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AEROSPACE NUCLEAR SAFETY

A COMPARISON OF THE RESULTS OF THE
SANDIA CORPORATION TIA TRAJECTORY
PROGRAM AND THE ATOMICS INTERNATIONAL
RESTORE TRAJECTORY PROGRAM

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PRIME CONTRACTOR TO THE
UNITED STATES ATOMIC
ENERGY COMMISSION
ALBUQUERQUE, NEW MEXICO
LIVERMORE, CALIFORNIA

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IN NUCLEAR SCIENCE ABSTRACTS

SC-RR-66-22

A COMPARISON OF THE RESULTS
OF THE SANDIA CORPORATION TTA
TRAJECTORY PROGRAM AND THE
ATOMICS INTERNATIONAL RESTORE
TRAJECTORY PROGRAM

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February 1966

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ABSTRACT

This study compares the results of the Sandia Corporation TTA and the Atomics International RESTORE trajectory programs. Initial conditions used for both trajectories correspond to an orbital decay trajectory which is very sensitive to any variation in initial conditions or input data. The comparison of the results, which indicated relatively small differences between the two trajectories, verified the accuracy of the trajectory programs.

ACKNOWLEDGMENT

The author acknowledges the assistance and suggestions provided in this study by Mr. J. A. F. Allensworth, Mathematical Computing Services Division, Sandia Corporation. (Mr. Allensworth developed the TTA trajectory program.)

The author also acknowledges the assistance of Mr. V. Sanders, Hughes Aircraft Company, and Mr. J. Baughn, Aerospace Nuclear Safety Program, Atomics International, who reviewed the sections on the RESTORE trajectory program to insure their accuracy. (Mr. Sanders, formerly with the Aerospace Nuclear Safety Program, Atomics International, developed the RESTORE trajectory program.)

Summary

In the Aerospace Nuclear Safety Program, safety analyses are required to determine the behavior of nuclear systems during launch aborts and re-entry after use in space. These analyses require usage of theoretical trajectory programs to define the history of the re-entering nuclear system and attached hardware.

Theoretical trajectories are also required for research programs and re-entry flight test programs conducted in support of the Aerospace Nuclear Safety Program. The research programs, which include both theoretical studies and experiments conducted in facilities on the ground, require theoretical trajectories to define inputs for the theoretical studies and to define the re-entry environment to be simulated in the ground facilities. Re-entry flight test programs require theoretical trajectories to provide input data for preliminary feasibility studies, flight test definition, system design, preflight prediction of flight test results, and to aid in the reduction of flight test data.

This report briefly describes the Sandia Corporation TTA and the Atomic International RESTORE trajectory programs. The initial conditions and object characteristics used in the trajectories are defined. These initial conditions correspond to a very sensitive trajectory representative of orbital decay. The steps taken in the use of the TTA trajectory program to obtain the solution to the equations of motion are also presented.

A comparison of the results of the two trajectory programs shows very good agreement. The relatively small differences between the two trajectories are shown to be at least an order of magnitude less than the variations in an actual trajectory which would result from the accuracy with which the input data would be known.

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A COMPARISON OF THE RESULTS
OF THE SANDIA CORPORATION TTA
TRAJECTORY PROGRAM AND THE
ATOMICS INTERNATIONAL RESTORE
TRAJECTORY PROGRAM

Introduction

In the Aerospace Nuclear Safety Program, accurate trajectory programs are required to assure that the results of independent investigations are not affected by the different trajectories resulting from the use of the same initial conditions with different trajectory programs. In the determination of the accuracy of trajectory programs, a trajectory representative of orbital decay would be the type of trajectory most sensitive to any differences in the programs.

To further verify the accuracy of the RESTORE trajectory program, the Aerospace Nuclear Safety Program group of Atomics International requested (in March 1965) that the Sandia Corporation Aerospace Nuclear Safety Department use the TTA trajectory program to compute a trajectory with a set of conditions representative of orbital decay trajectories. This trajectory could then be compared with the results of a trajectory computed on the Atomics International RESTORE program.

The results of the Sandia Corporation TTA trajectory program had previously been compared with the results of trajectory programs used by the Air Force Special Weapons Center, AVCO Corporation, General Electric, Ling Temco Vought Corporation, Lockheed, and the National Aeronautics and Space Administration. However, the trajectories previously used to compare results would not be as sensitive to slight variations in computer programs as orbital decay trajectories. While all the previous comparisons showed good agreement

between the results of the TTA and other trajectory programs, the time and effort necessary to document the comparisons had not been expended.

This report documents the comparison of the results from the TTA and RESTORE trajectory programs for a trajectory representative of orbital decay trajectories. (This information was sent in memorandum form to the Atomic International Aerospace Nuclear Safety Program group on July 26, 1965.) As part of the comparison, the sensitivity of the representative orbital decay trajectory to small variations in initial conditions and input data is defined.

The Sandia Corporation TTA Trajectory Program

The TTA trajectory program (Theoretical Trajectory program A) was developed in 1961 to provide a versatile tool to generate theoretical trajectories in support of Sandia Corporation activities. Since late 1961, it has been used to generate over 14,000 rocket-boostered, free-fall, and re-entry trajectories in support of various weapons programs, research activities, and the Aerospace Nuclear Safety Program. The TTA trajectory program is continually being revised and updated to increase its capabilities and flexibility.

The TTA trajectory program numerically integrates the equations of motion for a rigid object flying a 6-degree of freedom trajectory in the vicinity of the Earth. (However, only the point mass 3-degree of freedom option was needed for the trajectories discussed in this report.) The integration subroutine uses a modified Adams-Moulton predictor-corrector method of order two (parabolic). The numerical integration step size is controlled by an automatic mesh control system. The rigid object may be subjected to all the aerodynamic forces and moments (including magnus forces and moments) and to the thrust, gravity, buoyancy forces, and arbitrary external forces and moments acting on the object while moving relative to a rotating oblate Earth. The atmospheric models currently used have properties that are functions of height alone and rotate with the Earth. (Provisions are available for including wind velocities in the atmospheric model.)

The shape and rotational rate in the Earth model can be easily changed and any theoretical or measured set of atmospheric properties can be used. The input data can be either inertial or Earth relative. Coordinates, while normally in a geodetic system, can be expressed in a geocentric system or in a cartesian coordinate system. Output data can be either inertial or Earth relative. The number of parameters available as output data are approximately 250. The TTA trajectory program is currently being used on a Control Data Corporation 3600 electronic computer.

Further details on the TTA trajectory program will be available in Reference 1, while some additional details are available in Reference 2 and in Appendix VII-D of Reference 3.

TTA Earth Model

The TTA trajectory program considers the Earth as an oblate spheroid of revolution. The values currently used to define the TTA Earth model are:

Equatorial radius = 20,925,540 feet

Polar radius = 20,855,107 feet

Angular rate of rotation = $0.729211513186 \times 10^{-4}$ radians per second

The TTA trajectory program uses the equations below to define the Earth's gravitational field; the rotational effects in the radial or R direction (direction of RADVC, defined in the following section) and the latitudinal or ℓ direction (perpendicular to RADVC and pointed poleward) are not included in these equations:

$$G_R = G_2 \left(\frac{R_e}{P} \right)^2 + \frac{1}{2} G_4 \left(\frac{R_e}{P} \right)^4 (3 \sin^2 \ell - 1), \text{ and}$$

$$G_\ell = G_4 \left(\frac{R_e}{P} \right)^4 (\sin \ell \cdot \cos \ell)$$

where

G_R = radial component of the gravitational field

G_ℓ = latitudinal component of the gravitational field

G_2 = coefficient of the gravitational field

= -32.1465889954 feet per second²

R_e = mean Earth equatorial radius

= 20,925,540 feet

P = length of the radius vector from the center of the Earth to the point
in question, feet

G_4 = coefficient of the gravitational field

= -0.1049648809 feet per second²

ℓ = absolute value of the geocentric latitude, degrees

TTA Coordinate System

The sketch below shows the geodetic coordinate system normally used for the input and output coordinate system for the TTA trajectory program.

The parameters shown on the sketch and other pertinent parameters are defined below:

GAMMA	Earth relative re-entry angle in degrees; i.e., the angle between the Earth relative velocity vector, whose magnitude is V_T , and a plane perpendicular to a line from the re-entering object perpendicular to the surface of the rotating oblate Earth.
HITE	Altitude in feet above mean sea level measured along a line from the re-entering object perpendicular to the surface of the rotating oblate Earth.
LAT	The geodetic latitude in degrees of the intersection of a line from the re-entering object perpendicular to the surface of the rotating oblate Earth.
LONG	The longitude in degrees of the intersection of a line from the re-entering object perpendicular to the surface of the rotating oblate Earth.
RADVC	The length in feet of the line from the Earth's center to the re-entering object.
TAU	The angle, in degrees, positive in the counter-clockwise direction, between the projection of the Earth relative velocity vector, whose magnitude is V_T , on a plane at the Earth's surface (perpendicular to a line from the re-entering object which is perpendicular to the surface of the rotating oblate Earth) and East.
V_T	The velocity in feet per second of the re-entering object relative to a point on the surface of the rotating oblate Earth where a line from the re-entering object is perpendicular to the Earth's surface.

TTA Input Data

To define the initial conditions for a TTA trajectory (using only the 3-degree of freedom option) and to provide the data necessary for the subsequent calculations, the following must be defined:

1. Initial position of the object.
2. Initial magnitude and orientation of the velocity vector of the object.
3. Initial object characteristics along with any variation of the object characteristics during the trajectory.
4. Atmospheric data to be used in the calculation of the trajectory.

The initial position of the object is defined by specifying LAT, LONG, and HITE. Specification of VT, GAMMA, and TAU defines the initial magnitude and orientation of the velocity vector of the object. (These six TTA trajectory variables were defined in the previous section.) Alternate forms of specification are available, but these forms permit direct usage of the initial conditions supplied by Atomics International.

The initial object characteristics are defined by specifying the initial values of object weight (WT) in pounds, the object reference area (AREA) in square feet, and the object drag coefficient (CD) which is dimensionless. (Specification of the variation of these characteristics during the trajectory is not necessary as the characteristics were specified as constant during the trajectory.)

Definition of the atmospheric characteristics is accomplished by specifying values for the speed of sound (SOFS), atmospheric density (RHO), and atmospheric pressure (PA) in tabular form as a function of altitude (HITE). Linear interpolation with HITE is used between data points for all atmospheric properties. (Exponential interpolation with altitude on density is not used as this would require a separate interpolation routine, which would use more computer time. The accuracy of exponential interpolation can be obtained by programming more data points. The usage of linear interpolation on the log of the density and then the exponentiation of the result, is not used as this requires an intermediate step

when supplying the atmospheric density data. The elimination of the intermediate step is desirable as the TTA trajectory program is often used with actual measured atmospheric characteristics to help reduce flight test data.

The atmospheric model normally used with the TTA trajectory program is ICAO 1962 ATMOSPHERE KLETT (based on the 1962 U. S. Standard Atmosphere). This atmospheric model consists of the values of atmospheric properties from Reference 4 tabulated at the intervals presented below:

<u>Altitude Range</u>	<u>Altitude Interval between Points</u>
0 to 100, 000 feet	1, 000 feet
100, 000 to 200, 000 feet	5, 000 feet
200, 000 to 500, 000 feet	10, 000 feet
500, 000 to 1, 000, 000 feet	20, 000 feet

These data point intervals were selected to make the density model as accurate as needed to be consistent with the accuracy with which one can actually define the input data for a trajectory.

While the above model atmosphere provides atmospheric density data to the same accuracy with which one can define the trajectory initial conditions and vehicle characteristics for an actual re-entry, the trajectory specified by the Atomics International initial conditions is extremely sensitive. (The sensitivity of this trajectory is detailed in a subsequent section.) Therefore, a parameter deck, SPAHR 1962 AT, was prepared. This deck, which presents atmospheric density data (RHO) as a function of altitude (HITE), was used to replace the atmospheric density data in the ICAO 1962 ATMOSPHERE KLETT. The parameter deck, SPAHR 1962 AT, contains the atmospheric density data from Reference 4 at 1000-foot intervals for altitudes of 0 to 400, 000 feet and at 2000-foot intervals from 400, 000 to 426, 000 feet. (Reference 4 contains atmospheric density data only at 2000-foot intervals above 400, 000 feet.)

Atomics International RESTORE Trajectory Program

The RESTORE (Re-Entry SNAP Trajectories on an Oblate Rotating Earth) trajectory program was developed by the Atomics International Aerospace Nuclear Safety Program for use in determining the trajectories and corresponding re-entry environment of re-entering SNAP reactor systems and their components (such as fuel elements). These trajectories and environments are used in studies of the re-entry behavior of the SNAP reactor systems. The RESTORE trajectory program has been used to determine specific trajectories and to complete parametric studies of the effect of the complex Earth model on the behavior of re-entering SNAP systems.

Program preparation was started in 1962 and completed in 1964. The RESTORE trajectory program is now finalized and no future modifications are planned. The options of the program permitting the user to vary the Earth model, atmospheric data, and object drag characteristics will be used to supply the current best input data to the program.

The RESTORE trajectory program integrates numerically the equations of motion for a nonlifting point mass, or sphere, flying a 3-degree of freedom trajectory in the vicinity of the Earth. The integration subroutine uses a fourth order Adams-Moulton method with variable step size. The point mass is subjected to the forces of drag and gravity while moving relative to a rotating oblate Earth. The model atmospheres, which have properties that are functions of height alone, rotate with the Earth.

Options are available permitting the user to vary the Earth model and the atmospheric characteristics. The input data can be either inertial or Earth relative, while the output data is relative to the rotating Earth. All coordinates are in a geocentric system. The RESTORE trajectory program is currently being used on an International Business Machines 7094 electronic computer.

Further details on the Atomics International RESTORE trajectory program will be available in Reference 5.

RESTORE Earth Model

The RESTORE trajectory program considers the Earth as an oblate spheroid of revolution. The values currently used to define the RESTORE Earth model are:

Equatorial radius = 20,925,738 feet

Polar radius = 20,855,588 feet

Angular rate of rotation = $0.72921154 \times 10^{-4}$ radians per second

The RESTORE trajectory program uses an Earth gravitational potential function with first, second, and third harmonic as defined below:

First harmonic, $J = 0.16234499 \times 10^{-2}$

Second harmonic, $H = 0.5750 \times 10^{-5}$

Third harmonic, $D = 0.78749999 \times 10^{-5}$

This potential function provides the radial and latitudinal Earth gravitational components. (The exact equation appears at the front of the RESTORE trajectory printout in Appendix B in FORTRAN language.)

RESTORE Coordinate System

The sketch below shows the geocentric coordinate system used as the input and output coordinate system for the RESTORE program.

