrical coordinates
STALØC	3x9		km, deg	Array of tracking station locations; coordinate system determined by SPHLØC; for Ith station, STALØC(1,I) = radius or spin radius STALØC(2,I) = latitude or longitude STALØC(3,I) = longitude or z-height Default stations correspond to: I = 1, Goldstone, California I = 2, Madrid, Spain I = 3, Canberra, Australia I = 4, Johannesburg, South Africa I = 5, Carnavon, Australia I = 6, Fairbanks, Alaska I = 7, Rosman, New Mexico I = 8, Santiago, Chile I = 9, Corpus Christi, Texas
YAWI	1	136200.	$kg-m^2$	Moment of inertia about yaw axis.

2.2 TOPSEP Input Description

The input for the TOPSEP mode is transmitted via the namelists $TRAJ and $TØPSEP. $TRAJ contains the basic trajectory and spacecraft information for a nominal low thrust mission. $TØPSEP contains the necessary parameters to alter the nominal trajectory in order to obtain a more desirable trajectory. All namelist vairables assume the program default values if they are not specified by input. In addition, once a variable has been set by namelist input or by default, it will resume that value at the beginning of all succeeding stacked cases even though the value may have been changed by the program during any one stacked case.

Namelist $TØPSEP:

Variable	Dim	Default	Units	Definition
BTØL	1	.05	-	Tolerance on control bounds within which a modified control correction may be implemented (See Page 143). The tolerance region within the minimum and maximum bounds (ULIMIT(I,1),ULIMIT (I,2)) is defined by BTØL x (ULIMIT(I,2)-ULIMIT(I,1)).
DFMAX	1	1000.	-	Maximum increase allowed in the cost index per iteration (decimal percent of nominal cost index value) (See Page 146)
DP2	1	0.04	-	Estimated region of linearity (See Page 150).

Variable	Dim	Default	Units	Definition
EPSØN	1	0.0	-	Scalar multiple for control perturbation; if no acceptable control step, then a new sensitivity matrix will be calculated based upon the revised perturbations H(I,J) = H(I,J) X EPSØN. (See Page 144).
EDIT	200	200*0.0	-	This array is used to input real variables for temporary program modiciations.
G	20x1	20*0.0		Performance gradient (may be input if available from a previous computer run) (See Page 146).
GTRIAL	5x1			One-dimensional search constants (See Page 144). Let P = P (γ) be the function to be minimized (the cost index and/or the error index) and γ be the step size scale factor to be optimized, then
GTRIAL(1)		0.1	-	γ_{i+1} may not be less than γ_i x GTRIAL(1).
GTRIAL(2)		5.0	-	γ_i may not be greater than GTRIAL(2).
GTRIAL(3)		0.01	-	If the Δ% of γ_{i+1} to γ_i is less than GTRIAL(3) then P(γ) is considered minimized.
GTRIAL(4)		1.E-15	-	If the Δ% of the estimated P_i to the actual P_i is less than GTRIAL(4) then P(γ) is considered minimized.
GTRIAL(5)		4.0	-	Real flag designating the extent of the curve fitting in the new control direction. = 1., two-point-one-slope fit; = 2., three-point-one-slope fit; = 3., three-point fit; = 4., four-point fit. (e.g., GTRIAL(5) = 4. indicates that all four curve fitting techniques may be applied in the preceding order).

Variable	Dim	Default	Units	Definition
H	10x22	220*0.	Mixed	Array of control designations. A non-zero value indicates the associated parameter is a control. If IASTM = 0, values of H are perturbations used in finite differencing. IASTM = 1, values of H are used only as activating flags. The first 20 columns of H correspond to elements of the THRUST array (See Page 10-B) (e.g., H (4,1) = .1 identifies the cone angle of the first phase as a control. Note: THRUST (I,J), I = 2,7 and J = 1,20 are the only valid thrust controls). The last two columns of H correspond to the parameters listed below. When the grid mode is operative the H array represents the first step for the selected controls (See HMULT for designating second step).
				<u>Parameters Selected as Controls</u>
H(1,21)			km	x, STATE(1) } Geocentric or Heliocentric Ecliptic Initial State
H(2,21)			km	y, STATE(2) } Geocentric or Heliocentric Ecliptic Initial State
H(3,21)			km	z, STATE(3) } Geocentric or Heliocentric Ecliptic Initial State
H(4,21)			km	r, STATE(7) } Geocentric or Heliocentric Ecliptic Initial State
H(5,21)			km/sec	$\dot{x}$, STATE(4) } Geocentric or Heliocentric Ecliptic Initial State
H(6,21)			km/sec	$\dot{y}$, STATE(5) } Geocentric or Heliocentric Ecliptic Initial State
H(7,21)			km/sec	$\dot{z}$, STATE(6) } Geocentric or Heliocentric Ecliptic Initial State
H(8,21)			km/sec	v, STATE(8) } Geocentric or Heliocentric Ecliptic Initial State
H(9,21)			km	Parking orbit radius of periapsis.
H(10,21)			km	Parking orbit radius of apoapsis.
H(1,22)			deg	Inclination of parking orbit.
H(2,22)			deg	Longitude of ascending node of parking orbit.
H(3,22)			deg	Argument of periapsis of parking orbit.
H(4,22)			deg	True anomaly of S/C at initial trajectory time.
H(5,22)			kw	Base power at 1 au, ENGINE (1)
H(6,22)			km/sec	Exhaust velocity, ENGINE (10)
H(7,22)			kg	Initial mass, SCMASS
H(I,22)			-	I = 8,10 ; not used

Variable	Dim	Default	Units	Definition
HMULT	20	20*0	-	Scalar multiple of non-zero elements of the H array (max of 20) used to define the second step in the grid mode. See p. 138.
IASTM	1	1	-	Flag designating the method of computing the targeting sensitivity matrix = 0, finite differencing by means of perturbed trajectories = 1, integrated state transition matrices If IASTM = 1 the parameters available as controls are restricted. See Page 140 and Page 15.
IEDIT	20	20*0.	-	This array is used to input integer variables for temporary programs modifications.
IMØDE	1	2	-	TØPSEP submode designation. = 1, reference trajectory propagation. = 2, target and optimize. = 3, generate trajectory grid.
INSG	1	0	-	If flag set to 1, then target sensitivities S and the performance gradient G are input; if flag left 0, ignore (See Page 146).
IWATE	1	1	-	Type of control weighting (See Page 141-A). = 1, unity weighting. = 2, normalized control weighting. = 3, sensitivity weighting. = 4, combined sensitivity, target error, and control weighting. = 5, target gradient weighting. = 6, averaged gradient and control weighting.
JWATE	1	0	-	Target weighting flag (See P. 142) = 0, do not weight target variables. = 1, use tolerances to weight targets.
LEDIT	20	20*F	-	This array is used to input logical variables for temporary program modifications.

Variable	Dim	Default	Units	Definition
MPRINT	10x1	10*0	-	Print option flags. =-1, print every XPRINT days and at control phase and primary body changes. = 0, no trajectory print. = I, print every I integration steps. MPRINT(1), reference trajectory and grid print. MPRINT(2), perturbation trajectory print. MPRINT(3), trial trajectory print. MPRINT(4), supplementary print fo~ targeting mode. MPRINT(5) - (10), not used.
NMAX	1	1	-	Maximum number of iterations allowed.
ØPTEND	1	89.999	deg	Optimization termination angle; optimization is considered complete when $\cos\theta = \frac{\underline{G} \cdot \Delta \underline{U}_2}{\lvert\underline{G}\rvert \times \lvert\Delta \underline{U}_1\rvert}$ approaches 0 (when θ approaches 90 deg). If ØPTEND $<\theta<$ 90 optimization is considered complete. If ØPTEND is set to 0 deg TOPSEP will generate a targeted but not optimized trajectory.
ØSCALE	1	1.0	-	Scale on performance index for simultaneous targeting and optimization (See P. 149).
PCT	1	0.2	-	Fraction of target error to be removed in the first iteration (See P. 143).
PRNML	1	F	-	Do (T), do not (F) print input namelist $TØPSEP

Variable	Dim	Default	Units	Definition
S	6x20	120*0.0	Mixed	Target sensitivities (may be input if available from previous computer run) See Page 146.
STØL	1	0.001	-	Minimum difference allowed between the inner products of the columns of the sensitivity matrix and the inner product of exactly linearly dependent vectors. If $\underline{S}_1$ and $\underline{S}_2$ represent the first two columns of the S matrix and $1 - \left[\frac{\underline{S}_1 \cdot \underline{S}_2}{\lvert\underline{S}_1\rvert * \lvert\underline{S}_2\rvert}\right] < STØL$ then the two columns are considered linearly dependent and the control associated with one of the columns (U(1) or U(2)) will be dropped from further consideration during the current iteration. (See Page 142)
TARGET	6x1	6*0.0	Mixed	Target values; must be input in the same numerical order as indicated by the index on the TARTØL vector.
TARTØL	25x1	25*0.0		Vector of target tolerances; a non-zero value of any component indicates that the associated target parameter will be included in the targeting process. A positive tolerance denotes an ecliptic reference system. A negative tolerance denotes an equatorial reference system. If any target is flagged equatorial, all targets are assumed referenced to the equatorial system. The desired target value should be input in TARGET. The targets are evaluated at the stopping condition (ISTØP in $TRAJ) WRT the target body (NTP in $TRAJ). The targets which are allowed are:

Variable	Dim	Default	Units	Definition
TARTØL(1)			km	(1) x-comp of S/C WRT target body.
TARTØL(2)			km	(2) y-comp of S/C WRT target body.
TARTØL(3)			km	(3) z-comp of S/C WRT target body.
TARTØL(4)			km	(4) $\underline{r}$, radial distance from target body.
TARTØL(5)			km/sec	(5) $\dot{x}$-comp.
TARTØL(6)			km/sec	(6) $\dot{y}$-comp.
TARTØL(7)			km/sec	(7) $\dot{z}$-comp.
TARTØL(8)			km/sec	(8) $\lvert\underline{v}\rvert$, velocity magnitude.
TARTØL(9)			-	(9) Not used.
TARTØL(10)			km	(10) Radius of periapsis.
TARTØL(11)			km	(11) Radius of apoapsis.
TARTØL(12)			deg	(12) Geocentric equatorial latitude.
TARTØL(13)			deg	(13) Geocentric equatorial longitude.
TARTØL(14)			days	(14) Time of periapsis passing.
TARTØL(15)			km	(15) a, semi-major axis.
TARTØL(16)			-	(16) e, eccentricity.
TARTØL(17)			deg	(17) i, inclination.
TARTØL(18)			deg	(18) Ω , longitude of ascending node.
TARTØL(19)			deg	(19) ω , argument of periapsis.
TARTØL(20)			deg q	(20) MA, mean anomaly.
TARTØL(21)			deg	(21) TA, true anomaly.
TARTØL(22)			days	(22) Time of apoapsis crossing.
TARTØL(23)			kg	(23) Final S/C mass.
TARTØL(I)				I = 24, 25 not used.

Variable	Dim	Default	Units	Definition
TLØW	1	1.0	-	Limit of quadratic error index (EMAG) below which optimization only is performed. (See Page 150).
TUP	1	1.0	-	Limit of quadratic error index (EMAG) above which simultaneous targeting and optimization is discontinued and targeting only is initiated. (See Page 150).
ULIMIT	20x2	$20*(-10^{20}, 10^{20})$	Mixed	Minimum and maximum bounds on the controls in the control vector. The units are the same as those of the controls (See Page 141-A).
UWATE	20x1	20*1.0	-	User input control weightings which are applied for all choices of the variable IWATE.

Tug Parameters

Variable	Dim	Default	Units	Definition
AZMAX	1	120.	deg	Maximum launch azimuth constraint for inner parking orbit (launch from Cape Kennedy)
AZMIN	1	35.	deg	Minimum launch azimuth constraint for inner parking orbit (launch from Cape Kennedy)
RP1	1	6567.26	km	Inner parking orbit radius
TGFUEL	1	10673.0	kg	Maximum weight of fuel for transfer stage
TUGISP	1	309.2	sec	Specific impulse of transfer stage
TUGWT	1	1714.6	kg	Dry weight of transfer stage

2.3 GODSEP Input Description

Three forms of input are used by the error analysis mode. The namelist $GØDSEP is used to define output, all measurement and event information (except the scheduling of measurements and propagation events), and all covariance initialization and propagation information. Immediately following $GØDSEP are NSCHED cards defining the scheduling of all measurements and propagation events. The format for these cards, as well as a definition of data type codes, appears after namelist $GØDSEP is defined.

Following the measurement schedule cards are a series of optional namelists for guidance, each called $GEVENT. Reading of $GEVENT is controlled by the guidance flag array IGREAD, described in $GØDSEP.

Reference is made below in the definitions of IPFØRM and IGFØRM to the "packed" and "unpacked" forms of a matrix. If the solve-for covariance matrix PS is dimensioned 10 x 10, but the current run has only 2 solve-for parameters, the 2 x 2 PS matrix is considered "packed" if the four covariance elements occupy the first four consecutive words of storage for the PS matrix. This can be achieved in namelist input by

```
PS = 9., .63, .63, 4.,
```

If, however, the namelist input contains

```
PS(1,1) = 9., PS(1,2) = .63,
PS(2,1) = .63, PS(2,2) = 4.,
```

the four elements of PS will occupy words 1, 2, 11, and 12 of the

PS matrix due to internal storage standards and the matrix is termed "unpacked."

2.3.1 Namelist $GØDSEP - Covariance Initialization and Propagation:

Variable	Dim	Default	Units	Definition
IPFØRM	1	0	-	= 0, input knowledge standard deviations and correlation coefficients in packed form (see above for definition of packed and unpacked) = 1, input knowledge in unpacked form.
IRØT	1	0		= 0, knowledge covariance is in ecliptic coordinates. = 1, covariance is equatorial.
P	6x6	1000 km, .05 km/s each component		Standard deviations and correlation coefficients of state at epoch defined by TCURR
CXS	6x11	0	-	Correlations between state and solve-for parameters
CXU	6x13	0	-	Correlations between state and dynamic consider parameters.
CXV	6x15	0	-	Correlations between state and measurement consider parameters
CXW	6x10	0	-	Correlations between state and ignore parameters.
PS	11x11	0	-	Std. dev. and correlation coefficients of solve-for parameters
CSU	11x13	0	-	Correlations between solve-for and dynamic consider parameters
CSV	11x15	0	-	Correlations between solve-for and measurement consider parameters
CSW	11x10	0	-	Correlations between solve-for and ignore parameters

Variable	Dim	Default	Units	Definition
PU	13x13	0	-	Std. deviations and correlation coefficients of dynamic consider parameters
CUV	13x15	0	-	Correlations between dynamic consider and measurement consider parameters
CUW	13x10	0	-	Correlations between dynamic consider and ignore parameters
PV	15x15	0	-	Std. deviations and correlation coefficients of measurement consider parameters
CVW	15x10	0	-	Correlations between measurement considers and ignore parameters
PW	10x10	0	-	Std. deviations and correlation coefficients of measurement consider parameters
IGFØRM	1	0	-	Ignored if CØNRD =.FALSE.; if CØNRD =.TRUE., =0, input control uncertainties packed =1, input control uncertainties unpacked. (see above definitions of packed and unpacked)
PG CXSG CXUG CXVG CXWG PSG CSUG CSVG CSWG PUG CUVG CUWG PVG CVWG PWG				Standard deviations and correlations of control covariance (analgous to P, CXS, ..., PW); if CØNRD = .FALSE., then control covariance is set to a-priori knowledge; if CØNRD = .TRUE., then control must be input at epoch defined by TG.
CØNRD	1	F	-	=F, set apriori control to a priori knowledge =T, assume a-priori control read in namelist (See Page 159)

Variable	Dim	Default	Units	Definition
DYNØIS	1	T	-	=T, compute effective process noise matrix for use with state transition matrix propagation =F, don't compute effective process noise
SCMVAR	1	0.	kg	initial S/C mass standard deviation
SIGØN	1	0.	sec	Standard deviation in thrust start-up process.
ITVERR	1	1	-	Type of second thrust noise process = 1, thruster dependent = 2, thruster independent (vehicle dependent)
EPSIG	3x2		mixed	Process noise standard deviations, used only for STM (not PDOT).
EPSIG(1,1)		.035	-	Std. dev. in magnitude proportionality noise
EPSIG(2,1)		.01	rad	Std. dev. in pitch (or in-plane) angle noise.
EPSIG(3,1)		.01	rad	Std. dev. in yaw (or out-of-plane) angle noise.
EPSIG(1,2)		0	-	Std. dev. in secondary process for magnitude proportionality.
EPSIG(2,2)		0	rad	Std. dev. in secondary noise process for pitch (or in-plane) pitch angle.
EPSIG(3,2)		0	rad	Std. dev. in secondary noise process for yaw (or out-of-plane) angle.
EPTAU(1,1)		4	days	corresponding to EPSIG (I,J) and PDOT process noise (See Page 159)
EPTAU(2,1)		1	days	
EPTAU(3,1)		1	days	
EPTAU(1,2)		0	days	
EPTAU(2,2)		0	days	
EPTAU(3,3)		0	days	
IAUG	50	50*0	-	Parameter augmentation control IAUG(I) controls augmented of parameters to state vector as follows =0, not used =1, parameter solved-for =2, parameter considered =3, parameter ignored (generalized covariance only)

Variable	Dim	Default	Units	Definition
				IAUG(I) parameters available
				(1) thrust acceleration proportionality
				(2) pitch (or in-plane) angle bias
				(3) yaw (or out-of-plane) angle bias.
				(4) gravitational constant of the Earth
				(5) gravitational constant of the Sun
				(6) J_2 zonal harmonic
				(7) not used
				(8) thrust noise magnitude (9) thrust noise pitch angle (10) thrust noise yaw angle } first noise process*
				(11) thrust noise magnitude (12) thrust noise pitch angle (13) thrust noise yaw angle } second noise process*
				(14) radius, Station #1
				(15) longitude, Station #1
				(16) latitude, Station #1
				(17), (18), (19) radius, longitude, latitude for Station #2
				(20), (21), (22) radius, longitude, latitude for Station #3
				(23), (24) 2-way doppler, range bias from Station #1
				(25), (26) 2-way doppler, range bias from Station #2
				(27), (28) 2-way doppler, range bias from Station #3
				(29), (30) 3-way doppler, range bias from Station #1, 2
				(31), (32) 3-way doppler, range bias from Station #1, 3
				(33), (34) 3-way doppler, range bias from Station #2, 3
				(35), (36) azimuth, elevation angle biases from Station #1
				(37), (38) azimuth, elevation angle biases from Station #2
				(39), (40) azimuth, elevation angle biases from Station #3
				(41) star-planet angle bias star #1
				(42) star-planet angle bias star #2
				(43) star-planet angle bias star #3
				(44) apparent planet diameter angle bias
				(45) horizon scanner altitude (CO_2) bias

*Pitch and yaw may be replaced by in-plane and out-of-plane angles.

Variable	Dim	Default	Units	Definition
				(46), (47), (48) horizon scanner angle biases (49), (50) Not used.
PDØT	1	F	-	logical flag controlling covariance integration = T, propagate covariance by integration = F, propagate covariance by state transition matrix method
PRØPG	1	F	-	not used for input, overridden internally
SCHFTL	1	T	-	logical flag = T, failure to mesh on STM file within tolerances defined by TØLFØR and TØLBAK is fatal = F, mesh failure not fatal
TCURR	1	TSTART ($TRAJ)	days	Epoch for input knowledge uncertainties, referenced to TLNCH (if PDOT = .TRUE. and TCURR ≠ TSTART, (See Section 4.2.5).
TFINAL	1	TEND ($TRAJ)	days	Error analysis final time, referenced to TLNCH
TG	1	TCURR	days	Epoch for input control uncertainties if CØNRD = T and control epoch different from knowledge epoch
TØLBAK	1	1.0	days	Backward tolerance on meshing scheduled event times with STM file times
TØLFØR	1	.002	days	Forward tolerance on meshing scheduled event times with STM file times

Measurement Related Variables

Variable	Dim	Default	Units	Definition
CØRLØN	1	.9	-	Station-to-station longitude correlation for ground-based tracking stations

Variable	Dim	Default	Units	Definition
DØPCNT	1	12	Meas./ Day	Nominal number of dopler measurements to be taken per day for scaling doppler noise (SIGMES(1) and SIGMES(3))
GAINCR	1	F		Controls GAIN file creation (See Page 162) = T, create GAIN file = F, do not create GAIN file
GENCØV	1	F	-	= F, current run not generalized covariance = T, generalized covariance run, forces IGAIN = 4
HCØ2	1	1.03632	km	Altitude of CO2 layer for horizon scanner
IGAIN	1	1	-	Defines OD filtering algorithm = 1, Kalman-Schmidt = 2, sequential weighted least squares = 3, User-supplied filter (See Analytic Manual, Section 6.4) = 4, read filter gain from GAIN file (TAPE 4)
NSCHED	1	0	-	Number of measurement and propagation event scheduling cards to follow namelist $GØDSEP
SIGMES	15		mixed	Array of measurement white noise standard deviations
SIGMES(1)		1.0	mm/sec/1 min sample	2-way doppler
SIGMES(2)		3.0	meter	2-way range
SIGMES(3)		.1	mm/sec/1 min sample	3-way drequency drift
SIGMES(4)		10.1	meter	3-way range

Variable	Dim	Default	Units	Definition
SIGMES(5)		1600.	μ-rad	azimuth angle
SIGMES(6)		1600.	μ-rad	elevation angle
SIGMES(7)		150.	μ-rad	on-board optics -- star planet angle
SIGMES(8)		150.	μ-rad	on-board optics -- apparent planet diameter
SIGMES(9)		10.	km	on-board optics -- center-finding uncertainty; used in conjunction with star-planet angle
SIGMES(10)		.48	km	horizon scanner altitude
SIGMES(11)		291.	μ-rad	horizon scanner angle
SIGMES(12)-(15)		-	-	not used
SPHLØC	1	.T.	-	coordinate system of station locations and their errors = .T., spherical = .F., cylindrical
SIGALT	1	35.	meter	altitude } a-priori standard deviations of equivalent station locations (See IAUG and SPHLØC)
SIGLAT	1	35.	meter	latitude
SIGLØN	1	35.	meter	longitude
SIGRS	1	35.	meter	spin radius
SIGZ	1	35.	meter	z-height
STALØC	3x9	-	km,deg	Array of tracking station locations (See REFSEP input, P. 12-B)
STARDC	3x9		-	array of ecliptic star direction cosines (or, equivalently, unit vectors in star directions) used for star-planet angle measurements; vector locating Jth star loaded in Jth column of STARDC default values are (fictitious stars) STARDC(1,1) = .98, .16, -.07 STARDC(1,2) = -.64, .70, -.31 STARDC(1,3) = -.34, -.86, .37

Event Variables

Variable	Dim	Default	Unit	Definition
NEIGEN	1	0	-	Number of eigenvector events to be scheduled (maximum 10).
TEIGEN	10	10*0.	days	Array of eigenvector event times (See Page 158).
NPRED	1	0	-	Number of prediction events to be scheduled (maximum 10)
TPRED	10	10*0.	days	Array of prediction event times
TPRED2	10	10*0.	days	Array of times predicted to
NGUID	1	0	-	Number of guidance events to be scheduled (maximum 20)
TGUID	20	20*0.	days	Array of guidance event execution times
TDELAY	20	20*0.	days	Array of guidance event delay times. Guidance events are scheduled at execution time minus delay time, and covariances are propagated forward to execution time.
TCUTØF	20	20*0.	days	Array of guidance event cutoff times for impulsive maneuvers, set TCUTØF(I) = TGUID(I)
IGPØL	20	20*0.	-	Array of guidance policy control flags (targets evaluated at TIMFTA) = 0, no maneuver, print control uncertainties = 1, target to cartesian state, X,Y,Z = 2, semi-major axis (a), inclination (i) = 3, a, i, RCA = 4, $\lvert \underline{r} \rvert$, $\lvert \underline{v} \rvert$, i = 5, variable time of arrival (XYZ targeting)
IGREAD	20	20*0.	-	Array of guidance event read control flags (if non-zero, control weights CØNWT will be read), See Page 163.

Variable	Dim	Default	Unit	Definition
				= 0, do not read namelist $GEVENT = 1, read namelist $GEVENT, and recompute control and target variation matrices (VMAT and SMAT) = 2, read $GEVENT
NCØN	1	4	-	Number of controls for low thrust guidance (must be greater than or equal to number of target variables). Controls are ordered: magnitude pitch* yaw* cutoff time start-up time (or arrival time if IGPØL = 5) = 1, magnitude only = 2, magnitude and pitch* = 3, magnitude, pitch, yaw* = 4, magnitude, pitch, yaw* cutoff time = 5, use all five controls
CØNWT	5	5*1.	-	Relative weighting factors for controls defined by NCØN Small number weights out effect of control. CØNWT may also be re-defined in namelist $GEVENT
UMAX	5	5*50.	%, deg, day	Maximum allowable (1σ) control correction as defined by NCØN
TARWT	3	3*1.	-	Relative weighting factors for target parameters defined by IGPØL
TIMFTA	1	0.	days	Stop time for target conditions (overrides TFINAL).
SIGDV	4		mixed	Array of standard deviations defining impulsive Δ V execution errors
SIGDV(1)		.01	-	Standard deviation of proportionality error
SIGDV(2)		2.E-4	km/s	Standard deviation of resolution error

*Pitch and yaw angles may be replaced by in-plane and out-of-plane angles.

Variable	Dim	Default	Unit	Definition
SIGDV(3)		.065	rad	Standard deviation in ecliptic pointing angle
SIGDV(4)		.065	rad	Standard deviation in out of ecliptic pointing angle

Output Control

Variable	Dim	Default	Unit	Definition
CHEKPR	10	10*F	-	Array of logical flags controlling check point options which may be useful in debugging. The following elements of CHEKPR are activated if set equal to .TRUE.: (1) - writes to nominal output file (TAPE 6) all information on STM file (TAPE 3) during file generation and all information reads from the STM file. In addition, the results of each transition matrix chaining operation in subroutine STMRDR (See Program Manual) is also printed. (2) - Prints every measurement. (3) - Prints full covariance, not standard deviations and correlation coefficients, before and after each measurement. (4) - Writes to nominal output file (TAPE 6) all information written on GAIN file (TAPE 4) during creation, and all information read from GAIN file for IGAIN = 4 option. (5) - Writes to nominal output file (TAPE 6) knowledge and control uncertainties at end of burn interval and transition matrix over burn interval for low thrust guidance, or eigenvalues and eigenvectors of expected ΔV covariance for impulsive guidance.

Variable	Dim	Default	Unit	Definition
				(6) - computer time computation and display (7) - print 6x6 covariance in equatorial coordinates (8) - reads from STM file to compute coordinate transition matrices needed for guidance rather than calling TRAJ. (9) - Prints covariance before and after each propagation (10)- dump core when mission time ≥ TDUMP.
TDUMP	1	10^{20}	days	dump time (See CHEKPR(10))
IPRØP	1	0	-	Propagation event print control = 0, no print = 1, print standard deviations and correlation coefficients of S/C state only = 2, full eigenvector event
JØBLAB	10	Blank	-	Hollerith label to be printed with each measurement and event print
MPFREQ	12	12*0	-	Measurement print frequency control. If MPFREQ(I) = N, the first time the data type corresponding to MPFREQ(I) is scheduled it is printed. Thereafter, that data type will be printed each time its count is divisible by N. The following correspondences between MPFREQ and data type are used. (See also Section 2.3.2). (1) - two-way doppler (code 100X) (2) - three-way doppler (code 11XX) (3) - simultaneous 2-way/3-way doppler (code 12XX) (4) - differenced 2-way/3-way doppler (code 13XX) (5) - two-way range (code 200X) (6) - three-way range (code 21XX) (7) - simultaneous 2-way/3-way range (code 22XX) (8) - differenced 2-way/3-way range (code 23XX) (9) - azimuth-elevation angles (code 30XX and 300X). (10)- star-planet angles (code 4XXX, 40XX and 400X). (11)- apparent planet diameter (code 5000). (12) - not used. (13) - horizon scanner observations (code 7000)

Variable	Dim	Default	Units	Definition
PRNCØV	5		-	Print control for standard deviations and correlation coefficients. (T = TRUE, F = FALSE)
PRNCØV(1)		T	-	Do (T) or do not (F) print state standard deviations and correlation coefficients and correlations with all augmented parameters
PRNCØV(2)		T	-	Do (T), do not (F) print solve-for standard deviations and correlation coefficients and correlations with other parameters
PRNCØV(3)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for dynamic consider parameters and correlations with other parameters.
PRNCØV(4)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for measurement consider parameters and correlations with ignore parameters
PRNCØV(5)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for ignore parameters
PRNML	1	F	-	Do (T), do not (F) print input namelist $GØDSEP after reading
PRNSTM	5		-	Print control for state transition matrix partitions. The flagging of any PRNSTM element causes prints, with each state transition matrix print, of the sensitivity of the relevant parameter set to the entire augmented state vector.
PRNSTM(1)		T		Prints sensitivities for S/C state
PRNSTM(2)		F		Prints sensitivities for solve-for parameters
PRNSTM(3)		F		Prints sensitivities for dynamic consider parameters
PRNSTM(4)		F		Prints sensitivities for measurement consider parameters

Variable	Dim	Default	Unit	Definition
PRNSTM(5)		F		Prints sensitivities for ignore parameters
PUNCHE	5	5*F		Punch flag for complete knowledge or control standard deviations and correlation coefficients at events = T, causes punching = F, does not Elements of PUNCHE are: (1) - knowledge at propagation event (2) - knowledge at eigenvector event (3) - knowledge at thrust event (4) - knowledge at time TPRED2 for prediction events (5) - control before and after maneuver at each guidance event
SUMARY	1	T	-	= T, write SUMMARY file (TAPE 8) = F, do not write SUMMARY file (TAPE 8)

2.3.2 Measurement and Propagation Schedule Input

Measurement schedule cards follow directly behind namelist $GØDSEP. Each card contains three time control variables in Columns 1-30 in format 3F10.4 and one measurement code (MESCØD) right justified in Column 40 (format I10).

Time control variables are START, STØP, DELT

START = start time, referenced to TLNCH, for scheduling current data type;

STOP = stop time for current data type;

DELT = time interval increment for scheduling.

For example, if START = 10.5, STØP = 20. DELT = 1.0, the current data type will be scheduled ten times at 10.5, 11.5, 12.5, ..., 19.5 days. Internal tests modify START if it is less than TCURR, and STØP if it is greater than TFINAL so that no measurements are scheduled outside the requested error analysis interval.

One additional option is available on scheduling. Any scheduling card on which DELT is zero or negative redefines the allowable scheduling interval from (TCURR, TFINAL) to the (START, STOP) interval defined by that card. All succeeding measurements are scheduled in the interval defined by that card until another card with a zero or negative DELT is encountered.

If DELT is greater than zero and no measurement code appears (MESCØD = 0), propagation events will be scheduled. Except for propagation events, all other allowable measurement codes are 4-digits, defined as follows (station and star numbers are defined in STALØC and STARDC, respectively):

100n	2-way doppler (range-rate) from Station n;
11mn	3-way doppler from Stations m and n;
12mn	simultaneous 2-way/3-way doppler from Stations m and n;
13mn	differenced 2-way/3-way doppler from Stations m and n;
200n	2-way range from Station n;
21mn	3-way range from Stations m and n
22mn	simultaneous 2-way/3-way range from Stations m and n;
23mn	differenced 2-way/3-way range from Stations m and n

300n	azimuth and elevation measured from Station n;
300m	azimuth and elevation measured simultaneously from Stations m and n;
400n	on-board optics, angle measurement between primary body and star n, defined by n^{th} column in STARDC array;
40mn	two simultaneous star-planet angle measurements with primary body and Stars m and n
4kmn	three simultaneous star-planet angle measurements with primary body and Stars k, m and n;
5000	apparent planet diameter measurement of primary body.
600n	not used.
7000	horizon scanner measurement (3 simultaneous angles).

2.3.3 Namelist $GEVENT

One copy of namelist $GEVENT must appear after the measurement schedule cards for each guidance event which has its corresponding value of IGREAD greater than zero. Default values are nominal input or computed values prior to reading $GEVENT.

Variable	Dim	Default	Units	Definition
BURNP	4	4*0.	km/s, Kg	Thrust acceleration and mass at beginning and at end of guidance interval (See Page 163).
CØNWT	5	-	-	See namelist $GØDSEP
NCØN	1	-	-	See namelist $GØDSEP

Variable	Dim	Default	Units	Definition
SMAT	3x5	15*0.	mixed	Sensitivity matrix of target parameters WRT control parameters (See Page 163).
TARWT	3	-	-	See namelist $GØDSEP
UMAX	5	-	-	See namelist $GØDSEP
VMAT	3x6	18*0.	mixed	Variation matrix of target parameters WRT state at guidance epoch (See Page 163).

2.4 SIMSEP Input Description

Input to the simulation mode is transmitted to the program through three namelists: $TRAJ, $SIMSEP, and $GUID. As before, the $TRAJ namelist essentially defines the reference trajectory initial conditions, spacecraft parameters (thrust, mass, electric power, etc.) and other baseline quantities necessary to specify a reference mission. In general, the $TRAJ inputs for SIMSEP are obtained as results from a precursor TOPSEP analysis where a targeted reference trajectory has been determined.

The first namelist peculiar to the SIMSEP mode is called $SIMSEP. Its primary function is to initialize *a priori* statistical descriptions of those error sources which remain nearly constant during the course of an individual simulation in the basic Monte Carlo cycle. In addition, various parameters which, for example, specify the number of guidance events, the output frequency, the number of Monte Carlo cycles, etc., are also read from $SIMSEP.

The second of these namelists unique to SIMSEP is $GUID. As its name implies, it is responsible for initializing parameters and data used at guidance events. Unlike $SIMSEP which is read only once for each SIMSEP run, $GUID is read for each specified guidance event being simulated along the mission. Variables initialized by this namelist include such things as guidance event times, knowledge covariances, guidance law and policy specifications, etc.

Finally, it should be noted that both $SIMSEP and $GUID can also contain certain statistical arrays computed in previous SIMSEP analyses.

These arrays are key to SIMSEP's restart capability and provide the means to continue an analysis with many more Monte Carlo cycles in a series of SIMSEP runs. The format for input is, generally, a (nxn) correlation matrix of standard deviations and correlation coefficients. An extra column vector augmented to the right hand side of the (nxn) matrix, thus creating a (nx(n+1)) matrix, serves to store mean values to complete the statistical description for the parameter of interest. Unfortunately, the multitude of options available in SIMSEP make the real numerical format used for input a bit awkward. In particular, the variables, CCØVG, CNTCØV, TARCØV, etc., are actually read as one long column vector with separate columns in the correlation matrix being stored consecutively. This apparent difficulty is somewhat off-set by the fact that these arrays are ordinarily generated as output from a previous SIMSEP run and have automatically been punched in the requisite format.

Another important capability in SIMSEP which relates to the namelists $SIMSEP and $GUID is the multiple run or stacked case feature. In particular, once normal computer processing of a run is completed, the program automatically recycles to read $SIMSEP again if the $TRAJ variable, MØDE, has been set to a -3. When this occurs, only changes to $SIMSEP from the previous run need to be input. Likewise, the $GUID namelists are also read in the same sequence as they were for the first run. Guidance event data need not be read anew unless there are changes to a particular data set or if there are more guidance events in the second run. The only drawback here is that a zero-data namelist, i.e., a ∅GUID card followed by a ∅END card, must be input for each event even though there may be no changes. This is also a requirement for the ∅SIMSEP namelist upon recycling.

Given below are detailed descriptions of the variables, dimensions and default values (where applicable) for both ∅SIMSEP and ∅GUID. The parameters are divided into appropriate groupings; for ∅SIMSEP: run definition, a-priori control and ephemeris errors, spacecraft parameter errors, and accumulated statistics and parameters; for ∅GUID: event initialization data, optional initialization data, guidance law and policy, knowledge error, guidance control data, and accumulated statistical data.

2.4.1 Namelist: $SIMSEP

Run Definition Parameters:

Variable	Dim	Default	Units	Definition
AØK	1	100.	-	Backup convergence tolerance for the weak convergence test.
CPMAX	1	10000.	sec	Computer processing time limit (See Page 175).
DVMXN	1	0.1	km/sec	Maximum magnitude allowed for a delta-velocity correction.
INREF	1	0	-	Option flag to indicate whether or not state variables, s/c mass, targets, etc. are to be read as input during the ∅GUID namelist read. = 0, No data input (computed internally). = 1, Input data.

Variable	Dim	Default	Units	Definition
				If INREF = 1, the variables listed under <u>Optional Guidance Event Initialization Data</u> must be input along with MEND and XEND (See Page 172 and 173). If INREF = 0, the optional guidance event data are automatically computed.
IØUT	1	1	-	Print output flag which activates printout for every IØUT Monte Carlo cycle.
IPUNCH	1	0	-	Punch output flag. = 0, no punched statistical arrays (covariance matrices and vector means) at the end of the run. = 1, punch.
IRAN	1	1	-	Monte Carlo random number seed to initiate the generation of random number from RANF. ≠ 0, regular Monte Carlo analysis. = 0, forced Monte Carlo sampling of one-sigma for all error sources.
NCYCLE	1	1	-	Number of Monte Carlo mission cycles to be executed.
NGUID	1	1	-	Total number of guidance events, both low thrust and impulsive velocity changes, to be executed on each simulated mission. A maximum of five guidance events is allowed.
PRNML	1	F	-	Do (T), do not (F) print input namelist $SIMSEP after reading.

A-Priori Control and Gravitational Errors:

Variable	Dim	Default	Units	Definition
GMERR	2		km^3/sec^2	One sigma uncertainties in the gravitational constants.
GMERR(1)		0.		Solar mass error.
GMERR(2)		0.		Earth mass error.
J2ERR	1	0.	--	One sigma uncertainty in the J_2 - coefficient of the geo-gravity potential function.
PG	6x6	0,....,0	km km/sec	Correlation array describing the *a priori* Cartesian control errors associated with the initial reference state vector. A 6x6 array is read for the S/C control errors with standard deviations along the principal diagonal and correlation coefficients off-diagonal. Only the principal diagonal and lower triangular partition of this array are actually necessary.

S/C Parameter Errors:

Variables	Dim	Default	Units	Definition
EXVERR	4			One sigma midcourse velocity correction execution errors.
EXVERR(1)		0.	-	Proportionality error.
EXVERR(2)		0.	degs	In-ecliptic-plane pointing error.
EXVERR(3)		0.	degs	Out-ecliptic-plane pointing error.
EXVERR(4)		0.	km/sec	Resolution error.
SCERR	6			One sigma SEP s/c errors.
SCERR(1)	1	0.	kg	Initial s/c mass uncertainty.

Variables	Dim	Default	Units	Definition
SCERR(2)		0.	km/sec	Low thrust exhaust velocity uncertainty.
SCERR(3)		0.	kw	Uncertainty in electric power at 1 A.U.
SCERR(4)		0.	-	Uncertainty in thruster efficiency.
SCERR(5)		0.		Uncertainty in the effective radiation pressure coefficient.
SCERR(6)		0.	%	Per cent uncertainty in the effective thruster start-up time after exiting the shadow.
TCERR	9x20	0,....,0		One sigma thrust control biases.
TCERR(1, j)			days	j^{th} thrust phase end time.
TCERR(2, j)			-	j^{th} thrust phase throttling.
TCERR(3, j)			degs	j^{th} thrust phase angular coefficient number one, e.g., in-orbit-plane or pitch angle. (See Section 4.1 of the Analytic Manual. Also see Page 10-B of the User's Manual.)
TCERR(4, j)			degs or degs/sec	j^{th} thrust phase angular coefficient number two.
TCERR(5, j)			degs or degs/sec	j^{th} thrust phase angular coefficient number three.
TCERR(6, j)			degs	j^{th} thrust phase angular coefficient number four, e.g., out-orbit-plane or yaw angle.

Variables	Dim	Default	Units	Description
TCERR(7, j)			-	Not used.
TCERR(8, j)			degs or degs/sec	j^{th} thrust phase angular coefficient number five.
TCERR(9, j)			degs or degs/sec	j^{th} thrust phase angular coefficient number six
TVERR	6x3			One sigma time varying thrust control errors (dynamic process noise specifications), corresponding correlation times, and correlation time uncertainties for two simultaneous, independent processes.
TVERR(1, 1)		0.	-	First process, thrust proportionality uncertainty (per thruster).
TVERR(1, 2)		1.	days	Correlation time for thrust acceleration.
TVERR(1, 3)		0.	days	Uncertainty in the thrust acceleration correlation time.
TVERR(2, 1)		0.	degs	First process, pitch angle uncertainty.
TVERR(2, 2)		1.	days	Correlation time for pitch angle.
TVERR(2, 3)		0.	days	Uncertainty in the pitch angle correlation time.
TVERR(3, 1)		0.	degs	First process, yaw angle uncertainty.
TVERR(3, 2)		1.	days	Correlation time for yaw angle.
TVERR(3, 3)		0.	days	Uncertainty in the yaw angle correlation time.
TVERR(4, 1)		0.	-	Second process, thrust acceleration uncertainty (per thruster).
TVERR(4, 2)		1.	days	Correlation time for thrust acceleration.

Variables	Dim	Default	Units	Description
TVERR(4, 3)		0.	days	Uncertainty in the thrust acceleration correlation time.
TVERR(5, 1)		0.	degs	Second process, pitch angle uncertainty.
TVERR(5, 2)		1.	days	Correlation time for pitch angle.
TVERR(5, 3)		0.	days	Uncertainty in the pitch angle correlation time.
TVERR(6, 1)		0.	degs	Second process, yaw angle uncertainty.
TVERR(6, 2)		1.	days	Correlation time for yaw angle.
TVERR(6, 3)		0.	days	Uncertainty in the yaw angle correlation time.

Accumulated Statistics and Parameters:

Variable	Dim	Default	Units	Definition
ADVT	2			Accumulated delta-velocity magnitude statistics for all impulsive velocity corrections along a mission.
ADVT(1)		0.	km/sec	One-sigma delta-velocity magnitude.
ADVT(2)		0.	km/sec	Mean delta-velocity magnitude.
ENDCØV	6x7	0.,,,0.	km km/sec	S/C control error correlation array computed at the trajectory time TEND. This array is input as a (6x6) matrix of standard deviations and correlation coefficients. Only the principal diagonal and the lower triangular submatrix are necessary. The 7th column of this array contains the means.

Variables	Dim	Default	Units	Definition
AMASS	2			Accumulated S/C mass statistics at the final time.
AMASS(1)		0.	kg	One-sigma s/c mass.
AMASS(2)		0.	kg	Mean s/c mass.
MEND	1	0.	kg	Final s/c mass on the reference trajectory at time TEND. This variable is required only if INREF = 1 and is used in computing AMASS statistics.
MC	1	0.	-	Number of Monte Carlo cycles executed in a previous SIMSEP run in which statistical variables ADVT, AMASS, ENDCØV, and ATHCØV are computed. MC is used to restart accumulated statistics for the current run.
ATHCØV	420	0,...,0.		Accumulated statistics on the active thrust controls changed at scheduled low thrust guidance events. A maximum of twenty active thrust controls are allowed. This array is input as a (nxn) matrix of standard deviations and correlation coefficients, where n is the total number of low thrust controls. As before, only the principal diagonal and lower triangular submatrix need to be input. The $(n+1)^{th}$ column vector contains the means.
XEND	6	0,...,0.	km, km/sec	Final reference trajectory state vector at the trajectory time TEND. This vector is required input only if INREF = 1 and is used in computing the ENDCØV covariance matrix.

Variable	Dim	Default	Units	Definition
KATHC	1	0	--	Dimension of the ATHCØV matrix.

S/C Parameters for Midcourse Velocity Corrections:

Variable	Dim	Default	Units	Definition
SPFIMP	1	265.	sec	Specific impulse for chemical propulsion system.
DVMDØT	1	.05	kg/sec	Mass flow rate for chemical propulsion system.

2.4.6 Namelist: $GUID

Guidance Event Initialization Data:

Variable	Dim	Default	Units	Definition
KTER	1	0.	-	Option flag to indicate whether or not target errors are to be evaluated after the current guidance event. If KTER = 1, a trajectory is integrated from the point of the guidance event to the target.
TGUID	1	0.	days	Epoch of the current guidance event specified as either a Julian date or the interval of days since launch.
TTARG	1	0.	days	Designated epoch of arrival at the target specified either as a Julian date or as the interval of days since launch.

Optional Guidance Event Initialization Data: These variables are required input only if INREF = 1 (See $SIMSEP).

Variable	Dim	Default	Units	Definition
MGREF	1	0.	kg	S/C reference mass at the current guidance event.
MTREF	1	0.	kg	S/C reference mass at the designated target time.
S	36	0,...,0.	Mixed	Sensitivity or guidance matrix which has been computed in a previous analysis. For linear guidance, S is input as a guidance matrix. For nonlinear guidance, S is input as a targeting sensitivity matrix.

Variable	Dim	Default	Units	Definition
TARGET	6	0,...,0.	Mixed	Array of reference target values evaluated at the designated target time.
XGREF	6	0,...,0.	km, km/sec	Reference trajectory state vector at the current guidance event.
XTREF	6	0,...,0.	km, km/sec	Reference trajectory state vector at the designated target time.
PRNML	1	F	--	Do (T), do not (F) print namelist $GUID after reading.

Guidance Law and Policy Data:

Variable	Dim	Default	Units	Definition
IGUID	1	1	--	Guidance law flag. = -2, nonlinear, impulsive guidance. = -1, linear, impulsive guidance. = 0, zero-action guidance event with no maneuver performed but control statistics computed. = +1, linear, low thrust guidance event. = +2, nonlinear, low thrust guidance event.
ITARGT	25	0,....,0.	--	Target policy vector; a nonzero value of any component indicates that the associated target parameter will be included as a target variable. All targets are evaluated at the designated target time.
ITARGT(1)			km	X-component of the S/C state relative to the Earth.
ITARGT(2)			km	Y-component of the S/C state relative to the Earth.

Variable	Dim	Default	Units	Definition
ITARGT(3)			km	Z-component of the S/C state relative to the Earth.
ITARGT(4)			km	$\|\underline{r}\|$ - radial distance from the Earth.
ITARGT(5)			km/sec	V_x - component of the S/C state relative to the Earth.
ITARGT(6)			km/sec	V_y - component of the S/C state relative to the Earth. Earth.
ITARGT(7)			km/sec	V_z - component of the S/C state relative to the Earth.
ITARGT(8)			km/sec	$\|\underline{v}\|$ - velocity magnitude relative to the Earth.
ITARGT(9)			-	Not used.
ITARGT(10)			km	r_{ca} - radius of closest approach.
ITARGT(11)			km	Radius at apogee.
ITARGT(13)			degs	Geographic longitude of the S/C.
ITARGT(14)			days	Perigee measured relative to TLNCH.
ITARGT(15)			km	a, semi-major axis of the osculating conic relative to Earth.
ITARGT(16)			--	e, eccentricity of the osculating conic relative to the Earth.

Variable	Dim	Default	Units	Definition
ITARGT(17)			deg	i, inclination of the osculating conic relative to the Earth.
ITARGT(18)			deg	Ω, longitude of ascending node of the osculating conic relative to the Earth.
ITARGT(19)			deg	ω, argument of periapsis of the osculating conic relative to the Earth.
ITARGT(20)			deg	M, mean anomaly of the osculating conic relative to the Earth.
ITARGT(21)			deg	f, true anomaly of the osculating conic relative to the Earth.
ITARGT(22)			days	Time of apogee measured relative to TLNCH.
ITARGT(23)-(25)			--	Not used.

