ANALYTIC PLATFORM SIMULATION

PREPARED BY
ADVANCED ~~STUDIES~~ GROUP
AUBURN UNIVERSITY
J. L. LOWRY, PROJECT LEADER

TECHNICAL REPORT
APRIL 1966

CONTRACT—NAS 8-20004
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA 35812

AUBURN RESEARCH FOUNDATION
AUBURN UNIVERSITY
AUBURN, ALABAMA

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FOREWORD

This is a technical report prepared by the Advanced Studies Group, Electrical Engineering Department, Auburn University, toward fulfillment of Contract NAS8-20004, granted to Auburn Research Foundation, Auburn, Alabama. This contract was awarded January 19, 1965, and extended to January 18, 1966. It was further extended to April 18, 1966.

SUMMARY

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This technical report is a documentation of the analytic platform simulation program. The simulation program is written in Fortran IV computer language and follows the modular form as outlined by the NASA Computation Center, Huntsville, Alabama. Chapter I states the need for such a simulation program. Chapter II states the capabilities of the program, presents the definitions of the various quantities used in the computer program, and lists the equations solved in the various subroutines. A complete program listing is presented in Chapter III along with the analytic platform simulation flow chart. Chapters IV and V presents a typical test case and explains the operating procedures for the use of the simulation program. For more detailed information on the theory behind the simulation program, one should consult the companion report:

"An Introduction to Analytic Platforms for Inertial Guidance," <u>Technical Report</u>, Advanced Studies Group, Auburn Research Foundation, Auburn University, Auburn, Alabama, April 1966.

PERSONNEL

The following staff members of Auburn University have actively contributed in this study:

C. L. Phillips-	Professor of Electrical Engineering Project Leader, January 19, 1965 to October 19, 1965
J. L. Lowry-	Professor of Electrical Engineering Project Leader, October 19, 1965 to Present
C. L. Connor-	Graduate Assistant in Electrical Engineering 2/3 Time, September 1, 1965 to Present
W. B. Day-	Graduate Assistant in Electrical Engineering Full Time, June 1, 1965 to September 1, 1965
D. W. Kelly-	Graduate Assistant in Electrical Engineering Full Time, January 19, 1965 to Present
R. J. Vinson-	Graduate Assistant in Electrical Engineering Full Time, January 19, 1965 to September 1, 1965

I. INTRODUCTION

D. W. Kelly

The analytic platform system is one in which the mechanically stable platform is replaced by an analytic platform. A simplified block diagram of an analytic platform system is shown in Figure I-1. For more detailed information on the theory of analytic platforms, one should consult the companion report:

> "An Introduction to Analytic Platforms for Inertial Guidance," Technical Report, Advanced Studies Group, Auburn Research Foundation, Auburn University, Auburn, Alabama, April 1966.

To study the feasibility of the analytic platform system, it was simulated using a digital computer. It was determined that the following computer program conditions should hold:

(1). The program should be written in Fortram IV computer language, should be compatible with the IBM 7040 and IBM 7094 digital computer systems, and should be modular in form as outlined by NASA Computation Center, Huntsville, Alabama.

(2). The program should be general in nature so as to allow the use of different angular velocity and linear acceleration sensors, different schemes for the calculation of the rotational matrix, and different numerical integration techniques.

This report is a documentation of the described analytic platform simulation program. The outline for documentation was provided by NASA Computation Center, Huntsville, Alabama.

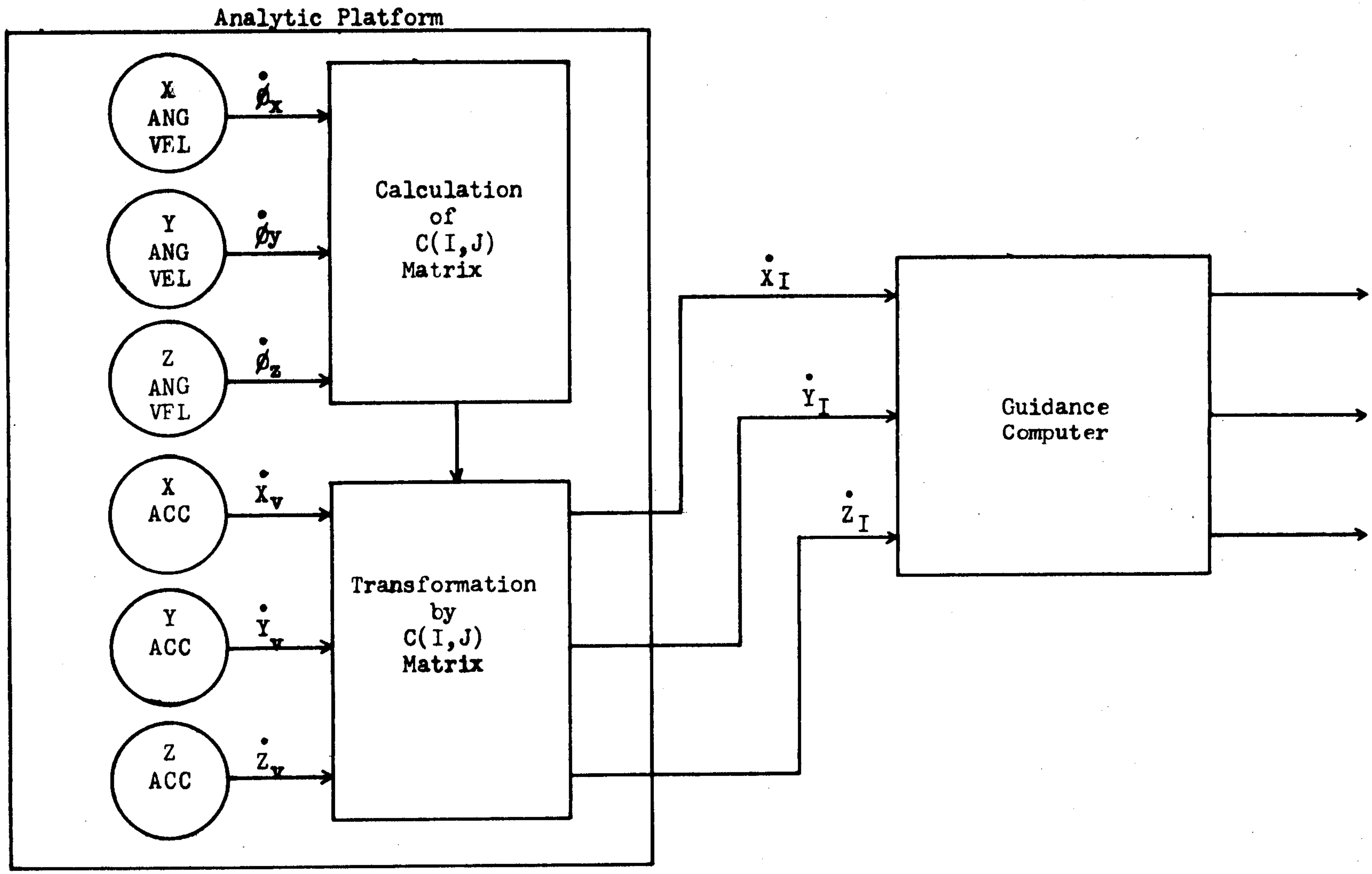


Fig. I-1--Simplified Block Diagram of the Analytic Platform Inertial Navigation Method.

II. PROBLEM DEFINITION

D. W. Kelly

A. General Problem

The purpose of the analytic platform simulation program is to calculate vehicle velocities and positions in the space-fixed coordinate system, given the angular velocities and the linear accelerations of the vehicle in the vehicle-fixed coordinate system, using the analytic platform concept. Figure II-1 is a simplified block diagram of the analytic platform concept. Figures II-2,3, and 4 are further subdivisions, in block diagram form, of the individual blocks of Figure II-1. Figure II-2 is a block diagram of either the angular velocity sensors or the linear acceleration sensors. The outputs from the angular velocity sensors are angular velocities of the vehicle, and the outputs from the linear acceleration sensors are changes in linear velocity of the vehicle in the vehicle-fixed coordinate system. These velocities are the inputs to the coordinate transformation calculation block as shown in Figure II-3. The angular velocities are used to calculate the rotational matrix, and then the rotational matrix is used to transform the changes in linear velocity from the vehicle-fixed to the space-fixed coordinate system. Provision is also made in this block to calculate the Euler angles from the rotational matrix. Figure III-4 is a block diagram showing the necessary calculations to obtain the velocity and position in the space-fixed coordinate system, taking into account gravity and initial conditions.

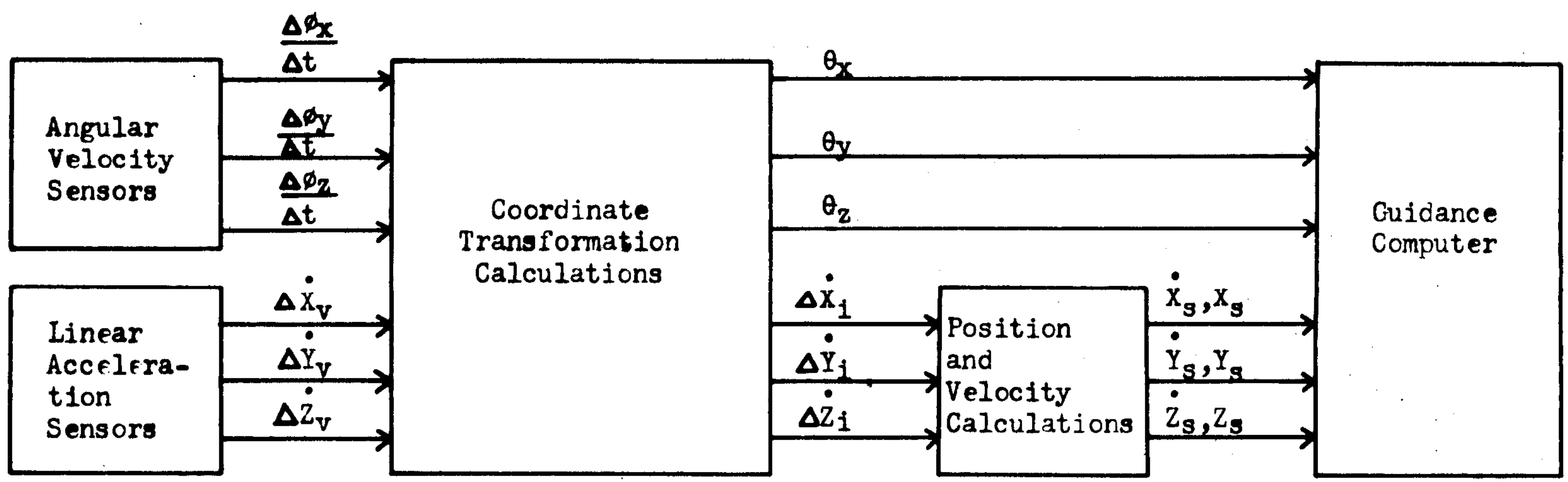


Fig. II-1--Simplified Block Diagram of the Analytic Platform Concept.

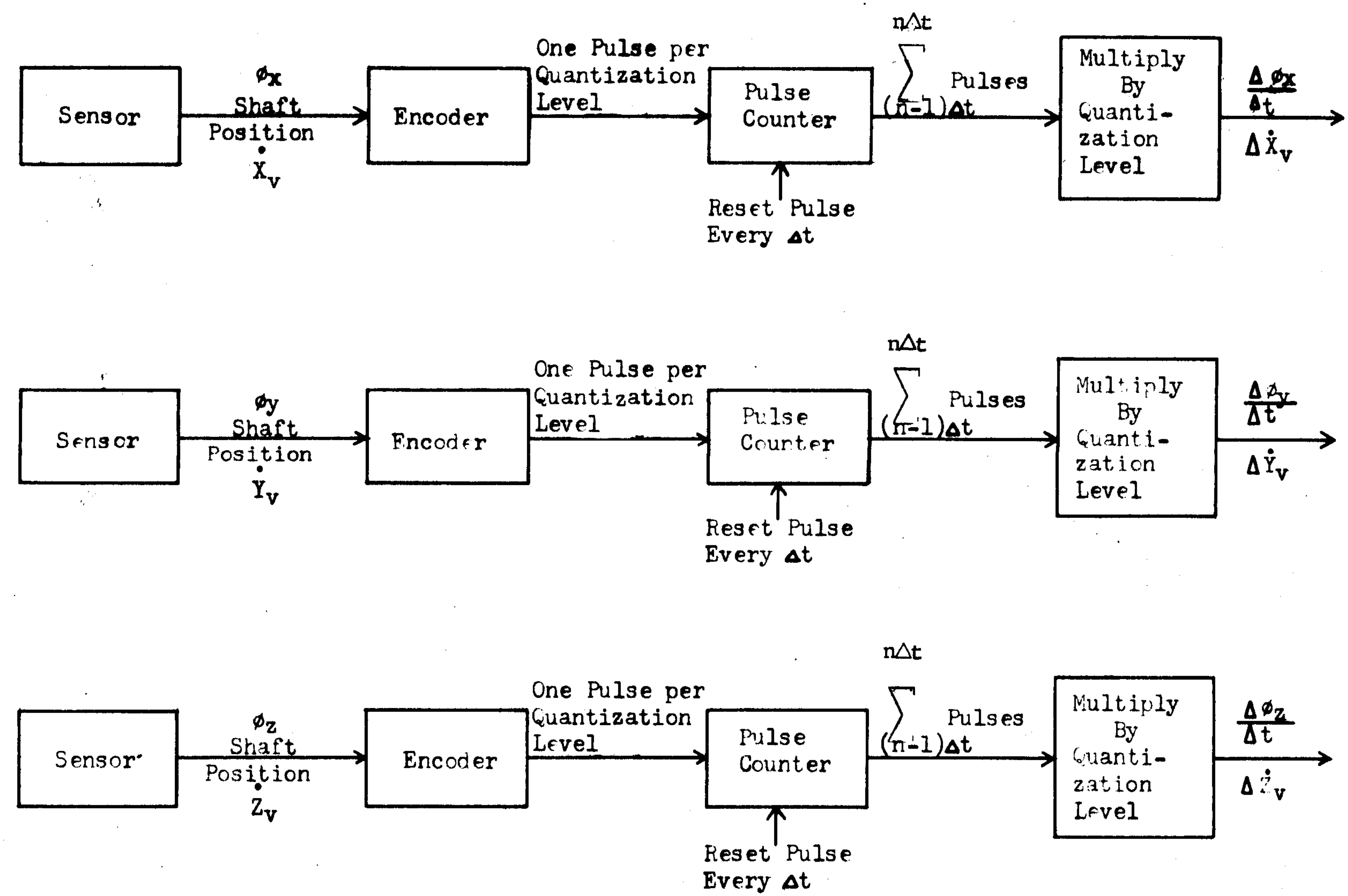


Fig. II-2--Block Diagram of Either the Angular Velocity Sensor or the Linear Acceleration Sensor.

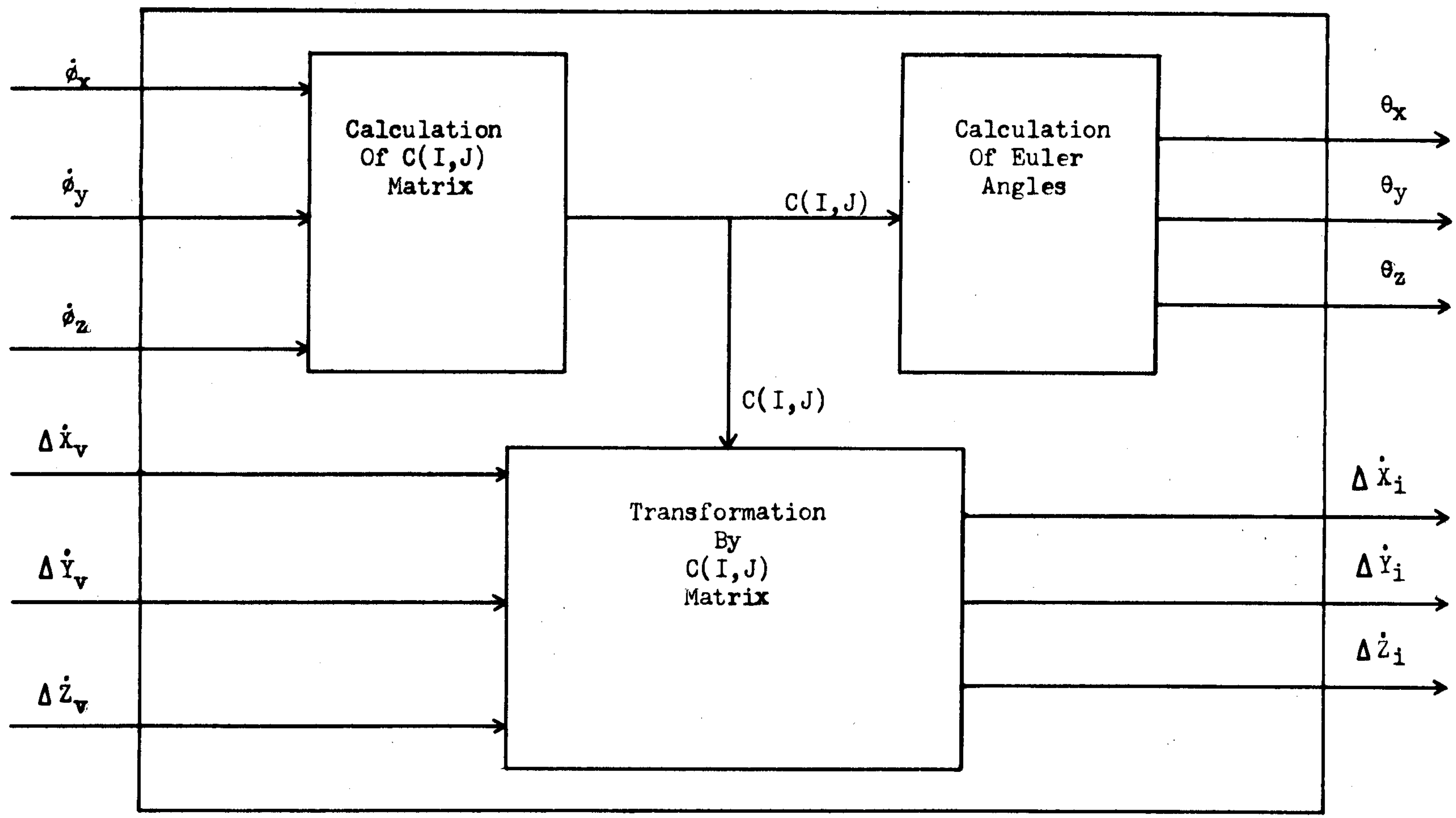


Fig. II-3--Block Diagram of the Coordinate Transformation Calculations.

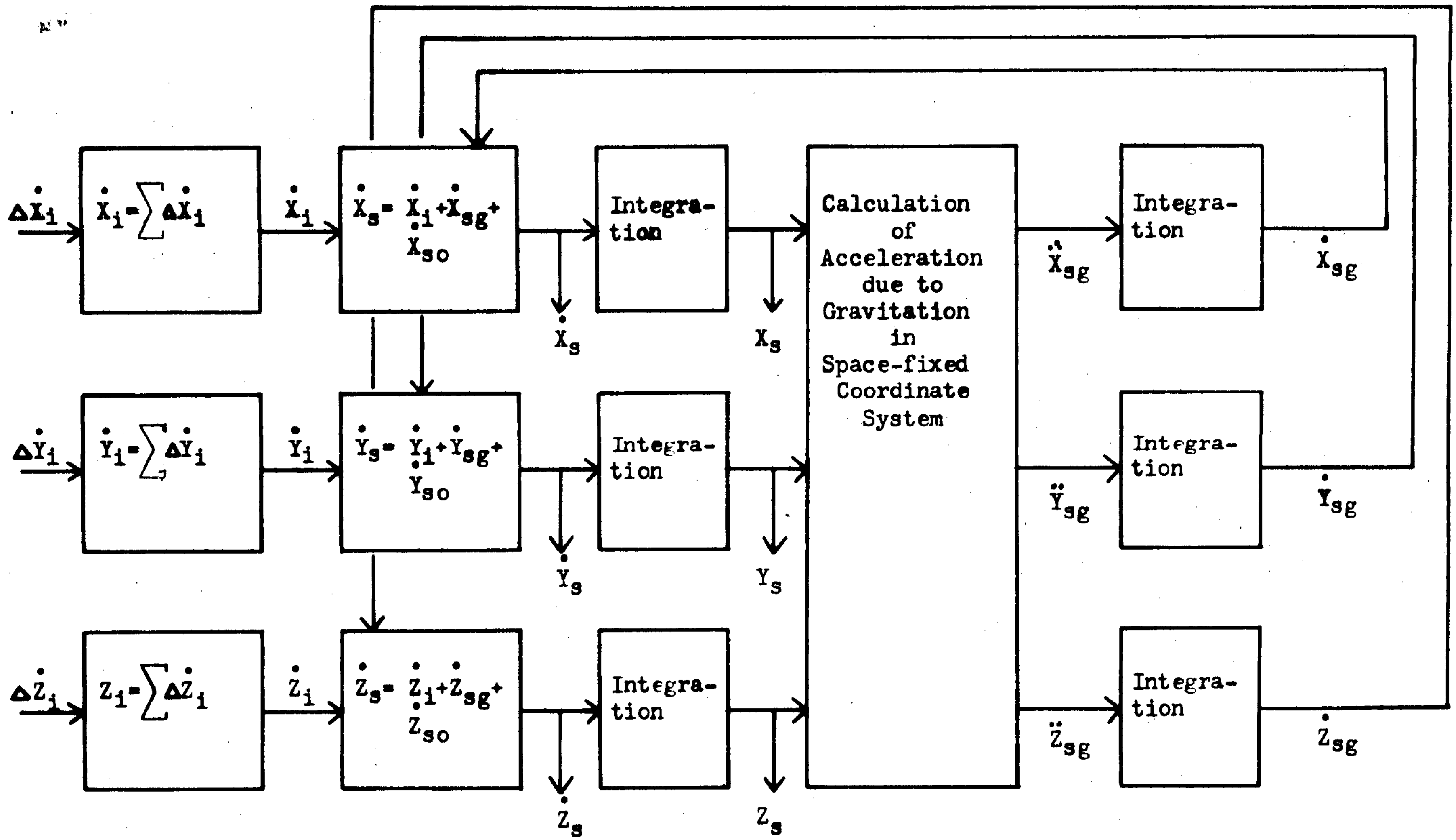


Fig. II-4--Block Diagram of the Space-Fixed Position and Velocity Calculations with Corrections for Gravity.

The following statements list the capabilities of the simulation program:

(1) The angular velocity and linear acceleration input data profiles are entered into the simulation program in tabular form at specified time intervals. Values between specified times are calculated from a straight-line interpolation.