The parameters shown on the sketch and other pertinent parameters are defined below:

ALTITUDE	Altitude in feet above mean sea level measured along a line from the re-entering object to the center of the rotating oblate Earth.
AZIMUTH	The angle in degrees, positive in the counter-clockwise direction, between the projection of the Earth relative velocity vector, whose magnitude is VELOCITY, on a plane at the Earth's surface (perpendicular to a line from the re-entering object which passes through the Earth's center) and North.
FLIGHT ANGLE	Earth relative re-entry angle in degrees; i.e., the angle between the Earth relative velocity vector, whose magnitude is VELOCITY, and a plane perpendicular to a line from the Earth's center to the re-entering object.
LATITUDE	The geocentric latitude in degrees of the intersection of a line from the re-entering object to the Earth's center and the Earth's surface.
LONGITUDE	The longitude in degrees of the intersection of a line from the re-entering object to the Earth's center and the Earth's surface.
R	The length of the line in feet from the Earth's center to the re-entering object.
VELOCITY	The velocity in feet per second of the re-entering object relative to a point on the surface of the rotating oblate Earth where a line from the re-entering object to the Earth's center intersects the Earth's surface.

RESTORE Input Data

To define the initial conditions for a RESTORE trajectory and to provide the data necessary for the subsequent calculations, the following must be defined:

1. Initial position of the object.
2. Initial magnitude and orientation of the velocity vector of the object.
3. Initial object characteristics along with any variation of the object characteristics during the trajectory.
4. Atmospheric data to be used in the calculation of the trajectory.

The initial position of the object is defined by specifying LATITUDE, LONGITUDE, and ALTITUDE. Specification of VELOCITY, FLIGHT ANGLE, and AZIMUTH define the initial magnitude and orientation of the velocity vector of the object. (These six RESTORE trajectory variables were defined in the previous section.)

The initial object characteristics are defined by specifying the initial values of object weight (MASS OF VEHICLE) in pounds, the object reference area (PROJECTED AREA) in square feet, and the object drag coefficient (DRAG COEF) which is dimensionless. (Specification of the variation of these characteristics during the trajectory is not necessary as the characteristics were specified as constant during the trajectory.)

Reference 5 will describe in detail the definition of the atmospheric characteristics. The only atmospheric property discussed here is the atmospheric density. (This is the only atmospheric property which affects the trajectory of the specified constant $W/C_D A$ object.)

Definition of the variation of atmospheric density (FS DENSITY) with altitude (ALTITUDE) is accomplished by specifying values for the log of the atmospheric density in tabular form as a function of altitude. Linear interpolation with height on the log of the atmospheric density and the subsequent exponentiation provides the equivalent of exponential interpolation.

The atmospheric model used for the trajectory presented in this report included the log of the atmospheric density (based on Reference 4) at 10,000-foot intervals from an altitude of 0 to 1,000,000 feet.

Specified Trajectory Initial Conditions and Object Characteristics

The following trajectory initial conditions and object characteristics were specified by Atomics International, who requested that a trajectory be run. The object was initially to be located on a line from the Earth's center through the Earth's surface at a geocentric latitude of 30 degrees and a longitude of 0 degree. (This corresponds to the RESTORE parameters of LATITUDE = 30 degrees and LONGITUDE = 0 degree.) The object was initially to be 417,601.75 feet above the Earth's surface; the distance was measured along the line to the Earth's center (this corresponds to the RESTORE parameter of ALTITUDE = 417,601.75).

Initially, the object was to have a velocity relative to the wind (or the Earth's surface) of 24,345.125 feet per second. The velocity vector of the object was to be parallel to the Earth's surface with an Earth relative azimuth of 90 degrees (due East) (this corresponds to the RESTORE parameters of VELOCITY = 24,345.125, FLIGHT ANGLE = 0, and AZIMUTH = 90).

The object was to have a constant ballistic parameter, $W/C_D A$, of 100 pounds per square foot (this corresponds to the RESTORE parameters of MASS OF VEHICLE = 100, PROJECTED AREA = 1.0, and DRAG COEF = 1.0). The 1962 U. S. Standard Atmosphere was to be used for the trajectory.

The above trajectory initial conditions and object characteristics correspond to the following TTA trajectory program parameters:

LAT = 30.1643

LONG = 0.0

HITE = 417,601.75

VT = 24,345.125

GAMMA = 0.0

TAU = 0.0

WT = 100.0

CD = 1.0

AREA = 1.0

Steps Used in the TTA Trajectory Solution

In any mathematical calculations (such as in a trajectory program) that involve complex numerical integration, a number of steps must be taken to insure an accurate solution.

These steps are:

1. Determination of a suitable time interval for the numerical integration.
2. Determination of the sensitivity of the calculations to slight perturbations in the input data and initial conditions.
3. Solution of the numerical integration (using the time interval of integration from step 1). The solution should use initial conditions and input data defined accurately enough (based on step 2), so that the accuracy of the problem solution does not depend on the accuracy of the initial conditions and input data.
4. Verification of the correct selection of the time interval of integration in step 1.

These four steps were followed in the use of the TTA trajectory program to obtain an accurate trajectory for the specified initial conditions and object characteristics. The details of each step are presented in the following four sections.

Determination of Time Interval for Numerical Integration

In a numerical integration problem, the departure of a precisely calculated numerical integration from the actual solution goes to zero as the time interval of integration goes to zero. However, an electronic computer can carry only a certain number of digits in its calculations. As the time interval of integration goes to smaller values, more steps are required in the integration. More steps require more calculations and thus can generate more error resulting from roundoff of the numbers used in the calculations. An "optimum" time interval of integration can be defined as the time interval of integration that provides the solution which lies closest to the actual solution. (References 6 and 7 provide more information on the "optimum" time interval of integration.)

Unfortunately, the actual solution is not normally known for meaningful problems. (If it were, one would not need to perform the numerical integration unless one wanted to check the accuracy of the numerical method.) An approach often taken is to slowly reduce the time interval of integration and observe the solution. When the solution appears to have converged to a limit for a certain time interval of integration and starts oscillating around this solution for smaller time intervals of integration, this time interval is used as the optimum time interval of integration.

As the approach outlined above can require a large amount of effort and computer time, it was decided that a "reasonable" rather than "optimum" time interval of integration would be defined. A reasonable time interval of integration was arbitrarily defined as the value of time for which a reduction by a factor of two would not produce any significant change in the solution.

The time interval of integration in the TTA trajectory program can be controlled by MAXTM. MAXTM is an upper bound on the allowable time interval of integration selected by the automatic mesh control system. Initialization of the problem on the TTA trajectory program is aided by defining a smaller value of MAXTM for the first few steps in the integration. Solution accuracy is increased by using a smaller value of MAXTM during the period of high atmospheric deceleration.

Four preliminary trajectories were computed to define a reasonable time interval of integration. The initial conditions and object characteristics previously defined and the atmospheric density data in the metro tape 1962 ICAO KLETT were used in these four preliminary trajectories. The table below presents the values of MAXTM used in these four preliminary trajectories.

<u>Preliminary Trajectory Number</u>	<u>Value of MAXTM Initially (seconds)</u>	<u>Number of Increments at Initial MAXTM</u>	<u>MAXTM After Initial Value (seconds)</u>
1	1.0	10	120.0
2	1.0	10	15.0
3	0.1	10	8.0
4	0.1	10	8.0*

*MAXTM was set to 1.0 second whenever the value of a longitudinal accelerometer reading in the re-entering object was greater than 1.4 g.

The conditions at 1800 seconds are tabulated below for these four preliminary trajectories.

<u>Preliminary Trajectory Number</u>	<u>TTA HITE (feet)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
1	383,373.937	-16.5597368	113.0680106
2	380,705.	-16.56	113.1
3	380,672.980	-16.559289	113.076848
4	380,673.	-16.5593	113.0768

The conditions at the time of impact, HITE = 0.0 are presented below for preliminary trajectories 3 and 4. (Preliminary runs 1 and 2 were terminated shortly after 1800 seconds to save computer time.)

<u>Preliminary Trajectory Number</u>	<u>Time of Impact (seconds)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
3	5385.12	30.145660	-23.242419
4	5385.1	30.1457	-23.24210

Based on the results of these four preliminary trajectories, the values of MAXTM used for preliminary trajectory 4 were selected as "reasonable" maximum time intervals of integration. A later section of this report shows that reducing these values of MAXTM by a factor of two produces no significant changes in the trajectory. Thus, this selection of MAXTM values is valid.

For comparison, the RESTORE trajectory used an initial integration time interval of 0.1 second. Later RESTORE time intervals of integration were between 0.1 and 0.8 second.

Determination of the Sensitivity of the Trajectory to Initial Conditions and Input Data

Examination of the results of the first four preliminary trajectories show that the re-entering object travels almost one revolution around the Earth during its re-entry. Such a trajectory will be very sensitive to any changes in input data or initial conditions.

Three additional preliminary trajectories were run to determine the sensitivity of this trajectory to any changes in input data or initial conditions. The specified initial conditions, the TTA Earth model, and the metro tape 1962 ICAO KLETT except for the one change per trajectory presented below were used in computing the three preliminary trajectories.

Preliminary
Trajectory
Number

Change

5	VT was increased by 1 foot per second.
6	The RESTORE Earth shape was used.
7	The object $W/C_D A$ was increased 1 percent from 100 to 101 pounds per square foot (this will provide a change comparable to a 1 percent decrease in atmospheric density.)

The conditions at 1800 seconds are tabulated below for these three preliminary trajectories. (The conditions from preliminary trajectory 4 are included for comparison.)

Preliminary Trajectory Number	TTA HITE (feet)	TTA LAT (degrees)	TTA LONG (degrees)
4	380,673	-16.5593	113.0768
5	383,380	-16.5563	113.0703
6	380,530	-16.5589	113.0761
7	380,723	-16.5593	113.0768

The conditions at impact, HITE = 0.0, are tabulated below for these three preliminary trajectories. (The conditions from preliminary trajectory 4 are included for comparison.)

Preliminary Trajectory Number	Time of Impact (seconds)	TTA LAT (degrees)	TTA LONG (degrees)
4	5385.1	30.1457	-23.24210
5	5680.1	28.2704	- 1.170985
6	5369.4	30.1228	-24.43710
7	5418.8	30.1403	-20.62230

Comparison of preliminary trajectories 5 and 7 with preliminary trajectory 4 illustrates the extreme sensitivity of this trajectory to very small changes in the initial velocity and in the ballistic parameter of the body. Comparison of preliminary trajectory 6 with trajectory 4 illustrates that the relatively small difference in Earth shape between the TTA and RESTORE Earth models produces a detectable change in the trajectory.

In any actual trajectory, the initial conditions and object characteristics can be measured or determined only within certain limits. The accuracies on the measurement of a few of the required initial conditions and object characteristics are discussed briefly below:

Velocity

Reference 8 shows that only for highly idealized conditions can a velocity measurement be obtained more accurately than ± 1 foot per second.

Ballistic Parameter, $W/C_D A$

For a constant object weight and shape, the weight and reference area of the re-entering object can be accurately measured. Therefore, almost all the variation in $W/C_D A$ results from inaccuracies in the prediction of the drag coefficient, C_D . One does not expect measured wind tunnel drag data to be closer than approximately ± 3 percent to the actual drag of the full scale object.

Atmospheric Density

References 9 and 10 and their references define the variability of atmospheric density with latitude, time of day, season, solar flux, etc. Even if measurements of atmospheric density are made, the error in the measurement can be greater than

Atmospheric Density (cont)

±10 percent (Reference 11) at altitudes
above 100,000 feet.

Thus, the slight perturbations in velocity and $W/C_D A$ in preliminary runs 5 and 7 are certainly no greater than the accuracy with which these parameters would be known for an actual re-entry.

The first important point is that this trajectory is extremely sensitive to any slight changes in trajectory initial conditions and object characteristics. Thus, the extreme sensitivity of this trajectory makes it an ideal trajectory to use for comparing the results of two trajectory programs.

The second important point is that the extreme sensitivity of the trajectory to the object $W/C_D A$ corresponds to an extreme sensitivity of the trajectory to the atmospheric density data used. Although the accuracy of the metro tape 1962 ICAO KLETT is consistent with the accuracy with which the initial conditions and other input data can be defined for an actual trajectory, more accurate atmospheric density data is needed to insure that the accuracy of the atmospheric density data does not limit the accuracy of this trajectory. To provide more accurate atmospheric density data, the parameter tape SPAHR 1962 AT was prepared. This parameter tape, discussed in more detail in a previous section, was then used on all subsequent runs to replace the atmospheric density data on the metro tape 1962 ICAO KLETT.

Computation of the Trajectory

The specified trajectory initial conditions and object characteristics were used with the 1962 ICAO KLETT metro tape and the SPAHR 1962 AT parameter tape to run the final trajectory. The only difference between the final trajectory and preliminary trajectory 4 is the usage of the more accurate atmospheric density data on the parameter tape.

The conditions at 1800 seconds are tabulated below for preliminary trajectory 4 and the final trajectory.

<u>Trajectory Identification</u>	<u>TTA HITE (feet)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
Preliminary trajectory 4	380,673	-16.5593	113.0768
Final trajectory	380,866	-16.5575	113.0774

The conditions at the time of impact are presented below for preliminary trajectory 4 and the final trajectory.

<u>Trajectory Identification</u>	<u>Time of Impact (seconds)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
Preliminary trajectory 4	5385.1	30.1457	-23.24210
Final trajectory	5455.9	30.0686	-17.86688

Thus, as expected, the relatively small change in atmospheric density data has a significant effect on the trajectory.

Verification of Correct Selection of Time Interval of Integration

The remaining step in obtaining an accurate trajectory was to verify that the values selected for the time interval of numerical integration were satisfactory. An additional trajectory, referred to as final trajectory A, was computed using values of MAXTM one-half those used for the final trajectory. (All other input data and the initial conditions were the same as those used for the final trajectory.)

The values of MAXTM used for the final trajectory and final trajectory A are presented below.

<u>Trajectory Identification</u>	<u>Value of MAXTM Initially (seconds)</u>	<u>Number of Increments at Initial MAXTM</u>	<u>MAXTM After Initial Value (seconds)</u>
Final trajectory	0.1	10	8.0*
Final trajectory A	0.05	10	4.0**

* MAXTM was set to 1.0 second whenever the value of a longitudinal accelerometer reading in the re-entering object was greater than 1.4 g.

** MAXTM was set to 0.5 second whenever the value of a longitudinal accelerometer reading in the re-entering object was greater than 1.4 g.

The conditions at 1800 seconds are presented below for the final trajectory and final trajectory A.

<u>Trajectory Identification</u>	<u>TTA HITE (feet)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
Final trajectory	380,866	-16.5575	113.0774
Final trajectory A	380,865	-16.5575	113.0774

The conditions at impact are presented below for the final trajectory and final trajectory A.

<u>Trajectory Identification</u>	<u>Time of Impact (seconds)</u>	<u>TTA LAT (degrees)</u>	<u>TTA LONG (degrees)</u>
Final trajectory	5455.9	30.0686	-17.86688
Final trajectory A	5455.5	30.0699	-17.89993

When the results of the final trajectory and final trajectory A are compared, a reduction by a factor of two in the values of MAXTM does not cause any significant change in the trajectory. (Halving the values of MAXTM doubled the computer time required to run the trajectory.) Thus, the values of MAXTM used for the final trajectory are satisfactory or "reasonable" time intervals for the numerical integration.