Variable	Dim	Default	Units	Definition
TARTØL	6	0,....,0.	Mixed	Target tolerance array. When the miss for each target variable is less than or equal to the corresponding TARTØL value, the strong convergence criterion is satisfied.

Knowledge Error Data:

Variable	Dim	Default	Units	Definition
CXS	6x11	0,...,0.	-	Cross correlation array of solve-for parameters which have been augmented to the state vector.
KDIMEN	1	6	-	Dimension of the augmented state vector. = 6, s/c state vector only. = 7, s/c state vector and one mass (sun or Earth). = 8, s/c state vector and two masses (sun and Earth). = 9, s/c state vector and thrust biases (magnitude, direction. = 10, s/c state vector, thrust biases, and one mass. = 11, s/c state vector, thrust biases, and two masses. = 12, s/c state vector and J2 error. = 13, s/c state vector, J2 error, and one mass. = 14, s/c state vector, J2 error, and two masses. = 15, s/c state vector, J2 error, and thrust biases. = 16, s/c state vector, J2 error, thrust biases, and one mass. = 17, s/c state vector, J2 error, thrust biases and two masses.

Variable	Dim	Default	Units	Definition
P	6x6	0,...,0.	km, km/sec	Correlation array describing the Cartesian knowledge errors associated with the actual trajectory state at the guidance event. The input format is the same as EPHERR (See Page 41).
PS	11x11	0,...,0.	Mixed	Correlation array of solve-for parameters which have been augmented to the s/c state vector. The input format is the same as PG.

Guidance Event Control Parameters:

Variable	Dim	Default	Units	Definition
H	10x20	0,...,0.		Array of quantities used to identify the active thrust control variables to be used during the current low thrust guidance event. Entries in H have a one-to-one correspondence to elements in the THRUST array. (See Page 10-B). If the sensitivity matrices are being computed by numerical differencing, the values of H also define the magnitude of the perturbation forced in each control variable. Comment: Only the first six non-zero entries will be used since a maximum of six controls at any given guidance event is allowed (See Page 170).
H(1,j)				Not used.
H(2,j)			days	Active thrust control is the j^{th} thrust phase end time (THRUST(2,j)).

Variable	Dim	Default	Units	Definition
H(3,j)			-	Active thrust control is the j^{th} thrust phase throttling level (THRUST(3,j)).
H(4,j)			degs	Active thrust control is the j^{th} thrust phase angular coefficient number one, e.g., in-orbit-plane or pitch angle (THRUST(4,j)).
H(5,j)			degs or degs/sec	Active thrust control is the j^{th} thrust phase angular coefficient number two.
H(6,j)			degs or degs/sec	Active thrust control is the j^{th} thrust phase angular coefficient number three.
H(7,j)			degs	Active thrust control is the j^{th} thrust phase angular coefficient number four, e.g., out-orbit-plane or yaw angle.
H(8,j)				Not used.
H(9,j)			degs or degs/sec	Active thrust control is the j^{th} thrust phase angular coefficient number five.
H(10,j)			degs or degs/sec	Active thrust control is the j^{th} thrust phase angular coefficient number six.
IASTM	1	0	-	Flag to indicate whether or not numerical differencing will be used in computing sensitivities matrices. Numerical differencing is used when IASTM = 0. Integrated variational equations are used when IASTM = 1.
NMAX	1	1	-	Maximum number of non-linear guidance iterations allowed.
UWATE	6	1.,...,1.	-	Array of control variable weights that may be used to arbitrarily increase the sensitivity of a given control relative to other controls.

Accumulated Guidance Event Statistical Data:

Variable	Dim	Default	Units	Definition
CCØVG	6x7	0,...,0.	km, km/sec	S/C state vector control error array computed at the current guidance event. This array is read as a (6x6) matrix of standard deviations and correlation coefficients. Only the principal diagonal and the lower triangular submatrix are necessary. The 7^{th} column of this array contains the mean values.
CCØVT	6x1	0,...,0.	km, km/sec	S/C state vector control error array computed at the designated target time. This array is read as a (6x6) matrix of standard deviations, correlation coefficients, and means in the same format as CCØVG. Computed whenever KTER=1.
CNTCØV	6x7	0,...,0.	Mixed	Correlation array for the active thrust control variables used at this guidance event. This array is input as an (nxn) matrix of standard deviations and correlation coefficients where n is the number of low thrust controls. Only the principal diagonal and lower triangular partition need to be input. The $(n+1)^{th}$ column vector contains the control means.
DVMAG	2			Delta-velocity magnitude statistics.

Variable	Dim	Default	Units	Definition
DVMAG(1)		0.	km/sec	One-sigma delta-velocity magnitude.
DVMAG(2)		0.	km/sec	Mean delta-velocity magnitude.
DVMCØV	3x4	0,...,0.	km/sec	Delta-velocity vector correlation array. Input format is the same as CCØVG (See Page 51).
GMSCØV	2			S/C mass statistics evaluated at the current guidance event.
GMSCØV(1)		0.	kg	One-sigma S/C mass.
GMSCØV(2)		0.	kg	Mean S/C mass.
MSAMP	1	0.	--	Number of Monte Carlo cycles executed in a previous SIMSEP run in which statistics on CCØVG, CCØVT, CNTCØV, DVMAG, DVMCØV, GMSCØV, TARCØV, and TMSCØV were computed. MSAMP is used to re-initialize the accumulation of statisicts for the current run.
TARCØV	42	0,...,0.	Mixed	Correlation array describing target error statistics. The format here is the same as CNTCØV (See Page 51) except the dimension of the input matrix is determined by the no. of target variables. This array is input whenever KTER = 1, or at the last guidance event.
TMSCØV	2			S/C mass statistics evaluated at the designated target time. Computed whenever KTER = 1.
TMSCØV(1)			kg	One-sigma s/c mass
TMSCØV(2)			kg	Mean s/c mass

2.5 REFSEP Input Description

Input to the detailed trajectory print mode of MAPSEP is made through the namelist $TRAJ and formatted cards. In addition to the baseline trajectory parameters, $TRAJ contains several variables used only in REFSEP (See Page 12-B). Of particular importance is the variable KARDS which must be set equal to the number of formatted print schedule cards to be input following the namelist. These cards contain such information as start and stop times and time intervals between specified blocks of trajectory output. The format for these cards is exactly the same as that for measurement schedule cards characteristic of the GODSEP mode (See Page 34). A brief summary of the format and an example follow.

Each schedule card contains three time control variables in Columns 1-30 (format 3F10.4) and one print code right justified in Columns 37-40 (format I10). The time control variables are START, STØP, and DELT where

START = start time, referenced to TLNCH, for scheduling current print blocks;

STØP = stop time for current print blocks;

DELT = time interval increment for scheduling.

Internal tests modify START if it is less than TSTART, and STØP if it is greater than TEND. TSTART and TEND are input variables in $TRAJ which define the initial and final trajectory times respectively. An additional option of specifying DELT=0. aids the user in redefining the range of times which are allowed on subsequent cards. The START and STØP times on a DELT=0. card designate the new scheduling interval for all succeeding cards until another DELT=0. card is encountered. The redefined interval supersedes the nominal (TSTART, TEND) interval.

The print code (klmn) is a four digit number designating the print blocks to be output at the appropriate times. Each digit represents a different type of print block and the value of the digit determines the level of detail to be printed (i.e. the largest value of the specified digit includes the print suggested by the smaller non-zero values). The blocks of print are selected as follows:

n = 0 to 3, Nominal Trajectory Print

$k\ell m0$	current time and the Julian date
$k\ell m1$	body relative S/C states and S/C accelerations
$k\ell m2$	individual perturbing accelerations, planetary ephermerides, flux data, and sun occultation data
$k\ell m3$	integration data, Encke formulation

m = 0 to 2, Primary Body Data

$k\ell 0n$	no primary body data
$k\ell 1n$	osculating conic data
$k\ell 2n$	relevant unit vectors

ℓ = 0 to 1, Target Data

$k0mn$	no target data
$k1mn$	closest approach parameters, and orbital elements relative to the target body

k = 0 to 1, Tracking Data

$0\ell mn$ — no tracking data

$1\ell mn$ — S/C in various topocentric coordinate systems; and azimuth, elevation, range, and range rate from specified tracking stations.

For the special case when the print code is set to (0000) or when the code is not input on the schedule card at all, the default print code of (0001) is assumed. If the variable KARDS is set to zero, no formatted input cards will be read by the program and thus no detailed print blocks will be scheduled. However, trajectory print may be obtained by setting IPRINT and MØRBIT to the desired values in the $TRAJ namelist.

Figure 2-5 is an example of one possible schedule card. If this card is encountered by REFSEP the print code 1123 will be scheduled at 100.5, 110.5, 120.5, ... , 190.5 days or a total of ten times. Note that the stop time of 200. days is not a scheduled print time.

	100.5	200.	10.	1123
Columns	1 to 5	11 to 14	21 to 23	37 - 40

Figure 2.5 REFSEP Detailed Print Schedule Card

The code 1123 designates all possible print blocks as previously described to be printed at the ten time points. The fact that tracking data is to be computed necessitates the inclusion of the Earth code in the NB array found in $TRAJ. Thrust phase change print and shadow phase change print are not included in this code. To obtain this output the flags IPRINT and MØRBIT in $TRAJ must also be specified. One way to obtain print for all thrust phase changes is to set IPRINT to a large positive number (e.g., 10,000). If MØRBIT is set to a negative integer between 0 and -1000, all computed shadow phase changes will be printed also.

REFSEP provides an important interface between the Earth orbital versions of TOPSEP and GODSEP. Due to the specialized function of REFSEP in this regard, an explanation of the specific input is required. Two REFSEP applications will be discussed: (1) preparation of the TOPSEP reference trajectory for GODSEP analysis, and (2) preparation of the measurement schedule for GODSEP from REFSEP tracking information.

The nature of the iterative process in TOPSEP requires that the shadowing logic be executed during trajectory propagation. However, in GODSEP the reference trajectory remains fixed. The shadow entrance and exit times are pre-determined over the total mission. To decrease the integration time in the GODSEP mode the shadow times, which are computed in TOPSEP, are scheduled as imposed coast periods. REFSEP provides a convenient means of incorporating the shadow phases in the thrust profile by punching the THRUST array on cards suitable for a GODSEP run. Each column of the THRUST array (ten parameters) will be punched on four successive cards. The necessary thrust controls for a "shadow-in" phase will be punched as a column of the THRUST array with the thrust policy (THRUST(1,J)) set to nine indicating that a coast phase is scheduled. The phase end time (THRUST(2,J)) set to the time of shadow exit. The remaining eight elements of the J^{th} column are set to zero. The "shadow-out" phase will be punched to reflect the original thrust control profile in effect for that time period. Once all the columns of THRUST are punched they may be attached to the $TRAJ namelist and submitted for a GØDSEP run. To implement this REFSEP option, the $TRAJ variable NPUNCH must be set to one and the shadow logic must be executed (See MØRBIT in $TRAJ namelist description, Page 8).

REFSEP may also aid in construction of a measurement schedule for GODSEP. The tracking information, which REFSEP provides, includes S/C elevation, azimuth, range, and range rate as measured from those stations designated in STALØC in the $TRAJ namelist. A time history of these data over segments of the trajectory is valuable in selecting those stations which can best track the S/C. A simple plot of the elevation angle versus time sufficiently identifies trajectory arcs which are plainly "visible" from each station. The following figure illustrates such a plot for the Goldstone tracking station. The data were assembled from the REFSEP sample case on Page 132-D.

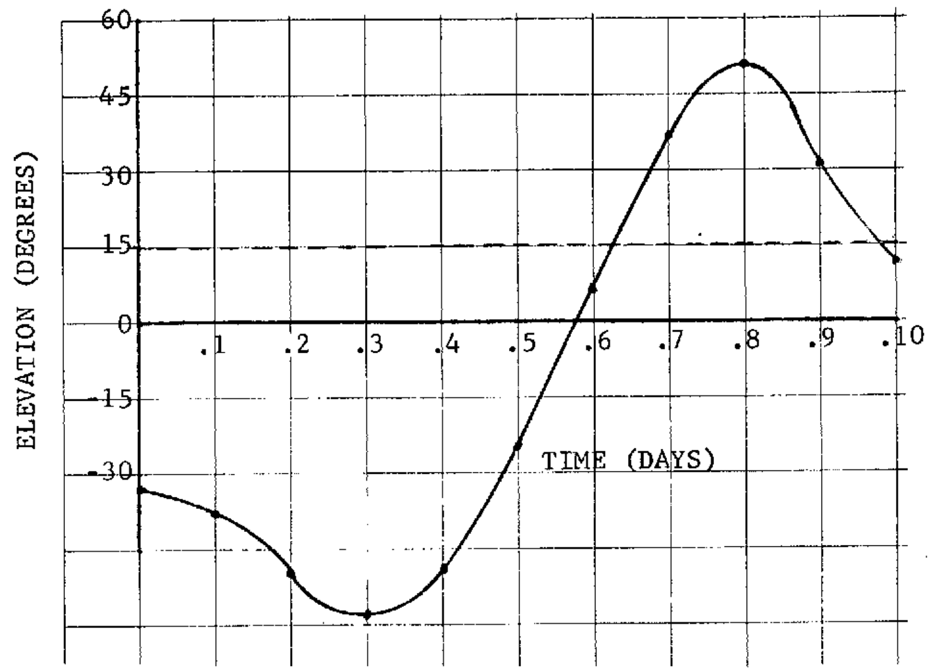

Figure An Elevation Angle Time History For a SEP S/C as Measured from the Goldstone Tracking Station

If a fifteen degree minimum elevation angle restriction is imposed (the dotted line), Goldstone will be able to track the S/C from roughly 0.6 day to 1.0 day or nearly one-third of the orbital period.

To obtain an adequate number of data points for an elevation time history, the user must choose an appropriate time interval for tracking computations (DELT on the REFSEP schedule card). Although the value is dependent upon the reference mission, one can generally rely upon an increment of one fifth of an orbital period to provide sufficient information. The user could specify tracking computations to be output over the entire mission in increments of DELT days; however, it is most economical to schedule such output over shorter trajectory arcs of probable interest during the mission.

3.0 OUTPUT AND SAMPLE CASES

The form, type and amount of MAPSEP output depends upon the operating mode and whatever options and submodes have been exercised. Output can be very extensive or it can be quite simple and in summary form. Because of MAPSEP complexity, a general rule of thumb is to output as much as possible unless the user has a very specific purpose in mind.

3.1 Card and Tape Output

All modes are capable of storing reference trajectory data via the $TRAJ namelist on disc (the STM file) for subsequent stacked cases. By transferring the results on tape (or permanent file), a permanent record can be obtained to be used for future runs. However, because of the relatively small amount of card input for $TRAJ, use of permanent STM file is not recommended except for GODSEP where a great deal of additional data is stored.

Available card and tape output is shown in Table 3-1 with the input flag that triggers the output. Certain output in the form of punched cards are automatically output if specific options are exercised. Obviously, more than setting an input flag is required for meaningful output, and the user is referred to Chapter 4 for recommended operating procedures.

3.2 Printout and Sample Cases

There are two blocks of printout which are common to all modes: initialization and TRAJ print. Initialization print is displayed on the first page of every run and contains the reference trajectory data, including start and end times, initial state vector, spacecraft characteristics, thrust control parameters, etc.

Mode	Input Control Flag	Output Format	Output Data
TOPSEP	ISTMF	STM File	$TRAJ namelist
GODSEP	ISTMF	STM File	$TRAJ namelist; state transition matrices and trajectory data at specified trajectory times.
	GAINCR	GAIN File	$GØDSEP namelist; event schedule; filter gains at measurement events.
	SUMMARY	SUMMARY File	Navigation summary
	PUNCHE	Cards	Knowledge (P) and control (PG) covariances at selected event types.
	IGREAD=0 (and NGUID≠0)	Cards	Computed variation (VARMAT) and sensitivity (S) matrices for guidance events.
SIMSEP	ISTMF	STM File	$TRAJ namelist
	IPUNCH	Cards	Cumulative statistics for each maneuver (CCØVG, CNTCØV, DVMCØV, GMSCØV, CCØVT, TARCØV, and TMSCØV) and for the total mission (ATHCØV, ADVT, ENDCØV, and AMASS).
	IPUNCH (and INREF=0)	Cards	Reference trajectory (XEND and MEND) and guidance event data (XGREF, MGREF, S, XTREF, MTREF and TARGET).
REFSEP	ISTMF	STM File	$TRAJ namelist
	NPUNCH	Cards	Thrust profile (THRUST)

Table 3-1 Card and Tape Output

TRAJ print is output when the trajectory propagation routine is called (and the related print flag is triggered) by the mode in operation. TRAJ print is used either by itself or in association with mode peculiar print and displays instantaneous trajectory information at a specified time. Trajectory data includes current mission time, spacecraft mass and thruster power, state and acceleration vectors, etc.

The best illustration of mode related output is by example. Hence, the following sections contain sample printout from TOPSEP, GODSEP and SIMSEP, including all necessary input to make the runs. The mission used for all three sample cases is an SEP Earth-orbital mission.

3.2.1 TOPSEP

The TOPSEP sample case illustrates the finite differencing targeting procedure for an Earth orbital SEP mission designed to raise the semi-major axis while maintaining circularity. This run represents one iteration in the later stages of the targeting process in which targeting error only is to be minimized. Convergence has not been attained at the conclusion of this iteration, but convergence really was not the prime motivation behind the targeting strategy. The desired target values were intentionally set much higher than those that were realistically attainable. By minimizing the error in the target conditions, the orbit is raised as high as possible within the alotted time.

The first page of output is a listing of the $TRAJ input cards which contain reference trajectory data and MØDE = 1 specifying the TOPSEP mode. All $TRAJ variables which are not listed on this page assume the default values as specified in Section 2.1 (Page 4). Together with the default parameters these variables specify the details of the Earth orbital mission. The initial state is defined by equatorial orbital elements (ICØØRD = -3 , INØRB = 1) for the launch date of March 21, 1980 (TLNCH = 2444320.). The trajectory control profile (THRUST) consists of three segments whose combined duration is 11 days (TEND = 11). The thrust policy is orbit plane (i.e., in-plane and out-of-plane thruster orientations). Since orbit plane changes are not required the out-of-plane control coefficients are set to zero. Note that the shadowing logic will be executed (MØRBIT = 1); however, the shadow phase changes will not be printed since the value of the shadowing flag is positive. A summary of the above variables and other pertinent $TRAJ parameters may be found on the first page of the sample case output.

The remaining output pages refer to the TOPSEP mode exclusively. The $TØPSEP input cards, following $TRAJ, contain control and target information. The TOPSEP submode flag (IMØDE = 2) designates the targeting and optimization option. The TOPSEP initialization summary follows on the next page and is self-explanatory. The abbreviations RP and SMA in the target parameter list refer to radius of periapsis and semi-major axis, respectively. The desired target values for both RP and SMA are 31500 km and the selected tolerances are 20 km. Four controls have been selected to raise the orbit and maintain circularity. They are: A1 and A2 of the second phase (H(5,2) and H(5,3)) and A0 and A2 of the third phase (H(4,3) and H(4,4)). These controls are coefficients in the instantaneous in-plane angle equation which may be found on Page 17 of the Analytic Manual. Corrections to these controls shape the low thrust trajectory from five days to the final time of 11 days: the five day trajectory arc from the initial launch epoch remains fixed.

The first operation that TOPSEP performs after initialization is the tug parking orbit transfer. The orbital elements for the inner parking orbit, the transfer orbit, and the outer parking orbit (orbit specified at launch epoch) are computed. The tug fuel requirements are estimated based upon the impulsive ΔV 's needed to complete the transfer. Beginning at the launch epoch, TOPSEP propagates the reference initial conditions over the eleven day arc. The termination print block follows immediately and displays the values of all possible target variables. Included in this list are the values of RP and SMA which are 30848.8 km and 31127.4 km respectively. The initial target error index is 1.4×10^3.

Following the zeroth iterate and each subsequent iteration is the iteration summary. The parameters which are listed in the summary are defined below and are discussed in Reference 1, Section 5.3.

F = performance index (mass)

DP2 = optimization scaling

EMAG = quadratic target error

GAMA = control step scale factor

E = target error (desired - actual)

DPSI = desired amount of target error to be removed

G = performance gradient WRT control parameters

DU1 = optimization control correction

DU2 = targeting control correction

DU = control correction for this iteration

C*DU = scaled control correction (GAMA*DU)

UOLD = nominal or previous control parameters

UNEW = control parameters after this iteration

P1 = net cost (Analytic Manual, Page 51) for nominal and each trial step

P2 = EMAG for nominal and each trial step

P1P2 = ØSCALE*P1 + P2

SENSITIVITY MATRIX (printed twice) = change in target parameters WRT control parameters.

The sensitivity matrix is computed next. Each of the four controls is perturbed in turn and the associated variant trajectory is propagated from the beginning of the active control phase to the end time. The appropriate weights are applied to the sensitivity matrix and the control correction (DU) is formulated which reduces the target error. The control correction is displayed in both the weighted and unweighted control space. The maximum scale factor (GMAX) for the control correction is then computed so that the values of the controls will always be within their appropriate bounds. Subsequently, four trial trajectories are integrated each of which incorporates a scaled control correction in the thrust profile. The scale (GAMA) is computed using a polynomial minimization technique which is summarized at the end of the four trial trajectories. Notice that the predicted minimum for the third trial trajectory is -10^{10}. This value indicates that the cubic fit predicted a continuously decreasing error index for an increasing value of GAMA. Indeed, the scale chosen for that trial trajectory is the largest allowed (GMAX). The best trial trajectory is, of course, the one which minimizes the error index. Clearly the best trial trajectory is number four which has reduced the error index to 3.43×10^2. For this trial trajectory, the radius of periapsis is 31150.5 km and the semi-major axis is 31377.8 km. Not only has the orbit been raised 250 km more than the reference trajectory by changing the four controls, but also the eccentricity has been reduced from 0.09 to 0.07. The new control vector is printed in the summary for the first iteration. It is formulated as follows:

$$\underline{u}_{new} = \underline{u}_{old} + \underline{u}$$

or

$$\begin{bmatrix} -6.521 \times 10^{-3} \\ 3.815 \\ -7.209 \\ 8.984 \end{bmatrix} = \begin{bmatrix} 1.100 \times 10^{-3} \\ 45.000 \\ 9.400 \\ 42.000 \end{bmatrix} + \begin{bmatrix} -7.621 \times 10^{-3} \\ -41.185 \\ -16.609 \\ -33.016 \end{bmatrix}$$

where the units for u_1 are in degrees/second and the units for u_2, u_3 and u_4 are in degrees. In terms of the printout in the iteration summary

UNEW = UØLD + C*DU

At the conclusion of each run the best trajectory is integrated once again and printed according to the format requested (MPRINT(1) = -1). For this Earth-orbital mission the fixed five day arc is not duplicated since it appears in the very first trajectory printout of the zeroth iterate. The trajectory segment which changes from iteration to iteration is printed, however. This arc includes the second and third thrust phases. If the iteration process were to continue, this trajectory would become the reference for the second iteration.

TOPSEP Sample Case

```
P$TRAJ
 PRNML = T,
  SCMASS=5000.,
 INORB =  1, ICOORD = -3, NTP=3, NB=3,
 STATE = 28571.,28571.,28.7 ,0.,0.,0.,
  TLNCH=2444320.,  TEND=11.,
 THRUST =
 2., 5., 1., 17., -1.1E-5, 0., 0., 1., 0., 0.,
 2., 8., 1., 12.2,  1.1E-5, 45., 0., 1., 0., 0.,
 2.,15., 1., 9.4, -5.1E-6, 42., 0., 1., 0., 0.,
 PHAS(1) = -45.,  PHAS(4) = 1.,
 STEP = 0.5,
  ENGINE=14.425,0.,14.425,  ENGINE(17)=1.E20,
 MORBIT = 1,
 MODE = 1,
  $END
```

```
P$TOPSEP
 PRNML = T, IMODE = 2 ,
 NMAX=1,
  IASTM=0,
 MPRINT=-1,0,0,1,
 H(5,2) = 1.E-6, -.5,
 H(4,3) = -.5,0.,-.5,
 ULIMIT(1,1) = -1.E-4, -90., -90., -90.,
 ULIMIT(1,2) = 1.E-4, 120., 90., 120.,
 UWATE = 1., 3*5.,
 TARTOL(10) = 20., TARTOL(15) = 20.,
 TARGET = 2*31500.,
 GTRIAL = .01, 5., .001, 1.E-6, 3.,
 STOL=1.E-5,
 PCT = .5,
  $END
```

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
     JULIAN DATE ....    2444320.0000000000
     CALENDAR DATE ....   1980 MAR     21        12 HR   0 MIN   0.0000 SECS
TRAJECTORY START EPOCH         0.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....    2444320.0000000000
     CALENDAR DATE ....   1980 MAR     21        12 HR   0 MIN   0.0000 SECS
TRAJECTORY END EPOCH        11.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....    2444331.0000000000
     CALENDAR DATE ....   1980 APL      1        12 HR   0 MIN   0.0000 SECS


INITIAL STATE INPUT IN EARTH EQUATORIAL COORDINATE SYSTEM
ORBITAL ELEMENTS AT            0.0000000000 DAYS AFTER THE REFFRENCE EPOCH

PERIAPSIS RADIUS                 .28571000000000E+05
APOAPSIS RADIUS                  .28571000000000E+05
INCLINATION                      .28700000000000E+02
ASCENDING NODE                  0.
ARGUMENT OF PERIAPSIS           0.
TRUE ANOMALY                    0.

INITIAL STATE VECTOR IN ECLIPTIC COORDINATE SYSTEM
                        X                        Y                        Z                        MAGNITUDE
     POSITION     .28571000000000E+05     0.                       0.                       .28571000000000E+05
     VELOCITY    0.                        .37194404391168E+01      .34230177090494E+00      .37351983209419E+01


SEPS MASS                              5000.0000000000 KG
EXHAUST VELOCITY                         29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.                14.4250000000 KW
FLUENCE                                   0.0000000000 E14 PARTICLES
THRUSTER EFFICIENCY                       1.0000000000
RADIATION PRESSURE COEFFICIENT           -1.0000000000

    LIST OF GRAVITATING BODIES
        SUN
        EARTH
    TARGET PLANET IS EARTH

    INTEGRATION STEP FACTOR     .5000

    THE SHADOWING LOGIC WILL BE EXECUTED.
```

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	5.000000	1.000000	17.000000	-.000011	0.000000	0.000000	1.000000	0.000000	0.000000
2	8.000000	1.000000	12.200000	.000011	45.000000	0.000000	1.000000	0.000000	0.000000
3	15.000000	1.000000	9.400000	-.000005	42.000000	0.000000	1.000000	0.000000	0.000000

THRUST CONTROL PHASING ANGLES (DEG)

```
   -45.000        0.000        0.000        .007
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
******************************************************************************************************
* * * * * * * * * * * * * * * * * * * * * * TOPSEP - TARGETING AND OPTIMIZATION MODE * * * * * * * * * * * * * * * * * * * * * *
******************************************************************************************************

TOPSEP SUBMODE DESIGNATION :  GENERATE TARGETED AND/OR OPTIMIZED TRAJECTORY

METHOD        THE PROJECTED GRADIENT METHOD

REFERENCES    ROSEN,J.B., THE GRADIENT PROJECTION METHOD FOR NONLINEAR PROGRAMMING
              1. PART I , J. SIAM , VOL. 8, NO. 1, MARCH, 1960.
              2. PART II, J. SIAM , VOL. 9, NO. 4, DEC    , 1961.

TARGETING AND OPTIMIZATION DATA

NO. OF TARGETS    2          TUP   =   .100000E+01        GTRIAL(1) =   .100000E-01
NO. OF CONTROLS   4          TLOW  =   .100000E+01        GTRIAL(2) =   .500000E+01
MAX. ITERATIONS   1          DP2   =   .400000E-01        GTRIAL(3) =   .100000E-02
OFMAX =    .100E+04          EPSON =  0.                  GTRIAL(4) =   .100000E-05
PCT   =    .500E+00          STOL  =   .100000E-04        GTRIAL(5) =   .300000E+01

TARGET PARAMETERS

    TARGET          VALUE                      TOLERANCE

  1  RP        .31500000000000E+05     .20000000000000E+02
  2  SMA       .31500000000000E+05     .20000000000000E+02

THRUST CONTROL PERTURBATIONS FOR COMPUTING THE SENSITIVITY MATRIX

THRUST   THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE    THRUST PHASE    THRUST PHASE  THRUST PHASE    THRUST PHASE
PHASE      END TIME     THROTTLING   A0 = PITCH         A1              A2         A3 = YAW          A4              A5
NUMBER      (DAYS)                      (DEG)      (DEG,DEG/SEC)   (DEG,DEG/SEC)      (DEG)      (DEG,DEG/SEC)   (DEG,DEG/SEC)
   1       0.00000       0.00000       0.00000       0.00000        0.00000         0.00000       0.00000         0.00000
   2       0.00000       0.00000       0.00000        .00000        -.50000         0.00000       0.00000         0.00000
   3       0.00000       0.00000       -.50000       0.00000        -.50000         0.00000       0.00000         0.00000

USER INPUT WEIGHTING

SCALE ON CONTROLS IN WEIGHTING ALGORITHM

     1    .10000E+01      2    .50000E+01      3    .50000E+01      4    .50000E+01

BOUNDS ON CONTROLS

MAX      .100000000000E-03    .120000000000E+03    .900000000000E+02    .120000000000E+03
MIN    -.100000000000E-03   -.900000000000E+02   -.900000000000E+02   -.900000000000E+02

INACTV(I) = 1, CONTROL ACTIVE
            0, CONTROL INACTIVE (ON BOUND)
           -1, CONTROL WITHIN TOLERANCE REGION

INACTV(I) =      1      1      1      1

(BLANK COMMON REQUIRED, 003566 OCTAL)
(CORE REQUIRED FOR THIS JOB, 064100 OCTAL)
```

ORIGINAL PAGE IS
OF POOR QUALITY

CURRENT CP TIME 2.249

REFERENCE TRAJECTORY INTEGRATION

***** TUG MULTIPLE-IMPULSE PARKING ORBIT TRANSFER *****

LAUNCH CONSTRAINTS

MINIMUM BOOSTER LAUNCH AZIMUTH	35.50000	DEG
MAXIMUM BOOSTER LAUNCH AZIMUTH	120.00000	DEG
LATITUDE OF LAUNCH SITE	28.60800	DEG

INNER PARKING ORBIT (CIRCULAR)

MAX ALLOWABLE EQ INCLINATION	59.76472	DEG
MIN ALLOWABLE EQ INCLINATION	28.60800	DEG

CONIC ELEMENTS	A	E	INC	NODE	APS
ECLIPTIC	.6567260E+04	0.	.5258145E+01	0.	0.
EQUATORIAL	.6567260E+04	0.	.2870000E+02	0.	0.

MODIFIED HOHMANN TRANSFER ORBIT

PERIAPSIS RADIUS	6567.26000000	KM
APOAPSIS RADIUS	28571.00000000	KM
MIN PLANE CHANGE	0.00000000	DEG

CONIC ELEMENTS	A	E	INC	NODE	APS
ECLIPTIC	.1756913E+05	.6262046E+00	.5258145E+01	0.	.1800000E+03
EQUATORIAL	.1756913E+05	.6262046E+00	.2870000E+02	0.	.1800000E+03

OUTER PARKING ORBIT (S/C AT INITIAL INTEGRATION TIME)

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C ECLIPTIC	.2857100E+05	.5296977E-13	.5258145E+01	0.	.1800000E+03	.1800000E+03	.1800000E+03
S/C EQUATORIAL	.2857100E+05	.5296977E-13	.2870000E+02	0.	.1800000E+03	.1800000E+03	.1800000E+03

TUG CHARACTERISTICS AND REQUIREMENTS

DRY WEIGHT	1714.60000	KG	FIRST IMPULSE, DELVA	.214422867E+01	KM/SEC	FUEL FOR DELVA	.881498376E+04	KG
MAX FUEL WEIGHT	10673.00000	KG	SECOND IMPULSE,DELVB	.145152699E+01	KM/SEC	FUEL FOR DELVB	.326125923E+04	KG
SEP S/C WEIGHT	5000.00000	KG	TOTAL VEL INCREMENT	.359575566E+01	KM/SEC	TOTAL FUEL	.120762430E+05	KG
TOTAL WEIGHT	17387.60000	KG						
SPECIFIC IMPULSE	309.20000	SEC						

THE FUEL REQUIRED FOR TRANSFER IS GREATER THAN THE TUGS FUEL CAPACITY

```
**** CONTROL PHASE CHANGE ****

JULIAN DATE      -- 2444320.00000000    CONTROL PHASE       --  1                 PRIMARY BODY          --  EARTH
DAYS FROM LAUNCH--          0.00000000    PRESENT MASS   (KG)-- 5000.000000000    FLUX           (E14)--  0.0000000000
DAYS FROM CUTOFF--         11.00000000    PRESENT PITCH (DEG)--   17.000000000    FLUX RATE (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00749042062242       PRESENT YAW   (DEG)--    0.000000000    AVAILABLE POWER (KW)-- 14.4250000000
```

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
5.0000000	1.0000000	17.0000000	-.0000110	0.0000000	0.0000000	1.0000	0.0000000	0.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14900365223641E+09	-.26945142067351E+07	0.	.14902801342902E+09
	VELOCITY	.52497597354054E-01	-.26173228827877E+02	.34230177090454E+00	.26175519742242E+02
EARTH	POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
	VELOCITY	0.	.37194404391168E+01	.34230177090454E+00	.37351583209419E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48830659348650E-03	-0.	-0.	.48830659348650E-03
PERTURBING BODIES	.22894211851704E-08	.62105475750162E-10	0.	.22902634025861E-08
THRUST	-.57345323823855E-07	.18677879915806E-06	.17189356612797E-07	.19613841865524E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

```
**** CONTROL PHASE CHANGE ****

JULIAN DATE      -- 2444325.00000000    CONTROL PHASE       --  2                 PRIMARY BODY          --  EARTH
DAYS FROM LAUNCH--          5.00000000    PRESENT MASS   (KG)-- 4986.643023990    FLUX           (E14)--  0.0000000000
DAYS FROM CUTOFF--          6.00000000    PRESENT PITCH (DEG)--  -19.619805153    FLUX RATE (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00704172645531       PRESENT YAW   (DEG)--    0.000000000    AVAILABLE POWER (KW)-- 14.4250000000
```

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	1.0000000	12.2000000	.0000110	45.0000000	0.0000000	1.0000	0.0000000	0.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14845913529137E+09	-.15611673367989E+08	-.26817824766848E+04	.14927772507645E+09
	VELOCITY	.62085265341286E+01	-.30431286451596E+02	-.64098790785989E-01	.31058221222070E+02
EARTH	POSITION	-.57656277311818E+04	-.29140529737003E+05	-.26817824766848E+04	.29826245049285E+05
	VELOCITY	.35847932365821E+01	-.69650835248657E+00	-.64098790785989E-01	.36523930633365E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.86615242134538E-04	.43776916526345E-03	.40287588689429E-04	.44807045431259E-03
PERTURBING BODIES	-.81501858655480E-09	.10528899542817E-08	.10699176495014E-09	.13357693625863E-08
THRUST	.16917109866123E-06	-.99866492288348E-07	-.91906236523370E-08	.19666378534785E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

```
                         ****  CONTROL PHASE CHANGE  ****

JULIAN DATE      -- 2444324.00000000        CONTROL PHASE       --     1                    PRIMARY BODY       --     EARTH
DAYS FROM LAUNCH--       8.00000000         PRESENT MASS   (KG) --  4970.591205300          FLUX           (E14)--    0.0000000000
DAYS FROM CUTOFF--       3.00000000         PRESENT PITCH (DEG) --   -20.298484810          FLUX RATE  (E14/SEC)--    0.
MOTION (DEG/SEC)--  .00681708583545         PRESENT YAW   (DEG) --     0.000000000          AVAILABLE POWER (KW)--   14.4250000000

   THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
     DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW       OF            A4            A5
      (DAYS)                      (DEG)        (DEG,SEC)     (DEG,SEC)    (DEG,SEC)   THRUSTERS    (DEG,SEC)     (DEG,SEC)
     7.0000000    1.0000000     9.4000000     -.0000051    42.0000000    0.0000000    1.0000     0.0000000     0.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                        MAGNITUDE
SUN      POSITION        -.14758243985251E+09     -.23295234889446E+08     -.27106573779832E+04      .14940965339855E+09
         VELOCITY         .76404315667580E+01     -.30439348287594E+02     -.83306689147231E-01      .31383706898712E+02

EARTH    POSITION        -.76624901449879E+04     -.29454759990824E+05     -.27106573779832E+04      .30555936738825E+05
         VELOCITY         .34873834957661E+01     -.90524638918288E+00     -.83306689147231E-01      .36039221240375E+01

S/C ACCELERATIONS                 X                        Y                        Z                        MAGNITUDE
PRIMARY BODY              .10706344688750E-03      .41155395598447E-03      .37874413764934E-04      .42693525453388E-03
PERTURBING BODIES        -.11289011999177E-08      .94596660286446E-09      .10785753219770E-09      .14767884006053E-08
THRUST                    .16153754795205E-06     -.11225307465543E-06     -.10330346244351E-07      .19698184744155E-06
J2 + RAD. PRESSURE       0.                       0.                       0.                       0.
-----------------------------------------------------------------------------------------------------------------------------


JULIAN DATE      -- 2444331.00000000        CONTROL PHASE       --     3                    PRIMARY BODY       --     EARTH
DAYS FROM LAUNCH--      11.00000000         PRESENT MASS   (KG) --  4970.493559095          FLUX           (E14)--    0.0000000000
DAYS FROM CUTOFF--       0.00000000         PRESENT PITCH (DEG) --   -33.885266553          FLUX RATE  (E14/SEC)--    0.
MOTION (DEG/SEC)--  .00681708583545         PRESENT YAW   (DEG) --     0.000000000          AVAILABLE POWER (KW)--   14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                        MAGNITUDE
SUN      POSITION        -.14633192145055E+09     -.30894099053680E+08     -.66855656225123E+03      .14955760292340E+09
         VELOCITY         .64735806612136E+01     -.32723742628046E+02     -.31920471066177E+00      .33359443487731E+02

EARTH    POSITION        -.30288044444767E+05     -.72646867719314E+04     -.66855656225123E+03      .31154265808383E+05
         VELOCITY         .80625502976738E+00     -.34686579918219E+01     -.31920471066177E+00      .35754058629145E+01

S/C ACCELERATIONS                 X                        Y                        Z                        MAGNITUDE
PRIMARY BODY              .39926582802669E-03      .95765218010001E-04      .88131074258257E-05      .41068461046506E-03
PERTURBING BODIES        -.24248782389601E-08     -.47740548824881E-09      .26523113014422E-10      .24715691269953E-08
THRUST                   0.                       0.                       0.                       0.
J2 + RAD. PRESSURE       0.                       0.                       0.                       0.

++++++++++++++++++++++++++++++++++++++++++++ TERMINATION DATA ++++++++++++++++++++++++++++++++++++++++++++++++++++++

REQUESTED STOPPING CONDITION , TEND                     FLIGHT TIME       .11000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                     FINAL S/C MASS    .49704935590950E+04

                     ECLIPTIC                                                   EQUATORIAL

  X =  -.30288044444767E+05    VX=   .80625502976738E+00    X =  -.30288044444767E+05    VX=   .80625502976738E+00
  Y =  -.72646867719314E+04    VY=  -.34686579918219E+01    Y =  -.63991264979553E+04    VY=  -.30553842907984E+01
  Z =  -.66855656225123E+03    VZ=  -.31920471066177E+00    Z =  -.35034014663423E+04    VZ=  -.16727542398932E+01
  R =   .31154269808383E+05    V =   .35754058629145E+01    R =   .31154265808383E+05    V =   .35754058629145E+01

RP  =   .30846805074280E+05    RA  =   .31405958287320E+05    LAT    =  -.64567596923170E+01
VP  =   .36106657930052E+01    VA  =   .35784952976422E+01    LON    =   .18192950357917E+03
TRP =   .10833023450539E+02    TRA =   .11149308221517E+02    PERIOD =   .63256954195755E+00

CONIC ELEMENTS           A              E              INC            NODE           APS            MA             TA
S/C ECLIPTIC        .3112738E+05   .8949568E-02   .5257868E+01   .3599996E+03   .9749495E+02   .9502759E+02   .9604813E+02
S/C EQUATORIAL      .3112738E+05   .8949568E-02   .2869972E+02   .3599999E+03   .9749462E+02   .9502759E+02   .9604813E+02

*************************************************************************************************************************
```

```
*************************************************************************************************************

SUMMARY FOR ITERATION NUMBER  0

F     =   -.497049355909E+04              DP2   =    .400000000000E-01
EMAG  =    .140726810772E+04              GAMA  =   0.
E     =   -.651199925720E+03   -.372618319200E+03
DPSI  =   0.                   0.
G     =   0.                   0.                  0.                  0.
DU1   =   0.                   0.                  0.                  0.
DU2   =   0.                   0.                  0.                  0.
DU    =   0.                   0.                  0.                  0.
C*DU  =   0.                   0.                  0.                  0.
UOLD  =    .110000000000E-04    .450000000000E+02   .940000000000E+01   .420000000000E+02
UNEW  =    .110000000000E-04    .450000000000E+02   .940000000000E+01   .420000000000E+02
P1    =   0.                   0.                  0.                  0.                  0.                  0.
P2    =   0.                   0.                  0.                  0.                  0.                  0.
P1P2  =   0.                   0.                  0.                  0.                  0.                  0.

SENSITIVITY MATRIX
   0.                  0.                  0.                  0.
   0.                  0.                  0.                  0.

  0.         0.         0.         0.
  0.         0.         0.         0.
*************************************************************************************************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
***********************************************************************************************************
* * * * * * * * * * * * * * * * * * * * * * * * TRAJ. INTEG. FOR CONTROL NO.  1 * * * * * * * * * * * * * * *
***********************************************************************************************************

U

      .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U

      .100000000000E-05   0.                   0.                   0.

++++++++++++++++++++++++++++++++++++++++++++++++++++ TERMINATION DATA ++++++++++++++++++++++++++++++++++++++++++++

REQUESTED STOPPING CONDITION , TEND                        FLIGHT TIME        .11000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                        FINAL S/C MASS     .49704960007776E+04

                    ECLIPTIC                                                        EQUATORIAL

   X =  -.30151194973375E+05    VX=   .85423226394352E+00    X =  -.30151194973375E+05    VX=   .85423226394352E+00
   Y =  -.75975217882648E+04    VY=  -.34629423762537E+01    Y =  -.66923058555297E+04    VY=  -.30503496756509E+01
   Z =  -.69918581465455E+03    VZ=  -.31867869688313E+00    Z =  -.36639105423869E+04    VZ=  -.16699978650755E+01
   R =   .31101539454648E+05    V =   .35809550086342E+01    R =   .31101539454648E+05    V =   .35809550086342E+01

RP  =   .30900853493538E+05    RA  =  .31336075478983E+05    LAT    =  -.67654280507427E+01
VP  =   .36041239692799E+01    VA  =  .35790078912332E+01    LON    =   .18251413282251E+03
TRP =   .10850461984929E+02    TRA =  .11166610854460E+02    PERIOD =   .63229773906123E+00

CONIC ELEMENTS          A             E             INC           NODE          APS           MA            TA
S/C ECLIPTIC        .3111846E+05  .6992986E-02  .5257868E+01  .3599996E+03  .1082620E+03  .8513977E+02  .8593879E+02
S/C EQUATORIAL      .3111846E+05  .6992986E-02  .2869972E+02  .3599999E+03  .1082616E+03  .8513977E+02  .8593879E+02

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

PERTURBED TRAJECTORY SUMMARY

REFERENCE CONTROL   1            .11000000000000E-04

PERTURBATION                     .99999999999999E-06

PERFORMANCE INDEX               -.49704960007776E+04

PERFORMANCE GRADIENT ELEMENT    -.24416826781817E+04

SENSITIVITY MATRIX COLUMN        .52048419258091E+08
                                -.89171945394482E+07

PERTURBED TARGETS    ... RP      .30900853493538E+05
                     ... SMA     .31118464486261E+05

DELTA FROM NOMINAL TARGETS       .52048419258092E+02
                                -.89171945394482E+01
```

```
* * * * * * * * * * * * * * * * * * * * * * TRAJ. INTEG. FOR CONTROL NO.  2 * * * * * * * * * * * * * * * * * * * * * * *

U

     .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U

     0.                  -.500000000000E+00   0.                   0.

++++++++++++++++++++++++++++++++++++++++++++ TERMINATION DATA ++++++++++++++++++++++++++++++++++++++++++++

REQUESTED STOPPING CONDITION , TEND                    FLIGHT TIME       .11000000000000E+02
ACTUAL STOPPING CONDITION    ; TEND                    FINAL S/C MASS    .49704942064787E+04

                    ECLIPTIC                                                   EQUATORIAL

  X =  -.30205952701208E+05   VX=   .83068214663084E+00   X =  -.30205952701208E+05   VX=   .83068214663084E+00
  Y =  -.73969220968364E+04   VY=  -.34682979319473E+01   Y =  -.65156065596522E+04   VY=  -.30550671356111E+01
  Z =  -.58072553820610E+03   VZ=  -.31917156058364E+00   Z =  -.35671716517996E+04   VZ=  -.18725805871471E+01
  R =   .31105906529487E+05   V =   .35806415420039E+01   R =   .31105906529487E+05   V =   .35806415420039E+01

RP  =   .30903103229355E+05   RA  =   .31340403830239E+05   LAT    =  -.65850687025610E+01
VP  =   .36040512139786E+01   VA  =   .35788187659034E+01   LON    =   .18217228034370E+03
TRP =   .10849906873478E+02   TRA =   .11166105867021E+02   PERIOD =   .63239798708650E+00

CONIC ELEMENTS      A             E             INC           NODE          APS           MA            TA
S/C ECLIPTIC     .3112175E+05  .7025642E-02  .5257868E+01  .3599996E+03  .1075709E+03  .8544228E+02  .8624535E+02
S/C EQUATORIAL   .3112175E+05  .7025642E-02  .2869972E+02  .3599999E+03  .1075706E+03  .8544228E+02  .8624535E+02

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

PERTURBED TRAJECTORY SUMMARY

REFERENCE CONTROL  2               .45000000000000E+02

PERTURBATION                      -.50000000000000E+00

PERFORMANCE INDEX                 -.49704942064787E+04

PERFORMANCE GRADIENT ELEMENT       .12947674840689E-02

SENSITIVITY MATRIX COLUMN         -.10859631015081E+03
                                   .11256302005611E+02

PERTURBED TARGETS    ... RP        .30903103229355E+05
                     ... SMA       .31121753529797E+05

DELTA FROM NOMINAL TARGETS         .54298155075405E+02
                                  -.56281510028057E+01
```

```
*** TRAJ. INTEG. FOR CONTROL NO.  3 ***

U

     .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U

     0.                   0.                   -.500000000000E+00   0.