(2) The rotational matrix may be calculated by using either the angular velocity from the input profiles, an approximated value obtained from a change in angular displacement divided by the time interval or the approximated value rounded down to the nearest quantization level. A change in velocity or a quantized change in velocity may be transformed from the vehicle-fixed to the space-fixed coordinate system.

(3) The quantization levels for the angular velocity and the linear acceleration sensors may be varied.

(4) The time between calculations, that is, the period of updating the rotational matrix may be varied. The period of updating the space-fixed velocity and position may also be varied.

(5) The rotational matrix may be calculated by either the direction cosines method, the Euler three angle method or the quaternion method.

(6) Four different numerical integration techniques may be used: Simpson's, rectangular, trapezoidal or weighted averages.

(7) Other quantities that may be controlled by the operator are cutoff time, printing time, velocity cutoff, initial conditions and input data printing.

B. Symbols and Definitions

This section lists the symbols, both mnemonic and mathematical, and their definitions as used in the analytic platform simulation program.

Mnemonic Internal	Mnemonic Printed	Mathematical	Definition
XS(1) XS(2) XS(3)	XS YS ZS	X_s Y_s Z_s	Position of the vehicle in the space-fixed coordinate system.
VXS(1) VXS(2) VXS(3)	VXS VYS VZS	$\dot{X}_s$ $\dot{Y}_s$ $\dot{Z}_s$	Velocity of the vehicle in the space-fixed coordinate system.
VXI(1) VXI(2) VXI(3)	VXI VYI VZI	$\dot{X}_i$ $\dot{Y}_i$ $\dot{Z}_i$	Velocity of the vehicle in the space-fixed coordinate system not corrected for gravity.
VXSG(1) VXSG(2) VXSG(3)	VXSG VYSG VZSG	$\dot{X}_{sg}$ $\dot{Y}_{sg}$ $\dot{Z}_{sg}$	Velocity of the vehicle due to gravity in the space-fixed coordinate system.
AXSG(1) AXSG(2) AXSG(3)	AXSG AYSG AZSG	$\ddot{X}_{sg}$ $\ddot{Y}_{sg}$ $\ddot{Z}_{sg}$	Acceleration of the vehicle due to gravity in the space-fixed coordinate system.
RS		R_s	Radial distance from the earth center to the vehicle.
VS		V_s	Magnitude of the vehicle velocity.
GAMMA		γ	Flight path angle relative to the local horizontal.

G	G	Flight path angle relative to the local vertical.
RSLL	R_o	Radial distance from the earth center to the launch site.
GME	μ_e	Earth gravitational constant.
NUMBER	Number	Number of points on the angular velocity and linear acceleration profiles.
TXYZ	T_{xyz}	Time between points on the angular velocity and linear acceleration input data profiles.
XINPUT (1, number) XINPUT (2, number) XINPUT (3, number)	$\dot{\phi}_x$(number) $\dot{\phi}_y$(number) $\dot{\phi}_z$(number)	Angular velocity input profiles in the x, y, and z directions (radians/second).
XINPUT (4, number) XINPUT (5, number) XINPUT (6, number)	$\ddot{X}_v$(number) $\ddot{Y}_v$(number) $\ddot{Z}_v$(number)	Linear acceleration input profiles in the x, y, and z directions (meters/second^2).
XINPUT (7, number)	T (number)	Time for input profiles (seconds).
C(I,J)	C(i,j)	The ijth element of the three by three orthogonal matrix, determined by angular velocities of the vehicle, used to transform from the vehicle-fixed to space-fixed coordinate systems.
VPHIX(1) VPHIX VPHIX(2) VPHIY VPHIX(3) VPHIZ	$\dot{\phi}_x$ $\dot{\phi}_y$ $\dot{\phi}_z$	The angular velocities of tne vehicle.
VPHIX(4) VPHIX(5) VPHIX(6)	$\Delta\phi_x/\Delta t$ $\Delta\phi_y/\Delta t$ $\Delta\phi_z/\Delta t$	The approximated values of angular velocities.
VPHIX(7) VPHIX(8) VPHIX(9)	$\Delta\phi_{xq}/\Delta t$ $\Delta\phi_{yq}/\Delta t$ $\Delta\phi_{zq}/\Delta t$	The approximated values of angular velocities rounded down to the nearest quantization level.
DELVXV(1) DELVXV(2) DELVXV(3)	$\Delta\dot{X}_v$ $\Delta\dot{Y}_v$ $\Delta\dot{Z}_v$	The changes in linear velocity.
DELVXV(4) DELVXV(5) DELVXV(6)	$\Delta\dot{X}_{vq}$ $\Delta\dot{Y}_{vq}$ $\Delta\dot{Z}_{vq}$	The changes in linear velocity rounded down to the nearest quantization level.

DELVXI(1) DELVXI(2) DELVXI(3)	DELVXI DELVYI DELVZI	$\Delta\dot{X}_i$ $\Delta\dot{Y}_i$ $\Delta\dot{Z}_i$	Change in velocity of the vehicle in space-fixed coordinates,not corrected for gravity.
P Q R		P Q R	The particular values of angular velocities that are used to calculate the transformation matrix. See KEXACT.
X Y Z		X Y Z	The particular values of changes in linear velocity that are transformed from the vehicle-fixed to space-fixed coordinate system. See KEXACT.
NX NY NZ		N_x N_y N_z	Whole numbers representing the number of quantization levels in angular velocity.
PX PY PZ		P_x P_y P_z	Whole numbers representing the number of quantization levels in a change in linear velocity.
XOLD YOLD ZOLD		$\dot{\phi}_x(t_o)$ or $\ddot{X}_v(t_o)$ $\dot{\phi}_y(t_o)$ or $\ddot{Y}_v(t_o)$ $\dot{\phi}_z(t_o)$ or $\ddot{Z}_v(t_o)$	Previous values of both the quantities represented. Since they are in different subroutines the quantities retain their correct values.
XLEFT YLEFT ZLEFT		$\Delta\phi_{x1}(t_o)$ or $\Delta\dot{X}_{v1}$ $\Delta\phi_{y1}(t_o)$ or $\Delta\dot{Y}_{v1}$ $\Delta\phi_{z1}(t_o)$ or $\Delta\dot{Z}_{v1}$	Remainder terms which must be accounted for in the computations of VPHIX and DELVXV. Since they are in different subroutines the quantities retain their correct values.
QANG		Qang	Quantization level of the angular velocity sensors (radians).
QVEL		Qvel	Quantization level of the linear acceleration sensors (meters/second).
TCIJ		Tcij	Period of updating the C(I,J) transformation matrix.
TOTCIJ		Totcij	Time at which the C(I,J) should be updated again.
TNAV		Tnav	Period of computing the position and velocity.

TOTNAV	Totnav	Time at which the next position and velocity should be computed.
TCUT	Tcut	Time at which the system should cutoff. Usually associated with burnout.
VCUT	Vcut	Velocity at which the system should cutoff. Usually the required velocity for orbit.
KREAD		Internal flag used to eliminate the necessity of reading all initial conditions went another run is desired.
KCUT		Internal flag used to start the final run through the system when indicated by TCUT or VCUT.
KEXACT		System option, externally controlled, used to select the quantities that are used to calculate the C(I,J) matrix and the quantities that are transformed to the space-fixed coordinate system. KEXACT = 1 P = VPHIX(1) Q = VPHIX(2) R = VPHIX(3) X = DELVXV(1) Y = DELVXV(2) Z = DELVXV(3) KEXACT = 2 P = VPHIX(4) Q = VPHIX(5) R = VPHIX(6) X = DELVXV(1) Y = DELVXV(2) Z = DELVXV(3) KEXACT = 3 P = VPHIX(7) Q = VPHIX(8) R = VPHIX(9) X = DELVXV(4) Y = DELVXV(5) Z = DELVXV(6)
KOPT		System option, externally controlled, used to select the particular method of calculating the C(I,J) matrix. KOPT = 1 Direction Cosines KOPT = 2 Euler Three Angles KOPT = 3 Quaternions

INNER			System option, externally controlled, used to select the particular integration scheme that will be used. INNER = 1 Weighted Averages Integration INNER = 2 Trapezoidal Integration INNER = 3 Simpson's Integration INNER = 4 Rectangular Integration
TPRINT		Tprint	Period of printing time.
TPRNOW		Tprnow	Time at which the next printing is due.
THX(1) THX(2) THX(3)	THX THY TYZ	θ_x θ_y θ_z	Euler angles.
VTHX(1) VTHX(2) VTHX(3)	VTHX VTHY VTHZ	$\dot{\theta}_x$ $\dot{\theta}_y$ $\dot{\theta}_z$	Rates of change of Euler angles.
E1 E2 E3 E4		E_1 E_2 E_3 E_4	Cayley-Klein parameters
A1 A2 A3 A4 A5 A6		A_1 A_2 A_3 A_4 A_5 A_6	Orthogonality checks of C(I,J) matrix.
B1 B2 B3 B4 B5 B6		B_1 B_2 B_3 B_4 B_5 B_6	Normality checks of C(I,J) matrix.
AORBIT		A_{orbit}	Semimajor axis of orbit.
BORBIT		B_{orbit}	Semiminor axis of orbit.
EORBIT		E_{orbit}	Eccentricity of orbit.
RAORB		R_{aorb}	Apogee radius of orbit.

RPORB	R_{porb}	Perigee radius of orbit.
VAORB	V_{aorb}	Orbital velocity at apogee.
VPORB	V_{porb}	Orbital velocity at perigee.
D1 D2 KDUM K1 K2 K3 L1 L2 L3 A B D E F		Dummy variables used only to save constants and/or for convenience.

C. Equations and Abstracts

This section lists all the equations that are used in the analytic platform simulation program. The abstract for each routine is also given.

Routine MAIN

This routine controls the entire simulation program flow. It calls the different subroutines and directs the steps to be done.

Routine READ1

This routine reads and prints the input profiles of both angular velocity and linear acceleration of the vehicle.

Routine READ2

This routine reads and prints all initial conditions and all system options.

Routine ANGVEL

This routine simulates a simplified version of the encoder attached to the angular velocity sensor. The following equations are solved in this routine.

$$J = K + 1$$

$$\dot{\phi}_x(t) = \dot{\phi}_x(K) + \left[\dot{\phi}_x(J) - \dot{\phi}_x(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\dot{\phi}_y(t) = \dot{\phi}_y(K) + \left[\dot{\phi}_y(J) - \dot{\phi}_y(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\dot{\phi}_z(t) = \dot{\phi}_z(K) + \left[\dot{\phi}_z(J) - \dot{\phi}_z(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\Delta\phi_x(t) = \left[\dot{\phi}_x(t) + \dot{\phi}_x(t_o)\right] T_{cij} / 2$$

$$\Delta\phi_y(t) = \left[\dot{\phi}_y(t) + \dot{\phi}_y(t_o)\right] T_{cij} / 2$$

$$\Delta\phi_z(t) = \left[\dot{\phi}_z(t) + \dot{\phi}_z(t_o)\right] T_{cij} / 2$$

$$\frac{\Delta\phi_x(t)}{\Delta t} = \frac{\Delta\phi_x(t)}{T_{cij}}$$

$$\frac{\Delta\phi_y(t)}{\Delta t} = \frac{\Delta\phi_y(t)}{T_{cij}}$$

$$\frac{\Delta\phi_z(t)}{\Delta t} = \frac{\Delta\phi_z(t)}{T_{cij}}$$

$$\left.\begin{aligned} N_{xq} &= \left[\Delta\phi_x(t) + \Delta\phi_{x1}(t_o)\right] / \text{Qang} \\ N_{yq} &= \left[\Delta\phi_y(t) + \Delta\phi_{y1}(t_o)\right] / \text{Qang} \\ N_{zq} &= \left[\Delta\phi_z(t) + \Delta\phi_{z1}(t_o)\right] / \text{Qang} \end{aligned}\right\} \quad \text{Rounded down to whole number.}$$

$$\frac{\Delta\phi_{xq}(t)}{\Delta t} = N_{xq} \cdot \text{Qang} / T_{cij}$$

$$\frac{\Delta\phi_{yq}(t)}{\Delta t} = N_{yq} \cdot \text{Qang} / T_{cij}$$

$$\frac{\Delta\phi_{zq}(t)}{\Delta t} = N_{zq} \cdot \text{Qang} / T_{cij}$$

$$\Delta\phi_{x1}(t_o) = \Delta\phi_x(t) - \Delta\phi_{xq}(t) + \Delta\phi_{x1}(t_o)$$

$$\Delta\phi_{y1}(t_o) = \Delta\phi_y(t) - \Delta\phi_{yq}(t) + \Delta\phi_{y1}(t_o)$$

$$\Delta\phi_{z1}(t_o) = \Delta\phi_z(t) - \Delta\phi_{zq}(t) + \Delta\phi_{z1}(t_o)$$

The calculations should be done in the order shown

Routine DIRCOS

This routine calculates the direction cosines from the vehicle angular velocities ,that is, it updates the C(IJ) matrix. The following equations are solved in this routine:

$$\dot{C}(1,1) = C(1,2)\,R - C(1,3)\,Q$$

$$\dot{C}(1,2) = C(1,3)\,P - C(1,1)\,R$$

$$\dot{C}(1,3) = C(1,1)\,Q - C(1,2)\,P$$

$$\dot{C}(2,1) = C(2,2)\,R - C(2,3)\,Q$$

$$\dot{C}(2,2) = C(2,3)\,P - C(2,1)\,R$$

$$\dot{C}(2,3) = C(2,1)\,Q - C(2,2)\,P$$

$$\dot{C}(3,1) = C(3,2)\,R - C(3,3)\,Q$$

$$\dot{C}(3,2) = C(3,3)\,P - C(3,1)\,R$$

$$\dot{C}(3,3) = C(3,1)\,Q - C(3,2)\,P$$

These equations are then integrated according to some numerical technique to obtain the new values of the C(I,J) matrix.

Routine INTEGR

This routine contains four different integration schemes; Simpson's, rectangular, trapezoidal, and weighted averages. The following computations are made to accomplish this.

Weighted averages

$$Z_n = Z_{n-1} + \frac{\Delta t}{2}\,(3\dot{Z}_n - \dot{Z}_{n-1})$$

Trapezoidal rule

$$Z_n = Z_{n-1} + \frac{\Delta t}{2}\,(\dot{Z}_n - \dot{Z}_{n-1})$$

Simpson's rule

$$Z_n = Z_{n-2} + \frac{\Delta t}{3}\,(\dot{Z}_n + 4\dot{Z}_{n-1} + \dot{Z}_{n-2})$$

Rectangular rule

$$Z_n = Z_{n-1} + \Delta t\,\dot{Z}_n$$

Routine EULER 3

This routine calculates the Euler angles from the vehicle angular velocities. The following equations are solved in this routine:

$$\dot{\theta}_x = P \cos \theta_y + R \sin \theta_y$$

$$\dot{\theta}_y = P \sin \theta_y \tan \theta_x + Q - R \cos \theta_y \tan \theta_x$$

$$\dot{\theta}_z = (-P \sin \theta_y / \cos \theta_x) + (R \cos \theta_y / \cos \theta_x)$$

These equations are then integrated according to some numerical technique to obtain the new values of the Euler angles. Afterwards the following computations are performed to obtain the C(I,J) matrix.

$$C(1,1) = \cos \theta_y \cos \theta_z - \sin \theta_x \sin \theta_y \sin \theta_z$$

$$C(1,2) = - \cos \theta_x \sin \theta_z$$

$$C(1,3) = \sin \theta_y \cos \theta_z + \sin \theta_x \cos \theta_y \sin \theta_z$$

$$C(2,1) = \cos \theta_y \sin \theta_z + \sin \theta_x \sin \theta_y \cos \theta_z$$

$$C(2,2) = \cos \theta_x \cos \theta_z$$

$$C(2,3) = \sin \theta_y \sin \theta_z - \sin \theta_x \cos \theta_y \cos \theta_z$$

$$C(3,1) = -\cos \theta_x \sin \theta_y$$

$$C(3,2) = \sin \theta_x$$

$$C(3,3) = \cos \theta_x \cos \theta_y$$

<u>Routine QUATER</u>

This routine calculates the Cayley-Klein parameters from the vehicle angular velocities. The following equations are solved in this routine.

$$\dot{E}_1 = \frac{1}{2}(-E_4P - E_3Q - E_2R)$$
$$\dot{E}_2 = \frac{1}{2}(-E_3P + E_4Q + E_1R)$$
$$\dot{E}_3 = \frac{1}{2}(+E_2P + E_1Q - E_4R)$$
$$\dot{E}_4 = \frac{1}{2}(+E_1P - E_2Q + E_3R)$$

These equations are then integrated according to some numerical technique to obtain the new values of the parameters. Afterwards the following computions are performed to obtain the C(I,J) matrix.

$$C(1,1) = E_1^2 - E_2^2 - E_3^2 + E_4^2$$
$$C(1,2) = 2(-E_1E_2 + E_3E_4)$$
$$C(1,3) = 2(+E_2E_4 + E_1E_3)$$
$$C(2,1) = 2(+E_3E_4 + E_1E_2)$$
$$C(2,2) = E_1^2 - E_2^2 + E_3^2 - E_4^2$$
$$C(2,3) = 2(+E_2E_3 - E_4E_1)$$
$$C(3,1) = 2(-E_1E_3 + E_2E_4)$$
$$C(3,2) = 2(+E_2E_3 + E_1E_4)$$
$$C(3,3) = E_1^2 + E_2^2 - E_3^2 - E_4^2$$

Routine LINAC

This routine simulates a simplified version of the encoder attached to the linear acceleration sensor. The following equations are solved in this routine.

$$J = K + 1$$

$$\ddot{X}_v(t) = \ddot{X}_v(K) + \left[\ddot{X}_v(J) - \ddot{X}_v(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\ddot{Y}_v(t) = \ddot{Y}_v(K) + \left[\ddot{Y}_v(J) - \ddot{Y}_v(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\ddot{Z}_v(t) = \ddot{Z}_v(K) + \left[\ddot{Z}_v(J) - \ddot{Z}_v(K)\right] \left[t - T(K)\right] / T_{xyz}$$

$$\Delta\dot{X}_v(t) = \left[\ddot{X}_v(t) + \ddot{X}_v(t_o)\right] T_{nav}/2$$

$$\Delta\dot{Y}_v(t) = \left[\ddot{Y}_v(t) + \ddot{Y}_v(t_o)\right] T_{nav}/2$$

$$\Delta\dot{Z}_v(t) = \left[\ddot{Z}_v(t) + \ddot{Z}_v(t_o)\right] T_{nav}/2$$

$$\left.\begin{aligned} P_{xq} &= \left[\Delta\dot{X}_v(t) + \Delta\dot{X}_{v1}(t_o)\right] / Q_{vel} \\ P_{yq} &= \left[\Delta\dot{Y}_v(t) + \Delta\dot{Y}_{v1}(t_o)\right] / Q_{vel} \\ P_{zq} &= \left[\Delta\dot{Z}_v(t) + \Delta\dot{Z}_{v1}(t_o)\right] / Q_{vel} \end{aligned}\right\} \quad \text{Rounded down to whole number.}$$

$$\Delta\dot{X}_{vq} = P_{xq} Q_{vel}$$

$$\Delta\dot{Y}_{vq} = P_{yq} Q_{vel}$$

$$\Delta\dot{Z}_{vq} = P_{zq} Q_{vel}$$

$$\Delta\dot{X}_{v1}(t_o) = \Delta\dot{X}_v(t) - \Delta\dot{X}_{vq}(t) + \Delta\dot{X}_{v1}(t_o)$$

$$\Delta\dot{Y}_{v1}(t_o) = \Delta\dot{Y}_v(t) - \Delta\dot{Y}_{vq}(t) + \Delta\dot{Y}_{v1}(t_o)$$

$$\Delta\dot{Z}_{v1}(t_o) = \Delta\dot{Z}_v(t) - \Delta\dot{Z}_{vq}(t) + \Delta\dot{Z}_{v1}(t_o)$$

$$\ddot{X}_v(t_o) = \ddot{X}_v(t)$$

$$\ddot{Y}_v(t_o) = \ddot{Y}_v(t)$$

$$\ddot{Z}_v(t_o) = \ddot{Z}_v(t)$$

Routine TRANS

This routine transforms the velocities from vehicle-fixed coordinates to space-fixed coordinates. The following computations are made

$$\Delta\dot{X}_i(t) = C(1,1)\ \Delta\dot{X}_v(t) + C(1,2)\ \Delta\dot{Y}_v(t) + C(1,3)\ \Delta\dot{Z}_v(t)$$
$$\Delta\dot{Y}_i(t) = C(2,1)\ \Delta\dot{X}_v(t) + C(2,2)\ \Delta\dot{Y}_v(t) + C(2,3)\ \Delta\dot{Z}_v(t)$$
$$\Delta\dot{Z}_i(t) = C(3,1)\ \Delta\dot{X}_v(t) + C(3,2)\ \Delta\dot{Y}_v(t) + C(3,3)\ \Delta\dot{Z}_v(t)$$

$$\dot{X}_i(t) = \dot{X}_i(t_o) + \Delta\dot{X}_i(t)$$
$$\dot{Y}_i(t) = \dot{Y}_i(t_o) + \Delta\dot{Y}_i(t)$$
$$\dot{Z}_i(t) = \dot{Z}_i(t_o) + \Delta\dot{Z}_i(t)$$

$$\dot{X}_i(t_o) = \dot{X}_i(t)$$
$$\dot{Y}_i(t_o) = \dot{Y}_i(t)$$
$$\dot{Z}_i(t_o) = \dot{Z}_i(t)$$

<u>Routine GRAV</u>

This routine corrects the velocities and distances for gravity assumming a spherical earth. The following calculations are made.

$$\ddot{X}_{sg} = \mu_e\ X_s\ /\ (X_s^2 + Y_s^2 + Z_s^2)^{\frac{3}{2}}$$
$$\ddot{Y}_{sg} = \mu_e\ Y_s\ /\ (X_s^2 + Y_s^2 + Z_s^2)^{\frac{3}{2}}$$
$$\ddot{Z}_{sg} = \mu_e\ Z_s\ /\ (X_s^2 + Y_s^2 + Z_s^2)^{\frac{3}{2}}$$

These equations are then integrated to obtain the velocities due to gravity, $\dot{X}_{sg}$, $\dot{Y}_{sg}$, and $\dot{Z}_{sg}$. Then

$$\dot{X}_s = \dot{X}_i - \dot{X}_{sg}$$
$$\dot{Y}_s = \dot{Y}_i - \dot{Y}_{sg}$$
$$\dot{Z}_s = \dot{Z}_i - \dot{Z}_{sg}$$

These equations are then integrated to obtain the position of the vehicle in space-fixed coordinate system.