Comparison of the Results of the TTA and RESTORE Trajectory Programs

The conditions at 1800 seconds are tabulated below for the TTA final trajectory and the RESTORE trajectory.

<u>Program Used</u>	<u>TTA HITE and RESTORE ALTITUDE (feet)</u>	<u>TTA LAT, Geodetic (degrees)</u>	<u>RESTORE LATITUDE Geocentric (degrees)</u>	<u>TTA LONG and RESTORE LONGITUDE (degrees)</u>
TTA	380,866.00	-16.5575		113.0774
RESTORE	381,005.25	-	-16.452800	113.075337

The results of the two trajectory programs show very good agreement at a time of 1800 seconds when one considers that:

1. Most of the apparent difference in altitude at a time of 1800 seconds results from the differences in Earth shape in the two Earth models.
2. The TTA geodetic latitude of -16.5575 degrees converts to a geocentric latitude of approximately -16.452 degrees.

The conditions at impact are tabulated below for the TTA final trajectory and the RESTORE trajectory.

<u>Program Used</u>	<u>Time of Impact (seconds)</u>	<u>TTA LAT, Geodetic (degrees)</u>	<u>RESTORE LATITUDE Geocentric (degrees)</u>	<u>TTA LONG and RESTORE LONGITUDE (degrees)</u>
TTA	5455.9	30.0686	-	-17.86688
RESTORE	5459.6114	-	29.890513	-17.575313

The results of the two trajectory programs show very good agreement when one considers that:

1. The TTA geodetic latitude of 30.0686 degrees converts to a geocentric latitude of approximately 29.902 degrees.
2. This very sensitive trajectory makes almost one revolution around the Earth before impact.

As the agreement was very good, no effort was made to determine the source of the very small differences. Potential sources which could contribute to the small differences would be:

1. The slight differences in Earth models.
2. The slight differences in coordinate systems.
3. The slight differences in methods of inputting atmospheric data.
4. The different methods of numerical integration used.

A tabulated listing of the TTA trajectory program output for the final trajectory is presented in Appendix A. Appendix B contains a tabulated listing of the RESTORE trajectory program output.

Conclusions

The results presented in this report indicate that the TTA and RESTORE trajectory programs provide almost identical trajectories when a set of initial conditions are used that produce an extremely sensitive trajectory. (The computer times required by the two trajectory programs to run the trajectory are

close.) Because the differences between the results of the two trajectory programs are very small, further work to define the exact source of the very small differences is not required. As shown in one of the sections in this report, the tolerances on the input data available for an actual trajectory of this type would generate uncertainties in the trajectory at least an order of magnitude larger than the relatively small differences in the results of the two trajectory programs. Thus, both the TTA and RESTORE trajectory programs can generate accurate theoretical trajectories for the most sensitive trajectories of interest to any Aerospace Nuclear Safety study.

It should be noted that the TTA and RESTORE trajectory programs both utilize Earth models based on data available in about 1962. Recent references, such as Reference 12, indicate that more accurate and more complex Earth models may be available now. A request for the Earth model data currently being used by NASA has been submitted to NASA Headquarters. When the information is received, it will be transmitted to all companies involved in Aerospace Nuclear Safety activities involving theoretical trajectory calculations.

APPENDIX A
TABULATED TTA TRAJECTORY PROGRAM RESULTS

TABULATED TTA TRAJECTORY PROGRAM RESULTS

The tabulated TTA trajectory program results for the final trajectory are presented in this Appendix. While any of the approximately 250 TTA outputs could have been provided, those parameters requested by Atomics International have been printed out.

The outputs appearing on the tabulated trajectory are defined below:

WT	Weight of the re-entering object, pounds.
CD	Drag coefficient of the re-entering object, dimensionless.
AREA	Reference area on which the drag coefficient of the re-entering object is based, square feet.
VICRCL	Inertial circular Earth orbital velocity at the current altitude and latitude, feet per second.
TIME	Time from the start of the trajectory, seconds.
LAT	The geodetic latitude of the intersection of a line from the re-entering object perpendicular to the surface of the rotating oblate Earth, degrees.
LONG	The longitude of the intersection of a line from the re-entering object perpendicular to the surface of the rotating oblate Earth, degrees.
HITE	Altitude above mean sea level measured along a line from the re-entering object perpendicular to the surface of the rotating oblate Earth, feet.
RADVC	The length of the line from the Earth's center to the re-entering object, feet.

VT	The velocity of the re-entering object relative to a point on the surface of the Earth where a line from the re-entering object is perpendicular to the Earth's surface, feet per second.
GAMMA	Earth relative re-entry angle; i. e., the angle between the Earth relative velocity vector, whose magnitude is VT, and a plane perpendicular to a line from the re-entering object perpendicular to the surface of the rotating oblate Earth, degrees.
TAU	The angle, positive in the counterclockwise sense, between the projection of the Earth relative velocity vector, whose magnitude is VT, on a plane at the Earth's surface (perpendicular to a line from the re-entering object which is perpendicular to the surface of the rotating oblate Earth) and East, degrees.
VI	The inertial velocity of the re-entering object (relative to the center of the Earth), feet per second.
GAMMAI	The same as GAMMA, defined above, except based on VI instead of VT, degrees.
TAUI	The same as TAU, defined above, except based on VI instead of VT, degrees.
ACT	The reading of an accelerometer in the re-entering object which is always oriented tangent to the flight path, g.
TDEL	The current time interval being used in the numerical integration, seconds.
SENTB	The value of a parameter used to set the maximum time interval of integration, MAXTM, to 1.0 second during the high deceleration part of the trajectory, dimensionless.

TIME	LAT	LON	HIT	RAUVC	VT	GAMMA	TAU	VI	GAMMAI	TAUI	ACT	THEL	SENT
0000.00	30.1643	0.0000	417602	21325469	24345.1	-0.0000	0.000	25692.	-0.0000	0.0000	-5.7-5	0.00732	0.000
30.000	30.1426	0.265461	417573.	21325464.	24345.1	-0.0045	-1.26	25692.	-0.0043	-1.198	-5.7-5	7.5000	0.000
60.000	30.0774	0.528687	417488.	21325447.	24345.2	-0.0090	-2.53	25692.	-0.0085	-2.393	-5.7-5	7.5000	0.000
90.000	29.9691	0.788075	417345.	21325419.	24345.3	-0.0134	-3.78	25692.	-0.0127	-3.583	-5.8-5	7.5000	0.000
120.00	29.8176	0.941156	417146.	21325381.	24345.5	-0.0178	-5.03	25692.	-0.0169	-4.766	-5.8-5	7.5000	0.000
150.00	29.6240	1.100615	416892.	21325330.	24345.8	-0.0222	-6.27	25692.	-0.0210	-5.938	-5.8-5	7.5000	0.000
180.00	29.3831	1.352113	416582.	21325268.	24346.1	-0.0265	-7.49	25692.	-0.0251	-7.098	-5.9-5	7.5000	0.000
210.00	29.1117	1.574437	416219.	21325195.	24346.5	-0.0307	-8.70	25692.	-0.0290	-8.242	-6.0-5	7.5000	0.000
240.00	28.7925	1.795422	415803.	21325109.	24347.0	-0.0347	-9.89	25693.	-0.0329	-9.370	-6.1-5	7.5000	0.000
270.00	28.4343	2.013915	415337.	21325011.	24347.6	-0.0387	-11.1	25693.	-0.0366	-10.48	-6.1-5	7.5000	0.000
300.00	28.0369	2.232773	414821.	21324901.	24348.2	-0.0425	-12.2	25693.	-0.0402	-11.57	-6.3-5	7.5000	0.000
330.00	27.6012	2.448875	414258.	21324778.	24348.8	-0.0461	-13.3	25694.	-0.0437	-12.63	-6.4-5	7.5000	0.000
360.00	27.1282	2.663112	413649.	21324642.	24349.6	-0.0496	-14.4	25694.	-0.0470	-13.67	-6.5-5	7.5000	0.000
390.00	26.6189	2.876389	412998.	21324492.	24350.3	-0.0529	-15.5	25694.	-0.0501	-14.68	-6.6-5	7.5000	0.000
420.00	26.0745	3.085629	412305.	21324330.	24351.2	-0.0560	-16.6	25695.	-0.0531	-15.67	-6.8-5	7.5000	0.000
450.00	25.4960	3.293764	411575.	21324153.	24352.1	-0.0589	-17.6	25695.	-0.0558	-16.63	-7.0-5	7.5000	0.000
480.00	24.8847	3.499752	411809.	21323963.	24353.0	-0.0616	-18.6	25696.	-0.0584	-17.55	-7.2-5	7.5000	0.000
510.00	24.2417	3.703271	411010.	21323758.	24354.0	-0.0641	-19.5	25696.	-0.0607	-18.45	-7.4-5	7.5000	0.000
540.00	23.5683	3.905184	409181.	21323539.	24355.0	-0.0663	-20.4	25697.	-0.0629	-19.32	-7.6-5	7.5000	0.000
570.00	22.8657	4.104594	408325.	21323305.	24356.0	-0.0683	-21.3	25697.	-0.0648	-20.15	-7.8-5	7.5000	0.000
600.00	22.1351	4.301819	407445.	21323057.	24357.1	-0.0701	-22.2	25698.	-0.0665	-20.95	-8.1-5	7.5000	0.000
630.00	21.3778	4.496551	406544.	21322793.	24358.1	-0.0716	-23.0	25699.	-0.0679	-21.72	-8.3-5	7.5000	0.000
660.00	20.5950	4.689747	405625.	21322513.	24359.2	-0.0729	-23.8	25699.	-0.0691	-22.45	-8.6-5	7.5000	0.000
690.00	19.7880	4.880544	404691.	21322218.	24360.4	-0.0740	-24.5	25700.	-0.0701	-23.15	-8.9-5	7.5000	0.000
720.00	18.9581	5.069293	403746.	21321908.	24361.5	-0.0747	-25.2	25700.	-0.0708	-23.82	-9.3-5	7.5000	0.000
750.00	18.1065	5.256048	402792										

TTA7622 3H-64 12352 SPAHR 5424#65 AI TRAU NEA METRO
 CONTROL12352 SPAHR DATA-A= DATA-R=
 OBSERVER 0.0000=LAT 0.0000=LONG 0.0000=ORNT