+++ TERMINATION DATA +++

REQUESTED STOPPING CONDITION , TEND                 FLIGHT TIME        .11000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                 FINAL S/C MASS     .49704932039012E+04

                       ECLIPTIC                                                   EQUATORIAL

  X =  -.30301104189429E+05   VX=   .80173927361144E+00   X =  -.30301104189429E+05   VX=   .80173927361144E+00
  Y =  -.72277237432815E+04   VY=  -.34693037220343E+01   Y =  -.63665674332746E+04   VY=  -.31559530841937E+01
  Z =  -.66515502604609E+03   VZ=  -.31926413729335E+00   Z =  -.34855761124146E+04   VZ=  -.16730656449434E+01
  R =   .31158294831658E+05   V =   .35750222052365E+01   R =   .31158294831658E+05   V =   .35750222052365E+01

RP  =   .30849429497996E+05   RA  =   .31408083518192E+05   LAT    =  -.64229347640459E+01
VP  =   .36106716772408E+01   VA  =   .35784161831684E+01   LON    =   .18186555951312E+03
TRP =   .10832078516349E+02   TRA =   .11148384241953E+02   PERIOD =   .63261145120727E+00

CONIC ELEMENTS        A              E              INC            NODE           APS            MA             TA
S/C ECLIPTIC     .3112876E+05   .8973279E-02   .5257868E+01   .3599998E+03   .9688982E+02   .9555903E+02   .9658129E+02
S/C EQUATORIAL   .3112876E+05   .8973279E-02   .2869972E+02   .3599999E+03   .9688948E+02   .9555903E+02   .9658129E+02

+++

PERTURBED TRAJECTORY SUMMARY

REFERENCE CONTROL  3            .93999999999999E+01

PERTURBATION                   -.50000000000000E+00

PERFORMANCE INDEX              -.49704932039012E+04

PERFORMANCE GRADIENT ELEMENT   -.71038748137653E-03

SENSITIVITY MATRIX COLUMN      -.12488474329002E+01
                               -.27496545885224E+01

PERTURBED TARGETS  ... RP       .30849429497996E+05
                   ... SMA      .31128756508094E+05

DELTA FROM NOMINAL TARGETS      .62442371645011E+00
                                .13748272942612E+01
```

```
************************************************************************************************
* * * * * * * * * * * * * * * * * * * * * * * * TRAJ. INTEG. FOR CONTROL NO.   4 * * * * * * * * * * * * * * * * * * * * * * * * *
************************************************************************************************

U
        .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U
        0.                   0.                   0.                  -.500000000000E+00

************************************ TERMINATION DATA ************************************

REQUESTED STOPPING CONDITION , TEND                FLIGHT TIME        .11000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                FINAL S/C MASS     .49704930688441E+04

                       ECLIPTIC                                               EQUATORIAL

  X =  -.30304443865882E+05   VX=   .80009080298787E+00   X =  -.30304443865882E+05   VX=   .80009080298787E+00
  Y =  -.72118073635372E+04   VY=  -.34697970122919E+01   Y =  -.63525474128085E+04   VY=  -.30563876008502E+01
  Z =  -.66369030406931E+03   VZ=  -.31930953371847E+00   Z =  -.34779004657663E+04   VZ=  -.16733035343901E+01
  R =   .31157823548864E+05   V =   .35751356866361E+01   R =   .31157823548864E+05   V =   .35751356866361E+01

RP  =  .30851951847021E+05    RA  =   .31407624681152E+05   LAT    =  -.64088287030042E+01
VP  =  .36104378701409E+01    VA  =   .35783568817221E+01   LON    =   .18183889976966E+03
TRP =  .10832559998719E+02    TRA =   .11148877450282E+02   PERIOD =   .63264290312923E+00

CONIC ELEMENTS        A              E              INC            NODE           APS            MA             TA
S/C ECLIPTIC       .3112979E+05   .8925098E-02   .9257868E+01   .3599996E+03   .9714122E+02   .9528257E+02   .9629987E+02
S/C EQUATORIAL     .3112979E+05   .8925098E-02   .2869972E+02   .3599999E+03   .9714089E+02   .9528257E+02   .9629987E+02
************************************************************************************************

PERTURBED TRAJECTORY SUMMARY

REFERENCE CONTROL  4                .42000000000030E+02

PERTURBATION                       -.50000000000000E+00

PERFORMANCE INDEX                  -.49704930688441E+04

PERFORMANCE GRADIENT ELEMENT       -.98050176165997E-03

SENSITIVITY MATRIX COLUMN          -.62935454829130E+01
                                   -.48131665731780E+01

PERTURBED TARGETS  ... RP           .30851951847021E+05
                   ... SMA          .31129788264087E+05

DELTA FROM NOMINAL TARGETS          .31467727414565E+01
                                    .24065832865890E+01
```

WEIGHTED SENSITIVITY MATRIX

```
    .29822E+10   -.31111E+05   -.35777E+03   -.18030E+04
   -.51092E+09    .32247E+04   -.78772E+03   -.13789E+04
```

CONTROL VECTOR INNER PRODUCTS

```
 1   0.00000    .99780    .25384    .68034
 2    .99780   0.00000    .31745    .72747
 3    .25384    .31745   0.00000    .88159
 4    .68034    .72747    .88159   0.00000
```

THE FOLLOWING CONTROLS ARE LINEARLY DEPENDENT

```
 0
```

********** WEIGHTED SPACE (INTERNAL UNITS) **********

DPSI

```
        -.325597462860E+03   -.186309159600E+03
```

STNV

```
        -.158991062554E-09   -.288537194137E-09
        -.450781197832E-04   -.263114690096E-03
        -.181786491959E-04   -.106106213401E-03
        -.361375812567E-04   -.210930015262E-03
```

DU1

```
        -0.                  -0.                  -0.                  -0.
```

DU2

```
        -.589338301604E-06   -.636979982220E-01   -.256874802010E-01   -.510644986489E-01
```

DU

```
        -.589338301604E-06   -.636979982220E-01   -.256874802010E-01   -.510644986489E-01
```

********** UNWEIGHTED SPACE (INTERNAL UNITS) **********

SINV

```
        -.158991062554E-09   -.288537194137E-08
        -.225390598916E-03   -.131557345048E-02
        -.900932259793E-04   -.530531067094E-03
        -.180687906284E-03   -.105465007631E-02
```

```
WS

    .298215475387E+10   -.311105512117E+05   -.357768435805E+03   -.180296797172E+04
   -.510917612207E+09    .322469298923E+04   -.787718015206E+03   -.137887065368E+04

WG

   -.139898152370E+06    .370923561440E+00   -.203511022509E+00   -.280893063741E+00

DU1

    0.                   0.                   0.                   0.

DU2

   -.589338301604E-06   -.318489991110E+00   -.128437401005E+00   -.255322493244E+00

DU

   -.589338301604E-06   -.318489991110E+00   -.128437401005E+00   -.255322493244E+00

ULIMIT

   -.174532925199E-05    .174532925199E-05
   -.157079632679E+01    .209439510239E+01
   -.157079632679E+01    .157079632679E+01
   -.157079632679E+01    .209439510239E+01

MAXIMUM GAMMA ALLOWED

GAM

    .328727229240E+01    .739801738190E+01    .135074149968E+02    .902323404161E+01

GMAX

    .328727229240E+01
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * TRIAL TRAJ. INTEG. NO.  1 * * * * * * * * * * * * * * * * * * * * * * * * * * *

U
        .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U
       -.337665973873E-04   -.182481323078E+02   -.735892100922E+01   -.146289012777E+02

++++++++++++++++++++++++++++++++++++++++++++++++ TERMINATION DATA ++++++++++++++++++++++++++++++++++++++++++++++++

REQUESTED STOPPING CONDITION , TEND                    FLIGHT TIME      .110000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                    FINAL S/C MASS   .497042754104593E+04

                 ECLIPTIC                                                   EQUATORIAL

  X = -.313534917775517E+05   VX= -.623872976188852E-01   X = -.313534917775517E+05   VX= -.623872976188852E-01
  Y =  .348211465614499E+03   VY= -.354619131374350E+01   Y =  .306731835163370E+03   VY= -.312367966030270E+01
  Z =  .320240228822774E+02   VZ= -.326340337541310E+00   Z =  .167905759641540E+03   VZ= -.171014509015680E+01
  R =  .313554416873000E+05   V =  .356172191846590E+01   R =  .313554416873000E+05   V =  .356172191846590E+01

RP  =  .310802589819520E+05   RA  =  .314995587364890E+05   LAT    =  .306815558750890E+00
VP  =  .359318441821860E+01   VA  =  .356918933522360E+01   LON    =  .169439231915890E+03
TRP =  .118809006072884E+02   TRA =  .111277712276180E+02   PERIOD =  .637530309467770E+00

CONIC ELEMENTS        A            E            INC          NODE         APS          MA           TA
S/C ECLIPTIC      .3128991E+05  .6700241E-02  .5257868E+01  .3599996E+03  .7078221E+02  .1078503E+03  .1085792E+03
S/C EQUATORIAL    .3128991E+05  .6700241E-02  .2869972E+02  .3599999E+03  .7078188E+02  .1078503E+03  .1085792E+03

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

C*DU
       -.589338381604E-06   -.318489991110E+00   -.128437401005E+00   -.255322493244E+00

P1
        .783915764199E-01    .704888871046E-01   0.                   0.                   0.                   0.

P2
        .140724810772E+04    .559802234080E+03   0.                   0.                   0.                   0.

P1P2
        .140732669929E+04    .550872722967E+03   0.                   0.                   0.                   0.

GAMMA
       0.                    .100000000000E+01   0.                   0.                   0.                   0.
```

```
************************ TRIAL TRAJ. INTEG. NO.  2 ************************

U
      .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U
     -.431567805617E-04   -.233227716916E+02   -.940536991404E+01   -.186970854774E+02

******************************** TERMINATION DATA ********************************

REQUESTED STOPPING CONDITION , TEND                  FLIGHT TIME       .11000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                  FINAL S/C MASS    .49704281121624E+04

                  ECLIPTIC                                              EQUATORIAL

  X =  -.31349110872917E+05    VX=  -.24295341373885E+00    X =  -.31349110872917E+05    VX=  -.24295341373885E+00
  Y =   .19489348468014E+04    VY=  -.35340657504374E+01    Y =   .17167367419452E+04    VY=  -.31129987514770E+01
  Z =   .17933147134594E+03    VZ=  -.32522459641124E+00    Z =   .93989199502226E+03    VZ=  -.17042976676120E+01
  R =   .31410145802529E+05    V =   .35573048966560E+01    R =   .31410145802529E+05    V =   .35573048966560E+01

RP  =   .31113673600611E+05    RA  =   .31529260486916E+05    LAT    =   .17146558855062E+01
VP  =   .35911366752416E+01    VA  =   .35673907977414E+01    LON    =   .16686524508986E+03
TPP =   .10796180657942E+02    TRA =   .11115428182173E+02    PERIOD =   .63849504846170E+00

CONIC ELEMENTS        A             E             INC           NODE          APS           MA            TA
S/C ECLIPTIC      .3132147E+05  .6634218E-02  .5257888E+01  .3599996E+03  .6082234E+02  .1149186E+03  .1156056E+03
S/C EQUATORIAL    .3132147E+05  .6634218E-02  .2869972E+02  .3599999E+03  .6082200E+02  .1149186E+03  .1156056E+03
*************************************************************************************

C*DU
     -.753227915362E-06   -.407059156710E+00   -.164154672368E+00   -.326325353041E+00

P1
      .783915764199E-01    .704868871046E-01    .692749018504E-01   0.             0.             0.

P2
      .140724830772E+04    .550802234080E+03    .452805258318E+03   0.             0.             0.

P1P2
      .140732649929E+04    .550872722967E+03    .452874533220E+03   0.             0.             0.

GAMMA
     0.                    .100000000000E+01    .127809089162E+01   0.             0.             0.
CUBIC HAS NO EXTREMA
```

```
********************************* TRIAL TRAJ. INTEG. NO.  3 *********************************

U
      .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

DELTA U
     -.111000000000E-03   -.599865797734E+02   -.241907771356E+02   -.460891818383E+02

********************************* TERMINATION DATA *********************************

REQUESTED STOPPING CONDITION , TEND                  FLIGHT TIME       .110000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                  FINAL S/C MASS    .497043144500070E+04

                    ECLIPTIC                                                   EQUATORIAL

  X =  -.312985497008185E+05    VX=  -.474507178474430E+00    X =  -.312985497008180E+05    VX=  -.474507178474430E+00
  Y =   .415558288139170E+04    VY=  -.349293602146340E+01    Y =   .366047328756990E+04    VY=  -.307676936942140E+01
  Z =   .382399581733230E+03    VZ=  -.321439766403990E+00    Z =   .200400443463300E+04    VZ=  -.168446306603980E+01
  R =   .315755334371035E+05    V =   .353964442223870E+01    R =   .315755334371030E+05    V =   .353964442223870E+01

RP  =  .310973792445350E+05    RA  =  .315830133915860E+05    LAT    =  .363883703931080E+01
VP  =  .359406401431740E+01    VA  =  .356632479463250E+01    LON    =  .163329104594650E+03
TRP =  .107059713203990E+02    TRA =  .110255052071520E+02    PERIOD =  .639067773505730E+00

CONIC ELEMENTS         A             E             INC           NODE          APS           MA            TA
S/C ECLIPTIC      .3134019E+05  .7747848E-02  .5257868E+01  .3599996E+03  .6555107E+01  .1656324E+03  .1658507E+03
S/C EQUATORIAL    .3134019E+05  .7747848E-02  .2869972E+02  .3599999E+03  .6554770E+01  .1656324E+03  .1658507E+03
************************************************************************************************

C*DU
     -.193731546971E-05   -.104696332318E+01   -.422208709632E+00   -.839314557669E+00

P1
      .783915764199F-01    .704868871046E-01    .692749018504E-01    .655955601439E-01    0.                0.

P2
      .140724810772E+04    .550802234080E+03    .452805258318E+03    .469111374234E+03    0.                0.

P1P2
      .140732659929E+04    .550872722967E+03    .452874533220E+03    .469176969794E+03    0.                0.

GAMMA
     0.                    .100000000000E+01    .127809089162E+01    .328727229240E+01    0.                0.
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * TRIAL TRAJ. INTEG. NO.  4 * * * * * * * * * * * * * * * * * * * * * * * * * * *

U

   .110000000000E-04   .450000000000E+02   .940000000000E+01   .420000000000E+02

DELTA U

  -.762099495799E-04  -.411848647597E+02  -.166086129490E+02  -.330164923479E+02

******************************************* TERMINATION DATA *******************************************

REQUESTED STOPPING CONDITION , TEND                FLIGHT TIME       .110000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                FINAL S/C MASS    .497043044840028E+04

                    ECLIPTIC                                                    EQUATORIAL

  X =  -.311270658808296E+05   VX=  -.594053503203373E+00   X =  -.311270658808296E+05   VX=  -.594053503203373E+00
  Y =   .511593005183352E+04   VY=  -.348005116451855E+01   Y =   .450639969155503E+04   VY=  -.396541964965521E+01
  Z =   .470776054497060E+03   VZ=  -.320254109337390E+00   Z =   .246713035909920E+04   VZ=  -.167524943728811E+01
  R =   .315481948171800E+05   V =   .354488622763590E+01   R =   .315481948171800E+05   V =   .354488622763590E+01

RP  =   .311504675079540E+05   RA  =   .316052005759100E+05   LAT     =   .448522123627970E+01
VP  =   .359010578473350E+01   VA  =   .356418513514380E+01   LON     =   .161762017380850E+03
TRP =   .107541327388360E+02   TRA =   .110742424409900E+02   PERIOD  =   .640219404308490E+00

CONIC ELEMENTS          A             E              INC           NODE           APS            MA             TA
S/C ECLIPTIC       .3137783E+05   .7246088E-02   .5257868E+01   .3599996E+03   .3182610E+02   .1382529E+03   .1388021E+03
S/C EQUATORIAL     .3137783E+05   .7246088E-02   .2869972E+02   .3599999E+03   .3182576E+02   .1382529E+03   .1388021E+03

********************************************************************************************************

C*DU

  -.133009876517E-05  -.718811492945E+00  -.289874980149E+00  -.576246498930E+00

P1

   .783915764199E-01   .704888871046E-01   .692749018504E-01   .655955601439E-01   .658205879095E-01   0.

P2

   .140724810772E+04   .550802234080E+03   .452805298318E+03   .469111374234E+03   .342743710767E+03   0.

P1P2

   .140732649929E+04   .550872722967E+03   .452874533220E+03   .469176969794E+03   .342809531355E+03   0.

GAMMA

   0.                  .100000000000E+01   .127809089162E+01   .328727229240E+01   .225693589158E+01   0.
```

76

SELECTION OF THE BEST TRIAL TRAJECTORY

I, TRIAL TRAJECTORY NUMBER

X(I), SCALE (GAMMA) ON CONTROL CORRECTION (DU)
X(1) NOMINAL FIRST STEP SCALE FACTOR
X(2) QUADRATIC EXTREMUM ESTIMATION (TWO POINTS, ONE SLOPE)
X(3) CUBIC EXTREMUM ESTIMATION (THREE POINTS, ONE SLOPE)
X(4) CUBIC EXTREMUM ESTIMATION (FOUR POINTS)
X(5) QUADRATIC EXTREMUM ESTIMATION (THREE POINTS)

Y(I), QUADRATIC ERROR INDEX (EMAG)

DYDX1, EXPECTED CHANGE IN QUADRATIC ERROR INDEX WRT CHANGE IN SCALE FACTOR

I	X(I)	Y(I)	PREDICTED MIN
0	0.	.14072481077174E+04	
1	.10000000000000E+01	.55980273408013E+03	
2	.12760908916195E+01	.45280525831845E+03	.50824110670204E+03
3	.32872722924029E+01	.46911137423362E+03	-.10000000000000E+11
4	.22569358915777E+01	.34274371076709E+03	.30178871606735E+03
5	0.	0.	0.

DYDX1= -.1406796664E+04   MIN=-4   Y(MIN)= .34274371076709E+03

INACTV(I) = 1 1 1 1

```
*****************************
*                           *
* CURRENT CP TIME    58.822 *
*                           *
*****************************
```

```
*******************************************************************************************************

THE MAXIMUM NO. OF ITERATIONS HAS BEEN REACHED

SUMMARY FOR ITERATION NUMBER  1

F     =  -.497043044040E+04                DP2  =   .400000000000E-01

EMAG  =   .342743710767E+03                GAMA =   .225693589158E+01

E     =  -.349532492046E+03   -.122165958068E+03

UPSI  =  -.325597462860E+07   -.186309159600E+03

G     =  -.244168267818E+04    .129476748407E-02   -.710387481377E-03   -.980501761660E-03

DU1   =   0.                   0.                   0.                   0.

DU2   =  -.337665973873E-04   -.182481323078E+02   -.735892100922E+01   -.146289012777E+02

DU    =  -.337665973873E-04   -.182481323078E+02   -.735892100922E+01   -.146289012777E+02

C*DU  =  -.762090455799E-04   -.411848647597E+02   -.166086129490E+02   -.330164923479E+02

UOLD  =   .110000000000E-04    .450000000000E+02    .940000000000E+01    .420000000000E+02

UNEW  =  -.652090455799E-04    .381513524034E+01   -.720861294900E+01    .898350765210E+01

P1    =   .783919764199E-01    .704888871046E-01    .692749018504E-01    .655955601439E-01    .658205879095E-01   0.

P2    =   .140726810777E+04    .550802234080E+03    .452805258318E+03    .469111374234E+03    .342743710767E+08   0.

P1P2  =   .140732649929E+04    .550872722967E+03    .452874533220E+03    .469176969794E+03    .342809531355E+03   0.

SENSITIVITY MATRIX

   .520484192581E+08   -.108596310151E+03   -.124884743298E+01   -.629354548291E+01
  -.891719453949E+07    .112563020056E+02   -.274965458852E+01   -.481316657318E+01

   .5E+08  -.1E+03  -.1E+01  -.6E+01
  -.9E+07   .1E+02  -.3E+01  -.5E+01
*******************************************************************************************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

REFERENCE TRAJECTORY INTEGRATION

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444325.00000000	CONTROL PHASE --	2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	5.00000000	PRESENT MASS (KG) --	4986.643023989	FLUX (E14) --	0.0000000000
DAYS FROM CUTOFF--	5.00000000	PRESENT PITCH (DEG) --	9.502292000	FLUX RATE (E14/SEC) --	0.
MOTION (DEG/SEC) --	.30677278146844	PRESENT YAW (DEG) --	0.000000000	AVAILABLE POWER (KW) --	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	1.0000000	12.2000000	-.0000652	3.8151352	0.0000000	1.0000	0.0000000	0.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14845913529130E+09	-.15611673368819E+08	-.26817824766849E+04	.14927772507647E+09
	VELOCITY	.62985265342921E+01	-.30431286451578E+02	-.64098790785913E-01	.31058221222085E+02
EARTH	POSITION	-.57656277311750E+04	-.29140529737004E+05	-.26817824766849E+04	.29826245049285E+05
	VELOCITY	.35847932365822E+01	-.69650835248575E+00	-.64098790785913E-01	.36523930633364E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.86615242134439E-04	.43776916526348E-03	.40287588689432E-04	.44807045431260E-03
PERTURBING BODIES	-.81501858657206E-09	.10528899542738E-08	.10699176495011E-09	.13357693625906E-08
THRUST	.19659290502932E-06	-.52573838056538E-08	-.48381297730325E-09	.19666378534785E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444329.00000000	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	8.00000000	PRESENT MASS (KG) --	4978.592969552	FLUX (E14) --	0.0000000000
DAYS FROM CUTOFF--	1.00000000	PRESENT PITCH (DEG) --	-13.560912129	FLUX RATE (E14/SEC) --	0.
MOTION (DEG/SEC) --	.30677278072807	PRESENT YAW (DEG) --	0.000000000	AVAILABLE POWER (KW) --	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
7.0000000	1.0000000	-7.2086129	-.0000051	8.9835077	0.0000000	1.0000	0.0000000	0.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14758581784640E+09	-.23294258646070E+08	-.26208166713001E+04	.14941283787590E+09
	VELOCITY	.75147544822846E+01	-.30816552920624E+02	-.11802000805144E+00	.31719794945706E+02
EARTH	POSITION	-.11040484030901E+05	-.28478517814542E+05	-.26208166713001E+04	.30695944499932E+05
	VELOCITY	.33617064112927E+01	-.12824599222125E+01	-.11802000805144E+00	.35999554283227E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.15275220263678E-03	.39401862103836E-03	.36260685503262E-04	.42414472347128E-03
PERTURBING BODIES	-.13699667005939E-08	.84785826906236E-09	.10427608705148E-09	.16144800839275E-08
THRUST	.16229352356150E-06	-.11116642037470E-06	-.10230343044384E-07	.19698177763754E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

ORIGINAL PAGE IS OF POOR QUALITY

```
JULIAN DATE       -- 2444331.80000000        CONTROL PHASE        --        3              PRIMARY BODY           --       EARTH
DAYS FROM LAUNCH--        11.00000000        PRESENT MASS    (KG)--   4970.430439750         FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--         0.00000000        PRESENT PITCH  (DEG)--    -17.513691986         FLUX RATE   (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00677278072807         PRESENT YAW    (DEG)--      0.000000000         AVAILABLE POWER (KW)--   14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES           X                        Y                        Z                        MAGNITUDE
SUN     POSITION         -.146332760376 46E+09    -.108817180973 59E+08     .470807296985 78E+03     .149555866726 32E+09
        VELOCITY          .507324629997 00E+01    -.327351359586 84E+02    -.320254123891 18E+00     .331274737485 00E+02

EARTH   POSITION         -.311269703590 52E+05     .511626954927 78E+04     .470807296985 78E+03     .315481561639 51E+05
        VELOCITY         -.594079331476 24E+00    -.348005132246 04E+01    -.320254123891 18E+00     .354489071240 77E+01

S/C ACCELERATIONS                  X                        Y                        Z                        MAGNITUDE
PRIMARY BODY              .395146716245 42E-03    -.649493699034 42E-04    -.597674477285 62E-05     .400493532392 81E-03
PERTURBING BODIES        -.219941980840 08E-08    -.925916601647 52E-09    -.186788141236 23E-10     .237722319771 92E-08
THRUST                   -.900691901974 18E-07    -.174803806353 83E-06    -.160869404154 01E-07     .197305264637 31E-06
J2 + RAD. PRESSURE        0.                       0.                       0.                       0.

++++++++++++++++++++++++++++++++++++++++++++++++ TERMINATION DATA ++++++++++++++++++++++++++++++++++++++++++++++++

REQUESTED STOPPING CONDITION , TEND                   FLIGHT TIME       .110000000000000E+02
ACTUAL STOPPING CONDITION    , TEND                   FINAL S/C MASS    .497043043975000E+04

                  ECLIPTIC                                                        EQUATORIAL

  X =  -.311269703590052E+05   VX=  -.594079331476240E+00   X =  -.311269703590052E+05   VX=  -.594079331476240E+00
  Y =   .511626954927780E+04   VY=  -.348005132246040E+01   Y =   .450669873948920E+04   VY=  -.306541978876830E+01
  Z =   .470807296985780E+03   VZ=  -.320254123891180E+00   Z =   .246729408122500E+04   VZ=  -.167824951346780E+01
  R =   .315481561639510E+05   V =   .354489071240770E+01   R =   .315481561639510E+05   V =   .354489071240770E+01

RP  =   .311505827574570E+05   RA  =   .316050894530040E+05   LAT    =   .448552499819260E+01
VP  =   .359009271409230E+01   VA  =   .356418501795950E+01   LON    =   .161761453307310E+03
TRP =   .107541024525710E+02   TRA =   .110742121862990E+02   PERIOD =   .640219467456450E+00

CONIC ELEMENTS          A              E              INC            NODE           APS            MA             TA
S/C ECLIPTIC       .3137784E+05   .7242480E-02   .5257868E+01   .3599996E+03   .3180890E+02   .1382700E+03   .1388187E+03
S/C EQUATORIAL     .3137784E+05   .7242480E-02   .2869972E+02   .3599999E+03   .3180898E+02   .1382780E+03   .1388187E+03

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

******************************
*                            *
* CURRENT CP TIME    65.539  *
*                            *
******************************
```

79-B

ORIGINAL PAGE IS
OF POOR QUALITY

3.2.2 GODSEP

The GODSEP sample case performs a short error analysis over a trajectory similar to that used in the TOPSEP sample case, except there are no radiation flux or shadow effects. The initial conditions correspond to a 12000 km circular orbit on March 21, 1980. The run actually consists of two cases, the first to create an STM file containing appropriate state transition matrices and the second case performs the error analysis.

The first page of output is a reproduction of the \$TRAJ and \$GØDSEP namelists used to create the STM file. Of particular interest in \$TRAJ are the variables MØDE = 2 (for GODSEP), ISTMF = 1 (for STM generation), and IAUGDC = 1, 1 (for augmenting the basic spacecraft state vector with thrust bias parameters). The \$GØDSEP namelist specifies STM time span from 0 to 7 days and only one scheduling card. STM time points will correspond to the single eigenvector event of .5 days and to the scheduling card which follows \$GØDSEP. The scheduling card is a set of dummy measurements to create transition matrices at one day intervals.

Output from the run begins on the next page with MAPSEP initialization print. This is followed on the next two pages by GODSEP initialization print and the standard TRAJ print blocks every 35 integration steps (IPRINT = 35 in \$TRAJ) which are displayed during the creation of the STM file. STM generation ends with the output of the last STM record, over the next two pages. This contains trajectory related data such as current (TCURR) and previous (TPAST) STM time points, and finally the transition matrix (PHI) over the interval TPAST to TCURR.

Next, the namelists \$TRAJ and \$GØDSEP are shown for the subsequent error analysis using the previously generated STM file. With ISTMF = 2 in

$TRAJ, reference trajectory data is obtained from the STM file. $GØDSEP namelist for the second case specifies a spherical a-priori knowledge covariance, one guidance event executing after one day, and no measurement print. The total augmented state consists of nine solve-for parameters (S/C state and thrust biases).

Five scheduling cards specify three measurements occuring at .5 days (2-way range-rate, 2-way range, simultaneous azimuth/elevation angles, all from Canberra), one CO2 horizon scanner measurement at 3 days, and one star/planet (Earth horizon) measurement at 6 days.

Output from the error analysis run begins with MAPSEP initialization print followed by 3 pages of GODSEP initialization print, including the input a-priori covariance.

The first event printed is a low thrust guidance correction. This begins with a TRAJ print at day one which marks the beginning of the guidance interval. The state transition matrix and effective process noise (Q) matrix are displayed. These are used to map the error covariances since the time of the last processed measurement (.5 days) to the guidance execution time (1 day). Next, TRAJ prints are output corresponding to the end of the guidance interval (4 days) and time at which target variables are evaluated (7 days). After the TRAJ prints, the sensitivity matrix of guidance cutoff state with respect to thrust control parameters (thrust magnitude, direction angles, and cutoff time) is shown.

The knowledge (estimation error) covariance is printed at guidance initiation in standard deviations and correlation coefficients. After the knowledge covariance, the control (actual error) covariance is shown in analogous fashion.

namelist for the second case specifies a spherical a-priori knowledge covariance, one guidance event executing at L + 567 days with a half day delay time, and no measurement print. The total augmented state consists of 15 solve-for parameters (S/C state, thrust biases and Encke's state) and nine consider parameters (tracking station location biases).

Four scheduling cards specify (1) simultaneous 2-way/3-way doppler measurements twice per day from Goldstone and Madrid, (2) 2-way range once per day from Madrid, (3) 3-way range once per day from Goldstone and Madrid, and (4) three simultaneous star-Encke angle measurements taken twice per day.

Output from the error analysis run begins with MAPSEP initialization print followed by four pages of GODSEP initialization print, including the input a-priori covariance.

The first event printed is a low thrust guidance correction. This begins with generation of required transition and sensitivity matrices, as represented by TRAJ print at 566.5 days (last effective time of tracking to be used for guidance computations), 567 days (beginning of guidance interval over which thrust control corrections will be computed), 587 days (end of guidance interval and time of nominal thrust shutdown), and 593.5 days (desired target time and time of nominal Encke encounter). After the TRAJ print, the sensitivity matrix of guidance cutoff state with respect to thrust control parameters is shown.

The knowledge (estimation error) covariance is printed at guidance

After the control covariance display, VMAT and SMAT are printed. These are sensitivity matrices of target parameters WRT guidance initiation state and target parameters WRT thrust control parameters, respectively. VMAT, SMAT and BURNP (S/C mass and thrust acceleration magnitude at guidance start and end) are also provided on punched cards to be used in subsequent GODSEP runs in order to minimize computational time (See $GEVENT in Section 2.3.3).

Guidance corrections are computed next. The reader is referred to Section 6.6 of the Analytic Manual to better understand the actual guidance computation logic. The guidance cycle uses the various sensitivity matrices, thrust control constraints, and control and target weighting in ultimately computing a "final" set of control corrections. The cutoff time refers to an imposed coast period in the nominal thrusting profile, but would normally be associated with thrust shutdown for a shadowing segment. Also shown is the additional propellant needed to execute these corrections, in this case .1356 Kg. The GAMMA matrix is the final guidance matrix of control corrections WRT guidance initiation state error.

Finally, the guidance event ends with a display of the new control covariance, which assumes all guidance corrections have occurred, and the projected target dispersions before and after guidance initiation.

A measurement event is printed next for a star/horizon. This is the last measurement in the run and is printed even when no measurement print was requested. The TRAJ print is followed by the knowledge covariance before measurement processing. Navigation related matrices are output which include the observation matrix of augmented state WRT the measurement and the filter gain matrix. The knowledge covariance is then printed after the measurement(s) have been processed.

The final event shown is a "zero burn" guidance event. This occurs automatically (if a previous guidance event has been executed) at termination time (TFINAL = 7 days in $GØDSEP) to display the final knowledge and control covariances.

For this GODSEP run, the contents of the SUMARY file are printed. Results of every measurement (before and after processing) are displayed and include measurement time and code, RSS S/C position and velocity, and the standard deviations of the knowledge covariances for both S/C state and augmented solve-for parameters.

By necessity, only a limited amount of program and print options were exercised in this sample case. The user should read Pages 31-34 on output control for a better understanding of GODSEP flexibility in terms of printout.

GODSEP Sample Case

```
P$TRAJ
  TLNCH=2444320.,  TEND=7.,
  SCMASS=5000.,
  STATE= 28571.,0.,0.,0., 3.7209449,-.3255405,
  THRUST=3.,10.,1.,20.,.00717,10.,-7.,6.,0.,63.,
  PHAS=0.,90.,
  STEP=1.,
  ENGINE=14.425,0.,14.425,                  ENGINE(17)=1.E20,
  ISTOP=1,
  IPRINT=35,
  IAUGDC=1,1,
  ISTMF=1,
 $END  TRAJ


P$GODSEP
  TCURR=0.,  TFINAL=7.,
  NEIGEN=1,   TEIGEN=.5,
  NSCHED=1,
  $END GODSEP


 0.        7.        1.                  1001
```

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
     JULIAN DATE ....   2444321.0000000000
     CALENDAR DATE ..... 1980 MAR  21     12 HR  0 MIN  0.0000 SECS
TRAJECTORY START EPOCH       0.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....   2444320.0000000001
     CALENDAR DATE ..... 1980 MAR  21     12 HR  0 MIN  3.0000 SECS
TRAJECTORY END EPOCH         7.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....   2444327.0000000000
     CALENDAR DATE ..... 1980 MAR  28     12 HR  0 MIN  3.0000 SECS
```

INITIAL STATE VECTOR IN ECLIPTIC COORDINATE SYSTEM

	X	Y	Z	MAGNITUDE
POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
VELOCITY	0.	.37209449000000E+01	-.32554050000000E+00	.37351583053435E+01

```
SEPS MASS                          5000.0000000000 KG
EXHAUST VELOCITY                     29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.            14.4250000000 KW
FLUENCE                               0.0000000000 E14 PARTICLES
THRUSTER EFFICIENCY                   1.0000000000
RADIATION PRESSURE COEFFICIENT       -1.0000000000

LIST OF GRAVITATING BODIES
     SUN
     EARTH
TARGET PLANET IS EARTH

INTEGRATION STEP FACTOR    1.0000

THE SHADOWING LOGIC WILL NOT BE EXECUTED.
```

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	10.000000	1.000000	20.000000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000

THRUST CONTROL PHASING ANGLES (DEG)

0.000	90.000	0.000	0.000

GOOSEP INITIALIZATION AND SETUP FOR STM FILE GENERATION RUN DATE 02/22/75

SCHEDULED TRAJECTORY TIME 0.0000 DAYS
STM FILE TRAJECTORY TIME 0.0000 DAYS

MEASUREMENT AND PROPAGATION EVENT SCHEDULE

FROM 0.00000 DAYS TO 7.00000 DAYS IN INCREMENTS OF 1.00000 DAYS -- CODE NO. 1001

1 EIGENVECTOR EVENTS

EVENT TIME (DAYS)

.500

0 THRUST EVENTS

0 GUIDANCE EVENTS

0 PREDICTION EVENTS

CURRENT RUN SEGMENT CREATES STM FILE

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444320.00000000	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	0.00000000	PRESENT MASS (KG)--	5000.000000000	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	7.00000000	PRESENT PITCH (DEG)--	20.000000000	FLUX RATE (E14/SEC)--	0.
		PRESENT YAW (DEG)--	290.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
10.0000000	1.0000000	20.0000000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14900365223641E+09	-.26945142067351E+07	0.	.14902801342902E+09
	VELOCITY	.52497597352775E-01	-.26171724366265E+02	-.32554050000000E+00	.26173801575595E+02
EARTH	POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
	VELOCITY	0.	.37209449000000E+01	-.32554050000000E+00	.37351583053435E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48829866860519E-03	-0.	-0.	.48829866860519E-03
PERTURBING BODIES	.22894211851794E-08	.62105475750162E-10	0.	.22902634025861E-08
THRUST	-.24079844144338E-07	.62612529986232E-07	-.18430982466295E-06	.19613841865524E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

ORIGINAL PAGE IS OF POOR QUALITY

JULIAN DATE -- 2444321.99919011
DAYS FROM LAUNCH-- 1.99919011
DAYS FROM CUTOFF-- 5.00080989

CONTROL PHASE -- 1
PRESENT MASS (KG)-- 4994.241791753
PRESENT PITCH (DEG)-- 182.045033630
PRESENT YAW (DEG)-- 51.846766201

PRIMARY BODY -- EARTH
FLUX (E14)-- 0.0000000000
FLUX RATE (E14/SEC)-- 0.
AVAILABLE POWER (KW)-- 14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14896115005425E+09	-.78657581234280E+07	.94276836368194E+03	.14916867760102E+09
	VELOCITY	.24363887298239E+01	-.33307787900624E+02	.31616970532835E+00	.33396098646916E+02
EARTH	POSITION	-.27038222495259E+05	-.10320902403406E+05	.94276836368194E+03	.28956438218664E+05
	VELOCITY	.13233724131724E+01	-.34515998618940E+01	.31616970532835E+00	.37100969573772E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.44389386067663E-03	.16944136493383E-03	-.15477684923702E-04	.47538573049988E-03
PERTURBING BODIES	-.22189159289824E-08	.23860786387679E-09	-.37695013972690E-10	.22320265515164E-08
THRUST	.13716355688680E-07	-.12083326114631E-06	.15441348143257E-06	.19636456026132E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444324.03848436
DAYS FROM LAUNCH-- 4.03848437
DAYS FROM CUTOFF-- 2.96151563

CONTROL PHASE -- 1
PRESENT MASS (KG)-- 4988.368072696
PRESENT PITCH (DEG)-- 355.199359711
PRESENT YAW (DEG)-- 306.136204629

PRIMARY BODY -- EARTH
FLUX (E14)-- 0.0000000000
FLUX RATE (E14/SEC)-- 0.
AVAILABLE POWER (KW)-- 14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14862902154366E+09	-.13090730203484E+08	-.18662808681337E+04	.14920440095379E+09
	VELOCITY	-.32523550730126E+00	-.27047417188989E+02	-.26172493683395E+00	.27050638710999E+02
EARTH	POSITION	.21867106558926E+05	.19459015100219E+05	-.18662808681337E+04	.29330983996599E+05
	VELOCITY	-.24562944905526E+01	.27349397735790E+01	-.26172493683395E+00	.36853464059683E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.34542029039041E-03	-.30738125451195E-03	.29480410573921E-04	.46332224989346E-03
PERTURBING BODIES	.19307285370094E-08	-.53014476146159E-09	.74566529592023E-10	.20035591057719E-08
THRUST	-.28693665312049E-09	.11593368040632E-06	-.15877404900888E-06	.19659577621066E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444325.11474758
DAYS FROM LAUNCH-- 6.11474760
DAYS FROM CUTOFF-- .88525240

CONTROL PHASE -- 1
PRESENT MASS (KG)-- 4982.387873028
PRESENT PITCH (DEG)-- 216.914150788
PRESENT YAW (DEG)-- 21.708383519

PRIMARY BODY -- EARTH
FLUX (E14)-- 0.0000000000
FLUX RATE (E14/SEC)-- 0.
AVAILABLE POWER (KW)-- 14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14818679794281E+09	-.18469597028026E+08	.26259775945211E+04	.14933337470152E+09
	VELOCITY	.64503991263510E+01	-.31345248034442E+02	.16687869060440E+00	.32002501023002E+02
EARTH	POSITION	-.13595472193991E+05	-.26232124585996E+05	.26259775945211E+04	.29662383296016E+05
	VELOCITY	.32568986344624E+01	-.16758265214745E+01	.16687869060440E+00	.36665558420155E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.20764075095061E-03	.40363765129639E-03	-.40105996461588E-04	.45302726192118E-03
PERTURBING BODIES	-.14436608547616E-08	.79824671752583E-09	-.10464830648924E-09	.16529687697180E-08
THRUST	.12707794939310E-06	-.13150548734386E-06	.72802726179220E-07	.19683174378800E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

ORIGINAL PAGE IS OF POOR QUALITY

```
TCURR          7.0000
TPAST          6.0000
NPRI                3
NTPHAS              1
APERT
   .15352759E-08   -.74468149E-09    .10609938E-09
   .15352759E-08   -.74468149E-09    .10609938E-09
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
APRIM       -.21397626E-03   -.39008623E-03    .39815590E-04
MASS         .49798381E+04
RPACC       0.               0.               0.
THRACC      -.91671818E-07    .12818580E-06   -.11809784E-06
UP
  0.               0.               0.
  -.14791167E+09   -.20710604E+08   0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
VP
  0.               0.               0.
   .36447488E+01   -.29609750E+02   0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
UPFL
  -.14789736E+09   -.20684518E+08   -.26625730E+04
   .14309154E+05    .26086090E+05   -.26625730E+04
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
  0.               0.               0.
UPFLM
   .14933679E+09
   .29871814E+05
  0.
  0.
  0.
  0.
  0.
  0.
  0.
  0.
```

ORIGINAL PAGE IS OF POOR QUALITY

```
 0.
VREL
 -.43952001E+01  -.27870083E+02  -.17613907E+00
 -.32052288E+01   .17396662E+01  -.17613907E+00
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
 0.               0.              0.
VRELM
  .27874105E+02
  .36511580E+01
 0.
 0.
 0.
 0.
 0.
 0.
 0.
 0.
 0.
 0.
UTRUE      .14339154E+05   .26186090E+05  -.26625730E+04
VTRUE     -.32052288E+01   .17396662E+01  -.17613907E+00
UTRUEM     .29871814E+05
VTRUEM     .36511580E+01
HPOWER     .14425000E+02
GT
  -.91671818E-07   .12818580E-06  -.11809784E-06
  -.12818559E-06  -.91673904E-07  -.24898216E-11
  -.68770974E-07   .96058706E-07   .15759226E-06
GTSAVE
  -.91671818E-07   .12818580E-06  -.11809784E-06
  -.12818559E-06  -.91673904E-07  -.24898216E-11
  -.68770974E-07   .96058706E-07   .15759226E-06
GPERT      0.              0.              0.
FLX        0.
FLXDOT     0.
PHI
  -.25870728E+02   .11716009E+02  -.11676639E+01  -.16284631E-02  -.27979448E-02   .28233583E-03
  0.               0.              0.               .32348353E+01  -.45836211E+00   .10833925E-01
   .28642987E-03   .28261755E-03  -.16945717E-04  0.               0.              0.
  -.31439234E+00   .98526540E-02  -.33443962E+00  -.28106584E-04  -.15641749E-04   .11941992E-03
  0.               0.              0.              -.50864231E+05   .30717436E+05  -.30726093E+04
  -.25299250E+01  -.58826246E+01   .59128021E+00  0.               0.              0.
  -.24156806E+06   .10650350E+06  -.11385734E+05  -.14951581E+02  -.24825198E+02   .24730332E+01
  0.               0.              0.               .24329504E+05  -.11511086E+05  -.66421796E+04
   .15767057E+01   .24699272E+01  -.57859605E+00  0.               0.              0.
   .14455055E+04  -.54420467E+03  -.31766818E+01   .96318941E-01   .15127774E+00  -.19080050E-01
   .10000000E+01  0.              0.               .39393175E+03  -.14351611E+03   .17767129E+02
   .25758380E-01   .42477396E-01  -.47722379E-02  0.               .10000000E+01  0.
  -.87316898E+02   .43376794E+02   .23212916E+01  -.13827347E-02   .32949258E-02  -.22439385E-02
  0.               0.              .10000000E+01
```

ORIGINAL PAGE IS OF POOR QUALITY

```
P$TRAJ
  ISTMF=2,    $END



P$GODSEP
   IPFORM = 1,
  P(1,1)=.1,   P(2,2)=.1,   P(3,3)=.1,
  P(4,4)=.0001,   P(5,5)=.0001,   P(6,6)=.0001,
   PS(1,1) = .022,    PS(2,2) = .035,    PS(3,3) = .035,
  MPFREQ=13*0,
  IAUG=3*1,
  TCURR=0.,   TFINAL=7.,
  NGUID=1,  TGUID=1., TCUTOF=4.,  TIMFTA=7.,  IGPOL=1,
  NSCHED=5,
  EPSIG(1,2)=.1,.01,.01,
  EPTAU(1,2)=3*.02,
 $END    EARTH ORBIT GODSEP


  .5        .5         .05           1003
  .5        .5         .05           2003
  .5        .5         .05           3003
 3.        3.          .05           7000
 6.        6.          .05           4001
```

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
      JULIAN DATE ....   2444320.0000000000
      CALENDAR DATE ....  1980 MAR   21        12 HR  0 MIN  0.0000 SECS
TRAJECTORY START EPOCH        0.0000000000 DAYS AFTER THE INITIAL EPOCH
      JULIAN DATE ....   2444320.0000000000
      CALENDAR DATE ....  1980 MAR   21        12 HR  0 MIN  0.0000 SECS
TRAJECTORY END EPOCH          7.0000000000 DAYS AFTER THE INITIAL EPOCH
      JULIAN DATE ....   2444327.0000000000
      CALENDAR DATE ....  1980 MAR   28        12 HR  0 MIN  0.0000 SECS
```

INITIAL STATE VECTOR IN ECLIPTIC COORDINATE SYSTEM

	X	Y	Z	MAGNITUDE
POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
VELOCITY	0.	.37209449000000E+01	-.32554050000000E+00	.37351583053435E+01

```
SEPS MASS                          5000.0000000000 KG
EXHAUST VELOCITY                     29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.            14.4250000000 KW
FLUENCE                               0.0000000000 E14 PARTICLES
THRUSTER EFFICIENCY                   1.0000000000
RADIATION PRESSURE COEFFICIENT       -1.0000000000
```

LIST OF GRAVITATING BODIES
- SUN
- EARTH

TARGET PLANET IS EARTH

INTEGRATION STEP FACTOR 1.0000

THE SHADOWING LOGIC WILL NOT BE EXECUTED.