Routine PRINTO

This routine prints pertinent information for a complete analysis of the system. This routine performs a few calculations necessary for the print out. These calculations are:

$$R_s = \sqrt{X_s^2 + Y_s^2 + Z_s^2}$$

$$V_s = \sqrt{\dot{X}_s^2 + \dot{Y}_s^2 + \dot{Z}_s^2}$$

$$D_1 = X_s\dot{X}_s + Y_s\dot{Y}_s + Z_s\dot{Z}_s$$

$$D_2 = \sqrt{(V_sR_s)^2 - D_1^2}$$

$$\gamma = \mathrm{Tan}^{-1}\,(D_1/D_2)$$

$$h = R_s - R_o$$

$$G = 90.0 - \frac{180\gamma}{\pi}$$

and

$$A_1 = C(1,1)\ C(1,2) + C(2,1)\ C(2,2) + C(3,1)\ C(3,2)$$

$$A_2 = C(1,1)\ C(1,3) + C(2,1)\ C(2,3) + C(3,1)\ C(3,3)$$

$$A_3 = C(1,2)\ C(1,3) + C(2,2)\ C(2,3) + C(3,2)\ C(3,3)$$

$$A_4 = C(1,1)\ C(2,1) + C(1,2)\ C(2,2) + C(1,3)\ C(2,3)$$

$$A_5 = C(1,1)\ C(3,1) + C(1,2)\ C(3,2) + C(1,3)\ C(3,3)$$

$$A_6 = C(2,1)\ C(3,1) + C(2,2)\ C(3,2) + C(2,3)\ C(3,3)$$

$$B_1 = C(1,1)^2 + C(2,1)^2 + C(3,1)^2$$

$$B_2 = C(1,2)^2 + C(2,2)^2 + C(3,2)^2$$

$$B_3 = C(1,3)^2 + C(2,3)^2 + C(3,3)^2$$

$$B_4 = C(1,1)^2 + C(1,2)^2 + C(1,3)^2$$

$$B_5 = C(2,1)^2 + C(2,2)^2 + C(2,3)^2$$

$$B_6 = C(3,1)^2 + C(3,2)^2 + C(3,3)^2$$

Routine ORBIT

This routine calculates and prints the orbital parameters. The following calculations are made.

$$D_1 = (R_s V_s^2) / \mu_e$$

$$\text{Aorbit} = R_s / (2-D_1)$$

$$\text{Borbit} = \text{Aorbit } D_1 \cos^2(\gamma)$$

$$\text{Eorbit} = 1 - D_1(2-D_1) \cos^2(\gamma)$$

$$\text{Raorb} = \text{Aorbit } (1 + \text{Eorbit})$$

$$\text{Rporb} = \text{Aorbit } (1 - \text{Eorbit})$$

$$D_2 = V_s / (D_1 \cos \gamma)$$

$$\text{Vaorb} = D_2 (1 - \text{Eorbit})$$

$$\text{Vporb} = D_2 (1 + \text{Eorbit})$$

III. COMPUTER PROGRAM AND FLOW CHART

This section contains:

1) Analytic Platform Simulation Program Listing.

2) Memory Map of Analytic Platform Simulation Program.

3) Analytic Platform Simulation Program Flow Chart.

Analytic Platform Simulation Program Listing.

```
$IBFTC MAIN     DECK
      COMMON /COMM01/ NUMBER,TXYZ,XINPUT
      COMMON /COMM02/ VXS,XS
      COMMON /COMM03/ INNER
      COMMON /COMM04/ RSLL,GME
      COMMON /COMM05/ QANG,J
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM07/ QVFL,L
      COMMON /COMM08/ TNAV,TOTNAV
      COMMON /COMM09/ TCUT,VCUT
      COMMON /COMM10/ VPHIX
      COMMON /COMM11/ DELVXV
      COMMON /COMM12/ VXI
      COMMON /COMM13/ C
      COMMON /COMM14/ P,Q,R
      COMMON /COMM15/ X,Y,Z
      COMMON /COMM16/ KREAD,KEXACT,KOPT
      COMMON /COMM17/ TPRINT,TPRNOW
      COMMON /COMM18/ AXSG
      COMMON /COMM19/ RS,VS,GAMMA
      DIMENSION XINPUT(7,700),VXS(3),XS(3),VXI(3),DELVXV(6),VPHIX(9),C(3
     1,3),AXSG(3),VXSG(3),THX(3),VTHX(3)
      KREAD=1
      CALL READ1
    1 CALL READ2
      KCUT=1
    2 IF (TOTCIJ.GE.TCUT) GO TO 3
      IF (TOTCIJ.LE.TOTNAV) GO TO 4
      GO TO 5
    3 TCIJ=TCUT-TOTCIJ+TCIJ
      TNAV=TCUT-TOTNAV+TNAV
      TOTCIJ=TCUT
      TOTNAV=TCUT
      KCUT=2
    4 CALL ANGVEL
      K1=KEXACT*3-2
      K2=KEXACT*3-1
      K3=KEXACT*3
      P=VPHIX(K1)
      Q=VPHIX(K2)
      R=VPHIX(K3)
      GO TO (6,7,8), KOPT
    6 CALL DIRCOS
      GO TO 9
    7 CALL EULER3
      GO TO 9
    8 CALL QUATER
    9 IF (KCUT.EQ.2) GO TO 5
      TOTCIJ=TOTCIJ+TCIJ
      GO TO 2
```

Continued

```
 5 CALL LINAC
   KDUM=1
   IF (KEXACT.GT.2) KDUM=2
   L1=KDUM*3-2
   L2=KDUM*3-1
   L3=KDUM*3
   X=DELVXV(L1)
   Y=DELVXV(L2)
   Z=DELVXV(L3)
   CALL TRANS
   CALL GRAV
   VS=SQRT(VXS(1)**2+VXS(2)**2+VXS(3)**2)
   IF (VCUT.LE.VS) KCUT=2
   IF (KCUT.EQ.2) GO TO 11
   IF (TPRNOW.LE.TOTNAV) GO TO 11
   TOTNAV=TOTNAV+TNAV
   GO TO 2
11 CALL PRINTO
   TPRNOW=TPRNOW+TPRINT
   TOTNAV=TOTNAV+TNAV
   IF (KCUT.EQ.2) GO TO 12
   GO TO 2
12 CALL ORBIT
   GO TO 1
   END
```

Continued

```
$IBFTC READ1   DECK
      SUBROUTINE READ1
C     ABSTRACT.....THIS ROUTINE READS AND PRINTS THE INPUT PROFILES OF
C     BOTH ANGULAR VELOCITY AND LINEAR ACCELERATION OF THE VEHICLE.
      COMMON /COMM01/ NUMBER,TXYZ,XINPUT
      DIMENSION XINPUT(7,700)
   10 FORMAT(5X,I5,5X,F7.4,5X,I2)
   20 FORMAT(3(5X,E15.8),5X,F7.1)
   30 FORMAT(30X,20H ERROR IN INPUT DATA,5X,F6.1)
   40 FORMAT(1H1,6X,57HINPUT PROFILES...ANGULAR VELOCITY AND LINEAR ACCE
     1LERATION)
   50 FORMAT(//,6X,23HTOTAL NUMBER OF POINTS=,I5)
   55 FORMAT(//,6X,20HTIME BETWEEN POINTS=,F4.1,////)
   60 FORMAT(6X,4HTIME,6X,11HX ANG. VEL.,8X,11HY ANG. VEL.,8X,11HZ ANG.
     1VEL.,//)
   70 FORMAT(4X,F6.1,3(4X,E15.8))
   80 FORMAT(//,5X,4HTIME,7X,14HX ACCELERATION,5X,14HY ACCELERATION,5X,1
     14HZ ACCELERATION,//)
      READ(5,10) NUMBER,TXYZ,KPRINT
      N=NUMBER
      DO 1 J=1,N
    1 READ(5,20) XINPUT(1,J),XINPUT(2,J),XINPUT(3,J),XINPUT(7,J)
      DO 2 J=1,N
      READ(5,20) XINPUT(4,J),XINPUT(5,J),XINPUT(6,J),T
      IF (T.NE.XINPUT(7,J)) GO TO 3
    2 CONTINUE
      IF (KPRINT.EQ.2) RETURN
      GO TO 4
    3 WRITE(6,30) T
      STOP
    4 WRITE(6,40)
      WRITE(6,50) NUMBER
      WRITE(6,55) TXYZ
      WRITE(6,60)
      DO 5 J=1,N
    5 WRITE(6,70) XINPUT(7,J),XINPUT(1,J),XINPUT(2,J),XINPUT(3,J)
      WRITE(6,80)
      DO 6 J=1,N
    6 WRITE(6,70) XINPUT(7,J),XINPUT(4,J),XINPUT(5,J),XINPUT(6,J)
      RETURN
      END
```

Continued

```
$IBFTC READ2   DECK
      SUBROUTINE READ2
C     ABSTRACT.....THIS ROUTINE READS AND PRINTS ALL INITIAL CONDITIONS
C     AND ALL SYSTEM OPTIONS.
      COMMON /COMM02/ VXS,XS
      COMMON /COMM03/ INNER
      COMMON /COMM04/ RSLL,GME
      COMMON /COMM05/ QANG,J
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM07/ QVEL,L
      COMMON /COMM08/ TNAV,TOTNAV
      COMMON /COMM09/ TCUT,VCUT
      COMMON /COMM12/ VXI
      COMMON /COMM13/ C
      COMMON /COMM16/ KREAD,KEXACT,KOPT
      COMMON /COMM17/ TPRINT,TPRNOW
      DIMENSION VXS(3),XS(3),VXI(3),C(3,3)
   10 FORMAT(3(5X,E15.8))
   20 FORMAT(//,30X,60HX-INITIAL VELOCITY (M/S).........................
     1...........,F15.8,//)
   30 FORMAT(30X,60HY-INITIAL VELOCITY (M/S)............................
     1.........,E15.8,//)
   40 FORMAT(30X,60HZ-INITIAL VELOCITY (M/S)............................
     1.........,E15.8,//)
   50 FORMAT(30X,60HX-INITIAL DISPLACEMENT (METERS).....................
     1.........,E15.8,//)
   60 FORMAT(30X,60HY-INITIAL DISPLACEMENT (METERS).....................
     1.........,E15.8,//)
   70 FORMAT(30X,60HZ-INITIAL DISPLACEMENT (METERS).....................
     1.........,E15.8,//)
   80 FORMAT(30X,60HINITIAL RADIAL DISPLACEMENT (METERS)................
     1.........,E15.8,//)
   90 FORMAT(30X,60HEARTH GRAVITY CONSTANT (M/S/S)......................
     1.........,E15.8,//)
  100 FORMAT(3(I2,2X))
  110 FORMAT(30X,60HPRINTING TIME (SEC).................................
     1.........,E15.8,//)
  120 FORMAT(30X,60HCUTOFF TIME (SEC)...................................
     1.........,E15.8,//)
  130 FORMAT(30X,60HVELOCITY CUTOFF (M/S)...............................
     1.........,E15.8,//)
  140 FORMAT(30X,60HNAVIGATIONAL CYCLING TIME (SEC).....................
     1.........,E15.8,//)
  150 FORMAT(30X,60HC(I,J) CYCLING TIME (SEC)...........................
     1.........,E15.8,//)
  160 FORMAT(30X,60HANGULAR DISPLACEMENT QUANTIZATION LEVEL (DEG).......
     1.........,E15.8,//)
  170 FORMAT(30X,60HLINEAR VELOCITY QUANTIZATION LEVEL (M/S)............
     1.........,E15.8,//)
  180 FORMAT(40X,29HANGULAR VELOCITY.........EXACT,//)
  190 FORMAT(40X,37HCHANGE IN VELOCITY......NOT QUANTIZED,//)
```

Continued

```
200 FORMAT(40X,37HANGULAR VELOCITY........NOT QUANTIZED,//)
210 FORMAT(40X,33HANGULAR VELOCITY........QUANTIZED,//)
220 FORMAT(40X,33HCHANGE IN VELOCITY......QUANTIZED,//)
230 FORMAT(1H1)
250 FORMAT(40X,49HINPUT DATA.......INITIAL CONDITIONS AND CONSTANTS,/)
260 FORMAT(40X,26HINPUT DATA.......VARIABLES,///)
270 FORMAT(40X,36HOPTION ONE.........DIRECTION COSINES,//)
280 FORMAT(40X,37HOPTION TWO.........EULER THREE ANGLES,//)
290 FORMAT(40X,30HOPTION THREE.......QUATERNIONS,//)
300 FORMAT(40X,29HWEIGHTED AVERAGE INTEGRATION )
310 FORMAT(40X,24HTRAPEZOIDAL INTEGRATION )
320 FORMAT(40X,21HSIMPSONS INTEGRATION )
330 FORMAT(40X,24HRECTANGULAR INTEGRATION )
340 FORMAT(////////)
    GO TO (1,2), KREAD
  1 WRITE(6,230)
    WRITE(6,340)
    WRITE(6,250)
    READ(5,10) VXS(1),VXS(2),VXS(3)
    READ(5,10) XS(1),XS(2),XS(3)
    READ(5,10) RSLL,GMF
    WRITE(6,20) VXS(1)
    WRITE(6,30) VXS(2)
    WRITE(6,40) VXS(3)
    WRITE(6,50) XS(1)
    WRITE(6,60) XS(2)
    WRITE(6,70) XS(3)
    WRITE(6,80) RSLL
    WRITE(6,90) GME
    A=VXS(1)
    B=VXS(2)
    G=VXS(3)
    D=XS(1)
    E=XS(2)
    F=XS(3)
    KREAD=2
  2 READ(5,100) KEXACT,KOPT,INNER
    READ(5,10) TPRINT,TCUT,VCUT
    READ(5,10) TNAV,TCIJ
    READ(5,10) QVEL,QANG
    DO 17 I=1,3
 17 READ(5,10) (C(I,J),J=1,3)
    VXS(1)=A
    VXS(2)=B
    VXS(3)=G
    XS(1)=D
    XS(2)=E
    XS(3)=F
    VXI(1)=VXS(1)
    VXI(2)=VXS(2)
    VXI(3)=VXS(3)
    L=1
```

Continued

```
      J=1
      TPRNOW=0.0
      TOTNAV=0.0
      TOTCIJ=0.0
      WRITE(6,230)
      WRITE(6,340)
      WRITE(6,260)
      WRITE(6,110) TPRINT
      WRITE(6,120) TCUT
      WRITE(6,130) VCUT
      WRITE(6,140) TNAV
      WRITE(6,150) TCIJ
      WRITE(6,160) QANG
      WRITE(6,170) QVEL
      QANG=QANG*3.14159265/180.0
      GO TO (3,4,5), KEXACT
    3 WRITE(6,180)
      WRITE(6,190)
      GO TO 6
    4 WRITE(6,200)
      WRITE(6,190)
      GO TO 6
    5 WRITE(6,210)
      WRITE(6,220)
    6 CONTINUE
      GO TO (7,8,9), KOPT
    7 WRITE(6,270)
      GO TO 11
    8 WRITE(6,280)
      GO TO 11
    9 WRITE(6,290)
   11 CONTINUE
      GO TO (12,13,14,15), INNER
   12 WRITE(6,300)
      GO TO 16
   13 WRITE(6,310)
      GO TO 16
   14 WRITE(6,320)
      GO TO 16
   15 WRITE(6,330)
   16 RETURN
      END
```

Continued

```
$IBFTC ANGVEL  DECK
      SUBROUTINE ANGVEL
C     ABSTRACT.....THIS ROUTINE SIMULATES A SIMPLIFIED VERSION OF THE
C     ENCODER ATTACHED TO THE S.A.R.
      COMMON /COMM01/ NUMBER,TXYZ,XINPUT
      COMMON /COMM05/ QANG,J
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM10/ VPHIX
      DIMENSION XINPUT(7,700),VPHIX(9)
      IF (TOTCIJ.EQ.0.0) GO TO 1
    2 IF (TOTCIJ.GT.XINPUT(7,J)) GO TO 3
      GO TO 4
    3 J=J+1
      GO TO 2
    4 K=J-1
      XK=(TOTCIJ-XINPUT(7,K))/TXYZ
      VPHIX(1)=(XINPUT(1,J)-XINPUT(1,K))*XK+XINPUT(1,K)
      VPHIX(2)=(XINPUT(2,J)-XINPUT(2,K))*XK+XINPUT(2,K)
      VPHIX(3)=(XINPUT(3,J)-XINPUT(3,K))*XK+XINPUT(3,K)
      GO TO 5
    1 VPHIX(1)=0.0
      VPHIX(2)=0.0
      VPHIX(3)=0.0
      XOLD=0.0
      YOLD=0.0
      ZOLD=0.0
      XLEFT=0.0
      YLEFT=0.0
      ZLEFT=0.0
    5 VPHIX(4)=(VPHIX(1)+XOLD)*TCIJ/2.0
      VPHIX(5)=(VPHIX(2)+YOLD)*TCIJ/2.0
      VPHIX(6)=(VPHIX(3)+ZOLD)*TCIJ/2.0
      NX=(VPHIX(4)+XLEFT)/QANG
      NY=(VPHIX(5)+YLEFT)/QANG
      NZ=(VPHIX(6)+ZLEFT)/QANG
      VPHIX(4)=VPHIX(4)/TCIJ
      VPHIX(5)=VPHIX(5)/TCIJ
      VPHIX(6)=VPHIX(6)/TCIJ
      PX=NX
      PY=NY
      PZ=NZ
      VPHIX(7)=PX*QANG/TCIJ
      VPHIX(8)=PY*QANG/TCIJ
      VPHIX(9)=PZ*QANG/TCIJ
      XLEFT=(VPHIX(4)-VPHIX(7))*TCIJ+XLEFT
      YLEFT=(VPHIX(5)-VPHIX(8))*TCIJ+YLEFT
      ZLEFT=(VPHIX(6)-VPHIX(9))*TCIJ+ZLEFT
      XOLD=VPHIX(1)
      YOLD=VPHIX(2)
      ZOLD=VPHIX(3)
      RETURN
      END
```

Continued

```
$IBFTC DIRCOS  DECK
      SUBROUTINE DIRCOS
C     ABSTRACT.....THIS ROUTINE CALCULATES THE DIRECTION COSINES FROM
C     THE VEHICLE ANGULAR VELOCITIES.
      COMMON /COMM03/ INNER
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM13/ C
      COMMON /COMM14/ P,Q,R
      DIMENSION C(3,3)
      X1=C(1,2)*R-C(1,3)*Q
      X2=C(1,3)*P-C(1,1)*R
      X3=C(1,1)*Q-C(1,2)*P
      X4=C(2,2)*R-C(2,3)*Q
      X5=C(2,3)*P-C(2,1)*R
      X6=C(2,1)*Q-C(2,2)*P
      X7=C(3,2)*R-C(3,3)*Q
      X8=C(3,3)*P-C(3,1)*R
      X9=C(3,1)*Q-C(3,2)*P
      IF (TOTCIJ.GT.0.0) GO TO 1
      Y1=X1
      Y2=X2
      Y3=X3
      Y4=X4
      Y5=X5
      Y6=X6
      Y7=X7
      Y8=X8
      Y9=X9
      Z1=Y1
      Z2=Y2
      Z3=Y3
      Z4=Y4
      Z5=Y5
      Z6=Y6
      Z7=Y7
      Z8=Y8
      Z9=Y9
      GO TO 2
    1 CALL  INTEGR(TCIJ,Z1,Y1,X1,C(1,1))
      CALL  INTEGR(TCIJ,Z2,Y2,X2,C(1,2))
      CALL  INTEGR(TCIJ,Z3,Y3,X3,C(1,3))
      CALL  INTEGR(TCIJ,Z4,Y4,X4,C(2,1))
      CALL  INTEGR(TCIJ,Z5,Y5,X5,C(2,2))
      CALL  INTEGR(TCIJ,Z6,Y6,X6,C(2,3))
      CALL  INTEGR(TCIJ,Z7,Y7,X7,C(3,1))
      CALL  INTEGR(TCIJ,Z8,Y8,X8,C(3,2))
      CALL  INTEGR(TCIJ,Z9,Y9,X9,C(3,3))
    2 RETURN
      END
```

Continued

```
$IBFTC INTEGR  DECK
      SUBROUTINE INTEGR(DT,Z3,Z2,Z1,Z)
C     ABSTRACT.....THIS ROUTINE CONTAINS FOUR DIFFERENT INTEGRATION
C     SCHEMES,SIMPSON,RECTANGULAR,TRAPEZODIAL. AND WEIGHTED AVERAGES.
      COMMON /COMM03/ INNER
      GO TO (1,2,3,4), INNER
    1 Z=Z+DT*(3.0*Z1-Z2)/2.0
      GO TO 5
    2 Z=Z+DT*(Z2+Z1)/2.0
      GO TO 5
    3 Z=Z+DT*(Z3+4.0*Z2+Z1)/6.0
      GO TO 5
    4 Z=Z+DT*Z1
    5 Z3=Z2
      Z2=Z1
      RETURN
      END
```

Continued

```
$IBFTC EULER3  DECK
      SUBROUTINE EULER3
C     ABSTRACT.....THIS ROUTINE CALCULATES THE EULER ANGLES FROM
C     THE VEHICLE ANGULAR VELOCITIES.
      COMMON /COMM03/ INNER
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM13/ C
      COMMON /COMM14/ P,Q,R
      DIMENSION C(3,3),THX(3),VTHX(3)
      IF (TOTCIJ.GT.0.0) GO TO 1
      THX(1)=ARSIN(C(3,2))
      THX(2)=ARCOS(C(3,3)/COS(THX(1)))
      THX(3)=ARCOS(C(2,2)/COS(THX(1)))
    1 TAN=SIN(THX(1))/COS(THX(1))
      VTHX(1)=P*COS(THX(2))+R*SIN(THX(2))
      VTHX(2)=P*SIN(THX(2))*TAN+Q-R*COS(THX(2))*TAN
      VTHX(3)=-P*SIN(THX(2))/COS(THX(1))+R*COS(THX(2))/COS(THX(1))
      IF (TOTCIJ.GT.0.0) GO TO 2
      Y1=VTHX(1)
      Y2=VTHX(2)
      Y3=VTHX(3)
      Z1=Y1
      Z2=Y2
      Z3=Y3
      GO TO 3
    2 CALL INTEGR(TCIJ,Z1,Y1,VTHX(1),THX(1))
      CALL INTEGR(TCIJ,Z2,Y2,VTHX(2),THX(2))
      CALL INTEGR(TCIJ,Z3,Y3,VTHX(3),THX(3))
      C(1,1)=COS(THX(2))*COS(THX(3))-SIN(THX(1))*SIN(THX(2))*SIN(THX(3))
      C(1,2)=-COS(THX(1))*SIN(THX(3))
      C(1,3)=SIN(THX(2))*COS(THX(3))+SIN(THX(1))*COS(THX(2))*SIN(THX(3))
      C(2,1)=COS(THX(2))*SIN(THX(3))+SIN(THX(1))*SIN(THX(2))*COS(THX(3))
      C(2,2)=COS(THX(1))*COS(THX(3))
      C(2,3)=SIN(THX(2))*SIN(THX(3))-SIN(THX(1))*COS(THX(2))*COS(THX(3))
      C(3,1)=-COS(THX(1))*SIN(THX(2))
      C(3,2)=SIN(THX(1))
      C(3,3)=COS(THX(1))*COS(THX(2))
    3 RETURN
      END
```