ATMOS= ICAO 1962 ATMOSPHERE KLETT
 DATA-C= DATA-D=SPAHR 1962 AT
 0=X 0=Y 0=Z

TIME	LAT	LONG	HTE	VT	GAMMA	TAU	VI	GAMMAI	TAUI	ACT	TDEL	SENTR
1500.0	-6.86097	95.54026	383676.	21308220.	24383.4	-0.023	-31.1	25717.	-0.0306	-29.32	-2.1-4	7.5000 .000
1530.0	-7.87990	97.24061	383277.	21307504.	24383.7	-0.0299	-30.8	25717.	-0.0283	-29.09	-2.1-4	7.5000 .000
1560.0	-8.80084	98.94903	382908.	21306780.	24384.0	-0.0276	-30.6	25718.	-0.0261	-28.82	-2.1-4	7.5000 .000
1590.0	-9.80272	100.6093	382568.	21306045.	24384.2	-0.0253	-30.2	25718.	-0.0240	-28.52	-2.1-4	7.5000 .000
1620.0	-10.8844	102.3499	382256.	21305304.	24384.4	-0.0232	-29.9	25719.	-0.0220	-28.19	-2.2-4	7.5000 .000
1650.0	-11.8640	104.1424	381969.	21304555.	24384.5	-0.0212	-29.5	25719.	-0.0201	-27.82	-2.2-4	7.5000 .000
1680.0	-12.8328	105.8990	381707.	21303800.	24384.6	-0.0194	-29.1	25720.	-0.0184	-27.42	-2.2-4	7.5000 .000
1710.0	-13.7873	107.6690	381468.	21303039.	24384.7	-0.0177	-28.6	25720.	-0.0167	-26.99	-2.2-4	7.5000 .000
1740.0	-14.7270	109.4550	381249.	21302273.	24384.7	-0.0161	-28.1	25720.	-0.0153	-26.52	-2.3-4	7.5000 .000
1770.0	-15.6508	111.2578	381049.	21301503.	24384.7	-0.0147	-27.6	25721.	-0.0139	-26.01	-2.3-4	7.5000 .000
1800.0	-16.5575	113.0774	380866.	21300730.	24384.7	-0.0135	-27.0	25721.	-0.0128	-25.48	-2.3-4	7.5000 .000
1830.0	-17.4458	114.9150	380698.	21299955.	24384.7	-0.0124	-26.4	25721.	-0.0118	-24.90	-2.3-4	7.5000 .000
1860.0	-18.3147	116.7715	380541.	21299179.	24384.6	-0.0116	-25.7	25722.	-0.0110	-24.30	-2.3-4	7.5000 .000
1890.0	-19.1628	118.6477	380395.	21298402.	24384.6	-0.0109	-25.0	25722.	-0.0103	-23.66	-2.3-4	7.5000 .000
1920.0	-19.9888	120.5442	380256.	21297625.	24384.5	-0.0104	-24.3	25723.	-0.0099	-22.98	-2.4-4	7.5000 .000
1950.0	-20.7916	122.4616	380122.	21296852.	24384.4	-0.0101	-23.6	25723.	-0.0096	-22.27	-2.4-4	7.5000 .000
1980.0	-21.5696	124.4004	379990.	21296079.	24384.3	-0.0100	-22.8	25723.	-0.0095	-21.53	-2.4-4	7.5000 .000
2010.0	-22.3222	126.3609	379859.	21295311.	24384.3	-0.0101	-21.9	25724.	-0.0096	-20.75	-2.4-4	7.5000 .000
2040.0	-23.0475	128.3436	379725.	21294546.	24384.2	-0.0104	-21.1	25724.	-0.0099	-19.94	-2.4-4	7.5000 .000
2070.0	-23.7445	130.3485	379587.	21293787.	24384.1	-0.0109	-20.2	25724.	-0.0103	-19.10	-2.4-4	7.5000 .000
2100.0	-24.4118	132.3757	379441.	21293033.	24384.0	-0.0115	-19.3	25725.	-0.0109	-18.22	-2.4-4	7.5000 .000
2130.0	-25.0483	134.4252	379286.	21292287.	24384.0	-0.0124	-18.3	25725.	-0.0117	-17.31	-2.5-4	7.5000 .000
2160.0	-25.6527	136.4967	379119.	21291548.	24383.9	-0.0134	-17.3	25725.	-0.0127	-16.37	-2.5-4	7.5000 .000
2190.0	-26.2237	138.5898	378938.	21290818.	24383.9	-0.0146	-16.3	25726.	-0.0138	-15.41	-2.5-4	7.5000 .000
2220.0	-26.7603	140.7043	378741.	21290097.	24383.9	-0.0160	-15.2	25726.	-0.0151	-14.41	-2.5-4	7.5000 .000
2250.0	-27.2612	142.8367	378526.	21289385.	24383.9	-0.0175	-14.1	25726.	-0.0165	-13.39	-2.5-4	7.5000 .000
2280.0	-27.7254	144.9930	378291.	21288686.	24383.9	-0.0191	-13.0	25727.	-0.0181	-12.34	-2.6-4	7.5000 .000
2310.0	-28.1518	147.1659	378034.	21287947.	24384.0	-0.0209	-11.9	25727.	-0.0198	-11.26	-2.6-4	7.5000 .000
2340.0	-28.5395	149.3564	377754.	21287320.	24384.1	-0.0228	-10.7	25727.	-0.0216	-10.17	-2.6-4	7.5000 .000
2370.0	-28.8875	151.5630	377449.	21286656.	24384.2	-0.0248	-9.55	25728.	-0.0235	-9.049	-2.7-4	7.5000 .000
2400.0	-29.1950	153.7843	377117.	21286005.	24384.4	-0.0269	-8.35	25728.	-0.0255	-7.913	-2.7-4	7.5000 .000
2430.0	-29.4612	156.0186	376758.	21285368.	24384.5	-0.0291	-7.13	25728.	-0.0276	-6.760	-2.7-4	7.5000 .000
2460.0	-29.6855	158.2647	376371.	21284745.	24384.8	-0.0314	-5.90	25729.	-0.0298	-5.592	-2.8-4	7.5000 .000
2490.0	-29.8673	160.5202	375954.	21284137.	24385.0	-0.0338	-4.66	25729.	-0.0320	-4.413	-2.8-4	7.5000 .000
2520.0	-30.0062	162.7835	375508.	21283543.	24385.3	-0.0361	-3.40	25729.	-0.0342	-3.224	-2.9-4	7.5000 .000
2550.0	-30.1017	165.0524	375031.	21282965.	24385.6	-0.0386	-2.14	25730.	-0.0365	-2.028	-2.9-4	7.5000 .000
2580.0	-30.1537	167.3250	374523.	21282401.	24386.0	-0.0410	-0.873	25730.	-0.0388	-0.8272	-3.0-4	7.5000 .000
2610.0	-30.1619	169.5991	373984.	21281854.	24386.4	-0.0434	0.396	25730.	-0.0412	0.3752	-3.1-4	7.5000 .000
2640.0	-30.1264	171.8726	373414.	21281322.	24386.8	-0.0459	1.66	25731.	-0.0435	1.577	-3.2-4	7.5000 .000
2670.0	-30.0472	174.1435	372813.	21280805.	24387.3	-0.0483	2.93	25731.	-0.0457	2.775	-3.2-4	7.5000 .000
2700.0	-29.9245	176.4097	372183.	21280304.	24387.8	-0.0506	4.19	25731.	-0.0480	3.967	-3.3-4	7.5000 .000
2730.0	-29.7588	178.6690	371522.	21279819.	24388.3	-0.0529	5.44	25732.	-0.0502	5.151	-3.4-4	7.5000 .000
2760.0	-29.5502	179.0803	370832.	21279349.	24388.8	-0.0552	6.67	25732.	-0.0523	6.324	-3.5-4	7.5000 .000
2790.0	-29.2905	176.8402	370115.	21278894.	24389.4	-0.0574	7.90	25733.	-0.0544	7.483	-3.7-4	7.5000 .000
2820.0	-29.0072	174.6125	369370.	21278453.	24390.0	-0.0594	9.10	25733.	-0.0563	8.626	-3.8-4	7.5000 .000
2850.0	-28.6740	172.3988	368599.	21278027.	24390.6	-0.0614	10.3	25733.	-0.0582	9.751	-3.9-4	7.5000 .000
2880.0	-28.3006	170.2006	367804.	21277615.	24391.3	-0.0633	11.5	25734.	-0.0600	10.86	-4.1-4	7.5000 .000
2910.0	-27.8883	168.0197	366985.	21277215.	24391.9	-0.0651	12.6	25734.	-0.0617	11.94	-4.2-4	7.5000 .000
2940.0	-27.4377	165.8560	366146.	21276830.	24392.6	-0.0667	13.7	25734.	-0.0632	13.00	-4.4-4	7.5000 .000
2970.0	-26.9498	163.7118	365286.	21276455.	24393.3	-0.0682	14.8	25734.	-0.0646	14.03	-4.6-4	7.5000 .000

TTA7622 38-64 12352 SPAHR 5#24#65 AI TRAJ NEW METRO
 CONTROL12352 SPAHR DATA-A= DATA-R=

ATMOS= ICAO 1962 ATMOSPHERE KLETT
 DATA-C= DATA-D=SPAHR 1962 AT
 OBSERVER 0.0000=LAT 0.0000=LONG 0.0000=ORNT 0=ELEV P=X 0=Y 0=Z

TIME	LAT	LONG	WITE	RADVC	VT	GAMMA	TAU	VI	GAMMAI	TAUI	ACT	TDEL	SENR
100.000000005	1.00000	1.00000	25729.9818										
3000.0	-26.4258	-161.5877	364409.	21276092.	24393.9	-.0695	15.9	25735.	-.0659	15.04	-4.8-4	7.5000	.000
3030.0	-25.8667	-159.4843	363515.	21275740.	24394.6	-.0707	16.9	25735.	-.0670	16.02	-5.0-4	7.5000	.000
3060.0	-25.2738	-157.4024	362608.	21275397.	24395.3	-.0717	17.9	25735.	-.0680	16.97	-5.2-4	7.5000	.000
3090.0	-24.6481	-155.3421	361688.	21275062.	24396.0	-.0726	18.9	25736.	-.0688	17.89	-5.5-4	7.5000	.000
3120.0	-23.9911	-153.3040	360758.	21274735.	24396.6	-.0733	19.9	25736.	-.0695	18.78	-5.7-4	7.5000	.000
3150.0	-23.3038	-151.2881	359821.	21274415.	24397.3	-.0739	20.8	25736.	-.0701	19.64	-6.0-4	7.5000	.000
3180.0	-22.5876	-149.2943	358877.	21274100.	24397.9	-.0743	21.6	25736.	-.0704	20.46	-6.2-4	7.5000	.000
3210.0	-21.8437	-147.3227	357929.	21273789.	24398.5	-.0745	22.5	25736.	-.0707	21.25	-6.5-4	7.5000	.000
3240.0	-21.0734	-145.3729	356980.	21273480.	24399.1	-.0746	23.5	25736.	-.0707	22.01	-6.8-4	7.5000	.000
3270.0	-20.2781	-143.4445	356030.	21273173.	24399.7	-.0745	24.1	25736.	-.0706	22.73	-7.1-4	7.5000	.000
3300.0	-19.4587	-141.5372	355083.	21272865.	24400.2	-.0743	24.8	25736.	-.0704	23.42	-7.4-4	7.5000	.000
3330.0	-18.6168	-139.6503	354140.	21272555.	24400.7	-.0739	25.5	25736.	-.0701	24.07	-7.7-4	7.5000	.000
3360.0	-17.7536	-137.7833	353202.	21272243.	24401.2	-.0734	26.1	25736.	-.0696	24.69	-8.1-4	7.5000	.000
3390.0	-16.8702	-135.9354	352272.	21271925.	24401.6	-.0727	26.8	25736.	-.0690	25.28	-8.4-4	7.5000	.000
3420.0	-15.9680	-134.1050	351351.	21271602.	24401.9	-.0720	27.4	25736.	-.0683	25.83	-8.8-4	7.5000	.000
3450.0	-15.0482	-132.2938	350440.	21271269.	24402.2	-.0711	27.9	25736.	-.0674	26.35	-9.2-4	7.5000	.000
3480.0	-14.1119	-130.4983	349540.	21270925.	24402.5	-.0702	28.4	25736.	-.0665	26.83	-9.6-4	7.5000	.000
3510.0	-13.1604	-128.7184	348654.	21270572.	24402.7	-.0691	28.9	25736.	-.0655	27.28	-.0010	7.5000	.000
3540.0	-12.1947	-126.9533	347781.	21270203.	24402.8	-.0680	29.3	25735.	-.0645	27.69	-.0010	7.5000	.000
3570.0	-11.2162	-125.2018	346922.	21269818.	24402.9	-.0669	29.7	25735.	-.0634	28.07	-.0011	7.5000	.000
3600.0	-10.2259	-123.4628	346078.	21269415.	24402.9	-.0657	30.1	25735.	-.0623	28.41	-.0011	7.5000	.000
3630.0	-9.22492	-121.7354	345249.	21268993.	24402.9	-.0645	30.5	25734.	-.0612	28.73	-.0012	7.5000	.000
3660.0	-8.21442	-120.0184	344434.	21268548.	24402.8	-.0633	30.8	25734.	-.0600	29.00	-.0012	7.5000	.000
3690.0	-7.19549	-118.3106	343635.	21268079.	24402.6	-.0621	31.0	25734.	-.0589	29.25	-.0013	7.5000	.000
3720.0	-6.16921	-116.6110	342850.	21267584.	24402.3	-.0610	31.2	25733.	-.0579	29.46	-.0013	7.5000	.000
3750.0	-5.13668	-114.9184	342079.	21267059.	24402.0	-.0600	31.4	25733.	-.0569	29.64	-.0014	7.5000	.000
3780.0	-4.09895	-113.2316	341321.	21266504.	24401.6	-.0590	31.6	25732.	-.0560	29.78	-.0014	7.5000	.000
3810.0	-3.05710	-111.5494	340573.	21265915.	24401.2	-.0582	31.7	25731.	-.0551	29.90	-.0015	7.5000	.000
3840.0	-2.01210	-109.8707	339836.	21265290.	24400.7	-.0574	31.8	25731.	-.0545	29.98	-.0015	7.5000	.000
3870.0	-0.965242	-108.1943	339106.	21264627.	24400.1	-.0569	31.8	25730.	-.0539	30.02	-.0016	7.5000	.000
3900.0	0.082664	-106.5190	338383.	21263923.	24399.4	-.0565	31.9	25729.	-.0536	30.04	-.0017	7.5000	.000
3930.0	1.13049	-104.8435	337663.	21263175.	24398.7	-.0563	31.8	25729.	-.0534	30.02	-.0017	7.5000	.000
3960.0	2.17719	-103.1668	336943.	21262382.	24397.9	-.0563	31.8	25728.	-.0534	29.97	-.0018	7.5000	.000
3990.0	3.22171	-101.4875	336221.	21261541.	24397.1	-.0566	31.7	25727.	-.0537	29.88	-.0019	7.5000	.000
4020.0	4.26300	-99.80461	335494.	21260648.	24396.2	-.0571	31.6	25726.	-.0542	29.76	-.0019	7.5000	.000
4050.0	5.30001	-98.11684	334758.	21259702.	24395.2	-.0580	31.4	25725.	-.0550	29.61	-.0020	7.5000	.000
4080.0	6.33167	-96.42303	334008.	21258869.	24394.2	-.0591	31.2	25724.	-.0561	29.43	-.0021	7.5000	.000
4110.0	7.35691	-94.72203	333242.	21257635.	24393.1	-.0606	31.0	25724.	-.0575	29.21	-.0022	7.5000	.000
4140.0	8.37464	-93.01266	332454.	21256512.	24391.9	-.0625	30.7	25723.	-.0593	28.96	-.0023	7.5000	.000
4170.0	9.38379	-91.29379	331639.	21255322.	24390.7	-.0647	30.4	25722.	-.0614	28.68	-.0024	7.5000	.000
4200.0	10.3632	-89.56430	330793.	21254064.	24389.5	-.0674	30.1	25721.	-.0639	28.36	-.0025	7.5000	.000
4230.0	11.3719	-87.82307	329910.	21252734.	24388.1	-.0705	29.7	25719.	-.0668	28.01	-.0026	7.5000	.000
4260.0	12.3486	-86.06903	328985.	21251329.	24386.7	-.0740	29.3	25718.	-.0702	27.62	-.0027	7.5000	.000
4290.0	13.3122	-84.30111	328011.	21249847.	24385.3	-.0781	28.8	25717.	-.0740	27.20	-.0029	7.5000	.000
4320.0	14.2615	-82.51830	326983.	21248282.	24383.7	-.0826	28.3	25716.	-.0783	26.75	-.0030	7.5000	.000
4350.0	15.1954	-80.71960	325893.	21246632.	24382.0	-.0877	27.8	25714.	-.0831	26.26	-.0032	7.5000	.000
4380.0	16.1128	-78.90408	324735.	21244892.	24380.3	-.0933	27.3	25713.	-.0885	25.74	-.0034	7.5000	.000
4410.0	17.0122	-77.07084	323501.	21243058.	24378.5	-.0996	26.7	25712.	-.0944	25.18	-.0037	7.5000	.000
4440.0	17.8927	-75.21905	322184.	21241125.	24376.5	-.1064	26.0	25710.	-.1009	24.59	-.0039	7.5000	.000
4470.0	18.7528	-73.34792	320774.	21239089.	24374.3	-.1140	25.4	25708.	-.1081	23.97	-.0042	7.5000	.000

TTA7622 3H-64 12352 SPAHR 5*24*65 A1 TRAU NEW METRO
 CONTROL12352 SPAHR DATA-A= DATA-R=
 OBSERVER 0.0000=LAT 0.0000=LONG 0.0000=ORNT