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	10.000000	1.000000	20.000000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000

THRUST CONTROL PHASING ANGLES (DEG)

0.000	90.000	0.000	0.000

GODSEP INITIALIZATION AND SETUP FOR ERROR ANALYSIS RUN DATE 02/22/75
****

SCHEDULED TRAJECTORY TIME 0.0000 DAYS
STM FILE TRAJECTORY TIME 0.0000 DAYS

TOTAL JOB FIELD LENGTH = 061100 OCTAL
LENGTH OF BLANK COMMON = 002304

MEASUREMENT AND PROPAGATION EVENT SCHEDULE

FROM	.50000	DAYS TO	.50000	DAYS IN INCREMENTS OF	.05000	DAYS --	CODE NO.	1003
FROM	.50000	DAYS TO	.50000	DAYS IN INCREMENTS OF	.05000	DAYS --	CODE NO.	2003
FROM	.50000	DAYS TO	.50000	DAYS IN INCREMENTS OF	.05000	DAYS --	CODE NO.	3003
FROM	3.00000	DAYS TO	3.00000	DAYS IN INCREMENTS OF	.05000	DAYS --	CODE NO.	7000
FROM	6.00000	DAYS TO	6.00000	DAYS IN INCREMENTS OF	.05000	DAYS --	CODE NO.	4001

0 EIGENVECTOR EVENTS

0 THRUST EVENTS

1 GUIDANCE EVENTS

EVENT TIME (DAYS)	CUTOFF TIME (DAYS)	GUIDANCE DELAY TIME (DAYS)	GUIDANCE POLICY	READ CONTROL
1.000	4.000	0.000	1	0
7.000	7.000	0.000	0	0

0 PREDICTION EVENTS

FILTERING ALGORITHM IS KALMAN-SCHMIDT

MEASUREMENT WHITE NOISE STANDARD DEVIATIONS

DATA TYPE	STD DEV	
2-WAY DOPPLER	.10000000E+01	MM/S PER 1 MIN SAMPLE AT 12.0000 COUNTS/DAY
2-WAY RANGE	.30000000E+01	METERS
3-WAY DOPPLER	.10000000E+00	MM/S (FREQ DRIFT)
3-WAY RANGE	.10000000E+02	METERS
AZIMUTH	.16000000E+04	MICRO-RADIANS
ELEVATION	.16000000E+04	MICRO-RADIANS
STAR-PLANET ANGLE	.15000000E+03	MICRO-RADIANS
PLANET LIMB ANGLE	.15000000E+03	MICRO-RADIANS
CENTER-FINDING	.10000000E+02	KILOMETERS
CO2 LAYER ALTITUDE	.48000000E+00	KILOMETERS
HORIZON SENSOR ANGLE	.29100000E+03	MICRO-RADIANS

TOLERANCE ON MESHING SCHEDULED TIME POINTS WITH THOSE AVAILABLE ON STM FILE = .200E-02 DAYS
TOLERANCE ON MESHING SCHEDULED TIME POINTS WITH THOSE AVAILABLE ON STM FILE = .100E+01 DAYS
FAILURE TO MESH WITHIN TOLERANCE IS FATAL
CONTROL IS PROPAGATED SIMULTANEOUSLY WITH KNOWLEDGE

INITIAL TRAJECTORY TIME 0.0000 DAYS
FINAL TRAJECTORY TIME 7.0000 DAYS

PRINT CONTROL
0 0 0 0 0 0 0 0 0 0 0 0 0

STATION LOCATION COORDINATES

	RADIUS	LONGITUDE	LATITUDE	ALTITUDE
1	.637200000E+04	243.167	35.160	-6.163
2	.637001900E+04	355.831	40.267	-8.144
3	.637211100E+04	148.978	-35.402	-6.062
4	.637564100E+04	27.707	-25.735	-2.522
5	.637440900E+04	143.726	-24.760	-3.754
6	.636090800E+04	212.487	64.824	-17.195
7	.637139700E+04	277.125	35.017	-6.176
8	.637254200E+04	289.334	-32.975	-5.621
9	.637355600E+04	262.622	27.495	-4.607

EQUIVALENT STATION LOCATION ERRORS (ONE-SIGMA)

ALTITUDE 35.000000 METERS
LONGITUDE 35.000000 METERS
LATITUDE 35.000000 METERS
LONGITUDE CORRELATION .900000

THRUST NOISE PROCESS ONE IS THRUSTER DEPENDENT
SECOND PROCESS IS 1 WHERE 1=THRUSTER INDEP, 2=DEPENDANT

DYNAMIC NOISE PARAMETERS

PROCESS	STD DEV	CORRELATION TIME
MAGNITUDE 1	.350000E+01 PER CENT	.400000E+01 DAYS
PITCH	.100000E-01 RADIANS ,	.100000E+01 DAYS
YAW	.100000E-01 RADIANS ,	.100000E+01 DAYS
MAGNITUDE 2	.100000E+02 PER CENT	.200000E-01 DAYS
PITCH	.100000E-01 RADIANS ,	.200000E-01 DAYS
YAW	.100000E-01 RADIANS ,	.200000E-01 DAYS

STD DEV IN THRUST ON TIME= 0.00 SEC

A PRIORI KNOWLEDGE UNCERTAINTY AT TRAJECTORY TIME 0.0000 DAYS

RSS POSITION = .17320508E+00 KM
RSS VELOCITY = .17320508E+00 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.10000000E+00	1.00000000					
Y	.10000000E+00	0.00000000	1.00000000				
Z	.10000000E+00	0.00000000	0.00000000	1.00000000			
VX	.10000000E-03	0.00000000	0.00000000	0.00000000	1.00000000		
VY	.10000000E-03	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	
VZ	.10000000E-03	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
ACCPRO		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
PITCH		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
YAW		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.22000000E-01	1.00000000		
PITCH	.35000000E-01	0.00000000	1.00000000	
YAW	.35000000E-01	0.00000000	0.00000000	1.00000000

INITIAL S/C MASS ERROR 0.0000 KG

GODSEP ANALYSIS EVENT PRINTOUT   RUN DATE 02/22/75

SCHEDULED TRAJECTORY TIME   1.0000 DAYS
SIM FILE TRAJECTORY TIME   1.0000 DAYS

GUIDANCE

JULIAN DATE	-- 2444321.00000000	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG)--	4997.119729523	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	6.00000000	PRESENT PITCH (DEG)--	27.609469526	FLUX RATE (E14/SEC)--	0.
		PRESENT YAW (DEG)--	323.153003717	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.148938410437215E+09	-.533046216052414E+07	.248897330830740E+04	.149092807772209E+09
	VELOCITY	.417762451953748E+01	-.289314209320430E+02	-.794461810562110E-01	.292810795149730E+02
EARTH	POSITION	.694882926231790E+04	-.278127422245670E+05	.248897330830740E+04	.287851932881740E+05
	VELOCITY	.360935484992710E+01	-.897454506830190E+00	-.794461810562110E-01	.372010466522200E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.116797461327710E-33	.464807131847740E-03	-.415957741720990E-04	.481058754434520E-03
PERTURBING BODIES	.440150484950140E-09	.113924279339690E-08	-.996694325074360E-10	.122537356851740E-08
THRUST	.169247889753590E-06	.657406101516820E-07	-.744846733288530E-07	.196251470118320E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

EFFECTIVE S/C MASS STANDARD DEVIATIONS (KG)
CONTROL=   .3019   KNOWLEDGE= 188.4910

TRANSPOSE OF STATE TRANSITION MATRIX PARTITIONS OVER TIME INTERVAL   .5000 DAYS TO   1.0000 DAYS

STATE	X	Y	Z	VX	VY	VZ
X	-.135531522E+02	-.398616153E+01	.353689150E+00	.474432743E-03	-.170300544E-02	.151584332E-03
Y	.106698880E+02	.491316146E+01	-.287668352E+00	-.239412017E-03	.126851370E-02	-.105902430E-03
Z	-.959559503E+00	-.288247391E+00	.808599188E+00	.212865007E-04	-.105868650E-03	.902698074E-04
VX	-.908311650E+05	-.209433650E+05	.185352311E+04	.374441974E+01	-.110276564E+02	.981131999E+00
VY	-.112522870E+06	-.352353629E+05	.270420710E+04	.330912260E+01	-.128922334E+02	.121818291E+01
VZ	.100000155E+05	.270977956E+04	-.505268443E+04	-.293637225E+00	.121623090E+01	.669763236E+00

0   ******

.526603235010E+03	.152756713412E+03	-.365141029396E+02	-.169174384905E-01	.615200135484E-01	-.176973442163E-02
.152756713412E+03	.443258098877E+02	-.105933153748E+02	-.490535192984E-02	.178445104634E-01	-.513254337489E-03
-.365141029396E+02	-.105933153748E+02	.261708919001E+01	.117177512001E-02	-.426624926825E-02	.108995284671E-03
-.169174384905E-01	-.490535192984E-02	.117177512001E-02	.565241879901E-06	-.196829063878E-05	.477253745036E-07
.615200135484E-01	.178445104634E-01	-.426624926825E-02	-.196829063878E-05	.719057459663E-05	-.210274645906E-06
-.176973442163E-02	-.513254337489E-03	.108995284671E-03	.477253745036E-07	-.210274645906E-06	.125429756778E-07

ORIGINAL PAGE IS OF POOR QUALITY

```
****************************************************************************************************
----------------------------------------------------------------------------------------------------

                                ****          CONTROL PHASE CHANGE          ****

JULIAN DATE      -- 2444324.00000000        CONTROL PHASE         --    1                     PRIMARY BODY              --      EARTH
DAYS FROM LAUNCH--      4.00000000          PRESENT MASS    (KG)--  4998.478918093            FLUX            (E14)--    0.0000000000
DAYS FROM CUTOFF--      3.00100000          PRESENT PITCH (DEG)--    334.877599422            FLUX RATE   (E14/SEC)--    0.
                                            PRESENT YAW     (DEG)--  293.051433878            AVAILABLE POWER (KW)--    14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING   A0 = PITCH        A1            A2         A3 = YAW        OF          A4            A5
     (DAYS)                     (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
   10.0000000    1.0000000    20.0000000     .0071700    10.0000000    -7.0000000     6.0000     0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES            X                          Y                          Z                          MAGNITUDE
SUN      POSITION        -.148630021338703E+09     -.133022149334702E+08     -.860299250390106E+03     .149197656942256E+09
         VELOCITY         .983279001841520E+00     -.262916203170602E+02     -.333930799693942E+00     .263121197601190E+02

EARTH    POSITION         .279207180792130E+05      .893977027777380E+04     -.860299250390100E+03     .293296114102856E+05
         VELOCITY        -.112803925565580E+01      .349247103622070E+01     -.333930799693940E+00     .368528645835370E+01

S/C ACCELERATIONS                   X                          Y                          Z                          MAGNITUDE
PRIMARY BODY             -.441107131231490E-03     -.141235494370530E-03      .135914890606890E-04     .463365616622820E-03
PERTURBING BODIES         .229839592437150E-08     -.584167388944050E-10      .343775848762740E-10     .229939427279900E-08
THRUST                    .264838287646685E-07      .722779554353410E-07     -.180894128129890E-06     .196591407797550E-06
J2 + RAD. PRESSURE       0.                        0.                        0.                        0.

S/C MASS=  .49971 2E+04   THRUST=  .196251E-06   AT TIME    1.0000

S/C MASS=  .49884 8E+04   THRUST=  .196591E-06   AT TIME    4.0000
****************************************************************************************************
----------------------------------------------------------------------------------------------------

                                ****          CONTROL PHASE CHANGE          ****

JULIAN DATE      -- 2444327.00000000        CONTROL PHASE         --    1                     PRIMARY BODY              --      EARTH
DAYS FROM LAUNCH--      7.00000000          PRESENT MASS    (KG)--  4979.838106662            FLUX            (E14)--    0.0000000000
DAYS FROM CUTOFF--       .00100000          PRESENT PITCH (DEG)--     27.618844466            FLUX RATE   (E14/SEC)--    0.
                                            PRESENT YAW     (DEG)--  323.043480445            AVAILABLE POWER (KW)--    14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING   A0 = PITCH        A1            A2         A3 = YAW        OF          A4            A5
     (DAYS)                     (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
   10.0000000    1.0000000    20.0000000     .0071700    10.0000000    -7.0000000     6.0000     0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES            X                          Y                          Z                          MAGNITUDE
SUN      POSITION        -.147897309760840E+09     -.206845447475900E+08     -.265989710747950E+04     .149336749104110E+09
         VELOCITY         .443084076532830E+00     -.278635962410290E+02     -.176831788977540E+00     .278676799978600E+02

EARTH    POSITION         .143590059039600E+05      .260592907186480E+05     -.265989710747950E+04     .298721063175190E+05
         VELOCITY        -.320166470738540E+01      .174615330055610E+01     -.176831788977540E+00     .365116114806690E+01

S/C ACCELERATIONS                   X                          Y                          Z                          MAGNITUDE
PRIMARY BODY             -.214715431243470E-03     -.389674040330300E-03      .397744076738320E-04     .446688457011380E-03
PERTURBING BODIES         .153869514391210E-08     -.742857548754920E-09      .105992853768890E-09     .171191546774100E-08
THRUST                   -.915612999418160E-07      .127986940666890E-06     -.118398863343390E-06     .196932525168680E-06
J2 + RAD. PRESSURE       0.                        0.                        0.                        0.
```

UNWEIGHTED SENSITIVITY MATRIX (CUTOFF WRT CONTROLS)

.214057298098E+04	.955929017959E+03	-.651154731447E+02	0.
-.622355107033E+04	-.251071435236E+04	-.640017256332E+03	0.
.509933180338E+03	.250127784612E+03	.600893239289E+02	0.
.761317499722E+00	.346704352023E+00	.783989672687E-01	.264838287647E-07
.255257972297E+00	.976295871734E-01	.626171405488E-01	.722779554353E-07
-.443628152289E-01	-.916540227815E-02	-.743660911250E-02	-.180894128130E-06

KNOWLEDGE COVARIANCE AT MANEUVER EXECUTION TIME 1.0000 DAYS
BASED ON MEASUREMENTS UP TO 1.0000 DAYS

RSS POSITION = .29478797E+02 KM
RSS VELOCITY = .34693637E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.28224535E+02	1.00000000					
Y	.81732059E+01	.99665229	1.00000000				
Z	.23521331E+01	-.73464750	-.72272473	1.00000000			
VX	.93923941E-03	-.98348145	-.97343276	.71774923	1.00000000		
VY	.33346128E-02	.99940925	.99489537	-.72737697	-.98234636	1.00000000	
VZ	.18620209E-03	-.68183517	-.67926977	.17310568	.63305197	-.69960900	1.00000000
ACCPRO		-.31010932	-.35403263	.15812827	.27046248	-.31621149	.47391863
PITCH		.07887709	.04565081	.08874854	-.09239939	.07587769	-.09624859
YAW		-.02831659	-.08479346	.09306799	-.04928325	-.01145271	-.03464840

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.14063890E-01	1.00000000		
PITCH	.33854884E-01	.30969635	1.00000000	
YAW	.30936882E-01	.57342560	-.11129551	1.00000000

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 1.0000 DAYS

RSS POSITION = .65415141E+02 KM
RSS VELOCITY = .76441341E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.62320179E+02	1.00000000					
Y	.19508791E+02	.99583187	1.00000000				
Z	.38396600E+01	-.90199491	-.90713634	1.00000000			
VX	.17664321E-02	-.99046819	-.97772304	.89012707	1.00000000		
VY	.74157988E-02	.99952867	.99727035	-.90231445	-.98818317	1.00000000	
VZ	.56389119E-03	-.94282982	-.95024687	.77760284	.90637385	-.94692089	1.00000000
ACCPRO		-.22604764	-.29019500	.26194336	.18157576	-.24714889	.27294228
PITCH		.12083499	.12382398	-.04813501	-.11702456	.12556416	-.13097451
YAW		-.11392647	-.10118791	.09221746	.09788880	-.09537952	.08110845

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.22000000E-01	1.00000000		
PITCH	.35000000E-01	0.00000000	1.00000000	
YAW	.35000000E-01	0.00000000	0.00000000	1.00000000

TARGET WRT BURN START STATE

VMAT

-.194026566054E+01	.127987069112E+02	-.112073559365E+01	-.106682781560E+06	-.423815125510E+05	.371161284864E+04
.253312413606E+01	-.843650371162E+01	.645835610053E+00	.749458913403E+05	.173903279155E+05	-.912525686159E+03
-.252031786478E+00	.801612918044E+00	-.758630472677E+00	-.761030853849E+04	-.132421287997E+04	.560105215569E+04

TARGET WRT CONTRL

SMAT

-.457043579404E+04	-.145482510575E+04	-.115624412435E+04	.178124737714E-02
.140506004040E+04	.248323837301E+03	.318694600937E+03	-.353887121385E-02
-.326974869473E+03	-.252496381570E+02	-.419133047181E+02	-.591918023381E-03

CONTROL WEIGHTS

ACCPRO	.1000E+01
PITCH	.1000E+01
YAW	.1000E+01
CUTOFF	.1000E+01

TARGET WEIGHTS

X	.1000E+01
Y	.1000E+01
Z	.1000E+01

ORIGINAL PAGE IS
OF POOR QUALITY

UNWEIGHTED GUIDANCE MATRIX (CONTROLS WRT TARGETS)

-.181986157063E-03	-.594390840673E-03	.300845383795E-02
.100325890527E-02	.167153604566E-02	-.696663984132E-02
.370427221467E-03	.579145153849E-03	-.236769618041E-02
.315029207764E+02	.216028731741E+03	.492389645723E+03

UNCONSTRAINED CONTROL CORRECTIONS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW	CUTOFF
ACCPRO	.19693487E-01	1.00000000			
PITCH	.43874605E-01	-.98385709	1.00000000		
YAW	.14806456E-01	-.97807053	.99955288	1.00000000	
CUTOFF	.18593357E+04	-.68292798	.62738890	.61532918	1.00000000

ACCPRO, SIGMA= .19693E-01, MAX ALLOWED= .50000E+00
PITCH, SIGMA= .43875E-01, MAX ALLOWED= .87266E+00
YAW, SIGMA= .14806E-01, MAX ALLOWED= .87266E+00
CUTOFF, SIGMA= .18593E+04, MAX ALLOWED= .43200E+07

RESID TARGET ERROR

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.19342353E-10	1.00000000		
Y	.12457229E-10	.66137223	1.00000000	
Z	.11685494E-11	.85739446	.95284820	1.00000000

UNWEIGHTED GUIDANCE MATRIX (CONTROLS WRT TARGETS)

-.181986157063E-03	-.594390840673E-03	.300845383795E-02
.100325890527E-02	.167153604566E-02	-.696663984132E-02
.370427221467E-03	.579145153848E-03	-.236769618041E-02
.315029207764E+02	.216028731741E+03	.492389645723E+03

FINAL CONTROL CORRECTIONS INCLUDING CONSTRAINTS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW	CUTOFF
ACCPRO	.19693487E-01	1.00000000			
PITCH	.43874605E-01	-.98385709	1.00000000		
YAW	.14806456E-01	-.97807053	.99955288	1.00000000	
CUTOFF	.18593357E+04	-.68292798	.62738890	.61532918	1.00000000

CONTROL STANDARD DEVIATIONS AND MAXIMUM VALUES

ACCPRO	1.96935	50.00 PER CENT
PITCH	2.51383	50.00 DEGREES
YAW	.84835	50.00 DEGREES
CUTOFF	.02152	50.00 DAYS

MASS STANDARD DEVIATION FOR GUIDANCE= .1356

GAMMA MATRIX

-.189295705938E-02	.509700850737E-02	-.246222516453E-02	-.480276238485E+02	-.660763635062E+01	.167174416052E+02
.399328461929E-02	-.684605186194E-02	.524025481279E-02	.712625868796E+02	-.422575572085E+01	-.368221240349E+02
.132767850967E-02	-.204294664513E-02	.175508806429E-02	.219052418773E+02	-.249240802178E+01	-.124151921896E+02
.355525101253E+03	-.102462464659E+04	-.269329186541E+03	.908240951464E+07	.176964034104E+07	.267769496548E+07

STATE ERROR AFTER BURN

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 1.0000 DAYS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.29224535E+02	1.00000000					
Y	.81732059E+01	.99665229	1.00000000				
Z	.23521331E+01	-.73464750	-.72272473	1.00000000			
VX	.93923941E-03	-.98348145	-.97340276	.71774923	1.00000000		
VY	.33346128E-02	.99340925	.99489537	-.72737697	-.98234636	1.00000000	
VZ	.18620209E-03	-.68183517	-.67926977	.17310568	.63305197	-.69960900	1.00000000

TARGET ERROR BEFORE BURN

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.20426720E+02	1.00000000		
Y	.18016404E+02	-.80651377	1.00000000	
Z	.40619268E+01	.60144024	-.87442365	1.00000000

TARGET ERROR AFTER BURN

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.20315295E+02	1.00000000		
Y	.15932828E+02	-.95322209	1.00000000	
Z	.34851367E+01	.74991074	-.83769266	1.00000000

SCHEDULED MEASUREMENT PRINTOUT   RUN DATE 02/22/75

SCHEDULED TRAJECTORY TIME   6.0030 DAYS
STM FILE TRAJECTORY TIME   6.0000 DAYS

MEASUREMENT CODE = 4001
1   STAR-PLANET ANGLES

MEASUREMENT WITH STARS 1

STAR-PLANET ANGLE =   17.341 DEGS, MEASURED FROM STAR1

S/C GEOCENTRIC COORDINATES
LATITUDE = 2.31485 DEGS   LONGITUDE= 176.09012 DEGS   ALTITUDE = 23587.065 KM

JULIAN DATE -- 2444325.0000000	CONTROL PHASE -- 1	PRIMARY BODY -- EARTH	
DAYS FROM LAUNCH-- 5.0000000	PRESENT MASS (KG)-- 4982.718377140	FLUX (E14)-- 0.0000000000	
DAYS FROM CUTOFF-- 1.0000000	PRESENT PITCH (DEG)-- 27.618844466	FLUX RATE (E14/SEC)-- 0.	
	PRESENT YAW (DEG)-- 323.043480445	AVAILABLE POWER (KW)-- 14.4250000000	

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14823395444001E+09	-.18145391574786E+08	-.37662322605216E+03	.14934041812071E+09
	VELOCITY	.26517283443072E+01	-.33295081584546E+02	.36091989324447E+00	.33402460749216E+02
EARTH	POSITION	-.29379884080496E+05	.38776554239695E+04	-.37662322605216E+03	.29637065394837E+05
	VELOCITY	-.48319880389976E+00	-.36184282720097E+01	.36091989324447E+00	.36683466866026E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.44986365262309E-03	-.59374510377793E-04	.57668403207552E-05	.45380160299549E-03
PERTURBING BODIES	-.22341765325271E-08	-.57146639387158E-09	.15006756558614E-10	.23061534685622E-08
THRUST	-.67704323245118E-07	-.88634574105741E-07	.16216544885566E-06	.19681868792252E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

TRANSPOSE OF STATE TRANSITION MATRIX PARTITIONS OVER TIME INTERVAL   3.0000 DAYS TO   6.0000 DAYS

STATE

	X	Y	Z	VX	VY	VZ
X	-.252398350E+01	-.309110275E+02	.297643904E+01	.348244733E-02	-.711591382E-03	.687205758E-04
Y	.830089780E+01	.756933640E+02	-.725570193E+01	-.936945119E-02	.146992836E-02	-.150992195E-03
Z	-.797562488E+00	-.729013563E+01	.119680103E+01	.908114943E-03	-.153821819E-03	-.940293520E-04
VX	-.561129916E+05	-.618986270E+06	.596139339E+05	.778502481E+02	-.124071468E+02	.118911825E+01
VY	-.320059678E+05	-.238111572E+06	.236466711E+05	.295331166E+02	-.391793134E+01	.416628335E+00
VZ	.307713687E+04	.239367048E+05	.459619067E+04	-.288014111E+01	.434897509E+00	.440572471E+00

Q   ******

.12334945779E+04	.118865189037E+05	-.109398670276E+04	-.149659112851E+01	.243103216819E+00	-.198031446960E-01
.118865189037E+05	.114583563887E+06	-.105448382478E+05	-.144270783045E+02	.234400070791E+01	-.190887680332E+00
-.109398670276E+04	-.105448382478E+05	.970866715943E+03	.132768773323E+01	-.215698043523E+00	.175969118261E-01
-.149659112851E+01	-.144270783045E+02	.132768773323E+01	.181652557637E-02	-.295104017743E-03	.239902016441E-04
.243103216819E+00	.234400070791E+01	-.215698043523E+00	-.295104017743E-03	.480018107246E-04	-.396306071913E-05
-.198031446960E-01	-.190887680332E+00	.175969118261E-01	.239902016441E-04	-.396306071913E-05	.443060170974E-06

KNOWLEDGE COVARIANCE BEFORE THE MEASUREMENT AT 6.00000 DAYS

RSS POSITION = .43873717E+03 KM
RSS VELOCITY = .55241651E+02 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.43745946E+02	1.00000000					
Y	[illegible]	.98454939	1.00000000				
Z	.40997290E+02	-.98161596	-.99877539	1.00000000			
VX	.54498233E-01	-.98571848	-.99995245	.99846611	1.00000000		
VY	.91552988E-02	.96423427	.99541163	-.99426251	-.99470837	1.00000000	
VZ	.82117630E-03	-.85397598	-.84502034	.84471002	.84455838	-.83889353	1.00000000
ACCPRO		.26606538	.37052344	-.39688964	-.36432283	.41910391	-.19793474
PITCH		.37429267	.37488683	-.40166235	-.37153413	.35227089	-.30718027
YAW		.03181789	.19782294	-.20436603	-.19111902	.28306950	-.09894922

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.13495741E-01	1.00000000		
PITCH	.33739835E-01	.30435914	1.00000000	
YAW	.30695882E-01	.57162513	-.11623475	1.00000000

OBSERVATION MATRIX

X	.4363352296E-05
Y	.3216518007E-04
Z	-.9211585656E-05
VX	0.
VY	0.
VZ	0.
ACCPRO	0.
PITCH	0.
YAW	0.

MEAS NOISE

.1363491803555E-06

H*P*HT + R

.21167245175 9E-03

GAIN MATRIX

X	.296040221E+04
Y	.298639913E+05
Z	-.280745471E+04
VX	-.374380050E+01
VY	.619216452E+00
VZ	-.476944923E-01
ACCPRO	.343031659E+00
PITCH	.870894066E+00
YAW	.413097977E+00

KNOWLEDGE COVARIANCE AFTER THE MEASUREMENT AT 6.00000 DAYS

RSS POSITION = .13650967E+02 KM
RSS VELOCITY = .17852454E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.76508232E+01	1.00000000					
Y	.11080062E+02	.06334571	1.00000000				
Z	.72463338E+01	.15466459	-.43457518	1.00000000			
VX	.14687404E-02	-.31590497	-.93235575	.22819367	1.00000000		
VY	.91491911E-03	-.86663464	.33088955	-.15878198	-.09810370	1.00000000	
VZ	.43911943E-03	-.23300895	-.02061771	.03307146	-.01030092	.03324453	1.00000000
ACCPRO		-.60331491	.03551866	-.54185127	.21342663	.44947254	.23056551
PITCH		.02802246	-.02241876	-.52443598	.15482943	-.22795339	.02049020
YAW		-.03948940	.08360054	-.16462179	.17426475	.89093404	.12681610

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.12539034E-01	1.00000000		
PITCH	.31270307E-01	.19217626	1.00000000	
YAW	.30101749E-01	.54791379	-.21099205	1.00000000

GODSEP ANALYSIS EVENT PRINTOUT RUN DATE 02/22/75

SCHEDULED TRAJECTORY TIME 7.0000 DAYS
SIN FILE TRAJECTORY TIME 7.0000 DAYS

GUIDANCE

JULIAN DATE -- 2444327.00000000	CONTROL PHASE -- 1	PRIMARY BODY -- EARTH
DAYS FROM LAUNCH-- 7.00000000	PRESENT MASS (KG)-- 4979.838106664	FLUX (E14)-- 0.0000000000
DAYS FROM CUTOFF-- 0.00000000	PRESENT PITCH (DEG)-- 27.618844466	FLUX RATE (E14/SEC)-- 0.
	PRESENT YAW (DEG)-- 323.043480445	AVAILABLE POWER (KW)-- 14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES	X	Y	Z	MAGNITUDE
SUN POSITION	-.14789735961732E+09	-.20684517910349E+08	-.26625729545296E+04	.14933679476287E+09
VELOCITY	.43952003849298E+00	-.27870083367866E+02	-.17613906555721E+00	.27874105362147E+02
EARTH POSITION	.14309154119362E+05	.26086089815626E+05	-.26625729545296E+04	.29871813942557E+05
VELOCITY	-.32052287678350E+01	.17396661747822E+01	-.17613906555721E+00	.36511580114059E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.21397626229774E-03	-.39008623082465E-03	.39815589667484E-04	.44669720111778E-03
PERTURBING BODIES	.15352759032565E-08	-.74468148706148E-09	.10609938488595E-09	.17096431486615E-08
THRUST	-.31671818462774E-07	.12818579600820E-06	-.11809783601218E-06	.19693252516862E-06
J2 + RAD. PRESSURE	0.	0.	0.	0.

EFFECTIVE S/C MASS STANDARD DEVIATIONS (KG)
CONTROL= .8645 KNOWLEDGE= 185.1420

TRANSPOSE OF STATE TRANSITION MATRIX PARTITIONS OVER TIME INTERVAL 6.0000 DAYS TO 7.0000 DAYS

STATE	X	Y	Z	VX	VY	VZ
X	-.258707277E+02	.117160394E+02	-.116766394E+01	-.162846310E-02	-.279794483E-02	.282335827E-03
Y	.320483331E+01	-.459362113E+00	.108339253E-01	.286429368E-03	.282617552E-03	-.169457169E-04
Z	-.314392344E+00	.985265403E-02	-.334439621E+00	-.281065936E-04	-.156417493E-04	.119419922E-03
VX	-.508642315E+05	.307174365E+05	-.307260932E+04	-.252992502E+01	-.588262463E+01	.591280207E+00
VY	-.241568355E+06	.136503498E+06	-.113857338E+05	-.149515810E+02	-.248251978E+02	.247303318E+01
VZ	.243295042E+05	-.115110860E+05	-.664217956E+04	.150670575E+01	.246892717E+01	-.578596048E+00

0 ::::::

.323517290161E+04	-.150268842547E+04	.215657275653E+02	.195581166908E+00	.336873659337E+00	-.394074612900E-01
-.150268842547E+04	.698048106700E+03	-.997595607567E+01	-.908394321116E-01	-.156477827655E+00	.183067065589E-01
.215657275653E+02	-.997595607567E+01	.530910804644E+00	.130385291238E-02	.224700852056E-02	-.246287964915E-03
.195581166908E+00	-.908394321116E-01	.130385291238E-02	.118396517427E-04	.203483528916E-04	-.236764444013E-05
.336873659337E+00	-.156477827655E+00	.224700852056E-02	.203483528916E-04	.351055527524E-04	-.412393495437E-05
-.394074612900E-01	.183067065589E-01	-.246287964915E-03	-.236764444013E-05	-.412393495437E-05	.505008217156E-06

KNOWLEDGE COVARIANCE AT MANEUVER EXECUTION TIME 7.0000 DAYS
BASED ON MEASUREMENTS UP TO 7.0000 DAYS

RSS POSITION = .10978029E+03 KM
RSS VELOCITY = .12062668E+02 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.10000365E+03	1.00000000					
Y	.45114601E+02	-.99584465	1.00000000				
Z	.39565442E+01	.50462879	-.48038955	1.00000000			
VX	.61494969E-02	.99511824	-.98538628	.44272627	1.00000000		
VY	.10300165E-01	.99480215	-.99096836	.45687650	.99692158	1.00000000	
VZ	.12642225E-02	-.95930640	.94472797	-.39213946	-.97258257	-.97281634	1.00000000
ACCPRO		.16015662	-.10764941	-.11974177	.23116883	.20804556	-.34485951
PITCH		.39737003	-.33684025	.49910652	.42223404	.37788362	-.42424248
YAW		-.17810619	.19676805	-.49226095	-.09739621	-.08699460	-.01610464

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.12539034E-01	1.00000000		
PITCH	.31270307E-01	.19217626	1.00000000	
YAW	.30101749E-01	.54791379	-.21099205	1.00000000

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 7.0000 DAYS

RSS POSITION = .32752030E+04 KM
RSS VELOCITY = .39249256E+03 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.29888703E+04	1.00000000					
Y	.13332607E+04	-.99394415	1.00000000				
Z	.12658985E+03	.99946270	-.99942650	1.00000000			
VX	.20238240E+00	.99996829	-.99983889	.99943799	1.00000000		
VY	.33470103E+00	.99998838	-.99995527	.99946795	.99995727	1.00000000	
VZ	.32664888E-01	-.99992348	.99989835	-.99922622	-.99987258	-.99993360	1.00000000

ACCPRO	.36926611	-.37035748	.36218945	.36905261	.37083887	-.37751822
PITCH	.17572012	-.17742164	.17933924	.17302699	.17497766	-.18009368
YAW	.13925315	-.14018442	.13065962	.14113951	.14285108	-.14638985

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	PITCH	YAW
ACCPRO	.14063890E-01	1.00000000		
PITCH	.33854884E-01	.30969635	1.00000000	
YAW	.30936882E-01	.57342560	-.11129551	1.00000000

.5000	BEFORE	M=1003	P=	.2334E+02 KM	STATE	.1308E+02	.1914E+02	.2653E+01	.2161E-02	.1523E-02	.2176E-03
			V=	.2653E+01 M/S	SOLVE-FOR	.2200E-01	.3500E-01	.3500E-01			
.5000	AFTER	M=1003	P=	.3989E+01 KM	STATE	.2419E+01	.3038E+01	.9125E+00	.4525E-03	.3260E-03	.2163E-03
			V=	.5982E+00 M/S	SOLVE-FOR	.2182E-01	.3486E-01	.3471E-01			
.5000	BEFORE	M=2003	P=	.3984E+01 KM	STATE	.2419E+01	.3038E+01	.9125E+00	.4525E-03	.3260E-03	.2163E-03
			V=	.5982E+00 M/S	SOLVE-FOR	.2182E-01	.3486E-01	.3471E-01			
.5000	AFTER	M=2003	P=	.3826E+01 KM	STATE	.2198E+01	.3000E+01	.8962E+00	.4422E-03	.3154E-03	.2163E-03
			V=	.5846E+00 M/S	SOLVE-FOR	.1406E-01	.3386E-01	.3094E-01			
.5000	BEFORE	M=3003	P=	.3826E+01 KM	STATE	.2198E+01	.3000E+01	.8962E+00	.4422E-03	.3154E-03	.2163E-03
			V=	.5846E+00 M/S	SOLVE-FOR	.1406E-01	.3386E-01	.3094E-01			
.5000	AFTER	M=3003	P=	.3825E+01 KM	STATE	.2198E+01	.3000E+01	.8960E+00	.4421E-03	.3154E-03	.2162E-03
			V=	.5846E+00 M/S	SOLVE-FOR	.1406E-01	.3385E-01	.3094E-01			
3.0000	BEFORE	M=7000	P=	.4495E+03 KM	STATE	.3983E+03	.2074E+03	.1952E+02	.1760E-01	.5358E-01	.4672E-02
			V=	.5650E+02 M/S	SOLVE-FOR	.1406E-01	.3385E-01	.3094E-01			
3.0000	AFTER	M=7000	P=	.8939E+01 KM	STATE	.7581E+01	.4370E+01	.1824E+01	.4985E-03	.1167E-02	.2342E-03
			V=	.1290E+01 M/S	SOLVE-FOR	.1350E-01	.3374E-01	.3070E-01			
6.0000	BEFORE	M=4001	P=	.4387E+03 KM	STATE	.4375E+02	.4346E+03	.4091E+02	.5449E-01	.9055E-02	.8212E-03
	PRINT		V=	.5524E+02 M/S	SOLVE-FOR	.1350E-01	.3374E-01	.3070E-01			
6.0000	AFTER	M=4001	P=	.1765E+02 KM	STATE	.7651E+01	.1108E+02	.2246E+01	.1469E-02	.9149E-03	.4391E-03
	PRINT		V=	.1785E+01 M/S	SOLVE-FOR	.1254E-01	.3127E-01	.3010E-01			

ORIGINAL PAGE IS OF POOR QUALITY

104

Pages 105 through 116-F have been deleted.

3.2.3 SIMSEP

The SIMSEP sample case studies a seven day segment of an Earth orbital mission where solar electric propulsion is used to increase the semi-major axis. Initially the orbit is the same as that used for the GODSEP sample case (Section 3.2.2) with the period being 13.35 hours and the inclination equal to 5 degrees (with respect to the ecliptic plane). However, different analysis assumptions, e.g., the inclusion of shadowing and J_2 effects, cause the trajectories to diverge even after just seven days of propagation.

The SIMSEP sample case is simulated under the influence of control errors which directly affect the S/C motion, e.g., PG, SCERR, TVERR, TCERR, etc., and knowledge errors which affect the ability to control the motion, e.g., P, PS, and CXS. Only one sample mission is calculated in the program's "forced Monte Carlo" mode (IRAN = 0) where all error sources are sampled at their one-sigma levels. A single guidance correction has been included to indicate computational steps and effectiveness of the Newton-Raphson algorithm in re-targeting dispersed trajectories. Although the scope of this analysis is limited and in no way exercises the full capability of SIMSEP, it does use the fundamental computational cycle and displays the basic output.

Referring to the sample printout (see Page 119), the first page shows a listing of the $TRAJ namelist as has been presented in previous TOPSEP and GODSEP sample cases. The trajectory initialization data which follow define the reference trajectory integrating conditions underlying the SIMSEP analysis. Next, the first mode peculiar namelist, $SIMSEP, is listed and is followed by the SIMSEP initialization data on the two succeeding pages. Among the error sources are the initial s/c state (PG), the value of J_2 in the gravitational potential (J2ERR), s/c mass (SCERR(1)), exhaust velocity (SCERR(2)), and electric power to the thrusters (SCERR(3)). Thrust control biases (TCERR) in the reference control profile and thrust process noise (TVERR) are also input as error sources. For this run, NCYCLE is automatically set equal to one since the forced Monte Carlo mode is being used.

Because only one guidance maneuver has been specified in the $SIMSEP input, i.e., NGUID = 1, only one $GUID namelist is read. The resultant guidance initialization data are shown on the next three pages where the guidance event times, target times, active thrust controls, and targets are identified. Because INREF = 1 in $SIMSEP, the s/c state and mass at the maneuver time, sensitivity matrix of targets with respect to controls, and nominal target conditions are input and printed. If INREF had been zero, trajectory information relevant to the guidance event would not be available at this point in program execution, but would have been computed and printed at a later time.

The trajectory simulation begins when the initial s/c errors and any errors that act as biases throughout an entire mission are sampled. For example, the a-priori control error covariance is sampled to form a discrete actual trajectory state. Likewise, thrust biases, errors in the gravitational constants, and initial thrust process noise are computed for the current mission cycle. These actual values, the corresponding reference values, and the sample derivatives are printed as part of the actual trajectory initialization data. Subsequently, trajectory data are printed as the actual trajectory is propagated to the first guidance event time.

The single guidance event included in this sample output is a nonlinear correction scheduled at one day after the mission has begun. The active thrust controls are the thruster throttling and the initial pitch and yaw angles, acting over the second thrust phase. These three variables are used to control the perigee radius and semi-major axis of the osculating orbit at the target time. The designated target time corresponds to the nominal trajectory end time, thus making the duration of the guidance event six days.

Before the re-targeting algorithm is executed, the program simulates the orbit determination process to form a state vector on the estimated trajectory. Simply stated, the knowledge covariance is sampled to obtain a knowledge error. This error is then added to the actual trajectory state, thereby defining initial conditions for the estimated trajectory. The results of this sampling process and other auxiliary calculations are printed as part of the normal SIMSEP print at guidance events.

A numerical differencing procedure is used to calculate trajectory sensitivities of state variable changes with respect to control changes over the active thrust control phase. The integration of the reference and perturbed trajectories accounts for additional trajectory printout following the estimated trajectory print.

At the designated target time (P. 131-E), target conditions evaluated along the estimated trajectory are computed and compared with the reference, or desired, targets. The miss, i.e., deviations between the estimated and reference targets, is seen to be approximately 39 km for perigee and 41 km for semi-major axis, giving 78.11 for the quadratic error index. Various trajectory related information, i.e., ϕ, θ_u, and η matrices, are printed along with the guidance matrix computed from these sensitivities.

The first nonlinear guidance correction (printed as "UPDATES" at the top of Page 131-F) is calculated to be -.5%, .0234 rad., and -.0136 rad., and causes a slight reduction in the target deviations on the estimated trajectory computed for the next iteration. In particular, the updates over-corrected the thrust controls to yield misses of -39. km and -36 km, respectively. The third set of updates (P. 131-Q) decreased the target errors to 2.8 km and 7.3 km within the 5 and 10 km tolerances. Thus, the guidance procedure has converged, and the commanded and executed thrust control corrections are printed.

The actual trajectory is propagated to the final time (TEND) since there are no more maneuvers. At TEND, a Monte Carlo mission summary is displayed showing the final trajectory conditions.

If more sample missions had been requested and run, additional output in the same format would result (if requested) as the computational cycle proceeded. This would, of course, include the sampling of initial errors, data for the guidance maneuver, and summary print. In the event that more than one mission simulation had been executed (without guidance divergence), additional output is displayed after all Monte Carlo cycles in the form of accumulated statistics (means, variances, and correlations). In particular, state error covariances, s/c mass variation, estimated control correction covariances, etc. would be printed and punched (if requested).

<u>SIMSEP Sample Case</u>

```
P$TRAJ
  TLNCH=2444320.,  TEND=7.,
  SCMASS=5000.,
  STATE= 28571.,0.,0.,0., 3.7209449,-.3255405,
  PHAS=0.,90.,
   PHAS(4)=1.,
  STEP=1.,
  ENGINE=14.425,0.,14.425,                 ENGINE(17)=1.E20,
   ICOORD=3, NTP=3,  NB=3,
  TSTOP=1,
   DRMAX=50.,
   THRUST(1,1)=3.,1.,1.,20.,.00717,10.,-7.,6.,0.,63.,
   THRUST(1,2)=3.,4.,1.,279.488,.00717,10.,-7.,6.,0.,63.,
   THRUST(1,3)=3.,10.,1.,337.952,.00717,10.,-7.,6.,0.,63.,
   TSTME =0,
   MODE=-3,
   PRNML=T,
   J2FLG=1,
   IPRINT=-1,
   XPRINT=7.,
   MORBIT=1,
 $END  TRAJ
```

TRAJECTORY INITIALIZATION

INITIAL EPOCH (REFERENCE DATE)
JULIAN DATE 2444320.0000000000
CALENDAR DATE .... 1980 MAR 21 12 HR 0 MIN 0.0000 SECS
TRAJECTORY START EPOCH 0.0000000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2444320.0000000000
CALENDAR DATE .... 1980 MAR 21 12 HR 0 MIN 0.0000 SECS
TRAJECTORY END EPOCH 7.0000000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2444327.0000000000
CALENDAR DATE .... 1980 MAR 28 12 HR 0 MIN 0.0000 SECS

INITIAL STATE VECTOR IN ECLIPTIC COORDINATE SYSTEM

	X	Y	Z	MAGNITUDE
POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
VELOCITY	0.	.37209449000000E+01	-.32554050000000E+00	.37351583053435E+01

SEPS MASS	5000.0000000000 KG
EXHAUST VELOCITY	29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.	14.4250000000 KW
FLUENCE	0.0000000000 E14 PARTICLES
THRUSTER EFFICIENCY	1.0000000000
RADIATION PRESSURE COEFFICIENT	1.0000000000

LIST OF GRAVITATING BODIES
SUN
EARTH
TARGET PLANET IS EARTH

THE PERTURBING EFFECTS OF A NON-SPHERICAL CENTRAL BODY ARE MODELED AS A J2-TERM IN THE GRAVITATIONAL POTENTIAL
(J2 = .10826450E-02)

INTEGRATION STEP FACTOR 1.0000

THE SHADOWING LOGIC WILL BE EXECUTED.

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	1.000000	1.000000	20.000000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000
2	4.000000	1.000000	279.488000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000
3	10.000000	1.000000	337.952000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000

THRUST CONTROL PHASING ANGLES (DEG)
0.000 90.000 0.000 .007

```
$SIMSEP
  AOK=100.,
  INREF=1,
  IOUT=1, IPUNCH=1,
  IRAN=0,
  NCYCLE=1, NGUID=1,
  PRNML=T,
  GMERR=1.,.0001,
  SCERR=6*1.E-6,
  J2ERR=1.E-6,
  PG(1,1)=.5, PG(2,2)=.5, PG(3,3)=.5,
  PG(4,4)=5.E-4, PG(5,5)=5.E-4, PG(6,6)=5.E-4,
  TCERR(2,1)=.01, TCERR(3,1)=.57, TCERR(6,1)=.57,
  TCERR(2,2)=.01, TCERR(3,2)=.57, TCERR(6,2)=.57,
  TVERR(1,1)=.01, TVERR(1,2)=5.,
  TVERR(2,1)=.57, TVERR(2,2)=3.,
  TVERR(3,1)=.57, TVERR(3,2)=3.,
 XEND=          .559915709722E+04,     .289931943273E+05,     -.222519983155E+04,
          -.360378497285E+01,    .696106657727E+00,   -.736331001879E-01,
 MEND=         .497983810666E+04
$END
```

SIMSEP INPUT DATA

INITIAL CONTROL COVARIANCE AT TRAJECTORY TIME 0.00000 DAYS(J.D.= 2444320.00000)

STANDARD DEVIATIONS AND CORRELATIONS

	X	Y	Z	VX	VY	VZ
X	.500000000000E+00					
Y	0.0000000000	.500000000000E+00				
Z	0.0000000000	0.0000000000	.500000000000E+00			
VX	0.0000000000	0.0000000000	0.0000000000	.500000000000E-03		
VY	0.0000000000	0.0000000000	0.0000000000	0.0000000000	.500000000000E-03	
VZ	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000	.500000000000E-03

VARIANCES AND COVARIANCES

	X	Y	Z	VX	VY	VZ
X	.250000000000E+00	0.	0.	0.	0.	0.
Y	0.	.250000000000E+00	0.	0.	0.	0.
Z	0.	0.	.250000000000E+00	0.	0.	0.
VX	0.	0.	0.	.250000000000E-06	0.	0.
VY	0.	0.	0.	0.	.250000000000E-06	0.
VZ	0.	0.	0.	0.	0.	.250000000000E-06

EIGENVAULES OF THE INITIAL COVARIANCE

.250000000000E+00 .250000000000E+00 .250000000000E+00 .250000000000E-06 .250000000000E-06 .250000000000E-06

MATRIX OF EIGENVECTORS (IN COLUMNS)

EGVEC1	EGVEC2	EGVEC3	EGVEC4	EGVEC5	EGVEC6
.100000000000E+01	0.	0.	0.	0.	0.
0.	.100000000000E+01	0.	0.	0.	0.
0.	0.	.100000000000E+01	0.	0.	0.
0.	0.	0.	.100000000000E+01	0.	0.
0.	0.	0.	0.	.100000000000E+01	0.
0.	0.	0.	0.	0.	.100000000000E+01

STANDARD DEVIATION IN THE SOLAR GRAVITATIONAL CONSTANT .100000000000E+01 KM**3/SEC**2

STANDARD DEVIATION IN THE EARTH GRAVITATIONAL CONSTANT .100000000000E-03 KM**3/SEC**2

STANDARD DEVIATION IN THE J2-COEFFICIENT OF THE GRAVITATIONAL HARMONIC .100000000000E-05

UNCERTAINTIES IN THE FOLLOWING SEPS PARAMETERS (ONE-SIGMA)

	NOMINAL VALUE	STANDARD DEVIATION
S/C MASS	5000.0000000000	.0000010000 KG
EXHAUST VELOCITY	29.4180000000	.0000010000 KM/SEC
ELECTRIC POWER AT 1 A.U.	14.4250000000	.0000010000 KW
THRUSTER EFFECIENCY	1.0000000000	.0000010000
RADIATION PRESSURE COEFFICIENT	-1.0000000000	.0000010000
SHADOW-OUT ENGINE START UP ERROR		.0000010000 PER CENT

ORIGINAL PAGE IS OF POOR QUALITY

THRUST CONTROL ERRORS (ONE-SIGMA)

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	0.000000	.010000	.570000	0.000000	0.000000	.570000	6.000000	0.000000	0.000000
2	0.000000	.010000	.570000	0.000000	0.000000	.570000	6.000000	0.000000	0.000000
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	6.000000	0.000000	0.000000

TIME-VARYING THRUST ERRORS	ONE-SIGMA LEVEL	CORRELATION TIME	STANDARD DEVIATION IN CORRELATION TIME
THROTTLING	.100000000000E-01	.500000000000E+01	0.
CONE ANGLE	.570000000000E+00	.300000000000E+01	0.
CLOCK ANGLE	.570000000000E+00	.300000000000E+01	0.
THROTTLING	0.	.100000000000E+01	0.
CONE ANGLE	0.	.100000000000E+01	0.
CLOCK ANGLE	0.	.100000000000E+01	0.