Continued

```
$IBFTC QUATER  DECK
      SUBROUTINE QUATER
C     ABSTRACT.....THIS ROUTINE CALCULATES THE CALEY-KLEIN PARAMETERS
C     FROM THE VEHICLE ANGULAR VELOCITIES.
      COMMON /COMM03/ INNER
      COMMON /COMM06/ TCIJ,TOTCIJ
      COMMON /COMM13/ C
      COMMON /COMM14/ P,Q,R
      DIMENSION C(3,3)
      IF (TOTCIJ.GT.0.0) GO TO 1
      E1=1.0
      E2=0.0
      E3=0.0
      E4=0.0
    1 X1=0.5*(-E4*P-E3*Q-E2*R)
      X2=0.5*(-E3*P+E4*Q+E1*R)
      X3=0.5*(+E2*P+E1*Q-E4*R)
      X4=0.5*(+E1*P-E2*Q+E3*R)
      IF (TOTCIJ.GT.0.0) GO TO 2
      Y1=X1
      Y2=X2
      Y3=X3
      Y4=X4
      Z1=Y1
      Z2=Y2
      Z3=Y3
      Z4=Y4
      GO TO 3
    2 CALL INTEGR(TCIJ,Z1,Y1,X1,E1)
      CALL INTEGR(TCIJ,Z2,Y2,X2,E2)
      CALL INTEGR(TCIJ,Z3,Y3,X3,E3)
      CALL INTEGR(TCIJ,Z4,Y4,X4,E4)
      C(1,1)=E1*E1-E2*E2-E3*E3+E4*E4
      C(1,2)=2.0*(-E1*E2+E3*E4)
      C(1,3)=2.0*(+E2*E4+E1*E3)
      C(2,1)=2.0*(+E3*E4+E1*E2)
      C(2,2)=E1*E1-E2*E2+E3*E3-E4*E4
      C(2,3)=2.0*(+E2*E3-E4*E1)
      C(3,1)=2.0*(-E1*E3+E2*E4)
      C(3,2)=2.0*(+E2*E3+E1*E4)
      C(3,3)=E1*E1+E2*E2-E3*E3-E4*E4
    3 RETURN
      END
```

Continued

```
$IBFTC LINAC    DECK
      SUBROUTINE LINAC
C     ABSTRACT.....THIS ROUTINE SIMULATES A SIMPLIFIED VERSION OF THE
C     ENCODER ATTACHED TO THE P.I.G.A.
      COMMON /COMM01/ NUMBER,TXYZ,XINPUT
      COMMON /COMM07/ QVEL,L
      COMMON /COMM08/ TNAV,TOTNAV
      COMMON /COMM11/ DELVXV
      DIMENSION XINPUT(7,700),DELVXV(6)
      IF (TOTNAV.EQ.0.0) GO TO 1
    2 IF (TOTNAV.GT.XINPUT(7,L)) GO TO 3
      GO TO 4
    3 L=L+1
      GO TO 2
    1 XOLD=XINPUT(4,1)
      YOLD=XINPUT(5,1)
      ZOLD=XINPUT(6,1)
      DELVXV(1)=0.0
      DELVXV(2)=0.0
      DELVXV(3)=0.0
      DELVXV(4)=0.0
      DELVXV(5)=0.0
      DELVXV(6)=0.0
      ZLEFT=0.0
      YLEFT=0.0
      XLEFT=0.0
      GO TO 5
    4 K=L-1
      XK=(TOTNAV-XINPUT(7,K))/TXYZ
      XNEW=(XINPUT(4,L)-XINPUT(4,K))*XK+XINPUT(4,K)
      YNEW=(XINPUT(5,L)-XINPUT(5,K))*XK+XINPUT(5,K)
      ZNEW=(XINPUT(6,L)-XINPUT(6,K))*XK+XINPUT(6,K)
      DELVXV(1)=(XNEW+XOLD)*TNAV/2.0
      DELVXV(2)=(YNEW+YOLD)*TNAV/2.0
      DELVXV(3)=(ZNEW+ZOLD)*TNAV/2.0
      NX=(DELVXV(1)+XLEFT)/QVEL
      NY=(DELVXV(2)+YLEFT)/QVEL
      NZ=(DELVXV(3)+ZLEFT)/QVEL
      PX=NX
      PY=NY
      PZ=NZ
      DELVXV(4)=PX*QVEL
      DELVXV(5)=PY*QVEL
      DELVXV(6)=PZ*QVEL
      XLEFT=DELVXV(1)+XLEFT-DELVXV(4)
      YLEFT=DELVXV(2)+YLEFT-DELVXV(5)
      ZLEFT=DELVXV(3)+ZLEFT-DELVXV(6)
      XOLD=XNEW
      YOLD=YNEW
      ZOLD=ZNEW
    5 RETURN
      END
```

Continued

```
$IBFTC TRANS   DECK
      SUBROUTINE TRANS
C     ABSTRACT.....THIS ROUTINE TRANSFORMS THE VELOCITIES FROM VEHICLE-
C     FIXED COORDINATES TO SPACE-FIXED COORDINATES.
      COMMON /COMM12/ VXI
      COMMON /COMM13/ C
      COMMON /COMM15/ X,Y,Z
      DIMENSION C(3,3),VXI(3),DELVXI(3)
      DO 1 I=1,3
      DELVXI(I)=C(I,1)*X+C(I,2)*Y+C(I,3)*Z
    1 VXI(I)=VXI(I)+DELVXI(I)
      RETURN
      END
```

Continued

```
$IBFTC GRAV    DECK
      SUBROUTINE GRAV
C     ABSTRACT.....THIS ROUTINE CORRECTS THE VELOCITIFS AND DISTANCES
C     FOR GRAVITY ASSUMMING A SPHERICAL EARTH.
      COMMON /COMM02/ VXS,XS
      COMMON /COMM03/ INNER
      COMMON /COMM04/ RSLL,GME
      COMMON /COMM08/ TNAV,TOTNAV
      COMMON /COMM12/ VXI
      COMMON /COMM18/ AXSG
      DIMFNSION XS(3),VXS(3),VXI(3),AXSG(3),VXSG(3)
      RS=SQRT(XS(1)*XS(1)+XS(2)*XS(2)+XS(3)*XS(3))
      AXSG(1)=GME*XS(1)/(RS*RS*RS)
      AXSG(2)=GME*XS(2)/(RS*RS*RS)
      AXSG(3)=GME*XS(3)/(RS*RS*RS)
      IF (TOTNAV.GT.0.0) GO TO 1
      VXSG(1)=0.0
      VXSG(2)=0.0
      VXSG(3)=0.0
      Y1=AXSG(1)
      Y2=AXSG(2)
      Y3=AXSG(3)
      Z1=Y1
      Z2=Y2
      Z3=Y3
      GO TO 2
    1 CALL INTEGR(TNAV,Z1,Y1,AXSG(1),VXSG(1))
      CALL INTEGR(TNAV,Z2,Y2,AXSG(2),VXSG(2))
      CALL INTEGR(TNAV,Z3,Y3,AXSG(3),VXSG(3))
      VXS(1)=VXI(1)-VXSG(1)
      VXS(2)=VXI(2)-VXSG(2)
      VXS(3)=VXI(3)-VXSG(3)
      IF (TOTNAV.GT.0.0) GO TO 3
    2 Y4=VXS(1)
      Y5=VXS(2)
      Y6=VXS(3)
      Z4=Y4
      Z5=Y5
      Z6=Y6
      GO TO 4
    3 CALL INTEGR(TNAV,Z4,Y4,VXS(1),XS(1))
      CALL INTEGR(TNAV,Z5,Y5,VXS(2),XS(2))
      CALL INTEGR(TNAV,Z6,Y6,VXS(3),XS(3))
    4 RETURN
      END
```

Continued

```
$IBFTC PRINTO  DECK
      SUBROUTINE PRINTO
C     ABSTRACT.....THIS ROUTINE PRINTS PERTINENT INFORMATION FOR A
C     COMPLETE ANALYSIS OF THE SYSTEM.
      COMMON /COMM02/ VXS,XS
      COMMON /COMM04/ RSLL,GME
      COMMON /COMM08/ TNAV,TOTNAV
      COMMON /COMM10/ VPHIX
      COMMON /COMM11/ DELVXV
      COMMON /COMM12/ VXI
      COMMON /COMM13/ C
      COMMON /COMM18/ AXSG
      COMMON /COMM19/ RS,VS,GAMMA
      DIMENSION VXS(3),XS(3),VPHIX(9),DELVXV(6),VXI(3),C(3,3),AXSG(3)
  100 FORMAT(1H1,//////,10X,13H TIME (SEC) =,E12.5)
  101 FORMAT (/,28X,2HXS,18X,2HYS,18X,2HZS)
  102 FORMAT(/,28X,3HVXS,17X,3HVYS,17X,3HVZS)
  103 FORMAT(/,28X,3HVXI,17X,3HVYI,17X,3HVZI)
  104 FORMAT(/,10X,21H ORTHOGONALITY CHECK )
  105 FORMAT(/,10X,23H TRANSFORMATION MATRIX )
  106 FORMAT(22X,6E20.8)
  107 FORMAT(/,10X,21H HEIGHT ABOVE EARTH =,E15.8,1X,7H METERS)
  108 FORMAT(14X,17H TOTAL VELOCITY =,E15.8,1X,8H MET/SEC)
  109 FORMAT(23X,8H GAMMA =E15.8,1X,8H DEGREES)
  110 FORMAT(/,10X,16H NORMALITY CHECK)
  111 FORMAT(/,32X,6H VPHIX,14X,6H VPHIY,14X,6H VPHIZ)
  112 FORMAT(7X,15H(NOT QUANTIZED),3E20.8)
  113 FORMAT(11X,11H(QUANTIZED),3E20.8)
  114 FORMAT (/,32X,7H DELVXV,13X,7H DELVYV,13X,7H DELVZV)
  115 FORMAT(22X,3E20.8)
  116 FORMAT(/,28X,4HAXSG,16X,4HAYSG,16X,4HAZSG)
  117 FORMAT(10X,12H(DERIVATIVE),3E20.8)
      RS=SQRT(XS(1)*XS(1)+XS(2)*XS(2)+XS(3)*XS(3))
      VS=SQRT(VXS(1)*VXS(1)+VXS(2)*VXS(2)+VXS(3)*VXS(3))
      D1=XS(1)*VXS(1)+XS(2)*VXS(2)+XS(3)*VXS(3)
      D2=SQRT((VS*RS)**2-D1**2)
      GAMMA=ATAN2(D1,D2)
      H=RS-RSLL
      G=90.0-GAMMA*57.295779
      B1=C(1,1)*C(1,1)+C(2,1)*C(2,1)+C(3,1)*C(3,1)
      B2=C(1,2)*C(1,2)+C(2,2)*C(2,2)+C(3,2)*C(3,2)
      B3=C(1,3)*C(1,3)+C(2,3)*C(2,3)+C(3,3)*C(3,3)
      B4=C(1,1)*C(1,1)+C(1,2)*C(1,2)+C(1,3)*C(1,3)
      B5=C(2,1)*C(2,1)+C(2,2)*C(2,2)+C(2,3)*C(2,3)
      B6=C(3,1)*C(3,1)+C(3,2)*C(3,2)+C(3,3)*C(3,3)
      A1=C(1,1)*C(1,2)+C(2,1)*C(2,2)+C(3,1)*C(3,2)
      A2=C(1,1)*C(1,3)+C(2,1)*C(2,3)+C(3,1)*C(3,3)
      A3=C(1,2)*C(1,3)+C(2,2)*C(2,3)+C(3,2)*C(3,3)
      A4=C(1,1)*C(2,1)+C(1,2)*C(2,2)+C(1,3)*C(2,3)
      A5=C(1,1)*C(3,1)+C(1,2)*C(3,2)+C(1,3)*C(3,3)
      A6=C(2,1)*C(3,1)+C(2,2)*C(3,2)+C(2,3)*C(3,3)
```

Continued

```
      WRITE(6,100) TOTNAV
      WRITE(6,111)
      WRITE(6,117) VPHIX(1),VPHIX(2),VPHIX(3)
      WRITE(6,112) VPHIX(4),VPHIX(5),VPHIX(6)
      WRITE(6,113) VPHIX(7),VPHIX(8),VPHIX(9)
      WRITE(6,114)
      WRITE(6,112) DELVXV(1),DELVXV(2),DELVXV(3)
      WRITE(6,113) DELVXV(4),DELVXV(5),DELVXV(6)
      WRITE(6,105)
      DO 1 I=1,3
    1 WRITE(6,106) C(I,1),C(I,2),C(I,3)
      WRITE(6,104)
      WRITE(6,106) A1,A2,A3
      WRITE(6,106) A4,A5,A6
      WRITE(6,110)
      WRITE(6,106) B1,B2,B3
      WRITE(6,106) B4,B5,B6
      WRITE(6,116)
      WRITE(6,115) AXSG(1),AXSG(2),AXSG(3)
      WRITE(6,101)
      WRITE(6,115) XS(1),XS(2),XS(3)
      WRITE(6,102)
      WRITE(6,115) VXS(1),VXS(2),VXS(3)
      WRITE(6,103)
      WRITE(6,115) VXI(1),VXI(2),VXI(3)
      WRITE(6,107) H
      WRITE(6,108) VS
      WRITE(6,109) G
      RETURN
      END
```

Continued

```
$IBFTC ORBIT   DECK
      SUBROUTINE ORBIT
C     ABSTRACT.....THIS ROUTINE CALCULATES AND PRINTS THE ORBITAL
C     PARAMETERS.
      COMMON /COMM04/ RSLL,GME
      COMMON /COMM19/ RS,VS,GAMMA
   10 FORMAT(30X,39HSEMIMAJOR AXIS.........................,E15.8,//)
   20 FORMAT(30X,39HSEMIMINOR AXIS.........................,E15.8,//)
   30 FORMAT(30X,39HECCENTRICITY...........................,E15.8,//)
   40 FORMAT(30X,39HAPOGEE RADIUS..........................,E15.8,//)
   50 FORMAT(30X,39HPERIGEE RADIUS.........................,E15.8,//)
   60 FORMAT(30X,39HORBITAL VELOCITY AT APOGEE.............,E15.8,//)
   70 FORMAT(30X,39HORBITAL VELOCITY AT PERIGEE............,E15.8,//)
   80 FORMAT(1H1)
   90 FORMAT(/////////)
      D1=(RS*VS**2)/GME
      AORBIT=RS/(2.0-D1)
      BORBIT=AORBIT*D1*COS(GAMMA)**2
      EORBIT=SQRT(1.0-D1*(2.0-D1)*COS(GAMMA)**2)
      RAORB=AORBIT*(1.0+EORBIT)
      RPORB=AORBIT*(1.0-EORBIT)
      D2=VS/(D1*COS(GAMMA))
      VAORB=D2*(1.0-EORBIT)
      VPORB=D2*(1.0+EORBIT)
      WRITE(6,80)
      WRITE(6,90)
      WRITE(6,10) AORBIT
      WRITE(6,20) BORBIT
      WRITE(6,30) EORBIT
      WRITE(6,40) RAORB
      WRITE(6,50) RPORB
      WRITE(6,60) VAORB
      WRITE(6,70) VPORB
      WRITE(6,80)
      RETURN
      END
```

Continued

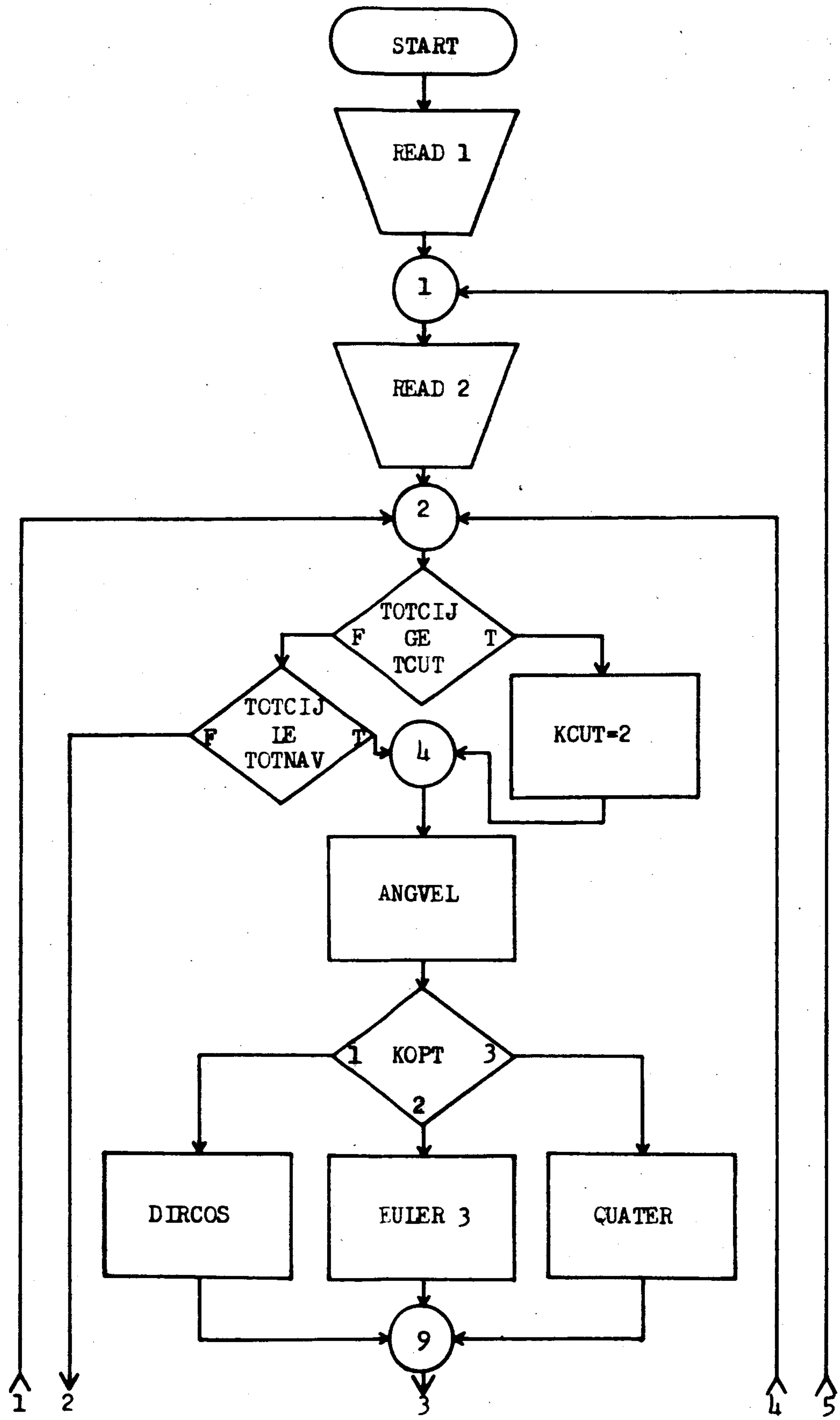
Memory Map of Analytic Platform Simulation Program.

SYSTEM, INCLUDING IOCS		00000 THRU 12442
FILE BLOCK ORIGIN		12451
NUMBER OF FILES - 2		
1. S.FBIN	12451	
2. S.FBOU	12474	
OBJECT PROGRAM		12517 THRU 40114
1. DECK 'MAIN ' *	12517	
2. DECK 'READ1 ' *	24631	
3. DECK 'READ2 ' *	25323	
4. DECK 'ANGVEL' •	27016	
5. DECK 'CIRCUS' *	27352	
6. DECK 'INTEGR' •	27713	
7. DECK 'EULER3' •	30056	
8. DECK 'QUATER' •	30701	
9. DECK 'LINAC ' *	31320	
10. DECK 'TRANS ' •	31637	
11. DECK 'GRAV ' *	31717	
12. DECK 'PRINTO' *	32204	
13. DECK 'ORBIT ' *	33500	
14. SUBR 'INSYFB'	00000	
15. SUBR 'OUSYFB'	00000	
16. SUBR 'POSTX '	34141	
17. SUBR 'F05 '	34207	
18. SUBR 'F06 '	34210	
19. SUBR 'ICS '	34211	
20. SUBR 'RWD '	34463	
21. SUBR 'ECV '	35170	
22. SUBR 'FCV '	35436	
23. SUBR 'HCV '	35537	
24. SUBR 'ICV '	35642	
25. SUBR 'XCV '	35662	
26. SUBR 'INTJ '	35700	
27. SUBR 'FFC '	36214	
28. SUBR 'FPT '	36614	
29. SUBR 'XEM '	37164	
30. SUBR 'S.WRIT'	37241	
31. SUBR 'CNSTNT' *	37255	
32. SUBR 'XIT '	37265	
33. SUBR 'ATN '	37267	
34. SUBR 'SCN '	37517	
35. SUBR 'ARSCN '	37676	
36. SUBR 'SQR '	40015	

(* - INSERTIONS OR DELETIONS MADE IN THIS DECK)

INPUT - OUTPUT BUFFERS	77067 THRU 77776
UNUSED CORE	40115 THRU 77062

OBJECT PROGRAM IS BEING ENTERED INTO STORAGE.