ATMOS= ICAO 1962 ATMOSPHERE KLETT
 DATA-C= DATA-D=SPAHR 1962 AT
 0=X, 0=Y, 0=Z

TIME	LAT	LONG	HITE	RAOVC	VT	GAMMA	TAU	VI	GAMMAI	TAUI	ACT	TDEL	SENTB
100.00000000	1.00000	1.00000000	25758.9085										
4500.0	19.5914	-71.45676	319264.	21236944.	24372.0	-1.1223	24.7	25706.	-1.1159	23.31	-1.0046	7.5000	.000
4530.0	20.4072	-69.54494	317644.	21234684.	24369.4	-1.1313	23.9	25704.	-1.1245	22.61	-1.0050	7.5000	.000
4560.0	21.1990	-67.61194	315904.	21232301.	24366.5	-1.1411	23.1	25701.	-1.1338	21.88	-1.0055	7.5000	.000
4590.0	21.9654	-65.65731	314033.	21229799.	24363.3	-1.1519	22.3	25698.	-1.1440	21.12	-1.0061	7.5000	.000
4620.0	22.7051	-63.68074	312019.	21227140.	24359.6	-1.1636	21.5	25695.	-1.1551	20.32	-1.0068	7.5000	.000
4650.0	23.4169	-61.68203	309849.	21224343.	24355.4	-1.1764	20.6	25691.	-1.1672	19.49	-1.0077	7.5000	.000
4680.0	24.0995	-59.66111	307509.	21221368.	24350.4	-1.1904	19.7	25686.	-1.1805	18.63	-1.0088	7.5000	.000
4710.0	24.7516	-57.61806	304983.	21218261.	24344.4	-1.2058	18.7	25681.	-1.1951	17.73	-1.0102	7.5000	.000
4740.0	25.3720	-55.55311	302251.	21214948.	24337.2	-1.2228	17.8	25674.	-1.2112	16.81	-1.0120	7.5000	.000
4770.0	25.9593	-53.46669	299293.	21211429.	24328.4	-1.2416	16.7	25665.	-1.2290	15.85	-1.0143	5.0000	.000
4780.0	26.1476	-52.76655	298252.	21210206.	24325.0	-1.2483	16.4	25662.	-1.2354	15.53	-1.0152	5.0000	.000
4790.0	26.3322	-52.06411	297183.	21208959.	24321.3	-1.2553	16.1	25658.	-1.2420	15.20	-1.0162	5.0000	.000
4800.0	26.5125	-51.35941	296083.	21207682.	24317.3	-1.2626	15.7	25654.	-1.2489	14.87	-1.0173	5.0000	.000
4810.0	26.6891	-50.65248	294952.	21206379.	24313.0	-1.2702	15.4	25650.	-1.2561	14.53	-1.0185	5.0000	.000
4820.0	26.8617	-49.94335	293788.	21205045.	24308.3	-1.2780	15.0	25645.	-1.2635	14.20	-1.0198	5.0000	.000
4830.0	27.0303	-49.23206	292591.	21203681.	24303.3	-1.2863	14.6	25640.	-1.2713	13.86	-1.0211	5.0000	.000
4840.0	27.1948	-48.51869	291358.	21202284.	24297.8	-1.2949	14.3	25635.	-1.2795	13.51	-1.0226	5.0000	.000
4850.0	27.3553	-47.80323	290088.	21200855.	24291.9	-1.3038	13.9	25629.	-1.2880	13.17	-1.0243	5.0000	.000
4860.0	27.5116	-47.08570	288780.	21199390.	24285.5	-1.3132	13.5	25622.	-1.2969	12.82	-1.0261	5.0000	.000
4870.0	27.6637	-46.36632	287431.	21197889.	24278.5	-1.3231	13.2	25615.	-1.3062	12.47	-1.0282	5.0000	.000
4880.0	27.8116	-45.64496	286040.	21196349.	24270.9	-1.3334	12.8	25608.	-1.3160	12.11	-1.0304	5.0000	.000
4890.0	27.9552	-44.92176	284605.	21194768.	24262.6	-1.3442	12.4	25599.	-1.3263	11.75	-1.0329	5.0000	.000
4900.0	28.0946	-44.19677	283123.	21193145.	24253.4	-1.3556	12.0	25590.	-1.3371	11.39	-1.0358	5.0000	.000
4910.0	28.2296	-43.47007	281592.	21191476.	24243.4	-1.3677	11.6	25580.	-1.3485	11.03	-1.0389	5.0000	.000
4920.0	28.3602	-42.74173	280010.	21189760.	24232.3	-1.3804	11.3	25569.	-1.3605	10.67	-1.0425	5.0000	.000
4930.0	28.4865	-42.01182	278372.	21187994.	24220.1	-1.3939	10.9	25557.	-1.3733	10.30	-1.0466	5.0000	.000
4940.0	28.6083	-41.28044	276678.	21186174.	24206.6	-1.4082	10.5	25543.	-1.3868	9.933	-1.0512	5.0000	.000
4950.0	28.7256	-40.54768	274922.	21184297.	24191.6	-1.4233	10.1	25528.	-1.4012	9.562	-1.0564	5.0000	.000
4960.0	28.8385	-39.81364	273101.	21182359.	24174.9	-1.4395	9.70	25512.	-1.4165	9.189	-1.0624	5.0000	.000
4970.0	28.9468	-39.07843	271211.	21180357.	24156.1	-1.4568	9.31	25493.	-1.4328	8.814	-1.0693	5.0000	.000
4980.0	29.0506	-38.34218	269247.	21178286.	24135.2	-1.4753	8.91	25472.	-1.4503	8.438	-1.0772	5.0000	.000
4990.0	29.1497	-37.60502	267204.	21176140.	24111.5	-1.4952	8.51	25448.	-1.4692	8.059	-1.0864	5.0000	.000
5000.0	29.2443	-36.86709	265076.	21173914.	24084.8	-1.5166	8.11	25421.	-1.4894	7.680	-1.0971	5.0000	.000
5010.0	29.3342	-36.12856	262858.	21171601.	24054.5	-1.5398	7.71	25391.	-1.5114	7.298	-1.1097	5.0000	.000
5020.0	29.4195	-35.38962	260541.	21169195.	24020.0	-1.5649	7.30	25356.	-1.5351	6.916	-1.1231	5.0000	.000
5030.0	29.5000	-34.65046	258118.	21166688.	23981.2	-1.5923	6.90	25318.	-1.5610	6.532	-1.1380	5.0000	.000
5040.0	29.5759	-33.91128	255579.	21164069.	23937.4	-1.6222	6.49	25274.	-1.5893	6.148	-1.1553	5.0000	.000
5050.0	29.6471	-33.17233	252915.	21161330.	23887.8	-1.6549	6.09	25224.	-1.6202	5.762	-1.1753	5.0000	.000
5060.0	29.7135	-32.43386	250114.	21158459.	23831.4	-1.6909	5.68	25167.	-1.6542	5.376	-1.1987	5.0000	.000
5070.0	29.7752	-31.69617	247163.	21155443.	23767.1	-1.7305	5.27	25103.	-1.6916	4.990	-1.2261	5.0000	.000
5080.0	29.8322	-30.95960	244049.	21152269.	23693.4	-1.7742	4.86	25029.	-1.7329	4.603	-1.2583	5.0000	.000
5090.0	29.8844	-30.22454	240754.	21148919.	23608.7	-1.8228	4.46	24944.	-1.7788	4.217	-1.2964	5.0000	.000
5100.0	29.9319	-29.49143	237261.	21145375.	23511.0	-1.8770	4.05	24846.	-1.8298	3.830	-1.3417	5.0000	.000
5110.0	29.9746	-28.76078	233550.	21141619.	23397.5	-1.9375	3.64	24732.	-1.8869	3.445	-1.3959	5.0000	.000
5120.0	30.0127	-28.03322	229596.	21137625.	23265.3	-1.006	3.24	24600.	-1.9511	3.060	-1.4609	5.0000	.000
5130.0	30.0461	-27.30944	225374.	21133367.	23110.5	-1.083	2.83	24445.	-1.023	2.677	-1.5396	5.0000	.000
5140.0	30.0748	-26.59031	220853.	21128816.	22928.2	-1.170	2.43	24262.	-1.106	2.296	-1.6351	5.0000	.000
5150.0	30.0990	-25.87685	215999.	21123937.	22712.5	-1.270	2.03	24046.	-1.199	1.917	-1.7516	5.0000	.000
5160.0	30.1186	-25.17028	210775.	21118691.	22455.7	-1.384	1.63	23789.	-1.307	1.542	-1.8946	5.0000	.000
5170.0	30.1338	-24.47210	205136.	21113035.	22148.5	-1.517	1.24	23482.	-1.430	1.171	-1.070	5.0000	.000

TTA7622 3R-64 12352 SPAHR 5x24x65 AI TRAJ NEW METRO
 CONTROL12352 SPAHR DATA-A= DATA-R=
 OBSERVER 0.0000=LAT 0.0000=LONG 0.0000=ORNT

ATMOS= ICAO 1962 ATMOSPHERE KLETT
 DATA-C= DATA-D=SPAHR 1962 AT
 1=X 0=Y 0=Z

TIME	LAT	LONG	HITE	RADVC	VT	GAMMA	TAU	VI	GAMMAI	TAUI	ACT	TDEL	SENTR
5180.0	30.1448	-23.78414	199034.	21106923.	21778.6	-1.671	.854	23111.	-1.575	.8045	-1.296	5.0000	.000
5190.0	30.1516	-23.10874	192417.	21100299.	21325.2	-1.852	.473	22657.	-1.743	.4447	-1.594	.62500	1.00
5200.0	30.1544	-22.44893	185229.	21093108.	20765.0	-2.068	.099	22096.	-1.943	.0931	-1.970	.62500	1.00
5210.0	30.1536	-21.80857	177413.	21085293.	20069.6	-2.327	-.265	21400.	-2.182	-.2481	-2.446	.62500	1.00
5220.0	30.1495	-21.19249	168916.	21076800.	19203.8	-2.642	-.616	20534.	-2.471	-.5760	-3.055	.62500	1.00
5230.0	30.1426	-20.60692	159698.	21067589.	18112.5	-3.033	-.952	19441.	-2.826	-.8867	-3.853	.62500	1.00
5240.0	30.1333	-20.05993	149755.	21057656.	16734.3	-3.526	-1.27	18062.	-3.266	-1.175	-4.889	.62500	1.00
5250.0	30.1227	-19.56197	139155.	21047067.	14982.3	-4.164	-1.56	16308.	-3.825	-1.433	-6.149	.62500	1.00
5260.0	30.1115	-19.12554	128080.	21036004.	12829.4	-5.017	-1.82	14153.	-4.546	-1.650	-7.347	.62500	1.00
5270.0	30.1008	-18.76228	116843.	21024779.	10365.8	-6.195	-2.04	11687.	-5.492	-1.811	-8.028	.62500	1.00
5280.0	30.0916	-18.47857	105847.	21013793.	7836.85	-7.878	-2.23	9153.3	-6.739	-1.903	-7.754	.62500	1.00
5290.0	30.0844	-18.27126	95446.8	21003400.	5589.71	-10.35	-2.37	6898.8	-8.369	-1.913	-6.420	.62500	1.00
5300.0	30.0791	-18.12744	85770.9	20993730.	3849.68	-14.01	-2.49	5146.3	-10.44	-1.836	-4.817	.62500	1.00
5310.0	30.0753	-18.03099	76768.6	20984732.	2621.44	-19.40	-2.58	3896.7	-12.91	-1.677	-3.443	.62500	1.00
5320.0	30.0728	-17.96765	68318.1	20976284.	1806.37	-27.04	-2.65	3046.8	-15.64	-1.452	-2.466	.62500	1.00
5330.0	30.0712	-17.92676	60321.2	20968289.	1289.37	-37.16	-2.71	2478.0	-18.32	-1.183	-1.847	.62500	1.00
5340.0	30.0701	-17.90094	52747.5	20960715.	973.016	-49.04	-2.76	2095.4	-20.53	-.8971	-1.511	.62500	1.00
5350.0	30.0694	-17.88524	45663.0	20953633.	777.401	-61.00	-2.81	1832.0	-21.79	-.6213	-1.354	1.2500	.000
5360.0	30.0691	-17.87623	39189.8	20947160.	647.599	-71.26	-2.84	1650.2	-21.82	-.3860	-1.280	2.5000	.000
5370.0	30.0688	-17.87142	33407.0	20941377.	555.178	-78.91	-2.87	1530.7	-20.85	-.2143	-1.209	2.5000	.000
5380.0	30.0687	-17.86901	28243.1	20936213.	492.870	-83.93	-2.89	1460.2	-19.61	-.1093	-1.154	5.0000	.000
5390.0	30.0687	-17.86785	23568.7	20931539.	446.984	-86.88	-2.87	1419.4	-18.33	-.0518	-1.120	2.5000	.000
5400.0	30.0687	-17.86732	19289.0	20927259.	411.004	-88.47	-2.81	1395.7	-17.12	-.0230	-1.096	5.0000	.000
5410.0	30.0687	-17.86709	15330.3	20923301.	381.856	-89.27	-2.62	1381.3	-16.05	-.0096	-1.079	5.0000	.000
5420.0	30.0686	-17.86698	11636.4	20919607.	357.664	-89.64	-2.23	1372.1	-15.11	-.0037	-1.066	5.0000	.000
5430.0	30.0686	-17.86693	8164.94	20916136.	337.182	-89.81	-1.56	1365.6	-14.29	-.0013	-1.057	2.5000	.000
5440.0	30.0686	-17.86691	4883.52	20912854.	319.525	-89.88	-.702	1360.7	-13.58	-3.5-4	-1.049	5.0000	.000
5450.0	30.0686	-17.86689	1767.03	20909739.	304.104	-89.91	.032	1356.8	-12.95	1.1-5	-1.043	2.5000	.000
5455.9	30.0686	-17.86688	.000000	20907971.	295.887	-89.92	.332	1354.8	-12.62	1.0-4	-1.040	1.2500	.000

END OF RUN.

APPENDIX B

TABULATED RESTORE TRAJECTORY PROGRAM RESULTS

TABULATED RESTORE TRAJECTORY PROGRAM RESULTS

The tabulated RESTORE trajectory program results for this trajectory are presented in this Appendix. A few of the outputs appearing on the tabulated trajectory are defined below. (Definitions of the other outputs will be available in Reference 5.)

TIME	Time from the start of the trajectory, seconds.
ALTITUDE	Altitude above mean sea level measured along a line from the re-entering object to the Earth's center, feet.
LATITUDE	The geocentric latitude of the intersection of a line from the re-entering object to the Earth's center and the Earth's surface, degrees.
LONGITUDE	The longitude of the intersection of a line from the re-entering object to the Earth's center and the Earth's surface, degrees.
R	The length of the line from the re-entering object to the Earth's center, feet.
AZIMUTH	The angle, positive in the counterclockwise sense, between the projection on the Earth relative velocity vector, whose magnitude is VELOCITY, on a plane at the Earth's surface (perpendicular to a line from the re-entering object to the Earth's center) and North, degrees.

VELOCITY

The velocity of the re-entering object relative to the point on the surface of the rotating oblate Earth where a line from the re-entering object to the Earth's center intersects the Earth's surface, feet per second.

FLIGHT ANGLE

The Earth relative re-entry angle; i. e., the angle between the Earth relative velocity vector, whose magnitude is VELOCITY, and a plane perpendicular to a line from the re-entering object to the Earth's center, degrees.