ORIGINAL PAGE IS
OF POOR QUALITY

```
ID
GUID=2.
DIMEN=12,
(1,1)=.01, P(2,2)=.01, P(3,3)=.01.
(4,4)=5.E-5, P(5,5)=5.E-5, P(6,6)=5.E-5,
S(1,1)=1.E-7,
MAX=5.
ASTM=0.
WATE=6*1..
TARGT(10)=1, ITARGT(15)=2.
ARTOL=5..10..
(3,2)=.001, H(4,2)=.01. H(7,2)=.01,
UID=      .244432100000E+07,
ARG=      .244432700000E+07,
REF=      .723226017574E+04,    -.277265796670E+05,    .236616864464E+04,
         .360320047611E+01,     .931784905969E+00,    -.788936341500E-01,
REF=      .499711972952E+04,
REF=      .562392733819E+04,     .289890629713E+05,    -.222454145189E+04,
        -.360314241483E+01.     .699154466145E+00.    -.738662121910E-01,
REF=      .497983810666E+04,
RGET=      .295910216000E+05,     .296495963112E+05,    0.
          .600811891774E+03,     .783503924700E+03,     .325236146734E+03,
          .393329140890E+03,    -.738794119936E+02,     .897843414985E+02,
D
```

```
************************************************************ GUIDANCE EVENT NUMBER 1 ************************************************************
****************************************************************** INPUT DATA ******************************************************************

GUIDANCE-EVENT TIME        2444321.00000 AT      1.00000 DAYS FROM LAUNCH
DESIGNATED TARGET TIME     2444327.00000 AT      7.00000 DAYS FROM LAUNCH
DURATION OF THE GUIDANCE TRAJECTOPY IS      6.00000 DAYS

REFERENCE TRAJECTORY STATE VECTOR AT THE GUIDANCE EVENT(J.D.=  2444321.00000)
      X           .723226017574E+04 KM
      Y          -.277265796670E+05 KM
      Z           .236615864464E+04 KM
      VX          .360320047611E+01 KM/SEC
      VY          .931784905969E+00 KM/SEC
      VZ         -.788936341500E-01 KM/SEC

SEPS MASS
     4997.11973 KG

CURRENT THRUST PHASE NUMBER
           2

SENSITIVITY MATRIX OF TARGET VARIABLES W.R.T. CONTROL VARIABLES(  2 X  3 )
       .600811891774E+03   .325236146734E+03  -.738794119936E+02
       .783593924700E+03   .393329140890E+03   .897843414985E+02

REFERENCE TRAJECTORY STATE VECTOR AT THE TARGET TIME(J.D.=  2444327.00000)
      X           .562392733819E+04 KM
      Y           .289890629713E+05 KM
      Z          -.222454145189E+04 KM
      VX         -.360314241483E+01 KM/SEC
      VY          .699154466145E+00 KM/SEC
      VZ         -.738662121910E-01 KM/SEC

SEPS MASS
     4979.83811 KG

DESIGNATED TARGET VARIABLES
                        TARGET VALUES         TOLERANCE
              RCA    .295910216000E+05    .500000000000E+01 KM
                A    .296495963112E+05    .100000000000E+02 KM

THE GUIDANCE LAW FOR THIS EVENT IS LOW THRUST-NONLINEAR WITH     5 ITERATION(S)

SENSITIVITY MATRICES OF TARGET CHANGE PER CONTROL CHANGE ARE COMPUTED BY NUMERICALLY DIFFERENCING
PERTURBED TRAJECTORIES WITH THE REFERENCE

ACTIVE THRUST CONTROLS FOR THIS GUIDANCE EVENT
                  THRUST PHASE NUMBER    CONTROL VARABLES          PERTURBATION
                          2                THROTTLING                 .0010
                          2                PITCH ANGLE                .0100
                          2                YAW   ANGLE                .0100

WEIGHTS SPECIFIED FOR EACH CONTROL VARIABLE.
       .100000000000E+01   .100000000000E+01   .100000000000E+01
```

```
  .100000000000E-01  0.                 0.                 0.                 0.                 0.
  0.                 .100000000000E-01  0.                 0.                 0.                 0.
  0.                 0.                 .100000000000E-01  0.                 0.                 0.
  0.                 0.                 0.                 .500000000000E-04  0.                 0.
  0.                 0.                 0.                 0.                 .500000000000E-04  0.
  0.                 0.                 0.                 0.                 0.                 .500000000000E-04

PS MATRIX

  .100000000000E-06

CXS MATRIX

  0.
  0.
  0.
  0.
  0.
  0.

AUG-P MATRIX

  .100000000000E-03  0.                 0.                 0.                 0.                 0.
     0.
  0.                 .100000000000E-03  0.                 0.                 0.                 0.
     0.
  0.                 0.                 .100000000000E-03  0.                 0.                 0.
     0.
  0.                 0.                 0.                 .250000000000E-08  0.                 0.
     0.
  0.                 0.                 0.                 0.                 .250000000000E-08  0.
     0.
  0.                 0.                 0.                 0.                 0.                 .250000000000E-08
     0.
  0.                 0.                 0.                 0.                 0.                 0.
     .100000000000E-13

EIGENVECTORS

  .100000000000E+01  0.                 0.                 0.                 0.                 0.
     0.
  0.                 .100000000000E+01  0.                 0.                 0.                 0.
     0.
  0.                 0.                 .100000000000E+01  0.                 0.                 0.
     0.
  0.                 0.                 0.                 .100000000000E+01  0.                 0.
     0.
  0.                 0.                 0.                 0.                 .100000000000E+01  0.
     0.
  0.                 0.                 0.                 0.                 0.                 .100000000000E+01
     0.
  0.                 0.                 0.                 0.                 0.                 0.
     .100000000000E+01

EIGENVALUES

  .100000000000E-03  .100000000000E-03  .100000000000E-03  .250000000000E-08  .250000000000E-08  .250000000000E-08
     .100000000000E-13

(CORE REQUIREMENTS FOR THIS JOB,  077000 OCTAL)
(LENGTH OF BLANK COMMON FOR THIS JOB,  001547 OCTAL)
****************************************************************************************************
                                     END OF SINSEP INPUT
```

ORIGINAL PAGE IS
OF POOR QUALITY

MONTE CARLO CYCLE NUMBER 1

OUTPUT DATA FOR THE ACTUAL TRAJECTORY AT TRAJECTORY INITIALIZATION

S/C STATE VECTOR AT TRAJECTORY TIME = 0.00000 DAYS(J.D.= 2444320.00000)

	ACTUAL	REFERENCE	DEVIATION	
X	.285715000000E+05	.285710000000E+05	.500000000000E+00	KM
Y	.500000000000E+00	0.	.500000000000E+00	KM
Z	.500000000000E+00	0.	.500000000000E+00	KM
VX	.500000000000E-03	0.	.500000000000E-03	KM/SEC
VY	.372144490000E+01	.372094490000E+01	.499999999988E-03	KM/SEC
VZ	-.325040500000E+00	-.325540500000E+00	.500000000001E-03	KM/SEC

S/C ORBITAL ELEMENTS

	ACTUAL	REFERENCE	DEVIATION	
A	.285789569328E+05	.285709997542E+05	.795717658523E+01	KM
E	.00030085	.00000001	.00030084	
I	4.99169226	5.00000006	-.00830780	DEG
NODE	180.01248246	180.00000000	.01248246	DEG
APSIS	150.12612078	0.00000000	150.12612078	DEG
M A	29.84519364	180.00000000	-150.15480636	DEG

SAMPLED S/C-SEP PARAMETERS

	ACTUAL	REFERENCE	DEVIATION	
S/C MASS	5000.00000	5000.00000	.00000	KG
EXHAUST VELOCITY	29.41800	29.41800	.00000	KM/SEC
ELECTRIC POWER	14.42500	14.42500	.00000	KW
THRUSTER EFF.	1.00000	1.00000	.00000	
RADIATION PRESS.	-1.00000	-1.00000	.00000	METERS**2
START-UP ERROR			.05400	PER CENT

DEVIATION OF ACTUAL THRUST CONTROLS FROM THE REFERENCE VALUES AFTER SAMPLING THRUST BIASES

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	0.000000	.004082	.232702	0.000000	0.000000	.232702	6.000000	0.000000	0.000000
2	0.000000	.004082	.232702	0.000000	0.000000	.232702	6.000000	0.000000	0.000000
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	6.000000	0.000000	0.000000

RECIPROCALS OF DIAGONAL ELEMENTS OF THE THRUST PROCESS TIME CORRELATION MATRIX

FIRST PROCESS =	5.0000000000	3.0000000000	3.0000000000	(DAYS)
SECOND PROCESS =	1.0000000000	1.0000000000	1.0000000000	(DAYS)

INITIAL VALUES FOR THE THRUST PROCESS NOISE

	FIRST PROCESS	SECOND PROCESS
THRUST MAGNITUDE	.0040824829	0.0000000000
PITCH ANGLE (DEG)	.2327015256	0.0000000000
YAW ANGLE (DEG)	.2327015256	0.0000000000

SAMPLED SOLAR GRAVITATIONAL CONSTANT

MU	.132712499001E+12	.132712499000E+12	.100000000000E+01	KM**3/SEC**2

SAMPLED EARTH GRAVITATIONAL CONSTANT

	ACTUAL	REFERENCE	DEVIATION	
MU	.398605668997E+06	.398605668897E+06	.999998301268E-04	KM**3/SEC**2

SAMPLED J2-COEFFICIENT IN THE GRAVITATIONAL POTENTIAL

	ACTUAL	REFERENCE	DEVIATION
J2	.108364500000E-02	.108264500000E-02	.999999999994E-06

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444320.00000000	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	0.00000000	PRESENT MASS (KG)--	5000.000001000	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	1.00000000	PRESENT PITCH (DEG)--	20.465403051	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00749042071626	PRESENT YAW (DEG)--	56.465403051	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1.0000000	1.0040825	20.2327015	.0071700	10.0000000	-6.7672985	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14900365173641E+09	-.26945137067351E+07	.50000000000000E+00	.14902801292006E+09
	VELOCITY	.52997597354252E-01	-.26171224367106E+02	-.32504050000000E+00	.26173296409612E+02
EARTH	POSITION	.28571500000000E+05	.50000000000000E+00	.50000000000000E+00	.28571500008750E+05
	VELOCITY	.50000000000000E-03	.37214449000000E+01	-.32504050000000E+00	.37356128975546E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48828958262187E-03	-.85450449332704E-08	-.85450449332704E-08	.48828950277141E-03
PERTURBING BODIES	.22894623494547E-08	.62086534366044E-10	-.20048325235619E-13	.22903040382714E-08
THRUST	-.39876799822414E-07	.10122589805650E-06	.16415925887737E-06	.19693934060159E-06
J2 + RAD. PRESSURE	-.39553089620554E-07	-.14165316823727E-11	-.23627122706223E-11	.39553089716488E-07

JULIAN DATE	-- 2444321.00000000	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG)--	4997.107969173	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	270.399193498	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00749042071626	PRESENT YAW (DEG)--	12.065964813	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831683826E+09	-.53045768159228E+07	.23656775687143E+04	.14909271183740E+09
	VELOCITY	.41764876877031E+01	-.28965727611882E+02	-.77075022428044E-01	.29265378283056E+02
EARTH	POSITION	.70832274200590E+04	-.27767914686300E+05	.23656775687143E+04	.28754575758808E+05
	VELOCITY	.36082180104452E+01	.91314782756147E+00	-.77075022428044E-01	.37227700338543E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875550845568E-03	.46554947791068E-03	-.39662321404470E-04	.48209157523308E-03
PERTURBING BODIES	.44788809382757E-09	.11378576612376E-08	-.94732311960998E-10	.12264982726284E-08
THRUST	.19252613992571E-06	.81976630784668E-08	.41188514188291E-07	.19705331749474E-06
J2 + RAD. PRESSURE	-.49725292082000E-08	.28962772182739E-07	.20177714950247E-07	.35646997066359E-07

MONTE CARLO CYCLE NUMBER 1
GUIDANCE EVENT NUMBER 1
OUTPUT DATA FOR GUIDANCE EVENT

GUIDANCE EVENT TIME 2444321.00000 AT 1.00000 DAYS FROM LAUNCH
DESIGNATED TARGET TIME 2444327.00000 AT 7.00000 DAYS FROM LAUNCH
DURATION OF THE GUIDANCE TRAJECTORY IS 6.00000 DAYS

S/C STATE VECTOR AT TRAJECTORY TIME = 1.00000 DAYS(J.D.= 2444321.00000)

	ACTUAL	REFERENCE	DEVIATION	
X	.708322742006E+04	.723226017574E+04	-.149032755681E+03	KM
Y	-.277679146863E+05	-.277265796670E+05	-.413350192999E+02	KM
Z	.236567756871E+04	.236616864464E+04	-.491075925747E+00	KM
VX	.360821801045E+01	.360320047611E+01	.501753433521E-02	KM/SEC
VY	.913147827561E+00	.931784905969E+00	-.186370784075E-01	KM/SEC
VZ	-.770750224280E-01	-.788936341500E-01	.181861172196E-02	KM/SEC
S/C MASS	4997.10797	4997.11973	-.01176	KG

S/C ORBITAL ELEMENTS

	ACTUAL	REFERENCE	DEVIATION	
A	.287476866074E+05	.287390514044E+05	.863520300773E+01	KM
E	.00029980	.00056543	-.00026564	
I	4.86682579	4.87536748	-.00854168	DEG
NODE	180.12618098	180.10902885	.01715213	DEG
APSIS	321.05661857	322.60870876	-1.55209020	DEG
M A	143.05769271	141.81133314	1.24635957	DEG

ESTIMATED S/C STATE VECTOR FROM SIMULATED ORBIT DETERMINATION

	ESTIMATE	ACTUAL	DEVIATION	
X	.708323742006E+04	.708322742006E+04	.999999998021E-02	KM
Y	-.277679046863E+05	-.277679146863E+05	.100000000093E-01	KM
Z	.236568756871E+04	.236567756871E+04	.999999999476E-02	KM
VX	.360826801045E+01	.360821801045E+01	.499999999874E-04	KM/SEC
VY	.913197827561E+00	.913147827561E+00	.499999999981E-04	KM/SEC
VZ	-.770250224280E-01	-.770750224280E-01	.500000000003E-04	KM/SEC
S/C MASS	4997.11973	4997.10797	.01176	KG

S/C ORBITAL ELEMENTS

	ESTIMATE	ACTUAL	DEVIATION	
A	.287485953514E+05	.287476866074E+05	.908743961947E+00	KM
E	.00026975	.00029980	-.00003005	
I	4.86664360	4.86682579	-.00018220	DEG
NODE	180.13575178	180.12618098	.00957080	DEG
APSIS	323.72934927	321.05661857	2.67273070	DEG
M A	140.37638253	143.05769271	-2.68131018	DEG

DEVIATION OF ESTIMATED TRAJECTORY FROM REFERENCE

	ESTIMATE	REFERENCE	DEVIATION	
X	.708323742006E+04	.723226017574E+04	-.149022755681E+03	KM
Y	-.277679046863E+05	-.277265796670E+05	-.413250192999E+02	KM
Z	.236568756871E+04	.236616864464E+04	-.481075925753E+00	KM
VX	.360826801045E+01	.360320047611E+01	.506753433520E-02	KM/SEC
VY	.913197827561E+00	.931784905969E+00	-.185870784075E-01	KM/SEC
VZ	-.770250224280E-01	-.788936341500E-01	.186861172196E-02	KM/SEC
S/C MASS	4997.11973	4997.11973	0.00000	KG

S/C ORBITAL ELEMENTS

	ESTIMATE	REFERENCE	DEVIATION	
A	.287485953514E+05	.287390514044E+05	.954394696967E+01	KM
E	.00026975	.00056543	-.00029569	
I	4.86664360	4.87536748	-.00872388	DEG

```
      NODE          180.13575178      180.10912885       .02672294  DEG
      APSIS         323.72934927      322.60870876      1.12064051  DEG
      M A           140.37638253      141.81133314     -1.43495061  DEG

ESTIMATED J2-COEFFICIENT OF THE GRAVITATIONAL POTENTIAL
              J2    .108374500000E-02   .108364500000E-02   .999999999959E-07
*******************************************************************************************
-------------------------------------------------------------------------------------------

                         ****          CONTROL PHASE CHANGE          ****

JULIAN DATE       -- 2444321.00000000     CONTROL PHASE         --   2                  PRIMARY BODY          --     EARTH
DAYS FROM LAUNCH--       1.00000000     PRESENT MASS    (KG)--  4997.119729520         FLUX             (E14)--  0.0000000000
DAYS FROM CUTOFF--       6.00000000     PRESENT PITCH (DEG)--   279.720701526         FLUX RATE   (E14/SEC)--  0.
MOTION (DEG/SEC)--  .00749042071626     PRESENT YAW     (DEG)--    56.232701526         AVAILABLE POWER (KW)--  14.4250000000

 THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
   DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW        OF           A4            A5
    (DAYS)                       (DEG)      (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
   3.0000000     1.0040825    279.7207015    .0071700     10.0000000    -6.7672985    6.0000     0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                       MAGNITUDE
SUN     POSITION        -.14899831602826E+09    -.53045768059227E+07     .23656875687142E+04     .14909271182705E+09
        VELOCITY         .41765376877030E+01    -.28965677611882E+02    -.77025022428043E-01     .29265335798968E+02

EARTH   POSITION         .70832374200590E+04    -.27767994686300E+05     .23656875687142E+04     .28754569387997E+05
        VELOCITY         .36082688104452E+01     .91319782756147E+00    -.77025822428043E-01     .37228297250271E+01

S/C ACCELERATIONS                 X                        Y                        Z                       MAGNITUDE
PRIMARY BODY            -.11875575504713E-03     .46554961969222E-03    -.39662515424468E-04     .48209178885580E-03
PERTURBING BODIES        .44788893589250E-09     .11378573050281E-08    -.94732712433455E-10     .12264982805963E-08
THRUST                   .10722982431425E-06     .22322251185824E-07     .16380852855914E-06     .19705266339022E-06
J2 + RAD. PRESSURE      -.49730120150273E-08     .28965500649637E-07     .20179556133724E-07     .35650323450704E-07
*******************************************************************************************
-------------------------------------------------------------------------------------------

                         ****          CONTROL PHASE CHANGE          ****

JULIAN DATE       -- 2444324.00000000     CONTROL PHASE         --   3                  PRIMARY BODY          --     EARTH
DAYS FROM LAUNCH--       4.00000000     PRESENT MASS    (KG)--  4988.443642125         FLUX             (E14)--  0.0000000000
DAYS FROM CUTOFF--       3.00000000     PRESENT PITCH (DEG)--   337.952000000         FLUX RATE   (E14/SEC)--  0.
MOTION (DEG/SEC)--  .00722649801007     PRESENT YAW     (DEG)--    56.000000000         AVAILABLE POWER (KW)--  14.4250000000

 THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
   DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW        OF           A4            A5
    (DAYS)                       (DEG)      (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
   6.0000000     1.0000000    337.9520000    .0071700     10.0000000    -7.0000000    6.0000     0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                       MAGNITUDE
SUN     POSITION        -.14863078369295E+09    -.13000359477796E+08    -.72928031946863E+03     .14919825461952E+09
        VELOCITY         .74777526289762E+00    -.26363795164829E+02    -.30036045259173E+00     .26376108123420E+02

EARTH   POSITION         .27158453871301E+05     .10795225951389E+05    -.72928031946863E+03     .29234403835769E+05
        VELOCITY        -.13635429946591E+01     .34202961892898E+01    -.30036045259173E+00     .36943053368983E+01

S/C ACCELERATIONS                 X                        Y                        Z                       MAGNITUDE
PRIMARY BODY            -.43327715064018E-03    -.17222352825342E-03     .11634701327257E-04     .46639618268792E-03
PERTURBING BODIES        .22574783244394E-08    -.13880395428021E-09     .29141714089192E-10     .22619293009592E-08
THRUST                   .32230863925580E-07     .10510202453914E-06     .16298301774816E-06     .19659279800113E-06
J2 + RAD. PRESSURE      -.30948315027701E-07    -.15862544098402E-07    -.73812055041598E-08     .35551381168981E-07
-------------------------------------------------------------------------------------------
```

ORIGINAL PAGE IS OF POOR QUALITY

```
JULIAN DATE       -- 2444327.00000000        CONTROL PHASE        --      3                 PRIMARY BODY          --      EARTH
DAYS FROM LAUNCH--          7.00000000       PRESENT MASS    (KG)--   4979.802830694        FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--          0.00000000       PRESENT PITCH (DEG)--      45.984556057        FLUX RATE   (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00722649801007         PRESENT YAW     (DEG)--      11.305522424        AVAILABLE POWER (KW)--    14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                      MAGNITUDE
SUN     POSITION       -.14790377416018E+09    -.20682099282039E+08    -.21965697902732E+04     .14934281250319E+09
        VELOCITY        .11090553774883E+00    -.28631829967495E+02    -.96703541200402E-01     .28632208068899E+02

EARTH   POSITION        .78946065542933E+04     .28504756263622E+05    -.21965697902732E+04     .29659245800950E+05
        VELOCITY       -.35338432462720E+01     .97791957492358E+00    -.96703541200402E-01     .36679321639204E+01

S/C ACCELERATIONS                 X                        Y                        Z                      MAGNITUDE
PRIMARY BODY           -.12061287010686E-03    -.43549231259738E-03     .33558934821242E-04     .45313046782735E-03
PERTURBING BODIES       .10784536089088E-08    -.94068438891484E-09     .87519304086010E-10     .14337394933195E-08
THRUST                 -.15612265097731E-06     .11365887450934E-06     .38605012923104E-07     .19693392020093E-06
J2 + RAD. PRESSURE     -.45863689565133E-08    -.25080805754937E-07    -.18375322154553E-07     .31428236695777E-07
*************************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------

                              ****           CONTROL PHASE CHANGE           ****

JULIAN DATE       -- 2444321.00000000        CONTROL PHASE        --      2                 PRIMARY BODY          --      EARTH
DAYS FROM LAUNCH--          1.00000000       PRESENT MASS    (KG)--   4997.119729520        FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--          6.00000000       PRESENT PITCH (DEG)--     279.720701526        FLUX RATE   (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00722649801007         PRESENT YAW     (DEG)--      56.232701526        AVAILABLE POWER (KW)--    14.4250000000

 THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
   DURATION     THROTTLING    A0 = PITCH       A1            A2         A3 = YAW       OF           A4            A5
    (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS    (DEG,SEC)     (DEG,SEC)
   3.5000000    1.0050825    279.7207015     .0071700    10.0000000    -6.7672985    6.0000      0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                      MAGNITUDE
SUN     POSITION       -.14899831602808E+09    -.53045768156202E+07     .23656875687142E+04     .14909271182721E+09
        VELOCITY        .41765376896394E+01    -.28965677611814E+02    -.77025022428043E-01     .29265335799177E+02

EARTH   POSITION        .70832374200590E+04    -.27767994686300E+05     .23656875687142E+04     .28754569387997E+05
        VELOCITY        .36082680104452E+01     .91319782756147E+00    -.77025022428043E-01     .37228297250271E+01

S/C ACCELERATIONS                 X                        Y                        Z                      MAGNITUDE
PRIMARY BODY           -.11875575504713E-03     .46554961969222E-03    -.39662515424468E-04     .48209178885580E-03
PERTURBING BODIES       .44788893567072E-09     .11378573050643E-08    -.94732712433150E-10     .12264982805489E-08
THRUST                  .10733661815308E-06     .22344482684308E-07     .16397167106122E-06     .19724891486033E-06
J2 + RAD. PRESSURE     -.49730120150273E-08     .28965500649637E-07     .20179556133724E-07     .35650323450704E-07
*************************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------

                              ****           CONTROL PHASE CHANGE           ****

JULIAN DATE       -- 2444324.00000000        CONTROL PHASE        --      3                 PRIMARY BODY          --      EARTH
DAYS FROM LAUNCH--          4.00000000       PRESENT MASS    (KG)--   4988.435001313        FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--          3.00000000       PRESENT PITCH (DEG)--     337.952000000        FLUX RATE   (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723553976991         PRESENT YAW     (DEG)--      56.000000000        AVAILABLE POWER (KW)--    14.4250000000

 THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
   DURATION     THROTTLING    A0 = PITCH       A1            A2         A3 = YAW       OF           A4            A5
    (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS    (DEG,SEC)     (DEG,SEC)
   6.0000000    1.0000000    337.9520000     .0071700    10.0000000    -7.0000000    6.0000      0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                      MAGNITUDE
SUN     POSITION       -.14863091269599E+09    -.13000114269958E+08    -.73024082961897E+03     .14919836185564E+09
        VELOCITY        .71323219982273E+00    -.26374338033953E+02    -.28577069283397E+00     .26385527695859E+02

EARTH   POSITION        .27029360791325E+05     .11840433789748E+05    -.73024082961897E+03     .29206348192177E+05
        VELOCITY       -.13980860577348E+01     .34097533201658E+01    -.28577069283397E+00     .36963126515616E+01

S/C ACCELERATIONS                 X                        Y                        Z                      MAGNITUDE
PRIMARY BODY           -.43246152045053E-03    -.17664356993157E-03     .11683630327412E-04     .46729265421808E-03
PERTURBING BODIES       .22498304040095E-08    -.14972247255399E-09     .29180032724069E-10     .22549955964265E-08
THRUST                  .32231098712809E-07     .10510215130196E-06     .16298330032777E-06     .19659313853303E-06
J2 + RAD. PRESSURE     -.30804889804671E-07    -.16256011978634E-07    -.76395514248505E-08     .35658966716666E-07
-------------------------------------------------------------------------------------------------------------------------
```

```
JULIAN DATE      -- 2444327.00000000        CONTROL PHASE      --    3                    PRIMARY BODY        --     EARTH
DAYS FROM LAUNCH--       7.00000000         PRESENT MASS   (KG)--  4979.794189883           FLUX            (E14)--  0.0000000000
DAYS FROM CUTOFF--       0.00000000         PRESENT PITCH (DEG)--    46.095371410           FLUX RATE  (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00723553976991          PRESENT YAW   (DEG)--     8.825129874           AVAILABLE POWER (KW)--  14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES           X                        Y                        Z                      MAGNITUDE
SUN     POSITION         -.14790540113363E+09    -.20681739850412E+08    -.21317398552907E+04    .14934437402287E+09
        VELOCITY          .57782815415777E-01    -.28830343942539E+02    -.75525704624630E-01    .28830500773155E+02

EARTH   POSITION          .62676331142121E+04     .28864187896582E+05    -.21317398552907E+04    .29613660405195E+05
        VELOCITY         -.35869659686051E+01     .77940559988002E+00    -.75525704624630E-01    .36714441410859E+01

S/C ACCELERATIONS                  X                        Y                        Z                      MAGNITUDE
PRIMARY BODY             -.96199045291582E-04    -.44302327021531E-03     .32719103870961E-04    .45452658230889E-03
PERTURBING BODIES         .95442466729866E-09    -.98045310781003E-09     .84933580226594E-10    .13739985598430E-08
THRUST                   -.15754807449474E-06     .11423209965053E-06     .30211596891750E-07    .19693426191559E-06
J2 + RAD. PRESSURE       -.35003824911134E-08    -.24893444599559E-07    -.19042586281668E-07    .31536588751501E-07
*******************************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------------

                                  ****              CONTROL PHASE CHANGE              ****

JULIAN DATE      -- 2444321.00000000        CONTROL PHASE      --    2                    PRIMARY BODY        --     EARTH
DAYS FROM LAUNCH--       1.00000000         PRESENT MASS   (KG)--  4997.119729520           FLUX            (E14)--  0.0000000000
DAYS FROM CUTOFF--       6.00000000         PRESENT PITCH (DEG)--   279.730701526           FLUX RATE  (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00723553976991          PRESENT YAW   (DEG)--    56.232701526           AVAILABLE POWER (KW)--  14.4250000000

   THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER    THRUST PHASE  THRUST PHASE
     DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW        OF           A4            A5
      (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
    3.0000000     1.0040825     279.7307015     .0071700    15.0000000    -6.7672985    6.0000     0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES           X                        Y                        Z                      MAGNITUDE
SUN     POSITION         -.14899831602808E+09    -.53045768156202E+07     .23656875687142E+04    .14909271182721E+09
        VELOCITY          .41765376896394E+01    -.28965677611814E+02    -.77025022428043E-01    .29265335799177E+02

EARTH   POSITION          .70832374200590E+04    -.27767904686300E+05     .23656875687142E+04    .28754569387997E+05
        VELOCITY          .36082688104452E+01    -.91319782756147E+00    -.77025022428043E-01    .37228297250271E+01

S/C ACCELERATIONS                  X                        Y                        Z                      MAGNITUDE
PRIMARY BODY             -.11875575504713E-03     .46554961969222E-03    -.39662515424468E-04    .48209178885580E-03
PERTURBING BODIES         .44788893567072E-09     .11378573050643E-08    -.94732712433150E-10    .12264982805489E-08
THRUST                    .10722592672799E-06     .22340965534262E-07     .16380852861038E-06    .19705266339022E-06
J2 + RAD. PRESSURE       -.49730120150273E-08     .28965500649637E-07     .20179556133724E-07    .35650323450704E-07
*******************************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------------

                                  ****              CONTROL PHASE CHANGE              ****

JULIAN DATE      -- 2444324.00000000        CONTROL PHASE      --    3                    PRIMARY BODY        --     EARTH
DAYS FROM LAUNCH--       4.00000000         PRESENT MASS   (KG)--  4988.443642125           FLUX            (E14)--  0.0000000000
DAYS FROM CUTOFF--       3.00000000         PRESENT PITCH (DEG)--   337.952000000           FLUX RATE  (E14/SEC)--  0.
```

ORIGINAL PAGE IS OF POOR QUALITY

MOTION (DEG/SEC)-- .00723540049519   PRESENT YAW (DEG)-- 56.000000000   AVAILABLE POWER (KW)-- 14.4250030000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0010000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14663091394261E+09	-.13000110516066E+08	-.72996706922002E+03	.14919836277043E+09
	VELOCITY	.71282728428085E+00	-.26374552176774E+02	-.28622707471778E+00	.26385735752502E+02
EARTH	POSITION	.27028114171127E+05	.11044187681468E+05	-.72996706922002E+03	.29206606942832E+05
	VELOCITY	-.13984909732758E+01	.34095391773447E+01	-.28622707471778E+00	.36963036052906E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.43243008159586E-03	-.17669893467296E-03	.11678939836739E-04	.46728437446513E-03
PERTURBING BODIES	.22497709718834E-08	-.14988203137367E-09	.29169092868506E-10	.22549467588475E-08
THRUST	.32231045891992E-07	.10510196844234E-06	.16298301793796E-06	.19659279800112E-06
J2 + RAD. PRESSURE	-.30799600294376E-07	-.16260268293049E-07	-.76435631459386E-08	.35657197882352E-07

JULIAN DATE	-- 2444327.00000000	CONTROL PHASE	-- 3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4979.802830694	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.093786815	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723540049519	PRESENT YAW (DEG)--	8.863548059	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790538699687E+09	-.20681742440894E+08	-.21342631735928E+04	.14934436038110E+09
	VELOCITY	.58226145431334E-01	-.28828613572460E+02	-.75974203753684E-01	.28828772482953E+02
EARTH	POSITION	.62817698716115E+04	.28861597415345E+05	-.21342631735928E+04	.29614312711584E+05
	VELOCITY	-.35865226385895E+01	.78113596995810E+00	-.75974203753684E-01	.36713880372842E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.96409652892494E-04	-.44295423831285E-03	.32755668538129E-04	.45450655906329E-03
PERTURBING BODIES	.95948027621692E-09	-.98052409083634E-09	.85034138524591E-10	.13745038006038E-08
THRUST	-.15752821127329E-06	.11422433538110E-06	.30341931142940E-07	.19693392020091E-06
J2 + RAD. PRESSURE	-.35106986595409E-08	-.24899074348814E-07	-.19031023694503E-07	.31535198927018E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444321.00000000	CONTROL PHASE	-- 2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG)--	4997.119729520	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	6.00000000	PRESENT PITCH (DEG)--	279.720701526	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723540049519	PRESENT YAW (DEG)--	56.242701526	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	1.0040825	279.7207015	.0071700	10.0000000	-6.7572985	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831602808E+09	-.53045768156202E+07	.23656875687142E+04	.14909271182721E+09
	VELOCITY	.41765376896394E+01	-.28965677611814E+02	-.77025022428043E-01	.29265335799177E+02
EARTH	POSITION	.70832374200590E+04	-.27767904686300E+05	.23656875687142E+04	.28754569387997E+05
	VELOCITY	.36082680104452E+01	-.91319782756147E+00	-.77025022428043E-01	.37228297250271E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875575504713E-03	.46554961969222E-03	-.39662515424468E-04	.48209176885560E-03
PERTURBING BODIES	.44788893567072E-09	.11378573050643E-08	-.94732712433150E-10	.12264982805489E-08
THRUST	.10720183278018E-06	.22316423969048E-07	.16382764241416E-06	.19705266339022E-06
J2 + RAD. PRESSURE	-.49730120150273E-08	.28965500649637E-07	.20179556133724E-07	.35650323450704E-07

ORIGINAL PAGE IS OF POOR QUALITY

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.443642124	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	337.952000000	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723541876279	PRESENT YAW (DEG)--	56.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863091415279E+09	-.13000110135360E+08	-.73000702765487E+03	.14919836294665E+09
	VELOCITY	.71276697910658E+00	-.26374572743653E+02	-.28621821683949E+00	.26385754585465E+02
EARTH	POSITION	.27027903984021E+05	.11044568388195E+05	-.73000702765487E+03	.29206557395752E+05
	VELOCITY	-.13985512784501E+01	.34095186104658E+01	-.28621821683949E+00	.36963067650315E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.43242891951330E-03	-.17670592501073E-03	.11679638583611E-04	.46728595990334E-03
PERTURBING BODIES	.22497583267298E-08	-.14989908484936E-09	.29170689482788E-10	.22549352969550E-08
THRUST	.32231046128579E-07	.10510196835266E-06	.16298301794902E-06	.19659279800113E-06
J2 + RAD. PRESSURE	-.30799444777887E-07	-.16260880906592E-07	-.76438484973754E-08	.35657404088566E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4979.802830694	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.093994874	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723541876279	PRESENT YAW (DEG)--	8.858509398	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790539026934E+09	-.20681741862156E+08	-.21342801767709E+04	.14934436354190E+09
	VELOCITY	.58125941803013E-01	-.28829016343688E+02	-.75938967320921E-01	.28829174956917E+02
EARTH	POSITION	.62784973991349E+04	.28862176152639E+05	-.21342801767709E+04	.29614183995678E+05
	VELOCITY	-.35866228422178E+01	.78073319873044E+00	-.75938967320921E-01	.36713995242518E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.96360684985578E-04	-.44296889644742E-03	.32756356610599E-04	.45451051003154E-03
PERTURBING BODIES	.95923649859008E-09	-.98059946833947E-09	.85034810572632E-10	.13743874623061E-08
THRUST	-.15753078475018E-06	.11422533047969E-06	.30324819183349E-07	.19693392020093E-06
J2 + RAD. PRESSURE	-.35087440045390E-08	-.24899207856449E-07	-.19031952247839E-07	.31535647174777E-07

ORIGINAL PAGE IS OF POOR QUALITY

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 1

TRAJECTORY STATE AT 7.00000 DAYS(J.D.= 2444327.00000)

	ESTIMATE	REFERENCE	DEVIATION	
X	.789460655429E+04	.562392733819E+04	.227067921610E+04	KM
Y	.285047562696E+05	.289890629713E+05	-.484306701679E+03	KM
Z	-.219656979027E+04	-.222454145189E+04	.279716616168E+02	KM
VX	-.353384324627E+01	-.360314241483E+01	.692991685580E-01	KM/SEC
VY	.977919574924E+00	.699154466145E+00	.278765108779E+00	KM/SEC
VZ	-.967035412004E-01	-.738662121910E-01	-.228373290094E-01	KM/SEC
S/C MASS	4979.80283	4979.83811	-.03528	KG

S/C ORBITAL ELEMENTS

	ESTIMATE	REFERENCE	DEVIATION	
A	.296906572672E+05	.296495963037E+05	.410609634878E+02	KM
E	.00203782	.00197557	.00006225	
I	4.50636596	4.45855352	.04781244	DEG
NODE	184.08199769	183.97618124	.10581645	DEG
APSIS	191.66969973	203.38768681	-11.71798708	DEG
M A	58.62410102	51.52277713	7.10132390	DEG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
RCA	.296301531865E+05	.295910216000E+05	.391315864746E+02	KM
A	.296906572672E+05	.296495963112E+05	.410609559531E+02	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE
Q = .781112634386E+02 FOR ITERATION NUMBER 1

PHI MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS

	X	Y	Z	VX	VY	VZ
X	-.212691287261E+01	.150131561689E+02	-.145731387222E+01	-.117851293647E+06	-.522017730052E+05	.324219650672E+04
Y	.186982473622E+01	-.643068140063E+01	.528325244060E+00	.545302811640E+05	.143034170251E+05	-.581819527906E+03
Z	-.217209108735E+00	.737776355688E+00	-.883023678196E+00	-.664863397816E+04	-.146291630064E+04	.426545758956E+04
VX	.279666449539E-04	.372154587674E-03	-.374873546644E-04	-.237233631880E+01	-.187815854192E+01	.122564294348E+00
VY	-.336024256022E-03	.186959390298E-02	-.186488238444E-03	-.144989300745E+02	-.587637192320E+01	.294774280620E+00
VZ	.294342276182E-04	-.162458702476E-03	-.515633172144E-04	.121741017510E+01	.409916865216E+00	-.801020168945E+00

THETA MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
X	-.162697344008E+07	-.924087349615E+07	-.925962338230E+07
Y	.359431626960E+06	.204454916066E+07	.204786508110E+07
Z	.648299349826E+05	.356990617153E+06	.356893196119E+06
VX	-.531227223331E+02	-.301830684711E+03	-.302404809210E+03
VY	-.198513975044E+03	-.112748700419E+04	-.112979471333E+04
VZ	.211778365758E+02	.118770354780E+03	.118972244668E+03

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
RCA	.121861216961E+01	.119561195956E+01	-.871545483824E-01	-.951750046061E+04	-.457223776175E+04	.307022594789E+03
A	.533482037135E+00	.192622334114E+01	-.148434316507E+03	-.156305267665E+05	.432543073199E+04	-.427728896087E+03

TARGET/CONTROL SENSITIVITY MATRIX(2 X 3)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
RCA	-.138808404050E+06	-.783389308207E+06	-.786187492979E+06
A	-.222619190577E+06	-.125446721477E+07	-.125916260009E+07

```
GUIDANCE MATRIX(  3 X  29 FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)
                       RCA                  A
THROTTLING      .406354090858E-02   -.253739454093E-02
PITCH ANGLE     -.173571828452E-02   .108341299398E-02
YAW   ANGLE     .101081424600E-02   -.631557323914E-03

ESTIMATED CONTROL CORRECTION FOR ITERATION   1 IN INTERNAL UNITS
                         OLD CONTROLS          UPDATES             NEW CONTROLS
         THROTTLING    .100406248290E+01  -.548249569603E-01   .949257525924E+00
         PITCH ANGLE   .488204722761E+01   .234354369216E-01   .490548266453E+01
         YAW   ANGLE  -.118111639844E+00  -.136224176181E-01  -.131734057462E+00
**********************************************************************************
----------------------------------------------------------------------------------

                       ****        CONTROL PHASE CHANGE        ****

JULIAN DATE       -- 2444321.00000000     CONTROL PHASE       --    2                PRIMARY BODY          --      EARTH
DAYS FROM LAUNCH--      1.00000000        PRESENT MASS   (KG)-- 4997.119729520       FLUX             (E14)--   0.0000000000
DAYS FROM CUTOFF--      6.00000000        PRESENT PITCH (DEG)--  281.063453152       FLUX RATE   (E14/SEC)--   0.
MOTION (DEG/SEC)--  .00723541876279       PRESENT YAW   (DEG)--   55.452194489       AVAILABLE POWER (KW)--  14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER    THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING    A0 = PITCH        A1            A2         A3 = YAW       OF           A4            A5
     (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS   (DEG,SEC)     (DEG,SEC)
   3.0000000     .9492575     281.0634532     .0071700    10.0000000    -7.5478055    6.0000     0.0000000    63.0700000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                      MAGNITUDE
SUN      POSITION       -.148998316028O8E+09     -.530457681562O2E+07      .236568756871 42E+04      .149092711827 21E+09
         VELOCITY        .417653768963 94E+01    -.289656776118 14E+02     -.770250224280 43E-01      .292653357991 77E+02

EARTH    POSITION        .708323742005 90E+04    -.277679046861 00E+05      .236568756871 42E+04      .287545693879 97E+05
         VELOCITY        .360826801044 52E+01    -.913197827561 47E+00     -.770250224280 43E-01      .372282972502 71E+01

S/C ACCELERATIONS                 X                        Y                        Z                      MAGNITUDE
PRIMARY BODY            -.118755755047 13E-03     .465549619692 22E-03     -.396625154244 68E-04      .482091788855 80E-03
PERTURBING BODIES        .447888935670 72E-09     .113785730506 43E-08     -.947327124331 50E-10      .122649828054 89E-08
THRUST                   .102697782159 99E-06     .239491521476 94E-07      .153439353848 06E-06      .186293184983 64E-06
J2 + RAD. PRESSURE      -.497301201502 73E-08     .289655006496 37E-07      .201795561337 24E-07      .356503234507 04E-07
**********************************************************************************
----------------------------------------------------------------------------------

                       ****        CONTROL PHASE CHANGE        ****

JULIAN DATE       -- 2444324.00000000     CONTROL PHASE       --    3                PRIMARY BODY          --      EARTH
DAYS FROM LAUNCH--      4.00000000        PRESENT MASS   (KG)-- 4988.917374239       FLUX             (E14)--   0.0000000000
DAYS FROM CUTOFF--      3.00000000        PRESENT PITCH (DEG)--  337.952000000       FLUX RATE   (E14/SEC)--   0.
MOTION (DEG/SEC)--  .00724476146398       PRESENT YAW   (DEG)--   56.000000000       AVAILABLE POWER (KW)--  14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER    THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING    A0 = PITCH        A1            A2         A3 = YAW       OF           A4            A5
     (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS   (DEG,SEC)     (DEG,SEC)
   6.0000000    1.0000000     337.9520000     .0071700    10.0000000    -7.0000000    6.0000     0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                        Y                        Z                      MAGNITUDE
SUN      POSITION       -.148631202881 39E+09    -.129994894828 23E+08     -.793087488251 83E+03      .149198596499 47E+09
         VELOCITY        .632564187857 51E+00    -.264069881612 50E+02     -.284192179657 91E+00      .264160921861 81E+02

EARTH    POSITION        .267391753851 35E+05     .116652209252 87E+05     -.793087488251 83E+03      .291837260691 08E+05
         VELOCITY       -.147875407469 92E+01     .337710319286 86E+01     -.284192179657 91E+00      .369760798134 44E+01

S/C ACCELERATIONS                 X                        Y                        Z                      MAGNITUDE
PRIMARY BODY            -.428814300542 55E-03    -.187074338669 85E-03      .127186890263 20E-04      .468017390263 55E-03
PERTURBING BODIES        .223340434777 52E-08    -.177139449387 94E-09      .316912020450 62E-10      .224064225111 41E-08
THRUST                   .322283701604 42E-07     .105091843201 78E-06      .162967559032 54E-06      .196574130159 01E-06
J2 + RAD. PRESSURE      -.303033742599 64E-07    -.170969451926 93E-07     -.804204840900 87E-08      .357109866718 11E-07
----------------------------------------------------------------------------------
```

ORIGINAL PAGE IS OF POOR QUALITY

```
JULIAN DATE        -- 2444327.00000000      CONTROL PHASE          --    3               PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        7.00000000        PRESENT MASS    (KG)--  4980.276562808       FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        0.00000000        PRESENT PITCH (DEG)--     46.191711711       FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--  .00724476146398         PRESENT YAW    (DEG)--     6.268135851       AVAILABLE POWER (KW)--    14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                          Y                          Z                          MAGNITUDE
SUN      POSITION       -.14799763021266E+09      -.20681389668662E+08      -.21811235637685E+04      .14934653257796E+09
         VELOCITY        .66537196713057E-02      -.29104732362071E+02      -.53828607423152E-01      .29104782900044E+02

EARTH    POSITION        .40385540786390E+04       .29218369646558E+05      -.21811235637685E+04      .29576685815849E+05
         VELOCITY       -.36380950643495E+01       .50501718034783E+00      -.53828607423152E-01      .36733738672599E+01

S/C ACCELERATIONS                 X                          Y                          Z                          MAGNITUDE
PRIMARY BODY            -.62218688116381E-04      -.45014344067444E-03       .33602780627649E-04      .45566372381292E-03
PERTURBING BODIES        .79172407451318E-09      -.10306924781099E-08       .86897376514697E-10      .13025763504076E-08
THRUST                  -.15865946719890E-06       .11463256423109E-06       .21497436189933E-07      .19691518752187E-06
J2 + RAD. PRESSURE      -.22143051238604E-08      -.24936955143444E-07      -.19368318726650E-07      .31652593089743E-07
*********************************************************************************************************************
---------------------------------------------------------------------------------------------------------------------

                            ****              CONTROL PHASE CHANGE              ****

JULIAN DATE        -- 2444321.00000000      CONTROL PHASE          --    2               PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        1.00000000        PRESENT MASS    (KG)--  4997.119729520       FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        6.00000000        PRESENT PITCH (DEG)--    281.063453152       FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--  .00724476146398         PRESENT YAW    (DEG)--     55.452194489      AVAILABLE POWER (KW)--    14.4250000000

   THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
     DURATION     THROTTLING    A0 = PITCH        A1            A2         A3 = YAW       OF            A4            A5
      (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS    (DEG,SEC)     (DEG,SEC)
     3.0000000     .9502575     281.0634532    .0071700     10.0000000   -7.5478055    6.0000      0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                          Y                          Z                          MAGNITUDE
SUN      POSITION       -.14899831602808E+09      -.53045768156202E+07       .23656875687142E+04      .14909271182721E+09
         VELOCITY        .41765376896394E+01      -.28965677611814E+02      -.77025022428043E-01      .29265335799177E+02

EARTH    POSITION        .70832374200590E+04      -.27767904686300E+05       .23656875687142E+04      .28754569387997E+05
         VELOCITY        .36082680104452E+01       .91319782756147E+00      -.77025022428043E-01      .37228297250271E+01

S/C ACCELERATIONS                 Y                          Y                          Z                          MAGNITUDE
PRIMARY BODY            -.11875575604713E-03       .46554961969222E-03      -.39662515424468E-04      .48209178885580E-03
PERTURBING BODIES        .44788893567072E-09       .11378573050643E-08      -.94732712433150E-10      .12264982805489E-08
THRUST                   .10300618033367E-06       .23974381499575E-07       .15360099528851E-06      .18648943645376E-06
J2 + RAD. PRESSURE      -.49730120150273E-08       .28965500649637E-07       .20179556133724E-07      .35650323450704E-07
*********************************************************************************************************************
---------------------------------------------------------------------------------------------------------------------

                            ****              CONTROL PHASE CHANGE              ****

JULIAN DATE        -- 2444324.00000000      CONTROL PHASE          --    3               PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        4.00000000        PRESENT MASS    (KG)--  4988.908733428       FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        3.00000000        PRESENT PITCH (DEG)--    337.952000000       FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--  .00724423361703         PRESENT YAW    (DEG)--     56.000000000      AVAILABLE POWER (KW)--    14.4250000000

   THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
     DURATION     THROTTLING    A0 = PITCH        A1            A2         A3 = YAW       OF            A4            A5
      (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS    (DEG,SEC)     (DEG,SEC)
     6.0000000    1.0000000     337.9520000    .0071700     10.0000000   -7.0000000    6.0000      0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                          Y                          Z                          MAGNITUDE
SUN      POSITION       -.14863119272066E+09      -.12999509298496E+08      -.79060127396438E+03      .14919858810389E+09
         VELOCITY        .63524392068466E+00      -.26405946877304E+02      -.28472233621580E+00      .26415121228076E+02

EARTH    POSITION        .26749336117465E+05       .11645405251425E+05      -.79060127396438E+03      .29185056048762E+05
         VELOCITY       -.14760743368720E+01       .33781445268143E+01      -.28472233621580E+00      .36975292697635E+01

S/C ACCELERATIONS                 X                          Y                          Z                          MAGNITUDE
PRIMARY BODY            -.42891860396081E-03      -.18673102543796E-03       .12677084516391E-04      .46797473559652E-03
PERTURBING BODIES        .22340009497458E-08      -.17625993895782E-09       .31591860054634E-10      .22411661819616E-08
THRUST                   .32228414157204E-07       .10509202991326E-06       .16296784060548E-06      .19657447062625E-06
J2 + RAD. PRESSURE      -.30316819679413E-07      -.17068896360120E-07      -.80299747851226E-08      .35706263784892E-07
```