Continued on next page

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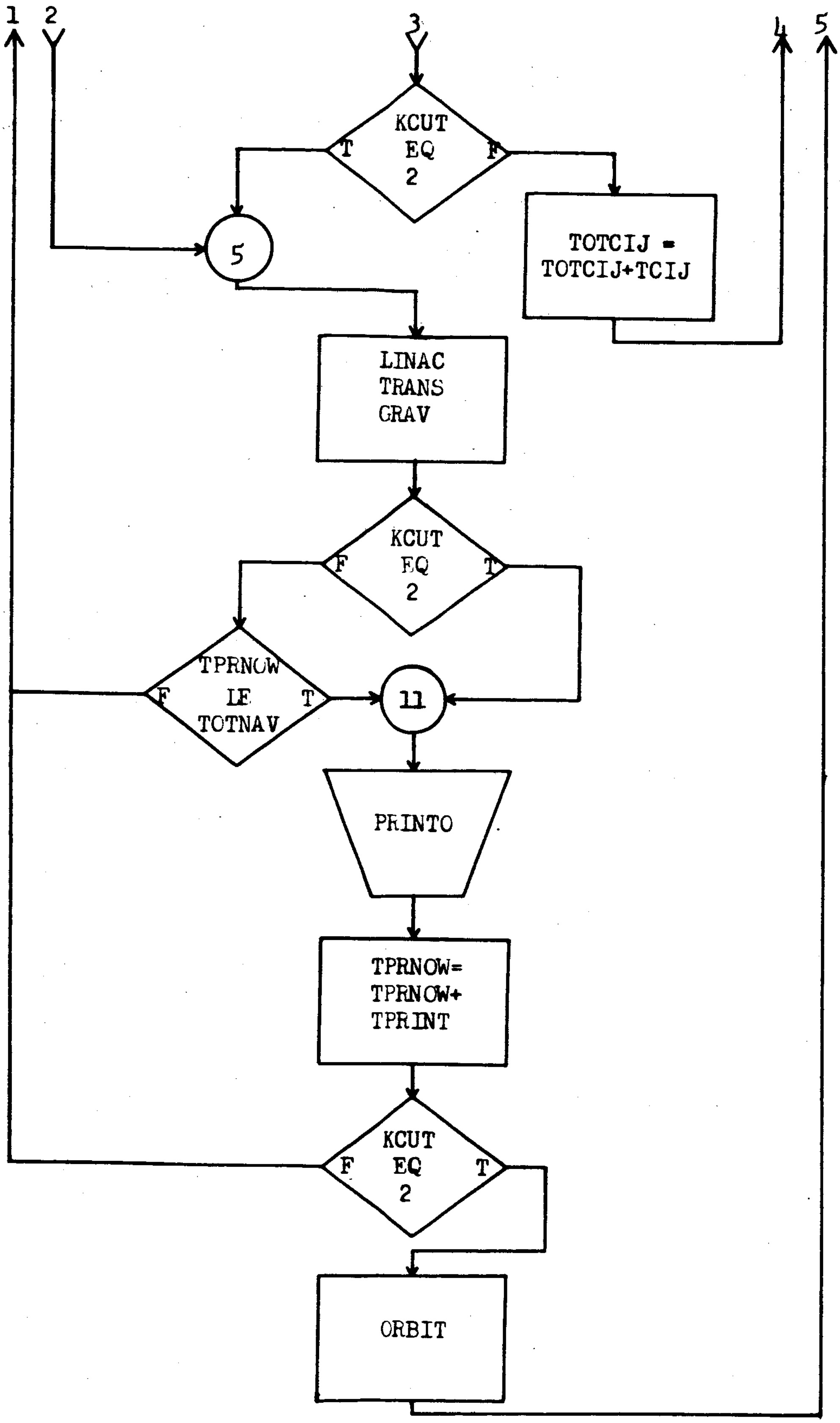

Fig. III-1--Analytic Platform Simulation Program Flow Chart.

IV. TEST CASE

In an effort to check the accuracy of the analytic platform simulation program, a test case was assumed with the angular velocity and linear acceleration profiles shown in Figure IV-1. The following equations represent the vehicle accelerations in the space-fixed coordinate system where a shperical earth gravity model has been assumed.

$$\ddot{X}_s = (k_2 t + k_3)\cos(k_1 t) - \frac{\mu_e X_s}{(X_s{}^2 + Z_s{}^2)^{3/2}}$$

$$\ddot{Z}_s = (k_2 t + k_3)\sin(k_1 t) - \frac{\mu_e X_s}{(X_s{}^2 + Z_s{}^2)^{3/2}}$$

where

$$k_1 = \pi/1200 \qquad 0 \le t \le 600$$

$$k_2 = \begin{cases} 1/4 & 0 \le t \le 160 \\ -1759/44 & 160 < t \le 161 \\ 1/44 & 161 < t \le 600 \end{cases}$$

$$k_3 = \begin{cases} 10 & 0 \le t \le 160 \\ 70360/11 & 160 < t \le 161 \\ 70/11 & 161 < t \le 600 \end{cases}$$

These differential equations are solved using a three-pass Runge-Kutta numerical technique on a digital computer with a Δt of 0.2 seconds. The results of this numerical solution is presented in the table at the end of the chapter.

This section contains:

1) Input profiles for the Test Case.

2) Input data for the Test Case.

3) Output data from the Analytic Platform Simulation, showing Vehicle Status.

4) Output data from the Analytic Platform Simulation, Showing Vehicle End-conditions.

5) Runge-Kutta numerical integration digital computer program.

6) Comparision of the Vehicle Position and Velocity as determined by both the numerical method and the simulation method.

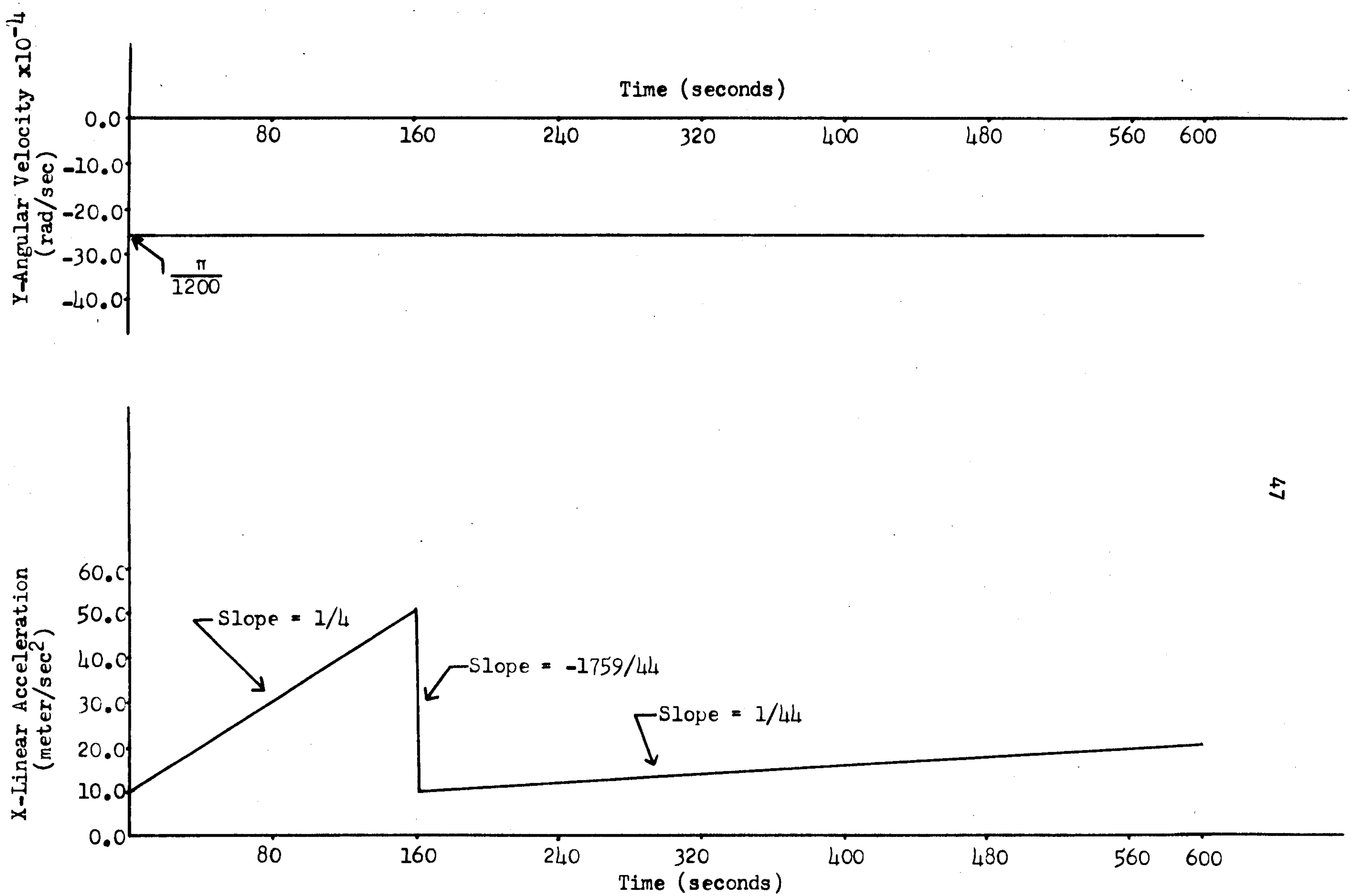

Fig. IV-1--Input profile for the test case.

INPUT PROFILES....ANGULAR VELOCITY

TOTAL NUMBER OF POINTS= 601

TIME BETWEEN POINTS= 1 SECOND

X ANG. VEL.	Y ANG. VEL.	Z ANG. VEL.	TIME
.	-0.26179938E-02	0.	0.0
.	-0.26179938E-02	0.	1.0
.	-0.26179938E-02	0.	2.0
.	-0.26179938E-02	0.	3.0
.	-0.26179938E-02	0.	4.0
.	-0.26179938E-02	0.	5.0
.	-0.26179938E-02	0.	6.0
.	-0.26179938E-02	0.	7.0
.	-0.26179938E-02	0.	8.0
.	-0.26179938E-02	0.	9.0
.	-0.26179938E-02	0.	10.0
.	-0.26179938E-02	0.	11.0
.	-0.26179938E-02	0.	12.0
.	-0.26179938E-02	0.	13.0
.	-0.26179938E-02	0.	14.0
.	-0.26179938E-02	0.	15.0
.	-0.26179938E-02	0.	16.0
.	-0.26179938E-02	0.	17.0
.	-0.26179938E-02	0.	18.0
.	-0.26179938E-02	0.	19.0
.	-0.26179938E-02	0.	20.0
.	-0.26179938E-02	0.	21.0
.	-0.26179938E-02	0.	22.0
.	-0.26179938E-02	0.	23.0
.	-0.26179938E-02	0.	24.0
.	-0.26179938E-02	0.	25.0
.	-0.26179938E-02	0.	26.0
.	-0.26179938E-02	0.	27.0
.	-0.26179938E-02	0.	28.0
.	-0.26179938E-02	0.	29.0
.	-0.26179938E-02	0.	30.0
.	-0.26179938E-02	0.	31.0
.	-0.26179938E-02	0.	32.0
.	-0.26179938E-02	0.	33.0
.	-0.26179938E-02	0.	34.0
.	-0.26179938E-02	0.	35.0
.	-0.26179938E-02	0.	36.0
.	-0.26179938E-02	0.	37.0
.	-0.26179938E-02	0.	38.0
.	-0.26179938E-02	0.	39.0
.	-0.26179938E-02	0.	40.0

Continued

.	-0.26179938E-02	0.	41.0
.	-0.26179938E-02	0.	42.0
.	-0.26179938E-02	0.	43.0
.	-0.26179938E-02	0.	44.0
.	-0.26179938E-02	0.	45.0
.	-0.26179938E-02	0.	46.0
.	-0.26179938E-02	0.	47.0
.	-0.26179938E-02	0.	48.0
.	-0.26179938E-02	0.	49.0
.	-0.26179938E-02	0.	50.0
.	-0.26179938E-02	0.	51.0
.	-0.26179938E-02	0.	52.0
.	-0.26179938E-02	0.	53.0
.	-0.26179938E-02	0.	54.0
.	-0.26179938E-02	0.	55.0
.	-0.26179938E-02	0.	56.0
.	-0.26179938E-02	0.	57.0
.	-0.26179938E-02	0.	58.0
.	-0.26179938E-02	0.	59.0
.	-0.26179938E-02	0.	60.0
.	-0.26179938E-02	0.	61.0
.	-0.26179938E-02	0.	62.0
.	-0.26179938E-02	0.	63.0
.	-0.26179938E-02	0.	64.0
.	-0.26179938E-02	0.	65.0
.	-0.26179938E-02	0.	66.0
.	-0.26179938E-02	0.	67.0
.	-0.26179938E-02	0.	68.0
.	-0.26179938E-02	0.	69.0
.	-0.26179938E-02	0.	70.0
.	-0.26179938E-02	0.	71.0
.	-0.26179938E-02	0.	72.0
.	-0.26179938E-02	0.	73.0
.	-0.26179938E-02	0.	74.0
.	-0.26179938E-02	0.	75.0
.	-0.26179938E-02	0.	76.0
.	-0.26179938E-02	0.	77.0
.	-0.26179938E-02	0.	78.0
.	-0.26179938E-02	0.	79.0
.	-0.26179938E-02	0.	80.0
.	-0.26179938E-02	0.	81.0
.	-0.26179938E-02	0.	82.0
.	-0.26179938E-02	0.	83.0
.	-0.26179938E-02	0.	84.0
.	-0.26179938E-02	0.	85.0
.	-0.26179938E-02	0.	86.0
.	-0.26179938E-02	0.	87.0
.	-0.26179938E-02	0.	88.0
.	-0.26179938E-02	0.	89.0
.	-0.26179938E-02	0.	90.0

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.	-0.26179938E-02	0.	91.0
.	-0.26179938E-02	0.	92.0
.	-0.26179938E-02	0.	93.0
.	-0.26179938E-02	0.	94.0
.	-0.26179938E-02	0.	95.0
.	-0.26179938E-02	0.	96.0
.	-0.26179938E-02	0.	97.0
.	-0.26179938E-02	0.	98.0
.	-0.26179938E-02	0.	99.0
.	-0.26179938E-02	0.	100.0
.	-0.26179938E-02	0.	101.0
.	-0.26179938E-02	0.	102.0
.	-0.26179938E-02	0.	103.0
.	-0.26179938E-02	0.	104.0
.	-0.26179938E-02	0.	105.0
.	-0.26179938E-02	0.	106.0
.	-0.26179938E-02	0.	107.0
.	-0.26179938E-02	0.	108.0
.	-0.26179938E-02	0.	109.0
.	-0.26179938E-02	0.	110.0
.	-0.26179938E-02	0.	111.0
.	-0.26179938E-02	0.	112.0
.	-0.26179938E-02	0.	113.0
.	-0.26179938E-02	0.	114.0
.	-0.26179938E-02	0.	115.0
.	-0.26179938E-02	0.	116.0
.	-0.26179938E-02	0.	117.0
.	-0.26179938E-02	0.	118.0
.	-0.26179938E-02	0.	119.0
.	-0.26179938E-02	0.	120.0
.	-0.26179938E-02	0.	121.0
.	-0.26179938E-02	0.	122.0
.	-0.26179938E-02	0.	123.0
.	-0.26179938E-02	0.	124.0
.	-0.26179938E-02	0.	125.0
.	-0.26179938E-02	0.	126.0
.	-0.26179938E-02	0.	127.0
.	-0.26179938E-02	0.	128.0
.	-0.26179938E-02	0.	129.0
.	-0.26179938E-02	0.	130.0
.	-0.26179938E-02	0.	131.0
.	-0.26179938E-02	0.	132.0
.	-0.26179938E-02	0.	133.0
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.	-0.26179938E-02	0.	135.0
.	-0.26179938E-02	0.	136.0
.	-0.26179938E-02	0.	137.0
.	-0.26179938E-02	0.	138.0
.	-0.26179938E-02	0.	139.0
.	-0.26179938E-02	0.	140.0

Continued

.	-0.26179938E-02	0.	141.0
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.	-0.26179938E-02	0.	144.0
.	-0.26179938E-02	0.	145.0
.	-0.26179938E-02	0.	146.0
.	-0.26179938E-02	0.	147.0
.	-0.26179938E-02	0.	148.0
.	-0.26179938E-02	0.	149.0
.	-0.26179938E-02	0.	150.0
.	-0.26179938E-02	0.	151.0
.	-0.26179938E-02	0.	152.0
.	-0.26179938E-02	0.	153.0
.	-0.26179938E-02	0.	154.0
.	-0.26179938E-02	0.	155.0
.	-0.26179938E-02	0.	156.0
.	-0.26179938E-02	0.	157.0
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.	-0.26179938E-02	0.	161.0
.	-0.26179938E-02	0.	162.0
.	-0.26179938E-02	0.	163.0
.	-0.26179938E-02	0.	164.0
.	-0.26179938E-02	0.	165.0
.	-0.26179938E-02	0.	166.0
.	-0.26179938E-02	0.	167.0
.	-0.26179938E-02	0.	168.0
.	-0.26179938E-02	0.	169.0
.	-0.26179938E-02	0.	170.0
.	-0.26179938E-02	0.	171.0
.	-0.26179938E-02	0.	172.0
.	-0.26179938E-02	0.	173.0
.	-0.26179938E-02	0.	174.0
.	-0.26179938E-02	0.	175.0
.	-0.26179938E-02	0.	176.0
.	-0.26179938E-02	0.	177.0
.	-0.26179938E-02	0.	178.0
.	-0.26179938E-02	0.	179.0
.	-0.26179938E-02	0.	180.0
.	-0.26179938E-02	0.	181.0
.	-0.26179938E-02	0.	182.0
.	-0.26179938E-02	0.	183.0
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.	-0.26179938E-02	0.	185.0
.	-0.26179938E-02	0.	186.0
.	-0.26179938E-02	0.	187.0
.	-0.26179938E-02	0.	188.0
.	-0.26179938E-02	0.	189.0
.	-0.26179938E-02	0.	190.0

Continued

.	-0.26179938E-02	0.	191.0
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.	-0.26179938E-02	0.	194.0
.	-0.26179938E-02	0.	195.0
.	-0.26179938E-02	0.	196.0
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.	-0.26179938E-02	0.	198.0
.	-0.26179938E-02	0.	199.0
.	-0.26179938E-02	0.	200.0
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.	-0.26179938E-02	0.	202.0
.	-0.26179938E-02	0.	203.0
.	-0.26179938E-02	0.	204.0
.	-0.26179938E-02	0.	205.0
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.	-0.26179938E-02	0.	214.0
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.	-0.26179938E-02	0.	217.0
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.	-0.26179938E-02	0.	228.0
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.	-0.26179938E-02	0.	231.0
.	-0.26179938E-02	0.	232.0
.	-0.26179938E-02	0.	233.0
.	-0.26179938E-02	0.	234.0
.	-0.26179938E-02	0.	235.0
.	-0.26179938E-02	0.	236.0
.	-0.26179938E-02	0.	237.0
.	-0.26179938E-02	0.	238.0
.	-0.26179938E-02	0.	239.0
.	-0.26179938E-02	0.	240.0

Continued

•	-0.26179938E-02	0.	241.0
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•	-0.26179938E-02	0.	244.0
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•	-0.26179938E-02	0.	254.0
•	-0.26179938E-02	0.	255.0
•	-0.26179938E-02	0.	256.0
•	-0.26179938E-02	0.	257.0
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•	-0.26179938E-02	0.	262.0
•	-0.26179938E-02	0.	263.0
•	-0.26179938E-02	0.	264.0
•	-0.26179938E-02	0.	265.0
•	-0.26179938E-02	0.	266.0
•	-0.26179938E-02	0.	267.0
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•	-0.26179938E-02	0.	269.0
•	-0.26179938E-02	0.	270.0
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•	-0.26179938E-02	0.	273.0
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•	-0.26179938E-02	0.	287.0
•	-0.26179938E-02	0.	288.0
•	-0.26179938E-02	0.	289.0
•	-0.26179938E-02	0.	290.0

Continued

.	-0.26179938E-02	0.	291.0
.	-0.26179938E-02	0.	292.0
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.	-0.26179938E-02	0.	294.0
.	-0.26179938E-02	0.	295.0
.	-0.26179938E-02	0.	296.0
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.	-0.26179938E-02	0.	298.0
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.	-0.26179938E-02	0.	301.0
.	-0.26179938E-02	0.	302.0
.	-0.26179938E-02	0.	303.0
.	-0.26179938E-02	0.	304.0
.	-0.26179938E-02	0.	305.0
.	-0.26179938E-02	0.	306.0
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.	-0.26179938E-02	0.	313.0
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.	-0.26179938E-02	0.	317.0
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.	-0.26179938E-02	0.	324.0
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.	-0.26179938E-02	0.	326.0
.	-0.26179938E-02	0.	327.0
.	-0.26179938E-02	0.	328.0
.	-0.26179938E-02	0.	329.0
.	-0.26179938E-02	0.	330.0
.	-0.26179938E-02	0.	331.0
.	-0.26179938E-02	0.	332.0
.	-0.26179938E-02	0.	333.0
.	-0.26179938E-02	0.	334.0
.	-0.26179938E-02	0.	335.0
.	-0.26179938E-02	0.	336.0
.	-0.26179938E-02	0.	337.0
.	-0.26179938E-02	0.	338.0
.	-0.26179938E-02	0.	339.0
.	-0.26179938E-02	0.	340.0

Continued

•	-0.26179938E-02	0.	341.0
•	-0.26179938E-02	0.	342.0
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•	-0.26179938E-02	0.	344.0
•	-0.26179938E-02	0.	345.0
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•	-0.26179938E-02	0.	348.0
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•	-0.26179938E-02	0.	355.0
•	-0.26179938E-02	0.	356.0
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•	-0.26179938E-02	0.	366.0
•	-0.26179938E-02	0.	367.0
•	-0.26179938E-02	0.	368.0
•	-0.26179938E-02	0.	369.0
•	-0.26179938E-02	0.	370.0
•	-0.26179938E-02	0.	371.0
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•	-0.26179938E-02	0.	378.0
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•	-0.26179938E-02	0.	388.0
•	-0.26179938E-02	0.	389.0
•	-0.26179938E-02	0.	390.0

Continued

.	-0.26179938E-02	0.	391.0
.	-0.26179938E-02	0.	392.0
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.	-0.26179938E-02	0.	394.0
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.	-0.26179938E-02	0.	397.0
.	-0.26179938E-02	0.	398.0
.	-0.26179938E-02	0.	399.0
.	-0.26179938E-02	0.	400.0
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.	-0.26179938E-02	0.	402.0
.	-0.26179938E-02	0.	403.0
.	-0.26179938E-02	0.	404.0
.	-0.26179938E-02	0.	405.0
.	-0.26179938E-02	0.	406.0
.	-0.26179938E-02	0.	407.0
.	-0.26179938E-02	0.	408.0
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.	-0.26179938E-02	0.	414.0
.	-0.26179938E-02	0.	415.0
.	-0.26179938E-02	0.	416.0
.	-0.26179938E-02	0.	417.0
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.	-0.26179938E-02	0.	424.0
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.	-0.26179938E-02	0.	426.0
.	-0.26179938E-02	0.	427.0
.	-0.26179938E-02	0.	428.0
.	-0.26179938E-02	0.	429.0
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.	-0.26179938E-02	0.	433.0
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.	-0.26179938E-02	0.	435.0
.	-0.26179938E-02	0.	436.0
.	-0.26179938E-02	0.	437.0
.	-0.26179938E-02	0.	438.0
.	-0.26179938E-02	0.	439.0
.	-0.26179938E-02	0.	440.0