RESTORE 1, ATOMICS INTERNATIONAL
 RE-ENTRY SNAP TRAJECTORIES ON AN OBLATE ROTATING EARTH
 MODELS USED IN THE FOLLOWING TRAJECTORY

IDENTIFICATION

REFERENCE AEROSPACE TRAJECTORY No.2

ATMOSPHERE

ALTITUDE DEPENDENT PROPERTIES BASED ON U. S. STANDARD ATMOSPHERE, 1962

EARTH RADIUS

VARIABLE RADIUS=SQRT(ER**2/(COS(T)**2+SIN(T)**2/(1-1/F)**2))
 ER=20925738. FT T=LATITUDE F= 298.300

GRAVITATIONAL FORCE PER UNIT MASS

EARTH POTENTIAL FUNCTION DEPENDENT, $\Phi = \text{GRAVC} * \text{ER} ** 2 / \text{R} * (1 + \text{J} / 3 * (\text{ER} / \text{R}) ** 2 * (1 - 3 \text{ST} ** 2) + \text{H} / 5 * (\text{ER} / \text{R}) ** 3 * (3 - 5 \text{ST} ** 2) * \text{ST} + \text{D} / 35 * (\text{ER} / \text{R}) ** 4 * (3 - 30 \text{ST} ** 2 + 35 \text{ST} ** 4))$ $\text{GRAVC} = 32.146546 \text{ FT/SEC} ** 2$
 $\text{J} = 0.16234499\text{E}-02$ $\text{H} = -0.5750000\text{E}-05$ $\text{D} = 0.78749999\text{E}-05$
 ER=EARTH RADIUS AT EQUATOR, R=DIST FROM CENTER OF EARTH, ST=SIN(LATITUDE)

DRAG COEFFICIENT

CONSTANT CD= 1.000000

EARTH ANGULAR VELOCITY= 0.72921154E-04 RAD/SEC

INTEGRATION SUBROUTINE USES A FOURTH ORDER ADAMS-MOULTON METHOD WITH VARIABLE STEP-SIZE

A2= 0.99999999E-08 A3= 0.09999999E 03 A4= 0.
 A5= 0.49999999E 01 A6= 0.09999999E-00 A7= 0.

CIRCULAR VELOCITY CALCULATED FROM INPUT VALUES OF ALTITUDE AND LATITUDE= 25696.835 FT/SEC

INITIAL CONDITIONS AND TRAJECTORY PARAMETERS

POSITION AND VELOCITY ELEMENTS ARE GIVEN IN EARTH RELATIVE COORDINATES

VELOCITY	= 24345.1250 FT/SEC	ALTITUDE	= 417601.750 FT
LONGITUDE	= 0. DEG	LATITUDE	= 30.000000 DEG
FLIGHT ANGLE	= 0. DEG	AZIMUTHAL HEADING	= 90.000000 DEG
PROJECTED AREA	= 1.000000 FT**2	MASS OF VEHICLE	= 100.000000 LBM
INITIAL W/CDA	= 100.000000 LBM/FT**2		

BEGINNING OF TRAJECTORY

SUMMARY-RESTORE

THIS PROGRAM INTEGRATES THE EQUATIONS OF MOTION FOR A POINT MASS SPHERE IN A THREE-DIMENSIONAL SPACE IN THE VICINITY OF THE EARTH. THE SPHERE IS SUBJECTED TO THE FORCES OF ATMOSPHERIC DRAG AND GRAVITY WHILE MOVING RELATIVE TO A ROTATING OBLATE EARTH TO WHICH IS ATTACHED AN ATMOSPHERE WITH PROPERTIES THAT ARE A FUNCTION OF ALTITUDE ALONE. THE DIFFERENTIAL EQUATIONS ARE WRITTEN FOR A COORDINATE SYSTEM FIXED IN A ROTATING EARTH AND ARE THEREFORE EARTH-RELATIVE.

THERE ARE A NUMBER OF OPTIONS BUILT INTO THE PROGRAM PERMITTING THE USER TO VARY THE COMPLEXITY OF THE MODEL OF THE EARTH AND ITS ATMOSPHERE AND OF THE FLOW ABOUT THE RE-ENTERING SPHERE. THE OPTIONS INVOLVE THE SHAPE OF THE EARTH AND ITS GRAVITATIONAL FIELD, ITS ATMOSPHERE AND THE DRAG COEFFICIENT FOR FLOW OVER THE SPHERE. THE PROGRAM WILL ACCEPT ANY DEFINITIVE COMBINATION OF INERTIAL OR EARTH-RELATIVE TRAJECTORY PARAMETERS AS THE INITIAL OR RELEASE CONDITIONS, OR IT CAN BE DIRECTED TO START THE INTEGRATION WITH THE CIRCULAR VELOCITY OF THE POINT MASS SPHERE. REVISION OF THE PROGRAM TO APPLY TO PLANETS OTHER THAN THE EARTH IS NOT RECOMMENDED SINCE THIS NOT ONLY REQUIRES INTERNAL PROGRAMMING MODIFICATIONS, BUT ALSO RENDERS MEANINGLESS CERTAIN OUTPUT ELEMENTS, WHICH APPLY STRICTLY TO THE EARTH'S ATMOSPHERE. SEVERAL SELECTED CRT OUTPUTS ARE PROVIDED IF THE USER SO DESIRES. FINALLY, A CHOICE OF PRODUCTION OR COMPLETE OUTPUT FORMATS IS AVAILABLE.

THE INPUT QUANTITIES, FORMULAS, CONSTANTS AND INITIAL VALUES USED IN THE INTEGRATION ARE DISPLAYED BELOW.

INPUT VALUES

INITIAL INTEGRATION STEP	=	0.5000000 SEC	PRINTOUT INTERVAL	=	120.000000 SEC
MAXIMUM TIME FOR IMPACT	=	6000.00000 SEC	MAXIMUM ALLOWABLE ALT.	=	500000.0000 FT
VELOCITY	=	24345.12500 FT/SEC	ALTITUDE	=	417601.7500 FT
LONGITUDE	=	0. DEG	LATITUDE	=	30.000000 DEG
FLIGHT ANGLE	=	0. DEG	HEADING	=	90.000000 DEG
PROJECTED AREA	=	1.000000 FT**2	MASS OF VEHICLE	=	100.000000 LBM
RATIO OF SPECIFIC HEATS	=	1.400000			

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. GROOTR INT. GROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
0.	417601.25 C. 21325735. 24345.125	29.999999 C. 90.000000 -0.000000	0.180 1.287 C. 12047.339	27.866 -0.002 0.006 0.006	0. 0. 0. C.	1. 16.46 25.58 1.00	0.62230E-09 0.30220E-04 0.27706E 02 870.6520
120.0	417148.00 C.2864E 07 21325648. 24345.491	29.654708 9.041100 95.030046 -0.003452	0.182 1.296 21.672 12046.572	27.867 0.008 0.006 0.006	0. 0. 0. C.	1. 16.51 25.20 1.00	0.63164E-09 0.30501E-04 0.27713E 02 865.9678
240.0	415812.50 C.5729E 07 21325379. 24347.000	28.632924 17.954094 99.892603 -0.007125	0.191 1.325 43.998 12044.762	27.868 0.017 0.006 0.006	0. 0. 0. C.	1. 16.65 24.14 1.00	0.66000E-09 0.31345E-04 0.27733E 02 852.3115
360.0	413666.25 C.8594E 07 21324913. 24349.540	26.974720 26.630924 104.439568 -0.011078	0.205 1.373 67.653 12042.073	27.869 0.025 0.007 0.007	0. 0. 0. C.	1. 16.87 22.52 1.00	0.70826E-09 0.32751E-04 0.27765E 02 830.8137
480.0	410840.50 C.1146E 08 21324241. 24352.949	24.740398 34.997320 108.555448 -0.015347	0.225 1.439 93.346 12038.793	27.871 0.031 0.007 0.007	0. 0. 0. C.	1. 17.17 20.55 1.00	0.77722E-09 0.34698E-04 0.27807E 02 803.3328
600.0	407486.75 C.1433E 08 21323335. 24356.992	22.003134 43.017733 112.161625 -0.019935	0.254 1.531 121.940 12034.338	27.874 0.036 0.008 0.008	0. 0. 0. C.	1. 17.58 18.22 1.00	0.87824E-09 0.37434E-04 0.27858E 02 768.3799

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CENT. QROOTR INT. QROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHC INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
720.0	4038.7.00 0.1719E 08 21322195. 24361.427	18.842027 50.692458 115.212811 -0.024811	0.292 1.642 154.601 12 29.575	27.878 0.038 0.009 0.009	0. 0. 0. 0.	2. 18.05 15.90 1.00	0.10087E-08 0.40796E-04 0.27913E 02 730.5505
840.0	399992.25 0.2006E 08 21320800. 24365.977	15.336841 58.050379 117.689065 -0.029901	0.337 1.765 192.253 12 25.764	27.882 0.038 0.011 0.011	0. 0. 0. 0.	2. 18.55 13.80 1.00	0.11644E-08 0.44600E-04 0.27970E 02 693.3007
960.0	396243.00 0.2293E 08 21319148. 24370.386	11.564855 65.140634 119.586696 -0.035097	0.392 1.905 235.949 12 21.619	27.887 0.035 0.013 0.013	0. 0. 0. 0.	2. 19.02 11.89 1.00	0.13547E-08 0.49371E-04 0.28030E 02 661.0627
1080.0	392719.25 0.2580E 08 21317224. 24374.403	7.599553 72.025345 120.910282 -0.040256	0.453 2.046 286.610 12 18.585	27.892 0.031 0.014 0.014	0. 0. 0. 0.	3. 19.47 10.33 1.00	0.15618E-08 0.54318E-04 0.28086E 02 632.1289
1200.0	389567.75 0.2867E 08 21315041. 24377.848	3.510705 78.774210 121.666630 -0.045211	0.514 2.181 344.616 12 16.247	27.899 0.026 0.016 0.016	0. 0. 0. 0.	3. 19.87 9.12 1.00	0.17728E-08 0.59238E-04 0.28136E 02 608.4070
1320.0	386877.75 0.3155E 08 21312607. 24380.592	-0.634677 85.460878 121.860822 -0.049778	0.571 2.300 409.762 12 15.587	27.906 0.020 0.018 0.018	0. 0. 0. 0.	4. 20.12 8.22 1.00	0.19698E-08 0.64228E-04 0.28177E 02 594.5239

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CENT. QRCOTR INT. QRCOTR STAG. P	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
1440.0	384717.50 0.3442E 08 213.9968. 24382.603	-4.770892 92.160587 121.494082 -0.053766	0.622 2.400 481.415 12014.925	27.913 0.014 0.020 0.020	0. 0. 0. 0.	4. 20.32 7.56 1.00	0.21438E-08 0.68538E-04 0.28209E 02 583.6035
1560.0	383052.50 0.3729E 08 21307129. 24383.869	-8.831886 98.948378 120.563235 -0.056994	0.664 2.480 558.643 12014.171	27.921 0.008 0.021 0.021	0. 0. 0. 0.	4. 20.47 7.09 1.00	0.22883E-08 0.72056E-04 0.28234E 02 575.3233
1680.0	381850.25 0.4017E 08 21304155. 24384.457	-12.749635 105.897232 119.061716 -0.059299	0.696 2.539 640.302 12013.365	27.929 0.003 0.022 0.022	0. 0. 0. 0.	5. 20.59 6.77 1.00	0.23987E-08 0.74708E-04 0.28252E 02 569.4172
1800.0	381005.25 0.4304E 08 21301090. 24384.619	-16.452800 113.075337 116.982244 -0.060556	0.719 2.581 725.271 12012.497	27.937 -0.001 0.023 0.023	0. 0. 0. 0.	5. 20.67 6.55 1.00	0.24794E-08 0.76631E-04 0.28265E 02 565.3023
1920.0	380346.00 0.4591E 08 21297947. 24384.369	-19.865982 120.541898 114.321443 -0.060685	0.738 2.615 812.667 12011.487	27.945 -0.002 0.024 0.024	0. 0. 0. 0.	5. 20.73 6.38 1.00	0.25443E-08 0.78165E-04 0.28275E 02 562.1125
2040.0	379807.50 0.4879E 08 21294869. 24384.044	-22.910051 128.341011 111.086623 -0.059666	0.755 2.643 902.021 12010.525	27.954 -0.003 0.024 0.024	0. 0. 0. 0.	5. 20.78 6.25 1.00	0.26005E-08 0.79487E-04 0.28283E 02 559.4212

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROCTR INT. QROCTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHQ INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
2160.0	379234.50 C.5166E 08 21291914. 24383.847	-25.503986 136.493788 107.304381 -C.057541	0.773 2.676 993.521 12009.604	27.962 -0.001 0.025 0.025	0. 0. 0. 0.	5. 20.84 6.10 1.00	0.26656E-08 0.81010E-04 0.28291E 02 556.3826
2280.0	378398.50 C.5453E 08 21289051. 24383.866	-27.568747 144.989861 103.029802 -0.054420	0.802 2.725 1087.886 12008.566	27.970 0.002 0.026 0.026	0. 0. 0. 0.	5. 20.93 5.88 1.00	0.27636E-08 0.83285E-04 0.28304E 02 551.9787
2400.0	377204.00 C.5741E 08 21286355. 24384.285	-29.033316 153.780916 98.353690 -C.050480	0.844 2.796 1186.419 12007.478	27.977 0.006 0.027 0.027	0. 0. 0. 0.	6. 21.05 5.59 1.00	0.29098E-08 0.86647E-04 0.28322E 02 545.7466
2520.0	375589.00 C.6028E 08 21283891. 24385.233	-29.842098 162.779911 93.403937 -C.045954	0.905 2.896 1291.071 12006.406	27.984 0.010 0.029 0.029	0. 0. 0. 0.	6. 21.23 5.22 1.00	0.31199E-08 0.91409E-04 0.28346E 02 537.4321
2640.0	373506.25 C.6316E 08 21281680. 24386.749	-29.962184 171.868969 88.338453 -C.041123	0.991 3.030 1404.472 12005.354	27.990 0.015 0.032 0.032	0. 0. 0. 0.	7. 21.45 4.78 1.00	0.34133E-08 0.97938E-04 0.28377E 02 526.8955
2760.0	370923.50 C.6603E 08 21279704. 24388.769	-29.388271 -179.084024 83.328677 -C.036306	1.108 3.204 1529.983 12004.255	27.996 0.019 0.035 0.035	0. 0. 0. 0.	8. 21.73 4.28 1.00	0.38158E-08 0.10669E-03 0.28416E 02 514.1152

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. GROOTR INT. GROOTR STAG. F	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
2880.0	367903.00 0.6891E 08 21277972. 24391.218	-28.143509 -170.204317 78.539745 -0.031843	1.274 3.437 1672.191 12042.985	28.001 0.022 0.041 0.041	0. 0. 0. 0.	9. 22.08 3.73 1.00	0.43869E-08 0.11884E-03 0.28459E 02 498.8792
3000.0	364504.00 0.7179E 08 21276438. 24393.855	-26.275917 -161.591366 74.111671 -0.028092	1.498 3.727 1837.867 12001.529	28.005 0.023 0.048 0.048	0. 0. 0. 0.	11. 22.49 3.18 1.00	0.51554E-08 0.13469E-03 0.28507E 02 481.9461
3120.0	360857.75 0.7466E 08 21275077. 24396.606	-23.851765 -153.307617 70.148876 -0.025419	1.781 4.065 2033.874 11999.964	28.010 0.022 0.057 0.057	0. 0. 0. 0.	14. 22.93 2.68 1.00	0.61301E-08 0.15405E-03 0.28558E 02 464.4181
3240.0	357070.75 0.7754E 08 21273803. 24399.085	-20.947958 -145.376406 66.718796 -0.024179	2.124 4.440 2267.471 11999.608	28.014 0.019 0.068 0.068	0. 0. 0. 0.	17. 23.24 2.25 1.00	0.73072E-08 0.17877E-03 0.28605E 02 452.8658
3360.0	353299.00 0.8042E 08 21272562. 24401.121	-17.645428 -137.786798 63.857371 -0.024709	2.528 4.844 2545.641 11999.310	28.018 0.014 0.080 0.081	0. 0. 0. 0.	20. 23.51 1.89 1.00	0.86935E-08 0.20789E-03 0.28650E 02 443.3598
3480.0	349664.00 0.8330E 08 21271263. 24402.492	-14.024437 -130.501726 61.577946 -0.027316	2.992 5.270 2875.889 11998.475	28.023 0.008 0.095 0.095	0. 0. 0. 0.	24. 23.77 1.60 1.00	0.10288E-07 0.24065E-03 0.28693E 02 434.3104