ORIGINAL PAGE IS OF POOR QUALITY

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4980.267921997	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.186654750	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724423361703	PRESENT YAW (DEG)--	6.415162880	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790752441523E+09	-.20681398107122E+08	-.21823313313673E+04	.14934642952233E+09
	VELOCITY	.86758113941272E-02	-.29091693268487E+02	-.55145426910963E-01	.29091746828191E+02
EARTH	POSITION	.41443515125553E+04	.29205931187111E+05	-.21823313313673E+04	.29579125004058E+05
	VELOCITY	-.36360729726267E+01	.51805627393140E+00	-.55145426910963E-01	.36732870433526E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.63832828173754E-04	-.44984050736851E-03	.33613070819728E-04	.45558857596756E-03
PERTURBING BODIES	.79970777890749E-09	-.10284912137741E-08	.86945674747474E-10	.13057129312421E-08
THRUST	-.15860441382777E-06	.11461404501064E-06	.21999687033408E-07	.19691552917157E-06
J2 + RAD. PRESSURE	-.22750100411199E-08	-.24939856233883E-07	-.19344821112543E-07	.31644813216864E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444321.00030000	CONTROL PHASE --	2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG)--	4997.119729520	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	6.00000000	PRESENT PITCH (DEG)--	281.073453152	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724423361703	PRESENT YAW (DEG)--	55.452194489	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	.9492575	281.0734532	.0071700	10.0000000	-7.5478055	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831602808E+09	-.53045768156202E+07	.23656875687142E+04	.14909271182721E+09
	VELOCITY	.41765376896394E+01	-.28965677611814E+02	-.77025022428043E-01	.29265335799177E+02
EARTH	POSITION	.70832374200590E+04	-.27767904686300E+05	.23656875687142E+04	.28754569387997E+05
	VELOCITY	.36082680104452E+01	.91319782756147E+00	-.77025022428043E-01	.37228297750271E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875575504713E-03	.46554961969222E-03	-.39662515424468E-04	.48209178885580E-03
PERTURBING BODIES	.44788893567072E-09	.11378573050643E-08	-.94732712433150E-10	.12264982805489E-08
THRUST	.10289360069237E-06	.23967110409090E-07	.15343935390423E-06	.18629318498364E-06
J2 + RAD. PRESSURE	-.49730120150273E-08	.28965508649637E-07	.20179556133724E-07	.35650323450704E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.917374239	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	337.952000000	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724444122004	PRESENT YAW (DEG)--	56.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863119856778E+09	-.12999497254500E+08	-.79184237604293E+03	.14919859287939E+09
	VELOCITY	.63366581367195E+00	-.26406598034239E+02	-.28465365676938E+00	.26415733565616E+02
EARTH	POSITION	.26743489002664E+05	.11657449248343E+05	-.79184237604293E+03	.29184539423500E+05
	VELOCITY	-.14776524438848E+01	.33774933198797E+01	-.28465365676938E+00	.36975594079152E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.42884762060478E-03	-.18693407475647E-03	.12697659562154E-04	.46799130393822E-03
PERTURBING BODIES	.22336642960695E-08	-.17679108770985E-09	.31641450565525E-10	.22408731462586E-08
THRUST	.32227836579717AE-07	-.10509184507384E-06	.16296755868820E-06	.19657413015902E-06
J2 + RAD. PRESSURE	-.30307187807537E-07	-.17085197718991E-07	-.80377920089171E-08	.35707642239120E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4980.276562808	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.188650309	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724444122004	PRESENT YAW (DEG)--	6.357346007	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790757235577E+09	-.20681392339329E+08	-.21829850981313E+04	.14934647620228E+09
	VELOCITY	.77728218218738E-02	-.29097606603178E+02	-.54655621375367E-01	.29097658972622E+02
EARTH	POSITION	.40964109643789E+04	.29211698980229E+05	-.21829850981313E+04	.29578190682313E+05
	VELOCITY	-.36369759621990E+01	.51214293924022E+00	-.54655621375367E-01	.36732644577779E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.63100409503351E-04	-.44997198376079E-03	.33626326760084E-04	.45561735886650E-03
PERTURBING BODIES	.79609223223331E-09	-.10294936226082E-08	.86971639741035E-10	.13042944557624E-08
THRUST	-.15862603285874E-06	.11462128050939E-06	.21802174906678E-07	.19691518752188E-06
J2 + RAD. PRESSURE	-.22480007730928E-08	-.24941059928232E-07	-.19351696984227E-07	.31648035547073E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444321.00000000	CONTROL PHASE --	2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG)--	4997.119729520	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	6.00000000	PRESENT PITCH (DEG)--	281.063453152	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724444122004	PRESENT YAW (DEG)--	55.462194489	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	.9492575	281.9634532	.0071700	10.0000000	-7.5378055	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831602808E+09	-.53045768156202E+07	.23656875687142E+04	.14909271182721E+09
	VELOCITY	.41765376896394E+01	-.28965677611814E+02	-.77025022428043E-01	.29265335799177E+02
EARTH	POSITION	.70832374200590E+04	-.27767904686300E+05	.23656875687142E+04	.28754569387997E+05
	VELOCITY	.36082680104452E+01	.91319782756147E+00	-.77025022428043E-01	.37228297250271E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875575584713E-03	.46554961969222E-03	-.39662515424468E-04	.48209178855580E-03
PERTURBING BODIES	.44788893567072E-09	.11378573059643E-08	-.94732712433150E-10	.12264982805489E-08
THRUST	.10287169757129E-06	.23943080858168E-07	.15345779057829E-06	.18629318498364E-06
J2 + RAD. PRESSURE	-.49730128150273E-08	.28965500649637E-07	.20179556133724E-07	.35650323450704E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.917374239	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	337.952000000	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724444536269	PRESENT YAW (DEG)--	56.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863119858390E+09	-.12999497256512E+08	-.79182580547732E+03	.14919859289563E+09
	VELOCITY	.63365897459670E+00	-.26406600409438E+02	-.28466354929433E+00	.26415735882540E+02
EARTH	POSITION	.26743472880764E+05	.11657447236399E+05	-.79182580547732E+03	.29184523396824E+05
	VELOCITY	-.14776592829600E+01	.33774909446802E+01	-.28466354929433E+00	.36975607329984E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.42884806858532E-03	-.18693435045831E-03	.12697414761686E-04	.46799181793302E-03
PERTURBING BODIES	.22336630013782E-08	-.17679117689394E-09	.31640788407338E-10	.22408718534187E-08
THRUST	.32228365814781E-07	.10509184507564E-06	.16296755868361E-06	.19657413015900E-06
J2 + RAD. PRESSURE	-.30307227448524E-07	-.17085245587667E-07	-.80378665105317E-08	.35707715559086E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4980.276562808	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.188690042	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724444536269	PRESENT YAW (DEG)--	6.356192170	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790757308451E+09	-.20681392306964E+08	-.21830513042232E+04	.14934647691951E+09
	VELOCITY	.77530133502819E-02	-.29097698079420E+02	-.54655640623415E-01	.29097750443451E+02
EARTH	POSITION	.40956822293107E+04	.29211731345404E+05	-.21830513042232E+04	.29578126616073E+05
	VELOCITY	-.36369957706706E+01	.51205146299866E+00	-.54655640623415E-01	.36732713180061E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.63089594148295E-04	-.44997540623672E-03	.33627565098361E-04	.45561933260359E-03
PERTURBING BODIES	.79603636629682E-09	-.10295067832203E-08	.86974276184559E-10	.13042769219643E-08
THRUST	-.15862646607051E-06	.11462142780577E-06	.21798233690394E-07	.19691518752188E-06
J2 + RAD. PRESSURE	-.22476393778283E-08	-.24941404547025E-07	-.19351760406979E-07	.31648320246109E-07

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 2

TRAJECTORY STATE AT 7.00000 DAYS(J.D.= 2444327.00000)

	ESTIMATE	REFERENCE	DEVIATION	
X	.403855407864E+04	.562392733819E+04	-.158537325955E+04	KM
Y	.292183696466E+05	.289890629713E+05	.229306675258E+03	KM
Z	-.218112356377E+04	-.222454145189E+04	.434178881216E+02	KM
VX	-.363809506435E+01	-.360314241483E+01	-.349526495195E-01	KM/SEC
VY	.505017180348E+00	.699154466145E+00	-.194137285797E+00	KM/SEC
VZ	-.538286074232E-01	-.738662121913E-01	.200376047678E-01	KM/SEC
S/C MASS	4980.27656	4979.83811	.43846	KG

S/C ORBITAL ELEMENTS

	ESTIMATE	REFERENCE	DEVIATION	
A	.296132772170E+05	.296495963337E+05	-.363190867048E+02	KM
E	.00207079	.00197557	.00009523	
I	4.31057216	4.45855352	-.14798136	DEG
NODE	183.30845925	183.97618124	-.66772199	DEG
APSIS	205.39143443	203.38768681	2.00374761	DEG
M A	53.27090975	51.52277713	1.74813263	DEG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
RCA	.295519542193E+05	.295910216000E+05	-.390673806666E+02	KM
A	.296132772170E+05	.296495963112E+05	-.363190942393E+02	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE
Q = .781112634386E+02 FOR ITERATION NUMBER 1
Q = .742411753496E+02 FOR ITERATION NUMBER 2

PHI MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS

	X	Y	Z	VX	VY	VZ
X	-.207361725451E+01	.153521591313E+02	-.141971277266E+01	-.119720749899E+06	-.540124387875E+05	.338348697199E+04
Y	.152375122988E+01	-.444173301518E+01	-.327860785486E+00	.391417754663E+05	.794263683248E+04	-.283111450375E+03
Z	-.169994787727E+00	.494844351106E+00	-.922001742904E+00	-.478755238260E+04	-.848584987511E+03	.336304723808E+04
VX	.745417471625E-04	.104504450112E-03	-.107452709927E-04	-.231298678345E+00	-.101911925466E+01	.679476763745E-01
VY	-.305426548093E-03	.186722434955E-02	-.177146740036E-03	-.143233183928E+02	-.610773454158E+01	.308940520145E+00
VZ	.249032409012E-04	-.150486842255E-03	-.393073675782E-04	.112235724592E+01	.393273110963E+00	-.863381943431E+00

THETA MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
X	.105797433916E+06	.331495536867E+06	.327320192488E+06
Y	-.124384594477E+05	-.382201027217E+05	-.380346639269E+05
Z	-.120776759883E+04	-.106658062407E+05	-.110451392051E+05
VX	.202209172282E+01	.641198300716E+01	.629848882507E+01
VY	.130390935836E+02	.408275910362E+02	.403034707795E+02
VZ	-.131681948781E+01	-.473844090603E+01	-.473855118923E+01

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
RCA	.987464228958E+00	.127649286471E+01	-.917610171018E-01	-.753327707370E+04	-.548681228142E+04	.381694604235E+03
A	.273766509490E+00	.198066211713E+01	-.147854546667E+00	-.160078757079E+05	.222211069072E+04	-.236849612265E+03

TARGET/CONTROL SENSITIVITY MATRIX(2 X 3)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
RCA	.142362788699E+04	.539916179182E+04	.527845184458E+04
A	.142228716908E+04	.583175180184E+04	.576423369993E+04

ORIGINAL PAGE IS OF POOR QUALITY

```
GUIDANCE MATRIX(  3 X  2) FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)
                         RCA                    A
THROTTLING       .774996599387E-02  -.713394047056E-02
PITCH ANGLE      .109065286242E-02  -.922649751049E-03
YAW   ANGLE     -.301635390748E-02   .286781282217E-02

ESTIMATED CONTROL CORRECTION FOR ITERATION   2 IN INTERNAL UNITS
                          OLD CONTROLS        UPDATES            NEW CONTROLS
          THROTTLING     .949257525924E+00   .436726118721E-01   .992930137796E+00
          PITCH ANGLE    .490548266453E+01   .909914729297E-02   .491458181182E+01
          YAW   ANGLE   -.131734057462E+00  -.136846821798E-01  -.145418739642E+00
********************************************************************************************
--------------------------------------------------------------------------------------------

                    ****          CONTROL PHASE CHANGE          ****

JULIAN DATE     -- 2444321.00000000    CONTROL PHASE      --    2             PRIMARY BODY        --     EARTH
DAYS FROM LAUNCH--       1.00000000    PRESENT MASS   (KG)-- 4997.119729520   FLUX           (E14)--  0.0000000000
DAYS FROM CUTOFF--       6.00000000    PRESENT PITCH (DEG)--  281.584795889   FLUX RATE  (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00724444536269     PRESENT YAW   (DEG)--   54.668119956   AVAILABLE POWER (KW)-- 14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
    DURATION    THROTTLING    A0 = PITCH        A1            A2        A3 = YAW       OF            A4            A5
     (DAYS)                     (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
    3.0000000     .9929301    281.5847959     .0071700    10.0000000    -8.3318800    6.0000      0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES           X                        Y                        Z                       MAGNITUDE
SUN     POSITION        -.148998316028O8E+09     -.530457681562O2E+07      .236568756871 42E+04      .149092711827 21E+09
        VELOCITY         .417653768963 94E+01    -.289656776118 14E+02    -.770250224280 43E-01      .292653357991 77E+02

EARTH   POSITION         .708323742005 90E+04    -.277679346863 00E+05     .236568756871 42E+04      .287545693879 97E+05
        VELOCITY         .360826801044 52E+01     .913197827561 47E+00    -.770250224280 43E-01      .372282972502 71E+01

S/C ACCELERATIONS                  X                        Y                        Z                       MAGNITUDE
PRIMARY BODY            -.118755755047 13E-03     .465549619692 22E-03    -.396625154244 68E-04      .482091788855 80E-03
PERTURBING BODIES        .447888935670 72E-09     .113785730506 43E-08    -.947327124331 50E-10      .122649828054 89E-08
THRUST                   .109523870150 95E-06     .265441640713 09E-07     .158971404445 64E-06      .194863992267 46E-06
J2 + RAD. PRESSURE      -.497301201502 73E-08     .289655006496 37E-07     .201795561337 24E-07      .356503234507 04E-07
********************************************************************************************
--------------------------------------------------------------------------------------------

                    ****          CONTROL PHASE CHANGE          ****

JULIAN DATE     -- 2444324.00000000    CONTROL PHASE      --    3             PRIMARY BODY        --     EARTH
DAYS FROM LAUNCH--       4.00000000    PRESENT MASS   (KG)-- 4988.540097435   FLUX           (E14)--  0.0000000000
DAYS FROM CUTOFF--       3.00000000    PRESENT PITCH (DEG)--  337.952000000   FLUX RATE  (E14/SEC)--  0.
MOTION (DEG/SEC)-- .00723503107552     PRESENT YAW   (DEG)--   56.000000000   AVAILABLE POWER (KW)-- 14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER     THRUST PHASE  THRUST PHASE
    DURATION    THROTTLING    A0 = PITCH        A1            A2        A3 = YAW       OF            A4            A5
     (DAYS)                     (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)    THRUSTERS   (DEG,SEC)     (DEG,SEC)
    6.0000000    1.0000000    337.9520000     .0071700    10.0000000    -7.0000000    6.0000      0.0000000    63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES           X                        Y                        Z                       MAGNITUDE
SUN     POSITION        -.148630946321 93E+09    -.130000274391 78E+08    -.739000549514 46E+03      .149198387787 93E+09
        VELOCITY         .703592473426 82E+00    -.263785573239 18E+02    -.286488244051 50E+00      .263894942045 86E+02

EARTH   POSITION         .269957348497 95E+05     .111272645695 07E+05    -.739000549514 46E+03      .292084206812 42E+05
        VELOCITY        -.140772578412 99E+01     .340553403020 08E+01    -.286488244051 50E+00      .369613709541 99E+01

S/C ACCELERATIONS                  X                        Y                        Z                       MAGNITUDE
PRIMARY BODY            -.431831580529 31E-03    -.177994941525 16E-03     .118212664735 55E-04      .467226342891 77E-03
PERTURBING BODIES        .224807718153 30E-08    -.153463054598 68E-09     .295300510449 31E-10      .225350259533 26E-08
THRUST                   .322304737305 14E-07     .105099918804 52E-06     .162979872038 46E-06      .196589003517 1E-06
J2 + RAD. PRESSURE      -.307171907375 04E-07    -.163594663759 73E-07    -.768822302751 45E-08      .356410819172 43E-07
--------------------------------------------------------------------------------------------
```

```
JULIAN DATE     -- 2444327.00000000      CONTROL PHASE    --    1              PRIMARY BODY          --     EARTH
DAYS FROM LAUNCH--        7.00000000     PRESENT MASS   (KG)--  4979.899196005    FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        0.00000000     PRESENT PITCH (DEG)--    46.089565143    FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723503107552     PRESENT YAW    (DEG)--     8.965419945    AVAILABLE POWER (KW)--  14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES         X                        Y                         Z                      MAGNITUDE
SUN    POSITION          -.14790543359187E+09   -.20681723417008E+08    -.21408285559994E+04     .14934440389275E+09
       VELOCITY           .58141131595676E-01   -.28834241044238E+02    -.75581878517800E-01     .28834398721124E+02

EARTH  POSITION           .62351748697747E+04    .28860621300464E+05    -.21408285559994E+04     .29623484590163E+05
       VELOCITY          -.35866076524252E+01    .77550849818035E+00    -.75581878517800E-01     .36702698134531E+01

S/C ACCELERATIONS                X                        Y                         Z                      MAGNITUDE
PRIMARY BODY             -.95605676788472E-04   -.44283462824550E-03     .32825921848091E-04     .45422515843213E-03
PERTURBING BODIES         .95618602147050E-09   -.98200227543056E-09     .85295644475817E-10     .13732791134991E-08
THRUST                   -.15747281002874E-06    .11420190329746E-06     .30687250737745E-07     .19693010936104E-06
J2 + RAD. PRESSURE       -.34803657169941E-08   -.24877677635932E-07    -.19000814516737E-07     .31496710024712E-07
***************************************************************************************************************************
---------------------------------------------------------------------------------------------------------------------------

                                   ****          CONTROL PHASE CHANGE          ****

JULIAN DATE     -- 2444321.00000000      CONTROL PHASE    --    2              PRIMARY BODY          --     EARTH
DAYS FROM LAUNCH--        1.00000000     PRESENT MASS   (KG)--  4997.119729520    FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        6.00000000     PRESENT PITCH (DEG)--   281.584795889    FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723503107552     PRESENT YAW    (DEG)--    54.668119956    AVAILABLE POWER (KW)--  14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER   THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW       OF          A4             A5
     (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS  (DEG,SEC)      (DEG,SEC)
    3.0000000     .9939301    281.5847959     .0071700     10.0000000    -8.3318800   6.0000     0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES         X                        Y                         Z                      MAGNITUDE
SUN    POSITION          -.14899831602808E+09   -.53045768156202E+07     .23656875687142E+04     .14909271182721E+09
       VELOCITY           .41765376896394E+01   -.28965677611814E+02    -.77025022428043E-01     .29265335799177E+02

EARTH  POSITION           .70832374200590E+04   -.27767904686300E+05     .23656875687142E+04     .28754569387997E+05
       VELOCITY           .36082680104452E+01    .91319782756147E+00    -.77025022428043E-01     .37228297250271E+01

S/C ACCELERATIONS                X                        Y                         Z                      MAGNITUDE
PRIMARY BODY             -.11875575504713E-03    .46554961969222E-03    -.39662515424468E-04     .48209178885580E-03
PERTURBING BODIES         .44788893567072E-09    .11378573050643E-08    -.94732712433150E-10     .12264982805489E-08
THRUST                    .10963417385308E-06    .26570897235165E-07     .15913150775845E-06     .19506025073758E-06
J2 + RAD. PRESSURE       -.49730120150273E-08    .28965500649637E-07     .20179556133724E-07     .35659323450704E-07
***************************************************************************************************************************
---------------------------------------------------------------------------------------------------------------------------

                                   ****          CONTROL PHASE CHANGE          ****

JULIAN DATE     -- 2444324.00000000      CONTROL PHASE    --    1              PRIMARY BODY          --     EARTH
DAYS FROM LAUNCH--        4.00000000     PRESENT MASS   (KG)--  4998.531366624    FLUX              (E14)--    0.0000000000
DAYS FROM CUTOFF--        3.00000000     PRESENT PITCH (DEG)--   337.952000000    FLUX RATE    (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723516983078     PRESENT YAW    (DEG)--    56.000000000    AVAILABLE POWER (KW)--  14.4250000000

  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  THRUST PHASE  NUMBER   THRUST PHASE  THRUST PHASE
    DURATION     THROTTLING    A0 = PITCH        A1            A2        A3 = YAW       OF          A4             A5
     (DAYS)                      (DEG)       (DEG,SEC)     (DEG,SEC)     (DEG,SEC)   THRUSTERS  (DEG,SEC)      (DEG,SEC)
    6.0000000    1.0000000    337.9520000     .0071700     10.0000000    -7.0000000   6.0000     0.0000000     63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES         X                        Y                         Z                      MAGNITUDE
SUN    POSITION          -.14863094513970E+09   -.13000031492132E+08    -.73916299165914E+03     .14919838696334E+09
       VELOCITY           .70402231663222E+00   -.26378304482258E+02    -.28601869378152E+00     .26389247838357E+02

EARTH  POSITION           .26996917081211E+05    .11123211616059E+05    -.73916299165914E+03     .29207973748168E+05
       VELOCITY          -.14072959409245E+01    .34057868718605E+01    -.28601869378152E+00     .36961700143625E+01

S/C ACCELERATIONS                X                        Y                         Z                      MAGNITUDE
PRIMARY BODY             -.43187031635134E-03   -.17793827736032E-03     .11824407730807E-04     .46724064176134E-03
PERTURBING BODIES         .22481284147749E-08   -.15329248773466E-09     .29516542632436E-10     .22535421814259E-08
THRUST                    .32270526464545E-07    .10510010173040E-06     .16298015438659E-06     .19658934087046E-06
J2 + RAD. PRESSURE       -.30723392339735E-07   -.16355400741885E-07    -.76845499036600E-08     .35643769126045E-07
---------------------------------------------------------------------------------------------------------------------------
```

JULIAN DATE -- 2444327.00000000	CONTROL PHASE -- 3	PRIMARY BODY -- EARTH	
DAYS FROM LAUNCH-- 7.00000000	PRESENT MASS (KG)-- 4979.890555193	FLUX (E14)-- 0.0000000000	
DAYS FROM CUTOFF-- 0.00000000	PRESENT PITCH (DEG)-- 46.091153986	FLUX RATE (E14/SEC)-- 0.	
MOTION (DEG/SEC)-- .00723516983078	PRESENT YAW (DEG)-- 8.927161737	AVAILABLE POWER (KW)-- 14.4250000000	

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14799544754093E+09	-.20681720945112E+08	-.21381399542842E+04	.14934441736505E+09
	VELOCITY	.57702466594553E-01	-.28835922720675E+02	-.75136429999277E-01	.28836078343119E+02
EARTH	POSITION	.62212258127455E+04	.28883093196902E+05	-.21381399542842E+04	.29622767691392E+05
	VELOCITY	-.35870463174263E+01	.77382682174357E+00	-.75136429999277E-01	.36703344148080E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.95398717883458E-04	-.44290468509403E-03	.32787077086356E-04	.45424714404816E-03
PERTURBING BODIES	.95514699626142E-09	-.98232376196869E-09	.85188501205963E-10	.13727792388193E-08
THRUST	-.15749279857497E-06	.11420974429592E-06	.30557409258182E-07	.19693045106251E-06
J2 + RAD. PRESSURE	-.34701278008939E-08	-.24871902744420E-07	-.19012918015890E-07	.31498323431718E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444321.00000000	CONTROL PHASE -- 2	PRIMARY BODY -- EARTH
DAYS FROM LAUNCH-- 1.00000000	PRESENT MASS (KG)-- 4997.119729520	FLUX (E14)-- 0.0000000000
DAYS FROM CUTOFF-- 6.00000000	PRESENT PITCH (DEG)-- 281.594795889	FLUX RATE (E14/SEC)-- 0.
MOTION (DEG/SEC)-- .00723516983078	PRESENT YAW (DEG)-- 54.668119956	AVAILABLE POWER (KW)-- 14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	.9929101	281.5947959	.0071700	10.0000000	-8.3318800	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831602808E+09	-.53045768156202E+07	.23656875687142E+04	.14909271182721E+09
	VELOCITY	.41765376896394E+01	-.28965677611814E+02	-.77025022428043E-01	.29265335799177E+02
EARTH	POSITION	.70832374200590E+04	-.27767934686300E+05	.23656875687142E+04	.28754569387997E+05
	VELOCITY	.36082680104452E+01	.91319782756147E+00	-.77025022428043E-01	.37228297250271E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875575504713E-03	.46554961969222E-03	-.39662515424468E-04	.48209178885580E-03
PERTURBING BODIES	.44788893567072E-09	.11878573950643E-08	-.94732712433150E-10	.12264982805489E-08
THRUST	.10951923566793E-06	.26563278748385E-07	.15897140450834E-06	.19486399926746E-06
J2 + RAD. PRESSURE	-.49730120150273E-08	.28965500649637E-07	.20179556133724E-07	.35650323450704E-07

```
****          CONTROL PHASE CHANGE          ****

JULIAN DATE       -- 2444324.00000000     CONTROL PHASE        --   3                  PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        4.00000000     PRESENT MASS   (KG)--  4988.540007435        FLUX             (E14)--    0.0000000000
DAYS FROM CUTOFF--      - 3.00000000     PRESENT PITCH (DEG)--   337.952000000        FLUX RATE  (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723535498040     PRESENT YAW   (DEG)--    56.000000000        AVAILABLE POWER (KW)--    14.4250000000

   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   NUMBER     THRUST PHASE   THRUST PHASE
     DURATION      THROTTLING     A0 = PITCH        A1             A2          A3 = YAW        OF            A4             A5
      (DAYS)                        (DEG)        (DEG,SEC)      (DEG,SEC)      (DEG,SEC)    THRUSTERS    (DEG,SEC)      (DEG,SEC)
    6.0000000      1.0000000     337.9520000     .0071700      10.0000000     -7.0000000     6.0000     0.0000000      63.0000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                       Y                       Z                        MAGNITUDE
SUN      POSITION        -.14863095045632E+09    -.13900019874854E+08    -.74032144498089E+03      .14919839124750E+09
         VELOCITY         .70250958073456E+00    -.26378898717243E+02    -.28598872162756E+00      .26389801191654E+02

EARTH    POSITION         .26991600458299E+05     .11134828893559E+05    -.74032144498089E+03      .29207515909971E+05
         VELOCITY        -.14088085768221E+01     .34051926368750E+01    -.28598872162756E+00      .36961964300147E+01

S/C ACCELERATIONS                 X                       Y                       Z                        MAGNITUDE
PRIMARY BODY             -.43180557169081E-03    -.17813249582925E-03     .11843496471387E-04      .46725529020253E-03
PERTURBING BODIES         .22478292386912E-08    -.15380145705718E-09     .29582831235422E-10      .22532790147720E-08
THRUST                    .32230477855154E-07     .10509991697312E-06     .16297987240379E-06      .19658900035171E-06
J2 + RAD. PRESSURE       -.30714428454076E-07    -.16371220952571E-07    -.76920779807667E-08      .35644930270277E-07
---------------------------------------------------------------------------------------------------------------------------

JULIAN DATE       -- 2444327.00000000     CONTROL PHASE        --   3                  PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        7.00000000     PRESENT MASS   (KG)--  4979.899196005        FLUX             (E14)--    0.0000000000
DAYS FROM CUTOFF--        0.00000000     PRESENT PITCH (DEG)--    46.093268139        FLUX RATE  (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723535498040     PRESENT YAW   (DEG)--     8.876101703        AVAILABLE POWER (KW)--    14.4250000000

======= ECLIPTIC =======
BODY RELATIVE S/C STATES          X                       Y                       Z                        MAGNITUDE
SUN      POSITION        -.14790549067008E+09    -.20681712593857E+08    -.21391944911892E+04      .14934445892215E+09
         VELOCITY         .56505671539327E-01    -.28841221836714E+02    -.74720237054270E-01      .28841373979741E+02

EARTH    POSITION         .61780966576622E+04     .28891444451931E+05    -.21391944911892E+04      .29621961344610E+05
         VELOCITY        -.35882431124815E+01     .76852770570494E+00    -.74720237054270E-01      .36703823482755E+01

S/C ACCELERATIONS                 X                       Y                       Z                        MAGNITUDE
PRIMARY BODY             -.94745095313352E-04    -.44306892721461E-03     .32805926678106E-04      .45427187473390E-03
PERTURBING BODIES         .95194602766484E-09    -.98334436906805E-09     .85230445275363E-10      .13712883054145E-08
THRUST                   -.15751871095387E-06     .11421969164207E-06     .30383971326534E-07      .19693010936104E-06
J2 + RAD. PRESSURE       -.34445118269042E-08    -.24872631974148E-07    -.19020613660152E-07      .31500733754245E-07
***************************************************************************************************************************
---------------------------------------------------------------------------------------------------------------------------

****          CONTROL PHASE CHANGE          ****

JULIAN DATE       -- 2444321.00000000     CONTROL PHASE        --   2                  PRIMARY BODY           --    EARTH
DAYS FROM LAUNCH--        1.00000000     PRESENT MASS   (KG)--  4997.119729520        FLUX             (E14)--    0.0000000000
DAYS FROM CUTOFF--        6.00000000     PRESENT PITCH (DEG)--   281.584795889        FLUX RATE  (E14/SEC)--    0.
MOTION (DEG/SEC)--   .00723535498040     PRESENT YAW   (DEG)--    54.678119956        AVAILABLE POWER (KW)--    14.4250000000

   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   NUMBER     THRUST PHASE   THRUST PHASE
     DURATION      THROTTLING     A0 = PITCH        A1             A2          A3 = YAW        OF            A4             A5
      (DAYS)                        (DEG)        (DEG,SEC)      (DEG,SEC)      (DEG,SEC)    THRUSTERS    (DEG,SEC)      (DEG,SEC)
    3.0000000       .9929301     281.5847959     .0071700      10.0000000     -8.3218800     6.0000     0.0000000      63.0000000
```

ORIGINAL PAGE IS OF POOR QUALITY

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899831602808E+09	-.53045768156202E+07	.23656875687142E+04	.14909271182721E+09
	VELOCITY	.41765376896394E+01	-.28965677611814E+02	-.77025022428043E-01	.29265335799177E+02
EARTH	POSITION	.70832374200590E+04	-.27767904686300E+05	.23656875687142E+04	.28754569387997E+05
	VELOCITY	.36082680104452E+01	.91319782756147E+00	-.77025022428043E-01	.37228297250271E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11875575504713E-03	.46554961969222E-03	-.39662515424468E-04	.48209178885580E-03
PERTURBING BODIES	.44788893567072E-09	.11378573050643E-08	-.94732712433150E-10	.12264982805489E-08
THRUST	.10949690342370E-06	.26537628232596E-07	.15899107094084E-06	.19486399926746E-06
J2 + RAD. PRESSURE	-.49730120150273E-08	.28965500649637E-07	.20179556133724E-07	.35650323450704E-07

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.540007435	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	337.952000000	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723535913722	PRESENT YAW (DEG)--	56.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000300	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863095045196E+09	-.13000019914136E+08	-.74029912559522E+03	.14919839124658E+09
	VELOCITY	.70250749465139E+00	-.26378899577385E+02	-.28599787402996E+00	.26389802092432E+02
EARTH	POSITION	.26991604818192E+05	.11134789611494E+05	-.74029912559522E+03	.29207504397827E+05
	VELOCITY	-.14088107629053E+01	.34051917767336E+01	-.28599787402996E+00	.36961971789884E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.43180615282846E-03	-.17813207803580E-03	.11843153414792E-04	.46725565854014E-03
PERTURBING BODIES	.22478291744221E-08	-.15379987725104E-09	.29581939365790E-10	.22532788311516E-08
THRUST	.32230477851607E-07	.18509991698377E-06	.16297987239762E-06	.19658900035170E-06
J2 + RAD. PRESSURE	-.30714484632842E-07	-.16371209459889E-07	-.76921298302443E-08	.35644984594834E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4979.899196005	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.093315526	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723535913722	PRESENT YAW (DEG)--	8.874955221	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790549132955E+09	-.20681712522263E+08	-.21392536277059E+04	.14934445956535E+09
	VELOCITY	.56480995603536E-01	-.28841304597793E+02	-.74721166220280E-01	.28841456694457E+02
EARTH	POSITION	.61774371898958E+04	.28891516045736E+05	-.21392536277059E+04	.29621897909145E+05
	VELOCITY	-.35882677884173E+01	.76844494462522E+00	-.74721166220280E-01	.36703891628810E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.94735590677820E-04	-.44307287166890E-03	.32807044343235E-04	.45427382038765E-03
PERTURBING BODIES	.95189616342623E-09	-.98335786808585E-09	.85232800309411E-10	.13712635169509E-08
THRUST	-.15751929745327E-06	.11421991844559E-06	.30380077897493E-07	.19693010936103E-06
J2 + RAD. PRESSURE	-.34441851681516E-08	-.24872933969571E-07	-.19020728249974E-07	.31501005682743E-07

ORIGINAL PAGE IS OF POOR QUALITY

CONVERGENCE IN THE NONLINEAR GUIDANCE ALGORITHM AFTER 3 ITERATIONS WITH Q0= .8553E+00

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 3

TRAJECTORY STATE AT 7.00000 DAYS(J.D.= 2444327.00000)

	ESTIMATE	REFERENCE	DEVIATION	
X	.623517486977E+04	.562392733819E+04	.611247531585E+03	KM
Y	.288806213005E+05	.289890629713E+05	-.108441670836E+03	KM
Z	-.214082855600E+04	-.222454145189E+04	.837128958907E+02	KM
VX	-.358660765243E+01	-.360314241483E+01	.165347624049E-01	KM/SEC
VY	.775508498180E+00	.699154466145E+00	.763540320354E-01	KM/SEC
VZ	-.755818785178E-01	-.738662121910E-01	-.171566632680E-02	KM/SEC
S/C MASS	4979.89920	4979.83811	.06109	KG

S/C ORBITAL ELEMENTS

	ESTIMATE	REFERENCE	DEVIATION	
A	.296568724276E+05	.296495963037E+05	.727612395945E+01	KM
E	.00212418	.00197557	.00014861	
I	4.30749424	4.45855352	-.15105929	DEG
NODE	183.66927247	183.97618124	-.30690877	DEG
APSIS	196.09224506	203.38768681	-7.29544175	DEG
M A	57.89167356	51.52277713	6.36889644	DEG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
RCA	.295938759175E+05	.295910216900E+05	.285431751027E+01	KM
A	.296568724276E+05	.296495963112E+05	.727611642471E+01	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE

Q = .781112634396E+02 FOR ITERATION NUMBER 1
Q = .742411753496E+02 FOR ITERATION NUMBER 2
Q = .855303840236E+00 FOR ITERATION NUMBER 3

PHI MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS

	X	Y	Z	VX	VY	VZ
X	-.207240885051E+01	.150994683529E+02	-.139770129214E+01	-.118131700629E+06	-.529996817065E+05	.328365956222E+04
Y	.171100252401E+01	-.555940622941E+01	.434225709282E+00	.477607032555E+05	.115808787126E+05	-.462362358498E+03
Z	-.186665000087E+00	.593400519886E+00	-.897654956824E+00	-.552731208128E+04	-.110874329387E+04	.388138325105E+04
VX	.584402253345E-04	.252262789856E-03	-.243795251229E-04	-.140701747715E+01	-.150745205141E+01	.980049575548E-01
VY	-.319082798235E-03	.186159552901E-02	-.177174565439E-03	-.143639680220E+02	-.598039524775E+01	.300119329712E+00
VZ	.253514721322E-04	-.148171020151E-03	-.474875011315E-04	.110527550707E+01	.380381072725E+00	-.828174117050E+00

THETA MATRIX OVER TRAJECTORY ARC 1.00000 TO 7.00000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
X	-.139490570292E+05	-.327034065620E+06	-.330812537594E+06
Y	.247189643816E+04	.620120900084E+05	.624222922989E+05
Z	.268860171513E+04	.936250170723E+04	.902367442516E+04
VX	-.438605001113E+00	-.937049587910E+01	-.951187857674E+01
VY	-.168167643678E+01	-.399969946498E+02	-.404711807074E+02
VZ	.445448518523E+00	.493684193138E+01	.493151820229E+01

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
RCA	.113913578854E+01	.125433684443E+01	-.887942727422E-01	-.904215426964E+04	-.507254875643E+04	.338672711514E+03
A	.421911053709E+00	.195424404286E+01	-.144861892913E+00	-.158278265293E+05	.342234592477E+04	-.333545410365E+03

TARGET/CONTROL SENSITIVITY MATRIX(2 X 3)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	THROTTLING	PITCH ANGLE	YAW ANGLE
RCA	-.380288145917E+03	-.629534701622E+04	-.637298884104E+04
A	-.404789988667E+03	-.836441280315E+04	-.849114536543E+04

GUIDANCE MATRIX(3 X 2) FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	RCA	A
THROTTLING	-.128042851569E-01	.962329664429E-02
PITCH ANGLE	-.118975784689E-02	.835638523974E-03
YAW ANGLE	.178240644334E-02	-.139969806154E-02

ESTIMATED CONTROL CORRECTION FOR ITERATION 3 IN INTERNAL UNITS

	OLD CONTROLS	UPDATES	NEW CONTROLS
THROTTLING	.992930137796E+00	-.334727314437E-01	.959457406353E+00
PITCH ANGLE	.491458181182E+01	-.268425653405E-02	.491189755529E+01
YAW ANGLE	-.145418739642E+00	.509681213356E-02	-.140321927508E+00

COMMANDED THRUST CONTROL CORRECTIONS

THRUST CONTROL CHANGE NUMBER	THRUST CONTROL PHASE NUMBER	THRUST CONTROL TYPE	COMMANDED CHANGE
1	2	THROTTLING	-.044625
2	2	PITCH ANGLE	1.710298 DEGS
3	2	YAW ANGLE	-1.272556 DEGS

ACTUAL THRUST CONTROLS AFTER CORRECTION

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	1.000000	1.004082	20.232702	.007170	10.000000	-6.767298	6.000000	0.000000	63.000000
2	4.000000	.959457	281.430999	.007170	10.000000	-8.039854	6.000000	0.000000	63.000000
3	10.000000	1.000000	337.952000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444321.80000000	CONTROL PHASE --	2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	1.00000000	PRESENT MASS (KG) --	4997.107969173	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	6.00000000	PRESENT PITCH (DEG) --	281.663700844	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00723535913722	PRESENT YAW (DEG) --	55.192847306	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	.9594574	281.4309993	.0071700	10.0000000	-8.0398542	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.148998316038008E+09	-.530457682562020E+07	.236567756871430E+04	.149092711837560E+09
	VELOCITY	.417648768963940E+01	-.289657276118140E+02	-.770750224280440E-01	.292653782832650E+02
EARTH	POSITION	.708322742005900E+04	-.277479146863000E+05	.236567756871430E+04	.287545757588080E+05
	VELOCITY	.360821801044520E+01	.913147827561470E+00	-.770750224280440E-01	.372277003385430E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.118755508455880E-03	.465549477910680E-03	-.396623214044700E-04	.482091575233080E-03
PERTURBING BODIES	.447888093605790E-09	.113785766127370E-08	-.947323119686920E-10	.122649827258100E-08
THRUST	.104425435798420E-06	.254608039271240E-07	.154603656340640E-06	.188295551546500E-06
J2 + RAD. PRESSURE	-.497252920820000E-08	.289627721827390E-07	.201777149502470E-07	.356469970663590E-07

MONTE CARLO CYCLE NUMBER 1
GUIDANCE EVENT NUMBER 1
OUTPUT DATA AT THE DESIGNATED TARGET TIME

GUIDANCE EVENT TIME 2444321.00000 AT 1.00000 DAYS FROM LAUNCH
DESIGNATED TARGET TIME 2444327.00000 AT 7.00000 DAYS FROM LAUNCH
DURATION OF THE GUIDANCE TRAJECTORY IS 6.00000 DAYS

S/C STATE VECTOR AT TRAJECTORY TIME = 7.00000 DAYS(J.D.= 2444327.00000)

	ACTUAL	REFERENCE	DEVIATION	
X	.459020571840E+04	.562392733819E+04	-.103372161979E+04	KM
Y	.291504924170E+05	.289890629713E+05	.161429445699E+03	KM
Z	-.217182710930E+04	-.222454145189E+04	.527143425878E+02	KM
VX	-.362711846890E+01	-.360314241483E+01	-.239760540715E-01	KM/SEC
VY	.572814981177E+00	.699154466145E+00	-.126339484968E+00	KM/SEC
VZ	-.591237787592E-01	-.738662121910E-01	.147424334318E-01	KM/SEC
S/C MASS	4980.17665	4979.83811	.33854	KG

S/C ORBITAL ELEMENTS

	ACTUAL	REFERENCE	DEVIATION	
A	.296255825203E+05	.296495963037E+05	-.240137833712E+02	KM
E	.00203417	.00197557	.00005860	
I	4.30799384	4.45855352	-.15055969	DEG
NODE	183.36707158	183.97618124	-.60910966	DEG
APSIS	204.41450679	203.38768681	1.02681998	DEG
M A	53.11678264	51.52277713	1.59400551	DEG

TARGET VARIABLES

	ACTUAL	REFERENCE	DEVIATION	
RCA	.295653191781E+05	.295910216000E+05	-.257024218976E+02	KM
A	.296255825203E+05	.296495963112E+05	-.240137909069E+02	KM

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444321.00000000	CONTROL PHASE -- 2	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH-- 1.00000000	PRESENT MASS (KG) -- 4997.107969173	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF-- 6.00000000	PRESENT PITCH (DEG)-- 281.663700844	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)-- .00724234358175	PRESENT YAW (DEG)-- 55.192847306	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
3.0000000	.9594574	281.4309993	.0071709	10.0000000	-8.0398542	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.148998316038 08E+09	-.530457682562 02E+07	.236567756871 43E+04	.149092711837 56E+09
	VELOCITY	.417648768963 94E+01	-.289657276118 14E+02	-.770750224280 44E-01	.292653782832 65E+02
EARTH	POSITION	.708322742005 90E+04	-.277679146863 00E+05	.236567756871 43E+04	.287545757588 08E+05
	VELOCITY	.360821801044 52E+01	.913147827561 47E+00	-.770750224280 44E-01	.372277003385 43E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.118755508455 88E-03	.465549477910 68E-03	-.396623214044 70E-04	.482091575233 08E-03
PERTURBING BODIES	.447888093605 79E-09	.113785766127 37E-08	-.947323119686 92E-10	.122649827258 10E-08
THRUST	.104425435798 42E-06	.254608039271 24E-07	.154603656340 64E-06	.188295551546 50E-06
J2 + RAD. PRESSURE	-.497252920820 00E-08	.289627721827 39E-07	.201777149502 47E-07	.356469970663 59E-07

ORIGINAL PAGE IS OF POOR QUALITY

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.817470922	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	338.184701526	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724234358175	PRESENT YAW (DEG)--	56.232701526	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863115084446E+09	-.12999592649694E+08	-.78290734776758E+03	.14919855364922E+09
	VELOCITY	.64629300643222E+00	-.26401473248549E+02	-.28452262221630E+00	.26410915119825E+02
EARTH	POSITION	.26791212316984E+05	.11562054053455E+05	-.78290734776758E+03	.29190119822706E+05
	VELOCITY	-.14650252511245E+01	.33826181055692E+01	-.28452262221630E+00	.36972094013066E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.42936654643535E-03	-.18529804324994E-03	.12547182266803E-04	.46781238527096E-03
PERTURBING BODIES	.22364422509586E-08	-.17256940943138E-09	.31284437953964E-10	.22433084627403E-08
THRUST	.31610129897861E-07	.10458965372212E-06	.16341607927792E-06	.19657825654034E-06
J2 + RAD. PRESSURE	-.30375938226849E-07	-.16949919431743E-07	-.79702271105379E-08	.35686438770175E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4980.176651438	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.400792374	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724234358175	PRESENT YAW (DEG)--	7.173683521	AVAILABLE POWER (KW)--	14.4250000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790707856102E+09	-.20681453545892E+08	-.21718271093022E+04	.14934599564081E+09
	VELOCITY	.17630315119305E-01	-.29036934561242E+02	-.59123778759174E-01	.29037000106124E+02
EARTH	POSITION	.45902057183983E+04	.29150492416999E+05	-.21718271093022E+04	.29589491879439E+05
	VELOCITY	-.36271184689815E+01	.57281498117677E+00	-.59123778759174E-01	.36725469379331E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.78625754185080E-04	-.44851486798622E-03	.33416133603614E-04	.45526939491242E-03
PERTURBING BODIES	.83330359632736E-09	-.10191011037800E-08	.86527933006706E-10	.13192607879294E-08
THRUST	-.15878420478239E-06	.11384283855479E-06	.24588742324800E-07	.19691932822276E-06
J2 + RAD. PRESSURE	-.25243602883545E-08	-.24910754704031E-07	-.19284079216352E-07	.31603699245695E-07

ORIGINAL PAGE IS OF POOR QUALITY

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444324.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	4.00000000	PRESENT MASS (KG)--	4988.817470921	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	3.00000000	PRESENT PITCH (DEG)--	338.184701526	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724209885533	PRESENT YAW (DEG)--	56.232701526	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
6.0000000	1.0000000	337.9520000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14863114760941E+09	-.12999598465546E+08	-.78193173526641E+03	.14919855093320E+09
	VELOCITY	.64712125089038E+00	-.26401188625861E+02	-.28488943668109E+00	.26410654834039E+02
EARTH	POSITION	.26794447365087E+05	.11556238204074E+05	-.78193173526641E+03	.29190759981000E+05
	VELOCITY	-.14641970066663E+01	.33829027282576E+01	-.28488943668109E+00	.36971699628656E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.42939014155957E-03	-.18519265169877E-03	.12530722276939E-04	.46779186708680E-03
PERTURBING BODIES	.22366373330996E-08	-.17230864354061E-09	.31245454857295E-10	.22434823616207E-08
THRUST	.31610126703310E-07	.10458965510245E-06	.16341607901243E-06	.19657825654035E-06
J2 + RAD. PRESSURE	-.30378557038499E-07	-.16941048194040E-07	-.79671555697804E-08	.35683769553218E-07

JULIAN DATE --	2444327.00000000	CONTROL PHASE --	3	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	7.00000000	PRESENT MASS (KG)--	4980.176651438	FLUX (E14)--	0.0000000000
DAYS FROM CUTOFF--	0.00000000	PRESENT PITCH (DEG)--	46.398336511	FLUX RATE (E14/SEC)--	0.
MOTION (DEG/SEC)--	.00724209885533	PRESENT YAW (DEG)--	7.241694161	AVAILABLE POWER (KW)--	14.4250300000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14790703471951E+09	-.20681459418437E+08	-.21732497151901E+04	.14934595303495E+09
	VELOCITY	.18581588803769E-01	-.29031545647367E+02	-.59765871251455E-01	.29031613112433E+02
EARTH	POSITION	.46340472322648E+04	.29144619871913E+05	-.21732497151901E+04	.29590645068226E+05
	VELOCITY	-.36261671952171E+01	.57820389505112E+00	-.59765871251455E-01	.36724624206773E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.71291972133312E-04	-.44837208677498E-03	.33434112853948E-04	.45523391063489E-03
PERTURBING BODIES	.83660023038028E-09	-.10181619398082E-08	.86584685262052E-10	.13206250750566E-08
THRUST	-.15875550415404E-06	.11383254186755E-06	.24820639405027E-07	.19691932822277E-06
J2 + RAD. PRESSURE	-.25503451583604E-08	-.24914217819275E-07	-.19270664765153E-07	.31600332761193E-07

MONTE CARLO MISSION SUMMARY FOR CYCLE 1

CP TIME FOR THIS CYCLE = 76.43300 SEC
TOTAL CP TIME USED TO THIS POINT IN EXECUTION = 77.40500 SEC

S/C STATE VECTOR AT TRAJECTORY TIME = 7.00000 DAYS(J.D.= 2444327.00000)

	ACTUAL	REFERENCE	DEVIATION	
X	.463404723226E+04	.559915709722E+04	-.965109864955E+03	KM
Y	.291446198719E+05	.289931943273E+05	.151425544613E+03	KM
Z	-.217324971519E+04	-.222519983155E+04	.519501163598E+02	KM
VX	-.362616719522E+01	-.360378497285E+01	-.223822223671E-01	KM/SEC
VY	.578203895051E+00	.696106657727E+00	-.117902762676E+00	KM/SEC
VZ	-.597658712515E-01	-.736331001879E-01	.138672289364E-01	KM/SEC
S/C MASS	4980.17665	4979.83811	.33854	KG

S/C ORBITAL ELEMENTS

	ACTUAL	REFERENCE	DEVIATION	
A	.296265275949E+05	.296491524030E+05	-.226248081010E+02	KM
E	.00203409	.00197674	.00005735	
I	4.31267833	4.45893398	-.14625564	DEG
NODE	183.40438050	183.97497615	-.57059565	DEG
APSIS	204.04508158	203.60604458	.43903700	DEG
M A	53.36284136	51.35451901	2.00832235	DEG

TARGET VARIABLES

	ACTUAL	REFERENCE	DEVIATION	
RCA	.295662647115E+05	.295910216000E+05	-.247568847739E+02	KM
A	.296265275949E+05	.296495963112E+05	-.230687163190E+02	KM

TOTAL DELTA-VELOCITY MAGNITUDE FOR IMPULSIVE MANEUVERS= 0. KM/SEC

ORIGINAL PAGE IS OF POOR QUALITY

3.2.4 REFSEP

The REFSEP sample case provides detailed trajectory print for an Earth-orbital mission. A run such as this is likely to be made after the reference trajectory has been determined in TOPSEP and prior to a GODSEP error analysis run. Of particular importance to the GODSEP user is the tracking information which is available over any desired trajectory arc and from which a measurement schedule can be made. The remaining output provides a detailed description of the integration process and the changing geometric relationships among the S/C and the bodies considered.