Continued

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•	-0.26179938E-02	0.	445.0
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•	-0.26179938E-02	0.	456.0
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•	-0.26179938E-02	0.	458.0
•	-0.26179938E-02	0.	459.0
•	-0.26179938E-02	0.	460.0
•	-0.26179938E-02	0.	461.0
•	-0.26179938E-02	0.	462.0
•	-0.26179938E-02	0.	463.0
•	-0.26179938E-02	0.	464.0
•	-0.26179938E-02	0.	465.0
•	-0.26179938E-02	0.	466.0
•	-0.26179938E-02	0.	467.0
•	-0.26179938E-02	0.	468.0
•	-0.26179938E-02	0.	469.0
•	-0.26179938E-02	0.	470.0
•	-0.26179938E-02	0.	471.0
•	-0.26179938E-02	0.	472.0
•	-0.26179938E-02	0.	473.0
•	-0.26179938E-02	0.	474.0
•	-0.26179938E-02	0.	475.0
•	-0.26179938E-02	0.	476.0
•	-0.26179938E-02	0.	477.0
•	-0.26179938E-02	0.	478.0
•	-0.26179938E-02	0.	479.0
•	-0.26179938E-02	0.	480.0
•	-0.26179938E-02	0.	481.0
•	-0.26179938E-02	0.	482.0
•	-0.26179938E-02	0.	483.0
•	-0.26179938E-02	0.	484.0
•	-0.26179938E-02	0.	485.0
•	-0.26179938E-02	0.	486.0
•	-0.26179938E-02	0.	487.0
•	-0.26179938E-02	0.	488.0
•	-0.26179938E-02	0.	489.0
•	-0.26179938E-02	0.	490.0

Continued

.	-0.26179938E-02	0.	491.0
.	-0.26179938E-02	0.	492.0
.	-0.26179938E-02	0.	493.0
.	-0.26179938E-02	0.	494.0
.	-0.26179938E-02	0.	495.0
.	-0.26179938E-02	0.	496.0
.	-0.26179938E-02	0.	497.0
.	-0.26179938E-02	0.	498.0
.	-0.26179938E-02	0.	499.0
.	-0.26179938E-02	0.	500.0
.	-0.26179938E-02	0.	501.0
.	-0.26179938E-02	0.	502.0
.	-0.26179938E-02	0.	503.0
.	-0.26179938E-02	0.	504.0
.	-0.26179938E-02	0.	505.0
.	-0.26179938E-02	0.	506.0
.	-0.26179938E-02	0.	507.0
.	-0.26179938E-02	0.	508.0
.	-0.26179938E-02	0.	509.0
.	-0.26179938E-02	0.	510.0
.	-0.26179938E-02	0.	511.0
.	-0.26179938E-02	0.	512.0
.	-0.26179938E-02	0.	513.0
.	-0.26179938E-02	0.	514.0
.	-0.26179938E-02	0.	515.0
.	-0.26179938E-02	0.	516.0
.	-0.26179938E-02	0.	517.0
.	-0.26179938E-02	0.	518.0
.	-0.26179938E-02	0.	519.0
.	-0.26179938E-02	0.	520.0
.	-0.26179938E-02	0.	521.0
.	-0.26179938E-02	0.	522.0
.	-0.26179938E-02	0.	523.0
.	-0.26179938E-02	0.	524.0
.	-0.26179938E-02	0.	525.0
.	-0.26179938E-02	0.	526.0
.	-0.26179938E-02	0.	527.0
.	-0.26179938E-02	0.	528.0
.	-0.26179938E-02	0.	529.0
.	-0.26179938E-02	0.	530.0
.	-0.26179938E-02	0.	531.0
.	-0.26179938E-02	0.	532.0
.	-0.26179938E-02	0.	533.0
.	-0.26179938E-02	0.	534.0
.	-0.26179938E-02	0.	535.0
.	-0.26179938E-02	0.	536.0
.	-0.26179938E-02	0.	537.0
.	-0.26179938E-02	0.	538.0
.	-0.26179938E-02	0.	539.0
.	-0.26179938E-02	0.	540.0

Continued

•	-0.26179938E-02	0.	541.0
•	-0.26179938E-02	0.	542.0
•	-0.26179938E-02	0.	543.0
•	-0.26179938E-02	0.	544.0
•	-0.26179938E-02	0.	545.0
•	-0.26179938E-02	0.	546.0
•	-0.26179938E-02	0.	547.0
•	-0.26179938E-02	0.	548.0
•	-0.26179938E-02	0.	549.0
•	-0.26179938E-02	0.	550.0
•	-0.26179938E-02	0.	551.0
•	-0.26179938E-02	0.	552.0
•	-0.26179938E-02	0.	553.0
•	-0.26179938E-02	0.	554.0
•	-0.26179938E-02	0.	555.0
•	-0.26179938E-02	0.	556.0
•	-0.26179938E-02	0.	557.0
•	-0.26179938E-02	0.	558.0
•	-0.26179938E-02	0.	559.0
•	-0.26179938E-02	0.	560.0
•	-0.26179938E-02	0.	561.0
•	-0.26179938E-02	0.	562.0
•	-0.26179938E-02	0.	563.0
•	-0.26179938E-02	0.	564.0
•	-0.26179938E-02	0.	565.0
•	-0.26179938E-02	0.	566.0
•	-0.26179938E-02	0.	567.0
•	-0.26179938E-02	0.	568.0
•	-0.26179938E-02	0.	569.0
•	-0.26179938E-02	0.	570.0
•	-0.26179938E-02	0.	571.0
•	-0.26179938E-02	0.	572.0
•	-0.26179938E-02	0.	573.0
•	-0.26179938E-02	0.	574.0
•	-0.26179938E-02	0.	575.0
•	-0.26179938E-02	0.	576.0
•	-0.26179938E-02	0.	577.0
•	-0.26179938E-02	0.	578.0
•	-0.26179938E-02	0.	579.0
•	-0.26179938E-02	0.	580.0
•	-0.26179938E-02	0.	581.0
•	-0.26179938E-02	0.	582.0
•	-0.26179938E-02	0.	583.0
•	-0.26179938E-02	0.	584.0
•	-0.26179938E-02	0.	585.0
•	-0.26179938E-02	0.	586.0
•	-0.26179938E-02	0.	587.0
•	-0.26179938E-02	0.	588.0
•	-0.26179938E-02	0.	589.0
•	-0.26179938E-02	0.	590.0

Continued

.	-0.26179938E-02	0.	591.0
.	-0.26179938E-02	0.	592.0
.	-0.26179938E-02	0.	593.0
.	-0.26179938E-02	0.	594.0
.	-0.26179938E-02	0.	595.0
.	-0.26179938E-02	0.	596.0
.	-0.26179938E-02	0.	597.0
.	-0.26179938E-02	0.	598.0
.	-0.26179938E-02	0.	599.0
.	-0.26179938E-02	0.	600.0

End of Input Profile ... Angular Velocity

INPUT PROFILES....LINEAR ACCELERATION

TOTAL NUMBER OF POINTS= 601

TIME BETWEEN POINTS= 1 SECOND

X ACCELERATION	Y ACCELERATION	Z ACCELERATION	TIME
.10000000E 02	0.	0.	0.0
.10250000E 02	0.	0.	1.0
.10500000E 02	0.	0.	2.0
.10750000E 02	0.	0.	3.0
.11000000E 02	0.	0.	4.0
.11250000E 02	0.	0.	5.0
.11500000E 02	0.	0.	6.0
.11750000E 02	0.	0.	7.0
.12000000E 02	0.	0.	8.0
.12250000E 02	0.	0.	9.0
.12500000E 02	0.	0.	10.0
.12750000E 02	0.	0.	11.0
.13000000E 02	0.	0.	12.0
.13250000E 02	0.	0.	13.0
.13500000E 02	0.	0.	14.0
.13750000E 02	0.	0.	15.0
.14000000E 02	0.	0.	16.0
.14250000E 02	0.	0.	17.0
.14500000E 02	0.	0.	18.0
.14750000E 02	0.	0.	19.0
.15000000E 02	0.	0.	20.0
.15250000E 02	0.	0.	21.0
.15500000E 02	0.	0.	22.0
.15750000E 02	0.	0.	23.0
.16000000E 02	0.	0.	24.0
.16250000E 02	0.	0.	25.0
.16500000E 02	0.	0.	26.0
.16750000E 02	0.	0.	27.0
.17000000E 02	0.	0.	28.0
.17250000E 02	0.	0.	29.0
.17500000E 02	0.	0.	30.0
.17750000E 02	0.	0.	31.0
.18000000E 02	0.	0.	32.0
.18250000E 02	0.	0.	33.0
.18500000E 02	0.	0.	34.0
.18750000E 02	0.	0.	35.0
.19000000E 02	0.	0.	36.0
.19250000E 02	0.	0.	37.0
.19500000E 02	0.	0.	38.0
.19750000E 02	0.	0.	39.0
.20000000E 02	0.	0.	40.0

Continued

.20250000E 02	0.	0.	41.0
.20500000E 02	0.	0.	42.0
.20750000E 02	0.	0.	43.0
.21000000E 02	0.	0.	44.0
.21250000E 02	0.	0.	45.0
.21500000E 02	0.	0.	46.0
.21750000E 02	0.	0.	47.0
.22000000E 02	0.	0.	48.0
.22250000E 02	0.	0.	49.0
.22500000E 02	0.	0.	50.0
.22750000E 02	0.	0.	51.0
.23000000E 02	0.	0.	52.0
.23250000E 02	0.	0.	53.0
.23500000E 02	0.	0.	54.0
.23750000E 02	0.	0.	55.0
.24000000E 02	0.	0.	56.0
.24250000E 02	0.	0.	57.0
.24500000E 02	0.	0.	58.0
.24750000E 02	0.	0.	59.0
.25000000E 02	0.	0.	60.0
.25250000E 02	0.	0.	61.0
.25500000E 02	0.	0.	62.0
.25750000E 02	0.	0.	63.0
.26000000E 02	0.	0.	64.0
.26250000E 02	0.	0.	65.0
.26500000E 02	0.	0.	66.0
.26750000E 02	0.	0.	67.0
.27000000E 02	0.	0.	68.0
.27250000E 02	0.	0.	69.0
.27500000E 02	0.	0.	70.0
.27750000E 02	0.	0.	71.0
.28000000E 02	0.	0.	72.0
.28250000E 02	0.	0.	73.0
.28500000E 02	0.	0.	74.0
.28750000E 02	0.	0.	75.0
.29000000E 02	0.	0.	76.0
.29250000E 02	0.	0.	77.0
.29500000E 02	0.	0.	78.0
.29750000E 02	0.	0.	79.0
.30000000E 02	0.	0.	80.0
.30250000E 02	0.	0.	81.0
.30500000E 02	0.	0.	82.0
.30750000E 02	0.	0.	83.0
.31000000E 02	0.	0.	84.0
.31250000E 02	0.	0.	85.0
.31500000E 02	0.	0.	86.0
.31750000E 02	0.	0.	87.0
.32000000E 02	0.	0.	88.0
.32250000E 02	0.	0.	89.0
.32500000E 02	0.	0.	90.0

Continued

.32750000E 02	0.	0.	91.0
.33000000E 02	0.	0.	92.0
.33250000E 02	0.	0.	93.0
.33500000E 02	0.	0.	94.0
.33750000E 02	0.	0.	95.0
.34000000E 02	0.	0.	96.0
.34250000E 02	0.	0.	97.0
.34500000E 02	0.	0.	98.0
.34750000E 02	0.	0.	99.0
.35000000E 02	0.	0.	100.0
.35250000E 02	0.	0.	101.0
.35500000E 02	0.	0.	102.0
.35750000E 02	0.	0.	103.0
.36000000E 02	0.	0.	104.0
.36250000E 02	0.	0.	105.0
.36500000E 02	0.	0.	106.0
.36750000E 02	0.	0.	107.0
.37000000E 02	0.	0.	108.0
.37250000E 02	0.	0.	109.0
.37500000E 02	0.	0.	110.0
.37750000E 02	0.	0.	111.0
.38000000E 02	0.	0.	112.0
.38250000E 02	0.	0.	113.0
.38500000E 02	0.	0.	114.0
.38750000E 02	0.	0.	115.0
.39000000E 02	0.	0.	116.0
.39250000E 02	0.	0.	117.0
.39500000E 02	0.	0.	118.0
.39750000E 02	0.	0.	119.0
.40000000E 02	0.	0.	120.0
.40250000E 02	0.	0.	121.0
.40500000E 02	0.	0.	122.0
.40750000E 02	0.	0.	123.0
.41000000E 02	0.	0.	124.0
.41250000E 02	0.	0.	125.0
.41500000E 02	0.	0.	126.0
.41750000E 02	0.	0.	127.0
.42000000E 02	0.	0.	128.0
.42250000E 02	0.	0.	129.0
.42500000E 02	0.	0.	130.0
.42750000E 02	0.	0.	131.0
.43000000E 02	0.	0.	132.0
.43250000E 02	0.	0.	133.0
.43500000E 02	0.	0.	134.0
.43750000E 02	0.	0.	135.0
.44000000E 02	0.	0.	136.0
.44250000E 02	0.	0.	137.0
.44500000E 02	0.	0.	138.0
.44750000E 02	0.	0.	139.0
.45000000E 02	0.	0.	140.0

Continued

.45250000E 02	0.	0.	141.0
.45500000E 02	0.	0.	142.0
.45750000E 02	0.	0.	143.0
.46000000E 02	0.	0.	144.0
.46250000E 02	0.	0.	145.0
.46500000E 02	0.	0.	146.0
.46750000E 02	0.	0.	147.0
.47000000E 02	0.	0.	148.0
.47250000E 02	0.	0.	149.0
.47500000E 02	0.	0.	150.0
.47750000E 02	0.	0.	151.0
.48000000E 02	0.	0.	152.0
.48250000E 02	0.	0.	153.0
.48500000E 02	0.	0.	154.0
.48750000E 02	0.	0.	155.0
.49000000E 02	0.	0.	156.0
.49250000E 02	0.	0.	157.0
.49500000E 02	0.	0.	158.0
.49750000E 02	0.	0.	159.0
.50000000E 02	0.	0.	160.0
.10022727E 02	0.	0.	161.0
.10045455E 02	0.	0.	162.0
.10068182E 02	0.	0.	163.0
.10090909E 02	0.	0.	164.0
.10113636E 02	0.	0.	165.0
.10136364E 02	0.	0.	166.0
.10159091E 02	0.	0.	167.0
.10181818E 02	0.	0.	168.0
.10204545E 02	0.	0.	169.0
.10227273E 02	0.	0.	170.0
.10250000E 02	0.	0.	171.0
.10272727E 02	0.	0.	172.0
.10295454E 02	0.	0.	173.0
.10318182E 02	0.	0.	174.0
.10340909E 02	0.	0.	175.0
.10363636E 02	0.	0.	176.0
.10386364E 02	0.	0.	177.0
.10409091E 02	0.	0.	178.0
.10431818E 02	0.	0.	179.0
.10454545E 02	0.	0.	180.0
.10477273E 02	0.	0.	181.0
.10500000E 02	0.	0.	182.0
.10522727E 02	0.	0.	183.0
.10545454E 02	0.	0.	184.0
.10568182E 02	0.	0.	185.0
.10590909E 02	0.	0.	186.0
.10613636E 02	0.	0.	187.0
.10636364E 02	0.	0.	188.0
.10659091E 02	0.	0.	189.0
.10681818E 02	0.	0.	190.0

Continued

.10704545E 02	0.	0.	191.0
.10727273E 02	0.	0.	192.0
.10750000E 02	0.	0.	193.0
.10772727E 02	0.	0.	194.0
.10795455E 02	0.	0.	195.0
.10818182E 02	0.	0.	196.0
.10840909E 02	0.	0.	197.0
.10863636E 02	0.	0.	198.0
.10886364E 02	0.	0.	199.0
.10909091E 02	0.	0.	200.0
.10931818E 02	0.	0.	201.0
.10954545E 02	0.	0.	202.0
.10977273E 02	0.	0.	203.0
.11000000E 02	0.	0.	204.0
.11022727E 02	0.	0.	205.0
.11045454E 02	0.	0.	206.0
.11068182E 02	0.	0.	207.0
.11090909E 02	0.	0.	208.0
.11113636E 02	0.	0.	209.0
.11136364E 02	0.	0.	210.0
.11159091E 02	0.	0.	211.0
.11181818E 02	0.	0.	212.0
.11204545E 02	0.	0.	213.0
.11227273E 02	0.	0.	214.0
.11250000E 02	0.	0.	215.0
.11272727E 02	0.	0.	216.0
.11295455E 02	0.	0.	217.0
.11318182E 02	0.	0.	218.0
.11340909E 02	0.	0.	219.0
.11363636E 02	0.	0.	220.0
.11386364E 02	0.	0.	221.0
.11409091E 02	0.	0.	222.0
.11431818E 02	0.	0.	223.0
.11454545E 02	0.	0.	224.0
.11477273E 02	0.	0.	225.0
.11500000E 02	0.	0.	226.0
.11522727E 02	0.	0.	227.0
.11545454E 02	0.	0.	228.0
.11568182E 02	0.	0.	229.0
.11590909E 02	0.	0.	230.0
.11613636E 02	0.	0.	231.0
.11636364E 02	0.	0.	232.0
.11659091E 02	0.	0.	233.0
.11681818E 02	0.	0.	234.0
.11704545E 02	0.	0.	235.0
.11727273E 02	0.	0.	236.0
.11750000E 02	0.	0.	237.0
.11772727E 02	0.	0.	238.0
.11795454E 02	0.	0.	239.0
.11818182E 02	0.	0.	240.0

Continued

.11840909E 02	0.	0.	241.0
.11863636E 02	0.	0.	242.0
.11886364E 02	0.	0.	243.0
.11909091E 02	0.	0.	244.0
.11931818E 02	0.	0.	245.0
.11954545E 02	0.	0.	246.0
.11977273E 02	0.	0.	247.0
.12000000E 02	0.	0.	248.0
.12022727E 02	0.	0.	249.0
.12045455E 02	0.	0.	250.0
.12068182E 02	0.	0.	251.0
.12090909E 02	0.	0.	252.0
.12113636E 02	0.	0.	253.0
.12136364E 02	0.	0.	254.0
.12159091E 02	0.	0.	255.0
.12181818E 02	0.	0.	256.0
.12204545E 02	0.	0.	257.0
.12227273E 02	0.	0.	258.0
.12250000E 02	0.	0.	259.0
.12272727E 02	0.	0.	260.0
.12295454E 02	0.	0.	261.0
.12318182E 02	0.	0.	262.0
.12340909E 02	0.	0.	263.0
.12363636E 02	0.	0.	264.0
.12386364E 02	0.	0.	265.0
.12409091E 02	0.	0.	266.0
.12431818E 02	0.	0.	267.0
.12454545E 02	0.	0.	268.0
.12477273E 02	0.	0.	269.0
.12500000E 02	0.	0.	270.0
.12522727E 02	0.	0.	271.0
.12545455E 02	0.	0.	272.0
.12568182E 02	0.	0.	273.0
.12590909E 02	0.	0.	274.0
.12613636E 02	0.	0.	275.0
.12636364E 02	0.	0.	276.0
.12659091E 02	0.	0.	277.0
.12681818E 02	0.	0.	278.0
.12704545E 02	0.	0.	279.0
.12727273E 02	0.	0.	280.0
.12750000E 02	0.	0.	281.0
.12772727E 02	0.	0.	282.0
.12795454E 02	0.	0.	283.0
.12818182E 02	0.	0.	284.0
.12840909E 02	0.	0.	285.0
.12863636E 02	0.	0.	286.0
.12886364E 02	0.	0.	287.0
.12909091E 02	0.	0.	288.0
.12931818E 02	0.	0.	289.0
.12954545E 02	0.	0.	290.0

Continued

.12977273E 02	0.	0.	291.0
.13000000E 02	0.	0.	292.0
.13022727E 02	0.	0.	293.0
.13045454E 02	0.	0.	294.0
.13068182E 02	0.	0.	295.0
.13090909E 02	0.	0.	296.0
.13113636E 02	0.	0.	297.0
.13136364E 02	0.	0.	298.0
.13159091E 02	0.	0.	299.0
.13181818E 02	0.	0.	300.0
.13204545E 02	0.	0.	301.0
.13227273E 02	0.	0.	302.0
.13250000E 02	0.	0.	303.0
.13272727E 02	0.	0.	304.0
.13295455E 02	0.	0.	305.0
.13318182E 02	0.	0.	306.0
.13340909E 02	0.	0.	307.0
.13363636E 02	0.	0.	308.0
.13386364E 02	0.	0.	309.0
.13409091E 02	0.	0.	310.0
.13431818E 02	0.	0.	311.0
.13454545E 02	0.	0.	312.0
.13477273E 02	0.	0.	313.0
.13500000E 02	0.	0.	314.0
.13522727E 02	0.	0.	315.0
.13545454E 02	0.	0.	316.0
.13568182E 02	0.	0.	317.0
.13590909E 02	0.	0.	318.0
.13613636E 02	0.	0.	319.0
.13636364E 02	0.	0.	320.0
.13659091E 02	0.	0.	321.0
.13681818E 02	0.	0.	322.0
.13704545E 02	0.	0.	323.0
.13727273E 02	0.	0.	324.0
.13750000E 02	0.	0.	325.0
.13772727E 02	0.	0.	326.0
.13795455E 02	0.	0.	327.0
.13818182E 02	0.	0.	328.0
.13840909E 02	0.	0.	329.0
.13863636E 02	0.	0.	330.0
.13886364E 02	0.	0.	331.0
.13909091E 02	0.	0.	332.0
.13931818E 02	0.	0.	333.0
.13954545E 02	0.	0.	334.0
.13977273E 02	0.	0.	335.0
.14000000E 02	0.	0.	336.0
.14022727E 02	0.	0.	337.0
.14045454E 02	0.	0.	338.0
.14068182E 02	0.	0.	339.0
.14090909E 02	0.	0.	340.0

Continued

.14113636E 02	0.	0.	341.0
.14136364E 02	0.	0.	342.0
.14159091E 02	0.	0.	343.0
.14181818E 02	0.	0.	344.0
.14204545E 02	0.	0.	345.0
.14227273E 02	0.	0.	346.0
.14250000E 02	0.	0.	347.0
.14272727E 02	0.	0.	348.0
.14295454E 02	0.	0.	349.0
.14318182E 02	0.	0.	350.0
.14340909E 02	0.	0.	351.0
.14363636E 02	0.	0.	352.0
.14386364E 02	0.	0.	353.0
.14409091E 02	0.	0.	354.0
.14431818E 02	0.	0.	355.0
.14454545E 02	0.	0.	356.0
.14477273E 02	0.	0.	357.0
.14500000E 02	0.	0.	358.0
.14522727E 02	0.	0.	359.0
.14545455E 02	0.	0.	360.0
.14568182E 02	0.	0.	361.0
.14590909E 02	0.	0.	362.0
.14613636E 02	0.	0.	363.0
.14636364E 02	0.	0.	364.0
.14659091E 02	0.	0.	365.0
.14681818E 02	0.	0.	366.0
.14704545E 02	0.	0.	367.0
.14727273E 02	0.	0.	368.0
.14750000E 02	0.	0.	369.0
.14772727E 02	0.	0.	370.0
.14795454E 02	0.	0.	371.0
.14818182E 02	0.	0.	372.0
.14840909E 02	0.	0.	373.0
.14863636E 02	0.	0.	374.0
.14886364E 02	0.	0.	375.0
.14909091E 02	0.	0.	376.0
.14931818E 02	0.	0.	377.0
.14954545E 02	0.	0.	378.0
.14977273E 02	0.	0.	379.0
.15000000E 02	0.	0.	380.0
.15022727E 02	0.	0.	381.0
.15045455E 02	0.	0.	382.0
.15068182E 02	0.	0.	383.0
.15090909E 02	0.	0.	384.0
.15113636E 02	0.	0.	385.0
.15136364E 02	0.	0.	386.0
.15159091E 02	0.	0.	387.0
.15181818E 02	0.	0.	388.0
.15204545E 02	0.	0.	389.0
.15227273E 02	0.	0.	390.0