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QRCOTR INT. QRCOTR STAG. P	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHC INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
3600.0	346199.25 C.8618E C8 21269743. 24472.934	-10.162048 -123.466284 59.880337 -0.032280	3.547 5.739 3267.537 11996.710	28.028 -0.000 0.113 0.113	C. 0. 0. C.	29. 24.04 1.35 1.00	0.12198E-07 0.27896E-03 0.28728E 02 425.1615
3720.0	342977.50 C.8906E C8 21267911. 24402.351	-6.131307 -116.614530 58.758312 -0.039862	4.155 6.211 3728.952 11994.142	28.033 -0.009 0.132 0.133	0. 0. 0. C.	35. 24.30 1.16 1.00	0.14289E-07 0.32003E-03 0.28760E 02 416.8267
3840.0	339968.25 C.9194E C8 21265620. 24400.696	-2.001664 -109.874325 58.205017 -0.050290	4.817 6.687 4266.415 11990.694	28.041 -0.018 0.153 0.154	0. 0. 0. C.	41. 24.53 1.00 1.00	0.16568E-07 0.36388E-03 0.28790E 02 409.1830
3960.0	337081.25 C.9482E C8 21262719. 24397.977	2.159852 -103.170498 58.216294 -0.063767	5.603 7.210 4890.260 11986.190	28.049 -0.027 0.178 0.179	0. 0. 0. C.	48. 24.77 0.86 1.00	0.19279E-07 0.41510E-03 0.28813E 02 401.4583
4080.0	334154.75 C.9771E C8 21259047. 24394.241	6.287058 -96.426962 58.792291 -0.080524	6.531 7.782 5616.042 11980.706	28.060 -0.035 0.208 0.208	0. 0. 0. C.	57. 25.02 0.74 1.00	0.22481E-07 0.47439E-03 0.28837E 02 393.7765
4200.0	330962.50 C.1006E C9 21254441. 24389.566	10.312909 -89.568465 59.937434 -0.100856	7.718 8.458 6467.218 11974.179	28.074 -0.043 0.246 0.246	0. 0. 0. C.	69. 25.29 0.62 1.00	0.26582E-07 0.54876E-03 0.28862E 02 385.5643

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QRCCTR INT. QRCCTR STAG. F	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
4320.0	327170.50 0.1035E 09 21248686. 24383.864	14.167904 -82.522748 61.658825 -0.125235	9.438 9.349 7488.847 11966.806	28.091 -0.053 0.301 0.301	0. 0. 0. 0.	85. 25.55 0.51 1.00	0.32530E-07 0.65785E-03 0.28884E 02 377.9916
4440.0	322385.00 0.1063E 09 21241553. 24376.714	17.778846 -75.223813 63.962826 -0.154534	12.182 10.616 8681.735 11957.798	28.112 -0.068 0.388 0.389	0. 0. 0. 0.	112. 25.84 0.40 1.00	0.42021E-07 0.82995E-03 0.28908E 02 369.4703
4560.0	316148.75 0.1092E 09 21232782. 24366.934	21.068363 -67.617026 66.849504 -0.190457	17.115 12.575 10062.896 11945.767	28.138 -0.100 0.545 0.547	0. 0. 0. 0.	162. 26.22 0.28 1.00	0.59111E-07 0.11335E-02 0.28932E 02 359.0162
4680.0	317819.25 0.1121E 09 21221944. 24351.065	23.955644 -59.666496 70.304795 -0.236577	27.277 15.858 11749.158 11927.100	28.172 -0.177 0.870 0.872	0. 0. 0. 0.	267. 26.72 0.18 1.00	0.94393E-07 0.17411E-02 0.28952E 02 345.5816
4800.0	296494.00 0.1150E 09 21208347. 24318.893	26.358910 -51.364932 74.290547 -0.301183	52.504 21.954 13978.452 11892.118	28.217 -0.398 1.677 3.274	1196. 9501. 3. 0.3710E-05	536. 27.30 0.09 1.00	0.18241E-06 0.32132E-02 0.28962E 02 330.1361
4810.0	295374.25 0.1152E 09 21207055. 24314.760	26.534832 -50.657996 74.644637 -0.307916	56.005 22.667 14201.432 11887.895	28.222 -0.430 1.789 3.492	1199. 9526. 3. 0.3949E-05	573. 27.33 0.09 1.00	0.19467E-06 0.34201E-02 0.28962E 02 329.2691

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROGTR INT. QROGTR STAG. P	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
4820.0	294221.50 0.1155E 09 21205733. 24310.290	26.756802 -49.948858 75.001876 -0.314930	59.850 23.425 14431.765 11883.340	28.227 -0.465 1.912 3.733	1202. 9552. 4. 0.4211E-05	614. 27.36 0.08 1.00	0.20815E-06 0.36470E-02 0.28963E 02 328.3789
4830.0	293036.50 0.1157E 09 21204382. 24305.448	26.874776 -49.237563 75.362197 -0.322247	64.077 24.230 14669.908 11878.419	28.232 -0.504 2.047 3.997	1205. 9579. 4. 0.4498E-05	659. 27.40 0.07 1.00	0.22299E-06 0.38960E-02 0.28963E 02 327.4664
4840.0	291816.00 0.1159E 09 21202999. 24300.194	27.038716 -48.524148 75.725548 -0.329892	68.740 25.88 14916.357 11873.093	28.237 -0.547 2.197 4.288	1208. 9607. 4. 0.4815E-05	709. 27.43 0.07 1.00	0.23937E-06 0.41702E-02 0.28963E 02 326.5291
4850.0	290559.50 0.1162E 09 21201583. 24294.483	27.198575 -47.808662 76.091856 -0.337890	73.893 26.001 15171.650 11867.319	28.243 -0.596 2.362 4.610	1211. 9635. 4. 0.5164E-05	765. 27.47 0.06 1.00	0.25749E-06 0.44727E-02 0.28964E 02 325.5670
4860.0	289279.25 0.1164E 09 21200147. 24288.283	27.354318 -47.091149 76.461069 -0.346270	79.422 26.945 15436.269 11861.200	28.249 -0.648 2.539 4.956	1215. 9664. 5. 0.5538E-05	823. 27.48 0.06 1.00	0.27697E-06 0.48048E-02 0.28964E 02 325.1415
4870.0	287945.25 0.1167E 09 21198661. 24281.516	27.505902 -46.371664 76.833104 -0.355066	85.521 27.947 15710.675 11854.636	28.256 -0.706 2.735 5.338	1218. 9694. 5. 0.5949E-05	887. 27.47 0.06 1.00	0.29849E-06 0.51782E-02 0.28964E 02 325.1452

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROOTR INT. QROOTR STAG. F	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS R+G INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
4880.0	286569.75 C.1169E 09 21197137. 24274.140	27.653286 -45.650262 77.207896 -C.364313	92.297 29.019 15995.445 11847.483	28.263 -C.770 2.953 5.762	1222. 9725. 6. C.6406E-05	958. 27.46 C.05 1.00	0.32243E-06 0.55936E-02 0.28964E 02 325.1490
4890.0	285151.25 C.1171E 09 21195574. 24266.081	27.796436 -44.927000 77.585372 -C.374049	99.841 30.165 16291.298 11839.671	28.270 -0.843 3.195 6.235	1226. 9757. 6. C.6913E-05	1037. 27.45 C.05 1.00	0.34914E-06 0.60569E-02 0.28964E 02 325.1530
4900.0	283686.50 C.1174E 09 21193968. 24257.257	27.935311 -44.201944 77.965453 -C.384318	108.272 31.394 16599.021 11831.120	28.279 -0.924 3.466 6.763	1229. 9789. 7. C.7479E-05	1125. 27.44 C.04 1.00	0.37903E-06 0.65756E-02 0.28964E 02 325.1570
4910.0	282174.25 C.1176E 09 21192319. 24247.573	28.069876 -43.475161 78.348062 -C.395170	117.715 32.713 16919.477 11821.738	28.288 -1.015 3.770 7.355	1233. 9823. 7. C.8112E-05	1224. 27.43 C.04 1.00	0.41259E-06 0.71578E-02 0.28964E 02 325.1612
4920.0	280611.00 C.1179E 09 21190623. 24236.917	28.200094 -42.746724 78.733109 -C.406657	128.333 34.132 17253.613 11811.420	28.298 -1.118 4.112 8.021	1237. 9858. 8. C.8822E-05	1336. 27.42 C.04 1.00	0.45040E-06 0.78138E-02 0.28964E 02 325.1655
4930.0	278994.50 C.1181E 09 21188877. 24225.163	28.325933 -42.016714 79.120510 -C.418845	140.317 35.661 17602.481 11800.043	28.309 -1.235 4.498 8.774	1242. 9894. 9. C.9623E-05	1462. 27.40 C.03 1.00	0.49317E-06 0.85560E-02 0.28964E 02 325.1684

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CGNT. QROOTR INT. QROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
4940.0	277321.75	28.447355	153.887	28.322	1246.	1605.	0.54174E-06
	C.1183E 09	-41.285214	37.313	-1.368	9930.	27.39	0.93986E-02
	21187080.	79.510172	17967.244	4.935	9.	0.03	0.28964E 02
	24212.160	-0.431803	11787.463	9.626	C.1053E-04	1.00	325.1705
4950.0	275589.25	28.564329	169.336	28.337	1250.	1768.	0.59708E-06
	C.1186E 09	-40.552317	39.099	-1.520	9968.	27.37	0.10359E-01
	21185227.	79.902006	18349.184	5.433	10.	0.03	0.28964E 02
	24197.734	-0.445610	11773.514	10.596	C.1156E-04	1.00	325.1726
4960.0	273793.25	28.676823	186.897	28.354	1255.	1954.	0.66044E-06
	C.1188E 09	-39.818123	41.035	-1.695	10007.	27.35	0.11458E-01
	21183315.	80.295904	18749.721	6.002	11.	0.03	0.28964E 02
	24181.680	-0.460358	11758.001	11.703	C.1273E-04	1.00	325.1747
4970.0	271930.00	28.784806	207.048	28.375	1260.	2168.	0.73327E-06
	C.1191E 09	-39.082737	43.138	-1.895	10047.	27.33	0.12722E-01
	21181340.	80.691759	19170.439	6.654	13.	0.02	0.28964E 02
	24163.756	-0.476151	11740.693	12.973	C.1407E-04	1.00	325.1770
4980.0	269994.50	28.888250	230.240	28.400	1265.	2415.	0.81745E-06
	C.1193E 09	-38.346282	45.427	-2.127	10089.	27.31	0.14182E-01
	21179297.	81.089473	19613.102	7.405	14.	0.02	0.28964E 02
	24143.674	-0.493109	11721.317	14.436	C.1561E-04	1.00	325.1822
4990.0	267982.25	28.987126	256.195	28.429	1270.	2684.	0.91215E-06
	C.1195E 09	-37.608885	47.846	-2.387	10132.	27.24	0.15877E-01
	21177182.	81.488906	20 79.289	8.248	16.	0.02	0.28964E 02
	24121.135	-0.511371	11699.842	16.077	C.1723E-04	1.00	326.2421

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROOTR INT. QROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
5000.0	265888.00 C.1198E 09 21174989. 24095.785	29.081407 -36.870685 81.889963 -0.531093	286.251 50.487 20570.750 11675.694	28.466 -2.690 9.225 17.979	1275. 10175. 17. C.1932E-04	2996. 27.17 0.02 1.00	0.10224E-05 0.17856E-01 0.28964E 02 327.3489
5010.0	263705.25 C.1200E 09 21172713. 24067.156	29.171070 -36.131840 82.292480 -0.552456	321.246 53.379 21089.856 11648.430	28.511 -3.045 10.365 20.199	1280. 10221. 20. C.2164E-04	3360. 27.09 0.01 1.00	0.11515E-05 0.20182E-01 0.28964E 02 328.5065
5020.0	261427.25 C.1202E 09 21170346. 24034.679	29.256088 -35.392519 82.696331 -0.575675	362.220 56.555 21639.276 11617.518	28.570 -3.462 11.703 22.802	1286. 10267. 22. C.2436E-04	3787. 27.00 0.01 1.00	0.13036E-05 0.22933E-01 0.28964E 02 329.7189
5030.0	259046.00 C.1205E 09 21167881. 23997.718	29.336442 -34.652917 83.101372 -0.600998	407.722 59.850 22221.631 11582.715	28.641 -3.927 13.193 25.702	1292. 10315. 25. C.2738E-04	4245. 26.85 0.01 1.00	0.14742E-05 0.26149E-01 0.28964E 02 332.4614
5040.0	256553.25 C.1207E 09 21165309. 23956.018	29.412114 -33.913243 83.507429 -0.628704	456.449 63.144 22836.344 11544.129	28.726 -4.427 14.796 28.819	1298. 10365. 28. C.3062E-04	4704. 26.59 0.01 1.00	0.16590E-05 0.29890E-01 0.28964E 02 337.6926
5050.0	253939.50 C.1210E 09 21162620. 23908.889	29.483087 -33.173719 83.914336 -0.659098	513.583 66.762 23485.586 11500.308	28.836 -5.016 16.680 32.485	1304. 10416. 32. C.3442E-04	5239. 26.32 0.01 1.00	0.18777E-05 0.34389E-01 0.28964E 02 343.2661