On the first page of output is a listing of the $TRAJ namelist describing the Earth-orbital mission. Except for two of the variable, KARDS and ELVMIN, the input is standard to all the MAPSEP modes. (Other REFSEP peculiar input is described in Section 2.1, Page 12-B of this manual.) The value of KARDS indicates the number of formatted print schedule cards which are to be read during the execution of the REFSEP run. Images of two print schedule cards (KARDS = 2) may be found immediately after the $TRAJ namelist on the first page. These cards specify the start times, stop times, and time increments for the various print codes. On the second page of output is a summary of the trajectory initialization data. As indicated on this summary page, the flux model, the non-spherical central body model, and the shadow model will be implemented during trajectory propagation (ISCED = 1, J2FLG = 1, MØRBIT = -1). The following pages of output illustrate control phase print (IPRINT = -1), shadow phase print (MORBIT = -1) and scheduled REFSEP print blocks. The fact that tracking computations are made from 0.4 day to 1.0 day in increments of 0.1 day provides a sufficient number of data points to allow the user to construct a short elevation angle time history of the S/C with respect to the input tracking stations (The default stations are: (1) Goldstone, (2) Madrid, (3) Canberra, (4) Johannesburg, (5) Carnarvon, (6) Fairbanks, (7) Rosman, (8) Santiago, and (9) Corpus Christi.) Thus, the user can identify those tracking stations from which the S/C is "visible". This information can then be applied to measurement scheduling for a GODSEP run.

REFSEP Sample Case

```
P$TRAJ
 SCMASS=6000.,
 TLNCH=2444320.,    TEND=1.,
 ISTOP=1,
 STATE= 28571.,0.,0.,0., 3.7209449,-.3255405,
 ICOORD=3,
 NP=3,
 NTP=3,
 ENGINE=14.425,0.,14.425,                    ENGINE(17)=1.E20,
 THRUST=3.,10.,1.,20.,.00717,10.,-7.,6.,0.,63.,
 PHAS=0.,90.,
 ISCD=1,
 J2FLG=1,
 MORBIT=-1,
 IPRINT = -1,
 STEP=.5,
 MODE=4,
 ELVMIN = 15.,
 KARDS=2,
 $END  TRAJ


0.4         1.0        1.0              1123
0.5         1.0        0.1              1000
```

TRAJECTORY INITIALIZATION

INITIAL EPOCH (REFERENCE DATE)
    JULIAN DATE 2444320.0000000000
    CALENDAR DATE .... 1980 MAR 21 12 HR 0 MIN 0.0000 SECS
TRAJECTORY START EPOCH 0.0000000000 DAYS AFTER THE INITIAL EPOCH
    JULIAN DATE 2444320.0000000000
    CALENDAR DATE .... 1980 MAR 21 12 HR 0 MIN 0.0000 SECS
TRAJECTORY END EPOCH 1.0000000000 DAYS AFTER THE INITIAL EPOCH
    JULIAN DATE 2444321.0000000000
    CALENDAR DATE .... 1980 MAR 22 12 HR 0 MIN 0.0000 SECS

INITIAL STATE VECTOR IN ECLIPTIC COORDINATE SYSTEM

	X	Y	Z	MAGNITUDE
POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
VELOCITY	0.	.37209449000000E+01	-.32554850000000E+00	.37351583053435E+01

SEPS MASS	5000.0000000000 KG
EXHAUST VELOCITY	29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.	14.4250000000 KW
FLUENCE	.0000000001 E14 PARTICLES
THRUSTER EFFICIENCY	1.0000000000
RADIATION PRESSURE COEFFICIENT	-1.0000000000

LIST OF GRAVITATING BODIES
    SUN
    EARTH
TARGET PLANET IS EARTH

THE PERTURBING EFFECTS OF A NON-SPHERICAL CENTRAL BODY ARE MODELED AS A J2-TERM IN THE GRAVITATIONAL POTENTIAL
(J2 = .10826450E-02)

INTEGRATION STEP FACTOR .5000

THE SHADOWING LOGIC WILL BE EXECUTED.

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
1	10.000000	1.000000	20.000000	.007170	10.000000	-7.000000	6.000000	0.000000	63.000000

THRUST CONTROL PHASING ANGLES (DEG)
    0.000 90.000 0.000 0.000

DETAILED PRINT EVENT SCHEDULE

    FROM .40000 DAYS TO 1.00000 DAYS IN INCREMENTS OF 1.00100 DAYS -- CODE NO. 1123
    FROM .50000 DAYS TO 1.00000 DAYS IN INCREMENTS OF .10000 DAYS -- CODE NO. 1000

(CORE REQUIRED FOR THIS JOB, 054400 OCTAL)

ORIGINAL PAGE IS
OF POOR QUALITY

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444320.00000000	CONTROL PHASE -- 1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH-- 0.00000000	PRESENT MASS (KG)-- 5000.000000000	FLUX (E14)--	.0000000001
DAYS FROM CUTOFF-- 1.00000000	PRESENT PITCH (DEG)-- 20.000000000	FLUX RATE (E14/SEC)--	0.
	PRESENT YAW (DEG)-- 290.000000000	AVAILABLE POWER (KW)--	14.4250000000

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE A0 = PITCH (DEG)	THRUST PHASE A1 (DEG,SEC)	THRUST PHASE A2 (DEG,SEC)	THRUST PHASE A3 = YAW (DEG,SEC)	NUMBER OF THRUSTERS	THRUST PHASE A4 (DEG,SEC)	THRUST PHASE A5 (DEG,SEC)
10.0000000	1.0000000	20.0000000	.0071700	10.0000000	-7.0000000	6.0000	0.0000000	63.0000000

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14900365223641E+09	-.26945142067351E+07	0.	.14902801342902E+09
	VELOCITY	.52497597354054E-01	-.26171724366994E+02	-.32554050000000E+00	.26173801576324E+02
EARTH	POSITION	.28571000000000E+05	0.	0.	.28571000000000E+05
	VELOCITY	0.	.37209449000000E+01	-.32554050000000E+00	.37351583053435E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48830659348649E-03	-0.	-0.	.48830659348649E-03
PERTURBING BODIES	.22894211851704E-08	.62105475750162E-10	0.	.22902634025861E-08
THRUST	-.24079844144338E-07	.62612529986232E-07	-.18430982466295E-06	.19613841865524E-06
J2 + RAD. PRESSURE	-.39519356007735E-07	0.	0.	.39519356007735E-07

**** SHADOW-IN PHASE CHANGE ****

JULIAN DATE -- 2444320.26014204	CONTROL PHASE -- 1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH-- .26014205	PRESENT MASS (KG)-- 4999.251946782	FLUX (E14)--	.0031914965
DAYS FROM CUTOFF-- .73985795	PRESENT PITCH (DEG)-- 179.135704790	FLUX RATE (E14/SEC)--	.884941E-07
	PRESENT YAW (DEG)-- 54.703659056	AVAILABLE POWER (KW)--	14.1716938014

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14905754876865E+09	-.33606245441016E+07	-.51175870865286E+03	.14909542797318E+09
	VELOCITY	-.57278110116444E+00	-.33531739080527E+02	.32028491249981E+00	.33538160151975E+02
EARTH	POSITION	-.28014583181520E+05	.57618439606119E+04	-.51175870865286E+03	.28605552147033E+05
	VELOCITY	-.75950261802283E+00	-.36417990599212E+01	.32028491249981E+00	.37339157790183E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.47706398444094E-03	-.98119190985847E-04	.87148056796122E-05	.48712767189764E-03
PERTURBING BODIES	-.22768354195354E-08	-.30635805871453E-09	.20491987911629E-10	.22479037273436E-08
THRUST	0.	0.	0.	0.
J2 + RAD. PRESSURE	.37734419855608E-07	-.97547309135403E-08	-.39088156592753E-08	.39170397711704E-07

**** SHADOW-OUT PHASE CHANGE ****

JULIAN DATE -- 2444320.30000433	CONTROL PHASE -- 1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH-- .30000433	PRESENT MASS (KG)-- 4999.251946782	FLUX (E14)--	.0033794893
DAYS FROM CUTOFF-- .69999567	PRESENT PITCH (DEG)-- 208.262334955	FLUX RATE (E14/SEC)--	.256412E-07
	PRESENT YAW (DEG)-- 54.137994875	AVAILABLE POWER (KW)--	14.1662169536

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14905661805982E+09	-.34762686841152E+07	.60539103535681E+03	.14909714897261E+09
	VELOCITY	.11102371602180E+01	-.33496405692647E+02	.31750540356400E+00	.33516303951355E+02
EARTH	POSITION	-.27762480315823E+05	-.69351227466563E+04	.60539103535681E+03	.28621979999702E+05
	VELOCITY	.90295102155109E+00	-.36069372886946E+01	.31750540356400E+00	.37317726127389E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.47195730525884E-03	.11789587262798E-03	-.10291541621086E-04	.48656864942045E-03
PERTURBING BODIES	-.22414898247074E-08	.19962911507935E-09	-.24240400768915E-10	.22504923938737E-08
THRUST	.55744112675187E-07	-.98132899599400E-07	.15612777770567E-06	.19264826771357E-06
J2 + RAD. PRESSURE	.36932352232358E-07	.11629250404172E-07	.47376410276887E-08	.39008759899350E-07

ORIGINAL PAGE IS OF POOR QUALITY

JULIAN DATE --	2444320.39999999	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	.40000000	PRESENT MASS (KG)--	4998.975118197	FLUX (E14)--	.0034399176
DAYS FROM CUTOFF--	.60000000	PRESENT PITCH (DEG)--	277.591227831	FLUX RATE (E14/SEC)--	.133334E-08
		PRESENT YAW (DEG)--	5.597874550	AVAILABLE POWER (KW)--	14.1644997933

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14903263339905E+09	-.37555487071592E+07	.24649978603893E+04	.14907984492716E+09
	VELOCITY	.39126645573833E+01	-.30628420124906E+02	.66520474671243E-01	.30877394453870E+02
EARTH	POSITION	-.56918022479408E+04	-.27976710817436E+05	.24649978603893E+04	.28656049543575E+05
	VELOCITY	.36537950213573E+01	-.74019722272078E+00	.66520474671243E-01	.37286103255997E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.96414935625872E-04	.47390486441207E-03	-.41755247227839E-04	.48541236180880E-03
PERTURBING BODIES	-.53992368312889E-09	.11013952564623E-08	-.98735101452487E-10	.12305842981364E-08
THRUST	.18933781718937E-06	.30112620005469E-07	.18787707183962E-07	.19263581401984E-06
J2 + RAD. PRESSURE	.40424407649313E-08	.29485236312837E-07	.20425123205343E-07	.36895791246560E-07

	PITCH	YAW	ROLL
ANGLE (DEG) ,	277.593	5.598	36.194
RATE (D/S) ,	.74308E-02	-.80507E-02	-.66181E-01
TORQUE (N-M),	-.48566E-04	-.51260E-03	.37075E-01

SOLAR ARRAY ROTATION= 80.576, ECC ANOMALY= 78.465

ORIGINAL PAGE IS OF POOR QUALITY

CUMULATIVE FLUX	=	.34399185E-02	10**14 PARTICLES
FLUX RATE	=	.1333342E-08	10**14 PART/SEC
POWER DEGRADATION=		1.8058340	PERCENT

SUN OCCULTATION DATA

ORBITAL PERIOD	13.350384950	HRS	SHADOW ENTERED, THRUSTERS INOPERATIVE	.260142391	DAYS
SHADOW TIME	57.401698154	MIN	SHADOW EXITED , THRUSTERS OPERATIVE	.300004335	DAYS
WARM-UP TIME	0.000000000	MIN	% OF ORBITAL PERIOD THRUSTERS INOPERATIVE	7.166046568	

INDIVIDUAL PERTURBING ACCELERATIONS

SUN	-.53992368312889E-09	.11013952564623E-08	-.98735101452487E-10	.12305842981364E-08

PLANETARY EPHEMERIDES

EARTH	POSITION	-.14902684159650E+09	-.37275719963418E+07	0.	.14907345273155E+09
	VELOCITY	.25886953602603E+00	-.29898222902185E+02	0.	.29889343948762E+02

INTEGRATION DATA, ENCKE FORMULATION

CONIC	POSITION	-.56968776631399E+04	-.27975296233527E+05	.24603441418129E+04	.28655277136306E+05
CONIC	VELOCITY	.36526335507012E+01	-.74008274303092E+00	.65742543021842E-01	.37274356338109E+01
DELTA	POSITION	.50754151990602E+01	-.14145839094758E+01	.46537185764064E+01	.70297925764698E+01
DELTA	VELOCITY	.11614706560741E-02	-.11447968986744E-03	.77793164940127E-03	.14026037699413E-02
DELTA	ACCE.	-.90275075740450E-07	.16227816392796E-07	-.55133902196484E-07	.10701706654720E-06

RECTIFICATIONS	2
INTEGRATION STEPS	15
STEP SIZE (DAYS)	.28402845274830E-01

----- TARGET DATA -----

SUN-TARGET-S/C ANGLE	102.893820715763 DEG		
EXHAUST-LINE OF SIGHT	109.843238782069 DEG		
S/C-TARGET UNIT VEC	.19862480483521E+00	.97629335735528E+00	-.86020156289893E-01

OSCULATING CONIC DATA WRT TARGET BODY

OSCULATING CONIC = ELLIPSE

PERIPOINT VECTOR	-.18890807418700E+05	.21409838149673E+05	-.18943566368274E+04	.28615247012617E+05
PERI-VEL VECTOR	-.28046258849550E+01	-.24555666478128E+01	.21556816222457E+00	.37339260235014E+01

CONIC ELEMENTS S/C WRT TARGET	A	E	INC	NODE	APS	MA	TA
	.28640F8E+05	.8879190E-03	.5039264E+01	.1802225E+03	.3110909E+03	.1271499E+03	.1272309E+03

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	102.883820715763	DEG
RANGE-VEL INCLUDED ANGLE	89.959472168671	DEG
GEOCENTRIC EQUATORIAL DEC	-18.027103968425	DEG
RIGHT ASCENSION	257.943356089829	DEG
EAST LONGITUDE	114.390957969646	DEG
GREENWICH HOUR ANGLE	143.552398120181	DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	-49.92924	276.91758	.33236374158816E+05	-.19096390862700E+00
2	-42.57643	86.04791	.32579312234956E+05	.25375745299550E+00
3	45.32595	290.44825	.23733207724248E+05	-.23529189592208E+00
4	-2.24691	105.02923	.28188875975824E+05	.33321862497528E+00
5	81.31350	5.37856	.22338582178016E+05	-.33632936509380E-03
6	-30.69994	269.36407	.31376774658123E+05	-.10366246853726E+00
7	-71.21705	313.47563	.34615156068159E+05	-.61265733328588E-01
8	-47.42285	186.17152	.33022367373006E+05	-.58770067484046E-01
9	-64.75914	281.15491	.34291903065615E+05	-.13850001859204E+00

JULIAN DATE -- 2444320.50000000
DAYS FROM LAUNCH- .50000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	38.590787571708	DEG
RANGE-VEL INCLUDED ANGLE	89.996764261598	DEG
GEOCENTRIC EQUATORIAL DEC	-10.955467399018	DEG
RIGHT ASCENSION	324.367476381643	DEG
EAST LONGITUDE	144.716514124746	DEG
GREENWICH HOUR ANGLE	179.650962856897	DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	-24.78590	265.74285	.30748563676563E+05	-.36735651710458E+00
2	-56.92047	51.86734	.33785711087105E+05	.23442795420152E-01
3	58.59826	349.96502	.23035295460539E+05	.83883788501592E-01
4	-29.74351	112.63869	.31290530455144E+05	.35217266960234E+00
5	49.19387	70.40907	.23537786057771E+05	.26486543715987E+00
6	-13.27362	245.35302	.29451002236541E+05	-.32170618448850E+00
7	-49.02230	287.19277	.33171473885094E+05	-.26425589933494E+00
8	-43.84149	223.68979	.32710193233254E+05	-.22743031637786E-01
9	-39.56077	272.87358	.32302052419728E+05	-.31042798162464E+00

JULIAN DATE -- 2444320.59999999
DAYS FROM LAUNCH- .60000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	25.705387123170	DEG
RANGE-VEL INCLUDED ANGLE	90.009273482975	DEG
GEOCENTRIC EQUATORIAL DEC	8.332863507977	DEG
RIGHT ASCENSION	26.122379815461	DEG
EAST LONGITUDE	170.372852221850	DEG
GREENWICH HOUR ANGLE	215.749527593611	DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	6.05843	266.96803	.27284695095216E+05	-.40696886564888E+00
2	-49.44605	7.17986	.33205434591641E+05	-.13076870015417E+00
3	30.92972	28.97517	.24873606637691E+05	.29960491724176E+00
4	-57.38485	109.37765	.33929772742444E+05	.22011888208935E+00
5	13.17191	66.49581	.26533735541715E+05	.39830713770460E+00
6	13.88046	227.75493	.26467282067730E+05	-.31896914815634E+00
7	-20.65517	286.59386	.30287031644451E+05	-.38259176778434E+00
8	-39.72512	260.86635	.32218448682316E+05	-.11892959108349E+00
9	-10.75653	278.42757	.29163606049042E+05	-.39878674180494E+00

JULIAN DATE -- 2444320.69999999
DAYS FROM LAUNCH- .70000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	90.010493690981	DEG
RANGE-VEL INCLUDED ANGLE	89.970093838414	DEG
GEOCENTRIC EQUATORIAL DEC	19.358081744000	DEG
RIGHT ASCENSION	91.827276921249	DEG
EAST LONGITUDE	199.979184590924	DEG
GREENWICH HOUR ANGLE	251.848092330325	DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	38.29726	257.75198	.24284609750217E+05	-.25061340980352E+00
2	-37.37866	334.11321	.32089823835110E+05	-.99760271449592E-01
3	4.92946	50.74626	.27413857434066E+05	.25239817570203E+00
4	-81.58763	134.32540	.34964925263133E+05	.39557946338431E-01
5	-16.53387	71.76760	.29839712693536E+05	.33623520821053E+00
6	31.92897	196.26384	.24796136588768E+05	-.32030467137906E-01
7	7.99797	278.40858	.27083541111498E+05	-.32145560779310E+00
8	-21.29999	285.88279	.30366451043966E+05	-.30957250451934E+00
9	20.11258	275.28819	.25849843131865E+05	-.33410938758275E+00

JULIAN DATE -- 2444320.80000000
DAYS FROM LAUNCH- .80000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	154.262689164796	DEG
RANGE-VEL INCLUDED ANGLE	89.928748363585	DEG
GEOCENTRIC EQUATORIAL DEC	7.319054418887	DEG
RIGHT ASCENSION	157.170257258703	DEG
EAST LONGITUDE	229.223600191664	DEG
GREENWICH HOUR ANGLE	287.946657067039	DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

ORIGINAL PAGE IS OF POOR QUALITY

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	51.39417	207.96331	.23446289212699E+05	.63101138847437E-01
2	-32.44685	301.05906	.31612174945951E+05	-.26936588908580E-01
3	-9.04277	78.35988	.29005604320819E+05	.12676338348579E+00
4	-67.34771	231.83584	.34481003990983E+05	-.15130492844622E+00
5	-36.46125	94.03414	.32029050234246E+05	.16896411409656E+00
6	19.20874	160.47382	.25974016495111E+05	.27351512668033E+00
7	26.70848	249.35901	.25268457728610E+05	-.87610428764645E-01
8	7.49406	293.61113	.27168354890160E+05	-.40043910211277E+00
9	43.18085	243.74640	.23962213276713E+05	-.84343947434139E-01

**** SHADOW-IN PHASE CHANGE ****

JULIAN DATE --	2444320.81997560	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	.81997560	PRESENT MASS (KG)--	4997.790176244	FLUX (E14)--	.0062249051
DAYS FROM CUTOFF--	.18002440	PRESENT PITCH (DEG)--	166.025712335	FLUX RATE (E14/SEC)--	.155662E-06
		PRESENT YAW (DEG)--	54.805170178	AVAILABLE POWER (KW)--	14.1008583141

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14904169315623E+09	-.48065340095106E+07	-.49801160318604E+03	.14911917739951E+09
	VELOCITY	-.24528823968683E+00	-.33523945044331E+02	.32373416664651E+00	.33526405436111E+02
EARTH	POSITION	-.28176066871051E+05	.54928812887478E+04	-.49801160318604E+03	.28710808151829E+05
	VELOCITY	-.72074677833935E+00	-.36419277439850E+01	.32373416664651E+00	.37266496241998E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.47455613103552E-03	-.92513994196562E-04	.83877732367814E-05	.48356252481192E-03
PERTURBING BODIES	-.22312373230476E-08	-.32831094706160E-09	.19931995974191E-10	.22553503839059E-08
THRUST	0.	0.	0.	0.
J2 + RAD. PRESSURE	.37344310096809E-07	-.91363462403425E-08	-.36206207851114E-08	.38615789699288E-07

**** SHADOW-OUT PHASE CHANGE ****

JULIAN DATE --	2444320.85989694	CONTROL PHASE --	1	PRIMARY BODY --	EARTH
DAYS FROM LAUNCH--	.85989695	PRESENT MASS (KG)--	4997.790176244	FLUX (E14)--	.0067710531
DAYS FROM CUTOFF--	.14010305	PRESENT PITCH (DEG)--	195.174019080	FLUX RATE (E14/SEC)--	.153459E-06
		PRESENT YAW (DEG)--	54.034816796	AVAILABLE POWER (KW)--	14.0907982344

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14903964678098E+09	-.49222937001320E+07	.63076140557920E+03	.14912090828675E+09
	VELOCITY	.14276894723252E+01	-.33473149090830E+02	.31982818420036E+00	.33505108526219E+02
EARTH	POSITION	-.27805286292953E+05	-.71948029765654E+04	.63076140557920E+03	.28727982798231E+05
	VELOCITY	.93164792584374E+00	-.35918035748956E+01	.31982818420036E+00	.37244208738770E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.46747183049705E-03	.12096144891603E-03	-.18604573021344E-04	.48298451465973E-03
PERTURBING BODIES	-.22511159334225E-08	.17699866329119E-09	-.25244182926185E-10	.22582040339945E-08
THRUST	.33036747483546E-07	-.10761516720881E-06	.15513984098082E-06	.19167895334967E-06
J2 + RAD. PRESSURE	.36238642683318E-07	.11822142539650E-07	.48170366271590E-08	.38421427870713E-07

JULIAN DATE -- 2444320.99999999
DAYS FROM LAUNCH- .90000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	141.635597274339	DEG
RANGE-VEL INCLUDED ANGLE	89.938658330977	DEG
GEOCENTRIC EQUATORIAL DEC	-11.752974727421	DEG
RIGHT ASCENSION	219.813061083009	DEG
EAST LONGITUDE	254.767839279255	DEG
GREENWICH HOUR ANGLE	324.045221803754	DEG

ORIGINAL PAGE IS OF POOR QUALITY

MINIMUM ELEVATION ANGLE................ 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	30.93472	164.68554	.24951879292501E+05	.23869653654585E+00
2	-27.32389	267.96546	.31104766541139E+05	-.12226980008267E+00
3	-17.96487	108.78873	.30051098674969E+05	.14443490635665E+00
4	-40.52083	236.56409	.32474297321353E+05	-.29626120434332E+00
5	-46.13450	129.30767	.32997735239062E+05	.78064660234740E-01
6	-5.62145	138.41516	.28660770092804E+05	.29521501217009E+00
7	27.28516	208.47749	.25259009978764E+05	.46362757951472E-01
8	42.52733	295.73709	.24049719867482E+05	-.28725025836163E+00
9	40.26937	192.01525	.24209300476301E+05	.10582839663118E+00

JULIAN DATE -- 2444320.99999999
DAYS FROM LAUNCH- 1.00000000

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE	77.651910454914	DEG
RANGE-VEL INCLUDED ANGLE	89.985993487319	DEG
GEOCENTRIC EQUATORIAL DEC	-17.747744551937	DEG
RIGHT ASCENSION	285.092549015209	DEG
EAST LONGITUDE	284.948762474740	DEG
GREENWICH HOUR ANGLE	.143786540470	DEG

MINIMUM ELEVATION ANGLE................ 15.000 DEG

STATION	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	11.35239	136.04593	.26823668350573E+05	.16886927664221E+00
2	-11.23836	244.24190	.29205443163956E+05	-.31444294312976E+00
3	-33.12288	134.26412	.31747134340492E+05	.24951647883357E+00
4	-15.50035	248.49909	.29816022477191E+05	-.28943850862435E+00
5	-54.10563	167.77948	.33684655282636E+05	.84875060301547E-01
6	-20.77935	113.20975	.30399616362277E+05	.88349450587866E-01
7	25.14677	170.69258	.25472608040221E+05	-.12252514076734E-01
8	69.90523	344.41748	.22696505311736E+05	-.71649251673691E-02
9	28.63514	151.88333	.25160978280479E+05	.93414329915181E-01

JULIAN DATE -- 2444321.00000000
DAYS FROM LAUNCH-- 1.00000000
DAYS FROM CUTOFF-- 0.00000000

CONTROL PHASE -- 1
PRESENT MASS (KG)-- 4997.395218139
PRESENT PITCH (DEG)-- 289.181444520
PRESENT YAW (DEG)-- 337.523535468

PRIMARY BODY -- EARTH
FLUX (E14)-- .0077557414
FLUX RATE (E14/SEC)-- .515989E-07
AVAILABLE POWER (KW)-- 14.0758074941

======= ECLIPTIC =======

BODY RELATIVE S/C STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14899826602953E+09	-.53045646361106E+07	.24779610861788E+04	.14909266142881E+09
	VELOCITY	.41739099398373E+01	-.28960372021109E+02	-.80093934657639E-01	.29259717818620E+02
EARTH	POSITION	.71332361478904E+04	-.27755734874152E+05	.24779610861788E+04	.28764633971083E+05
	VELOCITY	.36056402625816E+01	.91850341822256E+00	-.80093934657639E-01	.37216535667368E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.11946852905747E-03	.46485728911479E-03	-.41501270936471E-04	.48175448536329E-03
PERTURBING BODIES	.45193744459635E-09	.11375853847544E-08	-.99228746921044E-10	.12280856263513E-08
THRUST	.16494142237453E-06	.64044562446703E-07	-.73219463871937E-07	.19149012685676E-06
J2 + RAD. PRESSURE	-.51071578851692E-08	.29201436180511E-07	.19741376839009E-07	.35616413297358E-07

ORIGINAL PAGE IS
OF POOR QUALITY

++ TERMINATION DATA ++

```
REQUESTED STOPPING CONDITION : TEND
ACTUAL STOPPING CONDITION    : TEND

FLIGHT TIME      .11000000000000E+01
FINAL S/C MASS   .49973962181390E+04

                    ECLIPTIC                                                    EQUATORIAL

  X =   .71332361478904E+04    VX=   .36056402625816E+01    X =   .71332361478904E+04    VX=   .36056402625816E+01
  Y =  -.27755734874152E+05    VY=   .91850341822256E+00    Y =  -.26450672817370E+05    VY=   .87455685516494E+00
  Z =   .24773610861788E+04    VZ=  -.80093934657639E-01    Z =  -.87682961319329E+04    VZ=   .29191406657789E+00
  R =   .28764633971083E+05    V =   .37216535667368E+01    R =   .28764633971083E+05    V =   .37216535667368E+01

RP  =   .28734633453098E+05    PA  =   .28766475568428E+05    LAT    =  -.17747879621681E+02
VP  =   .37255390505832E+01    VA  =   .37234765475293E+01    LON    =   .28494873610092E+03
TRP =   .76267391836564E+00    TRA =   .10434329480368E+01    PERIOD =   .56151805934223E+00
```

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C ECLIPTIC	.2875055E+05	.5537652E-03	.5094519E+01	.1803191E+03	.3118566E+03	.1521543E+03	.1521839E+03
S/C EQUATORIA.	.2875055E+05	.5537652E-03	.1834744E+02	.3599100E+03	.1322599E+03	.1521543E+03	.1521839E+03

++

4.0 OPERATING GUIDELINES

This chapter is intended to provide useful operating guidelines for MAPSEP. It is assumed that the user has (1) some knowledge of the methods (Volume I, Analytical Manual), input variables (Volume II, Chapter 2) and output (Volume II, Chapter 3) and (2) a particular analysis application. Among the latter possibilities, for example are:

- o time history relationships of the spacecraft, Earth and sun.
- o generation of an integrated trajectory meeting mission requirements;
- o trajectory sensitivity to selected parameters;
- o trajectory dispersions and their propagation effects;
- o ground based and on-board navigation requirements;
- o thrust control authority and thrust accuracy requirements;
- o trajectory and system estimation accuracies;
- o evaluation of dynamic and measurement error sources;
- o mission strategy evaluation;
- o probabilities of mission success or science return.

Many of these applications in terms of MAPSEP operation will be discussed in the following sections.

It is clear that MAPSEP has a sizeable amount of input in order to be flexible in its analysis capability. However, only a small segment of input is often used at any one time. The question of where these input values come from is problem dependent. For example, if MAPSEP is used as part of a Phase B system design process, then TOPSEP would be operated first to generate one or more integrated reference trajectories for the baseline configuration(s), GODSEP would be used parametrically to examine the effects of various levels of error sources on the system and trajectory, and SIMSEP would be operated sparingly to evaluate specific error values. The initial trajectory values, e.g., specific impulse, launch velocity and mass, power levels, etc. would be obtained from the mission analysts who performed mission opportunity searches. Earth based navigation characteristics (including their respective error sources) would be obtained from operational tracking networks. Thrust performance and other on-board characteristics, and uncertainty levels, would be obtained from the respective subsystem areas. Guidance success zones and mission strategy would depend primarily on science or other mission objectives. Unfortunately, many of the input values are not received in forms that are directly usable. A small amount of preparatory analysis and supplementary software is often needed. This requires knowledge both of the subsystem where the data originated and of MAPSEP. A reverse problem also exists, namely, how to translate MAPSEP results into information needed by other subsystems. Thus, operating MAPSEP effectively is considerably more involved than just being familiar with the input and output.

The common element of all mode usage is the $TRAJ namelist which describes the nominal trajectory. The required input of $TRAJ contains as a minimum the variables

TLNCH, TEND, STATE, SCMASS, THRUST, ENGINE, STEP, ICØØRD, ISTØP, NTP, NB, MØDE,

with other parameters being optional. In the following sections, it is assumed that the basic $TRAJ has been input, except as noted. Each mode is then treated as a separate program, which is true for most MAPSEP applications.

4.1 Trajectory Generation - TOPSEP

There are four basic applications of the TOPSEP mode: (1) trajectory propagation, (2) trajectory grids, that is, a matrix of trajectories corresponding to different control parameter steps (3) trajectory targeting to meet mission objectives, and (4) trajectory targeting and optimization. These submodes are often used in sequence to eventually obtain an optimal low thrust trajectory. They can also be used independently, for example, to generate a time history of Earth-Sun-vehicle relative geometries for a baseline mission. Each submode or TOPSEP option is defined by parameters in the namelist $TØPSEP which is input directly after $TRAJ.

The most common usage of TOPSEP is in generating a targeted trajectory with system constraints reflecting a proposed spacecraft and mission. Final mass optimization is generally not used because most low thrust trajectories have relatively flat performance curves in the local area of interest.

The targeting (and optimization) procedure begins with an initial guess of the trajectory controls: initial state and mass, thrust segments including duration, thrust magnitude and pointing, and vehicle characteristics including specific impulse, base power level, thruster efficiency, etc. These inputs are put in $TRAJ. The initial guess is often a combination of engineering intuition and results from a mission opportunity search program, for example, SECKSPOT (Reference 8) and POST (Reference 9). The value of a reasonably accurate initial guess cannot be overemphasized. The targeting process for low thrust trajectories is often so non-linear that many iterations are spent just to bring an initial guess into the "ball park".

Assuming that a bad initial guess occurs, which is generally the case, then many single trajectories are computed for various values of initial coast time, thrust direction and magnitude in dominant thrust phases, power level, etc. One or more trajectories are selected from this semi-random collection to start the targeting submode. An alternate, or supplementary, technique is to apply the grid submode. This permits a somewhat more organized search for acceptable trajectories and also reveals the extent of nonlinearity in the control vs. target error hyperspace. In any case, the integration step size factor should be set to a large value, e.g., STEP = 1., to minimize run time and cost because many trajectories may have to be examined before a satisfactory one is reached.

The initial guess selection represents the zeroth level of a targeting strategy. Thereafter, the targeting submode is entered and the strategy is to stabilize the targeting process and prevent divergence. An example of a targeting strategy for an Earth-orbital mission is Table 4-1 (specific numerical examples can be found in the sample case of Section 3.2.1). The first level varies initial conditions, segment times and control parameters in the early thrust (and coast) phases. The target parameters are usually specified at some intermediate point in the trajectory rather than at the mission end time. The second level strategy then continues to vary thrust duration and controls to target to other intermediate time points until the end time is finally reached and the end time targets are within rather loose tolerances. The third level then successfully refines the control parameters and the trajectory accuracy until all desired target conditions are met within the tight tolerances. (An alternative strategy might be to set the desired target values higher than those possibly attainable at the intermediate and final time points and simply remove as much of the target error as possible.) Thereafter, optimization with respect to final mass may be performed if desired.

LEVEL	STEP SIZE (STEP)	CONTROL PARAMETERS		TARGET PARAMETERS	
		TYPE	SENSITIVITY TO TARGETS	TYPE	TOLERANCES
0	Large	Initial Conditions, Early Segments	High-Medium	All (Intermediate time)	Very Loose
1	Medium	Initial Conditions, Early Segments	High-Medium	All (Intermediate time)	Loose
2	Medium	Early and Intermediate	High-Medium	All (Intermediate time)	Loose
3	Small	Intermediate and Late	Medium-Low	All (final time)	Tight

TABLE 4-1 Earth Orbital Targeting Strategy

It is apparent that every mission will have a different effective targeting strategy depending upon the initial guess and mission objective. Furthermore, there is a considerable amount of user decision making and intuitive reasoning that is required. The unfortunate result is that the targeting process becomes less mechanical and more subjective.

4.1.1 Trajectory Propagation

The simplest TOPSEP application is propagation of a single trajectory for spacecraft ephemeris information. In addition to the trajectory parameters in $TRAJ with MØDE = 1 (See Section 4.0), the required $TØPSEP parameters are IMØDE = 1 and MPRINT(1) equal to the appropriate print option.

4.1.2 Trajectory Grid

As mentioned earlier, the uses of a trajectory grid can be (1) searching for a reasonable initial trajectory to start the targeting submode, (2) investigating the non-linearity of the hyperspace containing control and target parameters, (3) determining appropriate perturbing step sizes in control parameters for numerical differencing, or (4) any combination of these.

The grid submode in TOPSEP requires only a few more parameters in $TØPSEP than the simple trajectory propagation. These are IMØDE = 3, H(I,J) = perturbation from the nominal for the (I, J) control parameter, HMULT = scale factor of perturbations for second step, and MPRINT(1) equal to the appropriate print option.

For example, an input of H (2, 2) = 2., H (8, 21) = .01, HMULT = 2., -.5, would result in the display of five trajectories: (1) the nominal, (2) nominal with duration of second thrust phase extended by two days, (3) nominal with duration of second thrust phase extended by four days, (4) nominal with initial velocity magnitude increased by .01 Km/sec, and (5) nominal with initial velocity magnitude decreased by .005 Km/sec.

If more than two steps in each control direction are desired, it is a simple matter to stack cases. The organization of the input deck is as follows. After the first case ($TRAJ and $TØPSEP namelists) each succeeding case requires only a $TØPSEP namelist with the appropriate changes to H and HMULT. To cycle back to the TØPSEP data overlay the parameter MØDE must be set to -1 in the $TRAJ namelist. The main overlay will not be re-entered; thus, the run will be terminated after the last $TØPSEP namelist. Any additional $TRAJ namelists will be skipped in the search for $TØPSEP namelists. If the user wishes to adjust the nominal trajectory for any of the subsequent stacked cases (i.e., add thrust phases, extend or reduce phase durations, change cone and clock angles, etc.) MØDE must be set to 1 in the first $TRAJ. Each of the following stacked cases consists of pairs of $TRAJ and $TØPSEP namelists. The user should realize, of course, that any inputs, which are not explicitly reset, maintain their last value in succeeding cases.

4.1.3 Trajectory Targeting

The primary purpose of the TOPSEP mode is to generate an integrated trajectory which fulfills a given set of mission constraints while minimizing fuel expenditure (or maximizing deliverable payload). By far the most difficult part of trajectory generation is the targeting process. Non-linearities in trajectory dynamics often wreak havoc with the linear methods used in both targeting and optimization. This is especially true for Earth orbital low thrust trajectories with an inaccurate initial guess. It is highly recommended that the user familiarize himself with Chapter 5 of the MAPSEP Analytic Manual, and continually refine his targeting strategy depending upon the results of each iteration.

Input for a TOPSEP targeting run consists of the namelists $TRAJ and $TOPSEP. The $TRAJ variables define the reference trajectory and serve as the initial guess (zeroth iterate) for the run. The $TOPSEP namelist defines the targeting strategy. Those parameters which are used to alter the initial trajectory in the TOPSEP mode are described below.

- IMØDE = 2 specifies the targeting (and optimization) submode.
- IASTM = 1 refers to the augmented state transition method of targeting. The sensitivity matrix, which is necessary to compute the control correction, is calculated from the integrated STMs. Selection of this option precludes the optimization process and also requires that the trajectory be terminated on final time (ISTØP = 1 in $TRAJ). The set of controls is restricted when STM targeting is used. The controls which may be selected are: 1) the initial state (x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$); 2) thrust phase end time; 3) throttling; 4) pitch angle (or in-plane angle); and 5) yaw angle (out-of-plane angle).

If IASTM = 0, numerical differencing techniques are used to compute the sensitivity matrix. This targeting procedure requires more computation time; however, there is no restriction on the set of controls which may be selected.

- o Non-zero values in the H array denote active control parameters. In addition, when IASTM = 0 the values of H represent the control perturbations to be used in constructing the sensitivity matrix. For example, if H(4, 21) = 10., H (2, 1) = .1, H (4, 5) = .5 are input, then there will be three active control parameters: initial position magnitude, phase end time of the first thrust phase and thrust pitch angle of the fifth phase. The perturbations used to construct sensitivity matrices will be 10 Km., .1 days and .5 degrees, respectively.
- o ULIMIT are the minimum and maximum bounds, if any, on the control parameters. ULIMIT can be used not only to impose hardware related constraints, but also to modulate the targeting process. Used in conjunction with PCT, ULIMIT insures that control corrections will not be unacceptably large. Also, proper usage of ULIMIT will restrict controls such as phase end times from drifting through any other set phases.
- o IWATE determines the type of weighting scheme to be applied to the control parameters. The most frequently used values of IWATE in order are:
    - oo IWATE = 2 for normalized control weighting when very little or no information about the targeting problem is present and when controls with

different units are used simultaneously. This is also valid when all the controls are thrust phase times, and normalization is still according to the magnitude of the controls.

- oo IWATE = 1 when the user has gained experience with the specific targeting problem and can select his own weights.

- o UWATE are control weightings which scale the basic weighting scheme specified by IWATE. The relative weights among the control parameters impact the targeting process.

In general, weights should be smaller for controls earlier in this mission than for similar control parameters in later mission phases to account for diminishing target sensitivities to controls in these latter phases.

- Non-zero values in the TARTØL array denote active target parameters and their tolerances, analgous to the H array for control parameters (any negative tolerance denotes equatorial targets).
- TARGET contains the desired values of the active target parameters.
- JWATE is used to "normalize" the target variables by dividing by their respective tolerances; this is especially helpful in determining linear control dependency (See STØL) when different types of target variables are used, e.g., position and velocity or time of flight and closest approach distance.
- STØL is used in linear dependency tests, that is, if two (or more) control parameters have the same effect on the target parameters, as measured by a vector inner product test of the appropriate columns of the sensitivity matrix, then at least one of the dependent control parameters is deactivated for the current iteration. STØL is the sine of the minimum acceptable "angle" between the column vectors of the sensitivity matrix and is highly sensitive to the control weights and target tolerances. If no target weighting is employed (JWATE = 0), then STØL should be quite small, for example STØL = 1.E-6; otherwise, STØL should be about .001. STØL can also be used to terminate a targeting run after the

sensitivity matrix has been computed and before any trial trajectories are taken (STØL=1).

- PCT determines what fraction of the target error should be eliminated for the current iteration and scales the control correction accordingly; if the targeting porcess is very non-linear, then the sensitivity matrix (used to compute control corrections) is valid only over small regions around the nominal, and PCT should be set to a small level, e.g., PCT = .1; on the other hand, a full control step (PCT = 1.) will attempt to remove all the target error at once which is effective only for relatively well-behaved (linear) problems.
- NMAX is the maximum number of iterations which is typically set to less than 3 so that the targeting process can be continually monitored and the targeting strategy can be changed accordingly.

The parameters H, ULIMIT, IWATE, UWATE, TARTØL, TARGET, JWATE, STØL, PCT and NMAX generally provide the most significant effects and are the most often used parameters in the adaptive targeting process. However, there are also a number of options which are very helpful in stabilizing or accelerating convergence of the targeting process under certain conditions.

- BTØL is used in conjunction with the control constraints (ULIMIT) to define a marginal area near control boundaries. If a control lies in this area and a control correction is made to the ULIMIT boundary, a modification is made to the iteration process. The control on the bound is made inactive and a control step using the remaining controls is computed from the modified performance gradient and sensitivity matrix without incrementing the iteration counter. If the control is in the feasible region but not in the tolerance region and a control correction is made to the boundary, the control is also made inactive; however, a new performance gradient and sensitivity matrix are computed for the next step.

- EPSØN determines what action is to be taken if all the trial trajectories are worse than the reference in terms of the quadratic target error index. If EPSØN is zero, the run is terminated; if EPSØN is non-zero, it is assumed that the sensitivity matrix is invalid and a new sensitivity matrix is computed using the reference trajectory and new control perturbations (the old values (H) scaled by EPSØN). The trial trajectory process is then repeated. EPSØN is used to compute a more well-behaved sensitivity matrix by changing secant partials to tangent partials, or vice versa, depending upon the strategy.
- GTRIAL are the one-dimensional search constants, which are used to find the minimum target error (or cost index) in the $\Delta \underline{U}$ direction. They are useful tools to restrict the search in the $\Delta \underline{U}$ direction depending upon the level of the targeting search (refer to Table 4-1).