Continued

.15250000E 02	0.	0.	391.0
.15272727E 02	0.	0.	392.0
.15295454E 02	0.	0.	393.0
.15318182E 02	0.	0.	394.0
.15340909E 02	0.	0.	395.0
.15363636E 02	0.	0.	396.0
.15386364E 02	0.	0.	397.0
.15409091E 02	0.	0.	398.0
.15431818E 02	0.	0.	399.0
.15454545E 02	0.	0.	400.0
.15477273E 02	0.	0.	401.0
.15500000E 02	0.	0.	402.0
.15522727E 02	0.	0.	403.0
.15545454E 02	0.	0.	404.0
.15568182E 02	0.	0.	405.0
.15590909E 02	0.	0.	406.0
.15613636E 02	0.	0.	407.0
.15636364E 02	0.	0.	408.0
.15659091E 02	0.	0.	409.0
.15681818E 02	0.	0.	410.0
.15704545E 02	0.	0.	411.0
.15727273E 02	0.	0.	412.0
.15750000E 02	0.	0.	413.0
.15772727E 02	0.	0.	414.0
.15795455E 02	0.	0.	415.0
.15818182E 02	0.	0.	416.0
.15840909E 02	0.	0.	417.0
.15863636E 02	0.	0.	418.0
.15886364E 02	0.	0.	419.0
.15909091E 02	0.	0.	420.0
.15931818E 02	0.	0.	421.0
.15954545E 02	0.	0.	422.0
.15977273E 02	0.	0.	423.0
.16000000E 02	0.	0.	424.0
.16022727E 02	0.	0.	425.0
.16045455E 02	0.	0.	426.0
.16068182E 02	0.	0.	427.0
.16090909E 02	0.	0.	428.0
.16113636E 02	0.	0.	429.0
.16136364E 02	0.	0.	430.0
.16159091E 02	0.	0.	431.0
.16181818E 02	0.	0.	432.0
.16204545E 02	0.	0.	433.0
.16227273E 02	0.	0.	434.0
.16250000E 02	0.	0.	435.0
.16272728E 02	0.	0.	436.0
.16295455E 02	0.	0.	437.0
.16318182E 02	0.	0.	438.0
.16340909E 02	0.	0.	439.0
.16363637E 02	0.	0.	440.0

Continued

.16386364E 02	0.	0.	441.0
.16409091E 02	0.	0.	442.0
.16431818E 02	0.	0.	443.0
.16454546E 02	0.	0.	444.0
.16477273E 02	0.	0.	445.0
.16500000E 02	0.	0.	446.0
.16522728E 02	0.	0.	447.0
.16545455E 02	0.	0.	448.0
.16568182E 02	0.	0.	449.0
.16590909E 02	0.	0.	450.0
.16613637E 02	0.	0.	451.0
.16636364E 02	0.	0.	452.0
.16659091E 02	0.	0.	453.0
.16681818E 02	0.	0.	454.0
.16704546E 02	0.	0.	455.0
.16727273E 02	0.	0.	456.0
.16750000E 02	0.	0.	457.0
.16772727E 02	0.	0.	458.0
.16795455E 02	0.	0.	459.0
.16818182E 02	0.	0.	460.0
.16840909E 02	0.	0.	461.0
.16863636E 02	0.	0.	462.0
.16886364E 02	0.	0.	463.0
.16909091E 02	0.	0.	464.0
.16931818E 02	0.	0.	465.0
.16954545E 02	0.	0.	466.0
.16977273E 02	0.	0.	467.0
.17000000E 02	0.	0.	468.0
.17022728E 02	0.	0.	469.0
.17045455E 02	0.	0.	470.0
.17068182E 02	0.	0.	471.0
.17090909E 02	0.	0.	472.0
.17113637E 02	0.	0.	473.0
.17136364E 02	0.	0.	474.0
.17159091E 02	0.	0.	475.0
.17181818E 02	0.	0.	476.0
.17204546E 02	0.	0.	477.0
.17227273E 02	0.	0.	478.0
.17250000E 02	0.	0.	479.0
.17272728E 02	0.	0.	480.0
.17295455E 02	0.	0.	481.0
.17318182E 02	0.	0.	482.0
.17340909E 02	0.	0.	483.0
.17363637E 02	0.	0.	484.0
.17386364E 02	0.	0.	485.0
.17409091E 02	0.	0.	486.0
.17431818E 02	0.	0.	487.0
.17454546E 02	0.	0.	488.0
.17477273E 02	0.	0.	489.0
.17500000E 02	0.	0.	490.0

Continued

.17522728F 02	0.	0.	491.0
.17545455E 02	0.	0.	492.0
.17568182E 02	0.	0.	493.0
.17590909E 02	0.	0.	494.0
.17613637E 02	0.	0.	495.0
.17636364E 02	0.	0.	496.0
.17659091E 02	0.	0.	497.0
.17681818E 02	0.	0.	498.0
.17704546F 02	0.	0.	499.0
.17727273E 02	0.	0.	500.0
.17750000F 02	0.	0.	501.0
.17772727E 02	0.	0.	502.0
.17795455E 02	0.	0.	503.0
.17818182E 02	0.	0.	504.0
.17840909E 02	0.	0.	505.0
.17863636E 02	0.	0.	506.0
.17886364E 02	0.	0.	507.0
.17909091E 02	0.	0.	508.0
.17931818E 02	0.	0.	509.0
.17954545E 02	0.	0.	510.0
.17977273E 02	0.	0.	511.0
.18000000F 02	0.	0.	512.0
.18022728E 02	0.	0.	513.0
.18045455E 02	0.	0.	514.0
.18068182E 02	0.	0.	515.0
.18090909E 02	0.	0.	516.0
.18113637E 02	0.	0.	517.0
.18136364E 02	0.	0.	518.0
.18159091E 02	0.	0.	519.0
.18181818E 02	0.	0.	520.0
.18204546E 02	0.	0.	521.0
.18227273F 02	0.	0.	522.0
.18250000E 02	0.	0.	523.0
.18272728E 02	0.	0.	524.0
.18295455E 02	0.	0.	525.0
.18318182E 02	0.	0.	526.0
.18340909E 02	0.	0.	527.0
.18363637E 02	0.	0.	528.0
.18386364F 02	0.	0.	529.0
.18409091E 02	0.	0.	530.0
.18431818E 02	0.	0.	531.0
.18454546E 02	0.	0.	532.0
.18477273E 02	0.	0.	533.0
.18500000F 02	0.	0.	534.0
.18522727E 02	0.	0.	535.0
.18545455F 02	0.	0.	536.0
.18568182E 02	0.	0.	537.0
.18590909E 02	0.	0.	538.0
.18613636E 02	0.	0.	539.0
.18636364E 02	0.	0.	540.0

Continued

.18659091E 02	0.	0.	541.0
.18681818E 02	0.	0.	542.0
.18704545E 02	0.	0.	543.0
.18727273E 02	0.	0.	544.0
.18750000E 02	0.	0.	545.0
.18772728E 02	0.	0.	546.0
.18795455E 02	0.	0.	547.0
.18818182E 02	0.	0.	548.0
.18840909E 02	0.	0.	549.0
.18863637E 02	0.	0.	550.0
.18886364E 02	0.	0.	551.0
.18909091E 02	0.	0.	552.0
.18931818E 02	0.	0.	553.0
.18954546E 02	0.	0.	554.0
.18977273E 02	0.	0.	555.0
.19000000E 02	0.	0.	556.0
.19022728E 02	0.	0.	557.0
.19045455E 02	0.	0.	558.0
.19068182E 02	0.	0.	559.0
.19090909E 02	0.	0.	560.0
.19113637E 02	0.	0.	561.0
.19136364E 02	0.	0.	562.0
.19159091E 02	0.	0.	563.0
.19181818E 02	0.	0.	564.0
.19204546E 02	0.	0.	565.0
.19227273E 02	0.	0.	566.0
.19250000E 02	0.	0.	567.0
.19272728E 02	0.	0.	568.0
.19295455E 02	0.	0.	569.0
.19318182E 02	0.	0.	570.0
.19340909E 02	0.	0.	571.0
.19363637E 02	0.	0.	572.0
.19386364E 02	0.	0.	573.0
.19409091E 02	0.	0.	574.0
.19431818E 02	0.	0.	575.0
.19454546E 02	0.	0.	576.0
.19477273E 02	0.	0.	577.0
.19500000E 02	0.	0.	578.0
.19522727E 02	0.	0.	579.0
.19545455E 02	0.	0.	580.0
.19568182E 02	0.	0.	581.0
.19590909E 02	0.	0.	582.0
.19613636E 02	0.	0.	583.0
.19636364E 02	0.	0.	584.0
.19659091E 02	0.	0.	585.0
.19681818E 02	0.	0.	586.0
.19704545E 02	0.	0.	587.0
.19727273E 02	0.	0.	588.0
.19750000E 02	0.	0.	589.0
.19772728E 02	0.	0.	590.0

Continued

.19795455E 02	0.	0.	591.0
.19818182E 02	0.	0.	592.0
.19840909E 02	0.	0.	593.0
.19863637E 02	0.	0.	594.0
.19886364E 02	0.	0.	595.0
.19909091E 02	0.	0.	596.0
.19931818E 02	0.	0.	597.0
.19954546E 02	0.	0.	598.0
.19977273E 02	0.	0.	599.0
.20000000E 02	0.	0.	600.0

End of Input Profile ... Linear Acceleration

INPUT DATA.......INITIAL CONDITIONS AND CONSTANTS

```
X-INITIAL VELOCITY (M/S).......................................... 0.

Y-INITIAL VELOCITY (M/S).......................................... 0.

Z-INITIAL VELOCITY (M/S).......................................... 0.40000000E 03

X-INITIAL DISPLACEMENT (METERS)................................... 0.63710000E 07

Y-INITIAL DISPLACEMENT (METERS)................................... 0.

Z-INITIAL DISPLACEMENT (METERS)................................... 0.

INITIAL RADIAL DISPLACEMENT (METERS).............................. 0.63710000E 07

EARTH GRAVITY CONSTANT (M/S/S).................................... 0.39818437E 15
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```
INPUT DATA.......VARIABLES

PRINTING TIME (SEC)........................................ 0.50000000E 02

CUTOFF TIME (SEC).......................................... 0.60000000E 03

VELOCITY CUTOFF (M/S)...................................... 0.10000000E 05

NAVIGATIONAL CYCLING TIME (SEC)............................ 0.10000000E 01

C(I,J) CYCLING TIME (SEC).................................. 0.99999999E-01

ANGULAR DISPLACEMENT QUANTIZATION LEVEL (DEG).............. 0.11111111E-01

LINEAR VELOCITY QUANTIZATION LEVEL (M/S)................... 0.10000000E 01

    ANGULAR VELOCITY........EXACT

    CHANGE IN VELOCITY......NOT QUANTIZED

    OPTION ONE.........DIRECTION COSINES

    WEIGHTED AVERAGE INTEGRATION
```

Analytic Platform Simulation Program Output Showing Vehicle Status Every 50 Seconds

```
TIME (SEC) = 0.

                        VPHIX                 VPHIY                 VPHIZ
   (DERIVATIVE)      0.                    0.                    0.
(NOT QUANTIZED)      0.                    0.                    0.
    (QUANTIZED)      0.                    0.                    0.

                        DELVXV                DELVYV                DELVZV
(NOT QUANTIZED)      0.                    0.                    0.
    (QUANTIZED)      0.                    0.                    0.

TRANSFORMATION MATRIX
                     0.10000000E 01        0.                    0.
                     0.                    0.10C00000E 01        0.
                     0.                    0.                    0.10000000E 01

ORTHOGONALITY CHECK
                     0.                    0.                    0.
                     0.                    0.                    0.

NORMALITY CHECK
                     0.10C00000E 01        0.10C0000CE 01        0.10000000E 01
                     0.1C0C0000E 01        0.1C0C0000E 01        0.10000000E 01

                     AXSG                  AYSG                  AZSG
                     0.98C99998E 01        0.                    0.

                     XS                    YS                    ZS
                     0.63710000E 07        0.                    0.

                     VXS                   VYS                   VZS
                     0.                    0.                    0.40000000E 03

                     VXI                   VYI                   VZI
                     0.                    0.                    0.40000000E 03

HEIGHT ABOVE EARTH = 0.                    METERS
    TOTAL VELOCITY = 0.40000000E 03        MET/SEC
             GAMMA = 0.90000000E 02        DEGREES
```

TIME (SEC) = 0.5C000E 02

	VPHIX	VPHIY	VPHIZ
(DERIVATIVE)	0.	-0.26179938E-02	0.
(NOT QUANTIZED)	0.	-0.26179938E-02	0.
(QUANTIZED)	0.	-0.38785093E-02	0.
	DELVXV	DELVYV	DELVZV
(NOT QUANTIZED)	0.22375000E 02	0.	0.
(QUANTIZED)	0.22000000E 02	0.	0.
TRANSFORMATION MATRIX			
	0.99142603E 00	-0.	-0.13065570E 00
	0.	0.10000000E 01	-0.
	0.13065570E 00	0.	0.99142603E 00
ORTHOGONALITY CHECK			
	-0.	-0.	0.
	0.	0.	0.
NORMALITY CHECK			
	0.99999647E 00	0.10000000E 01	0.99999647E 00
	0.99999647E 00	0.10000000E 01	0.99999647E 00
	AXSG	AYSG	AZSG
	0.97932123E 01	0.	0.31479781E-01
	XS	YS	ZS
	0.63767345E 07	0.	0.20958367E 05
	VXS	VYS	VZS
	0.31937882E 03	0.	0.46027913E 03
	VXI	VYI	VZI
	0.80964837E 03	0.	0.46106528E 03

HEIGHT ABOVE EARTH = 0.57689375E 04 METERS
TOTAL VELOCITY = 0.56023183E 03 MET/SEC
GAMMA = 0.55055652E 02 DEGREES

Continued

```
TIME (SEC) = 0.1C000E 03

                        VPHIX                  VPHIY                  VPHIZ
    (DERIVATIVE)     0.                    -0.26179938E-02        0.
 (NOT QUANTIZED)     0.                    -0.26179938E-02        0.
     (QUANTIZED)     0.                    -0.38785093E-02        0.

                        DELVXV                 DELVYV                 DELVZV
 (NOT QUANTIZED)     0.34875000E 02         0.                    0.
     (QUANTIZED)     0.35000000E 02         0.                    0.

    TRANSFORMATION MATRIX
                     0.96588840E 00        -0.                   -0.25894435E 00
                     0.                     0.10000000E 01       -0.
                     0.25894435E 00         0.                    0.96588840E 00

    ORTHOGONALITY CHECK
                    -0.                    -0.                    0.
                     0.                     0.                    0.

    NORMALITY CHECK
                     0.99999257E 00         0.10000000E 01        0.99999257E 00
                     0.99999257E 00         0.10000000E 01        0.99999257E 00

                     AXSG                   AYSG                  AZSG
                     0.96812250E 01         0.                    0.74569923E-01

                     XS                     YS                    ZS
                     0.64141978E 07         0.                    0.50147001E 05

                     VXS                    VYS                   VZS
                     0.12391748E 04         0.                    0.74661251E 03

                     VXI                    VYI                   VZI
                     0.22167734E 04         0.                    0.75001393E 03

    HEIGHT ABOVE EARTH = 0.43393750E 05  METERS
        TOTAL VELOCITY = 0.14467151E 04  MET/SEC
                 GAMMA = 0.30621355E 02  DEGREES
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Continued

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TIME (SEC) = 0.15000E 03

                         VPHIX                 VPHIY                  VPHIZ
   (DERIVATIVE)       0.                   -0.26179938E-02       0.
(NOT QUANTIZED)       0.                   -0.26179938E-02       0.
   (QUANTIZED)        0.                   -0.38785093E-02       0.

                         DELVXV                DELVYV                 DELVZV
(NOT QUANTIZED)       0.47375000E 02       0.                    0.
   (QUANTIZED)        0.47C00000E 02       0.                    0.

   TRANSFORMATION MATRIX
                      0.92382430E 00      -0.                   -0.38280178E 00
                      0.                   0.10000000E 01       -0.
                      0.38280178E 00       0.                    0.92382430E 00

   ORTHOGONALITY CHECK
                     -0.                  -0.                    0.
                      0.                   0.                    0.

   NORMALITY CHECK
                      0.99998854E 00       0.10000000E 01        0.99998854E 00
                      0.99998854E 00       0.10000000E 01        0.99998854E 00

                      AXSG                 AYSG                  AZSG
                      0.93935213E 01       0.                    0.14645724E 00

                      XS                   YS                    ZS
                      0.65122437E 07       0.                    0.10291377E 06

                      VXS                  VYS                   VZS
                      0.27102130E 04       0.                    0.14129244E 04

                      VXI                  VYI                   VZI
                      0.41652586E 04       0.                    0.14217625E 04

   HEIGHT ABOVE EARTH = 0.14205681E 06  METERS
       TOTAL VELOCITY = 0.30564047E 04  MET/SEC
                GAMMA = 0.26629156E 02  DEGREES
```

Continued

```
TIME (SEC) = 0.20000E 03

                     VPHIX                 VPHIY                 VPHIZ
   (DERIVATIVE)      0.                    -0.26179938E-02       0.
(NOT QUANTIZED)      0.                    -0.26179938E-02       0.
    (QUANTIZED)      0.                    -0.38785093E-02       0.

                     DELVXV                DELVYV                DELVZV
(NOT QUANTIZED)      0.10897727E 02        0.                    0.
    (QUANTIZED)      0.11000000E 02        0.                    0.

    TRANSFORMATION MATRIX
                     0.86595330E 00        -0.                   -0.50010911E 00
                     0.                    0.10000000E 01        -0.
                     0.50010911E 00        0.                    0.86595330E 00

    ORTHOGONALITY CHECK
                    -0.                    -0.                   0.
                     0.                    0.                    0.

    NORMALITY CHECK
                     0.99998423E 00        0.10000000E 01        0.99998423E 00
                     0.99998423E 00        0.10000000E 01        0.99998423E 00

                     AXSG                  AYSG                  AZSG
                     0.89620960E 01        0.                    0.24826320E 00

                     XS                    YS                    ZS
                     0.66648264E 07        0.                    0.18633734E 06

                     VXS                   VYS                   VZS
                     0.30895920E 04        0.                    0.17948685E 04

                     VXI                   VYI                   VZI
                     0.50031138E 04        0.                    0.18136529E 04

    HEIGHT ABOVE EARTH = 0.29643075E 06  METERS
        TOTAL VELOCITY = 0.35731123E 04  MET/SEC
                 GAMMA = 0.28552554E 02  DEGREES
```

Continued

```
TIME (SEC) = 0.25000E 03

                         VPHIX                 VPHIY                 VPHIZ
   (DERIVATIVE)       0.                -0.26179938E-02        0.
(NOT QUANTIZED)       0.                -0.26179938E-02        0.
    (QUANTIZED)       0.                -0.38785093E-02        0.

                         DELVXV                DELVYV                DELVZV
(NOT QUANTIZED)       0.12034091E 02     0.                    0.
    (QUANTIZED)       0.12000000E 02     0.                    0.

    TRANSFORMATION MATRIX
                      0.79326594E 00    -0.                   -0.60885821E 00
                      0.                 0.10000000E 01       -0.
                      0.60885821E 00     0.                    0.79326594E 00

    ORTHOGONALITY CHECK
                     -0.                -0.                    0.
                      0.                 0.                    0.

    NORMALITY CHECK
                      0.99997916E 00     0.10000000E 01        0.99997916E 00
                      0.99997916E 00     0.10000000E 01        0.99997916E 00

                      AXSG               AYSG                  AZSG
                      0.85462966E 01     0.                    0.35294244E 00

                      XS                 YS                    ZS
                      0.68202039E 07     0.                    0.28363258E 06

                      VXS                VYS                   VZS
                      0.31283722E 04     0.                    0.20995393E 04

                      VXI                VYI                   VZI
                      0.54791137E 04     0.                    0.21334439E 04

    HEIGHT ABOVE EARTH = 0.45509900E 06  METERS
        TOTAL VELOCITY = 0.37675957E 04  MET/SEC
                 GAMMA = 0.31485288E 02  DEGREES
```

Continued

```
TIME (SEC) = 0.30000E 03

                       VPHIX                 VPHIY                 VPHIZ
   (DERIVATIVE)     0.                 -0.26179938E-02      0.
(NOT QUANTIZED)     0.                 -0.26179938E-02      0.
    (QUANTIZED)     0.                 -0.38785093E-02      0.

                       DELVXV                DELVYV                DELVZV
(NOT QUANTIZED)     0.13170455E 02      0.                   0.
    (QUANTIZED)     0.13000000E 02      0.                   0.

    TRANSFORMATION MATRIX
                    0.70700575E 00     -0.                  -0.70718939E 00
                    0.                  0.10000000E 01      -0.
                    0.70718939E 00      0.                   0.70700575E 00

    ORTHOGONALITY CHECK
                   -0.                 -0.                   0.
                    0.                  0.                   0.

    NORMALITY CHECK
                    0.99997395E 00      0.10000000E 01       0.99997395E 00
                    0.99997395E 00      0.10000000E 01       0.99997395E 00

                    AXSG                AYSG                 AZSG
                    0.81454823E 01      0.                   0.46248535E 00

                    XS                  YS                   ZS
                    0.69780425E 07      0.                   0.39851963E 06

                    VXS                 VYS                  VZS
                    0.31843508E 04      0.                   0.24957509E 04

                    VXI                 VYI                  VZI
                    0.59519327E 04      0.                   0.25501253E 04

    HEIGHT ABOVE EARTH = 0.61841306E 06  METERS
        TOTAL VELOCITY = 0.40458450E 04  MET/SEC
                 GAMMA = 0.34819112E 02  DEGREES
```

Continued

TIME (SEC) = 0.35000E 03

	VPHIX	VPHIY	VPHIZ
(DERIVATIVE)	0.	-0.26179938E-02	0.
(NOT QUANTIZED)	0.	-0.26179938E-02	0.
(QUANTIZED)	0.	-0.38785093E-02	0.
	DELVXV	DELVYV	DELVZV
(NOT QUANTIZED)	0.14306818E 02	0.	0.
(QUANTIZED)	0.15000000E 02	0.	0.