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROOTR INT. QROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
5060.0	251193.25 0.1212E 09 21159804. 23855.337	29.549351 -32.434598 84.321922 -0.692535	581.031 70.748 24172.812 11450.646	28.980 -5.715 18.913 36.827	1311. 10468. 36. 0.3893E-04	5866. 26.04 0.01 1.00	0.21386E-05 0.39847E-01 0.28964E 02 349.2213
5070.0	248303.00 0.1214E 09 21156849. 23794.224	29.610894 -31.696164 84.729966 -0.729442	658.096 74.976 24901.439 11393.961	29.165 -6.519 21.477 41.811	1317. 10521. 41. 0.4409E-04	6578. 25.75 0.01 1.00	0.24410E-05 0.46284E-01 0.28964E 02 355.3874
5080.0	245255.00 0.1217E 09 21153741. 23724.452	29.667714 -30.958738 85.138264 -0.770310	747.340 79.512 25673.505 11329.326	29.405 -7.456 24.461 47.610	1324. 10576. 46. 0.5010E-04	7359. 25.44 0.01 1.00	0.27965E-05 0.53989E-01 0.28964E 02 361.8472
5090.0	242033.25 0.1219E 09 21150464. 23644.465	29.719806 -30.222684 85.546564 -0.815715	854.151 84.532 26493.297 11255.277	29.730 -8.585 28.052 54.587	1332. 10632. 53. 0.5733E-04	8377. 25.12 0.01 1.00	0.32287E-05 0.63532E-01 0.28964E 02 368.8029
5100.0	238620.75 0.1221E 09 21147002. 23552.036	29.767177 -29.488426 85.954600 -0.866354	979.656 89.946 27365.674 11169.907	30.164 -9.923 32.300 62.838	1339. 10689. 61. 0.6590E-04	9523. 24.77 0.00 1.00	0.37469E-05 0.75197E-01 0.28964E 02 376.1516
5110.0	234998.50 0.1224E 09 21143334. 23445.201	29.809835 -28.756451 86.362082 -0.923059	1125.800 95.702 28293.409 11.71.466	30.739 -11.496 37.287 72.522	1347. 10746. 70. 0.7598E-04	10856. 24.41 0.00 1.00	0.43650E-05 0.89395E-01 0.28964E 02 383.8494

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM Q CONT. QROOTR INT. QROOTR STAG. P	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHO INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
5120.0	231144.25 C.1226E 09 21139440. 23320.922	29.847799 -28.027324 86.768652 -C.986817	1303.450 102.777 29281.738 10957.382	31.536 -13.427 43.401 84.388	1355. 10803. 82. C.8838E-04	12476. 24.02 0.00 1.00	0.51351E-05 0.10746E-00 0.28964E 02 392.2132
5130.0	227033.25 C.1228E 09 21135294. 23175.483	29.881094 -27.301720 87.173905 -1.058848	1511.373 108.789 30335.956 10824.414	32.602 -15.717 50.640 98.431	1363. 10859. 95. C.1031E-03	14381. 23.61 0.00 1.00	0.60670E-05 0.12980E-00 0.28964E 02 400.9844
5140.0	222634.50 C.1231E 09 21130864. 23004.828	29.909757 -26.580437 87.577409 -1.140622	1762.269 116.048 31459.570 10669.269	34.068 -18.516 59.485 115.581	1372. 10914. 112. C.1213E-03	16692. 23.16 0.00 1.00	0.72327E-05 0.15839E-00 0.28964E 02 410.4386
5150.0	217919.00 C.1233E 09 21126123. 22802.992	29.933837 -25.864414 87.978613 -1.233956	2063.628 123.766 32658.722 10487.031	36.070 -21.935 70.274 136.488	1380. 10964. 132. C.1437E-03	19498. 22.68 0.00 1.00	0.86965E-05 0.19515E-00 0.28964E 02 420.5914
5160.0	212847.50 C.1235E 09 21121031. 22563.596	29.953400 -25.154802 88.376898 -1.341105	2424.002 131.823 33936.138 10272.712	38.780 -26.106 83.421 161.949	1389. 11009. 157. C.1713E-03	22908. 22.16 0.00 1.00	0.10544E-04 0.24272E-00 0.28964E 02 431.4698
5170.0	207379.25 C.1237E 09 21115547. 22277.390	29.968535 -24.452980 88.771555 -1.464886	2861.805 140.248 35296.645 10019.057	42.478 -31.291 99.753 193.553	1398. 11045. 187. C.2061E-03	27172. 21.60 0.00 1.00	0.12934E-04 0.30548E-00 0.28964E 02 442.6765

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
 OUTPUT ITEMS OF POSITION AND VELOCITY ARE GIVEN IN TERMS OF EARTH RELATIVE COORDINATES.

TIME	ALTITUDE RANGE R VELOCITY	LATITUDE LONGITUDE AZIMUTH FLIGHT ANGLE	FM C CONT. QROOTR INT. QROOTR STAG. H	ACCELERATION TAN. ACC. DYNAMIC P STAG. P	V INSIDE NS T INSIDE NS P INSIDE NS RHC INSIDE NS	RE NO./FT FS MACH NO. KN NO.*FT DRAG COEF.	FS DENSITY FS PRESSURE MOLECULAR WT. FS TEMP.
5180.0	201468.75 C.1239E 09 21109625. 21933.434	29.979355 -23.760648 90.838378 -1.608878	3392.904 148.837 36741.812 9718.062	47.483 -37.764 120.121 232.928	1406. 11068. 225. C.2506E-03	32556. 21.00 0.00 1.00	0.16067E-04 0.38928E-00 0.28964E 02 454.1073
5190.0	195063.00 C.1242E 09 21103212. 21515.355	29.986005 -23.079923 90.453924 -1.777711	4066.590 157.852 38274.988 9357.192	54.505 -46.243 146.769 284.393	1414. 11069. 275. C.3103E-03	39976. 20.41 0.00 1.00	0.20402E-04 0.50320E 00 0.28964E 02 462.2750
5200.0	188110.50 C.1244E 09 21096257. 21000.271	29.988679 -22.413531 90.000000 -1.977643	4898.934 166.465 39897.601 8921.575	64.094 -57.193 181.146 350.694	1421. 11038. 338. C.3905E-03	49904. 19.76 0.00 1.00	0.26431E-04 0.66247E 00 0.28964E 02 469.7736
5210.0	180552.00 C.1246E 09 21088699. 20361.946	29.987627 -21.764990 90.291415 -2.217133	5890.709 173.475 41598.821 8396.165	76.756 -71.056 224.647 434.442	1427. 10958. 419. C.4976E-03	62959. 19.00 0.00 1.00	0.34866E-04 0.88906E 00 0.28964E 02 477.9369
5220.0	172332.25 C.1248E 09 21080484. 19567.099	29.983174 -21.138731 90.649076 -2.507650	7047.329 177.677 43357.517 7763.963	93.268 -88.598 279.673 540.130	1430. 10806. 520. C.6434E-03	80605. 18.12 0.00 1.00	0.47004E-04 0.12166E 01 0.28964E 02 485.1322
5230.0	163404.00 C.1250E 09 21071564. 18571.276	29.975749 -20.540368 90.992563 -2.865137	8418.729 178.161 45140.448 7005.848	115.449 -111.674 352.012 678.663	1428. 10545. 652. C.8541E-03	106543. 17.16 0.00 1.00	0.65676E-04 0.17070E 01 0.28964E 02 487.1550

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5240.0	153747.50 C.1251E 09 21061918. 17311.250	29.965910 -19.977236 91.318550 -3.312992	9946.223 172.454 46899.481 6101.566	144.741 -141.713 446.150 858.177	1420. 10115. 822. C.1168E-02	146071. 16.08 0.00 1.00	0.95798E-04 0.24640E 01 0.28964E C2 482.0702
5250.0	143396.75 C.1253E 09 21051575. 15712.701	29.954384 -19.458839 91.622257 -3.887083	11423.747 157.509 48557.736 5043.957	181.914 -179.480 564.525 1082.439	1400. 9417. 1032. C.1652E-02	208131. 14.80 C.00 1.00	0.14714E-03 0.36817E 01 0.28964E 02 468.9953
5260.0	132483.00 C.1255E 09 21040679. 13714.774	29.942090 -18.996973 91.898024 -4.644716	12201.085 130.065 50006.231 3865.630	221.718 -219.691 690.816 1321.146	1314. 8048. 1255. C.2467E-02	300308. 13.15 C.00 1.00	0.23633E-03 0.57052E 01 0.28964E 02 452.4638
5270.0	121268.50 C.1256E 09 21029477. 11353.367	29.930091 -18.604036 92.139835 -5.678127	11475.508 92.351 51123.856 2671.343	251.200 -249.380 784.873 1495.559	1195. 6457. 1413. C.3723E-02	453176. 11.54 0.00 1.00	0.39182E-03 0.84226E 01 0.28964E 02 402.9001
5280.0	110131.50 C.1257E 09 21018351. 8813.758	29.919409 -18.289050 92.343668 -7.135900	9051.733 54.011 51851.409 1651.976	254.458 -252.630 797.486 1502.502	1185. 5194. 1395. C.4914E-02	575292. 8.79 0.00 1.00	0.66060E-03 0.14735E 02 0.28964E C2 418.0729
5290.0	99464.50 C.1258E 09 21007693. 6421.265	29.910737 -18.052859 92.509815 -9.255081	5801.471 25.641 52238.441 921.572	222.713 -220.600 701.568 1311.096	1061. 3380. 1195. C.6628E-02	708392. 6.48 0.00 1.00	0.10949E-C2 0.23849E C2 0.28964E 02 408.2714

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5300.0	89497.50 C.1258E 09 20997733. 4470.913	29.904230 -17.885956 92.644216 -12.391060	3132.747 10.369 52408.804 495.946	170.972 -168.220 544.103 1013.209	926. 1995. 901. C.8461E-02	797867. 4.54 0.00 1.00	0.17516E-02 0.37646E 02 0.28964E 02 402.8402
5310.0	80241.25 C.1258E 09 20988482. 3049.015	29.899607 -17.772757 92.756351 -17.028533	1546.377 3.874 52475.012 281.167	121.168 -117.370 393.829 746.129	769. 1122. 647. C.1080E-01	855696. 3.12 0.00 1.00	0.27260E-02 0.57860E 02 0.28964E 02 397.8246
5320.0	71587.50 C.1259E 09 20979832. 2085.296	29.896429 -17.697888 92.856690 -23.729562	752.543 1.444 52499.571 181.200	82.558 -77.316 280.231 549.995	725. 711. 453. C.1193E-01	899186. 2.15 0.00 1.00	0.41468E-02 0.86972E 02 0.28964E 02 393.0986
5330.0	63418.50 C.1259E 09 20971665. 1464.514	29.894289 -17.649209 92.955574 -32.891512	386.876 0.578 52518.942 136.619	55.463 -48.652 205.130 429.531	778. 519. 321. C.1158E-01	941938. 1.51 0.00 1.00	0.61543E-02 0.12830E 03 0.28964E 02 390.7420
5340.0	55672.25 C.1259E 09 20963920. 1079.665	29.892876 -17.618157 93.064549 -44.229931	224.861 0.266 52512.909 116.874	37.448 -29.738 161.725 373.891	903. 419. 239. C.1067E-01	1009027. 1.12 0.00 1.00	0.89276E-02 0.18575E 03 0.28964E 02 389.9609
5350.0	48380.25 C.1259E 09 20956629. 844.185	29.891967 -17.598946 93.200010 -56.390667	152.338 0.146 52514.884 107.824	25.490 -18.447 140.127 403.372	0. 0. 0. C.	1118161. 0.87 0.00 1.00	0.12653E-01 0.26324E 03 0.28964E 02 389.9543

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5360.0	41652.50 C.1259E 09 20949902. 693.276	29.891405 -17.587640 93.391548 -67.487522	116.422 0.092 52516.044 103.191	17.361 -12.390 130.401 493.638	0. 0. 0. C.	1267027. 0.72 0.00 1.00	0.17458E-01 0.36324E 03 0.28964E 02 389.9627
5370.0	35588.50 C.1259E 09 20943838. 590.224	29.891074 -17.581418 93.700851 -76.203361	93.434 0.063 52516.809 102.830	11.337 -8.452 122.925 606.858	0. 0. 0. C.	1375018. 0.60 0.00 1.00	0.22706E-01 0.48393E 03 0.28964E 02 399.4640
5380.0	30165.25 C.1259E 09 20938415. 517.317	29.890884 -17.578212 94.259710 -82.195884	78.854 0.047 52517.354 104.096	7.650 -6.341 118.364 743.151	0. 0. 0. C.	1473992. 0.52 0.00 1.00	0.28460E-01 0.62479E 03 0.28964E 02 411.4594
5390.0	25298.75 C.1259E 09 20933549. 464.316	29.890772 -17.576645 95.360471 -85.883648	67.761 0.036 52517.765 107.071	5.016 -4.491 113.323 886.045	0. 0. 0. C.	1521679. 0.46 0.00 1.00	0.33824E-01 0.77272E 03 0.28964E 02 428.1863
5400.0	20869.00 C.1259E 09 20929119. 424.429	29.890705 -17.575918 97.645377 -87.940807	60.505 0.030 52518.092 110.204	3.733 -3.571 110.698 1047.825	0. 0. 0. C.	1578320. 0.41 0.00 1.00	0.39543E-01 0.93713E 03 0.28964E 02 444.1915
5410.0	16791.50 C.1259E 09 20925042. 392.646	29.890656 -17.575593 102.434931 -88.997163	54.841 0.025 52518.363 113.127	2.865 -2.821 108.456 1215.897	0. 0. 0. C.	1629280. 0.37 0.00 1.00	0.45268E-01 0.11074E 04 0.28964E 02 458.5318

OUTPUT IS DISPLAYED WITH DIMENSIONS OF UNITS IN FT, SEC, LBM, LBF, BTU, DEG R AND DEG ARC.
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5420.0	12998.00 0.1259E 09 20921248. 366.830	29.890621 -17.575447 111.841979 -89.494864	50.635 0.021 52518.592 115.980	2.386 -2.376 107.122 1357.254	0. 0. 0. 0.	1682941. 0.34 0.00 1.00	0.51225E-01 0.12901E 04 0.28964E 02 472.0500
5430.0	9442.75 0.1259E 09 20917693. 344.716	29.890589 -17.575382 126.434966 -89.704831	47.092 0.019 52518.791 118.758	2.032 -2.030 106.081 1592.353	0. 0. 0. 0.	1736008. 0.32 0.00 1.00	0.57445E-01 0.14863E 04 0.28964E 02 484.9365
5440.0	6091.25 0.1259E 09 20914342. 326.186	29.890562 -17.575347 141.022539 -89.781494	44.163 0.016 52518.965 121.323	1.715 -1.715 105.134 1790.004	0. 0. 0. 0.	1784340. 0.30 0.00 1.00	0.63584E-01 0.16849E 04 0.28964E 02 496.6566
5450.0	2911.75 0.1259E 09 20911162. 310.028	29.890536 -17.575327 150.372801 -89.807056	41.754 0.015 52519.120 123.849	1.527 -1.526 104.580 2002.331	0. 0. 0. 0.	1834587. 0.28 0.00 1.00	0.70013E-01 0.18978E 04 0.28964E 02 508.0370
5459.6	0. 0.1259E 09 20908250. 296.061	29.890513 -17.575313 154.991735 -89.815879	39.714 0.13 52519.253 126.236	1.380 -1.380 104.164 2220.384	0. 0. 0. 0.	1882823. 0.27 0.00 1.00	0.76470E-01 0.21162E 04 0.28964E 02 518.6876

TRAJECTORY COMPLETED, MINIMUM ALTITUDE REACHED 0.54596114E 04 SECONDS AFTER INJECTION

MACHINE TIME REQUIRED FOR THIS CASE = 98. SEC

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3. Contract number under which document was prepared

AT-(29-1)-789

4. Document date

February 1966

5. Document is (check one)

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