- oo GTRIAL(1) is most useful in restricting the percentage decrease in the size of the control scale factor from the preceding estimate.
- oo GTRIAL(2) restricts the scale factor estimate to a maximum allowable value.
- oo GTRIAL(3) is a minimization tolerance on the control scale factor. A "loose" tolerance value of .1 will cause the search to terminate if the estimated control scale factor is within 10% of the preceding value. A "tight" tolerance of .01 or less may result in the use of all of the possible polynominal curve fits in the $\Delta \underline{U}$ direction since convergence is based upon a 1% difference in two successive scale factor estimates.
- oo GTRIAL(4) has a similar control on the search as GTRIAL(3). The factors which are compared are the estimate and actual values of the index to be minimized. If GTRIAL(4) is relatively small ($< .01$) it is likely that more trial steps will be taken per iteration than if the tolerance is "loose" ($> .1$).
- oo GTRIAL(5) restricts the extent of the search in the $\Delta \underline{U}$ direction. The maximum value is 4 which indicates that all four curve fitting techniques may be used if convergence is not realized up to the fourth fit (e.g., two-point-one-slope fit, three-point-one-slope fit, three-point fit, four-point fit).

- o An option that can save significant computer time is the ability to input the target sensitivity matrix S and performance gradient G, by setting INSG = 1 in $TØPSEP, instead of computing S and G internally. This might be done, for example, if (1) a previous run computed a sensitivity matrix, but neither the trial trajectories nor a control correction were implemented, or, (2) the number of controls and/or targets were to be changed (the input G and S would be composed of elements from previous G and S matrices) assuming the reference trajectory has not been changed (much), or (3) a sensitivity matrix is available from some other program or method.
- o DFMAX is used to restrict increases in the cost index (negative of payload) associated with a targeting step. For example, if a targeting control correction reduces the target error but also reduces the SEP payload more than the DFMAX specification the control correction will be appropriately scaled.

The targeting process can best be illustrated by a simple example. Figure 4-1 is a diagram of control parameter space (U_1, U_2) with contours of constant target error (T_5 T_4 ... T_o). Target contours are a strong function of the particular types of target and control parameters, and are often very non-linear. The outer dashed lines represent control constraints (ULIMIT) and the region between the inner and outer dashed lines represent the "marginal" area. The starting point or initial guess lies at U_2 = 0 and the boundary U_1 = ULIMIT(1, 2). The eventual point of convergence is near one of two possible minima and on the boundary U_2 = ULIMIT(2, 2). Convergence to a local minimum and not to a point of zero target error is generally the case rather than the exception even though there are more

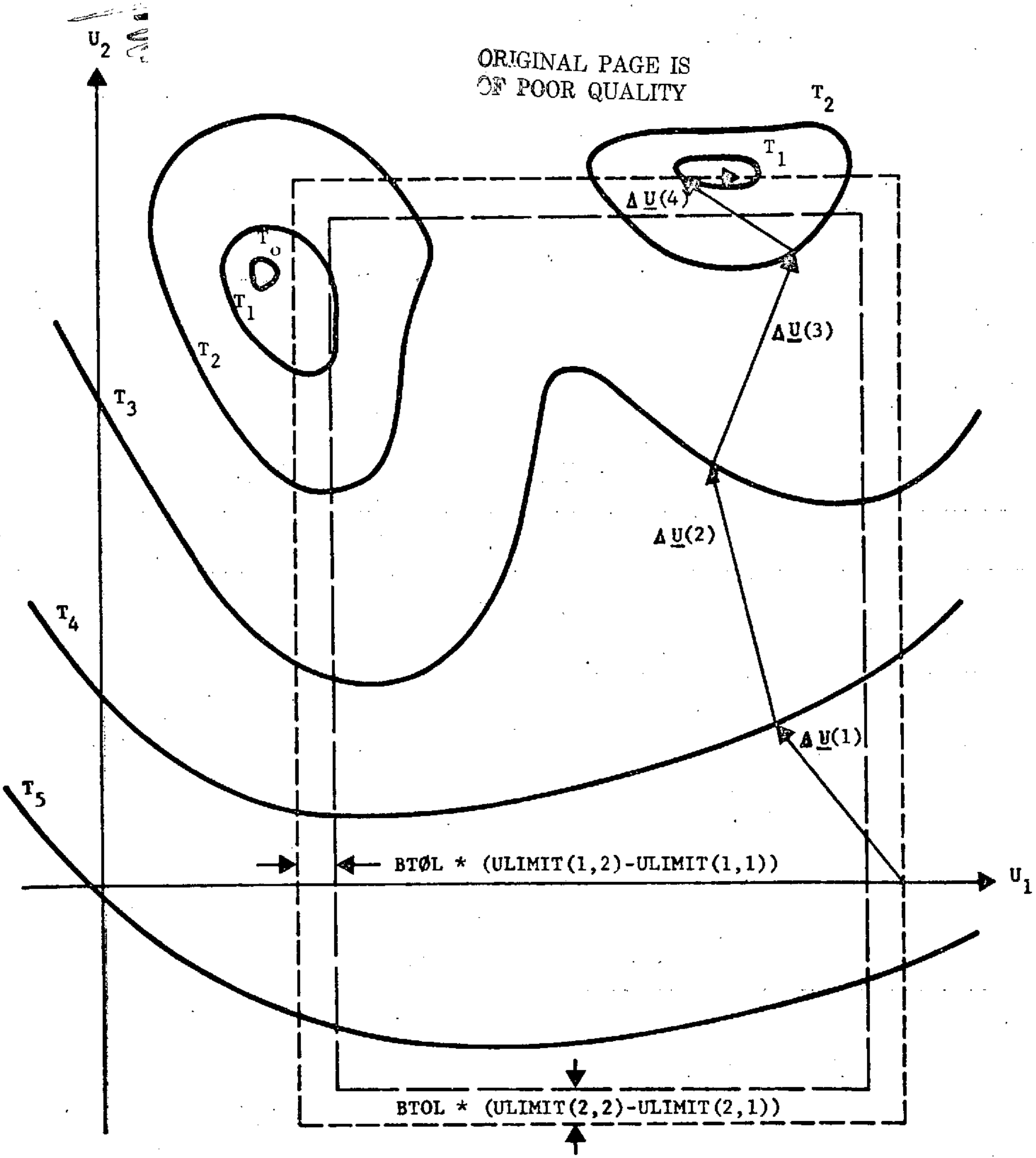

Figure 4-1. Example of Targeting Process

controls than target parameters. The control correction steps $\Delta \underline{U}(1)$, ..., $\Delta \underline{U}(5)$ represent the results of five corresponding iterations of TOPSEP, each one of which includes computation of the sensitivity matrix and trial trajectories. Note that $\Delta \underline{U}(3)$ resulted in controls which lie in the feasible region but outside the marginal area, and the next iteration $\Delta \underline{U}(4)$ resulted in contact with the U_2 boundary. The next iteration $\Delta \underline{U}(5)$ moved along the U_2 boundary to the point of minimum target error. If $\Delta \underline{U}(3)$ had ended up within the marginal area, but not necessarily on the U_2 boundary itself, then the BTØL logic discussed above would be exercised.

Although the control corrections appear to be orthogonal to the target error contours, this is not always the case (except in a small region near the reference control point of each iteration). The control parameter weights (UWATE) and basic weighting scheme (IWATE) are used to alter the shape of the general contours such that the control correction is applicable over a wider control area, rather than the localized area near the reference point. Indeed, a more accurate representation of the contours and targeting process would be in "weighted" space, that is, control and target parameters divided by their respective weights. In weighted space, wherein the control corrections are actually computed, contours might look completely different. Furthermore, the test of linear dependency (STØL) between control parameters takes on a more obvious geometrical significance because the weighted control and target parameters are not so dependent upon units (seconds vs. days, radians vs. degrees, etc.) or mission segment (early vs. late).

The targeting strategy can be reduced to choosing appropriate control and target parameters and their weights. Because of this, targeting is more an art than a science. Furthermore, a good initial guess is required to minimize computer time and "artistic" effort.

4.1.4 Trajectory Optimization

When a trajectory has been found which meets, or nearly meets, desired targeting conditions, TOPSEP can be used to refine the trajectory and maximize payload. However, this option is rarely used because by the time a targeted trajectory has been computed which also meets the varied constraints of the mission and S/C system, there is little performance left to optimize. It is probable of course that only a local optimum has been reached, but to find another local optimum (much less the global optimum) requires untargeting the trajectory, at least temporarily, to reach a significantly different point in control vs. performance space.

The optimization problem is similar to that illustrated previously in Figure 4-1 where target error contours are replaced by performance contours. A significant difference, however, is that the starting point is already very close to the (local) optimum.

The inputs to $TØPSEP for optimization include all of those required for targeting, in addition to

- ØSCALE, used to establish the relative weighting between net cost (See Analytic Manual) and target error for simultaneous optimization and targeting; that is, the parameter to be minimized is the sum of net cost, multiplied by ØSCALE, plus the quadratic target error; note that the quadratic target error depends upon both the actual target error and their tolerances, and it is close to or less than one for a reasonably targeted trajectory.

- TUP is the boundary of quadratic target error above which targeting only is performed and below which simultaneous targeting and optimization occurs.
- TLØW is the boundary of quadratic target error above which simultaneous targeting and optimization occurs and below which optimization only is performed.
- DP2 is a constant which is used to scale the optimization correction relative to the constraint correction. Thus, the user is capable of restricting optimization control corrections which introduce large target errors. (Analytic discussion in Reference 1, page 50.)

4.2 Linear Error Analysis - GODSEP

The linear error analysis mode provides a relatively quick evaluation of trajectory errors due to anticipated system and environmental uncertainties. There are several analysis techniques available within GODSEP depending upon the mission segment, affected systems and desired analysis depth. The most common options are (1) generation of trajectory and state transition matrix data related to a selected reference trajectory and storing the data on disc and/or tape, the STM file, (2) a covariance analysis about some portion or all of the reference trajectory using data on the STM file, (3) a combined STM file generation and covariance analysis in a single run, (4) an evaluation of error source mismodeling effects (generalized covariance) based upon a previous covariance analysis (which assumed perfect modeling), and (5) a covariance analysis of the reference trajectory using integrated covariances (PDOT) instead of the transition matrix methods.

Whatever option is chosen, the namelist $GØDSEP must be input directly after $TRAJ to specify necessary parameter values. Other input features are optional, for example, specification of STM and/or GAIN files, input of namelist $GEVENT for guidance events, and input of fixed field cards containing measurement event and propagation event data.

A typical error analysis needs as input (1) an integrated reference trajectory, (2) expected dynamic and navigation error sources, (3) a guidance and navigation strategy, and (4) system constraints, tolerances and evaluation criteria. The reference trajectory is obtained from TOPSEP as discussed in the previous section. Both expected error source levels and the guidance and navigation strategy are related to mission objectives and subsystem characteristics. Strategy includes the type and density of observations used in navigation, both on-board and ground based, orbit determination (OD) method, and the type and frequency of guidance updates.

System constraints and tolerances can be defined a-priori or can be determined as part of the error analysis. Generally, some baseline requirements are established and the error analysis either confirms them or points out needed changes. Another criterion for evaluation of trajectory errors is the guidance success zone. This is the region of acceptable terminal error as determined by minimum science return and/or by post encounter requirements.

In terms of MAPSEP and GODSEP operation, once a trajectory has been defined by TOPSEP, that is, initial state vector, thrust/coast segment times, thrust controls, etc., then the linear error analysis begins with generation of an STM file. The STM file is created by propagating the reference trajectory and writing, on disc, state transition matrix and trajectory related data at specified epochs. The STM file can be saved on tape for permanent storage such that subsequent analyses do not need to regenerate the reference data. This is often the case for a parametric examination of error sources and mission strategies.

Once an STM file is created, GODSEP can be operated in the standard covariance mode. That is, a-priori covariances (control and knowledge) are propagated using transition matrices, off the STM file, from one event to the next. At each event the control and/or knowledge covariance is modified. For example, at a measurement event, observation matrices and a filter gain are computed, then the knowledge covariance is updated to reflect the new trajectory estimate (non-deterministically). The only exceptions where a covariance is not modified at an event are eigenvector (for instantaneous covariance display) and prediction (for display of a future covariance assuming no further measurements or guidance). Thus, a time history of expected uncertainties in actual (control) and estimated (knowledge) parameters is computed as the sequence of mission events unfolds.

In the course of a system design, the standard covariance analysis is run many times with varying levels of error sources, measurement schedules, guidance policies, etc. At some time, however, certain key assumptions should be evaluated. One of these assumptions is the effective process noise model which is an integral part of covariance propagation using transition matrices. The PDOT option in GODSEP permits a more realistic (in a mathematical sense) evaluation of thrust process noise by integrating a state covariance explicitly. The state is augmented by parameters which characterize the noise process. Correlations between thrust noise and other parameters, dynamic and measurement, are computed as part of the PDOT covariance propagation. This is in direct contrast to the standard covariance analysis where these correlations are assumed to be zero. In many cases, these correlations will be small, but in some mission phases they may contribute significantly to the error analysis results.

The PDOT option does not use the STM file, but is more costly to run than STM file generation and a standard covariance analysis combined, primarily because of the augmented state. Furthermore, because of its support role, no guidance or prediction events are allowed in PDOT.

A second assumption in the standard covariance analysis is that all process characteristics and expected performance deviations are known. That is, the OD algorithm assumes that uncertainties in dynamic and measurement parameters are perfectly described by input levels. If the true uncertainty in any parameter is different from that assumed by the OD process, the error analysis results may be invalid. Verifying error analysis results can be done by simulation (See SIMSEP description) but this can be expensive. So, an alternative verification technique is provided in the error analysis mode, called generalized covariance.

The importance of parameter mismodeling is not just knowing that it exists -- it will always be impossible to model the real world exactly -- but also knowing what its impact is on the error analysis. To determine this, generalized covariance first requires running of a standard covariance analysis with the filter gains at each measurement being written on the GAIN file. The GAIN file should be created in the course of any standard covariance analysis if it is anticipated that a generalized covariance will be run later to evaluate suspected mismodeling.

In execution, generalized covariance operates on a set of "true" covariances, propagating them by using the STM file and updating them at a measurement with the assumed filter gain from the GAIN file. The "true" covariances may have different a-priori levels on some parameters and may even include parameters not appearing in the original error analysis. The resulting output may then be compared to the original results to determine the sensitivity of the OD process to the mismodeling.

Note that generalized convariance handles, in effect, two types of mismodeling: differences in the level of process uncertainty and mismodeling of the process itself. Obviously, a more rigorous analysis would apply the trajectory simulation mode, SIMSEP. However, running SIMSEP would be very costly to produce the studies that generalized covariance can perform in one short run. This assumes of course that linearity is valid which is the key assumption in GODSEP. By using generalized covariance in GODSEP, SIMSEP can be used primarily for testing linearity assumptions and not mismodeling.

4.2.1 STM File Generation

A basic requirement for the standard covariance analysis is a reference trajectory with associated transition matrix information. The trajectory data is first created by GODSEP and stored on a disc file (STM). The STM file can then be used and reused for any number of linear error analyses related to the reference mission.

In addition to the standard trajectory variables (Section 4.0), the $TRAJ namelist requires

- o ISTMF = 1
- o MØDE = 2
- o IAUGDC to designate which dynamic parameters are augmented to the basic spacecraft state of position and velocity.

Since the STM file is intended for many applications, it is recommended that IAUGDC activate all parameters that the analyst thinks might be needed in subsequent error analyses. Also, since the THRUST array computed by TOPSEP does not contain explicitly any coast periods due to shadow (TOPSEP shadowing is accounted for internally), then the THRUST array must be modified to include explicit coast periods representing shadow plus thruster start-up delay time. This can be done automatically if REFSEP is used (See P. 52-E). Since the THRUST array is currently limited to 40 phases, GODSEP can analyze a trajectory segment that contains at most 19 shadowed occurrences, in any one run.

The next namelist, $GØDSEP, is required to establish the grid of trajectory points at which spacecraft state and mass, thrust acceleration and other trajectory data are computed, and between which transition matrices for the augmented state are computed. The grid of time points need not correspond either one to one or to an exact time of events of a following error analysis but should be set up to cover approximately the expected events. For example, a greater intensity of time points should be inserted where Earth-based tracking arcs are anticipated whereas only a few points should be placed between tracking arcs. It is very important that the time grid on the STM file cover the maximum conceivable event schedule to avoid regeneration of an STM file.

Time points can be established in many ways. The simplest method is to set NSCHED equal to the number of scheduling cards and then follow the $GØDSEP namelist (which would contain only NSCHED) with scheduling cards corresponding to a desired trajectory grid. Either arbitrary measurements or propagation events can be used.

An alternate scheme is to use an anticipated error analysis event schedule. That is, specify appropriate eigenvector events (NEIGEN and TEIGEN), prediction events (NPRED, TPRED and TPRED2), guidance events (NGUID, TGUID, TCUTØF and TDELAY) and NSCHED. Then follow with scheduling cards corresponding to a desired measurement schedule. Of course, the composite event schedule should be set up to cover all possible future analyses.

Whatever the method of establishing time points for the STM file, a number of additional time points will be inserted automatically. These correspond to thrust policy changes, that is, thrust reorientation and thrust/coast switching, and to changes in the number of operating thrusters.

4.2.2 Standard Covariance Analysis

Once an STM file is generated, the standard covariance analysis can be run either as a stacked case or as a separate run. The only variables required in $TRAJ are ISTMF = 2 and MØDE = 2. Inputs to $GØDSEP are much more involved and depend upon the particular analysis in mind.

The easiest GODSEP application is propagating a covariance from one time point to another. This may be desired, for example, to look at effects of thrust or other dynamic uncertainties on the growth of trajectory errors. In this case $GØDSEP requires:

- o TCURR = input epoch of the a-priori covariance;
- o TFINAL = GODSEP termination time; this is required only if it is different from the final time on the STM file;
- o P is the a-priori covariance (in standard deviations) and associated dynamic and/or measurement covariances: CXS, CXU, CXV, PS, CSU, CSV, PU, CUV, PV. Note that the augmented parameters for a simple covariance propagation may be input as either solve-for or consider parameters;
- o IAUG denotes the augmented parameters which correspond to the input covariances;
- o NEIGEN the number of time points at which the covariance is printed and TEIGEN is the array of time points; the exact times will correspond to whatever is available on the STM file, near the desired times, within the forward and backward time tolerances, TØLFØR and TØLBAK, respectively; the user shall keep in mind that thrust control events (switching of thrust policy or number of operating thrusters) are automatically printed at the exact times of occurrence;

- EPTAU and EPSIG are required if thrust noise is present, otherwise DYNØIS = .FALSE. must be set;
- JØBLAB is used for a job heading to describe this run.

No other input needs to be included in $GØDSEP, nor are scheduling or any other cards required.

The most common GODSEP usage is the evaluation of a navigation strategy and a set of error sources for the reference mission. This includes tracking, orbit determination (OD), guidance and, possibly, prediction, propagation and eigenvector events for additional data display. In this case, $GØDSEP requires all of the inputs needed for the simple covariance propagation plus

- CØNRD = .TRUE., and PG, CXSG, ..., PVG, for the a-priori control covariance if it is different from the input knowledge covariance, and TG, XG, GMASS to define the trajectory epoch;
- Guidance event parameters: NGUID, TGUID, TCUTØF, TDELAY, CØNWT, IGPØL, IGREAD, TIMFTA to denote

characteristics of the thrust update process; if IGPØL is zero for any guidance event (that is, an artifical guidance event whose sole function is to print the control covariance, analgous to an eigenvector event), then the corresponding event values in TCUTØF, TDELAY, CØNWT, and IGREAD are ignored;

- Other non-measurement events: NEIGEN and TEIGEN for eigenvector; NPRED, TPRED and TPRED2 for prediction;
- IGAIN for the type of OD filter;
- SIGMES, SIGALT, SIGLAT, SIGLØN, CØRLØN for tracking measurement noise standard deviations;
- PUNCHE to denote at which event types punched card output is obtained (covariance and state);
- NSCHED

There are of course many optional parameters which may be input depending upon the particular GODSEP application. For example, if the number of 2-way doppler measurements per day is different than 12, then DØPCNT should be changed, or, if the error analysis event schedule must be meshed with a fairly different STM grid, then the tolerances TØLFØR and TØLBAK might be altered.

With regard to schedule tolerances, the user should keep in mind the process of which events are chosen to be executed at which

STM time points. For example, in Figure 4-2, Event E_1 will be performed at the STM time point STM(I). Event E_2 will not be processed

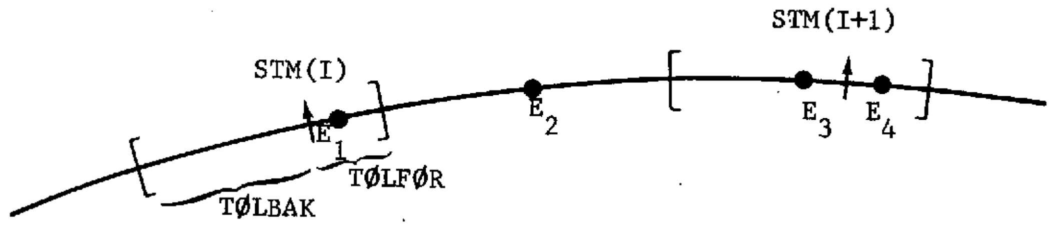

Figure 4-2. Event and STM Meshing

at all; if SCHFTL = .TRUE., then the run will be terminated immediately. Events E_3 and E_4 will both occur at STM(I+1). In Figure 4-3, where TØLBAK is so large that it overlaps a previous STM point, E_1 is still executed at STM(I) because an earlier STM point and its tolerances take precedence over subsequent STM points. Events E_2, E_3 and E_4 are all executed at STM(I+1). Thus, it is very important that some foresight be applied to creation of the STM file and some consideration be applied to the use of the STM file in event scheduling of a covariance analysis.

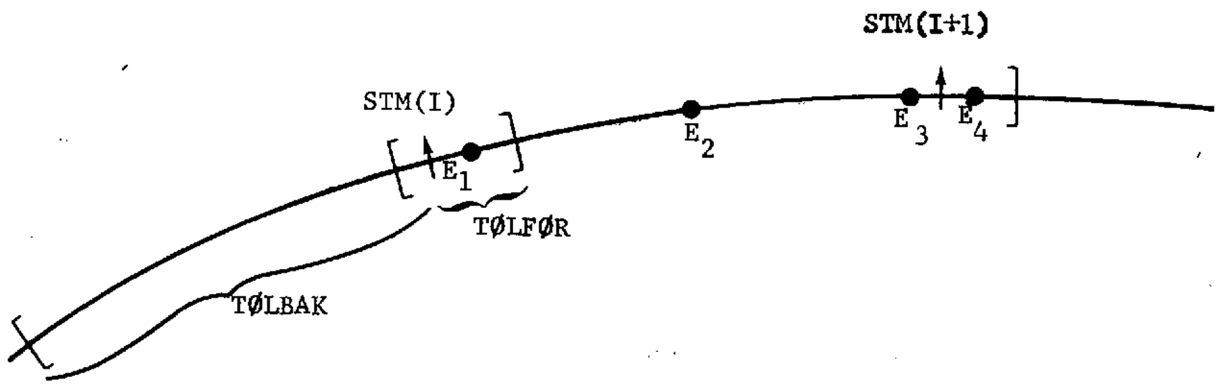

Figure 4-3. Event and STM Meshing

A number of print and input/output options also exist in $GØDSEP. One of the more important output controls is GAINCR which determines whether or not a GAIN file is to be created for a subsequent generalized covariance analysis (Section 4.2.4). Another option is the punch flag, PUNCHE, which produces punched cards of state and covariance for selected event types. This option is quite useful in subsequent error analyses to eliminate unnecessary repetition of mission segments, especially tracking arcs.

Following the $GØDSEP namelist are fixed field schedule cards which determine the type, density and span of measurements used for navigation and the spacing of propagation events. Propagation events are used primarily to condition the process noise terms, in particular, to break up long propagation intervals, for example those greater than 2 days, wherein there are no other events and in which the effective process noise model breaks down.

An option which can be used to facilitate parametric operation of GODSEP is storing the $GØDSEP namelist on the GAIN file (GAINCR = .TRUE.) even if no subsequent generalized covariance analysis is intended. In any following error analysis run, setting ISTMF = 3 in $TRAJ will cause the $GØDSEP namelist to be read off the GAIN file and the user need only input those parameters in $GØDSEP which are different from the run that created the GAIN file. The user will still, however, be required to input NSCHED and follow the $GØDSEP namelist with the appropriate measurement and propagation event scheduling cards.

After the scheduling cards there exists the possibility of one more set of cards, the namelist $GEVENT. If guidance events are requested and if any of the entries in IGREAD (in $GØDSEP) are non-zero, then the $GEVENT namelist must be input immediately after the scheduling cards. If IGREAD = 2, $GEVENT allows input of VMAT, the variation matrix of target parameters with respect to guidance start state, SMAT, the sensitivity matrix of target with respect to guidance thrust controls and BURNP, guidance burn parameters. If IGREAD = 1 or 2, $GEVENT also allows updating of values in CØNWT, NCØN, TARWT and UMAX. One $GEVENT namelist is required for each non-zero entry in IGREAD up to the number of guidance events (NGUID). Using $GEVENT increases the speed of a GODSEP run by eliminating guidance related computations already performed by earlier runs. A standard output at all guidance events are punched cards for VMAT, SMAT and BURNP whenever these matrices are computed and not already input.

It is apparent that GODSEP input (Figure 4-4) is complicated because of the requirement for extensive analysis capability.

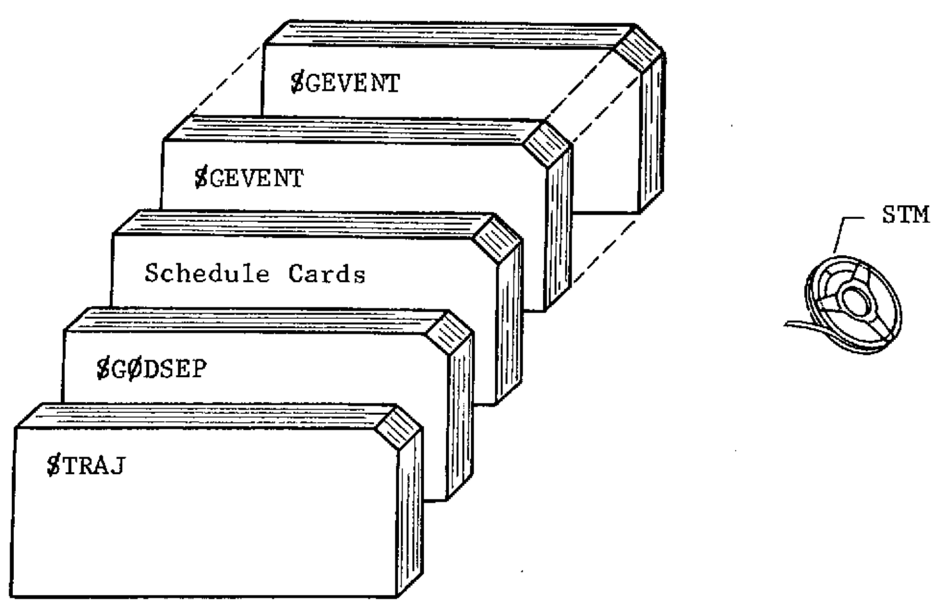

Figure 4-4. Standard Covariance Analysis Input

There is no substitute for experience in terms of what input/output options are chosen and what sequence of GODSEP runs should be made for a specific mission or problem.

4.2.3 Combined STM File Generation and Error Analysis

In general, it is not recommended that GODSEP cases be stacked in a single run because of the amount of output which the user should look at before submitting the next case. There is one recognized exception -- combining the STM file generation with a standard covariance analysis. However, even this stacked case is not without peril because of the danger of miscreating the STM file with subsequent operation by an unsuspecting covariance analysis. The combined STM generation and analysis run may be used for two reasons: (1) the covariance analysis is a simple check case to verify the adequacy of the STM file, or (2) the reference mission is relatively unique and no further analysis is anticipated.

The inputs to MAPSEP are straightforward (Figure 4-5) and

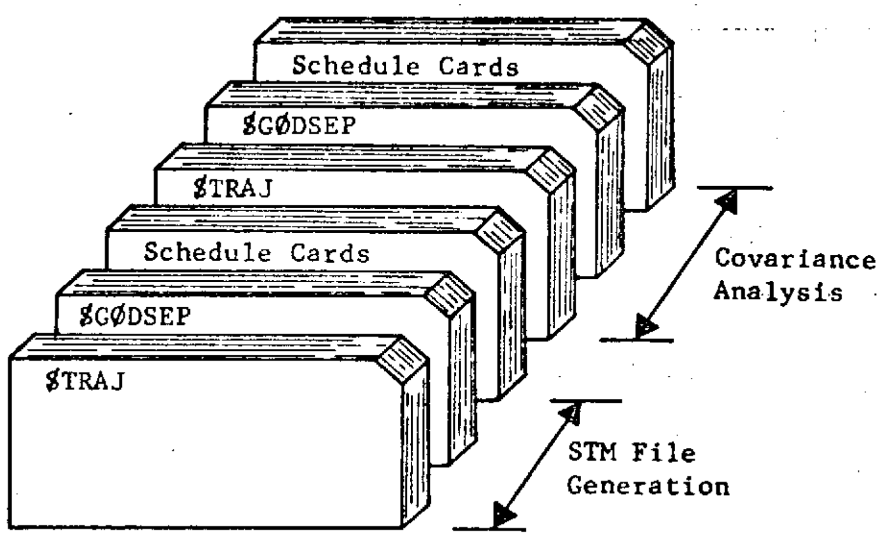

Figure 4-5. Combined STM Generation and Error Analysis Input

follow the detailed descriptions contained in Sections 4.2.1 and 4.2.2 for generation of the STM file and covariance analysis, respectively. Since GODSEP does not retain event information from one run to the next, the event and scheduling cards used to generate the STM file must be repeated for the error analysis (assuming the STM file is to be applied only for that error analysis).

4.2.4 Generalized Covariance

A standard covariance analysis (SCOV) assumes the OD filter knows percisely the form, behavior and initial-level of any process uncertainties, and can estimate and/or consider their appropriate effects. Generalized covariance (GCOV) is used to examine differences between the assumed and real-world uncertainties as they interact with the OD process. Thus, an explicit requirement for exercising the GCOV option is a previous SCOV run which has written its filter gains on a GAIN file (GAINCR = .TRUE. in $GØDSEP). The GCOV run(s) can be stacked behind the SCOV, although this is generally not recommended.

Exercising GCOV requires two tapes or files, STM and GAIN. The $TRAJ namelist requires only MØDE = 2 and ISTMF = 3. The $GØDSEP namelist also requires only a few inputs because the measurement, propagation, and print schedule, a-priori covariance, noise levels, etc. are all obtained from the GAIN file. Thus, $GØDSEP input is

- GENCØV = .TRUE. and GAINCR = .FALSE.;
- IAUG to activate ignore parameters, that is, those parameters known to the real-world

(GCOV) but not by the assumed world (SCOV); note that only those parameters not already activated as solve-for or consider in the SCOV are available to be used as ignore parameters;

- CXW, CSW, CUW, CVW, PW (covariance terms) for the ignore parameters;
- Any parameters to be mismodeled, for example, covariance P, CXS, ..., PV, measurement noise SIGMES, thrust noise EPTAU and EPSIG, etc.;
- Changes in events, although this is not recommended because it may alter the covariances even without mismodeling.

If the user is confident of his input, then several cases of GCOV can be stacked (by repeating the $TRAJ and $GØDSEP input described above). Such a run might include, for example, comparison of different thrust noise levels and correlation times from those assumed by the OD filter. The sensitivity to mismodeling of thrust errors can be a very important criteria in the choice of an OD filter for low thrust missions.

4.2.5 PDOT

One of the key assumptions in a standard covariance analysis is the effective thrust noise model. A means of evaluating this model, as well as other dynamic modeling assumptions is the explicit integration of the covariance matrix differential equations (PDOT). This is in contrast to the transition matrix methods used in the standard covariance analysis.

Since no transition matrices are required, the STM file is not needed except in the possible case where a default $TRAJ namelist is desired which contains reference trajectory parameters. In this case, MØDE = 2 and ISTMF = 2 are the only inputs required in $TRAJ. Otherwise, the normal $TRAJ inputs are required: TLNCH, ..., NB, along with MØDE = 2 and ISTMF = 0.

The $GØDSEP namelist and scheduling cards are identical to that used in the standard covariance run (Section 4.2.2) except for PDØT = .TRUE. Most of the options are also available, for example, generalized covariance.

There are a number of restrictions on PDOT capability because of its function as a support option intended to check on covariance propagation modeling. In particular, no prediction or guidance events can be performed. Furthermore, if the input covariance epoch, TCURR, is not equal to the trajectory epoch, TSTART (in $TRAJ), then STATE and SCMASS in $TRAJ must be altered and correspond to TCURR.

4.3 Trajectory Simulation - SIMSEP

The two main purposes of trajectory simulation are to examine (1) deterministic trajectories, especially the effects of dynamic nonlinearities, and (2) the impact of process mismodeling on trajectory errors. Each trajectory is simulated in an operational environment with a parallel set of "real world" and "assumed world" conditions. The real world conditions are randomly selected from a set of uncertainties associated with the dynamic, environmental, and systems models. The assumed world conditions represent a best estimate of what the real world is like. It is obtained by direct (but corrupted) and indirect observations of the real world processes. The trajectory or mission is carried through a set of trajectory related events, e.g., orbit determination and guidance, until a stopping condition is reached, usually target encounter.

Once a mission has been completed, the trajectory is characterized by fuel expenditure, terminal error, magnitude of thrust control updates, etc. In line with the main objectives, a comparison can then be made between real and estimated world terminal conditions. Furthermore, it will also be possible to make a comparison between real (and estimated) terminal conditions computed in SIMSEP and results computed in an equivalent linear error analysis run. Based upon these comparisons many actions may be taken, the most obvious being an update of assumed world processes and models to reflect the real world more accurately.

SIMSEP has been designed to run a sequence of trajectory simulations in order to generate statistics on the terminal conditions.

Clearly, the confidence attached to these statistics is largely dependent on the number of samples taken. As a consequence, this Monte Carlo approach is, generally, very expensive in terms of computer processing time. This often restricts SIMSEP operation to a support role or to analysis of specific processes, e.g., terminal guidance algorithms or thrust noise effects.

Because SIMSEP can have a complicated input, and is expensive to run, it is recommended that a zero-error case be made first to prevent undue expense as a result of input mistakes. This involves running a single cycle of the reference mission, including all guidance events and related inputs, but with zero-values input for dynamic errors or knowledge uncertainties. The results from one mission cycle with no errors should compare favorably with the targeted reference trajectory obtained from TØPSEP, except for small differences due to numerical integration noise. After a successful zero-error case, SIMSEP can be executed to examine any desired problem.

4.3.1 Single Cycle - No Error

The zero-error case is a means of verifying the basic mission input and is one of the easiest SIMSEP runs to make (Figure 4-6).

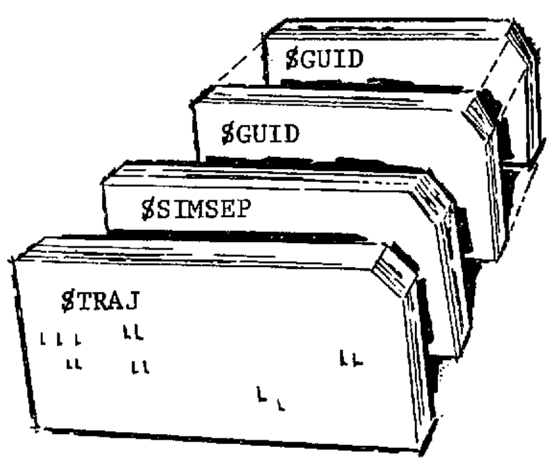

Figure 4-6. SIMSEP Mode Input

After the standard $TRAJ namelist containing TLNCH, ..., NB, and MØDE = 3, the input to $SIMSEP is NGUID for the number of maneuvers or guidance events and INREF = 0, forcing SIMSEP to compute reference trajectory conditions at each event and at the final time. For each guidance event, there must be a corresponding $GUID namelist containing

- o KTER to determine whether or not target conditions are to be computed after this guidance event in order to evaluate its success;
- o TGUID for the maneuver epoch;
- o ITARGT and IGUID for the guidance philosophy;
- o H array to define the active low thrust control parameters for this guidance event; note that, if numerical differencing is to be used in generating state/control sensitivities, then the value of each component of H is also interpreted as a perturbation forced in the control. In addition, it should be noted that controls can be either an impulsive delta-velocity or low thrust parameters; if they are impulsive, no entries are required in H;
- o TTARG for the target time;

- o UWATE for control parameter weights;
- o TARTØL for allowable tolerances on the target errors; and
- o NMAX for the maximum allowable number of iterations if non-linear guidance is specified.

The zero-error case should result in extremely small guidance corrections and target errors. Besides confirming the mission and guidance input, a zero error case will generate punched card output (independent of IPUNCH) which will greatly facilitate subsequent SIMSEP runs. Assuming INREF = 0, the punched cards will include at each guidance event, the reference state, mass, target variables and either a sensitivity matrix of target parameters w.r.t. control parameters (for the nonlinear guidance case) or a guidance matrix of control corrections w.r.t. state errors at the guidance time (for linear guidance). The reference state and mass at the trajectory end (TEND) time will also be punched.

4.3.2 <u>Single Cycle - Forced Monte Carlo</u>

A very useful method of evaluating either specific errors or worst case missions is a "forced" Monte Carlo run. With the random number seed, IRAN, set to zero, all error sources are set at their one sigma levels. Thus, discrete known levels of errors can be studied, instead of randomly sampled. Of course, if all the error levels are one-sigma, the mission itself may represent a very improbable case, possibly as high as 100 σ.

Input for a forced Monte Carlo run is the same as for the previous zero-error case with the obvious exception of non-zero errors. The $TRAJ namelist is the same, and the $SIMSEP namelist contains

- o IRAN = 0;
- o J2 and gravitational errors: J2ERR, GMERR
- o Spacecraft and thrust related errors: SCERR, TCERR, TVERR;
- o ΔV execution errors: EXVERR, if there are impulsive maneuvers; the chemical propulsion specific impulse SPFIMP;
- o The control covariance, PG, representing the initial position and velocity uncertainties; a forced Monte Carlo state error consists of a vector containing the square root of each eigenvalue rotated back into state space;
- o AØK, the upper bound of acceptable quadratic target error for non-linear guidance events (total convergence occurs when the quadratic target error is less than unity);
- o INREF = 0, or if reference conditions are available, then INREF = 1, and the reference state and mass at the final time (XEND and MEND, respectively) must be input;
- o NGUID for the number of maneuvers.

Each $GUID namelist must contain

- o KTER, TGUID, ..., NMAX, the guidance characteristics as in the zero error case;
- o If INREF = 1 in $SIMSEP, then the reference state (XGREF and mass MGREF) at the maneuver epoch, target conditions (TARGET, XTREF, MTREF) and either the sensitivity matrix for nonlinear guidance or the guidance matrix for linear guidance (S) must all be input;
- o KDIMEN to denote the augmented parameters to the spacecraft state which have been estimated for this maneuver; If the J2-term in the gravitational harmonic function has been estimated, then KDIMEN is read as twelve or greater, depending on the number of augmented parameters. (See Page 48 on the SIMSEP input description.);
- o P, PS, CXS are estimation uncertainties corresponding to the spacecraft state, augmented parameters and correlations, respectively.

The forced Monte Carlo option is often used in parametric fashion to study specified levels of a particular error source, for example, thrust noise. Stacked cases can be used to perform the parametric study by repeating the namelist sequence $TRAJ, $SIMSEP and the appropriate number of $GUID's. An alternate, and more efficient, method is to set MØDE = -3 in the first case $TRAJ namelist and make use of the fact that the initial $SIMSEP and $GUID namelists are saved on disc. After the first case, the $SIMSEP and $GUID namelists are repeated for each subsequent case. If this operational procedure is used, those variables that are different from the first case need to be redefined during input after the variables read during the previous analysis are set to zero. In addition, the user must be careful to read zero-length namelists, i.e. $SIMSEP or $GUID card followed by a ＄END card, for all namelists nominally requested even if the original is unchanged.

4.3.3 Monte Carlo

The most often used application of SIMSEP is in the Monte Carlo mode where all mission uncertainties are sampled and the trajectory is simulated accordingly. By looking at a number of typical missions, each with varying degrees of expected errors, an idea of the trajectory errors and required control corrections can be obtained. Statistical analysis of key parameters, such as final target error and mass, total required thrust control correction, etc. should evaluate or define realistic system constraints and probability of mission success. Obviously, a large number of missions, on the order of hundreds, are needed to have reliable statistical data, but even a few sample missions will reveal the scope of trajectory non-linearities and mis-modeling effects.

Input to a full Monte Carlo simulation is basically the same as that for the forced Monte Carlo. The namelists ＄TRAJ, ＄SIMSEP, and ＄GUID are all needed with parameters as specified in the previous section. Additional variables to be considered in ＄SIMSEP are

- IØUT to specify which sample missions are to be printed in detail; if only a few missions are generated then all of them should be printed;

- IPUNCH = 1 to provide punched cards of all the cumulative statistics at the end of the run; this will allow a subsequent run to continue the statistical analysis rather than starting anew;
- IRAN is the random number seed, typically set to unity for the first Monte Carlo run;
- NCYCLE for the number of missions to be simulated;
- CPMAX is an optional parameter for maximum computer processing time; if the actual processing time approaches CPMAX and it is estimated that the desired number of missions (NCYCLE) cannot be completed, then the current mission is completed and final output is generated. This includes punched cards for restarting another run.

The cost of simulating one sample mission with a number of guidance events can be quite high, especially if nonlinear guidance is used. Therefore, it is recommended that considerable planning be made before a full Monte Carlo study is run. Some of the possible short cuts are increasing the trajectory integration step size (STEP in $TRAJ), using linear guidance wherever possible, minimizing the maximum number of iterations (NMAX in $GUID) for nonlinear guidance, and eliminating unnecessary computations (for example, KTER = 0 in $GUID). Another possibility is simulating only key mission segments, in particular the terminal approach phase, and studying other segments with a few simulations and/or with the forced Monte Carlo option.

4.3.4 Monte Carlo Continuation

It is often wise to divide a Monte Carlo analysis into smaller sample sizes than one large run. This serves two purposes: (1) the early detection of input errors before sizable computer time is spent, and (2) examination of missions as they are generated. The latter reason could conceivably result in a change in guidance strategy which would cause the Monte Carlo study to begin again.

A prerequisite to the Monte Carlo continuation are punched cards containing statistical results of all previous runs (IPUNCH = 1 in $SIMSEP). The input to a Monte Carlo continuation is the same as in the previous section except for inclusion of the cumulative statistics. In $SIMSEP these include the total thrust control correction covariance (only of the active controls used in guidance events) ATHCOV, total ΔV variance, ADVT, state covariance at the final time ENDCOV, final spacecraft mass variance AMASS, and the number of Monte Carlo cycles used to generate these statistics, MC. In each $GUID namelist the parameters to be included are: state control covariance CCØVG, ΔV covariance DVMCØV, ΔV magnitude variance DVMAG, spacecraft mass variance GMSCØV, thrust control correction matrix CNTCØV, state error covariance at the target time CCØVT, spacecraft mass variance at the target time TMSCØV, target error covariance TARCØV. CCØVT, TMSCØV, and TARCØV are computed only if KTER = 1. The number of maneuvers used in computing these statistics is specified by the variable MSAMP. All of the matrices noted above contain not only variances and covariances but also the cumulative mean values.

4.4 Case Stacking and Mixed Mode Operation

Case stacking is generally not recommended within modes and definitely not recommended for mixed mode operation. There is too much room for error, even for the experienced user, to assume the input and operation of one case will successfully provide the required data for the next case. There are a few exceptions which might warrent case stacking, and some of these conditions have been discussed in previous sections.

The MØDE flag in namelist $TRAJ controls not only the mode (TOPSEP, GODSEP or SIMSEP), but also the point to which program logic will cycle back. A positive MØDE will return to MAPSEP main and will expect a $TRAJ namelist for the next case. A negative MØDE will return to the mode main and expect a mode namelist. Note that once recycling is done within the mode, logic will never return to MAPSEP main, therefore, (1) any subsequent cases must apply only to that mode and (2) no changes to the reference mission are allowed.

Some of the possible conditions under which case stacking might be performed are:

Mode	MØDE Flag	Function	Conditions
TOPSEP	+1	Trajectory Propagation	Generating time histories for different missions.
TOPSEP	+1 or -1	Initial Guess	Generating more than one initial guess for subsequent targeting by applying different sets of initial conditions, thrust parameters, and/or mission constraints for each case.

Mode	MØDE Flag	Function	Conditions
TOPSEP	-1	Grid Generation	Extending the scope of the trajectory grid.
TOPSEP	-1	Targeting	Examining various targeting strategies for a given mission.
GODSEP	+2	STM Generation	Generating a STM file with verification by a simple error analysis check case.
GODSEP	+2	Covariance Analysis	Generating a STM file for a unique mission with a subsequent error analysis.
GODSEP	+2	Covariance Analysis	Analyzing different navigation strategies and/or error sources for the same mission.
GODSEP	+2	Generalized Covariance	Performing a standard error analysis to generate a GAIN file and using generalized covariance to evaluate suspected mismodeling effects.
GODSEP	+2	Generalized Covariance	Analyzing different mismodeling assumptions with generalized covariance runs.
GODSEP	+2	PDOT	Performing parametric variations of dynamic error sources and evaluating their covariance propagation effects with the PDOT option.
SIMSEP	+3	Missions	Simulating several different missions for comparison.
SIMSEP	+3	Errors	Examining different sets of error sources on the same mission (forced Monte Carlo).
SIMSEP	-3	Guidance	Examining different guidance strategies for a given mission.

5.0 REFERENCES

1. "MAPSEP, Volume I - Analytical Manual," P. Hong, et al, Final Report for NAS8-29666, December, 1973.

2. "Low Thrust Orbit Determination Program - Final Report, Contract NAS1-11686," P. Hong, et al, NASA CR-112256, December, 1972.

3. "MAPSEP, Volume III - Programmer's Manual," K. Huling, et al, Final Report for NAS8-29666, December, 1973.

4. "System Design Impact of Guidance and Navigation Analysis for a SEP 1979 Encke Flyby," P. Hong, G. Shults, R. Boain, Presented at AIAA 10th Electric Propulsion Conference, October 31, 1973.

5. "Guidance and Navigation Analysis for Solar Electric 1979 Encke Flyby and 1981 Encke Rendezvous Missions," P. Hong and G. Shults, MCR-73-182, July, 1973.

6. "Extended Definition Feasibility Study for a Solar Electric Propulsion Stage Concept Selection - Midterm Briefing," Rockwell Corporation, SD73-SA-0081-1, June 20, 1973.

7. "Guidance and Navigation Techniques for a Solar Electric Mercury Orbiter," P. Hong and G. Shults, AIAA Paper 72-917 Presented at AIAA/AAS Astrodynamics Conference, September 11, 1972.

8. "SECKSPOT - Solar Electric Control Knob Setting Program for Optimal Trajectories," N. H. Malchow, L. Sackett, T. Edelbaum, NAS5-21791, May 31, 1974.

9. "POST - Program to Optimize Shuttle Trajectories," D. Cornick, et al, MCR-71-287, 1971.