TRANSFORMATION MATRIX

0.60864879E 00	-0.	-0.79342007E 00
0.	0.10000000E 01	-0.
0.79342007E 00	0.	0.60864879E 00

ORTHOGONALITY CHECK

-0.	-0.	0.
0.	0.	0.

NORMALITY CHECK

0.99996875E 00	0.10000000E 01	0.99996875E 00
0.99996875E 00	0.10000000E 01	0.99996875E 00
AXSG	AYSG	AZSG
0.77556218E 01	0.	0.57898754E 00
XS	YS	ZS
0.71387248E 07	0.	0.53568452E 06
VXS	VYS	VZS
0.32390124E 04	0.	0.29872014E 04
VXI	VYI	VZI
0.64036916E 04	0.	0.30676971E 04

HEIGHT ABOVE EARTH = 0.78779531E 06 METERS
TOTAL VELOCITY = 0.44061971E 04 MET/SEC
GAMMA = 0.38392621E 02 DEGREES

Continued

```
TIME (SEC) = 0.40000E 03

                    VPHIX                VPHIY                VPHIZ
   (DERIVATIVE)     0.                   -0.26179938E-02      0.
(NOT QUANTIZED)     0.                   -0.26179938E-02      0.
    (QUANTIZED)     0.                   -0.38785093E-02      0.

                    DELVXV               DELVYV               DELVZV
(NOT QUANTIZED)     0.15443182E 02       0.                   0.
    (QUANTIZED)     0.15000000E 02       0.                   0.

    TRANSFORMATION MATRIX
                    0.49987793E 00       -0.                  -0.86607487E 00
                    0.                   0.10000000E 01       -0.
                    0.86607487E 00       0.                   0.49987793E 00

    ORTHOGONALITY CHECK
                   -0.                   -0.                  0.
                    0.                   0.                   0.

    NORMALITY CHECK
                    0.99996361E 00       0.10000000E 01       0.99996361E 00
                    0.99996361E 00       0.10000000E 01       0.99996361E 00

                    AXSG                 AYSG                 AZSG
                    0.73743604E 01       0.                   0.70358174E 00

                    XS                   YS                   ZS
                    0.73016845E 07       0.                   0.69991625E 06

                    VXS                  VYS                  VZS
                    0.32729890E 04       0.                   0.35744099E 04

                    VXI                  VYI                  VZI
                    0.68155031E 04       0.                   0.36870595E 04

    HEIGHT ABOVE EARTH = 0.96415363E 06  METERS
        TOTAL VELOCITY = 0.48465310E 04  MET/SEC
                 GAMMA = 0.42045059E 02  DEGREES
```

Continued

```
TIME (SEC) = 0.45000E 03

                        VPHIX                VPHIY                VPHIZ
   (DERIVATIVE)     0.                 -0.26179938E-02      0.
(NOT QUANTIZED)     0.                 -0.26179938E-02      0.
    (QUANTIZED)     0.                 -0.38785093E-02      0.

                        DELVXV               DELVYV               DELVZV
(NOT QUANTIZED)     0.16579546E 02     0.                   0.
    (QUANTIZED)     0.16000000E 02     0.                   0.

    TRANSFORMATION MATRIX
                    0.38255512E 00    -0.                  -0.92391077E 00
                    0.                 0.10000000E 01      -0.
                    0.92391077E 00     0.                   0.38255512E 00

    ORTHOGONALITY CHECK
                   -0.                -0.                   0.
                    0.                 0.                   0.

    NORMALITY CHECK
                    0.99995953E 00     0.10000000E 01       0.99995953E 00
                    0.99995953E 00     0.10000000E 01       0.99995953E 00

                    AXSG               AYSG                 AZSG
                    0.70004363E 01     0.                   0.83651502E 00

                    XS                 YS                   ZS
                    0.74653733E 07     0.                   0.89594407E 06

                    VXS                VYS                  VZS
                    0.32665055E 04     0.                   0.42545805E 04

                    VXI                VYI                  VZI
                    0.71679858E 04     0.                   0.44058313E 04

    HEIGHT ABOVE EARTH = 0.11479437E 07  METERS
        TOTAL VELOCITY = 0.53639084E 04  MET/SEC
                 GAMMA = 0.45640790E 02  DEGREES
```

Continued

```
TIME (SEC) = 0.5C000E 03

                         VPHIX                  VPHIY                    VPHIZ
   (DERIVATIVE)      0.                  -0.26179938E-02          0.
(NOT QUANTIZED)      0.                  -0.26179938E-02          0.
    (QUANTIZED)      0.                  -0.38785093E-02          0.

                        DELVXV                 DELVYV                   DELVZV
(NOT QUANTIZED)      0.17715910E 02       0.                      0.
    (QUANTIZED)      0.18000000E 02       0.                      0.

    TRANSFORMATION MATRIX
                     0.25868694E 00      -0.                     -0.96593814E 00
                     0.                   0.10000000E 01         -0.
                     0.96593814E 00       0.                      0.25868694E 00

    ORTHOGONALITY CHECK
                    -0.                  -0.                      0.
                     0.                   0.                      0.

    NORMALITY CHECK
                     0.99995540E 00       0.10000000E 01          0.99995540E 00
                     0.99995540E 00       0.10000000E 01          0.99995540E 00

                     AXSG                 AYSG                    AZSG
                     0.66332025E 01       0.                      0.97725911E 00

                     XS                   YS                      ZS
                     0.76272558E 07       0.                      0.11282697E 07

                     VXS                  VYS                     VZS
                     0.31998803E 04       0.                      0.50215445E 04

                     VXI                  VYI                     VZI
                     0.74418064E 04       0.                      0.52182499E 04

    HEIGHT ABOVE EARTH = 0.13392544E 07  METERS
        TOTAL VELOCITY = 0.59544222E 04  MET/SEC
                 GAMMA = 0.49078963E 02  DEGREES
```

Continued

TIME (SEC) = 0.55000E 03

	VPHIX	VPHIY	VPHIZ
(DERIVATIVE)	0.	-0.26179938E-02	0.
(NOT QUANTIZED)	0.	-0.26179938E-02	0.
(QUANTIZED)	0.	-0.38785093E-02	0.

	DELVXV	DELVYV	DELVZV
(NOT QUANTIZED)	0.18852273E 02	0.	0.
(QUANTIZED)	0.19000000E 02	0.	0.

TRANSFORMATION MATRIX

0.13039322E 00	-0.	-0.99143801E 00
0.	0.10000000E 01	-0.
0.99143801E 00	0.	0.13039322E 00

ORTHOGONALITY CHECK

-0.	-0.	0.
0.	0.	0.

NORMALITY CHECK

0.99995171E 00	0.10000000E 01	0.99995171E 00
0.99995171E 00	0.10000000E 01	0.99995171E 00

AXSG	AYSG	AZSG
0.62722672E 01	0.	0.11246433E 01

XS	YS	ZS
0.77838250E 07	0.	0.14009991E 07

VXS	VYS	VZS
0.30540631E 04	0.	0.58657832E 04

VXI	VYI	VZI
0.76182381E 04	0.	0.61151589E 04

HEIGHT ABOVE EARTH = 0.15379018E 07 METERS
TOTAL VELOCITY = 0.66132227E 04 MET/SEC
GAMMA = 0.52292594E 02 DEGREES

Continued

TIME (SEC) = 0.6C000E 03

	VPHIX	VPHIY	VPHIZ
(DERIVATIVE)	0.	-0.26179938E-02	0.
(NOT QUANTIZED)	0.	-0.26179938E-02	0.
(QUANTIZED)	0.	-0.	0.

	DELVXV	DELVYV	DELVZV
(NOT QUANTIZED)	0.19988637E 02	0.	0.
(QUANTIZED)	0.20000000E 02	0.	0.

TRANSFORMATION MATRIX

-0.15095221E-03	-0.	-0.99997396E 00
0.	0.10000000E 01	-0.
0.99997396E 00	-0.	-0.15095221E-03

ORTHOGONALITY CHECK

0.	0.	0.
-0.	-0.	0.

NORMALITY CHECK

0.99994794E 00	0.10000000E 01	0.99994794E 00
0.99994794E 00	0.10000000E 01	0.99994794E 00

AXSG	AYSG	AZSG
0.59172478E 01	0.	0.12769906E 01

XS	YS	ZS
0.79306510E 07	0.	0.17176773E 07

VXS	VYS	VZS
0.28111888E 04	0.	0.67745299E 04

VXI	VYI	VZI
0.76797213E 04	0.	0.70840821E 04

HEIGHT ABOVE EARTH = 0.17435326E 07 METERS
TOTAL VELOCITY = 0.73346464E 04 MET/SEC
GAMMA = 0.55242517E 02 DEGREES

Continued

Analytic Platform Simulation Program Output
Showing Vehicle End-conditions.

```
SEMIMAJOR AXIS.......................... 0.89794392E 07

SEMIMINOR AXIS.......................... 0.66447497E 07

ECCENTRICITY............................ 0.57557010E 00

APOGEE RADIUS........................... 0.14147736E 08

PERIGEE RADIUS.......................... 0.38111425E 07

ORBITAL VELOCITY AT APOGEE.............. 0.34562219E 04

ORBITAL VELOCITY AT PERIGEE............. 0.12830198E 05
```

```
$IBFTC
C      ABSTRACT.....THIS ROUTINE CALCULATES FLIGHT CONDITIONS FOR THE
C      SIMPLIFIED VEHICLE PROFILES.
       DOUBLE PRECISION T,XS,ZS,TO,XO,ZO,A1,A2,A3,B1,B2,B3,DELT,VXO,VZO,P
      1IE,GME,XK1,XK2,XK3,PART1,PART2,DELXS,DELZS,DELVXS,DELVZS
   10 FORMAT(5(5X,D15.8))
       TO=0.0
       DELT=0.2
       XO=6371000.0
       ZO=0.0
       VXO=0.0
       VZO=400.0
       GME=0.39818437E+15
       PIE=3.14159265
       XK1=PIE/1200.0
       XK2=0.25
       XK3=10.0
       GO TO 1
    2  XK2=-1759.0/44.0
       XK3=70360.0/11.0
       GO TO 1
    3  XK2=1.0/44.0
       XK3=70.0/11.0
    1  T=TO
       XS=XO
       ZS=ZO
       PART1=(XK2*T*DCOS(XK1*T)+XK3*DCOS(XK1*T)-GME*XS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
       PART2=(XK2*T*DSIN(XK1*T)+XK3*DSIN(XK1*T)-GME*ZS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
       A1=PART1
       B1=PART2
       T=TO+DELT/2.0
       XS=XO+DELT*VXO/2.0+DELT*A1/8.0
       ZS=ZO+DELT*VZO/2.0+DELT*B1/8.0
       PART1=(XK2*T*DCOS(XK1*T)+XK3*DCOS(XK1*T)-GME*XS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
       PART2=(XK2*T*DSIN(XK1*T)+XK3*DSIN(XK1*T)-GME*ZS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
       A2=PART1
       B2=PART2
       T=TO+DELT
       XS=XO+DELT*VXO+DELT*A2/2.0
       ZS=ZO+DELT*VZO+DELT*B2/2.0
       PART1=(XK2*T*DCOS(XK1*T)+XK3*DCOS(XK1*T)-GME*XS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
       PART2=(XK2*T*DSIN(XK1*T)+XK3*DSIN(XK1*T)-GME*ZS/(DSQRT(XS**2+ZS**2
      1)**3))*DELT
```

Continued

```
A3=PART1
B3=PART2
DELXS=DELT*(VXO+(A1+2.0*A2)/6.0)
DELZS=DELT*(VZO+(B1+2.0*B2)/6.0)
DELVXS=(A1+4.0*A2+A3)/6.0
DELVZS=(B1+4.0*B2+B3)/6.0
XO=XO+DELXS
ZO=ZO+DELZS
TO=TO+DELT
VXO=VXO+DELVXS
VZO=VZO+DELVZS
WRITE(6,10) TO,XO,ZO,VXO,VZO
IF (T.GE.601.0) STOP
IF (T.LE.160.0) GO TO 1
IF (T.GE.161.0) GO TO 3
GO TO 2
END
```

Runge-Kutta Numerical Integration Digital Computer Program.

Time (Sec.)	XS(RK) (m)	XS(AP) (m)	% Diff. $100 \left\| \frac{XS(RK)-XS(AP)}{XS(RK)} \right\|$
0	6 371 000.0	6 371 000.0	0.0
50	6 376 416.8	6 376 734.5	0.004980
100	6 412 970.9	6 414 197.8	0.019130
150	6 509 580.7	6 512 243.7	0.040900
200	6 660 056.0	6 664 826.4	0.071627
250	6 813 163.3	6 820 203.9	0.103338
300	6 968 695.4	6 978 042.5	0.134129
350	7 127 049.3	7 138 724.8	0.163819
400	7 287 674.4	7 301 684.5	0.192243
450	7 449 040.7	7 465 373.3	0.219257
500	7 608 630.5	7 627 255.8	0.244791
550	7 762 956.0	7 783 825.0	0.268828

Time (Sec.)	ZS(RK) (m)	ZS(AP) (m)	% Diff $100 \left\| \frac{ZS(RK) - ZS(AP)}{ZS(RK)} \right\|$
0	0.0	0.0	
50	20 872.473	20 958.367	0.0
100	49 669.414	50 147.001	0.961530
150	101 545.07	102 913.77	1.347870
200	183 452.26	186 337.34	1.572659
250	279 059.94	283 632.58	1.638587
300	392 145.33	398 519.63	1.625494
350	527 394.03	535 684.52	1.571972
400	689 598.17	699 916.25	1.496245
450	883 493.71	895 944.07	1.409218
500	1 113 592.90	1 128 269.70	1.317968
550	1 384 015.60	1 400 999.10	1.227117

(RK) - Runge-Kutta Numerical Method
(AP) - Analytic Platform Simulation Method

Comparison of the Vehicle Position Between Solutions

Time (Sec.)	VXS(RK) (M/S)	VXS(AP) (M/S)	% Diff. $100\left\lvert\frac{VXS(RK)-VXS(AP)}{VXS(RK)}\right\rvert$
0	0.0	0.0	0.0
50	319.45018	319.37882	0.02233
100	1 239.5540	1 239.1748	0.03059
150	2 711.2843	2 710.2130	0.03951
200	3 045.0830	3 089.5920	1.461667
250	3 083.5393	3 128.3722	1.453942
300	3 139.0876	3 184.3508	1.441922
350	3 193.2432	3 239.0124	1.433313
400	3 226.6628	3 272.9890	1.435731
450	3 219.5907	3 266.5055	1.457170
500	3 152.3594	3 199.8803	1.507470
550	3 005.9277	3 054.0631	1.601349

Time (Sec.)	VZS(RK) (M/S)	VZS(AP) (M/S)	% Diff. $100\left\lvert\frac{VZS(RK)-VZS(AP)}{VZS(RK)}\right.$
0	400.0	400.0	0.0
50	459.11773	460.27913	0.252960
100	743.44619	746.61251	0.425890
150	1 407.0174	1 412.9244	0.419820
200	1 767.4580	1 794.8685	1.550843
250	2 071.6470	2 099.5393	1.346382
300	2 467.4385	2 495.7509	1.147440
350	2 958.5376	2 987.2014	0.968850
400	3 545.4706	3 574.4099	0.816232
450	4 225.4483	4 254.5805	0.689446
500	4 992.3069	5 021.5445	0.585673
550	5 836.5303	5 865.7832	0.501204

(RK) - Runge-Kutta Numerical Method.
(AP) - Analytic Platform Simulation Method

Comparison of the Vehicle Velocities Between Solutions.

V. OPERATING INSTRUCTIONS

Figure V-1 is a pictorial listing of the subroutines of the analytic platform simulation program in the order of their entry. The header cards for the program and subroutines may vary among installations. Figure V-2 is a pictorial listing of the input data for the analytic platform simulation program in the order of their entry. The format for the data is given in subroutines READ1 and READ2. The symbols that are used are explained in Chapter II, Section B.

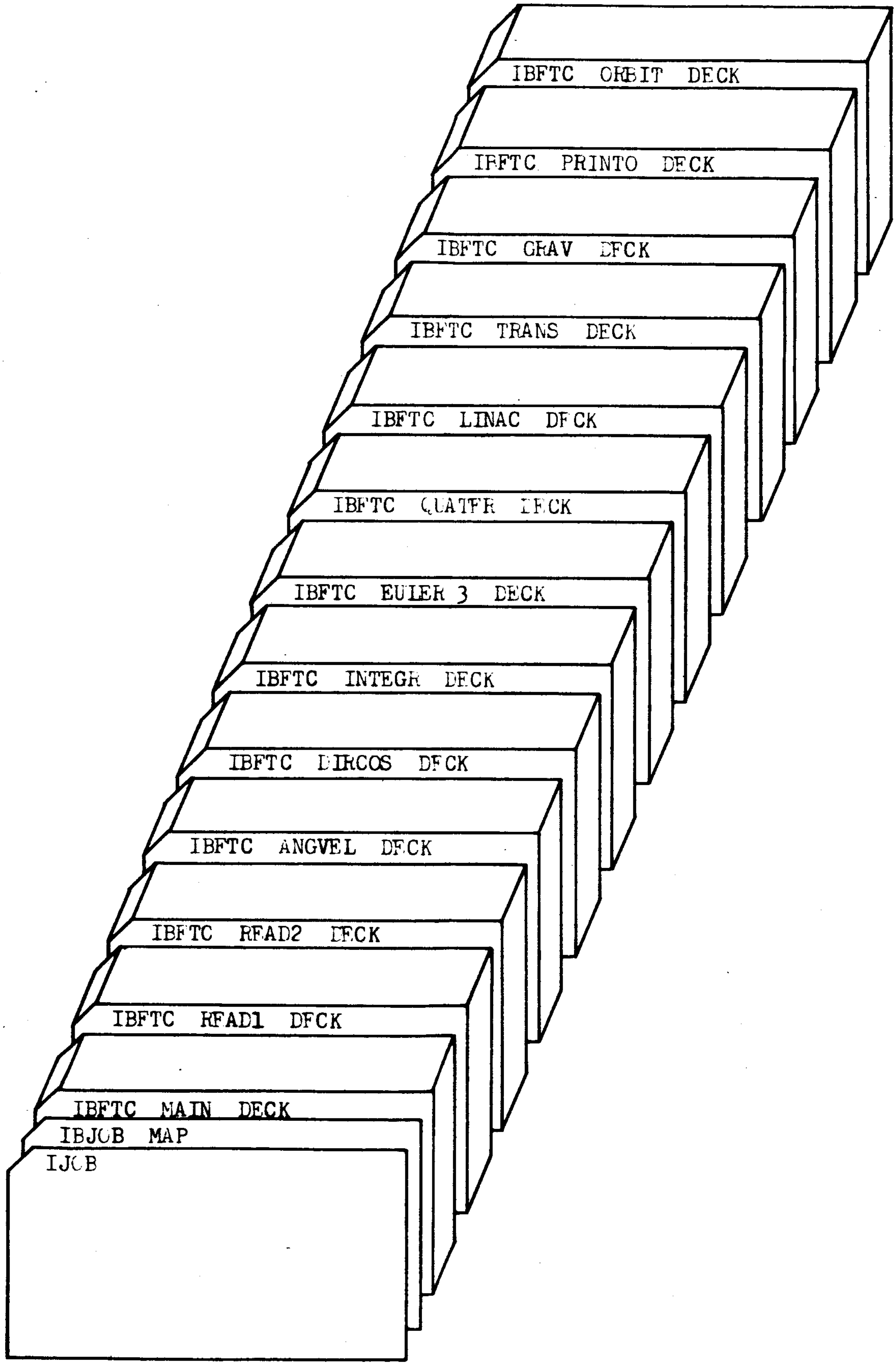

Fig. V-1--Pictorial Listing of the Subroutines of the Analytic Platform Simulation Program in the Order of Their Entry.

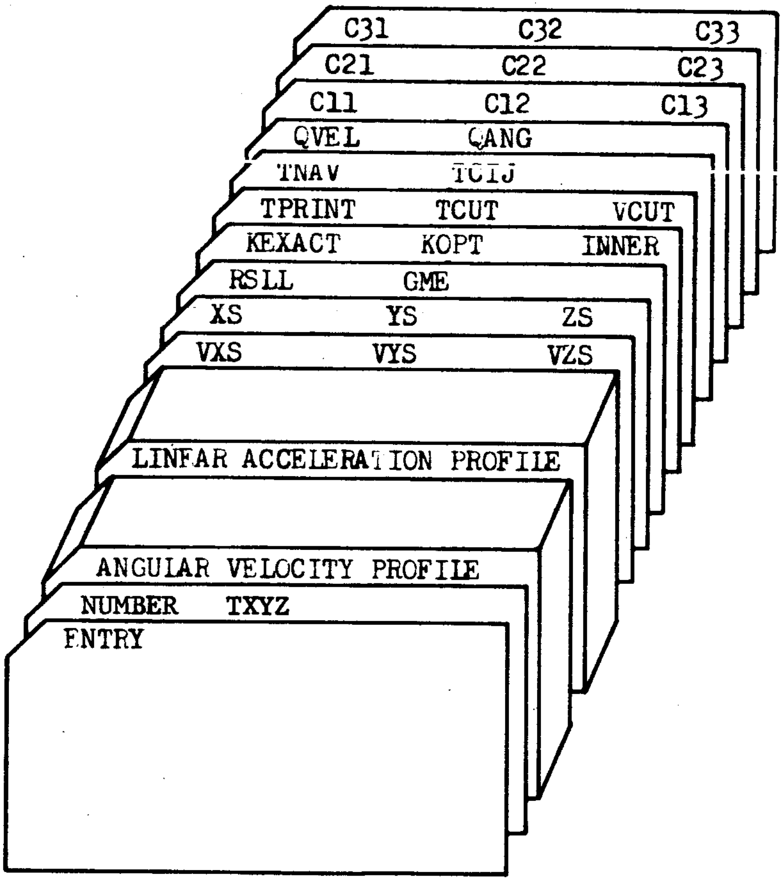

Fig. V-2--Pictorial Listing of the Input Data for the Analytic Platform Simulation Program in the order of their entry.

PHASE	MIN	SEC
LOADER	1	26
EXECUTION	8	48
SYSTEM	0	24
TOTAL	10	38

CARDS READ 1656

PAGES PRINTED 44

Time Page Showing the Time for the Test Case Analytic Platform Simulation Computer Run.